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Rural electrification programmes in Kenya: Policy conclusions from a valuation study

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ABSTRACT

Developing countries have struggled with low electrification rates in rural areas. This study investigates one major issue which is impeding rural electrification programmes: high connection payments. This paper uses estimates obtained from a stated preference study in rural Kenya using a contingent valuation method which was completed in 2007, in order to examine the subjects' willingness to pay to connect to grid electricity and photovoltaic services. The key findings suggest that the government needs to reform the current energy subsidies, establish financial schemes and create a multilevel critical analysis of the political economy of energy systems.

Introduction

The electricity market involves a complex system, in which economic, technical, institutional, financial, social, political and environmental factors interact to influence the demands of different consumers. Among all these factors, the institutions which deliver electricity services and provide reliable services, particularly to household customers, probably exert the greatest influence on these markets. In particular, when a government is seeking to promote access to renewable energy sources, it needs to implement policies that take into account factors such as affordability, disposable income, availability and the high quality of modern energy sources (Barnes et al., 2005). In the case of the residential sector in developing countries, affordability is a key obstacle to having access to reliable modern energy, especially for those living in rural areas who are often poor and vulnerable. As a result, such communities are heavily dependent upon the continued use of traditional sources of fuel, including firewood, charcoal and farm residues, for their lighting, cooking and heating.

In the case of Kenya, which provides the focus for this study, replacing the dominant traditional forms of energy with modern ones such as electricity creates social, economic and health-related benefits, particularly for rural households which depend solely on traditional fuels. However, one of the impediments faced by rural households wishing to use these services is the high cost of connection. One of the main objectives set out in this paper is to discover whether or not households are willing to pay a reasonable amount for electricity services, particularly for those which are not connected to grid and/or off-grid sources, in order to meet their present and future needs in a healthier, environmentally benign and sustainable way. The contribution of this paper to understanding these issues is through using the estimates obtained from a willingness to pay (WTP) survey (see Abdullah and Jeanty, 2011) which was carried out among rural households in the Kisumu district of the Nyanza province, Kenya, in order to improve the relevant stakeholders' decision-making in the field of electricity connection. More specifically, the aim is to assist the rural electrification strategy in Kenya by presenting empirical data that reveal the differences between WTP and the cost of service provision. These data consequently enable clear estimates of the level of subsidies required and plausible policy solutions for increasing rural electricity coverage. In the context of Kenya, we believe that this could be best achieved through the existing rural electrification programme (REP), with some adjustments.

Like most countries in sub-Saharan Africa (SSA), Kenya is not an exception in that it is facing an energy problem. The overall electricity access rates in SSA in 2008 were about 28.5%, with the figures for urban and rural areas standing at 57.5% and 11.9% respectively (International Energy Agency (IEA), 2008). However, Kenya's levels are even lower than these modest SSA averages, with 15% overall access and a breakdown of 51.3% and 5% for urban and rural areas respectively. One reason for this low level of electrification in rural areas is the lack of available finance to cover the capital and operating costs for the generation, transmission and distribution of electricity, all of which are higher than in urban areas. Moreover, the high connection costs coupled with low consumption of electricity and low incomes among rural households are further obstacles to their electrification.

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The Ministry of Energy (MoE) came to accept that a new approach is needed if the rural poor are to be better serviced in terms of their electricity supply. Consequently, another initiative promoting access to electricity was launched in 2006/7 in rural areas. This scheme, named "*Umeme Pamoja*," which translates as "Electricity Together," financed by the Kenya Power & Lighting Company (KPLC), had the stated aim of getting groups of rural households collectively connected to the grid, thereby saving costs (KPLC, 2006). However, in spite of these efforts, the challenge still remains for Kenya to establish an energy market that manifests a sustainable balance between investment and supply (Eberhard and Gratwick, 2005). In particular, more effective actions than those existing at present need to be taken in order to facilitate investment in the transmission and distribution stages.

This paper is structured in five sections. First, in this section, an introduction to the topic of interest has been presented. Section two contains the energy data on current fuel usage among households in rural areas. In section three, comparative estimates for grid electricity (GE) and solar photovoltaic (PV) systems, taken from a contingent valuation study in Kisumu district, Kenya, are used to construct a tariff design that could lead to the cost of an electricity connection being met. Subsequently, recommendations are put forward with the aim of increasing coverage and the affordability of electricity services in rural areas in section four, and section five contains the conclusion.

Non-electrified energy usage patterns in rural areas

Rural households not only have limited access to modern energy sources at reasonable rates, but also incur high expenditure on traditional fuel sources, which exacerbates their lack of affordability in relation to household fuels. Following Kebede's (2006) estimation of the impact of energy subsidies on Ethiopian households, Table 1 shows the mean monthly fuel consumption of non-electrified rural households, taken from the Kisumu sample used in this particular research, converted into gross energy use in mega joules (MJ).

As indicated in Table 1, for non-electrified, the proportion of their total expenditure which is spent on total energy use is 21%. However, according to Fankhauser and Tepic (2005) a rule of thumb for the budgetary limit for energy services is 10% of total expenditure and/or income. Thus, it can be seen that the proportion of expenditure spent on energy for non-electrified households, in this instance, is above the limit set by this rule of thumb. Furthermore, the three main aforementioned fuel sources (firewood, charcoal and kerosene) represent a major proportion of their fuel usage. However, in comparative terms, these three fuel sources make up 98% of total energy expenses. One way of reducing the consumption of these fuels (especially kerosene, which is a popular fuel for lighting and cooking and which accounts for nearly 70% of the total gross energy use in MJ households) is to provide them with electricity for lighting, information and communication technology (ICT) and entertainment purposes, as cooking using electricity requires a lot of power (kW); in other words, using electricity for cooking would be very expensive.

Moreover, the best way to make progress in terms of fuel efficiency for non-electrified households is to concentrate on giving them access to electricity for modern lighting facilities as mentioned above. One way of addressing the issue of obtaining an electricity supply for rural, non-connected households is to evaluate how they could afford to connect and pay for monthly electricity consumption. This suggestion is examined in greater detail in the next section, in which a valuation methodology is described and WTP values are obtained from grid and solar PV systems. Their respective connection costs are then compared to other off-grid options, such as pico-hydro. Of course, stated WTP can be different from ability to pay, with the latter being more closely related to actual household earnings than the former, in which households state the maximum amount that they wish to pay for electricity services.

Valuation estimations and affordability

Valuing energy services, particularly clean energy, such as electricity, is important for policy planning and for improving socioeconomic conditions, the environment and the well-being of households. However, there is a dearth of valuation work in the energy services in SSA. Hence, the basis of this section is the use of hypothetical markets to examine WTP values, which refer to the maximum amount which households who do not have electricity are prepared to pay for connection. In this particular case, a stated preference valuation exercise using a contingent valuation (CV) method was used in order to estimate the WTP values for non-electrified households to gain connection to grid electricity (GE) and/or solar PV systems.

One of the applications of WTP estimates is to assist in the formulation of effective tariff and subsidy design. In other words, these values, when measured against the full cost of recovery, can enable the identification of the proportion of the population who can afford the provision of electricity services at their own values. It is estimated that approximately 70% of the households in SSA and India cannot afford to pay the full cost of recovery (Foster and Yepes, 2006). Hence, if a high proportion of the population is unable to afford the cost of the service and consumption is considered to be socially desirable, then financial transfers or cross-subsidies are required (Komives et al., 2005).

For this valuation exercise, a questionnaire survey was conducted using 200 households as part of a wider study and was restricted to those living within a 600-metre radius of an electricity transformer. Given that time and financial constraints were of paramount

Table 1
Mean monthly fuel consumption for non-electrified rural households.
Source: Survey 2007.

		Energy content (MJ per unit)	Quantity	Price	Expenditure (Ksh)	Gross energy use (MJ)
Agricultural residue	kg	13.5	7.59	0.00	0	103
Dung cakes	kg	14.5	6.00	0.00	0	87
Firewood	kg	16	35.79	10.94	392	573
Charcoal	kg	30	29.57	48.79	1443	887
Liquefied petroleum gas (LPG)	kg	45.5	0.00	0.00	0	0
Kerosene	L	43	81.64	4.32	353	3511
Electricity	kWh	3.6	0.00	0.00	0	0
Candles	klumen	0.2	13.00	3.46	45	3
Total monthly energy expenditure (Ksh)					2232	
Total monthly household expenditure (Ksh)					10,755	
Proportion of total energy to total expense (%)					21	

Notes:
Energy content for all energy sources except electricity are found in O'Sullivan and Barnes (2006).
Energy content for electricity from Kebede (2006).

importance, this study examined areas where electrification is feasible within the cost range of the local households. The reference article for this valuation exercise is Abdullah and Jeanty (2011), where the sample size was compared to the national rural sample, thereby showing that there was a close resemblance between the two socioeconomic and demographic profiles, suggesting that the sample reflected the general rural population at the national level. As pointed out by Abdullah and Mariel (2010), not all districts in Kenya have similar characteristics, but nearly all of the districts in Kenya are facing congruent issues to those faced by Kisumu with regard to rural households' energy-use patterns. They further point out that electrification issues are not a local problem but a national one facing rural dwellers. The questionnaire format was divided into three main sections: breakdown of energy use, WTP questions and household characteristics (socioeconomic and demographic). The hypothetical scenarios, which in this case comprised the WTP section, were translated into the local language (*Luo*) so as to avoid biases caused by misunderstandings. In this regard, the interviewees were presented with a set of connection programmes through which to electrify their households in relation to two aspects: payment schedules (monthly and one-time payment) and product type (grid electricity and photovoltaic systems).[1] More specifically, each household was asked four binary questions regarding electricity provision, each of which referred to: grid electricity (GE) monthly, GE lump sum, solar photovoltaic (PV) monthly or PV lump sum payment arrangements. Such questionnaires are said to use a double-bounded (two yes/no questions) format.[2] In this CV study, however, we did not examine the subjects' willingness to accept (WTA)[3] or opportunity costs for these two products and payment plans, owing to time and budget constraints in exploring these other aspects.

The results from the survey revealed that out of the two electricity sources (namely GE and solar PV systems), the WTP levels for the non-electrified households were substantially higher for the former, because of its perceived wider applicability. In addition, monthly payments were found to be more popular than a lump sum for the connection charge. The WTP estimates excluding protests are shown in Table 2.[4]

In the next sub-section, these WTP estimates are analysed with regard to GE, solar PV systems and other off-grid systems, as well as the cost of electrifying households against their affordability levels.

Product options: GE and solar PV systems

The WTP for a GE system, as mentioned above, was higher than the WTP for a solar PV system. One of the key reasons for the lower WTP for solar PV systems among households is the awareness of the limitations of such services, i.e., the restricted duration of a 40 watts peak (Wp) provision and the perception that the benefits of electricity extend beyond lighting, ICT and entertainment purposes, to uses such as being able to drive machinery for income-based activities. Table 3 shows the upfront costs for GE, solar PV and pico-hydro (mini-grid) systems at a household level, and it can be seen that the costs of connecting to the grid are much higher than those of the other options. This fact was confirmed in a recent study in Kenya by Parshall et al. (2009) of the capital and recurrent cost of a solar PV system (less than 50 Wp) at the household level and the grid and diesel mini-grid systems for 1000 to 2000 households.

We postulate that the alternative option (in this case, the pico-hydro system at the household level) offers a comparable service to the grid and is greater in terms of provision than a solar PV of less than 50 Wp. Moreover, according to the United Nations Industrial Development Organization (UNIDO) (2010) report, more than 260 small hydropower sites were identified in Kenya with more than 600 MW of potential energy. Around 45% of these sites are located in the Lake Victoria drainage basin or the Tana river drainage basin,

Table 2
Average WTP for connecting to GE and solar PV systems.
Source: Survey 2007.

	Connection fee amount	
	Ksh	US$[a]
GE lump	20,090	301
GE monthly[b]	870	13
PV lump	18,560	278
PV monthly[b]	700	10

[a] 1 US$ = Ksh 67 (30 July 2008); source: Central Bank of Kenya, found at http://www.centralbank.go.ke [accessed on 10 September 2008].
[b] Monthly payments are over a period of five years.

Table 3
Upfront cost analysis of GE, solar PV systems and pico-hydro systems in Kenya.
Source: Survey 2007 and Karekezi et al., 2004.

	Grid electricity: 2007 survey[a]	Solar PV system: 2007 survey[b]	Pico-hydro mini-grid serving 110 households (2.2 kW)[c]
Capital cost per household incl. internal wiring and fittings (US$)	271	200	54[d]
Project design and management and labour cost per household (US$)	n.a	n.a	17
Subscription/installation or connection cost per household (US$)[e]	534	421	80
Useful lifespan (years)	n.a	n.a	20
Total upfront cost per household (US$)	805	621	151
Total upfront cost as% of annual household income (non-electrified)	44	34	18

[a] Estimated cost of grid-extension within a 600-metre radius of the transformer for one household and associated cost (including wires and fittings) in Kisumu district, Kenya.
[b] Cost of PV system installed in one household in the Kisumu district, Kenya. The system comprises a 40 Wp panel, a battery, a charge controller, lights and appropriate wires and fittings.
[c] Costs are extrapolated from Maher (2002) based on the village of Thima in the Kirinyaga district, Kenya, where the cost of the penstock, turbine and generator equipment was met by the project funders (European Commission) and all other costs were contributed by the 110 households.
[d] Total cost of: civil works, generation equipment, control and protection gear and the distribution system.
[e] Refers to a one-off payment to initiate the electricity service. The amount indicated for pico-hydro is the maximum fee chargeable (for two lights and one socket). A lower fee of around US$60 is chargeable where only one light and a socket are used. In the case of the solar PV system, this is the cost of installing the system.

[1] We considered this decentralised option (namely pico-hydro) for the dense, non-electrified rural population located in this district because of their close proximity to the Lake Victoria area, where untapped small hydro sites with a constant water supply have been identified (UNIDO, 2010).
[2] Pre-testing was conducted in April and July 2007, which involved respondents in the Kisumu district participating in focus group discussions. Subsequently, the questionnaires were revised in response to the feedback received. A face-to-face survey of households was carried out between July and September 2007 by five trained enumerators who elicited responses from the heads of the households or the decision makers.
[3] Some assumptions were made when pricing solar PV systems during the interviews, such as the size of the solar kit, which was assumed to be a 40-watt peak (Wp) system which was priced at a similar level to the one-time GE connection fee, this being Ksh 35,000.
[4] Hanemann et al. (1991) found that four outcomes are likely to arise following the first and second questions of a double-bounded dichotomous choice (DBDC): “yes-yes”; “no-no”; “yes-no” and “no-yes”. The responses from each respondent were averaged, and by using maximum likelihood estimations and a fitted parametric distribution we obtained the willingness to pay (WTP). All of the estimates used in this study were computed using STATA software and the codes are available from the author upon request.

and in the districts of Kirinyaga, Thika, Maragua, Meru South and Meru Central. As the cost of the alternatives to GE is lower, if the household confers value on them equally, it would seem reasonable to promote them owing to the cheaper price. Indeed, one way to reduce the cost of such systems, particularly for pico-hydro projects, is to lower construction expenses[5] by using local materials and labour instead of out-of-town products and/or services. For instance, in the case of community driven pico-hydro projects in Kenya, production factors such as labour assistance from community members, the hiring of local technicians and the use of local components and materials (poles) has reduced the cost per kWh of electricity (Maher et al., 2003). However, the use of local materials should not compromise the efficiency of the system through the use of short-lived low-quality poles, improper conductors and inefficient design and construction, which can be a false economy and may increase the life-cycle cost in the long run (Energy Sector Management Assistance Programme (ESMAP), 2000).

Additionally, under these circumstances, the connection subsidy required for the solar PV and pico-hydros systems would be lower than for GE. However, the results of the WTP study, as shown in Table 2, have revealed that it is not that simple, because the WTP estimates that have emerged with regard to the value given to solar PV and grid systems by the households were not the same. In other words, households expressed a strong preference for the latter, in spite of the WTP amount offered (both lump sum and monthly) to households during the survey for both GE and solar PV being equally priced.

Payment options: monthly and one-time

In order to assess the affordability of connecting to both grid and PV electricity services, it is necessary to compare household income with payment schedules. In this regard, although there has been some progress in reducing the costs of both grid and off-grid services, substantial hurdles remain in relation to the initial connection fees and monthly consumption costs for low-income households (Townsend, 2000). Affordability refers to the actual ability of a household to pay for goods/services, and one can distinguish between the affordability of access and the affordability of consumption (Estache et al., 2002), which are both examined in this study. Table 4 illustrates the WTP connection payments as a proportion of monthly income in deciles, for both GE and solar PV systems, for two payment options: monthly connection and a one-off lump sum payment. The table compares these values against the proportion of income required to meet the costs in full.

It is apparent from the table that the lower deciles would face prohibitive payment levels if they had to make a one-off payment, regardless of whether they were subsidised or not. In contrast, it can be seen from columns A^{I}, B^{I}, C^{I} and D^{I} that the most realistic payment system is a monthly one, but that even under this arrangement the WTP is still less than the connection cost for both GE and PV provision. Hence, it follows that it would be necessary to spread the payments over a much longer period, maybe as much as 10 years, and to reduce the interest rate to 5%,[6] if there is to be a substantial increase in the uptake of electricity connections. In Table 5, columns A^{II} A^{III}, A^{IV} and A^{V} show four different monthly payment periods at the proposed 5% interest level for GE at WTP B^{I} (as previously shown in Table 4). Similarly, C^{II}, C^{III}, C^{IV} and C^{V} illustrate the same concept for a solar PV system. As can be seen, for payments stretching over approximately 100 months or more, the lower deciles' incomes are less than their WTP estimates, which suggests that choosing such a repayment option would make connecting to either the grid or a solar PV system feasible for the poorer members of the community.

Energy consumption patterns revisited

For non-electrified households to connect to a source of electricity and still maintain their present energy expenditure, they would have to reduce their consumption of other types of energy, such as firewood, charcoal and candles, in order to release some money for improved energy services. Table 6 shows the amounts and pattern of energy and expenditure under one such arrangement, with before and after scenarios relating to the situation pre- and post-electricity connection. In the post-connection scenario, the price of electricity is estimated to be Ksh 24.99 per kWh (equal to US¢0.35 kWh). Moreover, in this particular example it is assumed that households buy about 35 kWh at this price, including connection and fixed metre rental charges.[7] This consumption figure was adopted because it was estimated that this would ensure that the households would be able to maintain their present monthly energy expenditure at around 21% of their total expenditure. The aforementioned price of Ksh 24.99 per kWh excludes taxes and other monthly surcharges, namely: an energy regulatory commission (ERC) levy, fuel cost adjustment (FCA), foreign exchange rate fluctuation adjustment (FXFA) and value added tax (VAT). Taken together, these would raise the full cost per kWh well above this figure to Ksh 31.28/kWh.

The inclusion of these monthly taxes would increase the monthly energy expenditure for non-electrified households from around Ksh 2298 to Ksh 2518, or from 21% of the total expenditure to nearly 23%. This incremental amount may seem small, but clearly for poor rural households this difference is significant and therefore some form of additional subsidy is needed if households are to be electrified. Consequently, one of several ways proposed in this paper to maintain a monthly expenditure of around 21% is by cutting down on the use of firewood and charcoal by a shift factor of 0.5 and 0.6 respectively (see Table 6 under the column 'post-electrification').[8]

A further option would be to lower the lifeline price, but here we have to bear in mind that the current lifeline rate is already low at Ksh 2 per kWh. Alternatively, reducing the monthly connection payments by spreading them over a longer period and/or adopting a lower interest rate would increase their affordability. Moreover, given that the availability of traditional fuels, such as woodfuel and/or kerosene, fluctuates over time, if the payments for electricity were extended over a longer duration, this would provide greater consistency in terms of cost, thereby increasing its attractiveness to the consumer.

With regard to the valuation estimations, as noted above, the monthly charge for connecting non-electrified households under such arrangements is Ksh 684 if the capital cost of Ksh 35,000 is spread over 60 monthly payments at an interest rate of 6.5%.[9] As

[5] The preference for applying a WTP over a WTA approach in this survey arose because the former is employed when the respondent favours a change of programme or service to the current situation, as was the matter of interest here. The latter, in contrast, is preferred when the respondent prefers the current situation, i.e., the status quo, over a change of programme or service (Bateman et al., 2002).

[6] Protest zeros or zero bids are honest replies given by low-income respondents, those who hold negative views about the good (service) or those who refuse to participate in the study (Mitchell and Carson, 1989). In this study, there were 41 households who answered 'no' to all four questions on product and payment types. Protest zeros were important to identify, because although they count as WTP values of Ksh 0 (US $0), such people still value the good or service in question.

[7] One reviewer pointed out that capital cost (equipment) is more important than variable/operating cost, as well as the availability of water throughout the year and the cost of a stand-by system. Nevertheless, the availability of a skilled mechanic or operator can be an issue in rural areas where expertise and technical know-how is limited.

[8] The market interest rate of 5% was arbitrarily selected in order to illustrate the sensitivity of varied interest rates as opposed to a consistent 10% interest rate, as used in Table 4.

[9] In respect to this issue, there is currently a fixed consumption charge (equivalent to meter rental) of Ksh 120 and a fixed connection payment of Ksh 35,000. The connection charge of Ksh 35,000, if spread over 60 months at an interest rate of 6.5% per annum, would result in a monthly connection payment of Ksh 684. Taking this together with the fixed consumption and current lifeline tariff of Ksh 2 per kWh for the first 35 kWh, we have a cost per kWh of Ksh 24.99.

Table 4
Proportion of connection payments (monthly and one-time) for grid electricity (GE) and solar photovoltaic (PV), by income deciles.
Source: Survey 2007.

		One-time connection payment				Monthly connection payment spread over 5 years			
		A	B	C	D	A^{I}	B^{I}	C^{I}	D^{I}
Income deciles	Monthly income (Ksh)	GE actual connection cost (one-time,%)[a]	GE WTP connection estimate (one-time,%)[b]	PV actual connection cost (one-time,%)[a]	PV WTP connection estimate (one-time,%)[b]	GE actual connection cost (monthly,%)[c]	GE WTP connection estimate (monthly,%)[b]	PV actual connection cost (monthly,%)[d]	PV WTP connection estimate (monthly,%)[b]
1	2 692	2 093	657	1 615	531	44	24	34	18
2	4 531	1 244	393	959	358	26	17	20	10
3	5 579	1 010	285	779	258	21	14	17	10
4	6 676	844	274	651	257	18	13	14	10
5	7 766	726	268	560	257	15	10	12	8
6	9 223	611	191	471	185	13	9	10	7
7	11 298	499	123	385	123	11	7	8	5
8	14 154	398	133	307	159	8	7	7	5
9	16 838	335	119	258	103	7	6	5	4
10	30 630	184	103	142	73	4	3	3	2

[a] The one-off lump sum for both GE and solar PV capital and connection cost is Ksh 56,350 (US$805) and Ksh 43,470 (US$621) respectively, which excludes any variable cost and taxes.
[b] Connection at WTP values by income deciles without variable cost, i.e., consumption cost and taxes.
[c] The monthly capital and connection cost (excluding variable cost and taxes) is Ksh 1197.27 for 60 months at a 10% interest rate.
[d] Monthly capital and connection cost with zero variable cost is Ksh 923.61 for 60 months at a 10% interest rate.

found in the survey results, this figure is less than the mean value that the households are willing to pay per month, which is Ksh 870 (see Table 2) for a connection. Consequently, it would appear that the non-electrified households could afford an electricity connection, as long as the total energy expenditure could be kept within the area of around 21% of the total monthly expenditure. In the next section, we provide some policy suggestions for dealing with rural electrification in terms of financing the products and payment schedules Moreover, the subsidisation of consumption cost is discussed as well as promoting the need to understand the political economy of energy systems, when the goal is to improve the levels of rural electrification.

Policy recommendations

The recommendations developed in this section go beyond current government policy, in that they provide clear direction as to how access to electricity services can be granted to a substantially greater proportion of rural domestic users than has previously been the case. In particular, we contend that the findings presented above allow for a more targeted set of policy alternatives than those already put forward by: researchers, think tanks, the government and multilateral institutions. The range of policies proposed here involve a combination of establishing financial schemes, reformed subsidies and the employment of a multi-level critical analysis of the political economy of energy systems.

Establishing financial schemes

A good example of a situation in which this approach was adopted is the case of Bolivia, where the number of new customers doubled when the cost of connection was spread over 5 years, despite an increase from 25 to 30 cents per kWh in GE prices (Barnes and Foley, 2004). In sharp contrast to this outcome, when new customers in Malawi were charged the full cost of their line extension upfront (with a 30 year life), this resulted in only a 2% increase in rural electrification rates. In the case of Kenya, the issue of loans raises a number of problems. To start with, most of the financial institutions in rural areas only cater to salaried employees, such as civil servants, teachers and self-employed proprietors, and thus for many of those wanting to connect to GE or solar PV systems for the first time, loans through banks or micro financers are difficult to obtain. This situation is not helped by the fact that many of the rural poor are illiterate and often do not possess the appropriate documentation, such as valid title deeds for their properties, to be able to secure funds. Moreover,

Table 5
Monthly connection costs with varying payment duration and interest rates.
Source: Survey 2007.

	GE monthly						PV monthly					
	A^{I}	B^{I}	A^{II}	A^{III}	A^{IV}	A^{V}	C^{I}	D^{I}	C^{II}	C^{III}	C^{IV}	C^{V}
Monthly income of deciles	GE actual connection cost over 60 months at 10%	GE WTP connection estimate (%)	GE actual connection cost over 60 months at 5%	GE actual connection cost over 80 months at 5%	GE actual connection cost over 100 months at 5%	GE actual connection cost over 120 months at 5%	PV actual connection cost over 60 months at 10%	PV WTP connection estimate (%)	PV actual connection cost over 60 months at 5%	PV actual connection cost over 80 months at 5%	PV actual connection cost over 100 months at 5%	PV actual connection cost over 120 months at 5%
1	44	24	39	30	25	22	34	18	30	24	20	17
2	26	17	23	18	15	13	20	10	18	14	12	10
3	21	14	19	15	12	10	17	10	15	12	10	8
4	18	13	16	12	10	9	14	10	12	10	8	7
5	15	10	13	10	9	7	12	8	11	8	7	6
6	13	9	12	9	7	6	10	7	9	7	6	5
7	11	7	10	8	6	5	8	5	7	6	5	4
8	8	7	7	6	5	4	7	5	6	5	4	3
9	7	6	6	5	4	3	5	4	4	3	3	2
10	4	3	4	3	2	2	3	2	3	2	2	1

Table 6
Pre and post-electrification consumption patterns for non-electrified households (assuming no increase in expenditure on energy and some variations in total energy provision). Source: Survey 2007.

Energy source	Quantity (pre-electrification)	Shift factor[a]	Quantity (post-electrification)	Price	Expenditure (Ksh)	Gross energy use (MJ)
Agricultural residue	7.59	0.3	2.28	0.00	0	31
Dung cakes	6.00	0.3	1.80	0.00	0	26
Firewood	35.79	0.5	17.89	10.94	196	286
Charcoal	29.57	0.6	17.74	48.79	866	532
LPG	0.00	0.0	0.00	47.72	0	0
Kerosene	81.64	1.0	81.64	4.32	353	3 511
Electricity	0.00	1.0	35.00	24.99	875	126
Candles	13.00	0.2	2.60	3.46	9	1
Total monthly energy expenditure (Ksh)					2 298	
Total monthly household expenditure (Ksh)					10 755	
Proportion of total monthly household expenditure spent on energy (%)					21	

[a] The shift factor reflects the consumption pattern for a rural electrified household for all fuel types except LPG.

what financial programmes are available for connecting households to electricity services vary according to the type of system involved. More specifically, the financial schemes for connecting to solar PV systems of less than 50 Wp are far easier to access than those for GE, given their shorter repayment duration and smaller loan amount. As a result, there is a need to establish long-term schemes with which to finance the initial or upfront costs where appropriate, especially for those on low or intermittent incomes. However, careful attention will need to be paid to the details of how to deal with defaults, where customers do not pay the monthly payments. Indeed, problematic consumers are difficult to manage and require high administrative costs to monitor, particularly in developing countries.

Nevertheless, in spite of the obstacles regarding the acquisition of loans, the results of this study have shown that there is a high WTP for GE electricity, even for those in poor households where the costs comprise a substantial share of their income. However, the enthusiasm is not so strong for solar PV systems of less than 50 Wps owing to their limited application, as previously explained. Regarding the actual figures in this respect, Table 7 illustrates the differences between the WTP estimates and the total cost by deciles, and it can be seen that these are higher for GE when compared to solar PV systems in nearly all cases. Moreover, this condition holds regardless of whether payment is over 60 months (5 years) at an interest rate of 10% or over 120 months (10 years) at a rate of 5%. However, in spite of these WTP differences, given the low connection costs of solar PV systems of less than 50 Wps in contrast to GE systems, the PV option would appear to be a more fruitful direction for government programmes to pursue in terms of providing an electricity supply to poor non-electrified households, because lower levels of subsidisation would be required and repayments would not be too much of a burden on household finances. Furthermore, if this approach were adopted, although the supply would be inferior to that of GE for such households, it could act as a stepping-stone to eventual wider grid coverage when the necessary finance becomes available.

Subsidising connection and consumption, including tax charges

In Kenya, there are at present no subsidies for connecting households to GE. However, in recent years, the government has revised its initial policy of large lump sum connection charge of Ksh 35,000, excluding home wiring (with a deposit of Ksh 2500), by allowing consumers to pay a fixed deposit of Ksh 15,000 and monthly payments of Ksh 1695 per month for the next 12 months. The Government of Kenya (GoK) has previously subsidised solar PV systems by removing import duties on PV components. In this regard, initially, the imported components were subject to an import charge of 30%, which substantially raised the cost of the systems (Barnes and Floor, 1996). Nevertheless, even the elimination of this charge has been insufficient to advance the adoption of this alternative at a fast enough pace. Assuming that a PV supply of less than 50 Wp is more affordable than a connection to the grid, as discussed in section (a) above, we contend that the government should do more to increase the uptake of solar PV systems among rural households, using subsidies for connection costs. What we propose here is to subsidise the connection costs for both GE and solar PV systems, meaning that the GoK, through the local authorities, could subsidise a third of the connection cost, with the rest being paid by the household. However, this connection subsidy would not cover the wiring and consumption costs, for which the end-users would be responsible.

Moreover, the GoK, along with the ERC, need to develop an appropriate system that can identify the target group for subsidised connection and lifeline tariffs, i.e., the poor, which can be difficult. One proposition is to reduce the monthly taxes incurred for those consuming 35 kWh or less in low-income households, for in most rural areas low-income households generally consume small amounts of electricity, which they use for lighting purposes. The exclusion of taxes would ensure that the poorest households would be able to cover the monthly connection and consumption costs and thus would not be subject to undue levels of financial strain.

As shown in Table 8, without any subsidies, only the two deciles with the highest income could afford GE systems, if we accept the

Table 7
Difference between GE and solar PV system costs and WTP values by deciles (monthly payments in Ksh and interest rates)[a] .
Source: Survey 2007.

	GE monthly		PV monthly	
WTP values by deciles	Difference between total cost and WTP value over 60 months at 10%[b]	Difference between total cost and WTP value over 120 months at 5%[b]	Difference between total cost and WTP value over 60 months at 10%[c]	Difference between total cost and WTP value over 120 months at 5%[c]
1	−864	−264	−439	24
2	−727	−127	−454	8
3	−717	−117	−391	71
4	−632	−33	−283	180
5	−742	−142	−294	168
6	−651	−51	−259	203
7	−700	−100	−335	128
8	−454	146	−267	195
9	−500	100	−246	217
10	−586	13	−287	176

[a] A negative sign indicates that the total cost is higher than the WTP value.
[b] The monthly total market cost inclusive of variable cost for a monthly consumption of 50 kWh costing Ksh 300 (including taxes and metre rental charges). For a GE system, the total monthly cost is Ksh 1497.27 for 60 months at an interest rate of 10% and Ksh 897.68 for 120 months at a 5% interest rate.
[c] The monthly total market cost for a PV system for 60 months at an interest rate of 10% is Ksh 923.61 with zero variable cost, whereas for 120 months at an interest rate of 5% it is Ksh 461.07.

Table 8
Comparison of monthly charges for connection at actual and subsidised payment cost for GE and solar PV systems, as % of income.
Source: Survey 2007.

Monthly income deciles	GE actual connection cost (monthly) inclusive of 50 kWh usage charge (%)[a]	PV actual connection cost (monthly,%)[b]	GE subsidised connection cost (1/3 off inclusive of 50 kWh consumption charge) (monthly,%)	PV subsidised-connection cost (1/3 off) (monthly,%)
1	56	39	43	26
2	33	23	26	15
3	27	19	21	12
4	22	16	17	10
5	19	13	15	9
6	16	11	13	8
7	13	9	10	6
8	11	7	8	5
9	9	6	7	4
10	5	3	4	2

[a] The monthly total market cost inclusive of variable cost for a monthly consumption of 50 kWh costing Ksh 300 (including monthly taxes and metre rental charges). For a GE system, the total monthly cost is Ksh 1497.27 for 60 months at an interest rate of 10%.

[b] The monthly total market cost for a PV system for 60 months at an interest rate of 10% is Ksh 923 with zero variable cost.

10% rule of thumb as discussed previously. This figure rises to the four highest deciles when considering a non-subsidised solar PV system. However, when a subsidy of a third is considered, the proportion of GE households coming within the 10% affordability benchmark rises to four deciles and, perhaps more importantly, regarding solar PV systems, seven deciles fall within this range. This indicates that subsidising a PV electricity system of less than 50 Wp would be a far more effective way of fulfilling the REP objectives in Kenya, because by doing so, more people would be able to afford it than if GE was subsidised by an equivalent amount.

Considering that subsidies are not sustainable in the long run, we propose that other cost-reduction strategies should be considered for both grid and off-grid options. The relevant stakeholders need to conduct energy assessments based on rural households' energy mixes in the present and in the future. As pointed out by Kaundinya et al. (2009), such energy assessments of the systems are imperative, and are based on techno-economic-environmental factors which are site-specific.

Multi-level critical analysis of the political economy of energy systems

Understanding the political economy of the situation is essential when addressing issues pertaining to energy, because the various stakeholders such as politicians, firms, consumers and other interest groups can all influence the decision-making process. According to Büscher (2009), alternatives to the rather simplistic neoliberal approaches are needed if a better understanding of energy systems is to be obtained. The author argues that without a critical theory that takes into account social and political realities as well as the market function, very little progress can be made in addressing the energy-related challenges which are being faced, in particular, by developing countries. More specifically, the key elements of energy inequality and sustainability must be central to any policy development, and both of these fall largely into the realm of political orientation. In particular, in this regard, if energy infrastructures are to be made sustainable, the needs of the vulnerable poor who often do not have their voices heard need to be included, for without strenuous efforts to do so, any local, regional or national policy initiative will be ineffective.

Turning to the specific case of Kenya, the poor electricity coverage in rural areas, as mentioned in the introduction, can be attributed, to a great extent, to the failure of governance at all levels. This abnegation of responsibility by the various authorities leads us to conclude that the best way forward is to galvanise local communities into taking action in order to ensure improved rates of electrification, through collaboration with NGOs, the private sector and financial institutions. Moreover, by targeting the disadvantaged people in rural areas in their residential setting in this way, not only does this facilitate getting to grips with their particular needs, but it will also act to circumvent the widespread corruption at the regional and national levels. One essential aspect of such collaborations, regardless of their configuration, is that policy should be geared towards reducing the dependency on wood as fuel, thereby addressing the detrimental effects of the long-term costs to people's health and the environment, which in turn will help to bolster the economy as a whole.

Conclusion

Rural electrification programmes in developing countries face socio-economic and political barriers, with a key factor that is impeding their development being the inability of rural households to connect to electricity services. In this paper, we have highlighted the fact that one of the key reasons why this situation is prevalent in SSA countries, and especially Kenya, is the prohibitive connection cost, and we have put forward some proposals for overcoming this issue, drawing on the data collected from a CV study. These data comprised quantifiable WTP estimations from a sample of 200 rural households in the Kisumu district in relation to a number of payment options, for both GE and solar PV systems. These estimations were subsequently weighed up against the actual income earned, so as to ascertain the affordability of connection according to the different ranked deciles of the sample. Having compiled these data, a set of proposals relating to payment regimes and plausible subsidies that would help to maximise the uptake by rural households of either GE or solar PV systems were put forward. In particular, it was advised that lengthening the payment schedule, reducing the interest rate and lowering the monthly taxes on the lifeline tariff could all prove to be beneficial in this endeavour.

In general, the CV method employed in this study matched to income decile has illustrated a way in which to estimate the affordability of an energy service and subsequently to provide policy options in order to improve this level of affordability. In other words, as has been done here, having estimated the affordability by income decile, valid calculations can then be made in terms of potential subsidies and payment regime arrangements that can improve the extant situation regarding rural electrification levels. Moreover, we would contend that this method would be valid in other developing country settings and for different energy sources, especially given the difficulties in obtaining reliable comprehensive statistical data for such locations.

Nevertheless, a major challenge that has emerged that needs to be addressed in the case of Kenya is its poor level of governance, particularly at the regional and national levels. We suggest that the most appropriate way to do so is to extend the involvement of other sets of actors, including the rural poor, in the decision-making process regarding rural electrification, so as to introduce a higher level of transparency into the process, especially at the local level. This, in turn, will engender greater trust amongst those involved. In sum, we would argue that following a path along the lines of that set out in this paper offers the best way to improve on the lamentable levels of electrification in countries such as Kenya, as well providing a springboard for incorporating sustainable approaches to energy into the policy agenda.

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References

Abdullah S, Jeanty PW. Willingness to pay for renewable energy: evidence from a contingent valuation survey in Kenya. Renew Sustain Energy Rev 2011;15:2974–83.

Abdullah S, Mariel P. Choice experiment study on the willingness to pay to improve electricity services. Energy Policy 2010;38:4570–81.

Barnes D, Floor WM. Rural energy in developing countries: a challenge for economic development. Annu Rev Energy Environ 1996;21:497–530.

Barnes D, Foley G. Rural electrification in the developing world: a summary of lessons from successful programs [online]. Washington, DC: UNDP/World Bank; 2004 http://iis-db.stanford.edu/evnts/3961/Doug_Barnes_paper.pdf [20 December 2007].

Barnes D, William HF, Krutilla K. The urban household energy transition: social and environmental impacts in the developing world. Washington, DC: Resources for the Future; 2005.

Bateman I, Carson R, Day B, Hanemann M, Hanley N, Hett T, et al. Economic valuation with stated preferences: a manual. Cheltenham, UK: Edward Elgar; 2002.

Büscher B. Connecting political economies of energy in South Africa. Energy Policy 2009;37:3951–8.

Eberhard A, Gratwick K. The Kenyan IPP experience. Program on energy and sustainable development. Working Paper No. 49. Stanford, USA: Center for Environmental Science and Policy, Stanford University; 2005.

Energy Sector Management Assistance Programme (ESMAP). Reducing the cost of grid extension for rural electrification. Report No. 227/00. Washington, DC: World Bank; 2000.

Estache A, Wodon Q, Foster V. Accounting for poverty in infrastructure reform: learning from Latin America's experience. Washington, DC: World Bank; 2002.

Fankhauser S, Tepic S. Can poor consumers pay for energy and water? An affordability analysis for transition countries. Working Paper Number 92. London, UK: European Bank for Reconstruction and Development; 2005.

Foster V, Yepes T. Is cost a feasible objective for water and electricity? The Latin American experience. World Bank Policy Research Working paper WPS3943. Washington, DC: World Bank; 2006.

Hanemann WM, Loomis J, Kanninen B. Statistical efficiency of double-bounded dichotomous choice contingent valuation. Am J Agric Econ 1991;73:1255–63.

International Energy Agency (IEA). World Energy Outlook 2008. Paris: International Energy Agency; 2008 http://www.worldenergyoutlook.com/database_electricity/electricity_access_database.htm [01 December 2010].

Karekezi S, Kimani J, Amenya S. The potential of renewables in electrifying the poor in East Africa. Nairobi, Kenya: AFREPREN/FWD; 2004 http://www.afrepren.org/project/gnesd/conferen.pdf [10 October 2008].

Kebede B. Energy subsidies and costs in urban Ethiopia: the cases of kerosene and electricity. Renew Energy 2006;31:2140–51.

Kenya Power & Lighting Company (KPLC). Annual report 2005–2006. Nairobi, Kenya: KPLC; 2006 http://www.kplc.co.ke/documents/annualrep2006.pdf. [30 May 2008].

Komives K, Foster V, Halpern J, Quentin W. Water, electricity and the poor: who benefits from utility subsidies? Washington, DC: World Bank; 2005.

Kaundinya DP, Balachandra P, Ravindranath NH. Grid-connected versus stand-alone energy systems for decentralized power — a review of literature. Renew Sustain Energy Rev 2009;13:2041–50.

Maher P. Community pico hydro in Sub-Saharan Africa—case study two—Thima, Kirinyaga disrict, Kenya. UK: Micro Hydro Center, The Nottingham Trent University; 2002 http://www.eee.nottingham.ac.uk/picohydro/docs/CaseStudy_Thima(a).pdf [14 March 2011].

Maher P, Smith NPA, Williams AA. Assessment of pico hydro as an option for off-grid electrification in Kenya. Renew Energy 2003;28(9):1357–69.

Mitchell RC, Carson RT. Using surveys to value public goods: the contingent valuation method. Washington, DC: Resource for the Future; 1989.

O'Sullivan K, Barnes DF. Energy policies and multitopic household surveys: guidelines for questionnaire design in living standards measurement studies. Energy and Mining Sector Board Discussion Paper (ESMAP). Paper No. 17. Washington, DC: ESMAP; 2006.

Parshall L, Dana P, Mohan S, Sanoh A, Modi V. National electricity planning in settings with low pre-existing grid coverage: development of a spatial model and case study of Kenya. Energy Policy 2009;37:2395–410.

Townsend A. Energy access, energy demand and the information deficit. In: Brook PJ, Smith S, editors. Energy services for the world's poor. Washington, DC: World Bank; 2000. p. 8-13 http://www.worldbank.org/html/fpd/esmap/energy_report2000/ch2.pdf. [21 August 2008].

United Nations Industrial Development Organization (UNIDO). UNIDO projects for the promotion of small hydro power for productive use. Vienna: Independent Thematic group; 2010 http://www.unido.org/fileadmin/user_media/About_UNIDO/Evaluation/Project_reports/e-book_small-hydro.PDF [12 July 2011].