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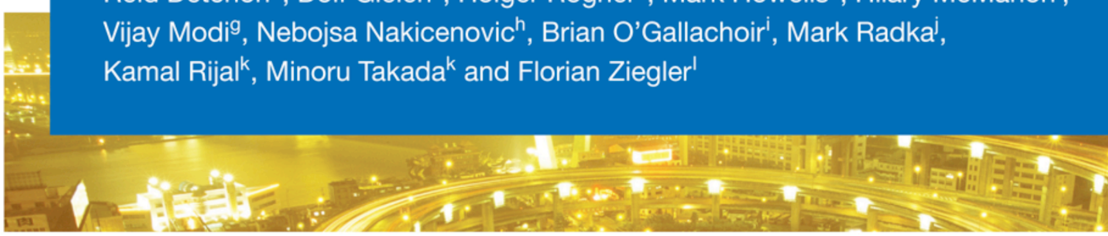
MEASURING ENERGY ACCESS: SUPPORTING A GLOBAL TARGET



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This paper was informed from an expert group meeting held at Columbia University, New York, on 31 March 2010

Abstract

The provision of modern energy services is recognised as a critical foundation for sustainable development. There are increasing discussions within the international community about establishing an international target for universal access to modern energy services. Such a target would provide a much needed political prioritisation and build on ongoing national activity. To ensure effectiveness, and to underpin delivery and policy formation, will require analytical work on both definitions and measurement. There is considerable precedent in the use of indicators and indices in the development and energy sectors. Drawing on that literature, we outline several options that could inform future work in this area. Such measurement and reporting tools will need to be simple, politically attractive, and analytically robust – a difficult balancing act. We propose that annual measurement and reporting at the national level be established in five to seven pilot countries through two composite indices and their respective indicators, and three to five new innovative and complementary metrics.

Contents

1. Introduction

Access to sustainable, modern, affordable, and reliable energy services[1] is central to addressing many of today's global development challenges, including poverty, gender inequality, climate change, food security, health and education. Yet nearly one-third of humanity[2] lacks access to modern energy forms and services (IEA, 2009a). Although energy is not an explicit part of the Millennium Development Goals (MDGs), the provision of modern energy services[3] is recognised as a critical foundation for sustainable development (e.g. UN-Energy, 2005; DFID, 2002; Modi et al., 2005; UNDP, 2005). Yet, progress is far behind what is needed. If current trends continue, more people will be without access to modern energy services in 2030 than at present (IEA, 2009a), a situation that is clearly unacceptable. Changing this trend requires international political commitment that goes beyond abstraction and sets out targets, actions and associated benchmarks.

The issue of energy access is receiving more attention than ever before. It is crucial to capitalise on this momentum. Providing a rigorous analytical basis for policy-making by developing a robust set of metrics for measuring energy poverty is therefore timely. To this end we explore the design and use of tools for measuring and reporting on energy access progress and targets.

This paper first describes the relevant context, definitions, data, and links to national policies and energy planning. Section 2 reviews relevant development and energy metrics. Several options for measuring energy access are then presented in section 3. Finally, Section 4 offers thoughts on implementing the recommendations in pilot countries.

1.1 Measurement to support targets

Measurement and reporting is central to the implementation of any global, regional or national target. It should not be relegated to an operational issue that can be addressed after a national target is forged. The use of measurement tools is widespread in national and international policy, fiscal, and regulatory work. As Stiglitz et al. (2009) note, "Statistical indicators are important for designing and assessing policies aiming at advancing the progress of society...More and more people look at statistics to be better informed or to make decisions."

IEA (2009b) cites "sound statistical data…and a clear description of the [energy services] situation" as the first of the preconditions for successful rural energy access policies[4].

The consideration of robust measuring and reporting mechanisms will help in (Fransen et al., 2008):

- Improving availability of information about the range and impacts of actions that countries are taking to increase access to energy
- Helping countries clearly delineate and monitor actions they can take to meet their agreed target
- Increasing awareness among countries of policy options and best practice

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[1] The terms: energy poverty, energy access, and access to energy services are used interchangeably in the document. We consider lack of access to energy services as one aspect of a wider condition of energy poverty. We discuss definitions in Section 1.2 to some degree – but further work remains. Simply, a modern energy service uses less primary energy and is more affordable. Modern energy services have a higher service quality in terms of light, heat etc., and reduce household expenditure and resource efficiency simultaneously allowing the target population to enter a sustainable technological path of development.

[2] This number includes the roughly 1.5 billion people without access to electricity, and the roughly 2.5 billion people relying on solid fuels.

[3] As Lovins (1976) wrote, "People do not want electricity or oil, nor such economic abstractions as 'residential services', but rather comfortable rooms, light, vehicular motion, food, tables, and other real things."

[4] Closely related, but outside of our scope, is the issue of effective metering and information on customer demand.

- Enhancing the effectiveness of implementation of such policies at national and local levels, and the credibility of all countries' efforts

Specifically, we focus on supporting progress in reaching a global target for universal[5] access to energy services by 2030[6]. It is recognised that such a target is inherently political, and yet essential for further economic and social development. In other words, such a target would help to catalyse the requisite political momentum and associated support activities. We recognise that significant effort is under way in governments (and utilities) to deliver on existing targets. A global effort, therefore, must support these activities and be aligned with their goals, while assuring complementary support activities toward the universal access. Indicators will likely need to be put in place at the national level while reflecting regional and local differences. We consider measurement and reporting for both quantitative and qualitative targets.

While providing universal energy access poses a number of challenges, there are various successful examples of significant scale in the developing world[7]. For instance, more new household electricity connections were made in the 1990s than would be required in each of the next two decades to achieve universal access (AGECC, 2010). This is a possible proxy indicator that could be used in conjunction with utility programmes.

Drawing from the experience of climate change mitigation efforts (Teng et al., 2009), and the vocabulary of the climate negotiations, a measure, report and verify (MRV) framework can facilitate the identification of priorities, assess implementation, hold stakeholders accountable and support national implementation. However, the emerging language on monitor, assess, and evaluate (MAE) might be more appropriate to energy access metrics.

The issue of "clean" energy is not explicitly addressed. Thus, this paper is technology (and fuel) neutral[8]. We do, however, recognise the fundamental role for, and multiple benefits associated with, clean energy in addressing energy access, and the links to emerging "green growth" development discussions[9]. From a measurement perspective, the amount of clean energy in a national energy system can be considered and measured separately from access. In some composite indices it may be useful to consider the two in an integrated way (i.e. to assess access to clean energy services), but the definition of "clean" and the large array of issues and related literature are beyond the scope of this paper.

1.2 Defining energy poverty

A working definition of energy access needs to be clearly defined prior to the development of metrics. The IEA presented a three-step definition (Figure 1 as adapted in AGECC, 2010) that helps to clarify an evolution in access to energy services, starting from the case of full deprivation.

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[5] Noting that 100% is not feasible even in the richest parts of the world.
[6] As per the recent (April, 28, 2010) recommendation of the U.N. Secretary-General's Advisory Group on Energy and Climate Change (AGECC). We recognize that there is a need to describe a detailed roadmap, and that different timeframes may prove more realistic. In addition, the date of the target would not materially impact on the requirement to develop measurement methodologies.
[7] This type of grid extension occurred mainly in Asia, as well as South Africa and Brazil. Still, the challenge will likely increase in the future, as the deprived populations will tend to be more dispersed and have lower incomes.
[8] ECOWAS (2005) provides a precedent for this.
[9] In addition, most measures and policies directed toward universal access would have a co-benefit of reducing adverse impacts of inefficient use of traditional energy sources, ranging from health and in-door air pollution to, in some cases, reduced carbon dioxide emissions.

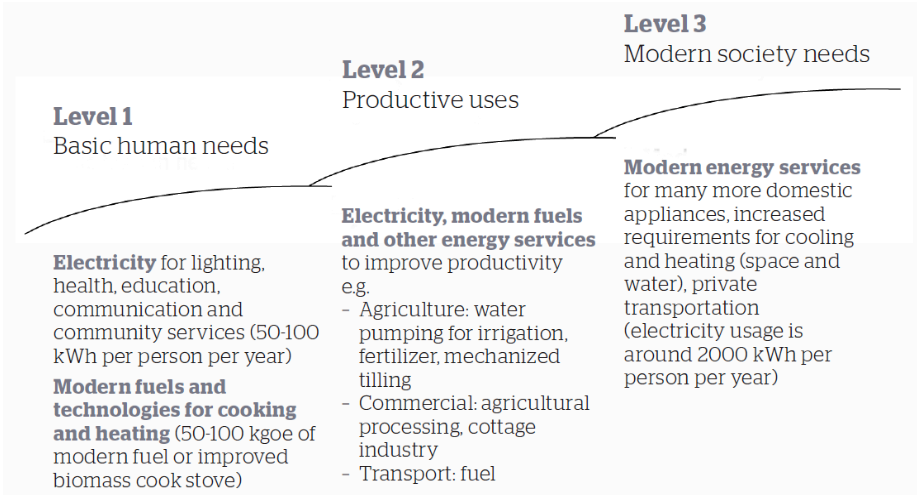

Figure 1: Incremental levels of access to energy services (AGECC, 2010)

There have been a number of attempts to quantitatively define energy access and the related metric of energy poverty. In the World Energy Assessment (UNDP, 2000) final household energy requirements for satisfying basic needs are estimated. Such calculations, however, rest on a set of arbitrary assumptions with regard to the consuming energy devices as well as a normative definition of what a set of basic needs consist of, and pay little attention to the type of energy sources accessible (Pachauri and Spreng, 2003).

Other approaches include the threshold of 10-30% of household income spent on energy services that is commonly used as a benchmark for energy poverty (see e.g. Fankhauser and Tepic, 2007; Bensch and Peters, 2010). Similarly, the U.N.'s Food and Agricultural Organization (FAO) uses national income and income distribution to estimate the number of people that receive a level of income that would lead to a given state of poverty – under-nourishment in this particular case. These methodologies can be criticised for their lack of scientific rationale, inability to capture wider dimensions of energy poverty (UNDESA, 2009), and inadequacy in contexts where the informal economy plays a significant role. In general, the discussion of affordability is beyond the scope of this paper, but the metrics will need in some way to consider it explicitly[10].

Goldemberg et al. (1985) used a simple model to estimate basic human energy needs for several regions. They conclude, "An emphasis on energy-efficiency improvement and modern energy carriers would make it possible to satisfy basic human needs, to radically expand the industrial infrastructure, and to allow for considerable improvements in living standards, beyond the satisfaction of basic needs, with little change in the overall per-capita level of energy use."

Energy access metrics need to reflect dimensions of both quantity and quality. However, issues such as: connection times, supply disruptions, outages, the value of lost output, voltage quality, frequency stability, and the need for on-site generation (World Bank, 2007) are often missing from the energy access agenda. Yet issues of energy quality need to be integrated into the measurement and policy-making for energy services in the developing world just as they are in the industrialised countries.

[10] As an example, affordability could be partially addressed in terms of percentage of household income spend on energy. Also, using the concept of deprivation provide a means to take into account affordability.

1.3 National policies

Any global target and measurement tools will need to be grounded in national policies. Not surprisingly, (IEA, 2009b) emphasised that sustained government support is a precondition to successful electrification strategies. (UNDP and WHO, 2009) showed that 68 developing countries have electricity targets (Table 1). (Considerably fewer targets for the other categories of: modern fuels, improved cookstoves, and mechanical power.) These national targets are an excellent foundation to build on.

Table 1: Countries with energy access targets (UNDP and WHO, 2009)

	All developing countries	*LDCs*	Sub-Saharan Africa
Electricity	68	25	35
Modern fuels	16	8	12
Improved cooking stoves	11	4	7
Mechanical power	5	0	5

Figure 2 (UNDP and WHO, 2009) illustrates the number of countries with data available under four categories, namely: electricity, modern fuels, cooking stoves, and mechanical power (with zero).

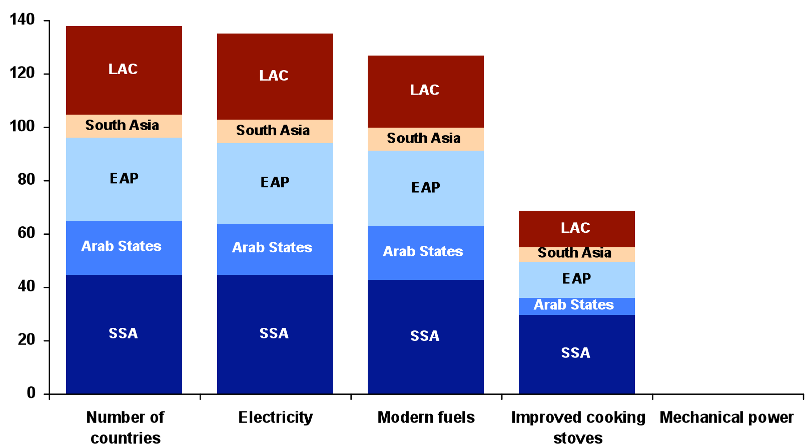

Figure 2: Countries with data on access in four categories (UNDP and WHO, 2009)

There are also several existing regional strategies with targets[11], and a number refer to measurement[12]. As an example, (EAC, 2006) describes four targets each with different target populations (Table 2). UNDP (2007) describes several benefits of regional plans[13], including: achieving economies of scale, and increasing the reliability, and maximizing the use, of local energy resources. In order to meet their

[11] E.g. Economic Community Of West African States (ECOWAS), East African Community (EAC), and the Economic Community of Central African States (CEMAC)

[12] ECOWAS (2005) notes, "…the Steering Committee will have a strategic role in guiding activities and monitoring progress of the energy access work plan on a yearly basis."

[13] In West Africa for example (UNDP, 2007), there are energy information systems in Bénin, Niger, Sénégal, and Togo. New systems are at different stages of planning in Burkina Faso, Cameroon, Côte d'Ivoire, Guinée Bissau, Mali, and Togo. These tools allow both evaluation of progress in extending access to energy and prospective studies to facilitate planning for infrastructure.

targets, these regions and countries will require financial support, capacity development, and better regulation and governance structures. Additionally, many of these countries may have existing structures for measurement and reporting on energy access and it may prove useful to garner best practice in this area. In other cases where reporting structures for energy access do not exist, extensive guidance will be required.

Challenges vary dramatically between different regions; some evidence of this is shown in the fact that the percentage of countries that have energy access targets ranges from 15% to 78% between regions. There are also significant variances in needs and solutions between rural and urban conditions (see e.g. GNESD, 2008). To help define specific targets, new benchmarks and norms may be required that consider these variances, although we also need to be wary of perverse incentives if these are employed. That approach can also encompass issues related to energy efficiency (these topics are beyond the scope of this paper).

Table 2: East Africa Regional Energy Access Strategy (EAC, 2006)

Target	Population Focus	Energy Service	Access to Energy in 2004: Actual		Goal: Additional Number to Be Reached	Goal: Percent of Category
			no. reached	% of category		
Target 1	Urban poor	LPG, ICS	3.0 million	47%	2.7 million households	73%
	Rural poor	ICS	1.5 million households	11%	6.1 million households	56%
	Nomadic and Conflict	ICS	0.2 million households	11%	0.9 million households	56%
Target 2	Urban poor	Electricity	2.0 million households	43%	5.3 million households	100%
	Urban slums	Electricity	0.5 million households	30%	2.2 million households	100%
Target 3	Schools	Standard level of service	1,848 schools	4%	46,545 schools	100%
	Clinics	Standard level of service	401clinics	4%	10,323 clinics	100%
	Hospitals	Standard level of service	38 hospitals	5%	750 hospitals	100%
Target 4	Rural communities	Electricity or other form of motive power and heating	955 communities	4%	23,240 communities	100%

Note: ICS: Improved Cooking Stoves; LPG: Liquefied Petroleum Gas

Another way to look at the focus on energy access in national policies is the reporting through national MDG reports. Takada and Fracchia (2007) quantified the number of references to energy in these reports and found large differences. Thorough coverage occurred in about 25% of the reports examined.

While national targets will be the backbone of energy access efforts, translating these targets into utility "obligations" is often the most feasible way to ensure delivery (IEA, 2009b), particularly if accompanied by financial incentives. Obligations on utilities as a policy instrument have considerable precedent and can be designed in many ways appropriate for both fuels and electricity. Obligations can also create the necessary governance frameworks for monitoring progress and improving data.

Monitoring national (or local) policies may also prove to be a useful indicator for energy poverty, although this is a slightly different exercise compared to analysing quantitative indicators. Policy frameworks are in most cases the key drivers for the change required. As an illustration, a recent review of climate mitigation polices and measures in China and the measurement and reporting structures assigned to them demonstrates that policy-specific measurement and reporting systems provide an important policy feedback loop which is essential to fostering transparency and accountability more broadly (Teng et al., 2009). Similarly, Fransen et al. (2008) highlight a set of metrics that could be considered to evaluate actions at national level. Whatever the specifics, a robust, and evolving, framework to track progress will promote action that expands access to modern energy services.

1.4 Supporting energy planning

Energy modelling and planning is an essential tool to help provide robust underpinning to policy-making. It also tends to be very data-intensive, which creates obstacles for many countries (Howells et al., 2010). Aligning energy modelling and planning exercises with the measurement activities proposed in this paper may provide useful synergies.

An initial step in energy planning exercises involves determining what the policy objective is and what metrics are best suited to measure that objective. Energy system modelling provides a toolkit to assess patterns of current and projected future, energy use in a quantified and transparent manner. This then provides a basis to estimate the extent to which physical requirements (how much of what fuel, appliance and supply technologies, as well as their costs) are needed to meet the goal. To do this, significant amounts of data are required.

A clear challenge is targeting policy and regulatory interventions that influence consumer preferences and are appropriate to cultural norms. The provision of affordable electricity access has had many benefits (Kanagawa and Nakata, 2008). However, these are often not realised due to consumer preferences. Ultimately, these preferences, and the appliances used to meet them, shape electrical load and thus costs of delivery.

Finally, it should be noted that the energy planning process is iterative (IAEA, 2008). Conditions may change (in part as policy goals are met), requiring recalibrating of the analysis. Thus, there should be feedback and monitoring of the effect of these policy measures (Mirakyan et al., 2008) in terms of the national energy poverty indicators chosen.

2. Review of Relevant Development and Energy Metrics

There are numerous examples of single indicators and composite indices to measure concepts related to both development and energy. This section reviews a number of these precedents in order to provide insights for the design of metrics for energy poverty. IAEA (2005) reflected that, "…indicators are not merely data; rather, they extend beyond basic statistics to provide a deeper understanding of the main issues and to highlight important relations that are not evident using basic statistics. They are essential tools for communicating energy issues related to sustainable development to policymakers and to the public, and for promoting institutional dialogue."

Focusing on income-based poverty, the World Bank set a threshold, referred to as the "$1 a day" line, with the objective of applying a common standard to measure absolute poverty (Chen and Ravallion, 2008). The $1 a day international poverty line (revised to $1.25) has been widely used as a benchmark to evaluate absolute poverty levels and trends[14]. Many analysts have noted the shortcomings of such methodology and questioned the intrinsic worth of the poverty line as a meaningful representation of the multifaceted aspects of poverty (UNDESA, 2009).

There are a number of initiatives aimed at providing a "dashboard" of individual indicators (e.g. IEA, 2009c). The United Nations Department of Economic and Social Affairs suggested a set of indicators organised around themes and sub-themes representing development policy issues (UNDESA, 2001a; UNDESA, 2007). The indicators directly related to energy are: annual (primary or final) energy consumption per capita, intensity of energy use per unit of output (e.g. GDP), and share of households without electricity or other modern energy forms. A related undertaking is the Millennium Development Goals Indicators programme. These were designed to help track progress on the commitment made in 2000 in the United Nations Millennium Declaration. Out of over 60 indicators, there is only one directly related to energy – GDP per unit of energy use[15] (which is the inverse of energy intensity and measures the energy productivity of a country).

The World Bank uses a set of core energy indicators to evaluate its access projects. They include: type of connection (grid or off-grid), the number of new community electricity connections by type, the average interruption frequency per year, technical and non-technical electricity losses, and transmission and distribution lines constructed. A specific monitoring and evaluation framework (CIF, 2010) has been designed for the Climate Investment Funds (CIF) (slightly different for different vehicles). Indicators are defined along with sources of data, collection methodologies, and collection responsibilities. Likewise, reporting responsibilities, baseline setting and target setting are established *ex-ante*. Project outputs will be translated into "catalytic replication" outputs and into a quantum of transformative impacts; each "level" has associated indicators.

Also from a project perspective, GTZ's Energising Development (EnDev) includes minimum thresholds to measure success, including: 300 lumen per household for lighting, and an 'improved energy source' for cooking is one whose consumption of fuel and the resulting purchase costs and/or time for fuel wood gathering will be reduced at least 40 % in comparison to an open fire. The program has succeeded in designing and implementing a simple monitoring process and also benchmarks country programs for immediate transfer of lessons – and to assign funds for up-scaling to strong performers. EnDev's support costs are subject to a maximum per type of technology, and are expressed in 'Euro per person who obtained sustainable access to modern energy services' - a range of €10 - €100 per person has been observed to date. The benchmarking system is currently being refocused on impacts rather than outcomes in terms of people with access to modern energy services.

The Human Development Index (HDI), developed by the United Nations Development Programme (UNDP) was an attempt to overcome the shortcomings of one-dimensional indicators (UNDP, 1990). The HDI combines indicators pertaining to three dimensions of human deprivation, namely life expectancy, knowledge and education, and standard of living measured as a function of GDP. The HDI has also been widely criticised in the development literature for inconsistencies and methodological flaws (McGillivray, 1991; Morse, 2003; UNDESA, 2009). As a complement to the HDI, UNDP developed the Human Poverty Index (HPI) as a metric specifically tailored for developing countries. The HPI measures similar dimensions of human deprivation as the HDI, but by using different, more specific indicators for poverty. Both of these indicators, due to their widespread adoption and reporting, are influential in national policy-making.

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[14] Other notable minimum benchmarks for development come from nutrition: (Dandekar and Rath, 1971) assumed a calorie intake of 2250 per day as sufficient for both rural and urban conditions. A joint health committee led by the WHO (in 1985) revised this to 2700 calories.

[15] This metric suffers from the general problems associated with using GDP to measure of a society's welfare.

The Environmental Sustainability Index (ESI), jointly developed by Yale and Columbia Universities, the World Economic Forum, and the European Commission's Joint Research Centre, benchmarks the ability of nations to protect the environment over time by integrating 76 variables, related to 21 indicators falling into 5 broad categories (Esty et al., 2005). The ESI score represents an equally weighted average of the 21 indicators' scores. Each indicator itself is a weighted sum of 2 to 12 underlying variables. Developed by the same group, the Environmental Performance Index (EPI) comprises 25 performance indicators tracked across 10 policy categories, covering both environmental public health and ecosystem vitality, with 1 to 4 indicators per category. Weights are attributed based on expert judgment.

Bandura (2006) considered an inventory of 165 composite indexes in the development space, and differentiated between simple and elaborate indexes. Eight of those use some form of energy indicator as a sub-set of the composite – for example, the Index of Human Insecurity uses net energy imports. They observe that index design is often linked to the type of public or private organisation undertaking the work, and note, "...there has been a growing trend, in both quantity of indices and variety of issuing institutions (either public or private) that are elaborating such indices."

AccountAbility (2010) presents two indices for climate "competitiveness". The Climate Accountability Index includes 13 variables examining the degree to which a country has the leadership, institutions, systems and practices in place to deliver climate competitiveness. So in addition to government actors, it considers the role of business associations, investment promotion agencies and consumer groups. The Climate Performance Index pulls together a broad range of national-level climate indicators, containing 13 hard and soft climate-related datasets. Performance covers price signals, energy networks, carbon management by businesses and the de-carbonisation track record to date (AccountAbility, 2010).

The World Energy Assessment's sustainability indicators (UNDP, 2000) consist of 13 individual indicators. More comprehensive, the Energy Indicators for Sustainable Development (EISD), a collaborative effort led by the International Atomic Energy Agency (IAEA), provides definitions, guidelines and methodologies for the development and use of a set of energy indicators (Vera and Langlois, 2007). Thirty individual indicators are classified into 3 dimensions (social, economic, and environmental) and further split into themes and sub-themes.

Mirza and Szirmai (2010) developed a new composite index to measure the degree of energy poverty among rural households in rural Pakistan. The index combines qualitative and quantitative indicators of "excess inconvenience" associated with the energy mix used and the lack of sufficient energy to meet basic household needs. They used a survey to investigate the factors which have an impact on the welfare of rural households when making choices concerning energy sources and energy mix.

The International Energy Agency (IEA) has a long history of using energy indicators. The Energy for Development Index (EDI), first presented in the 2004 World Energy Outlook (IEA, 2004), is a composite measure of energy use in developing countries. Designed to mirror the UNDP's HDI, the EDI is intended to assess a country's or region's progress in its transition to modern fuels and electricity in its energy end-use. The EDI is composed of three indicators: per-capita commercial energy consumption[16], share of commercial energy in total final energy use, and share of population with access to electricity. These three indicators have been chosen because they represent the best measures of a country's degree of transition towards modern energy use, taking into account the need to choose indicators for which data is available for the greatest possible number of countries. A separate indicator is created for each dimension, and the final index is then calculated as the arithmetic average of the three normalized indicators' values. In addition, WEO projections are used to evaluate future trends in EDI values, providing insights with regard to the need for policies and investments.

[16] Note that per-capita consumption would not reflect aspects of energy efficiency improvement.

These various efforts have produced a rich set of lessons-learned on which to draw when considering access to energy services. A mix of statistical rigour, transparency, national input, data availability, political attractiveness, simplicity, and usefulness for policy design will all be required. A wealth of literature (OECD, 2003; OECD, 2008; Saisana and Tarantola, 2002; Firoussi, 2009; UNDESA, 2001a) provides further useful insights for the development of indicators. When creating new metrics, Pinter et al. (2005) argue for a close coordination with existing indicator systems. A clear issue that emerges from practice and the literature is related to data paucity and quality. In addition, most metrics are focused on supply-side or input-oriented data, and better tracking of end-use energy services will be required. All of these issues need to be considered as an integral part of any approach to measuring energy access.

2.1 An energy security analogy

This sub-section considers the development of energy security metrics in order to inform the development of energy access metrics. Energy security and energy access are closely related in a number of respects: both areas include quantity, quality and temporal issues[17]. Thus, we can make use of some of the wide palette of security-related indicators. In addition, making explicit the strong link between energy access and energy security may prove a strong driver for action.

Power utilities and other energy companies regularly measure and report on security indicators. They are fundamental to managing and making transparent certain selected risks (Bazilian and Roques, 2008). The metrics range from plant availability rates (including forced outages and maintenance schedules) and loss-of-load probability, to system generation adequacy across different time frames[18]. The European Commission (2006) noted that energy security does not seek to maximise energy self-sufficiency or to minimise dependence, but aims to reduce the risks linked to import dependence.

The economic implications of unreliable energy services are daunting. A number of developing countries suffer from inadequate generation capacity, limited electrification, inefficient systems, and high costs. Countries affected by chronic energy issues take a heavy toll with regard to the loss of economic growth and productivity. Foster and Briceno-Garmendia (2010) estimated the cost of power shortages and found that they are substantial, representing up to a few percents of GDP (Figure 3). It is therefore of crucial importance to include a dimension related to the qualitative aspects of energy services in the metrics to measure energy poverty.

[17] There are other significant areas of overlap between the two topics such as energy governance, gas flaring, oil rich LDCs, etc. that we will not cover in this paper.

[18] (Bazilian et al., 2006) presented approximately 50 individual metrics organised by themes of price, fuel stocks and diversity, and reliability.

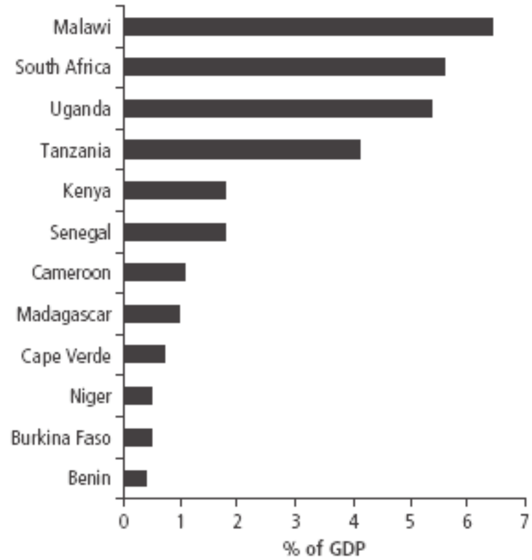

Figure 3: Economic cost of outages in selected countries (Foster and Briceno-Garmendia, 2010)

Jansen (2004) considered long-term energy security indices which address a larger number of long-term security aspects. An additional study by (Scheepers et al., 2007) provides two new indicators which can be compared across countries. The first is the Supply/Demand Index, which assesses the ability of a country's energy system to cover not only the supply of primary energy sources but also the conversion and transport of secondary energy carriers and final energy demands. The second indicator is the Crisis Capability Index (CCI). With this indicator the capability of a country or a region as a whole to manage and mitigate short-term supply interruptions can be assessed.

Given the potential number of individual energy security metrics (and energy access metrics that may emerge), classification is important. Pearce (2005) makes a distinction between 'upstream' security and 'downstream' security. The former refers to interruptions in supply of energy inputs to the electricity system (or any other energy supply system), the latter to interruptions in delivered energy from the electricity system. Helm (2002) categorises energy security into three discrete areas: supply (contracting) security, network (wires and delivery) security and diversity of fuel supply (or generation).

3. Options for Measuring Energy Access

3.1 Three categories

We briefly outline three types of metrics. The models presented are not mutually exclusive. The options entail respective advantages and drawbacks in terms of theoretical soundness, ability to convey clear and coherent policy messages, ease of computation and data requirements, etc.

A. Uni-dimensional indicator or set of indicators

A uni-dimensional indicator, such as the $1 a day, has the advantage of providing raw data without the flaws related to aggregation. It presents a simple, easy-to-interpret metric that can carry a strong and easily understandable message.

Such an indicator could be based on one of the variables currently used to evaluate energy poverty, such as the rate of access to electricity or commercial energy. Alternatively, a new indicator could be developed, bearing in mind the shortcomings related to data availability. For instance, we could define energy amounts (by fuel type and electricity) necessary for reaching the MDGs. Such an approach would require a number of normative assumptions that need careful analysis.

A set of indicators, or 'dashboard', would ideally be based on a number of independent variables. It provides more richness of information than a uni-dimensional indicator, but requires more data. The set could comprise quantitative as well as qualitative proxies. However, distilling a clear message for policy guidance or broader communication from a set of independent indicators might be more challenging than from a single metric, which is commonly more appealing from a communication viewpoint.

B. Composite index

Composite indices are single numerals calculated from a number of variables, on the basis of an underlying model that seeks to represent an aggregated value of a concept that might be in itself elusive (e.g. sustainable development). They have been widely used as an alternative to single, uni-dimensional values. The rationale for composite indices lies in the need for aggregated information at a level that makes analysis convenient. Composite indices are easier to interpret than trends in a number of separate variables. They have proven to be convenient in benchmarking performance – for example, between countries. If evaluated with the same methodology at regular time intervals, they provide information on changes across different units and time, thereby allowing trends to be identified.

The drawback of composite indices is that, by combining variables, the process results in some form of reduction to a single measure, with all the associated methodological issues that implies. Composite indicators can be misleading in terms of policy, particularly when the analysis of the results is too simplistic and/or when the indicator is poorly constructed. Pros and cons of composite indicators are summarised in the literature (e.g. Saisana and Tarantola, 2002). Various publications have underlined the lack of theoretical underpinning of a number of composite indices (OECD, 2003; Munda and Nardo, 2005), highlighting issues related to the aggregation model and/or the weightings in particular. This notwithstanding, many believe that composite indices provide a useful statistical summary of particular issues. Sharpe (2004) analyses the two schools of thought, the "aggregators" and the "non-aggregators": The former point to the potential to attract media and policy makers' attention, and the latter claim that aggregation and weighting, in particular, is arbitrary.

Often a simple additive method, or weighted sum, is used. This model has been widely applied for its transparency and ease of use, including by non-experts. It is important to note that linear additive models (weighted or not) assume complete substitutability between the various components (Munda and Nardo, 2005). Indeed, compiling a number of individual variables into a composite indicator inevitably implies a reduction of the information base and therefore a loss of information. This loss should be minimized to the extent possible. Zhou et al. (2006) argues that aggregation methods based on a weighted product might perform better than the commonly used simple additive weighting method. Other, more advanced approaches deriving from multi-criteria decision analysis are commonly more complicated to compute. There are clear trade-offs in the choice of the aggregation model, notably in terms of loss of information, level of compensability allowed between variables, ease of use, and transparency.

A simple composite index, consisting of say 3 or 4 variables, would make it possible to combine the information related to the multidimensional nature of the issue in a way that is easy to understand, while at the same time remaining transparent. A more elaborated composite index would be composed of a larger number of indicators, like the ESI. However, the transparency of the outcome and the ease of use of the tool decrease as the complexity and resource requirements increase in terms of data collection and computation.

C. Hybrid

A hybrid approach would consist of an aggregated set of indicators that are monitored and reported upon individually along with a composite index. A hybrid approach would reconcile the advantages of a single, easy-to-understand and -interpret composite metric with the legitimate concerns related to aggregating information of various kinds.

Independent variables provide diverse and rich information. Therefore, a dashboard of indicators would provide analysts and policy makers with a complete, unbiased picture of the state of play in regard to energy access. At the same time, the crucial importance of maintaining political attention to energy poverty over the long term should not be underestimated. With this in mind, there is value in constructing a simple, transparent composite index based on the set of indicators selected while at the same time acknowledging the cruder nature of the metrics.

Existing indicators and composite indices could be complemented by new metrics. Keeping in mind the limitations related to data availability and reliability, already well-established metrics such as the EDI could be strengthened in parallel to the development of new energy poverty metrics as progress is made with regard to methodological and data gathering issues. Such approach would provide policy makers with continuity in the information provided. At the same time, this information base would augment and be reinforced by new data and metrics.

3.2 What to measure: access vs. deprivation

Conventional approaches commonly aim at evaluating access to energy. In other words, most energy access metrics focus on quantifying the ability to use energy – essentially they adopt a supply-side perspective. Typical indicators include the quantity of energy consumed, and the share of households with access to electricity. While those metrics have proved to be useful, they do not reflect the demand side and therefore are not adequate in terms of measurement of development progress. Energy poverty should measure to what extend the fulfilment of basic needs has been undermined (by a lack of energy services). This is a complex assessment beyond an easy indicator such as kWh per person.

A complementary alternative is the measure of deprivation. Such an approach is consistent with the concept of development seen as the ability to choose (see Sen, 1999). This is supported in (UNDP, 2001), which stated, “Development is about expanding choices people have to lead lives that they value.” Viewing energy poverty in terms of deprivation entails a number of advantages, as well as challenges. Amongst the latter, the methodological tools are nascent, although precedents exist[19], and the set of data required is not universally available. The benefits, however, are manifold in that such an approach addresses some of the shortcomings of classical access-based methodologies.

For instance, the notion of affordability is naturally captured in indicators of deprivation, as is not necessarily the case when measuring access. Indeed, the lack of ability to pay for energy services represents a deprivation. For instance, an indicator on access to mechanical power for irrigation might provide biased insights in that the need for such energy services varies depending on a range of issues (e.g. availability of sufficient rainfall, and the possibility of using gravitational irrigation systems). An indicator of energy deprivation takes into account the notion of demand and therefore has the potential to better assess energy poverty[20].

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[19] In the context of the Clean Development Mechanism (CDM), the concept of suppressed demand is used for the definition of baselines (see e.g. Winkler and Thorne, 2002).

[20] Energy consumption data implicitly includes the effects of end-use energy efficiency. However, in many developing countries, efficient energy devices are not available. As a result, energy statistics can become “bloated”, while the actual energy services could be met with a significantly lower energy input, and at lower cost to the user.

Development is a complex issue and often characterised by non-linearities. The increase (or decrease) in an access variable cannot always unequivocally be interpreted as progress (or regress) in terms of development. For instance, a higher share of household expenditure on energy (often a characteristic in poor settings) is to be considered as adverse in terms of development. However, the shift from the use of non-commercial biomass to more modern, commercial fuels intrinsically implies an increase in household expenditure on energy. Here again, considering the issue from the perspective of energy deprivation allows us to better understand energy.

3.3 Using proxies

Focusing on energy services brings about new challenges with regard to identifying indicators. Quantifying some energy services, such as mechanical power or lighting, might benefit from the use of proxy indicators. The choice of the proxy entails some normative judgment in addition to the analysis, and it is crucial to ensure that it is closely correlated with the service to be quantified. The use of proxies represents a potentially powerful tool to explore new grounds in terms of quantifying energy poverty. The examples below could be useful as proxies to quantify deprivation with regard to important energy services. They could be utilised in any of the indicator-types described.

- Clean Cooking: The implications of the use of traditional biomass in open fires or charcoal are well covered in the literature (e.g. UNDP, 2009). As a proxy for lack of clean cooking, the use of solid fuels[21] such as traditional biomass[22] and coal, measure deprivation of cleaner cooking services provided by more modern fuels.
- Lighting: Kerosene-based lighting can frequently be the primary source of lighting for the poor. In such circumstances households' expenditures for kerosene does not provide the quality and intensity of light that an equivalent expenditure on electricity could if one had access to electricity at prices that those who do have access pay. The use of kerosene for lighting therefore represents an energy access deprivation. Hence one proxy for the lack of access to modern energy for lighting could be households reporting kerosene as the primary source of lighting[23].
- Mechanical power: Commercial energy consumed in rural agriculture could be used as a proxy for mechanical power[24]. The actual energy requirement is contingent on the context (e.g. availability of reliable rainfall) and requires a normative estimation based on minimal needs with which the actual consumption can be compared in order to derive the deprivation.

We note that other energy services such as refrigeration and aspects of communication are also essential to development and may be useful to track over time. The absence of adequate proxies for those services and the lack of data availability currently are major barriers to their inclusion in a representative analysis of energy poverty. As noted, another dimension that would provide valuable insights is that of policy. Indeed, widespread energy access is contingent on a well designed, dedicated policy framework. Nevertheless, identifying and computing a proxy for effective policy is rather challenging.

[21] The World Health Organization maintains the database on solid fuels on behalf of the UN System.
[22] The International Energy Agency has historical values since 1971, by country and regions, including actual consumption levels and share of household relying on traditional fuels as primary source for cooking.
[23] Noting that there would need to be another proxy to determine those populations that have access to neither kerosene or electricity.
[24] Energy for water pumping for irrigation purposes could also be considered.

4. Next Steps

4.1 A measurement framework

Defining energy poverty metrics and respective targets is a complex task. First, there is a need for an adequate understanding of the issue to be measured. Then, a theoretical framework is required and, finally, sufficient confidence in the set of indicators or the composite index should be gained through thorough testing.

Metrics of energy poverty would likely be best undertaken at the national level. The data could then be reported annually[25] and also serve as a basis for training and capacity development in the energy sector in developing countries. Computing energy poverty metrics would require the creation of new or augmented data-gathering systems and activities. This in turn would help increase the richness of energy planning analyses that could be conducted. These tertiary benefits of implementing measurement activities may prove to be even more valuable than the original impetus for them.

It is envisaged that energy access metrics could be aligned closely with measurements of sustainable development. In general, desirable principles of the metrics should (Atkinson et al., 2002):

- identify the essence of the problem and have a clear and accepted normative interpretation;
- be robust and statistically validated;
- be responsive to effective policy interventions but not subject to manipulation;
- be measurable in a sufficiently comparable way across countries, and comparable as far as practicable with the standards applied internationally;
- be timely and susceptible to revision;
- not impose too large a burden on stakeholders.

Ideally the metrics chosen should allow for comparison over time to evaluate the progress over time. Ranking of countries, although able to provide some insights, should not be regarded as the ultimate objective. The resulting “tool kit” should permit a wide range of additional statistical analysis that provides supplementary policy guidance.

We argue that the metrics to evaluate energy poverty should be designed around the concept of energy services to the extent possible. Although more difficult to measure, what matters ultimately to the end user is the utility of energy. With regard to energy access targets, we also need to further define either widespread access (less than 100%) or universal access (100%) or both, as different parts of a pathway.

4.2 Tools

Initially we suggest building upon and expanding from existing tools. The objective is to apply a set of tools that allows for coherent reporting. Therefore, a combination of two composite indices, including their respective indicators, with three to five complementary metrics would provide a useful structure to pilot in several countries in the short-term. We suggest, as a minimum, tracking these categories[26]:

- Cooking
- Lighting

[25] It is recognised that annual reporting may not be feasible for most least developed countries. Programmes could be put in place that begin with, say, 5 year reporting to follow national plans, move to bi-annual and then annual.

[26] In addition to these, the World Bank used the following classification for evaluating programmes: productive uses and energy efficiency, direct policies to support energy access, power plants, transmission and other infrastructure, general sector reform projects including capacity building

- Mechanical power[27]

In addition to these three categories, beginning to gather data on policies, related infrastructure, and regulation/governance would enhance the usefulness of the reporting schemes. For all categories creating and maintaining data sets and training people to undertake this task will be a crucial area. The IEA's EDI index could be produced on an annual basis and used for time series evaluation. It could also be augmented by a new index that includes some elements of quality issues, and/or proxies.

Finally, it is clear that financing needs and relevant mechanisms are integral to consideration of targets and their implementation. Measuring financing for energy access may also be a useful indicator. It can also help better assess both the scale and the design of the related financial policy and mechanisms required. The scale of financing directed in this area will also give a good indication of current priorities and a means to identify gaps.

4.3 Organisational aspects and pilots

The ultimate objective is to allow for tracking progress towards universal modern energy access. At the national level, data collection and measurement need to be tied to or aligned with central statistics offices. The international community needs to play an active role in building capacity and providing resources to increase the quality and quantity of data. Improving the data is an enormous task, and one that will take years. This exercise will require a cooperative and agreed approach conducted by an international body. Annual reporting, conducted at the national level, similar to that done for the HDI (or other metrics outlined in Section 2), is likely appropriate.

The UN is well placed to help take this work forward in partnership with the IEA, and other organisations. The UN has an interagency mechanism for energy, UN-Energy, which is specifically designed to help coordinate cross-cutting issues, and would benefit from such a mandate. The IEA's well-respected statistical resources would help leverage the UN's strengths (including UN-Stats[28]) and underpin a strong partnership. Dedicated financial and human resources would then be needed to coordinate the effort, maintain the database, report, and further develop and improve the methodology.

Piloting a measurement and reporting programme in 5-7 countries initially would provide valuable insights into: data gaps, data gathering techniques, appropriateness and usefulness of various indicators and proxies, training needs, institutional requirements, useful reporting formats, how best to support national policies, and the role of international cooperation. It would also provide the basis for the development of a more generalisable toolkit for policy makers and national statistics offices. This could be in part supported through the IEA statistics office and in-country UN offices. The pilot countries could then issue national reports within 12-18 months.

[27] Noting that mechanical power is much larger in scale than the other energy services, we suggest including this dimension also because mechanical power directly contributes to increase the efficiency and effectiveness of productive activities that directly support development, as well as physical processes fundamental to meeting basic human needs. These services also tend to have a large return on investment and result in significant development outcomes (ESMAP, 2008). The data paucity in this area is even more severe than the others.

[28] United Nations Statistics Division, with a mission to promote the development of national statistical systems.

5. Conclusions

Agreeing on a global target for universal access to energy services will be an important step in moving to inclusive sustainable development. A robust set of measurement tools will be crucial for informing and assuring appropriate national policy-making as well as effective international cooperation. Precedents exist from both the energy and the development communities for measuring a wide range of issues related to development. Designing the measurement toolbox and implementing a reporting system can help move energy access to the heart of the development agenda. Taking this work forward and ensuring continuity in these efforts will require creating an organisational mandate and related human and financial resources.

While an absolute measure of energy poverty is elusive, we believe that many aspects related to this issue can be meaningfully reflected by means of a well designed set of metrics and proxies. We nevertheless acknowledge that any measure of energy poverty will remain crude, entail shortcomings, particularly given the weak information available, and provide only an incomplete picture of the issue.

This paper recognises the need for establishing the theoretical underpinning of energy poverty. It also appreciates the need for pragmatism in the development of an indicator that is easily computable, flexible enough to be used in various contexts, and that acknowledges the issues related to the availability of reliable, comprehensive datasets. Appreciating the multidimensional nature of energy poverty, trade-offs exist, and decisions will have to be made to strike a balance between methodological sophistication and theoretical accuracy on the one hand, and applicability and transparency on the other. If this can be achieved, such a tool would be a useful support for national policy makers, a driver for the enormous changes required, and a powerful influence for moving energy poverty up political and developmental priority agendas.

Acknowledgments

Authors acknowledge the valuable contribution from all participants. In addition, useful information was also garnered from an expert meeting at the IEA, Paris, on May 7, 2010. Finally, we would like to acknowledge the support and guidance by Jose Goldemberg, Fatih Birol and Kandeh Yumkella.

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