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Review

Energy access programmes and sustainable development: A critical review and analysis

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ABSTRACT

This paper provides an overview of the debate on energy access and development, and argues that despite some progress in enhancing energy access, the programmes promoting energy access are neither sustainable nor adequately contributing to development. The paper substantiates this argument by considering the experience of energy access and by performing a simple multi-dimensional sustainability analysis. There has been a disproportionate emphasis on electrification in the past, which can neither resolve the energy access problem nor address the sustainable development issue. Ensuring access to clean energies to meet the demand for cooking and heating energy and providing economically viable and affordable options remains the greatest challenge. The paper suggests that a rebalancing of approaches to energy access provision is required to ensure their sustainability.

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Introduction

Since the Johannesburg Summit in 2002, the critical role played by energy in achieving sustainable development has been well recognized in the energy policy literature (see for example, WEC (2001), DfID (2002), IEA (2002), UNDP (2005) Bhattacharyya (2006), and Ailawadi and Bhattacharyya (2006)) and a consensus seems to exist that without affordable, reliable and clean energy services to the population, sustainable development cannot be achieved. Yet, the situation in terms of energy access has not changed much even after a decade, and billions of people are without access to such vital services and according to IEA (2011), even by 2030 this problem will not diminish unless actions are taken urgently. The United Nation's decision to declare 2012 as the “International Year of Sustainable Energy for All” has once again caught the global attention on this problem. However, the energy access debate has many dimensions — not all are well understood. For example, the term energy access itself is not well defined and need not be a static concept over time. Moreover, it is not clear whether development is promoted when just the basic needs are satisfied and whether the strategies being adopted to promote energy access are sustainable.

The purpose of this paper is to provide a critical review of the energy access concept and the related experience in promoting the access to argue that just meeting the basic needs does not necessarily lead to development per se and that the strategies being used to promote energy access are not sustainable in the long run. The paper strives to achieve this through a review of relevant literature and by applying a multi-dimensional sustainability framework to energy access programmes. The paper is organised as follows: Energy access and development section presents the concept of energy access by linking it with economic development and defines relevant terms for the sake of clarity; Review of experience on energy access provision section looks at the experience of energy access promotion while Sustainability analysis of energy access programmes section examines the sustainability dimension. Final concluding remarks are presented in Conclusion section.

Energy access and development

Energy access

There is no universal definition of the term “energy access.” IEA (2011) gives the following definition: “a household having reliable and affordable access to clean cooking facilities, a first connection to electricity and then an increasing level of electricity consumption over time to reach the regional average.” However, the definition implicitly assumes the regional average level of consumption as the acceptable minimum need which can be problematic due to its potential for encouraging wasteful consumption and perpetuation of unsustainable lifestyles.

In fact, reaching a consensus on the target is fraught with difficulties. The issue arises because the energy access literature draws parallel from the poverty literature where poverty is generally related to inadequate levels of income and consumption to fulfil the basic needs, which, in turn, implies the deprivation of the basic minimum needs of a population. From this perspective, the energy access would mean ensuring a minimum quantity of energy to meet the essential needs of a population. Generally, either engineering estimates or normative values[1] are used to determine the essential needs but these estimates have their own issues as well due to inherent subjectivity.

Moreover, the needs need not remain unchanged over time and consequently, the target itself can move, thereby creating the challenge of reaching a moving target. Further, the poor is not a homogeneous category, and both endowments and entitlements can vary even within a country and across countries, implying that the needs are not homogeneous for the poor. In the case of energy this becomes important as the needs depend on geographical location, climatic conditions, resource endowments, etc.

Pachauri (2011) explains that reaching a consensus on the definition of energy access hinges on agreements on three elements: 1) consensus on services defining the basic needs basket, 2) a clear definition of the thresholds defining the basic needs, and 3) assessing the household expenditure on energy by different income class. Reaching an agreement on these elements is not easy. In this paper, we have used the term access to mean access to modern and clean, affordable and reliable energy services by the population of a country.

Development

The term development is used here in the sense of sustainable development as defined in Our Common Future (or the Brundtland Report).[2] Such a development goes beyond economic growth and strives for a development that is economically feasible, socially desirable and environmentally benign. This, in other words, calls for equitable, environment-friendly and balanced development. This departs from the traditional focus on income or wealth as the measure of development to better quality of life for human beings living in the economies.

The empirical relationship between energy access and development is generally captured by linking either an economic indicator (e.g. GDP per capita) or the Human Development Index (HDI) (or its components) of a country with energy access. The UNDP HDI database reports indicators of quality of life and human development. A multi-dimensional poverty index was introduced in 2010 Human Development Report, which covers electricity and cooking energy poverty. The International Energy Agency has been publishing data on energy access since 2004 and a recent report by UNDP-WHO (2009) provides detailed data on electricity and cooking energy access for a large number of countries. The data from HDI database and UNDP-WHO (2009) are used in this paper to analyse the energy access and development link. UNDP-WHO (2009) provides country data for different years depending on the data availability. Data used in this paper come from Table 18 (% of population with electricity access) and Table 19 (% of population with access to modern fuels) of the report. This has been used here due to its wider coverage than any other available source, although this may ignore some improvements in the status since the publication of the report. It is important to highlight that both GDP per capita and HDI use national averages and therefore ignore the equity or distributional aspect. Although an inequity-adjusted HDI is also reported in the HDI reports, here the unadjusted values are used to maintain comparability with national average of energy access data.

Energy access development link

As is generally expected, higher levels of energy access are normally associated with a higher income level but a rapid improvement in access level occurs within an income band bounded by a lower threshold income level of about $1000 per person in PPP terms 2005 and an upper saturation level of about $15,000 per person in PPP terms (see Fig. 1).[3] Those below the lower threshold clearly lack access to clean energy, while everyone above the upper threshold has access to clean energy services. However, the scatter plot

[1] E.g. the Indian Planning Commission used to rely on such norms.

[2] The definition given here is as follows: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987).

[3] The horizontal axis is presented in logarithmic scale to capture the wide range of income variation across countries.

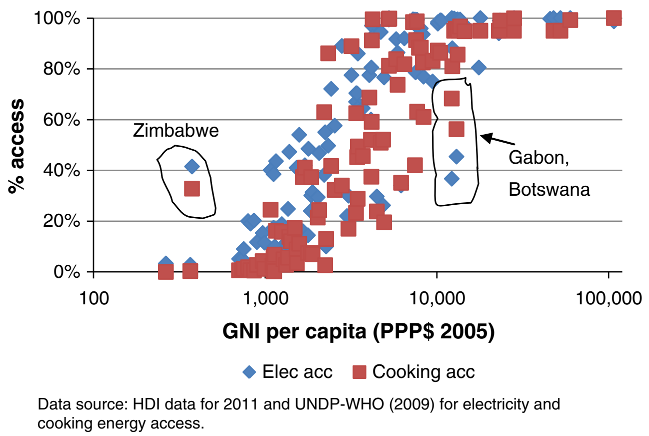


Fig. 1. Energy access improves with per capita income. Data source: HDI data for 2011 and UNDP-WHO (2009) for electricity and cooking energy access.

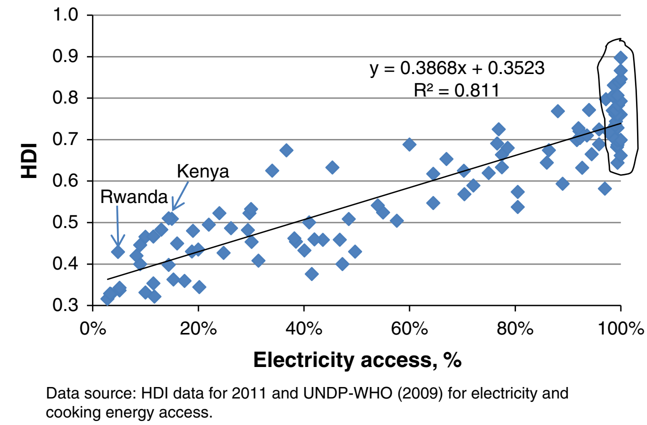


Fig. 2. HDI and electricity access. Data source: HDI data for 2011 and UNDP-WHO (2009) for electricity and cooking energy access.

shows a significant level of dispersion within the upper and lower thresholds, implying that some countries are able to reach better energy access at low income levels while some with high income have failed to deliver energy access to their population. For example, Zimbabwe has defied the trend to provide a comparable performance of middle-income group despite having an income level of $376 per capita (constant 2005 in PPP). Jordan and Egypt have succeeded in ensuring almost 100% energy access with a per capita GNI of close to $6000 (PPP terms) whereas Botswana with a $13,000 GNI per capita has only achieved 45% electrification. Botswana is a paradox case — it is often cited in the resource curse[4] literature as a country that escaped the resource curse but that did not help it in its energy access challenge. Clearly, income does not automatically ensure high level of energy access of a country and there are other drivers that play an important role. However, a detailed analysis of the causes, drivers and lessons from the successful/ unsuccessful cases is beyond the scope of this paper and is an area of further research.

The Human Development Index of a country, on the contrary, bears a better correlation with energy access than income. Using the HDI data for 2011 and energy access data presented in UNDP-WHO (2009), a few indicators linking HDI and economic development are presented in Figs. 2 to 5. Fig. 2 shows that better HDI scores are generally associated with higher levels of electricity access, while Fig. 3 shows that the HDI also is positively correlated with access to cooking energy. Similarly, the life expectancy and mean schooling years are also positively correlated to clean cooking energy access and electricity access (Figs. 4 and 5), although the goodness of fit of a linear relationship is less strong than the previous two cases.

However, the above figures also raise concerns about the use of HDI as a single measure of development. This is because of the following observations:

a) A number of countries with low level of energy access scored decent HDI scores. For example, Rwanda has a HDI score of 0.429 with only 4.8% access to electricity and 0.2% of its population having access to clean energies. Similarly, Kenya has scored an HDI of 0.509 with 15% electricity access and 17% clean cooking energy access. Madagascar and Uganda have HDI scores of 0.48 and 0.446 respectively despite the fact that less than 1% of their population has access to clean cooking energies.
b) Madagascar has a mean life expectancy of 67 years despite less than 1% of its having access to clean cooking energies. Uganda has recorded a life expectancy of above 45 years, and a mean schooling of 3 to 5 years and an average GNI per capita of close to $1000 PPP (constant 2005). On the other hand, many countries with very high cooking energy access rate have not seen much improved health expectancy (e.g. Trinidad and Tobago, Guyana both have 70 years of life expectancy at birth with almost 100% and 89% cooking energy access respectively).
c) Many countries with less than 20% electricity access have achieved 6 or more years of schooling that many countries with 100% electrification are also striving for.
d) Similarly, countries with a given level of energy access have also scored significantly differently on HDI scores or its component scores. For example, in Fig. 2, large variations in HDI scores can be seen for countries with 100% electricity access.

AS HDI focuses on three equally-weighted components (namely life expectancy at birth, mean schooling years and GNI per capita), and because energy is one of the many drivers (and thus has an indirect influence) behind the performance of these components, the influence of energy on HDI is not always very straightforward.

Energy access predominantly a rural problem

According to IEA (2011), 1.3 billion people in the world did not have access to electricity in 2009 while 2.7 billion people did not have access to clean cooking energies. With almost 40% of the global

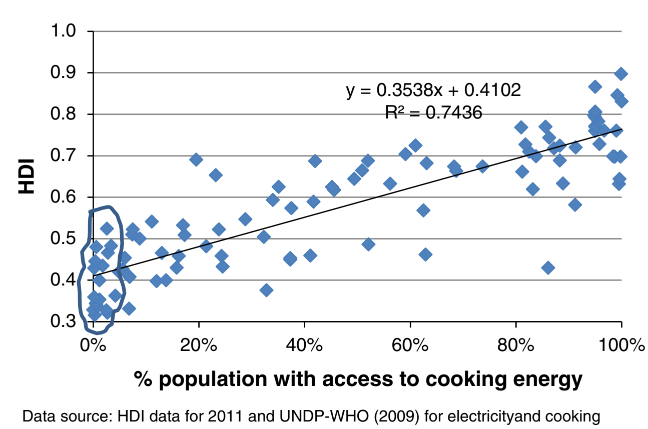
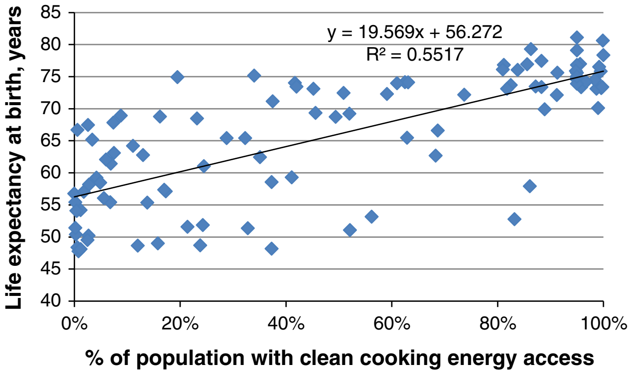


Fig. 3. HDI and cooking energy access. Data source: HDI data for 2011 and UNDP-WHO (2009) for electricity and cooking energy access.

[4] Resource curse is a term used to explain situations where resource abundance does not lead to economic development and better quality of life. There is a large volume of literature on resource curse. See Stevens and Dietsche (2008) for a recent review.

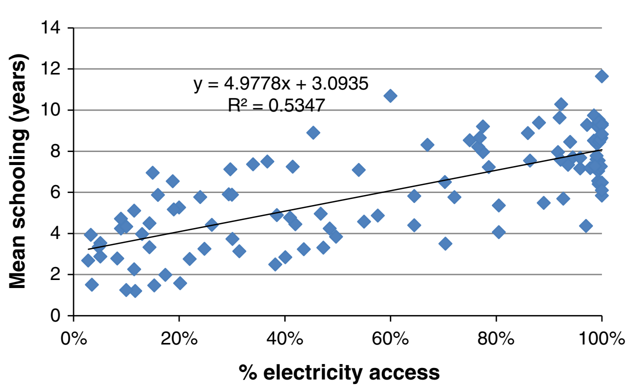


Data source: HDI data for 2011 and UNDP-WHO (2009) for electricity and cooking energy access.

Fig. 4. Life expectancy at birth and cooking energy access. Data source: HDI data for 2011 and UNDP-WHO (2009) for electricity and cooking energy access.

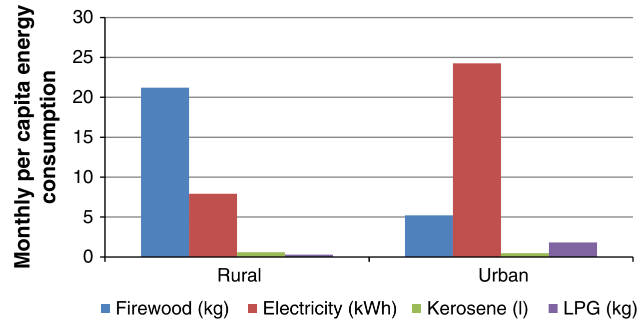
population is still lacking access to clean cooking energies, the challenge is daunting. The access problem has a distinct regional dimension — Sub-Saharan Africa and Developing Asia are two distinct regions where the problem is acute. 585 million people in Sub-Saharan Africa lack access to electricity while 675 million in Developing Asia face the same problem (IEA, 2011). Similarly, 653 million people in Sub-Saharan African and 1.9 billion in Developing Asia do not have access to clean cooking energies. Near 100% electrification in China has significantly improved the electricity access figure in Developing Asia but the cooking energy challenge persists. The regional averages also mask the severity of the problem faced by many countries. For example, 97% of population of Burundi, Liberia and Chad, 95% of Rwanda, Central African Republic and Sierra Leone lacked electricity access in 2008 (UNDP-WHO, 2009). 83% of Kenya's population and 93% of Ethiopia's population do not have access to cooking energy (IEA, 2011).

Further, energy access is predominantly a rural problem. 1.1 billion (out of 1.3 billion or 85%) lacking electricity access are found in rural areas. Similarly, more than 2.2 billion (out of 2.7 billion or 81%) lacking clean cooking energy access reside in rural areas (IEA, 2011). This disparity is acute in low income countries in general and in Sub-Saharan Africa in particular. UNDP-WHO (2009) indicated that 87 and 89% of rural population of LDC and SS-Africa lack access to electricity respectively. Similarly, 97 and 95% of rural population of LDC and SS-Africa lack access to clean cooking energies in 2008 (UNDP-WHO, 2009).



Data source: HDI data for 2011 and UNDP-WHO (2009) for electricity and cooking energy access.

Fig. 5. Mean schooling years against electricity access. Data source: HDI data for 2011 and UNDP-WHO (2009) for electricity and cooking energy access.



Data source: NSSO (2012).

Fig. 6. Disparity in energy use per capita between urban and rural India. Data source: NSSO (2012).

Generally, 90% of the energy needs of the poor originate from the heating and cooking energy demands whereas electricity is used for lighting and entertainment needs. The disparity in energy consumption mix and quantity consumed can be quite significant between urban and rural consumers. For example, based on NSSO (2012) data for Indian households (see Fig. 6), it can be seen that rural consumers rely heavily on firewood (and other solid biomass), whereas the urban consumers use electricity and LPG to meet their needs.

The predominance of solid fuels for cooking purposes is a characteristic feature of energy use (see Fig. 7) in developing countries. Of all regions, Sub-Saharan Africa relies on solid fuels the most, and woody fuel has the highest share (above 70%) but all other developing regions also rely on wood quite substantially. Coal and charcoal is used in China (and to some extent in India) and Sub-Saharan Africa respectively, while gas (LPG, biogas and natural gas) is more used outside SS Africa and low income countries.

While Fig. 7 provides an overall picture of the developing world, there exists a great urban–rural divide in cooking energy use. Fig. 8 provides further details, which confirms that rural populations rely much heavily on solid fuels. Again, the situation is precarious in SS-Africa and Least Developed Economies. High reliance on solid fuels has significant social impacts in terms of air pollution and health effects on women and children. UNDP-WHO (2009) reported that about 2 million deaths per year and 40 million disability-adjusted life years (DALYs) can be attributed to solid fuel use in developing countries. The issue of access to clean energies therefore assumes greater importance.

Review of experience on energy access provision

A number of approaches have commonly been used by countries in enhancing energy access but little attention has been given to critically analyse whether these efforts are sustainable solutions or not. This section provides a succinct review of experiences on electrification and cooking energy provisions and critically analyses their sustainability dimension.

Review of electrification experience[5]

There exists a well-developed body of literature on rural electrification and electricity access. Instead of providing a review of this literature, a digest of the experience is presented here. There is a long

[5] This section relies on the research carried out under the Off-grid Access Systems for South Asia (OASYS South Asia) project funded by Research Councils UK. A number of Working papers (e.g. WP1, WP2, WP4 and WP10) have been used in writing this material. See www.oasyssouthasia.info/ for further details. See also Palit and Chaurey (2011), Barnes (2011) and Cook (2011).

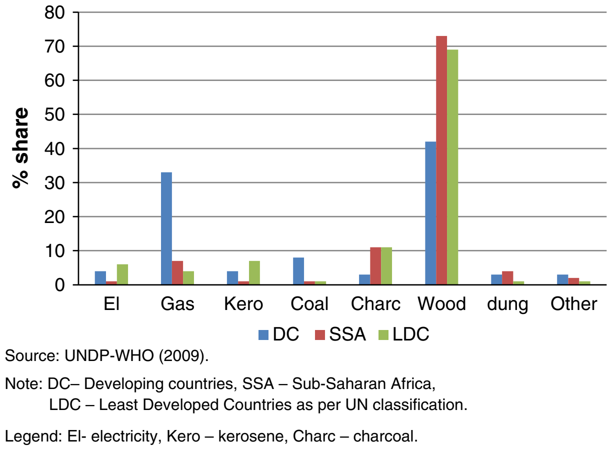


Fig. 7. Cooking fuel mix in the developing world. Source: UNDP-WHO (2009). Note: DC — developing countries, SSA — Sub-Saharan Africa, LDC — least developed countries as per UN classification. Legend: El — electricity, Kero — kerosene, Charc — charcoal.

tradition of supporting rural electrification programmes both by international organisations and national governments but as Cook (2011) indicates, the trend depended on the political thinking of a given time. The wave of state-led infrastructure development for rural areas of the 1960s was responsible for initial efforts in this area in most countries but the liberalisation policies of the 1980s and 1990s reduced state support in favour of private sector initiatives. Specific funds were often created to take care of non-market issues related to reforms, thereby creating a transparent regulatory mechanism for supporting social and public goods dimension. But, rural electrification received a set-back as the private investment interests were not often compatible with the rural market conditions. The return of state intervention to address the market failure issue is visible globally once again as the focus on electricity access has gained momentum.

Grid extension as the preferred electrification option

Many countries have made a significant progress in terms of electrification. The success is not restricted to any specific region either. Urban areas of Latin America have traditionally performed well in

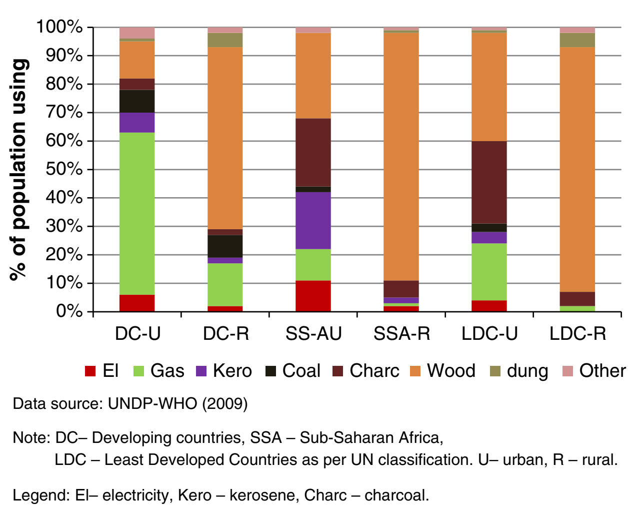


Fig. 8. Urban–rural divide in cooking fuel use. Data source: UNDP-WHO (2009). Note: DC — developing countries, SSA — Sub-Saharan Africa, LDC — least developed countries as per UN classification. U —urban, R — rural. Legend: El — electricity, Kero — kerosene, Charc — charcoal.

terms of electrification but East Asia, particularly China has set an excellent example of achieving universal electrification despite its billion-plus population and vast rural population. South East Asian countries have also been successful in reaching very high electrification rates and even relatively poorer economies like Vietnam and the Philippines are excellent success examples. South Africa on the other hand is a successful case in the African continent. At the same time, many countries including Indonesia, Botswana, Kenya, and Nigeria, have not performed well in terms of electrification progress.

Grid extension has emerged as the preferred mode of electrification in all successful cases, although off-grid electrification has been used either as a temporary solution (a pre-electrification option) or as an inferior solution. While off-grid options have received favour and support of international organisations and donor agencies, and a few technologies such as solar home systems (SHS) have emerged as leaders in this segment, there has been a relatively limited penetration of this option globally. High cost, limited application and poor performance of the technologies as well as the image of "inferior or temporary" nature of such options have hindered the development. Some country experiences are summarised in Box 1.

Limited progress with off-grid electrification

The progress in off-grid electrification on the other hand is more difficult to trace due to small-scale operation and absence of any systematic regulatory reporting requirement for such operations. However, off-grid solutions have been promoted where the grid has not reached or is unlikely to reach in the near future. Two modes of operation are prevalent: stand-alone systems and local-grid systems. The local-grid systems often rely on diesel generators or hydropower. According to World Bank (2008), portable 5–10 kW diesel generators are widely used as the conventional solutions. However, heavy reliance on diesel for small-scale power generation imposes cost burden on the utilities (more importantly on oil importing countries). The price fluctuations in the international market affect the overall cost of production and the viability of the business. This, in turn, imposes a heavy subsidy burden on the government.

Local-grid system has also developed in hydro-dominated areas. For example, China Statistical Yearbook (2008) reported that more than 27000 hydropower stations are operating in rural China with a total installed capacity of about 14 GW. Many hydropower plants were initially developed using a local grid system and then connected to the main grid. In the stand-alone category, the solar photovoltaic systems (in local grid or in battery charging systems) and the Solar Home Systems (SHS) have emerged as the preferred off-grid technology for rural areas (IFC, 2007). IFC (2007) estimates that SHS has provided electricity access to between 0.5 and 1 million households in developing countries and that through various projects supported by the World Bank and the IFC group, more than 1.3 million solar PV systems have been installed worldwide. The difference in the two figures may be due to abandonment, retirement at the end-of life, and errors in estimation. Despite such an impressive growth, SHS is catering only a miniscule share of the non-electrified population (just a million household as against 300 million households without electricity), which raises concerns about its future prospects.

Off-grid solutions appear to cater to limited needs of the consumers for lighting and some entertainment through radio/ TV connections. Very limited efforts have been found where these solutions have promoted productive use of energy for income generation. Similarly, very limited effort has so far gone into hybrid off-grid solutions to provide a reliable and affordable solution, because of system complexity, added cost and over-emphasis on lighting-only solutions.

State funding and subsidy

A related feature of grid extension programmes is that the state has generally funded the investments for electrification in all successful cases. Funds for rural electrification flowed from central and local

Box 1
Summary of selected country experiences.

China provides a successful example of providing electricity access to more than 900 million people over a period of 50 years (Peng and Pan, 2006) and presents a contrasting case compared to other developing countries. It is now estimated that only 2 million households lack access and the government plans to provide electricity to them by 2020 through off-grid means. Although China initiated its electrification programmes in the 1950, efforts saw a step change after the economic reforms were adopted in 1978 and within a decade, 78% of the rural population had access to electricity. Industrial activities through town and village enterprises were promoted during this period. Decentralised operation of local grids was continued but in addition to hydropower, thermal power based on coal started to gain importance. Between 1988 and 1997, electricity access was made almost universal and by 1997, 97% of the rural population had access.

China also followed a different strategy as well. While most of the countries adopted a top-down approach, China relied on a pragmatic approach in which multiple technologies (small hydro, coal, renewable energies), multi-mode delivery options (central grids, local grids and hybrid systems), a strong emphasis on rural development and a strong role for local level government had contributed significantly. China also followed a phased approach to development where the local-grid was initially developed in the rural areas to cater to low demand but as demand grew, the system was then renovated to integrate to the central grid system. The phased development strategy along with early recognition of electrification-rural development link ensured appropriate management of financial resources, initial demand creation and a self-reliant system. However, the strong government funding and policy support and strong commitment to electrification.

The Philippines, composed of more than 7000 islands, provides another example of successful rural electrification. According to IEA (2009), the country has achieved an electrification of almost 90% in 2009, with only 9.5 million lacking access. The Electricity Co-operatives, created in the 1960s following the US rural electric co-operatives model, were the main vehicle for electrification, who managed the local grid and distributed power in their area. The co-operatives generally buy power from power producers and distribute it through their distribution systems. Most of the power comes from diesel generators – either land-based or barge mounted. Heavy reliance on diesel for small-scale power generation imposes cost burden on the utilities of an oil importing country. The price fluctuations in the international market affect the overall cost of production and the viability of the business. This imposes in turn a heavy subsidy burden on the government. For remote rural areas where extending the grid is not cost effective or is not likely to materialise in the near future, off-grid solutions have been used. Mini-grid system has been used in such areas. Mini/ micro-hydro power was the preferred energy source where hydro potential exists. Similarly, geothermal power has also been exploited where available. Otherwise, new renewable energies such as solar power, wind and biomass have been used, although the development in these areas remains slow compared to other technologies.

Upon restructuring of the electricity sector in 2002, the Philippines adopted a competitive market model. In 2003, the government launched the Expanded Rural Electrification Programme to achieve 100% electrification by 2008 (extended to 2010 afterwards) and 90% household electrification by 2017. While electrification rate aims to enhance the facility by creating appropriate infrastructure, the household electrification programme has allowed participation of non-government and non-utility agencies in electricity provision and resource generation by involving qualified third parties (QTP). Where a co-operative or a franchisee finds it unviable to provide electricity, the Missionary Electrification project is undertaken, which receives a continuous flow of subsidy from a fund created by levying a universal charge, set by the electricity regulator, on electricity users. Thus, the country has relied on both state support and market-based mechanisms to enhance electricity access, and provides lessons for other countries.

Since the end of the Apartheid regime in 1994, South Africa has been active in promoting changes to its policies. In 2000, it declared the access to basic services, including electricity, as a social right. By 2009, the country has achieved a 75% electrification rate, with 88% urban and 55% rural population having access to electricity (IEA, 2010). The country has adopted an Integrated National Electrification Programme (INEP) which allows for both grid extension and non-grid supplies. But off-grid supply has not been widely used and is used only when grid cannot be extended. Lack of political will, non-payment of fees by consumers, and the perception of a temporary solution or inferior solution are among the factors affecting the success of off-grid supply. Coal remains the main fuel for electricity generation in the country. Where grid is not extended, solar home systems are used for electrification but the suppliers are also required to provide a cooking fuel (LPG or paraffin).

The electrification under the INEP was financed by the state budget and since 2003, has cost about $160 million per year. Escom, the state electricity company, initially thought the electrification programme could be self-financing but by late 1990s, it became apparent that this is unlikely and the state took the responsibility for funding the infrastructure development and subsidising supply (Bekker et al. (2008)).

Vietnam provides another example where rapid progress has been made in terms of rural electrification. According to IEA (2010), the country has achieved close to 98% electrification. From a mere 1.2 million population with electricity access in 1976 the country has managed to provide electricity to 82 million people by 2009 (World Bank, 2011). Although Vietnam started its electrification efforts in the mid-1970s as part of its post-war recovery process, rural electrification received attention much later when the country adopted the Chinese-style economic reforms in the late 1980s. The country made significant progress in rural electrification in the 1990s when the electricity generating capacities and transmission networks were available, and when the Electricity of Vietnam (EVN), the state company, was established to ensure integrated development of the electricity supply industry.

Vietnam also relied on grid extension as the main mode of electrification. The state played an important role in the entire electrification process – policy making, strategy development and delivery. Vietnam followed a logical approach in building the capacity and infrastructure first and then expansion of the system to rural areas. It also prioritised the process by putting emphasis on productive use of energy, which helped create demand for electricity. The creation of EVN and its effective support in promoting rural electrification contributed to the success of the programme as well. Finally, the involvement of various stakeholders and the focus on cost sharing and cost-recovery were also important features of the system.

Kenya on the other hand can be considered as a rural electrification paradox. The country has set up organizations and created dedicated funds for providing energy in deprived areas. It has received sustained international donor attention and has experimented with a variety of technologies and options. Yet, the country remains poorly served in terms of electricity and cooking energy access. While there have been cases of limited success in some areas or pilot projects, their replication and sustenance has not been ensured. This shows that it is not sufficient to have the legal framework or organizational arrangement for a successful electrification programme. It requires a strong government commitment and financial support, a strong strategy and a systematic plan to bring success.

governments in China. In South Africa, the state assumed the responsibility for funding rural electrification under the Integrated National Electrification Programme. In Brazil, the PRODEEM programme was funded by the donor agencies and the federal government while Light in the Countryside and Lights for All programmes are essentially funded by the federal government, although states can support through their contributions. In India, the Central government provides 90% of the investments for rural electrification through the Rajiv Gandhi Village Electrification Programme. Some countries, like Kenya and Tanzania, have created an electrification fund and general electricity users are levied a surcharge to generate revenues for the fund. However, these funds have not yet proved to be successful in enhancing infrastructure development in these countries. The funds may not be sufficient and the regulatory capacity in investing the funds may also be limited, creating barriers to electricity access provision.

While capital subsidy for infrastructure investments supports grid extension, additional support is also provided in many cases to allow consumers to use a minimum level of electricity. A 20-amp connection is given free of charge in South Africa to the poor and a 50 kWh free monthly allocation of electricity is given. Many other countries charge poor consumers a lifeline rate (for example India) which allows the lowest level of consumption either at a fixed monthly payment or at a subsidised rate. Cross-subsidisation has also been tried between urban and rural consumers: for example, in Thailand, the consumers of the Provincial Electricity Authority in Thailand benefit from cross-subsidised power purchase rate for rural supply.

The case for subsidising the required infrastructure to provide the supply relies on the public good argument: the limited demand will not justify private investment and the market will remain unserved if the profitability aspect is solely considered. But the social benefit of enhancing the access can be far greater than the private cost, due to reduced environmental damages and better living condition, thereby making state intervention to remedy the market failure justified. The support for energy use (or the operational cost) on the other hand invokes the idea of minimum energy needs for sustaining livelihood. If a section of the population is unable to procure the minimum level of energy needs, they could be supported on social equity grounds. However, a number of issues arise as a result of subsidies, including electricity leakage due to unmetered supply and/or theft, rise in consumer size which in turn increases the subsidy burden, poor revenue generation for the utilities that reduces their long-term interest, etc. As governments often did not either accept the subsidy liability or compensate the utilities on time, the subsidy burden affected the utilities financially.

Poor link between electrification and rural development

As the focus of electrification has been limited to mere grid extension, electrification did not necessarily lead to poverty reduction or

Box 2

The Chinese and Indian experience of rural electrification-rural development linkage[6]

[6] This is based on Bhattacharyya and Ohiare (2011), Bhattacharyya (2005) and Bhattacharyya (2006).

Although both China and India initiated their electrification efforts in the 1950s, the two most populous countries in the world have produced very different outcomes. With almost 100% electrification rate, China stands out in the developing world, whereas India still has a large population without electricity access. The differences in their approaches explain the outcomes to a large extent.

China has relied on a bottom-up approach, where the local-level administration and participation was responsible for the local solution. China also adopted a phased development approach where local grids at the village or community level were established initially, followed by an upgrading of the system to link to the regional or national network. China recognised that rural electrification and rural energy supply is closely linked to rural economic development. Its focus on agricultural development in the planned economy phase and on Town and Village Enterprises in the reform era clearly highlights this recognition. Through sustained rural economic activities, China was able to reduce rural poverty rapidly and improve the living conditions of its population. China allowed selection of locally-relevant energy sources and as a consequence allowed technological diversities to co-exist. Although the main emphasis was on small hydropower and coal initially, there was never a "single solution fits all" approach. Technological flexibility has also allowed local resource utilization and avoided highest cost options for difficult locations. The sense of local ownership has also ensured success of projects in remote areas. Further, strong state support and the ability to engage the local communities to the creation of local infrastructure have surely contributed to the success. Moreover, the pricing system ensured almost full cost recovery, which in turn allowed future sustainability of the system. In fact, China has avoided the trap of high electricity subsidy syndrome. The approach was thus flexible, pragmatic and anchored in self-reliance.

India on the other hand appreciated the need for extension of the electricity system to rural areas quite early, just after the independence of the country. State involvement for providing electricity to rural and disadvantaged section of the population was always prominent in the Indian policy agenda. Rural Electrification programme in India was launched in the 1950s with two distinct dimensions viz. 1) Village Electrification. 2) Irrigation Pump set Energisation. The former enhanced consumer satisfaction and the latter optimised crop yield. The area of focus was certainly maximising farm output, which did result in the Green Revolution in the mid-Sixties. Although the Green Revolution was limited to a few states and a few crops, it transformed the country from an importer of food grains to a self-sufficient (and even exporter) nation. Thus, from a macro point of view, rural electrification was a success with benefits having trickled down to the Indian farmers, though probably to those with comparatively bigger farm holdings.

A number of specifically targeted schemes were launched from time to time to facilitate electricity access to the poor.[7]

Most of these schemes were implemented by the state electric utilities with federal financial assistance disbursed through the Rural Electrification Corporation (REC). There was little local participation in the decision-making and no sense of local ownership of the initiatives. Moreover, the practice of subsidised and unmetered supply to agriculture and small consumers proved to be very costly for the utilities, making them financially unsound in the first place. As local resources or local grids were not used, electricity only reached villages during off-peak hours. The quality of supply was often very poor and neither the consumers nor the utility were happy with the entire process. This resulted in a poor rate of electrification until recently when a new drive for rural electrification was initiated in 2005 through a centrally-sponsored scheme. The country made significant progress since then but reaching the target of universal electrification will take some more time.

[7] These include Kutir Jyoti programme, Accelerated Rural Electrification Programme, Schemes for electrification of Scheduled Castes and Scheduled Tribe households, etc.

economic development. For example, an evaluation of World Bank rural electrification projects found that the benefits of rural electrification continue to accrue to non-poor households and that productive application of electricity is rare (World Bank, 2008). As electricity is mostly used for lighting and operating a television, its direct impact on income generation or economic growth is limited. In addition, the quality of supply often remained unsatisfactory and rural consumers did not receive reliable supply when they needed. China and India provide two contrasting examples where rural development was deliberately attempted through electrification to produce very different outcomes (see Box 2).

The main finding from the above analysis is that countries have relied on different strategies to record different levels of success, but the electrification process has heavily depended on government subsidies, which goes against sustainable solutions. Moreover, electrification has not necessarily enhanced economic opportunities for the poor and has not acted as a catalyst for economic development, as rural development was hardly linked with electrification.

Review of clean cooking energy access experience in developing countries

This section provides a brief review of the experience with clean cooking energy provision. A number of initiatives have been taken by various countries to reduce the negative effects of solid fuel reliance by promoting clean energies, both conventional energies and renewable energies. Similarly, demand-side interventions to improve the efficiency of solid energy use through improved technology have also been common.

Promotion of petroleum fuels

A relatively common approach to displace solid fuels used for cooking purposes was to promote liquid or gaseous hydrocarbons in the form of kerosene and liquid petroleum gas (LPG). Generally, petroleum fuels produce less environmental damages at the point of use compared to solid fuels due to better conversion efficiency (burners are more efficient). As these modern fuels have to compete with energies which are generally collected by the users without incurring any monetary costs,[8] the main policy intervention here was to subsidise the supply to ensure that consumers change their consumption behaviour in favour of the modern fuel but such an intervention did not always produce the desired outcomes, as the Indian example below explains.[9]

In India, the state oil companies were involved in petroleum product distribution and marketing. An administered pricing policy was followed which relied on a system of price discrimination by products. LPG and kerosene were treated differently for supply purposes. Depending on the availability of LPG and infrastructure for providing the supply, new connections were released by the supplier. Getting an LPG connection involved a significant waiting time, often several years, as supply infrastructure was not sufficient to meet the demand. The product came in a single standard size (of 14.2 kg cylinders) and required an initial investment in terms of security deposit, purchase of a cooking stove and at times modifications to the kitchen. In addition, the consumers had to bear the running cost of replenishing the LPG at a regular interval. The government provided a general price subsidy for LPG; however, there was no specific scheme for the poor and the subsidy scheme benefited the relatively better-off section of the population. Consequently, LPG use amongst the poor remained limited due to high initial cost of a connection and cooking appliance, lumpiness of LPG purchase cost (due to specific sizes of the refill cylinders), availability of cheap alternative fuels for cooking, etc. A part of the subsidised LPG entered the transport sector as it proved to be cheaper to run vehicles with a minor system modification.

Kerosene was traditionally supplied through fair price shops at subsidized prices. Supply from such public distribution system can be availed on production of a card, which is given to each member of a household upon registration to local authorities subject to some verification procedures. Each card entitles the cardholder to a fixed quantity of kerosene, which varies with geographical location (with an urban bias in many cases) and access to alternative cooking fuel like LPG (World Bank, 2000). In contrast to LPG, kerosene use requires little initial investment and the subsidized price offers significant incentive for unintended use of the product (smuggling and adulteration with diesel). Further, Rao (2012) contends that the kerosene subsidy is regressive and that the benefits accrue to the urban population compared to the rural poor, as rural population uses it for lighting.

Moreover, for import-dependent countries, the subsidised supply becomes a financial burden when prices in the international market harden and the governments operating under severe budget constrains faced difficulties in maintaining such subsidies in the long-run. It becomes difficult to remove such populist subsidies as well. Further, the supply chain issues did not receive adequate attention, implying that even when consumers decided to use the modern fuel, its regular availability was not ensured. The problem arose due to limited demand of such energies from poorer households, weak organisational arrangement of often state-owned suppliers for rural supply and poor financial viability due to high transaction costs.

Yet, innovations have taken place as well: smaller bottle sizes for LPG have emerged that make transportation easier and reduce the initial payment as well as the recurring costs; to prevent adulteration, dyed products for different market segments (controlled and decontrolled markets) have been attempted; support for initial investment in appliance purchase and connections was provided in some cases. IEA (2011) has estimated that to ensure cooking energy access for all will increase the oil demand by merely 0.9 million barrels per day (against 87.4 million barrels per day global demand in 2011),[10] yet the long-term sustainability of this approach is doubtful due to price volatility in the international market and increasing foreign exchange and subsidy requirement for preferential support. While LPG can still play a role, it is unlikely to emerge as a global rural solution.

Biogas as a solution

Alongside the promotion of petroleum fuels another option, namely the promotion of biogas, has received some attention, particularly from oil-importing countries. The economic logic is quite straightforward — the use of local resources can save foreign exchanges, limit exposure to fluctuations in international market prices, while at the same time provide clean energy. China is the world leader in biogas production (Yisheng et al., 2002) and about 26.5 million biogas plants are currently being used in the country (Chen et al., 2010). Countries in South Asia (such as India, Sri Lanka and Nepal) also use biogas to a lesser extent. For example, Bond and Templeton (2011) and Mahapatra et al. (2009) indicated that about 4 million biogas plants are operating in India. The use of biogas is also increasing elsewhere — such as in Vietnam, Brazil and Tanzania.[11]

However, the promotion of biogas is not a quick solution. It took China more than 40 years to reach its leading status. Although biogas was promoted in the 1970s, its rapid development started in the 1980s when a move was made towards an integrated energy strategy and rural energy management. A detailed system of management plan was developed to implement the strategy. It covered research

[8] Although wood is becoming commercial in many places.
[9] This is based on Ailawadi and Bhattacharyya (2006).
[10] BP Statistical Review of World Energy, 2011 data.
[11] See Bond and Templeton (2011) for a review of history.

and development, pilot studies, training, and setting up a system for manufacturing, sale and servicing of the plants (Catania, 1999). The development of a cadre of skilled technicians and project staff and the performance improvement through feedback loops were also essential factors. The existence of a large manufacturing base has also allowed the country to take advantage of the technology. Continued growth in demand and consequent exploitation of scale and scope economies have resulted in lower supply costs, making supply more affordable. The financial support from the government also helped. Chen et al. (2010) reported that the Central Treasury invested 61 billion RMB between 2003 and 2010 for this purpose. In general, between 800 and 1200 RMB per household is provided as subsidy towards biogas plants (Chen et al., 2010). Above all, the buying-in of local participants through sustained awareness campaigns has also played a role.

Bond and Templeton (2011) indicate that about 50% of the biogas plants in the world are non-functional due to poor maintenance and repair of existing facilities. Therefore, future prospects of the technology hinge on developing adequate servicing networks. They also argue for flexible designs to reduce dependence on livestock manure, cost reductions and enhanced functionality with an emphasis on indoor pollution reduction to improve the prospects of biogas plants in the future.

Ineffective technology intervention

While the above two options aim to change the consumption behaviour through policy interventions in alternative supply systems, the limitations of these approaches in terms of long lead time and slow penetration rate cannot be overlooked. This leads to the third option which recognises the importance of solid fuels in meeting the cooking and heating needs of the poor and tries to address the problem through technological improvements. The aim is to contain the damage by providing more efficient technologies and by reducing the exposure to risks.

Many initiatives have been supported over the past 25 years through international co-operation, NGO support, and government involvement. According to UNDP-WHO (2009), only a third of the biomass-using population in the world is using improved cook stoves and about two-thirds of those using them live in China and another 20% in other Asia-Pacific countries. But Sub-Saharan Africa, where 80% of the solid-fuel using population lives, accounts for only 4% of the improved cook stove-using population. This implies that the region with most needs has not benefited much from this intervention.

Shrimali et al. (2011) reported that the Chinese National Improved Stove Program is regarded as a successful intervention that distributed 130 million stoves but the Indian counterpart (The Indian National Program on Improved Chullhas) did not record much success due to poor technical design and high cost among other factors. Venkataraman et al. (2010) reported on the next generation of Indian National Biomass Cookstoves Initiative that focused on reducing emissions as well improving energy efficiency. According to them, if such an initiative existed this would have avoided 570,000 premature deaths and 4% of India's greenhouse gas emissions. Smith (2010) reported the launch of a new global initiative on clean cook stoves (Global Alliance for Clean Cookstoves). This initiative aims for providing 100 million clean cookstoves by 2020. He also mentioned another nascent initiative, Global Cookstove Accelerator Facility.

Despite all these initiatives, the low uptake rate of improved stoves around the world cannot be overlooked. UN (2011) estimates that 3 billion people will live in rural Asia and Africa by 2020, majority of whom would still rely on solid biomass for cooking. The new initiatives will cater to a small fraction of this population. This raises concerns about the adequacy of such initiatives and their effectiveness. As cooking and heating energy needs constitute the main energy demand by the poor, the development benefits cannot be harnessed unless the access to clean cooking energies is ensured. Foell et al. (2011) argue, despite the gravity of the problem, the global attention on clean cooking and heating energies has been relatively low compared to that for electrification. As argued in Bhattacharyya (2006), rural electrification alone cannot resolve the problem of energy access in rural areas due to the fact that electricity accounts for a minor share of rural households' energy needs and electricity is unlikely to be competitive with traditional firewood (or biomass-based fuels) used by the poor for cooking purposes, which imposes little private monetary cost burden, although they impose heavy social costs. This simple truth is often forgotten or ignored by the policymakers because of better prestige and higher visibility of electrification projects.

Thus, there is an urgent need to focus on clean cooking energy issues. These actions must go beyond sporadic or ad-hoc international support and non-governmental organisation involvement, and need to be sustained in the long run.

Sustainability analysis of energy access programmes

This section presents a stylised analysis of sustainability dimension of energy access programmes. First, the methodology is elaborated and the results of the analysis are then discussed.

Methodology

For the sustainability analysis of energy access programmes, an adaptation of a framework suggested by Ilskog (2008) is used. Ilskog

Table 1
Indicators of sustainability of energy access programmes.

Technical sustainability	Economic sustainability	Social/ ethical sustainability	Environmental sustainability	Institutional sustainability
Ability to meet present and future domestic needs	Cost effectiveness	Wider usability amongst the poor	Contribution to reductions in carbon emissions	Degree of local ownership
Ability to meet present and future productive needs	Cost recovery potential	Need for micro-credit or financial support systems	Contribution to reduction in indoor pollution	Need for skilled staff
Reliability of supply	Capital cost burden on the user	Potential to reduce human drudgery	Contribution to reduction land degradation	Ability to protect consumers
Reliance on clean energy sources	Running cost burden on the user	Potential to reduce effects on women and children	Contribution to reduction in water pollution	Ability to protect investors
Technical efficiency	Financial support needs			Ability to monitor systems
Reliance on local resources	Contribution to income generating opportunities			
Availability of support services				

(2008) considered five sustainability dimensions — technical, economic, social/ ethical, environmental and institutional sustainability. Each dimension was represented by a number of indicators and each indicator was scored on a scale of 1 to 7. The overall score obtained by simple averaging was used for final ranking of the programmes.

We retain the five sustainability dimensions and identify relevant indicators for each dimension. We then apply this to six generic programmes, namely grid extension, off-grid solar home systems, off-grid electrification through local mini grids, petroleum fuel promotion for cooking, biogas programmes and improved cook stoves programmes and apply a scoring on a scale of 1 (poorest) and 7 (highest). The score for each indicator was arrived at through a brainstorming session involving a number of energy specialists. We recognise that this is the weakest part of the methodology implementation, which can be improved using a stakeholder survey at a future date.

More specifically, we consider the following (see Table 1 also):

a) Technical sustainability is achieved if the system can meet the present and future needs reliably, efficiently and by using clean and renewable sources. This is captured by considering whether the program can satisfy the present and future needs (both residential and productive), whether reliable, efficient and renewable-energy based supply can be delivered and whether supporting services for maintenance and running the systems are locally available or not.
b) Economic sustainability is achieved if the system offers cost effective and affordable supply at present and in the future. This is captured by considering the cost effectiveness and cost recovery potential of supply, capital and operating cost burden imposed on the users, and financial support needs for the system.
c) Social sustainability requires that the solutions should be widely acceptable and accessible to ensure reduction/ removal of human drudgery and adverse effects on women and children.
d) Environmental sustainability aims to reduce the environmental impacts on the users and the society. This is captured by considering contributions to local and global pollution, health damages, and other environmental degradation.
e) Institutional sustainability requires that the provision is locally manageable and controllable. This is represented by the degree of local ownership, availability of skilled staff, ability to protect consumers and investors, and ability to monitor and control the systems.

While it is possible to include more factors in the sustainability analysis, the above provides a reasonable picture of the multi-dimensionality of the challenge. Although a more formal framework using multi-criteria decision-making approach is also possible, the above provides a good starting point.

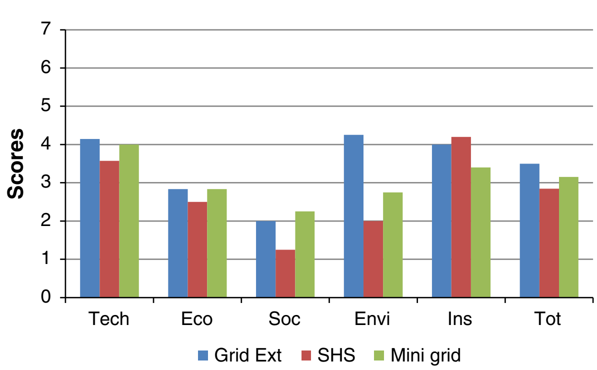


Fig. 9. Sustainability comparison of alternative lighting access programmes.

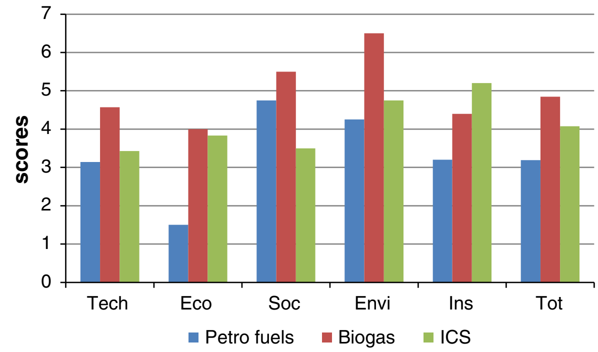


Fig. 10. Sustainability comparison of alternative cooking access programmes.

Analysis of the results

The result of the analysis is presented in Figs. 9 and 10 for lighting and cooking solutions respectively. Although biogas can be used for both cooking and lighting, it has been included in Fig. 10 as it is an excellent cooking fuel.[12] Grid extension emerges as the preferred alternative for lighting option, although it received just about 50% of the possible scores. This suggests its weakness as an all-round solution. On the other hand, biogas emerges as the best option followed by improved cook stoves in the other category. The possibility of using biogas for cooking as well as lighting purposes and its environmental and social influences have been positively reflected in the scores. Yet, the scores were lower than the maximum achievable score, which suggests the possibility for further improvement in various dimensions considered in the analysis. The SHS received the weakest score of all because of its limited ability to meet the needs. However, no option reaches the highest score of 7 in the overall assessment, indicating their weakness in certain areas. Details of the scores for each option are presented in Annex 1.

The scores related to the economic sustainability are relatively low, reflecting the problem of sustaining such solutions without some support mechanisms. Local resources fare better in this respect but cost issue remains a main problem in all options. Moreover, some sustainability issues exist for each dimension. The inability to meet future demand, particularly productive needs, and poor technical efficiency and reliability of the systems are serious technical constraints faced by most of the access options considered in this exercise. The inability of lighting-oriented access options to reduce drudgery and to promote wider clean energy use amongst the poor affects the social sustainability of such options. The options for cooking energy promotion perform better in this respect but do not reach the full score potential. The lighting options also score relatively low in terms of environmental benefits as these options miss the most important energy needs of the people.

The above analysis suggests that the existing practices of providing energy access are generally unsustainable from a number of perspectives although this has received limited attention. Overemphasis on limited-impact options needs to be avoided and a rebalancing of provision options is required to ensure a more sustainable approach to resolve the problem. Hybrid options are likely to perform better in this respect, although our analysis did not focus on these solutions. Also, further analysis of country-specific experiences is required to identify sustainability challenges in specific cases.

[12] Mahapatra et al. (2009) provide an excellent analysis of various lighting options.

Conclusion

Although energy access has re-emerged as a major challenge for economic development of many developing countries, a review of the experience with energy access promotion reveals a number of unsustainable features, including inability to meet the present and future needs, continued reliance on conventional fuels, heavy reliance on state support, and cost ineffective solutions. The emphasis on productive use of energy has been quite limited and the link between energy access and economic development has not received adequate attention at the project/ programme level. Consequently, there is an urgent need for refocusing and rebalancing the agenda to ensure better linkage with economic development.

China provides an exceptional example where electricity access has been successfully integrated with rural development. Similarly, an extensive use of biogas for cooking energy supply in China is also compatible with sustainable development. Our review also provides other successful examples but as Ulsrud et al. (2011) demonstrate transplanting successful interventions from one country to another is neither easy nor a recipe for automatic success as the institutional arrangements and socio-economic conditions differ greatly, and the dynamics between society and technology can be very different. Therefore, the search for sustainable country-specific solutions needs to be intensified to realise the desired objective of Sustainable Energy for All.

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Annex 1. Detailed scores of the sustainability analysis

Dimension	Criteria	Grid extension	SHS offgrid	Local mini-grid	Petroleum cooking fuels	Biogas	ICS
Technical	Ability to meet present and future domestic needs	7	2	3	7	5	4
	Ability to meet present and future productive needs	7	1	3	1	3	1
	Reliability of supply	3	4	4	4	5	5
	Reliance on clean energy sources	3	7	6	1	7	2
	Technical efficiency	3	2	4	5	4	4
	Reliance on local resources	1	5	5	1	5	4
	Availability of support services	5	4	3	3	3	4
Economic	Cost effectiveness	2	1	2	1	4	3
	Cost recovery potential	3	3	3	3	5	4
	Capital cost burden on the user	2	3	3	2	4	5
	Running cost burden on the user	3	5	3	1	5	5
	Financial support needs	4	2	3	1	2	5
	Contribution to income generating opportunities	3	1	3	1	4	1
Social	Wider usability amongst the poor	3	2	3	5	5	4
	Need for micro-credit or financial support systems	3	1	3	2	3	4
	Potential to reduce human drudgery	1	1	2	7	7	1
	Potential to reduce effects on women and children	1	1	1	5	7	5
Environmental	Contribution to reductions in carbon emissions	3	3	3	1	7	4
	Contribution to reductions in indoor pollution	2	1	2	6	7	5
	Contribution to reductions in land degradation	5	3	3	5	7	5
	Contribution to reduction in water pollution	7	1	3	5	5	5
Institutional	Degree of local ownership	1	5	4	1	7	7
	Need for skilled staff	3	5	2	1	2	5
	Ability to protect consumers	6	5	4	5	5	5
	Ability to protect investors	6	5	4	5	5	5
	Ability to monitor systems	4	1	3	4	3	4
	Total score	91	74	82	83	126	106

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