Advancing energy poverty measurement for SDG7

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Advancing Energy Poverty Measurement for SDG7

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Abstract

Existing indicators used to track progress towards achieving target 7.1 of the Sustainable Development Goals (SDGs) narrowly interpret energy poverty as a lack of connections. Recently proposed measurement frameworks are more multidimensional, but complex and conceptually muddled. We propose an alternative framework that simplifies and distinguishes two conceptually distinct aspects of energy access – energy supply conditions and the status of household energy poverty. This approach, with refinements through further applications to real data, can improve the design and targeting of policies to both service providers and vulnerable groups to accelerate affordable and reliable energy service provision.

1. Introduction

The United Nations' Sustainable Development Goal (SDG) 7.1 aims to end energy poverty globally by 2030 (1). Providing energy access universally is seen as a means of ending energy poverty and has been endorsed as a normative goal that is important for sustainable development. However, what 'access' means, what dimensions it comprises, and with what frameworks and indicators it should be measured are still being debated. Currently, two binary indicators are recommended to track Target 7.1 - Indicator 7.1.1: Proportion of population with access to electricity, and Indicator 7.1.2: Proportion of population with primary reliance on clean fuels and technology. While easy to communicate and measure, these indicators have several shortcomings. Most importantly, they tend to overestimate access as they fail to account for the quality of supply and user circumstances that determine real utilization of energy services (2).

Approaches to understanding energy poverty and measuring energy access have evolved over the last couple of decades with growing understanding of how different attributes of energy supply and aspects of household vulnerability matter for which energy services are utilized (3–10). Recent efforts have built off theoretical contributions on concepts of human capabilities and justice (10,11), such as those of Amartya Sen and Rawls (12,13). Most recent contributions, while differing in detail, emphasize the need to move beyond a binary formulation of access that focuses on connections alone to bring greater granularity to the concept. A key motivation to increase granularity is to better reveal injustices in energy provisioning and access that binary quantitative indicators alone might obfuscate (14). Newer conceptualizations emphasize three critical aspects. First that access is multidimensional, and that issues of affordability, reliability and quality of energy services are critical. Second, that there is a need to distinguish between key services or end-uses, at a minimum, between energy for cooking, lighting and other household uses. Third, there is also increasing awareness and agreement that energy access should go beyond a minimum required to meet basic energy services in the home and extend to energy for productive purposes and community services or decent living standards defined more broadly (15–18). In other words, access should be viewed as more of a continuum. Recent reviews of energy access and energy poverty metrics highlight the strengths and weaknesses of alternative approaches and the challenges with applying these in different contexts (19–25).

The World Bank, acting on its mandate to monitor achievements towards SDG 7, has proposed a new Multi-Tier Framework (MTF) as a multi-level, multidimensional measurement framework to measure energy access (26). While the MTF is a significant enhancement to the earlier binary formulations of energy access, we argue that it is now too complex and conceptually muddled to track access at a global scale. It can be further improved by disaggregating and simplifying two conceptually distinct aspects of energy access – energy supply conditions, and the status of household energy poverty – that require monitoring of different entities, namely utilities or energy providers and households respectively. Different policies may also be needed to either redress deficiencies in service provision or provide support to households. The simplifications we suggest make monitoring simpler and make transparent the links to energy access and poverty. Our modifications also simplify and reduce data requirements. Data are currently not available at a global scale to apply the MTF comprehensively. While this is also the case for our alternative framework, the coverage of surveys with adequate data is greater. Furthermore, as we discuss later, the World Bank (WB) and the World Health Organization (WHO) have recently coordinated the development of a set of new household energy survey questions that will cover all the data requirements of our framework. These standardized set of questions, related to household cooking, heating, and lighting, are recommended for inclusion in national surveys to monitor SDG 7 and track progress. To facilitate inclusion in standard existing surveys, three versions of the harmonized set of questions to align with common national surveys like UNICEF's Multiple Indicator Cluster Surveys (MICS) and USAID's Demographic and Health Surveys (DHS) and the World Bank's Living Standards Measurements Surveys (LSMS) have been made available for inclusion (27). The inclusion of these sets of questions in existing surveys along with ongoing data collection efforts through rollout of MTF surveys should make consistent and comparable monitoring of household energy use patterns across time and populations possible in the next few years. Currently, MTF surveys for 15 countries with the largest electricity access deficit are planned and being administered.

Applications of the MTF to actual regional or national contexts have been quite limited so far, but literature critiquing the approach is already emerging (7,20,21,28). The critiques suggest that the MTF is too complex for global tracking purposes and too prescriptive to gain acceptance in diverse national settings to guide policy and planning (23). Other key criticisms leveled against the MTF concern the choice of dimensions and attributes selected to measure aspects of energy poverty, the number of tiers or levels these dimensions are distinguished across, and thresholds chosen to distinguish performance among tiers or levels (7,28,29). In particular, the metrics used to capture some dimensions are considered inadequate. For instance, the MTF risk indicator was considered inadequate to capture the common energy risk factors related to burns and fires, especially common in crowded urban informal settings in the South African context. In addition, research shows that affordability in South Africa is better measured by a combination of both subjective and objective measures than the single budget share based measure defined in the MTF (28). There is also a lack of consensus of acceptable levels of service quality in defining specific thresholds for different contexts. Our refinements allay some of these concerns.

Here we first present an alternative framework for global tracking of energy access, embedded within a discussion of key conceptual challenges and limitations inherent in the MTF. In doing so, we have two objectives: first, to make more explicit the normative foundation that underlies the goal of energy access and frameworks and indicators used to measure it; and second, to simplify the MTF and thereby balance the need for accuracy of measurement with that of ease and transparency in facilitating wide adoption. We then compare this alternative framework to the MTF by applying both frameworks to household survey data from Ethiopia, India, and Rwanda. We restrict our comparison to household electricity access alone, though the approach could be extended to other energy services and end-uses. We show that the MTF underestimates the heterogeneity in the affordability and type of energy services to which poor people have access, and, as a result, underestimates energy poverty. We conclude with some insights on the applicability and usefulness of the frameworks and recommend enhancements to existing surveys and data collection efforts to better capture indicators of interest in such measurement frameworks.

2. Developing a simple yet comprehensive energy poverty measurement framework

2.1 Defining tiers of access along an energy 'service' ladder

The MTF framework includes household electricity consumption as one dimension of electricity access, wherein higher amounts put households in higher tiers. As a guide, the framework provides sample groups of appliances that are reflective of different tiers of electricity use, but these are largely defined in terms of rated capacity, not services. The implicit principle behind this framework, presumably, is that more energy use implies a higher level of welfare. However, the amount of energy used as a proxy for welfare from energy services is crude, both in principle and in practice. In principle, energy has no inherent value, but it is instrumental to obtain certain services that do have inherent value to human wellbeing, such as heating or cooling a home to comfortable levels or watching television for entertainment. Thus, tiers ought to be defined explicitly with reference to these services, rather than in terms of a quantum of energy. The same quantity of energy may offer different levels and quality of these services also depending on many technical factors associated with the delivery of the service, such as the efficiency of appliances and household structural conditions. Thus, two households may enjoy very different types of service and still be accorded the same energy poverty status based on their similar energy consumption.

Another concern with the existing tier structure of appliance energy use is that it offers no guidance for an aspirational standard. Although the tiers are intended to represent improvements in service conditions, the principles on the basis of which such an improvement is measured is absent. Households transition up an energy service ladder, acquiring new electrical appliances associated with additional services, as they become more affluent. Some recent literature has alluded to this transition as “energy mobility” (30). If the SDG were to be expanded to include these additional dimensions of access, targets would have to be specified for each, for instance which services should be included in an aspirational basket. A few measures of energy poverty offer such a threshold but encompass a wide range of services with limited justification. The ‘minimum energy poverty threshold’ (4) includes the level of energy demand required for subsistence, which the authors interpret and empirically estimate as a minimum level for lighting, cooking, and heating. Other measures implicitly consider electric energy for lighting, small appliances and clean stoves and fuels for cooking as a level of energy services that must be provided universally (31,32). In a few cases, additional services such as refrigeration or space cooling, information and communication, as well as energy (mechanical) for productive purposes are included in such measures (3,5,6,33). However, these proposals lack normative support for their assumptions, particularly in terms of the role of these services in enhancing human wellbeing. Building on a mix of sources from empirical testing, measurements and literature, Practical Action provides a broad discussion of minimum energy service needs and thresholds, including those for household needs, productive ends and community services (33). Another approach also lends support for many of these services as necessary *means* to achieve basic wellbeing (characterized as a 'decent living standard'), including good health and social affiliation (15). On this basis, in order to escape poverty and achieve basic wellbeing, households should be entitled to cook without dangerous indoor air pollution, store food in refrigerators, afford comfortable temperature/humidity conditions in the home, and have the devices and infrastructure to access broadcast media. This rationale, that energy access is a means of improving wellbeing, underlies the tier definitions we propose (Figure 1), as discussed further below. Geographic and cultural conditions may require these standards to be operationalized somewhat differently in terms of the actual appliances and affordability criteria they entail.

2.2 Focusing on additional critical dimensions of access

2.2.1 Reliability/Availability

Reliability, or regular availability of supply, enhances the economic benefits from electricity access, and consequently well-being. Recent evidence from rural India also suggests that daily supply duration is the best predictor of satisfaction with electricity supply (29,34–37). The World Bank's MTF defines reliability in terms of duration of supply, distinguishing between hours during the day and evening hours of supply, and frequency of outages or disruptions. The rationale for monitoring hours of use in the day and in the evening separately, while sound, has not found consensus in implementation due to the variation in socially and politically acceptable levels of supply disruption in different contexts (28,29). We suggest for simplicity to measure total daily availability. To decide on how many tiers or thresholds it is useful to distinguish between reliability tiers, we conducted a Theil decomposition analysis on our three household surveys that include data on average supply availability. The decomposition analysis is used to calculate the share of variability that is explained by variation within and between tiers (see Supplementary Table 1). The greater the between-group share of variability, the less the motivation to define more tiers. The analysis reveals that the between-group share dominates the within group share for anywhere from two to five tiers, but there are diminishing returns with increasing tiers. Based on this, we concluded that distinguishing three tiers is a reasonable compromise between accuracy and simplicity, the latter being important for successful implementation. The distinction we propose is between <8 hours, 8-16 hours and >16 hours of daily availability. This simplifies the more complex five tier differentiation of hours of availability and outage frequency defined in the MTF. At the same time, we expect that it will sufficiently capture observed variations in energy service utilization based on daily and seasonal supply profiles of a range of grid and decentralized intermittent energy supply provision options. It is likely that having electricity available for less than 8 hours, particularly if not predictable, can impede households' ability to enjoy 'decent' level of energy services, such as refrigeration or air conditioning, when required.

2.2.2 Affordability

The World Bank's MTF defines a single threshold for affordability, at 5 percent of household income, for a standard consumption package of 365kWh per year. Taking cooking and electricity together, this implies households spending more than 10 percent on household energy would be considered energy poor. Choosing a suitable affordability threshold for energy services in isolation is an ill-posed problem, considering that its effect on households' purchasing power depends on the costs of other basic necessities. Indeed, using a fixed proportion of income measure has been strongly critiqued in the European context (38). Further, for households in poor agrarian settings and engaged in more informal activities, asset or wealth indices could serve as a better base from which to assess relative affordability. At a global level, the intention of such a threshold is to carve out an adequate, but maximum, amount of financial space for energy services and thereby limit the financial burden on other necessities. However, energy metrics also measure relative progress within and across countries, to inform policies that provide support to households. In this regard, a single threshold may not provide the degree of information needed to prioritize efforts if a population is considerably large and diverse. Indeed, we show below that for the countries we consider, there are a non-trivial share of the poor who pay over 5 percent, and even above 10 percent just on electricity. We suggest that at least one more tier is needed to reveal the heterogeneity in financial conditions.

Another important consideration in keeping with the focus on energy services is that the costs included in an affordability measure should include the appliance costs as well, and not just expenditures on energy. We show later that this shifts a significant number of people downward in the tiers. Capturing the total cost of energy services, including that of appliances and supply equipment or connections, is particularly critical given increasing efforts now to provide electricity access through unregulated decentralized systems.

2.2.3 Cost of supply

We distinguish cost of supply, a supply dimension, as distinct from affordability, an energy poverty dimension. This is because cost of supply, both for connections and regular use, reflect service providers' efficiency, subsidies from government and the related political economy of the sector. People who cannot afford the cost of available energy are likely to remain excluded from access. Cost of supply can vary spatially or for different categories of customers depending on geographic factors (distance from generation or supply centers) or pricing policies (block tariff design, variations in taxes and subsidies), and may even be influenced by corruption and misappropriation of rents/ revenues. This can also serve as an indicator of the financial health of utilities and energy suppliers. Information on cost of supply (including fixed and variable charges) should ideally be collected from energy suppliers. Tiers for this dimension could then be defined as deviations from an average value, with thresholds defined as plus or minus a multiple of the standard deviation around the mean. One way to approach this indicator is to use national benchmarks for utilities and service providers based on best practices within countries or regions. In the application presented later for Ethiopia, India and Rwanda, we do not operationalize this indicator, as data for this was not consistently available across the three nations.

2.3 Energy supply as distinct from household energy poverty

The MTF conflates dimensions that describe aspects of energy delivery and supply with those that are related to user circumstances and preferences (21). The hours of availability, the voltage/frequency of electricity, costs of connection and the electricity tariff define supply conditions. On the other hand, lack of insulation is a property of the household's energy poverty. The per unit cost of electricity and building insulation, along with other factors, determine heating or cooling costs, and in turn the expenditure share of energy for a household.

Despite their relatedness, the risk of putting these dimensions together and aggregating them into a composite metric is manifold. Most obvious is that their aggregation masks the relative contributions of each. The deeper concern is that it masks where to target efforts of reform. Supply conditions should be monitored and ranked separately to target utilities and service providers for reform. Household conditions need to be considered more broadly in the context of poverty, so as design appropriate social support policies for housing or efficient appliance purchase. Because of this, even if the multiple dimensions were used as a dashboard (and not combined into a single indicator) their delineation into these two facets is useful to provide conceptual clarity and guide policy better.

2.4 Building an alternative measurement framework

Based on the above critique, we suggest simple revisions to the MTF that reduces the number of tiers from five to three, aligns these tiers more closely with a hierarchy of energy services, and groups these dimensions into supply-related and energy poverty-related ones (Figure 1). For global tracking purposes, we argue that at a minimum, the energy supply measure should include reliability and cost of service, and the energy poverty measure should include affordability and energy services. These attributes also capture those explicitly stated in Target 7.1 of the SDGs that were globally agreed on in September 2015.

As discussed above, in distinguishing tiers by energy services, we define a lower tier (Minimal) as a level of energy for basic safety and security, or 'energy subsistence'; a middle tier (Decent) as a level that affords a decent living standard; and the highest tier (Affluent) as reflecting discretionary energy use. In addition to capturing normative contributions of life quality, these tiers also reflect the order in which people tend to acquire electric appliances in the world (39). Energy subsistence includes lighting, fans for a minimal level of space conditioning required in much of the global south, and cell phone charging. Although cell phone charging may not be considered as fundamental, people tend to acquire it prior to any other appliance, and are often offered this in conjunction with lighting. 'Decent' energy services additionally include refrigerators and AC for food storage and space conditioning respectively, and TV or similar device to access broadcast media, which is important for social wellbeing. We include AC in the decent tier, because although it is typically a luxury item in practice, there are studies showing that AC would be necessary to avoid heat stress-related health impairments in large parts of the world (40–42). The risk that wealthy households in moderate climates that own ACs as a convenience would be classified in this tier is low, considering that such households likely also own other appliances that would put them in the 'affluent' category. Although washing is also a basic need, it can and often is met through communal washing facilities. Individual household ownership of washing machines is more of a luxury, typically lagging televisions and refrigerators in ownership rates. 'affluent' level of service includes all other appliances, including microwaves, computers and electronic gadgets (39). We suggest that households should be assigned to the highest tier into which *any* of their appliances fall. That is, a household would fall in the 'decent' category only if it owns either a refrigerator, TV (or equivalent device) or AC, but none of the appliances in the 'Affluent' tier.

We define two thresholds (and therefore three tiers) for affordability, to further distinguish households that pay over 10 percent of their total expenditure on electricity from those who pay over 5 percent. Similarly, we define two thresholds and three tiers for reliability or regular availability, to distinguish households for whom the duration of supply is less than 8 hours a day from those that can increasingly utilize additional appliances and energy services.

We now apply and compare this simplified framework to the MTF for the case of India, Ethiopia and Rwanda to illustrate that the MTF masks significant heterogeneity among the poor, which this new framework better reveals.

INSERT Figure 1: A simplified alternative framework compared to the Multi-Tier Framework for energy access measurement.

3. Testing the alternative framework to measure access

3.1 Data and methods

To apply the MTF and our alternative framework (AF) for energy poverty measurement in Ethiopia, India and Rwanda we use micro-data from existing national household surveys. For Ethiopia and Rwanda, we use surveys that were recently conducted by Multi-Tier Framework's (MTF) international initiative and that contain questions that are specifically tailored to collect data to assess energy access using the MTF measurement framework (43,44). We also employ data from the Indian Human Development Survey (IHDS) II, which is a multi-topic survey conducted in 2011-12 covering questions on health, education, employment, expenditures, and income that also includes details on energy use and housing conditions (45). We use this dataset for India to illustrate how general surveys, not specifically designed to collect MTF related data, can also be used to apply the framework. We use data on appliance ownership in the surveys to assign households across tiers of energy services as defined by the AF. Since the IHDS survey includes questions only on electricity expenditures and not on electricity consumption, we use another nationally representative survey dataset for India (the National Sample Survey Household Consumer Expenditure Survey Round 66) also conducted in 2011-2012 to estimate average electricity prices by quartiles of electricity use. The electricity expenditures in the IHDS survey are then divided by these quartile-specific average electricity prices to impute the implied electricity consumption. The imputed electricity consumption is used to assign households across tiers of electricity consumption as defined by the MTF.

To determine the assignment of households across electricity reliability or availability tiers in the MTF and AF, we use the question from the surveys on hours per day of electricity access. To determine the affordability dimension as specified in the MTF and AF, we determine the budget share of expenditures on electricity. For the proposed AF, we include in the electricity budget share, also the annualized discounted value of appliance costs. We use an annual discount rate of 10% to estimate the discounted values and source average lifetimes and appliance prices from the Euromonitor International consumer appliances and electronics database.

3.2 A comparison of the frameworks

The first thing to note from a comparison of the population distributions in all three countries across the MTF's six Tiers of electricity consumption and our 4 Tiers of electricity services is that consumption appears to be a poor proxy for access to energy *services* (Figure 2 (a)). Those defined as Tier 2 in Ethiopia and as Tier 3 in India under the MTF are distributed across all three tiers in the AF, indicating that these households enjoy very different levels of energy services. Yet, in the MTF, they would be considered as having the same energy poverty status. Similarly, households that fall in Tier 3 in Ethiopia and in Tier 4 in India fall are categorized as in 'decent' and 'affluent' tiers in the AF. Thus, some households that enjoy the same energy services, like 'decent' in the AF, fall into different tiers in the MTF (Tier 2 and 3 in Ethiopia, or Tier 3 and Tier 4 in India). However, among those in our top tier of electricity service access, i.e. 'affluent', more than half are categorized as having less than Tier 3 electricity consumption access according to the MTF assignment. In other words, households that enjoy a decent standard of living compared to most Indians, considering the energy services they enjoy, are categorized as consuming only a mid-Tier level of electricity consumption according to the MTF. In Rwanda, even among households in the 'affluent' tier of electricity service access as defined in the AF, almost none are categorized as having more than Tier 2 electricity consumption access by the MTF. In sum, it is clear that the categorization of households according to electricity consumption differs markedly from that according to energy services and wellbeing. If the objective of such a categorization is to reflect heterogeneity in the distribution of enjoyed energy services, the AF would seem to be preferable.

According to the MTF's indicator and threshold of affordability (>5%), practically no one in Ethiopia or India would be considered unable to afford electricity access (Figure 2(b)). However, if one considers in addition the discounted cost of appliances needed to consume electricity, about a fifth of households in India in the Improved tier shift to Basic in our framework (5-10%). In this case, close to a third of the population in India and Ethiopia might be categorized as facing issues with affordability (spending >5% of their budget on electricity services). In Rwanda, even without considering the discounted cost of appliances, most electricity consuming households spend more than even 10% of their budget on electricity.

Finally, we see that there is a strong overlap in the MTFs Tiers of availability/ reliability and those we define in our AF. The impact of fewer tiers is simply to collapse all households with greater than 16 hours of supply. We see no significant improvement in this regard with the AF other than simplicity. Applying either framework, it is evident that over half of the population in India and about a quarter of the population in Ethiopia receive less than 16 regular hours of electricity supply per day. Thus, reliability of electricity supply or regular availability is an issue that requires particular focus in these countries. The need for enhancing the quality of electricity supply has been emphasized by other recent research assessing the attributes of electricity supply most valued by consumers in India, as well.

INSERT Figure 2: Comparison of Alternative Framework (AF) to MTF. See Figure 1 for AF Tier definitions.

Note: In 2(a) for the AF classification across energy service categories, we consider households that report appliance ownership as having electricity access, since data on self-reported consumption in surveys may be unreliable, or people may underreport due to theft or ignorance of bills etc. In 2(b) the two bars of varying width are meant to denote the two alternative affordability indicators used – one that considers only the variable costs associated with electricity purchases as a share of total household budget or income, while the second also includes discounted values of the fixed costs of appliances in the budget share indicator.

4. Discussion and conclusions

Accurately characterizing what we mean by energy access and why we aim to improve it is important to the construction of new measurement frameworks and metrics for measuring it. Currently applied SDG indicators to track global progress towards Target 7.1 underestimate energy poverty and are inadequate to inform policies to improve access. Recognizing that access is neither binary nor unidimensional has led to the development of new measurement frameworks, such as the MTF, that are a significant improvement over existing metrics. Yet, the MTF requires simplification and conceptual clarity for application on a global scale. The AF we propose here achieves this by pruning the dimensions to those specified in the stated SDG target, and defining thresholds to mark fewer tiers. We also distinguish between dimensions that characterize energy supply from those that relate to household poverty. Furthermore, electricity consumption is a misleading indicator of electricity services. Instead, we suggest differentiating households based on the types of appliances they own, which reflect the contribution of electricity services to meeting or exceeding basic living standards. An application of our AF to Ethiopia, India and Rwanda suggests that there is greater heterogeneity among the energy poor than what is reflected by the MTF.

This AF is intended to be a starting point for developing an alternative energy poverty measurement framework. We have applied the proposed alternative to three countries. This is sufficient to demonstrate the limitations of the existing MTF framework but lends only limited support to our chosen thresholds. Application to other countries may reveal the need for greater granularity in tier definitions. The proposal also needs further refinements in conceptualization and its practicability. For example, affordability has been crudely measured, and the new thresholds (5-10%) are relatively arbitrary. The number and thresholds of tranches should be determined based on further investigation of the relationship between electricity expenditure and the poor's overall budget for basic subsistence. Affordability also needs to consider cash flow constraints. We have partly accounted for this by including the upfront capital outlay for appliances, but households may face cash flow constraints even for monthly purchases. The AF also does not capture intra-household disparities in access.

The MTF distinguishes between and has separate matrices defined to measure access to (i) electricity, (ii) energy for cooking; (iii) energy for productive enterprises, and (iv) energy for community institutions. We define and apply the new AF here to assess access to household electric services alone. However, the AF can be similarly applied to assess access to energy for other purposes using the same underlying principles. Thus, access to energy for cooking, for instance, can be measured by making a similar distinction between dimensions that characterize energy supply from those that relate to household poverty. Aspects of energy supply to assess cooking energy access would require distinguishing thresholds of reliability that may be measured in terms of time required for fuel collection (e.g. distance to LPG sales outlet, biomass source, etc.), as well as cost of supply.

Characterizing aspects of household poverty that relate to access to cooking energy would require applying a similar affordability indicator to measure the budget share spent on cooking. Tiers of energy services relating to cooking energy might be defined on the basis of the stove and fuel combination a household uses, accounting for the fact that households often use multiple fuels, and distinguishing tiers by primary reliance on polluting stoves, a mix of polluting and clean-burning stoves, and primary reliance on clean-burning stoves.

Further refinements and applications of the AF can help improve how we identify the most vulnerable and design and target policies to improve energy access for all. Such efforts need to go hand in hand with augmented and regular data collection. This is needed particularly in nations where access is far from universal that typically suffer from the greatest data paucity too. These might be through custom-designed surveys or enhancements to existing survey instruments. At present, the new MTF surveys, which have been conducted in nine countries, collect data on all the indicators required for application of the AF i.e. energy expenditures, hours of availability, and appliance ownership. Future research might apply this new framework more widely to additional countries, as the data from these surveys are released. Other existing national surveys, such as the IHDS for India, also include data on the indicators needed to apply the AF. As mentioned earlier, the World Bank and WHO are coordinating efforts to include a common set of questions on household energy in other regular national surveys for monitoring SDG Indicators 7.1.1 & 7.1.2. As new rounds of these existing surveys, such as the DHS, MICS and LSMS, that incorporate this standardized set of questions are completed, it will be possible to apply the AF more widely to multiple national datasets. Exploring the use of other publicly available data sources, such as satellite-based earth observations, and new ways of combining and processing these could also compliment analyses of surveys (46,47). New data gathering infrastructures need to also consider collecting information on how progress on one pillar interconnects with the attainment of other sustainable development objectives. Efforts in this direction can help ensure the inclusive and integrated spirit of the SDGs are realized.

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Figure 1

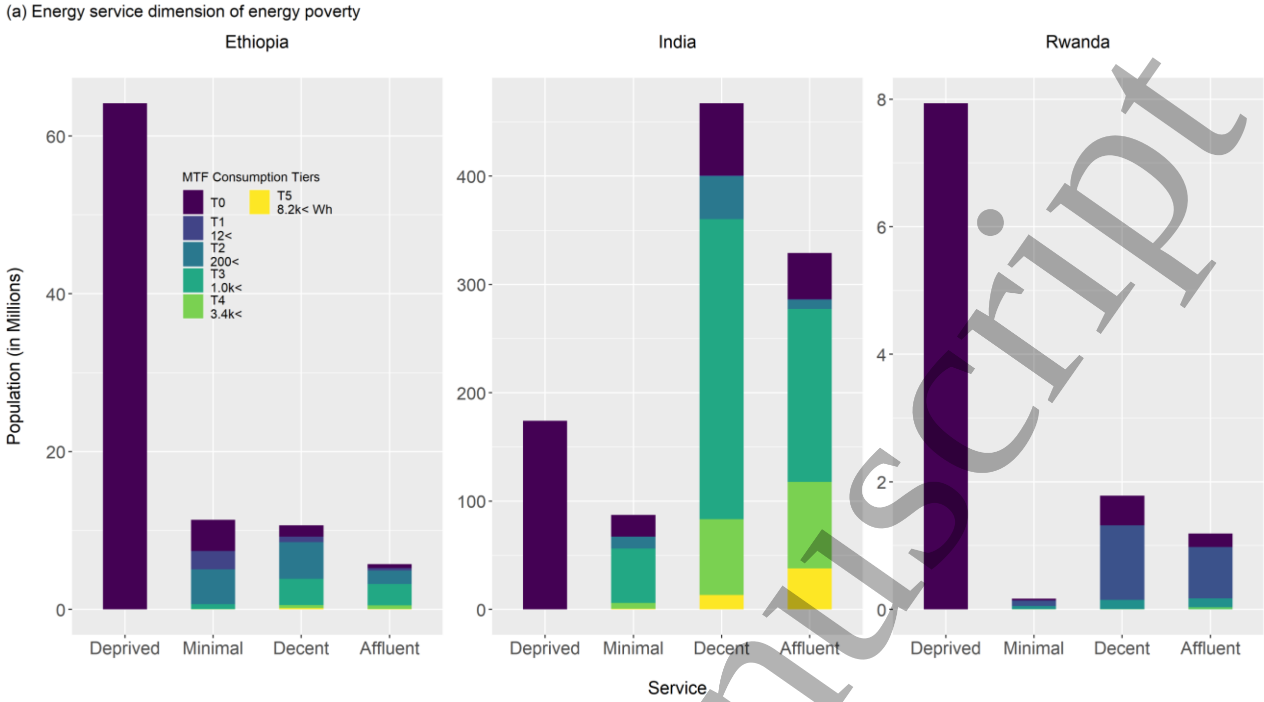
AF Measurement of Household Access to Electric Services				
	Tier 0	Tier 1	Tier 2	Tier 3
Energy Supply Poverty				
Availability	None	<8hrs	8-16hrs	>16hrs
Cost of supply^	NA	NA	NA	NA
Energy Service Poverty				
Service level	None	*Minimal* (Lighting/ phone charging)	*Decent* + (TV | fridge| cooling)	*Affluent* + (other appliances)
Affordability (budget share)	NA	>10%	5-10%	<5%

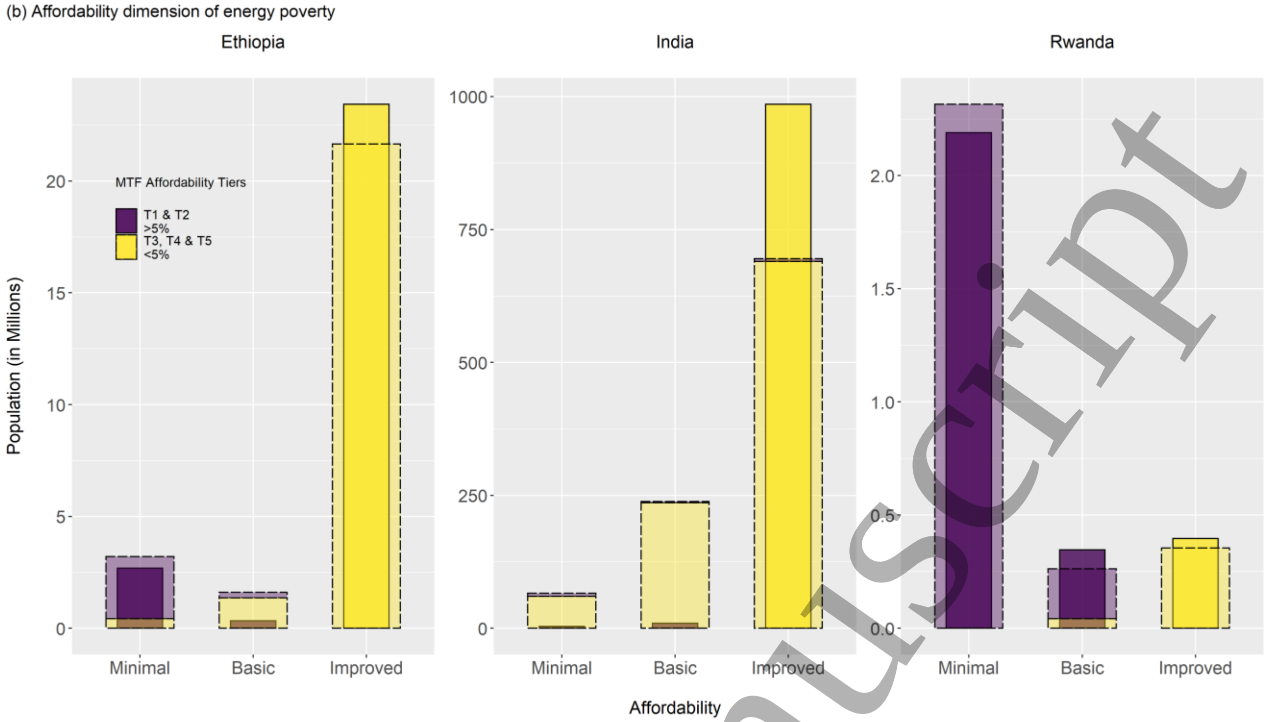
Note: ^ The cost of supply is context specific

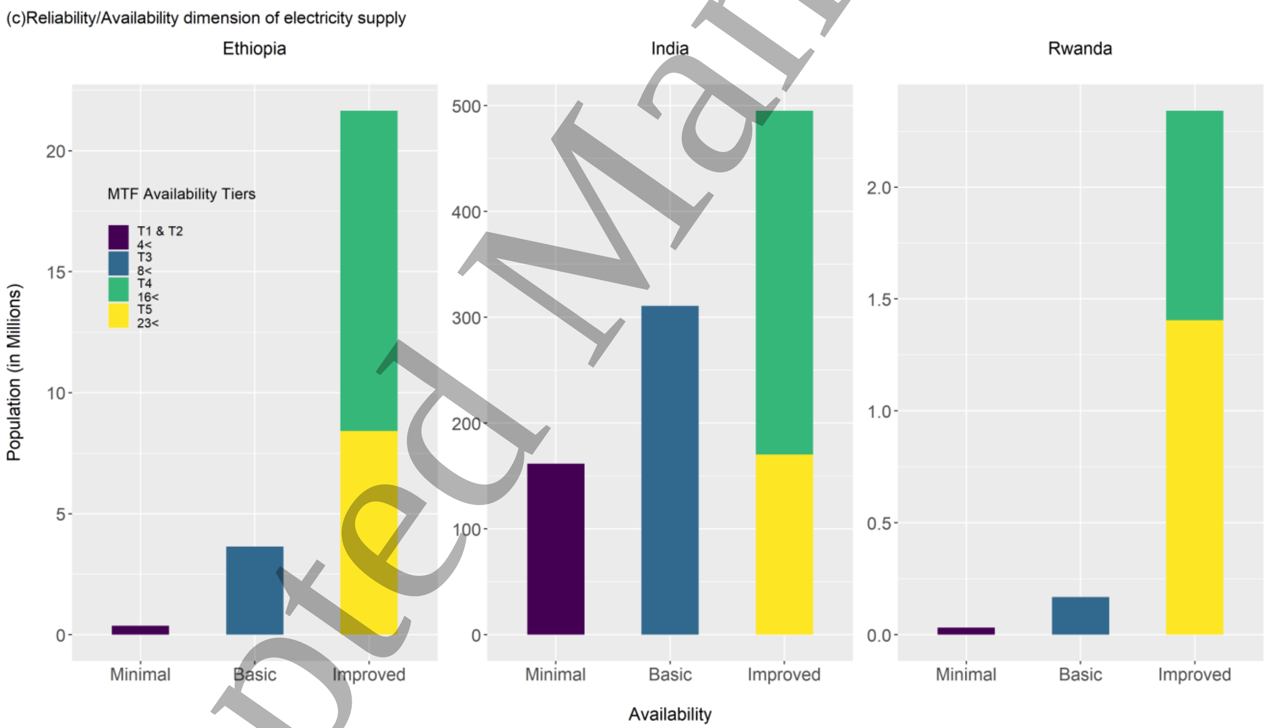
MTF Measurement of Household Access to Electric Services*						
	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Duration – Day Evening		≥ 4hrs	≥ 4hrs	≥ 8hrs	≥ 16 hrs ≥ 4hrs	≥ 23 hrs ≥ 4hrs
Quality					Voltage problems do not affect use of desired appliances	
Reliability Disruptions per week					≤ 14	≤ 3 of total duration < 2hrs
Capacity		≥ 3W	≥ 50W	≥ 200W	≥ 800W	≥ 2kW
Consumption levels, in Wh/day	<12	≥ 12	≥ 200	≥ 1,000	≥ 3,425	≥ 8,219
Affordability				Cost of standard consumption package of 365 kWh per annum is < than 5% of household income		

Note: * The MTF also includes dimensions - “Legality” & “Health and Safety”

Figure 2


(a) Energy service dimension of energy poverty
Ethiopia
India
Rwanda
Population (in Millions)
MTF Consumption Tiers
T0
T1 12<
T2 200<
T3 1.0k<
T4 3.4k<
T5 8.2k< Wh
Deprived
Minimal
Decent
Affluent
Service


(b) Affordability dimension of energy poverty
Ethiopia
India
Rwanda
MTF Affordability Tiers
T1 & T2 >5%
T3, T4 & T5 <5%
Population (in Millions)
Minimal
Basic
Improved
Affordability


(c)Reliability/Availability dimension of electricity supply
Ethiopia
India
Rwanda
MTF Availability Tiers
T1 & T2 4<
T3 8<
T4 16<
T5 23<
Population (in Millions)
Minimal
Basic
Improved
Availability