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Shonali Pachauri

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Shonali Pachauri [a,*], Daniel Spreng [b]

[a] International Institute for Applied Systems Analysis, Schlossplatz 1, A-2361 Laxenburg, Austria
[b] Energy Science Center, ETH Zurich, Switzerland

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ABSTRACT

This article undertakes a review of alternative measures and indicators of energy poverty targeted to specific audiences and for particular purposes. At the national and international scales there have been some efforts for constructing measures of energy poverty. However, much more needs to be done to develop an internationally consistent measurement framework and to put in place data collection systems that will enable regular reporting. At the programme and project level, indicator systems by necessity need to be designed for specific purposes. Nevertheless, the article proposes that in many instances it is desirable to widen the scope of metrics used for designing and evaluating policies and programmes. In the past, monitoring and evaluation indicators have focused largely on outputs, service delivery or dissemination. Central to the recommendations laid out in the paper is the call for widening the focus of evaluation and necessity to design indicators that adequately assess the needs of beneficiaries and describe the living conditions of families and communities, who are targeted by such programmes and initiatives.

1. Introduction

Today global efforts to improve the household energy situation of billions of people form a major part of the initiatives aimed at alleviating energy poverty and are considered fundamental to meeting the Millennium Development Goals (MDGs). The United Nations (UN) Secretary-General's Advisory Group on Energy and Climate Change (AGECC) recently called for universal energy access by 2030 (AGECC, 2010). At the MDGs review meeting in September 2010 the IEA, in collaboration with UNDP and UNIDO, released a special section on "Energy poverty: How to make modern energy access universal?" a special early excerpt of the 2010 World Energy Outlook (IEA, UNDP, UNIDO, 2010). In addition, the United Nations General Assembly recently declared 2012 as the "International Year for Sustainable Energy for All".

Akin to frequent declarations to improve sustainability, energy poverty reduction is now a growing concern in the public policy agenda. However, considerable progress still needs to be made to properly measure both sustainability and energy poverty. Only then will it be possible to accurately judge, whether progress toward these noble goals is being made. However, like sustainability, energy poverty is not easily boiled down to one number and it is difficult to trace back changes in energy poverty levels to specific efforts since other factors such as general economic growth, social and infrastructural development also influence it. In addition, a variety of environmental and behavioural factors can intervene on pathways between specific efforts and outcomes. It is for this reason that careful attention is needed to define and select indicators that can assess the outcomes or conditions that need to be compared or that a policy/project intends to influence. In addition, since policies operate on multiple scales, it is important that indicators are matched appropriately to the level and audience that these are intended to inform or impact.

Informed by the recent body of work in this field and a renewed commitment to accelerating the global reduction of energy poverty, this paper appraises alternative measures of household energy poverty, that aim to inform policy and programmes and suggests additional domains for which metrics need to be constructed to inform the design of new activities specifically aimed at accelerating the adoption of improved cooking fuels and stoves among the poor.

At the outset, in Section 2, a brief discussion of some energy-related sustainability indicators is presented. Section 3 then focuses on energy poverty and access indicators targeted to specific audiences and for particular purposes. At first, a discussion of metrics and indicators to understand underlying mechanisms related to energy poverty is presented. Section 3 also includes a discussion of the authors' own measure of energy poverty, known as the Energy Access-Consumption Matrix (Pachauri et al., 2004; Pachauri and Spreng, 2004) and presents some results from the application of this measure to recent

* Corresponding author. Tel.: +43 2236 807 475; fax: +43 2236 71313.
E-mail address: pachauri@iiasa.ac.at (S. Pachauri).

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survey data from India. This is followed, in Section 4, by an assessment of alternative approaches to measuring and monitoring energy poverty, in particular, with a view to the use of such indicators for national reporting, policy and programmes. In Section 5, the paper narrows its focus again on one important aspect of energy poverty, the lack of access to appropriate technologies and energy for cooking. We conclude with recommendations for key domains where there is a need to construct metrics that are instructive for suitable monitoring and evaluation of specific programmes or activities introducing improved cooking fuels and stoves in developing countries.

2. Energy indicators relating to sustainability

The role of an indicator is to fulfil the social purpose of improving communication. This goal was the starting point for the construction of suitable sustainability indicators (Hammond et al., 1995). Such indicators were envisioned to describe and diagnose trends of states and developments and identify limiting factors, educate the general public, prepare political decisions and monitor measures that have been taken. There is, however, no set of indicators that is suitable for all purposes.

The challenges with reaching a common understanding regarding the use of indicators of sustainable development are related both to the multitude of communication situations and purposes they are designed to serve and to the complexity of the topic. Sustainable development has complex interlinkages with several systems and issues.

Some authors have suggested that energy indicators might provide an impartial yardstick to analyse sustainability (e.g. Kemmler and Spreng, 2007), because energy is a fundamental physical quantity that is easily measurable in an everyday environment. However, it is also a quantity that is somewhat elusive. It is only since the middle of the 19th century that aspects such as the warmth of a body, heat radiation and mechanical motion have been lumped into the one quantity—energy. The usefulness of energy varies greatly depending on its form, its location and its temporal availability. This is why it is possible to misinterpret the meaning of a given value, even though the physical measurement may be clear-cut. Furthermore, there is no simple way to quantify the importance of easily accessible, clean energy for development. Although food, clean water, education and health and hygiene are probably more important, energy is linked to all of these. In practice, food, drink, education and health would not be available without energy. On the other hand, without food and drink, a certain level of education, health and hope for a brighter future, access to clean energy would not be valued. There is no simple cause–effect or outcome relationship.

Taking this 'direction for use' into account, energy is an ideal candidate for many kinds of indicators. Unlike money, energy consumption can be measured outside commercial economies. Energy per time unit – i.e., energy flow or power – is an essential attribute of life, growth and activity of any kind. Unlike money, energy does not require a currency converter and, in that sense, it is an incorruptible, global currency.

2.1. The IAEA report

In 2005, the International Atomic Energy Agency (IAEA) and other UN agencies published a report entitled "Energy indicators for sustainable development: Guidelines and Methodologies" (IAEA, 2005). It recommends what energy indicators should or could be collected, defines the recommended indicators and provides a suggested grouping of them. The list of indicators contains energy indicators in the social dimension, the economic dimension and the environmental dimension. The three dimensions are further divided into themes and sub-themes, with at least one energy indicator chosen for each sub-theme. The social dimension, for example, includes the themes of Equity and Health and the Equity theme includes the sub-themes of Accessibility,[1] Affordability[2] and Disparity.[3] The suggested indicators are a possible approach to the theme. They are chosen more from a supply perspective than from a consumer perspective and are suitable to compare countries. A household may, for instance, cover all its energy needs from its own abundant wood supply and use it in good stoves. Although this household may have all the access it needs, using the suggested indicators it would be considered an energy-poor household.

2.2. The 2000 W society

Growing concerns about the implications of excessive energy use for the environment and climate have led to an increasing degree of attention being focused on developing appropriate energy-related indicators that reflect sustainable development. There is an upper limit if climate science is taken seriously and if it is assumed that the energy mix is not going to change drastically from one day to the next. Goldemberg et al. (1987) suggested that there was a lower limit to energy use in order to meet a decent standard of living. As the upper and the lower limit of energy use per capita are very near each other, namely around 2×8760 kWh/year or 2000 W per capita, the idea of an energy use goal for all humans on this planet suggests itself. This idea was formulated in Switzerland (Kesselring and Winter, 1994, Spreng, 2005) and even taken-up by the government as a worthwhile long-term goal of its energy policy. For developed countries the goal is to increase their living standard, while reducing energy use massively, for developing nations it is to strive for economic growth while increasing overall energy use very moderately, if at all. However, the goal is so long-term that the policy impact may be marginal.

The major challenge for the development of appropriate energy-related sustainability indicators is accounting for the impact that current trajectories of changes and policies will have on future states. This requires projecting sustainability indicators into the future. Particularly in rapidly changing developing countries, it is of minor interest to know how sustainable the present situation would be if it was held constant. Any action or policy has a huge influence on future states and the question of sustainability must refer to developments that are taking place and will take place in the future. This requires linking energy indicators to energy models (see for e.g. Kemmler, 2007),[4] and for that matter to economic and systems models more generally. However, research in the area of connecting energy indicators to future scenarios is only in its infancy and it is clear that much more analytical work is needed in this direction. Hopefully, it can serve as a litmus test for measures, which are claimed to further sustainable development.

After this brief discussion of the usefulness of energy indicators in measuring sustainability and of instances where they have

[1] Share of households (or population) that are without electricity or commercial energy or are heavily dependant on non-commercial energy.

[2] Share of household income spent on fuel and electricity.

[3] Household energy use for each income group (quintiles) and the corresponding fuel mix.

[4] Kemmler and Spreng (2007) devised a small set of energy-panorama indicators that can be calculated from energy models, if the models include information closely related to the indicators. Their eight indicators include the three domains of sustainability.

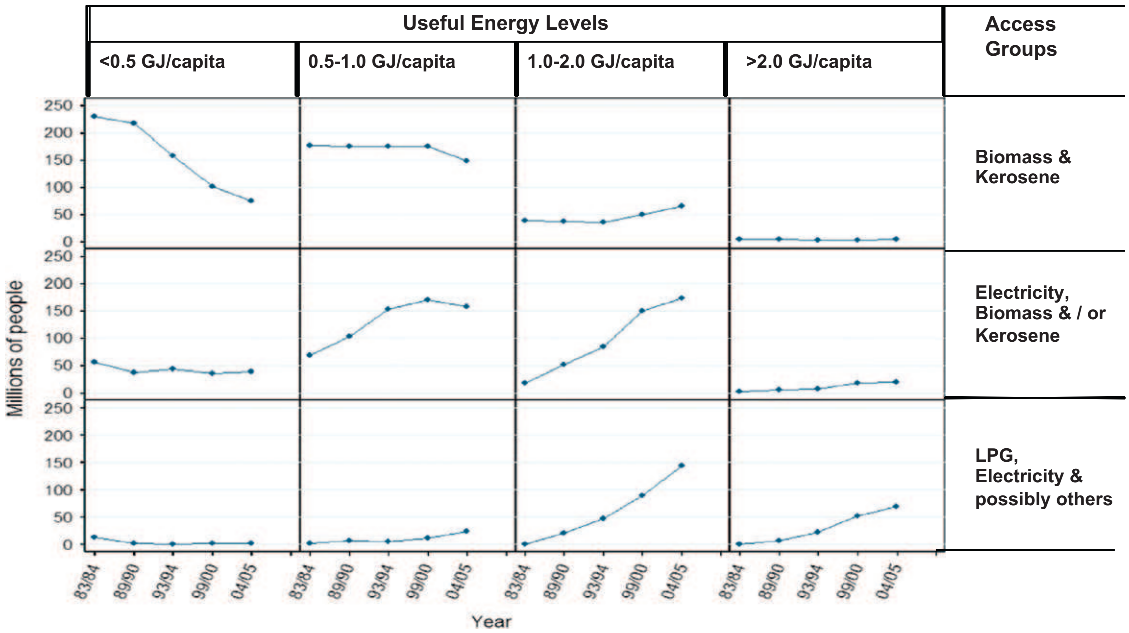

Fig. 1. Changes in household energy poverty and distribution in India applying the energy access-consumption matrix. *Source*: adapted and updated from Pachauri et al. (2004).

been used to do so, the following sections will focus more specifically on indicators and measures of energy poverty.

3. Metrics and measures for understanding underlying mechanisms of energy poverty

Understanding energy poverty is central to any efforts to alleviate it. As a first step, this requires a structured approach to the manner in which energy poverty is defined, measured, monitored, recorded and reported. Appropriate indicators are necessary for monitoring the progress towards alleviating energy poverty and additional benefits that can result from programmes implemented with this objective in mind. Knowing not just who is energy poor but how and why people are energy poor is essential for designing effective programmes and policies. Energy poverty is caused by a complex combination of factors, including lack of physical availability of certain energy types, lack of income and high costs associated with using energy, among others. For understanding underlying mechanisms highly aggregated indicators alone are generally not sufficient. An analysis of the underlying mechanisms and reasons for change of the indicator values requires detailed disaggregated information. Such measures need to be able to show shifts in the composition of energy poverty over time so that progress, or the lack of it, can be monitored. The design and implementation of any measures to reduce energy poverty require information on which subgroups of the population are most afflicted by energy poverty, the determinants of energy poverty and how the incidence has changed over time. It is often only at the micro-level where causal associations can be addressed directly. However, estimating causal impacts requires analysis that can effectively isolate the impacts of improved energy access. Since households with improved energy access are likely to have better development outcomes, accurately associating development outcome differences across households to energy interventions requires controlling for background characteristics that are strongly associated with energy access and better development outcomes (GTZ, 2007). In many developing countries, the kind of detailed data required for carrying out such in depth analysis is not available. In such circumstances, an important first step is determining how improved energy access correlates with other developmental indicators. Several examples of analysis that illustrate how improved energy access correlate with other developmental indicators such as improved health, productivity, literacy, etc. already exist (UNDP and WHO, 2009; Kanagawa and Toshihiko, 2007). Examples of studies that estimate causal directions and impacts are less forthcoming (Khandker et al., 2009; Dinkelman, 2008). Thus, the need for more research on this in the future is clear. However, simple diagnostic indicators or measures coupled with analysis of changes in these over time and the study of the relation of these to other development indicators can also serve to increase understanding of underlying mechanisms.

One example of such a measure, is the measure of energy poverty developed by Pachauri et al. (2004), referred to as the energy access-consumption matrix. This is not a measure of energy poverty per se, but it does provide a means to describe the entire population distribution of a nation in terms of their level of access to different modes of final energy and the amounts they consume in useful energy terms (this is used as a proxy for measuring the level of services enjoyed by different households). It is possible to draw a line on the matrix that provides a defining threshold both in terms of the level of access and quantity consumed to distinguish the energy poor from the non-poor. However, drawing such a line involves a degree of arbitrariness and any such endeavour would have to be made on a national scale. Nonetheless, the measure does provide a good basis for undertaking a comparison over time, given the data, and thus assessing how the distribution of the population is shifting both in terms of access and consumption levels. Fig. 1 provides such a depiction of the changes in the population distribution of India over the last two decades.

Fig. 1 reveals that not only has the number of energy poor declined in India, but also that there have been large shifts in inequality of the distribution of population by energy consumption and access between 1983/84 and 2004/05. The number of people living in desperately energy poor households having access to only biomass and kerosene and using barely enough of it to cook a full meal a day (top left cell of the matrix shown in

Fig. 1) decreased from 38% to 8%. At the same time, the number of people living in households having access to electricity and possibly also LPG and using more than is necessary to cook two full meals a day (all four cells near the bottom right of the matrix together) increased from 3.5% to 42%.

The matrix provides a means to visualize the level of energy services the entire population is able to enjoy and simultaneously indicates a level of wellbeing. Earlier studies by Pachauri and Spreng (2004) and Pachauri et al. (2004) suggest that not only do some important infrastructure characteristics correlate strongly with the energy access, but also literacy and other socio-economic characteristics. For the top row of the matrix that represents populations in households having access to only biomass and kerosene, previous analysis shows that a shift rightward to higher levels of energy use is almost uncorrelated with improvements in the level of some of the basic infrastructural characteristics of the households. Thus, for instance, analysis has shown that biomass and kerosene users in the highest energy use category do not differ significantly from those in the lowest energy use category in terms of literacy or access to tap water systems. However, even for the lowest energy use category, access to electricity (a shift downward in the matrix from biomass and kerosene users to electricity, biomass and/or kerosene users) correlates with a significant improvement in the indicators relating to literacy and access to tap water (Pachauri and Spreng, 2004). At the same time though, there are significant differences in the level of wellbeing of households falling in the biomass and kerosene category as one moves rightward from those who have very low levels of energy use to those who use more. These differences are reflected for instance in the size of land holdings they own. However due to the lack of market integration of these households, most of their consumption is not bought at a market place and might often come from production for self-consumption and from barter exchanges.

While information about the end-use devices that households employ is scarce in the surveys analysed for India, analysis presented in Pachauri (2007) provides evidence of there being a significant correlation between access to modern cooking energy sources, and the average daily intake of food calories. In other words, populations residing in households using cooking fuels like dung or firewood as their primary source of cooking energy are more likely to have a lower daily calorie intake on average than those that use more efficient and cleaner combusting fuels such as kerosene or LPG. In addition, there is strong evidence of the poor uptake of more efficient biomass stoves (improved cook stoves ICS) in India. Although India has installed a large number of improved stoves and hosts the world's second largest ICS programme after China, the actual impacts and achievements of the programme appear to be far from satisfactory (Bhattacharya and Jana, 2009). From 1983 to 2000, approximately 35 million ICS of various types were distributed in India (Greenglass and Smith, 2006). A survey carried out by the National Council for Applied Economic Research (NCAER) in 2001–2002 estimated that only 6.45 million of the total ICSs installed were working. According to ESMAP (2004), of the 7 percent of rural households that adopted ICSs, by the end of 2000 most reverted to traditional stoves as the ICSs developed cracks or needed spare parts and the required maintenance was not available.

All of this evidence points to the fact that households that are in the top left boxes of the matrix depicted in Fig. 1, have hardly sufficient amounts of energy to cook two square meals of day and in addition are deprived in many other dimensions of poverty as well. The fact that they cook with only biomass energy in highly inefficient devices, also suggests that they are likely to be exposed to high concentrations of harmful pollutants resulting from the incomplete combustion of biomass fuels, and also have to bear the burden and hazards associated with collecting biomass.

The grouping of households as described above does provide a rather detailed picture of the energy situations various households find themselves in. It also provides some information on the dynamics of energy poverty as it includes an assessment over different periods in time. It does not, however, do justice to the much more dramatic movement of individual households out of and back into poverty that very often occurs as a result of wars, economic shocks and natural catastrophes. There exists a significant body of literature that analyses the factors that cause chronic poverty and drivers of escape from and descent into poverty (see for e.g. Sen, 2003). However, similar analyses of factors that drive households to escape from energy poverty or the risks and vulnerabilities they face, which cause them to fall back into it is lacking so far. Such research is very data intensive and requires panel studies that track the same group of households over long periods of time. Clearly though, such studies could go a long way in understanding the underlying causes of energy poverty and help formulate more effective policies for reducing it.

4. Energy poverty indicators for national reporting and policy and programme design

Attempts to measure energy poverty have largely linked energy poverty to a lack of physical access to modern energy. Global efforts at providing consistent and comparable datasets on access to electricity and modern fuels include those made by the IEA, WHO and UNDP (IEA, 2010; UNDP and WHO, 2009). There has only been limited development of a broader spectrum of indicators or more complete measures of energy poverty that are internationally comparable. The IEA published estimates of the Energy Development Index (EDI) for about 75 countries in the 2004 edition of the World Energy Outlook (IEA, 2004). It has recently updated the work in its 2010 edition of the World Energy Outlook. The EDI, a composite index fashioned after the HDI, combines three indicators that are equally weighted: per capita commercial energy consumption, share of commercial energy in total final energy use, and the share of the population that has access to electricity. As is the case with all composite indices, the embedded trade-offs implied by the equal weighting of all indicators in such indices is problematic and require value-laden judgments to be made. The index has some value for international comparisons of the status of energy development in a given year. However, it does not allow for meaningful comparisons across time because its construction requires normalizing the values of each of its component indicators against the maximum and minimum values of that indicator among the sample of nations included for the estimation in a given year. The sample of nations for which the index has been constructed has varied over time, as have the maximum and minimum values of the indicators that compose the index.

Other efforts to undertake internationally consistent energy poverty measurement are lacking. While several institutions and agencies have proposed sets of indicators that may be used to measure energy access and poverty, no regular systems of data collection have as yet been put in place to estimate and report on these. At the international level, therefore, it is clear that much more needs to be done to develop an internationally consistent measurement framework and to put in place national data collection systems that will enable regular monitoring and reporting.

Internationally consistent measures of energy poverty that are produced on a regular basis are clearly needed. These provide a benchmark of progress, inform on the relative changes across nations and can serve to guide international and national agencies in setting priorities. However, in the absence of these, national measures can be important to inform policy makers in individual countries. Several national efforts have been made for measuring and monitoring energy poverty (see for e.g. Bazilian et al., 2010 for a review). Among these, some approaches have tried to assess energy poverty in terms of affordability. In order to capture the deprivation associated with not being able to afford adequate amounts of modern energy services, Foster et al.'s (2000) study for Guatemala estimated an energy poverty line by calculating the average amount of energy being consumed by households identified as living below the national general poverty line (measured in monetary terms). While this measure introduced an important element of affordability to measuring energy poverty and, in some way, also accounted for a minimum basic quantity of energy, it inherently assumed that there is a perfect correlation between people, who are monetarily poor and people, who are energy poor. It also fails to account for non-monetary transactions that are often a large part of the consumption basket of the poor. A high degree of correlation between these two factors can be expected. However, work on India by Pachauri and Spreng (2004) and Pachauri et al. (2004) showed that the correlation between general monetary poverty and energy poverty is not always high (see Table 1). Some households are very poor in monetary terms but do have access to adequate sources and amounts of energy to meet minimum needs; conversely, some households that are very rich in monetary terms do not have access to modern energy.

The application of policy relevant indicators depends on a number of considerations. For instance, what is the rationale for policy intervention? What is the scope for intervention? The rationale for government or public involvement in reducing energy poverty is usually explained in terms of market or system failure, i.e. situations in which price mechanisms do not take externalities into account or where existing institutions fail to facilitate the level of development considered desirable. For e.g. pricing of household fuels in India provides an interesting case in point. The government of India subsidizes kerosene for household consumption for social reasons in order to enable low-income households to gain access to this fuel. However, recent literature indicates that the policy has largely been ineffective in reaching its objective. There is evidence to indicate that much of the kerosene leaks to the black market (Gangopadhyay et al., 2005). In addition, since most rural households do not use kerosene for cooking but rather for lighting the kerosene subsidy is regressive and of negligible value in rural areas (Rao, 2010). If a regular system of policy monitoring had been in place and data for constructing indicators regarding the extent of subsidy, use of kerosene by different income groups, etc. had been regularly collected in the past, this might have helped inform policy makers and may have resulted in an early revision of the policy and design of a new policy that could have better met the equity objective.

Table 1
Percentage of population living below the national poverty line for each energy access-consumption group.

Access groups	Useful energy levels			
	< 0.5 GJ/ capita	0.5–1.0 GJ/ capita	1.0–2.0 GJ/ capita	> 2 GJ/ capita
Biomass & kerosene	87.8	79.7	62.9	39.4
Electricity, biomass &/or kerosene	74.3	67.1	39.5	18.1
LPG, electricity & possibly others	31.9	30.8	12.1	1.4

Some of the newer efforts to measure energy poverty have focused more specifically on capturing the monetary and non-monetary costs involved in using the specific types and amounts of energy consumed by households or the inconveniences (externalities) associated with the use of traditional fuels. For instance, a new study on rural Pakistan by Mirza and Szirmai (2010) developed a composite index that takes into account the shortfall in consumption (compared to a predefined basic minimum amount) and the inconveniences associated with using different energy sources at the household level. They then defined a total energy inconvenience threshold (TEIT), beyond which all households measured as suffering inconveniences are defined as energy poor. Including the inconveniences to the household associated with using less efficient and more polluting energy sources and equipment is clearly an improvement over existing measures of energy poverty. However, the measure falls short in terms of accounting for the direct costs associated with the use of a particular energy mix for the household or how affordable the energy itself and the end-use equipment are for the household. In many cases, the cost of the equipment and initial connection poses a major barrier to the adoption of new and more efficient energy sources for poor households. Furthermore, the approach requires very detailed survey data, which may be difficult to collect on a routine basis for some nations.

A recent study by Barnes et al. (2010) proposes a new measure of energy poverty for Bangladesh. The minimum end-use energy (MEE) approach estimates the energy poverty line based on the end-use or useful energy demand function for households and sets it at the level up to which useful energy demand is invariant to income. Naturally, such a measure presupposes that there is a level of income below which energy consumption (measured in useful energy terms) remains constant and that this level corresponds to the absolute minimum amount required for meeting basic needs for cooking and lighting. While this may well be the case in rural areas of less developed nations, it would be unusual in an urban setting, even among the energy poor. In addition, since the measure only defines energy poverty in a quantitative sense, and takes account of types of energy used only implicitly by including efficiencies, it is conceivable that the measure would classify a household with very high biomass consumption as energy-non-poor, even if the household lacks electric light and burns the biomass in inefficient and polluting stoves.

Finally, the Poor Peoples Energy Outlook (Practical Action, 2010) also puts forth a definition of total energy access (TEA) in terms of a range of energy services covering the range of services people want and need, along with proposed minimum levels for each of these, which could be considered as "access". In addition, to defining the service definitions at point of use, the report also develops an energy access index to indicate progress on the supply side towards the energy service standards outlined. The index measures are proposed as the three main supply dimensions of energy supplies—household fuels, electricity and mechanical power. However, much work is still needed to operationalize this concept and apply it to measure energy poverty in different national contexts.

Table 2 summarizes some of the key existing approaches to measuring energy poverty and provides examples of indicators or indices in use. It highlights that there are differences in the approaches taken based on differing perceptions of which dimensions of energy poverty are perceived as the most important. In reality, all these dimensions of energy poverty may be important for describing it along with others such as reliability and regularity of supply. While at the international level, aggregate indicators of energy poverty need to be simple, they need to describe and measure it accurately and can be supplemented at the national level by more comprehensive measures.

Table 2
Key international and national measures and indicators of energy poverty.

Scope	Dimension of energy poverty measured	Indicators/indices	Examples/sources
International	Physical availability or access to energy carriers	Household or population access	UNDP and WHO (2009)
	Energy Development Index	Index consisting of 3 equally weighted indicators: per capita commercial energy consumption, share of commercial energy in total final energy use, and the share of the population that has access to electricity.	IEA (2010), IEA (2004)
National	Physical availability or access to energy carriers	Village or community access	GoI (2001)
	Energy services	Minimum level of energy services associated with different needs, e.g. lighting, cooking, etc.	Practical Action (2010)
	Affordability	Share of energy expenses in total household budget	Foster et al. (2000)
		Share of energy expenses and annualised cost of end-use equipment in total household budget	Reddy et al. (2009), Ekholm et al (2010)
	Deprivation as defined as a deviation between actual energy access and/or use and an estimated basic minimum needs	Minimum energy needs based on engineering estimates of a normative set of basic energy services	Goldemberg et al. (1987)
		Minimum energy needs estimated as the average amount consumed by households living below the monetary poverty line	Foster et al. (2000)
		Minimum energy needs estimated as the amount till which energy use is invariant with income	Barnes et al. (2010)
		Minimum energy needs defined in useful energy terms and access to modern energy carriers	Pachauri et al., (2004), Pachauri and Spreng (2004)
	Inconveniences	Associated time costs Health impacts	Mirza and Szirmai (2010)

5. Indicators for monitoring and evaluating individual projects to reduce energy poverty

A significant body of work already exists on developing appropriate indicators for monitoring and evaluating individual projects or interventions in many different fields such as health, education, etc. In the case of household energy interventions and projects as well, examples of such work exist (WHO, 2008; GVEP, 2006). The conclusions of much of this work point to the need for making monitoring and evaluation an integral part of all projects and the critical role of this for generating the evidence needed to convince policy makers and donors of the positive impacts of household energy interventions. Another lesson is the necessity to make monitoring and evaluation a key part of any future projects right from the inception of these projects. Indicators to monitor and evaluate programmes and activities serve basically two main purposes. On the one hand they serve to keep the programmes honest by tracking achievements and measuring these against the stated goals and objectives envisioned. Second, they provide lessons for the design and development of new programmes and projects by increasing the evidence base of key impacts and effects (REEP, 2005).

Frequently, however, the evaluation of household energy projects has neglected the integration of social development and user perspectives, or existing institutional structures and concentrated instead on technical and financial factors (Annecke, 2008). In other words, typically the end-user has been relatively unstudied or understudied by project and programme designers (Ezzati and Kammen, 2002). Improved cooking fuels and stoves programmes affect living conditions of people, but present lifestyles in turn affect the effectiveness of such programmes. Correctly addressing users' priorities and preferences and understanding local circumstances and realities can be an important prerequisite for the success of new initiatives to improve access to cooking fuels and stoves among the poor. For example, poverty can often act as a trap that prevents people from trying anything new because the fight for survival absorbs all the human energy the poor have. Existing gender inequalities can also impact the outcome of initiatives. In cultures where women have no rights at all, the head of the household may not be inclined to agree to have anything introduced, which would ease the woman's toil. Understanding the local context, the living conditions, as well as the physical state of the house in which a family is expected to adopt a new stove or fuel that will impact the way meals are cooked, one of the central practices and traditions of the family, is crucial to the success of any policies or activities that address the household energy system.

Systems of indices have generally been constructed in view of the desirable attributes and the data that is available or can be gathered at reasonable cost. Typically, the type of data collected and indicators derived have been based on project goals and objectives. At the programme level the latter is different from situation to situation. Past experiences with programmes for reducing energy poverty provide additional evidence of the need for monitoring how allocated budgets are spent and determining whether and how projects contribute to better welfare for the populations they serve and improved environmental outcomes. Historically, household energy projects have focused largely on objectives related to service provision, without understanding existing energy sources or consumption patterns and the underlying development level, aspirations or realities of the targeted beneficiaries and how this relates to their choices of adopting new stoves and fuels. Clearly, provision alone does not imply use or even more importantly sustained use. Recent work by Ruiz-Mercado et al. (this issue) points to the need for collecting information not only on dissemination of new stoves, but also on the sustained actual use of the stoves. They discuss the emergence of a new generation of sensor-based tools that is making possible continuous and objective monitoring of the stove adoption process (from acceptance to sustained use or disadoption), and has enabled its scalability.

Clearly projects need to define "output", "outcome" and "impact" indicators to properly assess the adoption process and evaluate the outcomes of specific interventions. Defining targets solely in terms of outputs such as number of stoves disseminated is not sufficient, when the ultimate outcome is improved cooking efficiency, ease and cleanliness and better health for the population. To better understand the impacts of specific policies and activities, indicators that can monitor ongoing use and performance are needed, for e.g. do populations continue to use the new stoves and in the appropriate manner and does it have an impact on improving health, reducing time burdens and emissions.

Table 3
Indicator domains for household energy projects.

Domains	Sub-domains	Indicator examples
Macro	Local and national policies	Extent of energy subsidies, tariffs on imports of fuels, concessions for rural and renewable projects, etc.
	Energy balances	Percent of energy imports, production capacity, etc.
	Economic development	Percent population living below the poverty line, gini index, extent urbanization, literacy, etc.
	Governance and transparency	Indices of corruption, regulatory bottlenecks, etc.
Community	Local resource base and sources of fuels	Resource potentials: supply, quality, seasonality, etc.
	Access to markets and transport	Distance to closest markets, motorable roads, etc.
	Supply chains and institutional structures	Local manufacturers and suppliers of fuels and stoves, credit financing mechanisms, etc.
	Infrastructure and access to basic services	Access to electricity, schools, health care, clean water, etc.
	Economic activities and employment	Local businesses and industry, labour force participation by sector, etc.
	Community cohesion and gender roles	Gender parity in the workforce, social and religious stratification of the society, etc.
Household	Socio-economic and demographic profile	Size of household, number of children and adult members, Income and household expenditures
	Skills and livelihoods	Main sources of livelihood, working members, educational status, etc.
	Cooking practices and habits	Types of foods consumed, preparations of food, etc.
	House structure and kitchen features	Type of household construction, location of kitchen, ventilation, etc.
	Present energy use pattern and expenditures	Monthly or seasonal expenditures and consumption of fuels and electricity
	Stove/equipment characteristics and costs	Types of stoves used; efficiencies of stoves, costs of stoves, lifetimes of stoves, etc.
	Health status and hygiene	Disease incidence, sanitation and hygiene, smoking habits, etc.
	Pollutant emissions and exposures from current energy use	Room pollution levels of particulate matter and Carbon Monoxide; personal exposures for mothers, children or elderly

As pointed out by Thakuri et al. (this issue), appropriate metrics need to be designed and data needs to be collected prior to the implementation of any new programmes or projects in order to have a valid baseline or starting point. Thus, in addition to ensuring that monitoring is done on a sustained basis to adequately evaluate outcomes, obtaining adequate data and information before the start of a project is also crucial. This baseline is essential for preparing any project and can then be used during and after the programme is in progress for monitoring and evaluation of impacts and benefits. Thakuri et al.'s (this issue) work on conducting a detailed cost-benefit evaluation of household energy interventions requires extensive baseline data to be collected as well as a detailed follow-up assessment of those households that are impacted by the interventions.

The review of existing measures of energy poverty and assessment of indicators for monitoring and evaluation carried out in this paper lends itself to the following recommendation regarding domains where indicators can serve to inform new programmes for improved cooking fuels and stoves. Household energy projects that aim to introduce a certain new stove or fuel type, in addition to monitoring and evaluating adoption, need to develop indicators to track progress across several domains or thematic areas of importance. Any such system of indicators needs to include metrics that capture not only technical specifications (equipment efficiency, emissions, performance, etc.) or economics (fuel, start-up and equipment costs), but also the social acceptability and most importantly allow for regular monitoring and an evaluation of welfare and environmental impacts. Table 3 presents several indicator domains as potentially valuable in designing and evaluating new projects and activities to improve the household transition to improved cooking stoves and fuels. While several of these domains relate to household and community characteristics, information also needs to be collected on the macro environment within which these households and communities operate. In other words, local and national policies also impact the outcome of specific projects and interventions. Information about such policies also needs to be collected by prospective programme or activity initiators and implementers. By far the most important factor is the so-called "owner" or champion of the programme. If the owner, the initiator, the driver and the person, who takes the credit for its success or the blame for its failure, is someone who can carry this role, e.g. a popular minister (family minister, development minister, etc.) or a powerful business entity (a global player or a respected local institution), the probability of success is larger. It is worthwhile collecting indicators that can capture commitment to a particular programme or project or if such a champion exists.

Our recommendation for the need for such metrics should not be misunderstood as being a necessary prerequisite to be put in place before all programmes for introducing new cooking fuels and stoves are initiated. Neither should these recommendations be viewed as an ideal or exhaustive list of domains with several indicators needed to measure each domain described. In some instances, it may be possible for one indicator to serve as a proxy for several attributes. In other cases, one attribute may not need more than one indicator to adequately describe it. The central message of our recommendations is the importance of thinking about all the attributes listed above before initiating any activity or programme and to think of appropriate metrics to measure them in order to assess the chances of a programme's success and to enable the programme to be evaluated as it goes ahead. The lesson that can be drawn from the discussion of sustainability indicators is that indicators are a means of communication and are not worth much, if they are simply aggregations and compilations of toms of statistics. Indicators are most useful when picked to measure a specific impact or aspect, often targeted to themes of special interest. The discussion on indicators highlights the fact that poverty alleviation is about people, people who are in situations very difficult to imagine for many of us, who write or read papers like this one. Our list of attributes recommended for indicators for improved cooking fuels and stove programmes is meant as a practical help to programme designers and evaluators. Perhaps, it serves also as a reminder that the programmes are there to benefit end users, who we do not know intimately enough.

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