Widening access to electricity for the urban and rural poor in Africa

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1 RATIONALE FOR LOOKING AT ACCESS TO ELECTRICITY

There are two recurring themes in debates in the 1990s on economic development and in the programmes of international development agencies: the imperatives of promoting economic efficiency and environmental sustainability. The disbursement of aid and international finance has become conditional on poorly performing countries undertaking fundamental economic reforms aimed at achieving market competitiveness and improved economic efficiency. In addition the 1992 UNCED conference in Rio has set an agenda which asserts that the environment be considered in all development programmes. Institutions such as the World Bank now place great emphasis on these two goals of economic efficiency and environmental sustainability. Policy proposals for specific sectors of the economy, such as the electricity industry, build on these twin concerns.

However, the issue of improved social equity which underpinned debates in the 1970s and early 1980s around growth with redistribution, or the focus on the basic needs of the poor, is now all too often ignored. Equity slips from the development vocabulary of the 1990s. Structural adjustment programmes replace basic needs programmes. Economic efficiency and environmental sustainability now govern development policy at the cost of social equity.

The drive to economic efficiency is premised on a belief in the power of free markets to provide abundantly a large range of producer and consumer goods. Today, few would dispute the importance of efficiently functioning markets in generating wealth. Yet the countries that are making their uncertain and difficult way to a different economic and political system, through IMF-directed Structural Adjustment Programmes, or simply through the collapse of authoritarian states and planned economies, face intense and dangerous disorder. The restructuring of their economies, combined with a weakening of public institutions, has a very high social cost associated with a marked deterioration in the levels of equity. In these countries there is a growing divide between the affluent and the impoverished and unemployed. This underclass is alienated from the political process. Worldwide, political exclusion and economic deprivation leads to increased social turbulence and sometimes ethnic conflict. Investment is inhibited and economies stagnate. Economic growth and development cannot flourish in such social and political climates.

On the one hand, countries have to seek improved economic efficiency through modernizing their public sector, restructuring their economies to bring them into a world of intensive technological change and to become internationally competitive. On the other hand it is necessary to strengthen democracy, improve income distribution and invest in meeting the basic needs of the underclass. Moreover, all this has to be accomplished within the context of environmentally sustainable development.

Equity is thus a fundamental goal of development, not in opposition to the two previously defined goals of economic efficiency and environmental sustainability but in concert with them.
This project investigates the constraints to expanding access to electricity, and seeks to explore the potential for achieving greater equity and sustainable development through improving access. It does not suggest that access to electricity is the key to equity, or that domestic electrification is amongst the most important social investments, but rather that it is one of the contributing factors to increasing equity which needs to be maximised within the framework of economic sustainability. What becomes apparent through this study is that significant increases in access are achievable even without applying subsidies, but merely by

devising appropriate financing mechanisms within the electricity sector, and by the application of appropriate operational methods by utilities.

The investigation into widening access to electricity by households is undertaken by examining the situation regarding access mainly in four countries - Zambia, Malawi, Mali and Senegal. From these four case studies, general trends are extracted to give some perspective on common problems and opportunities facing African countries in general, and thus identifies how access may be maximised in a sustainable manner.

2 AREAS TO BE EXAMINED IN ADDRESSING ACCESS TO ELECTRICITY

Although the proportion of households connected to electricity is low in Africa, it is now relatively widely recognised that access to electricity is an important national focus. This is reflected in the policies and plans of many countries.

It is accepted that utilities should operate efficiently and maintain financial soundness. This implies that either only financially viable projects should be undertaken, suitable cross-subsidisation within the electricity supply industry must be in operation, or subsidies external to the electricity sector need to be applied. In practice, widening access focuses on lower income households, and thus returns on investments are often marginal at best. Currently, many utilities are in a state of flux. On the one hand, they are often struggling to move from a financially unsound position largely due to inefficient operation and sub-economic tariffs imposed by governments, to functioning on a commercial basis. This imposes certain constraints on their exploring new and potentially marginal areas of operation, such as low-income domestic electrification. On the other hand, there is often an internal and political pressure to embark on mass electrification projects.

It is therefore important that the question of access be carefully examined, and the balance between maximising access and strengthening the financial viability of the utility is preserved. Utilities need to develop the necessary experience and skills such that sustainable operating practices in low-cost electrification are established. In this regard, there is much relevant experience in Africa, and suitable technologies and financing practices have been successfully used in some countries.

Although facilitating access to electricity largely concerns the utility operation and focus, Departments of Energy (DoEs)[1] also have a key role to play. An appropriate role for the DoE may be broadly described as, firstly, establishing an energy policy framework within which electrification is located, and contextualising this within national development plans such that national resources are most effectively used. Further roles may be the financing of electrification where it is economically justified, and supporting utilities in establishing appropriate systems for low-cost electrification, including effective financial management. A suitable regulatory and accountability framework between the DoE and utility needs to exist such that the roles of each in policy implementation are well understood. In practice, however, resource constraints limit the ability of many DoEs to undertake suitable information gathering or research for policy development and implementation.

[1] although these are sometimes Energy Ministries, the term 'Department of Energy' is used in this paper as a general term describing the government body dealing with energy matters.

3 OBJECTIVES OF THE STUDY

The overall focus of this study is to explore the potential for improving access to electricity for households in Africa. More specifically, this project intends to achieve the following:

- With the four case-study countries covered in this report,
  - review the situation in these countries regarding access to electricity
  - analyse experience with programmes to increase access to electricity with a view to identifying constraints
  - identify opportunities to widen access in these countries
- Develop general recommendations relevant to African countries regarding approaches to move towards increase access in a sustainable manner.

4 SCOPE OF WORK AND ANALYSIS METHOD

This study is based largely on four specific case studies undertaken in Malawi, Zambia, Mali and Senegal, although the outputs of the study are intended to be relevant to as many countries as possible on the African continent. The four case studies are used to highlight general trends and opportunities regarding access to electricity by households. The case studies generally used existing information rather than undertaking any primary research other than via selected interviews. Studies which relate to access but which require more focussed and in-depth research, such as an analysis of utility financial management systems and efficiency, are only superficially covered.

Within each country study, the general approach used is described below.

1 Brief overview of national socio-economic profile, including household incomes
2 Description of the national energy profile
3 Identification of areas of focus to improve access to electricity
   - identification of constraints to access
   - policy environment relevant to increasing access
   - overview of the financial and economic feasibility of increased access
   - development of recommendations for increasing access

This paper presents some of the key information from the country study reports for comparative purposes, and synthesizes constraints and recommendations made to provide generalised recommendations useful to other African countries.

Overview: Access to electricity in Africa

COUNTRY	*Households with electricity (% of total) 1984*	*System losses (% of total output) 1990*	*Sources of electricity (% of total)*		
			Thermal	*Hydro*	*Other*
Low-income economies					
Mozambique	5*	42*	43	57	0
Ethiopia	-	-	20	80	0
Tanzania	6	20	6	94	0
Sierra Leone	-	36	100	0	0
Nepal	30	27	0	0	0
Uganda	-	40	0.4	100	0
Burundi	1	19	1	99	0
Malawi	4*	16*	0.2	100	0
Chad	-	-	100	0	0
Guinea-Bissau	4	-	100	0	0
Madagascar	-	17	44	56	0
Rwanda	-	15	3	97	0
Niger	-	-	100	0	0
Burkina Faso	-	10	100	0	0
Kenya	-	16	2	87	Geothermal 11%
Mali	8*	21*	20	80	0
Nigeria	81	51	78	22	0
Togo	10	26	90	10	0
Benin	-	20	100	0	0
Central Afric Rep.	-	32	20	80	0
Ghana	-	20	1	99	0
Guinea	-	37	67	33	0
Mauritania	-	-	80	20	0
Zimbabwe	14*	11*	63	37	0
Lesotho	-	-	100	0	0
Egypt, Arab Rep.	46	14	83	17	0
Somalia	-	-	100	0	0
Sudan	26	19	51	49	0
Zambia	18*	22*	0	100	0
Lower-middle-income economies					
Côte d'Ivoire	40	-	47	53	0
Senegal	26*	10	100	0	0
Cameroon	6	-	3	97	0
Congo	9	19	100	0	0
Morocco	37	14	87	13	0
Dominican Republ.	37	33	0	0	0
Namibia	-	-	7	93	0
Tunisia	63	12	99.3	0.7	0
Algeria	49	14	98	2	0
Upper-middle-income economies					
South Africa	60*	6*	91	2	Nuclear 7%
Mauritius	93	14	84	16	0
Botswana	10*	6*	100	0	0
Gabon	50	-	23	77	0

SOURCES: WORLD BANK, 1994.
* - DATA FOR 1993/4

5 OVERVIEW OF ACCESS TO ELECTRICITY

5.1 THE CONTEXT: SUMMARY OF RELEVANT CONDITIONS IN CASE STUDY COUNTRIES

Table 1: Summary statistics for the case study countries

	Zambia	Malawi	Mali	Senegal
Population (millions)	8.02	9.33	8.83	7.3
Urban % of total	47.1 %	12 %	26%	40%
Rural % of total	52.9 %	88 %	74%	60%
Total population growth (% p.a.)	3.7 %	3.3 %	1.8%	2.7%
Urban population growth (% p.a.)	7.4 %	6.5 %	4.6%	4.0%
GDP (million US$)	2 580	1 896	2 827	6 277
GDP/capita (US$)	290	210	310	780
GDP growth/capita (real) %	-2.9%	0.1%	-2.7%	-2.1%
Inflation rate	67.4% (1992)	34.6% (1992)	3.7% (1992)	5.2% (1992)
Exchnge rate/US$*	660 Kwacha	10.5 Kwacha	550 CFA Francs	550 CFA Francs
HDI**	0.35	0.26	n/a	0.32

* - Exchange rates for the end of 1994

** - The Human Development Index (HDI) considers three factors: (1) Longevity (measured by life expectancy) (2) Knowledge (measured by adult literacy & mean years of schooling) (3) Standard of living (measured by GDP/capita adjusted for local cost of living)

Source: World Bank, 1994; Borchers et al, 1995; EDRC, 1996a; EDRC, 1996b.

Zambia, Malawi, Mali and Senegal are all developing countries with poorly developed infrastructures, highly skewed income distributions, and limited production. All have low Human Development Indices (HDI), indicating relatively high levels of poverty and poorly developed social support systems. GDP per capita is low in Malawi, Zambia and Mali, although it is substantially higher in Senegal. The wealth within Senegal is also illustrated by the higher average household incomes (Table 2), although it is also apparent that the income distribution here is highly skewed, with 40% of urban households earning only 10% of total urban incomes2. Electrification projects amongst low-income households in Senegal may therefore not encounter higher disposable income than is the case for the other three countries. Real GDP per capita growth was negative, or at best close to zero, in all four countries for the 1993/4 period.

Although income data obtained by this study may often be inaccurate and is sometimes even conflicting, it is clear that urban incomes are generally higher than average rural incomes. Zambia and Senegal are the most urbanised, with upwards of 40% of the population living in urban areas.

[2]Similar figures for rural areas of Senegal are not available, although rural incomes are known to be much less than urban incomes.

Table 2: household income information

Country & av. persons/hh	Average income per month	Income distribution
Malawi (~8 persons/hh)	Urban: $ 53 Rural: $ 45	75% have incomes under $50 p.m. 8% have incomes over $150 p.m.
Zambia (~7 persons/hh)	All areas: $ 81	50% of households earn 20% of income 50% of all households are classified as 'low-income', most of which earn under US$44 p.m.
Mali (9 persons/hh)	All areas: $ 146	64% have incomes under $123 p.m. 16% have incomes over $ 219 p.m.
Senegal (8.7 persons/hh)	All areas: $1 435 Urban: $ 2 416 Rural: $ 714	30-60% of households below 'poverty line'* (income below about $260/hh/month)**

* - this is taken to be where households cannot spend US$1 per person per day.

** - this information appears to conflict with that given elsewhere in the Senegal case study paper (EDRC, 1996b), where it states that 40% of households have incomes of below $99 p.m.

5.2 Energy use characteristics

Table 3: National final energy use (% of total)

	Elec	Petroleum products	Coal	Fuelwood	Charcoal	Other biomass
Zambia (182 626TJ)	12.1%	14.0%	5.6%	57.3%	11%	0%
Malawi (142 460TJ)	1.8%	5.3%	1.2%	89.7%		2.1%
Mali (76 742 300TJ)	1%	10%	0%	86%	3%	0%
Senegal* (96 705 200TJ)	-	37%	-	63%		

* - primary energy use figures. Final energy use figures not available.

Table 4: Sectoral energy use (% of total)

	Domestic	Industry& commerce	Agric	Transport	Govt	Other
Zambia	62.3%	25.9%	2.5%	7.3%	2.0%	0%
Malawi	67.4%	5%	23.9%	3.4%	0.3%	0.1%
Mali	90%	3%	0%	7%	-	-
Senegal	91%	18%	-	20%	-	-

Tables 3 and 4 illustrate the reliance of all four of the case study countries on biomass, and that domestic demand dominates the national energy use profiles. Senegal uses more petroleum products than most African countries, partly because they have a local natural gas field, which is used for electricity generation. In Senegal households also use significant amounts of LPG, which is almost unused in the other three countries. Deforestation is considered particularly serious in Malawi and Senegal, while in Zambia and Mali deforestation is serious in localised areas but not yet on a national basis.

Table 5 suggests that the majority of households use biomass as an energy source, and paraffin is widely used as a lighting source. LPG is only used to any significant degree in Senegal.

Table 5: Household energy sources (percentage households using fuels)

	Elec	Paraffin	Charcoal	Wood	LPG	Candles	Other
Zambia*	42%	41%	88%	37%	0%	n/a	0%
Malawi*	38%	62%	36%	84%	0%	n/a	6%
Mali	n/a	n/a	n/a	n/a	n/a	n/a	-
Senegal	cook 3% light 26%	cook 7% light 59%	cook 21% light 0%	cook 61% light 8%	cook 16% light 0%	- light 6%	-

* - urban areas only. Information for entire country not available.

5.3 Access to electricity

The experience in the four case study countries and elsewhere on the African continent show that increasing access to electricity by households will not be achieved merely through the normal course of a utility's operations, but rather needs a directed and sustained focus. There are some fundamental constraints to increasing access, probably the most striking of which is the mismatch between the typically high costs involved in the connection of households and the low household incomes. In many countries the wealthier households, who can afford full connection and even grid extension costs, are often already connected, so widening access generally means targeting lower income households, and thus affordability inevitably becomes a central issue. There are however a number of other constraints to access, and these are common to many countries in Africa. There are also a number of potential strategies which are aimed at addressing these constraints. These are discussed in the sections below in more detail.

Table 6: Access to electricity by households

Country	No. households	Population growth (% p.a.)	No. Connected to elec	% total households connected	growth in No. of connections	Real growth in connections
Zambia	Urb 674 786 Rur 757 892 Tot 1 432 679	3.7%	Urb 246 900 Rur 15 200 Tot 262 100	Urban 37% Rural 2% **Total 18%**	7.2% p.a.	3.5% p.a.
Malawi	Urb 193 000 Rur 1 026 300 Tot 1 219 300	3.3%	Urb 35 847 Rur 11 320 Tot 47 167	Urban 19% Rural 1% **Total 4%**	9% p.a.	5.7% p.a.
Mali	Urb 267 000 Rur 742 000 Tot 1 009 000	1.8%	Urb 60 000 Rur (v. Low) Tot ~ 60 000	Urban 23 % Rural ~0% **Total 7.6 %**	~7%	~5.2%
Senegal	Urb 355 325 Rur 483 422 Tot 838 747	2.7%	Urb 206 879 Rur 12 541 Tot 219 420	Urban 58% Rural 3 % **Total 26%**	6%	3.3%

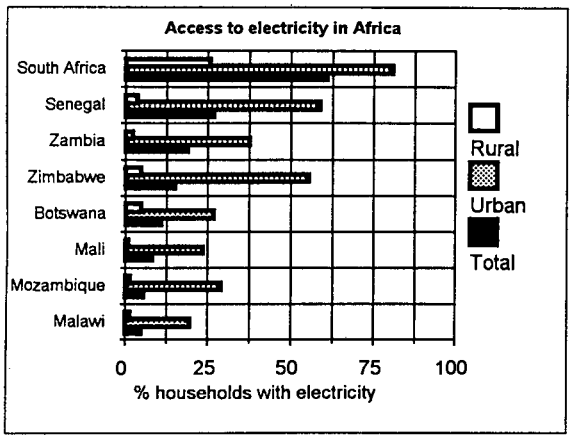


Figure 1: Access to electricity by households in selected countries

Table 6 and Figure 1 give an indication of the level of access to electricity by households in different countries. Rural access levels are particularly low, which reflects the high costs of extending power lines to remote settlements which often have a small customer base (and thus small revenue base), and also the high cost of providing electricity by other means such as diesel generation or solar photovoltaics.

5.4 Financial and economic feasibility of increasing access to electricity

Much has been written concerning the benefits of household electrification, often around the question of the justification of subsidies. This paper does not cover these issues in any depth, but rather focuses on the practicalities of increasing access to electricity. Nevertheless, some key points relating to the financial and economic justification for electrification are given below.

Economic analyses undertaken on the use of electricity in Malawi, Zambia, Mali and Senegal (Borchers et al, 1995; EDRC, 1996a&b) show that electricity is almost always the most cost-effective lighting energy source, but can be amongst the most expensive cooking energy sources[3]. It is also often a cost effective energy source for refrigeration. The real economic benefits of using electricity may however be in its ability to provide access to media such as TV, and to power a great range of motor-driven and other productive machinery and domestic appliances. Electricity is an effective water pumping energy source, and thus has a role in increasing agricultural production in some areas. Where electricity is used for cooking or space heating, there can be definite health benefits for women and children in particular as a result of reduced indoor pollution.

5.5 The constraints to access

The constraints to access from the potential users perspective can be divided into those relating to affordability, and those relating to accessibility in terms of connection procedures and general awareness concerning the use, costs and benefits of electricity. Affordability constraints cover not only the high capital cost of connection, but also the lack of financing of these costs which may render them unaffordable to many households. The cost of using electricity and the cost of obtaining appliances are also affordability issues.

On the supply side, constraints to increasing access to electricity include system capacity to handle the additional demand, the capacity of the utility to implement large scale electrification projects, and financial constraints relating to limits on forex availability which

[3] except possibly in countries like Malawi, where the cost of using wood does not reflect the high environmental cost linked to the serious deforestation problem.

in turn limit hardware imports, and the ability of the utility to source financing for large scale electrification projects. All of the above constraints will be discussed in more detail below.

Table 7: Summary of constraints to access to electricity by households

DEMAND-SIDE	Affordability	cost of connection	appropriate hardware (technology, supply level, house-wiring system)
			effective project management
			number of connections maximised
		payment method	financing of connection costs
		cost of electricity use	tariff level and structure
			appliance cost/financing
	Accessibility	connection procedure	accessible, understood procedures
		awareness	information availability on elec use, costs, benefits
SUPPLY-SIDE	system capacity		
	implementation capacity		
	financial	forex availability	
		electrification financing	

Connection and wiring costs

Electricity connection costs are typically expensive, and in many countries new users are required to pay all, or a large proportion of these costs before they are connected, so connection is usually unaffordable to the majority of houses (as shown in table 8). It is thus important that these charges to the user are reduced as far as possible if access is to be widened. This requires the following:

- that appropriate low cost technology be used which is well matched to users needs
- that low cost wiring techniques be made available
- that appropriate financing of connection costs be available to suit the level and periodicity of household incomes.

This section deals with connection and wiring technology costs, while financing is dealt with later.

Table 8: Affordability of connecting to electricity in different countries

Country	Connection charge* and wiring cost	Connection & wiring cost as % of household income	
		low-income hhs***	average income hhs
Zambia	Connection: $ 68 Wiring: $ 45 TOTAL: $ 113	280% (Income=$40 p.m.)	140% (Income=$81 p.m.)
Malawi	Connection: $ 11 Wiring: $ 43 TOTAL: $ 54	154% (Income=$35 p.m.)	113% (Income=$48 p.m.)
Mali	Connection: $ 363 Wiring: $ 136 TOTAL: $ 499	623% (Income=$80 p.m.)	342% (Income=$146 p.m.)
Senegal	Connection: $ 31** Wiring: $ 90 TOTAL: $ 121	151% (Income=$80 p.m.)	8% (Income=$1 435 p.m.)

* - for reticulated areas, excluding grid extension costs. In general the costs given apply to new projects in hi-density areas. Wiring costs are for basic wiring, for example a redi-bord, not full conduited house-wiring

** - although it is apparently uncommon for connections to be so little, as mostly extension costs have to be borne directly by the user. Costs may in practice be 10 or even 100 times greater than this.

*** - estimated from income distribution information in Table 2.

Note: connection costs typically vary within each country, depending on the area and electrification scheme applicable to the particular households. Costs given here thus merely provide an indication of costs which users may typically be required to pay.

Table 8 gives the current connection charges applicable to many users in the four case study countries. These charges are estimated to vary from between 150% to 620% of a typical low income household's monthly income. These up-front charges will need to be decreased substantially if access to electricity is to be substantially increased. Table 9 provides an indication of actual costs of different connection technologies used in different countries (note that connection *charge* is distinct from connection *cost*). Costs can potentially be between $400 and $ 600 per house for connection and a redi-bord[4] (including local MV and LV reticulation) if an appropriate technology mix is selected. However, technologies used in many countries result in substantially higher costs, and thus an appropriate selection of technologies to optimally supply user needs is important. ADMDs of at most 2kVA per household, load-limited supplies[5] (as opposed to metered supplies), and the use of redi-bords are amongst the measures which have been successfully adopted in some countries. Another strategy to reduce costs and maximise returns on investment is to install transformers for lower ADMDs initially (for example around 0.5 or 1kVA), and as demand grows to upgrade the transformers accordingly. This also avoids supplying connections with excessive capacity, which is common amongst some utilities who have not fully adapted electrification practices to low-income households, and results in unnecessarily poor returns on installed infrastructure costs. This trade-off between initial cost and operation cost (including upgrading) is a potentially important cost-optimising strategy and needs to be seriously evaluated by utilities.

[4]A redi-bord is a board with circuit breakers, earth-leakage protection, a light and a few plug points. With this board households need not install any other wiring prior to connection. Sometimes a prepayment meter is installed as a part of the redi-bord.

[5]Although utilities in some countries (e.g. Malawi) have tried load-limited supplies in the past and feel that they may not be appropriate for widespread use.

The cost of house-wiring is often also unaffordable to many households, with full house-wiring costing typically upwards of $100 (see Table 9). It is essential that alternatives to full house-wiring, such as the redi-bord, are offered to households.

Table 9: Costs of different technology options for domestic connections

Country	Technology description	Technology cost per household**
Zambia	redi-bord system conventional house-wiring	$ 1 245/connection*** $ 350 for a small house
Malawi	redi-bord system**** conventional house-wiring	$ 800/connection* $ 200 for a small house
Mali	standard connection house-wiring	$ 360/connection (no retic. included) $ 90 for a small house
Senegal	standard connection (between 5Amps and 60Amps) house-wiring	$ 1 800/connection* $ 90 for a small house
South Africa	60 Amp 1-phase with credit meter (excl.wiring) 60 Amp 3-phase with credit meter (excl.wiring) Redi-bord supply with prepayment meter Redi-bord supply without prepayment meter Load limited supply (2.5Amp) Grid extension - 3-phase MV 1-phase LV	$ 590/connection* $ 843/connection* $ 720/connection* $ 560/connection* $ 406/connection* $ 15 600/km $ 10 900/km

* - includes all MV and LV reticulation costs within settlement, not grid extension to settlement
** - 1994 exchange rate used for all countries. For South Africa R3.2=US$1.
*** - includes some network 'backbone' reinforcing
**** - Malawi was still only considering using this technology in 1994.
Note: technology costs vary between countries partly because they include different assumption concerning how much of the 'upstream' LV, MV and even HV network costs should be reflected in connection costs.

Connection and wiring hardware costs may also be increased by import duties and other taxes. For example in Zambia sales tax adds 23% to the cost of connection, while import duties add approximately 20% to all hardware costs. While access to electricity is a clear objective in the Zambian national energy policy, the finance department is reluctant to grant the electricity industry any exemption from these taxes or duties. The support of relevant government departments can therefore help reduce connection costs substantially in an electrification programme.

Effective project management

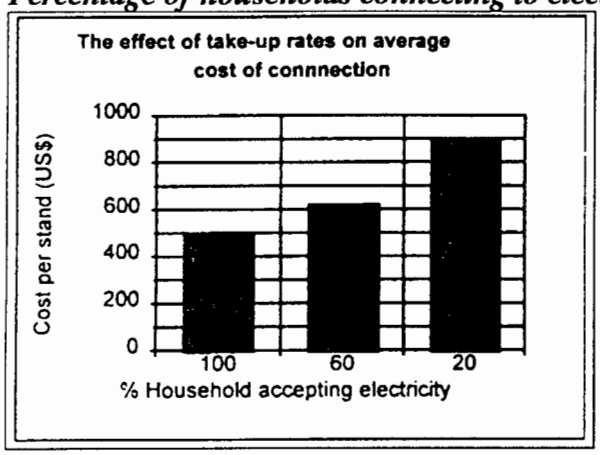
In many countries utilities are not very efficient implementing agents for electrification projects, and as a result total project costs are often increased where they are implemented by the utility. The private sector is usually better placed in this regard, as their viability is directly linked to their implementation performance. Many utilities contract out any significant electrification work to private sector consulting companies. In Zambia, a pilot low-income household electrification project was carried out by an efficient private consulting company from South Africa with experience in this field. As a result of their use of local labour, strict project management principles and appropriate technologies, they were able to keep costs per connection to between $500 and $600, including MV work. This represents a substantial saving over connection costs calculated by ZESCO, the local utility, which are in excess of $1000 per connection.

Use of local labour

The use of local labour in the implementation of electrification projects can not only help reduce total project electrification costs, but increases skills amongst those working on the

project and retains some of the project capital in the local community. It is thus a strategy which needs serious consideration by utilities and others involved in project implementation.

Percentage of households connecting to electricity ('take-up' rate)

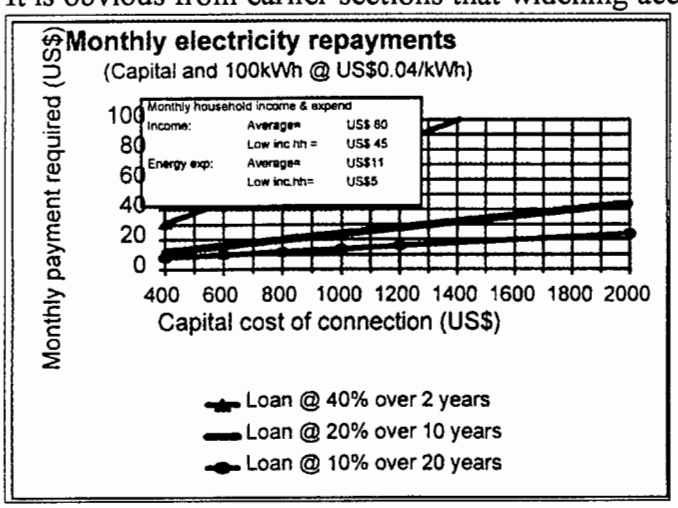


As a substantial proportion of total connection costs per household are MV and LV reticulation, the greater the 'take-up' rate by households, the lower will be the average cost per household, and the greater the returns will be on the capital invested. Figure 2 provides an indication of how 'take-up' rate affects electrification cost per household. The 'take-up' rate is not only a function of how affordable an electricity connection is, but also on the marketing of electricity by the utility, which should ensure that households are aware of the benefits of electricity and are informed on connection costs and procedures. These procedures should be simple and accessible to low-income householders, who may often have limited experience with this type of service application.

Figure 2: The effect of 'take-up' rates by households on average cost of connection

Connection cost payment method

It is obvious from earlier sections that widening access implies some form of connection cost financing. Although access is generally recognised as an important area of focus in the national energy policies of many of the case study countries, few have developed appropriate connection cost financing schemes. In Mali users are expected to pay connection costs up front, in Senegal the same principle is meant to apply, but in practice users are not always fully charged or may in some cases be able to repay costs over a short period, and in Malawi users are expected to cover the bulk of the connection costs up front - the remainder is collected as a hidden component of the basic and energy charges.



In Zambia, where low-cost electrification has been receiving substantial attention recently, 50% of connection costs may be financed over 12 months. While this is certainly an improvement over full up-front recovery, it is still unaffordable by most households. Financing of connection costs needs to be designed specifically with the target households in mind. Figure 3 shows monthly payments required by households in Zambia for different connection costs and three different loan financing scenarios. The importance of both favourable financing terms and minimising connection costs is illustrated. The figure makes it clear that financing at commercial rates (taken as 40% over 2 years in

Figure 3: Financing electrification in Zambia - payment scenarios compared with household incomes.

figure 3) will not be appropriate for most households, and thus existing financing channels (for example through commercial banks) cannot be considered.

Subsidies

Figure 3 also indicates that even with attractive and imaginative financing, many poorer households may not be able to afford to repay connection costs. If substantial widening of access is considered an important national objective, then some sort of subsidy is likely to be necessary to achieve this goal. The subsidy may be applied directly as a capital cost subsidy per user, or by linking capital repayment to energy use (i.e. including a capital recovery component in the cost per kWh as is done in South Africa). The latter results in a cross-subsidy from households with high electricity consumption to low-consumption users (which are typically new, low-income households) . Another potentially feasible form of subsidy is a cross-subsidy within the electricity supply industry, with tariffs for one sector (for example industrial consumers) including a small cross-subsidy component for low-income households.

In recent years many countries have become reluctant to apply subsidies in general. It should however be noted that subsidies can be structured that they are temporary - to 'kick start' a drive to increase access - and can be contained within the electricity supply industry - i.e. they need not affect the overall financial viability of the utility. Nevertheless, the debates around the economic grounds for subsidies is complex, with some studies indicating that subsidy application based on unquantifiable and unconfirmed benefits (as is often the case with electrification projects) should be approached with caution (Davis M, in Borchers at al, 1995, appendix 3). This debate is not entered into here.

Cost of using electricity

Maximising the use of electricity is important both from the cost recovery point of view as well as to maximise the general social benefits of the infrastructural investment. Increasing access to any significant degree means installing much infrastructure with low revenue returns in the short-term at least. The greater the utilisation of the infrastructure the more chance it will have of paying for itself, therefore maximising the use of electricity is of added importance.

Tariff level and structure

Table 10 shows that even moderate electricity consumption (150kWh) may be difficult for lower-income households to afford, although low-income, newly connected households typically use less electricity than this (in Mali about 30% of households use less than 50kWh/month, in South Africa newly electrified households use about 80kWh/month on average). Many utilities institute a lifeline tariff system[6] to enable such users to have the benefits of basic electricity use, and thus effectively cross-subsidise these customers. Such a strategy may be a necessary to compliment measures to reduce connection charges if users are to benefit from electricity.

Monthly bill payment methods

If poor households are faced with a bill or one of two month's electricity consumption, they may find it difficult to pay such a large lump sum which can lead to payments defaults and

[6]A lifeline tariff is one with a low charge for low energy consumption levels, typically up to about 50kWh per month.

jeopardise the financial viability of the project. It is thus important to try and accommodate the irregularity of their income flows by allowing them to buy what they can afford when they can afford it. Technologies such as prepayment meters allow this form of payment, and are becoming increasingly popular in several African countries.

Appliance costs

The typically low consumption of newly connected households is often as a result of their using electricity for lighting and radio only, which is partly because of the relatively high cost of appliances (see table 11). In some countries import duties and taxes contribute substantially to the high selling price of appliances. For example in Zambia a 2-plate cooker typically costs more than double what it does in the other case study countries partly for this reason. However, while making appliances affordable to households is an important part of a low-income electrification programme, it will not necessarily result in proportional increases in electricity consumption. Experience in South Africa has shown that in areas where 2-plate cookers, irons and kettles were made available at low cost to newly connected households, electricity consumption has not increased as much as anticipated.

Table 10: Affordability of electricity use*

Country	Av.household energy expenditure	Energy charge (LRMC assumed)	Cost of 150kWh (energy charge only, LRMC assumed)	Cost of 150kWh as% of monthly hh energy expenditure
Zambia	Average: $ 11 p.m. Low inc: $ 5 p.m.	US¢ 4 /kWh	$ 6.00	Average: 54 % Low inc: 120 %
Malawi	Average: $ 7 p.m. Low inc: $ 4 p.m.	US¢ 8 /kWh	$ 12.00	Average: 171 % Low inc: 300 %
Mali	Average:$12 p.m.** Low inc: $ 8 p.m.	US¢ 15 /kWh	$ 22.50	Average: 188 % Low inc: 280 %
Senegal	Average: $ 13 p.m. Low inc: $ 6 p.m.	US¢18 /kWh	$ 27.00	Average: 208 % Low inc: 450 %

* - excluding costs of connection, wiring and line extension

** - based on estimates: 10% of hh income for low inc hhs, 8% of hh income for average income hhs

Note: LRMC are extracted from papers on case study countries, and may be based on different assumptions

Table 11: Affordability of electrical appliances

Country	Appliance cost	Appliance cost as % of household income	
		low-income hhs	average income hhs
Zambia	2-plate cooker (hotplate): $ 100	250% (Income=$40 p.m.)	120% (Income=$81 p.m.)
Malawi	2-plate cooker (hotplate): $ 43 iron: $ 37 fridge: $ 560-930 stove & oven: $ 660	123% 105% 2000% 1890% (Income=$35 p.m.)	90% 77% 1400% 1370% (Income=$48 p.m.)
Mali*	2-plate cooker (hotplate): $ 40 iron: $ 20 kettle: $ 20	50% 25% 25% (Income=$80 p.m.)	27% 14% 14% (Income=$146 p.m.)
Senegal*	2-plate cooker (hotplate): $ 40 iron: $ 20 kettle: $ 20	50% 25% 25% (Income=$80 p.m.)	3% 1% 1% (Income=$1 435 p.m.)
South Africa	2-plate cooker (hotplate): $ 30 iron: $ 11 kettle: $ 11	20% 7% 7% (Income=$150 p.m.)	10% 4% 4% (Income=$ 312 p.m.)

* - appliance cost information not available for these countries, so appliance prices are estimated from prices in other countries, and is unlikely to be accurate.

Accessibility

Connection procedures

It should be easy for customers to connect and pay for electricity use - not just in terms of affordability, but the service application procedures should also be easily understood by the target market, and electricity 'payment-points' should be located where they are accessible to these households. It should be remembered that many low-income households may not have experience with such service application procedures, and may feel rather alienated by having to travel long distances to make an application, fill out complex forms, find the necessary people to hand the forms to or ask for help in completing them, and make initial payments.

Information provision

Many potential and new users are not familiar with electricity. They thus need to be made aware of connection procedures firstly, and also of how to use electricity safely and effectively, what costs are likely to be involved, and what the benefits of electricity can be. There is thus a need for marketing and user education as a component of electrification projects.

System capacity

Generation capacity

Widespread domestic electrification can affect the national peak demand, as domestic demand is typically evening peaking. Any firm plans for increasing access therefore needs to evaluate the impact on the country's generation capacity. In Senegal, much of the generation plant is old and operates at partial capacity often, and thus their system could not easily accommodate additional demand at present. The same can be said of Mali, although here the capacity constraints are geographically limited. In both of these countries this situation is

likely to be addressed in the short to medium-term. In Zambia and Malawi generation capacity is adequate for substantial increases in domestic demand.

Network capacity
As existing transmission, distribution and reticulation networks in many countries were not designed with widespread electrification of households in mind, it is common for such electrification programmes to require capacity upgrading of such networks. For example, while generation capacity is not a constraint in Zambia, the MV distribution network already is undercapacity in many areas. ZESCO has estimated that for the first phase of their household electrification programme it will cost $300 per household to upgrade the distribution system adequately.

Implementation capacity

In many countries utilities only have relatively small implementation teams, and so contract out any substantial electrification work to the private sector. Electrification programmes are thus not limited by the utility's implementation capacity. This is the case in Mali, Zambia and Senegal. In Malawi however, the capacity of the private sector to undertake such work is very limited, and thus the local utility (ESCOM) fulfills this function. Any substantial household electrification programme would therefore quickly overstretch their implementation capacity. Malawi could follow the example of Zambia, however, where experienced consultants from elsewhere in Southern Africa were employed to compliment local capacity.

Forex availability

Since many African countries have limited local manufacture of electrification hardware, they are usually dependent on imports, and thus forex availability becomes a major factor in electrification implementation. In both Malawi and Zambia limited forex availability is currently a serious constraint. In Zambia 70 to 80% of hardware is imported, which translates to about 40% of total electrification costs. In Malawi the forex shortage has limited the import of meters, and has thus already slowed the connection of new customers.

Forex availability is not a serious problem in Mali and Senegal, as these countries are in the African Franc Zone (CFA), and their currency is thus automatically convertible with French Francs (100 CFA Francs = 1 French Franc).

The potential for forex availability to affect electrification highlights the potential influence of central government policy on such programmes, and thus the importance of encouraging government to provide the necessary facilitating environment for initiatives to increase access.

Overall utility efficiency and financial viability

Utilities in many African countries are not yet operating in an efficient and financially sustainable manner. This has often been partly as a result of government intervention in utility finances, such as restricting tariffs to sub-economic levels for social reasons, and partly due to lack of effective management capacity.

In Senegal, the local utility (SENELEC) appears to have been financially viable in general, but it is currently not considered an efficient organisation, as one of its primary concerns at present is 'to improve the performance of management, especially in commercial areas' (EDRC, 1996b). Currently SENELEC has difficulty sourcing suitable financing, as the traditional sources of concessionary finance have withdrawn due 'to the failure to reach agreement on reforms with the government' (EDRC, 1996b). Service levels are thus declining, and programmes to widen access are unlikely to be able to take place effectively in this environment.

In Mali, the local utility (EDM) has also experienced declining performance recently, including very high non-technical losses. Funders have also withdrawn as a result of this poor performance. However, the Mali government has decided to contract out the management of EDM to an international team of consultants, who have the brief to set up management and operations systems over 5 years, including building local management capacity so that they can take over after this period. International funds have again been made available following the appointment of this international management team.

ZESCO, the Zambian utility, has recently embarked on a stringent programme to become efficient and financially viable following their near collapse in recent years. Tariffs have historically been held at sub-economic levels by the government, and thus ZESCO intends to bring these to sustainable levels. This demands a huge increase, however, and both ZESCO and the government are reluctant to make this jump too quickly due to the anticipated public reaction. ZESCO still, therefore sits with a sub-economic revenue base in the short-term. While they are also embarking on a programme to widen domestic access substantially, it is difficult to see how this can be sustainable given the current tariffs. Foreign investment may also be limited while this financial environment exists.

The utility in Malawi, ESCOM, has traditionally operated on a financially sound basis. Here the concern may rather be that their financial and other policies are too conservative to accommodate essential components of widespread low-income household electrification projects such as financing of connection costs, initial cross-subsidies and adopting very different technologies and standards to conventional household electrification.

Table 12: Electricity utility indicators and power generation information (~1993)

	Installed MW	GWH../yr sold	No customers	No domestic customers	Domestic % of total GWH.	Net profit (loss)	Losses (tech & non-tech)
Zambia	1 632	6413	143 990	140 000	16%	($21million)	22%
Malawi	190	720	50 997	47 167	22%	$ 7 million	16%
Mali	76	210	n/a	60000	n/a	($3million)	21%
Senegal	275	865	283 444	219 420	23%	n/a	10%**
South Africa	37 636	143 800	2 605 000	2 430 000*	16%	$499 million	6%

* - this has grown considerably between 1993 and 1997.
** - information from 1990 (World Bank, 1994)

Increasing the household proportion of the total customer base has implications for the financial operation systems of utilities, since the cost recovery characteristics of households differ from other users. This is particularly the case where financing is extended to a large number of households. It could affect the debt:equity structure of utility finances, which has

an impact on the tariffs. If domestic demand affects the national peak demand, this also has implications on the LRMC of electricity provision. Electrifying low-income households inevitably involves some form of financing or initial cross-subsidy, and thus any efforts to increase access on a wide scale need to consider the broader implications on the utility.

Where utilities are struggling with financial viability and organisational efficiency, it may be difficult for them to become involved in new and low-return areas such as low-cost household electrification. On the other hand, they often face political and internal pressure to increase access. It may thus be sensible for utilities in such countries to proceed with caution, drawing on experience of countries which have been involved in this area for some time.

Electrification financial planning

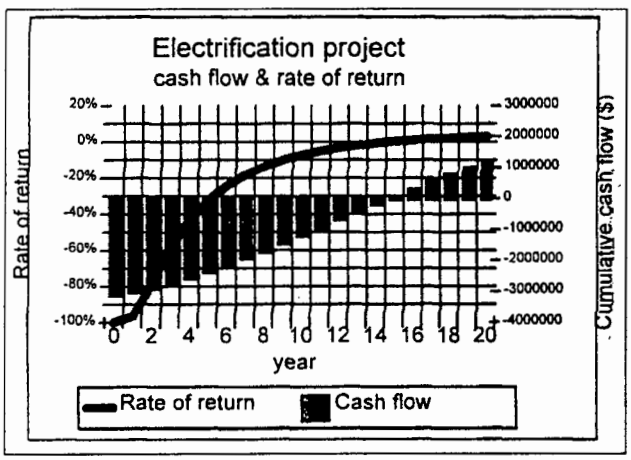


Figure 4: Example of electrification project financial modelling

Low-income household electrification needs to be carefully planned if it is not to threaten the financial viability of the utility. Proper financial modelling needs to be undertaken on a project and programme level to assess the financial implications of such programmes. Inputs into such financial models include number of connections, capital, operation and maintenance costs, consumption and revenue, amongst others.

To undertake adequate modelling, the potential market must be well understood such that implementation methods and technologies used are appropriate and acceptable, and to understand their ability to pay for the service. Here it may also be useful to draw on relevant experience from other projects or countries. Pilot projects are also important to evaluate affordability, technology choice and implementation methods.

Rural and urban electrification issues

Rural electrification is characterised by long grid extension distances or high electricity costs from stand-alone generation systems, and low financial returns on installed infrastructure due to the typically lower incomes of rural households. Settlement densities are also often low, which increases costs per connection still further. Programmes to increase access to electricity should first focus on unelectrified urban and peri-urban households, as here returns on investments will not only be higher due to lower connection costs and higher household incomes, but it is cheaper and easier to carry out adequate market research, and projects can be more easily managed and monitored. Once appropriate and efficient systems for provision of electricity to low-income households have been established, then utilities can consider extending the programme to increasingly rural areas.

It needs to be noted, however, that since this type of urban electrification is typically financially marginal at best, moving into rural areas will almost certainly imply the application of subsidies. Countries such as Senegal and Zambia have special funds to

subsidise rural electrification. It may make economic sense for these funds to be allocated to low-income urban electrification programmes if it is apparent that they will require subsidies.

5.6 Government and utility policies regarding access to electricity

Increasing access to electricity substantially usually involves a departure from conventional electrification practices to which utilities are accustomed. It thus requires a concerted focus and strong motivation. The government needs to provide a clear policy direction in this regard if serious progress is to be made, and could additionally be involved in support activities such as research and monitoring. In some countries performance contracting, or the setting of clear electrification and other performance goals, is also being considered by governments (e.g. in Botswana). Widening access to electricity needs to be seen as part of a development process, not merely the provision of electricity. As power utilities main business has historically been the technical supply of electricity, it is important that governments support and guide utilities on electrification practices and targets such that broader development needs are also met and users benefit from programmes as much as possible.

Governments not only need to provide a clear policy directions and goals regarding widening access, but energy departments also have a role in negotiating the exemption from, or reduction of taxes and duties, and facilitating access to forex, all of which are potentially important influences on the success of electrification programmes.

The Senegal government considers increasing access to electricity as a high priority, although their focus appears to be largely on rural electrification. The government as well as the utility are, however aware of the need to strengthen SENELEC's viability and efficiency before becoming seriously involved in a widespread electrification programme. Access to electricity by households is not specified as a policy goal, but rather 'widening access to modern energy sources, especially in rural areas' (EDRC, 1996b).

As with Senegal, Mali is focussing on increasing access in rural areas, and also does not address access to electricity by households specifically in the energy policy. The utility is, however looking into technology alternatives appropriate for low-income electrification.

The Zambian national energy policy clearly specifies increasing access by households to electricity, and the utility has recently been very proactive in this area. Part of the utility's motivation for this is, however, to strengthen their revenue base, which is unlikely to be a result of such a programme.

In Malawi, there is no specific focus on increasing access, although both the utility and energy department consider it to be important. It is also hoped that widespread household electrification will help ameliorate the serious deforestation situation by encouraging urban households in particular to cook with electricity rather than charcoal. Without a definite intent to commit the necessary resources to increasing access by households, impact in this regard is likely to be limited.

6 RECOMMENDATIONS ON INCREASING ACCESS SUSTAINABLY

6.1 Addressing demand-side constraints

Electrification of households is of necessity more than just the provision of electricity to houses - it needs to be seen as part of a development process. Thus it is important to ensure that the customer benefits from the process as much as possible. This of course has to be undertaken in the framework of financial sustainability.

- As widening access to any significant degree involves targeting low-income households, the biggest challenge in such electrification programmes is making the service affordable to households.

i. The first and most obvious affordability constraint faced by households is the connection charge, as a high connection charge immediately excludes most of the population from connecting. Thus innovative financing schemes need to be explored to enable customers to pay for the connection charge over a period of time. In addition to innovative financing options, the connection costs itself also needs to be kept as low as possible.

ii. The second affordability constraint faced by households is encountered when they attempt to obtain appliances. The purchasing of appliances usually involves a large once-off payment which is often difficult for poor customers to afford. This constraint limits the electricity they use and thus the benefits which they can realise from connection.

iii. A third affordability constraint that customers encounter is related to the payment for the electricity consumption itself. It is important to accommodate the irregularity of poor households income flows by allowing them to buy electricity when they can afford it. Technologies such as prepayment meters allow this form of payment.

- Supply levels and standards should be appropriate to the needs of the customers[7]. If households are to use electricity for lights and radio only, as many lower income households do, the supply should be pitched at this level. If a greater capacity supply is provided to such houses, the extra infrastructure will not be utilised and is likely to provide minimal revenue returns. In this respect user's needs should be carefully understood, and thus detailed market research is necessary.
- It should be easy for customers to connect and pay for electricity use - not just in terms of affordability, but the 'pay points' need to be located so that they are accessible, and connection procedures should be easily understood.
- Many new users are not familiar with electricity. They thus need to be made aware of how to use it safely and effectively, what costs are likely to be involved, and what the benefits of electricity can be. This points to the need for marketing and user education by the utility.

The electrification of low-income households clearly cannot be done in the manner in which most other customers are electrified. These users have a particular set of constraints which need to be understood and considered in designing the programme approach. To become successfully involved in this area utilities need to be committed to adapting their operations accordingly. Here the role of government in providing policy direction and in goal setting is important, as well as in supporting utilities through the learning process.

[7]Although safety standards must of course be adequate.

6.2 Addressing supply-side constraints

Initial capital costs

Because affordability of supply is the most serious constraint in widespread electrification programmes, and because utilities usually cannot afford to undertake financially unviable projects, the cost of supply is one of the major variables that needs to be optimised.

- Technology choice optimisation is important to reduce costs. The combinations of hardware which can be used are numerous, and trade-offs between initial cost and operation cost (including maintenance and upgrading) will need to be made.
- Efficient project management is important to keep costs low.
- Implementation techniques which maximise the use of local labour should be explored as this can not only reduce costs but also provides skills locally.

Financing of programmes

Before embarking on low-income household electrification projects and programmes, utilities need to undertake thorough financial modelling in order to understand the cash flow requirements of such programmes and to enable them to plan the financing thereof. Without this type of modelling it cannot be ascertained whether the programme is sustainable or not, nor what the major risks are, and thus financial planning is difficult.

Electrification can be financed in a number of ways (e.g. internal cross-subsidies, targeted government subsidies, grant or concessionary funding, etc), and thorough modelling will allow the need for, and feasibility of, each financing option to be more fully evaluated.

Once the options for financing the programme have become clearer the modelling can be further enhanced by assessing the impact that different financing options will have. This should be done in an integrated way with the total utility business operation.

Focus on urban electrification initially

It is likely to make financial and economic sense for electrification programmes to focus on urban or peri-urban areas rather than rural areas, as here implementation costs will be lower, returns of the infrastructure invested will be greater, and project management and monitoring will be easier. Once effective implementation strategies have been established and tested, and financial viability of projects established, utilities may consider venturing out into increasing rural areas.

Financial soundness of the utility

It is important that utilities embarking on low-income household electrification programmes do so from a sound foundation. Tariffs need to be set at economic levels, billing systems need to be working, and financial control and general management needs to be effective. As returns on low-income household electrification programmes are often marginal at best, utilities should not expect them to contribute to the strengthening of their financial position to any substantial degree.

Understanding the market

The customer base needs to be well understood if schemes are to be designed which meet needs effectively, provide appropriate levels of supply, and yet are affordable. For this reason market research needs to be undertaken. This will inform the financial modelling of

electrification programmes and enable them to be more realistic. Certain valuable information on electricity use characteristics of households can often only be verified by monitoring use patterns in completed projects. Experience from other countries in Africa or from appropriate local projects could help in this regard.

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Widening access to electricity for the urban and rural poor in Africa

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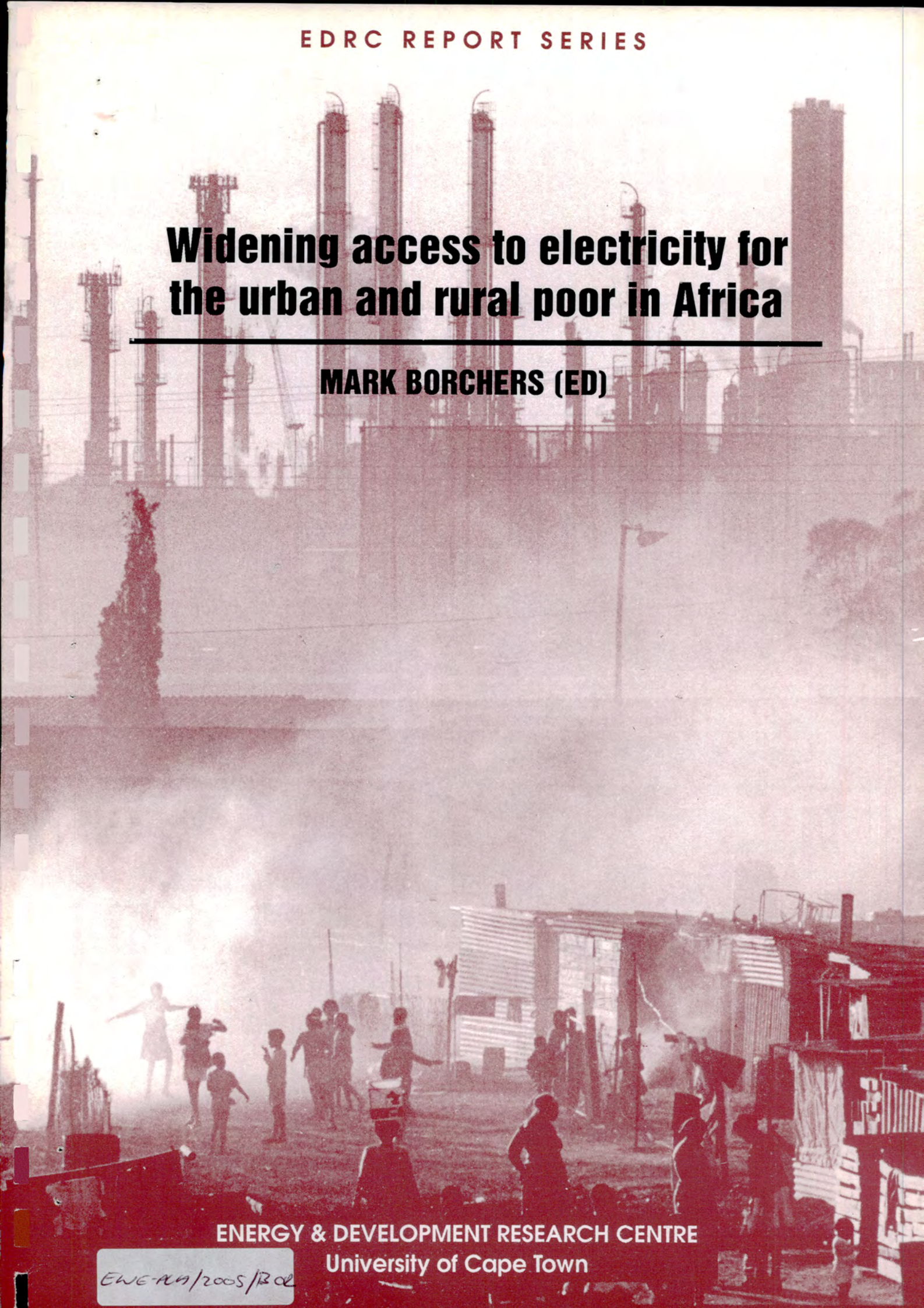

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