IMPLICATIONS OF ECONOMIC AND SOCIAL OBJECTIVES FOR ELECTRIFICATION IN SOUTHERN AFRICA

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1 Introduction

Electrification is an electrical engineering activity. The electrification networks are planned, designed, built and operated by electrical engineers and electricity distribution utilities. Traditionally the utilities have conservative management, so it is reasonably expected that the investments in electrification have been carefully assessed. However, other authorities, including national and local government and international development agencies, also have some responsibilities for electrification. All have their own goals and priorities for social and economic development, resulting in multiple objectives for implementing electrification. These multiple objectives often confuse the policies, perceptions and optimisation of electrification.

This paper introduces a concept of electrification for purely social objectives. It shows the concept is not widely recognised. Instead, most decisions about electrification are based on models that assume electrification contributes to economic and socio-economic development. The novel model of social electrification leads to the adoption of decisions different from those taken in most conventional electrification.

The paper is based current research into electrification that includes technological, financial, institutional and ethical aspects.

2 Historical electrification in South Africa

Electricity-for-All started in 1990, but electrification in South Africa started a hundred years earlier. Electrification started for economic reasons, to reduce the costs of mining, related industries and the railways. The convenience of electricity for lighting induced the municipalities to adopt it for public and private supplies, and the government recognised the importance of controlling and owning this economic function. For 80 years, economics drove electrification.

Socio-economic electrification developed in South Africa during the 1970s and 1980s when, spurred by political pressures, Escom (which became Eskom in 1987) extended subsidised supplies to rural areas. Even so, many farms were too far from the grid to be able to afford supplies at the high costs associated with the technologies and tariffs then in use.

Several new townships near the cities, built during the 1980s to house the influx of people from rural areas, emphasised the issue of whether electricity should and could be supplied to poor families. In many cases where electricity was available, expensive technical standards, uneconomic tariffs and bad debt made distribution unviable.

A business strategy process in the late 1980s identified the possibility of deriving significant socio-economic benefit from a national electrification programme. The “Electricity-for-All” programme commenced at the same time that South Africa started going through political change from apartheid to a broadly democratic government. Targets defined by the National Electrification Forum were adopted by the new government as the National Electrification Programme in 1994.

The achievements of the Electricity-for-All and National Electrification Programmes are shown in Tables 1 and 2. The urban areas served by the municipalities were already substantially electrified, with approximately 1,8 million domestic customers, before the programmes started. However, Eskom had fewer than 112'000 domestic customers in 1990 [1], so was responsible for the greater share of new electrification.

Table 1: Yearly domestic connections of Electricity-for-All programme [2]

	1991	1992	1993	1994
Eskom	31 035	145 522	208 801	254 383
Local government and other	51 435	74 335	107 034	164 635
Total	82 470	219 857	315 835	418 918

Table 2: Household connection targets of the NEP in 1994, and achievements

	1994	1995	1996	1997	1998	1999	Total
Eskom	250 000	300 000	300 000	300 000	300 000	300 000	1 750 000
Other	100 000	100 000	150 000	150 000	150 000	150 000	800 000
Total target	350 000	400 000	450 000	450 000	450 000	450 000	2 550 000
Achieved	418 918	478 767	453 995	499 391	427 426	443 290	2 669 345

[Derived from Eskom Annual Report, 1995, and NER reports, 1996-2001]

The overall extent of electrification was increased from about 36% of households in 1990 to 67% in 2000. The new connections planned and implemented by utilities have reduced since the electrification targets were reached at the end of 1999. As a result, with growing population, urbanisation and the construction of new houses, the percentage electrification nationally and in some regions has fallen since the highest figure reached in 1999.

Some have envisaged complete electrification by 2012: "*Government committed itself to funding both grid and non-grid connections at the average rate of R3000 per connection for 300'000 connections per year from 2001 to 2005, and 250'000 connections per year from 2006 to 2010. However, recent budgetary allocations indicate that these targets will not be met.*" [3]

Even when given access to electricity, it became evident that many people were too poor to benefit substantially from it, and the voter appeal of promising free services was recognised. Proposals for "poverty" tariffs and promises of free electricity indicate another reason for electrification, neither economic nor socio-economic, but the social objectives of poverty alleviation and political support.

Three different objectives can be identified then for the electrification in South Africa: initially economic, later socio-economic and recently social. Usually, different "solutions" are needed to reach different objectives.

3 The (un)viability of electrification

The viability of economically driven electrification is a simple business case, typically based on financial models of net present value or internal rate of return.

The analysis of electrification for socio-economic development is widely researched and reported. Despite differences in details, it is generally assumed that electrification supports development by contributing to improved education and health and the services that bring customers into the formal economy through improved production. Extensive literature shows that organisation structures, tariffs and technology have been developed on the basis that they should support the identified socio-economic objectives. However, the projects do not always meet all the objectives expected of electrification because, possibly, those various objectives are not differentiated.

There is little published evidence of electrification undertaken for purely social reasons, that is, with the primary objective of poverty alleviation. However, the concept that social development or poverty alleviation can be a driver for electrification is demonstrated by the electrification progress and decision-making in Southern Africa.

The cost of electrification has been high. South Africa has spent over R10 billion on new connections in the past ten years. The capital investment in distribution exceeded the investment in power stations and transmission in the same period. Completing universal access to electricity in South Africa (in accordance with government policy) will cost another

R7 billion. Energy generation and systems operations and maintenance after construction are also costly, such that building and operating distribution networks typically represents about a third of the cost of energy supply in most electricity distribution tariffs. By these measures, the electrification investment plus the future commitment in South Africa may be valued at about R60 billion over 20 years. How viable is this investment?

An evaluation of the NEP [4] found electrification in low-income areas was not financially viable. Economic analysis indicated the investment is marginal, but probably understates welfare and multiplier benefits.

The Deputy Minister of Minerals and Energy has stated: "*It is evident that successful household electrification has largely happened in the urban areas and a few of the more densely populated rural areas where the cost per service point is comparatively low. Consequently most rural areas today still lag far behind, while experience shows that the economics of electricity supply to those customers become progressively more adverse as more remote areas are targeted*." [5]

According to the National Electricity Regulator: "*The new challenge in electrification for South Africa in the next couple of years is to address the effective electrification of rural areas in a sustainable manner*." [6].

4 Technology change to meet the challenge

A change from the early approach of simply meeting numerical targets for connections was largely driven by recognition of the high costs of the existing standards and methods, comparisons between the utilities and a growing realisation that costs might not be recovered.

The remarkable achievements of the national electrification in South Africa from 1991 virtually doubled the number of domestic customers in 10 years. The electrification was characterised by a continuous and substantial change of technological standards. The changes included innovative research and development, including the greater application of single-phase instead of the traditional three-phase distribution, the adoption of new technologies in line design and feeder conductor selection, the broad application of prepayment metering, and revised industry standards and implementation procedures.

The development may be viewed as an engineering approach to problem solving. As the targets changed, so the staff of the electricity distribution industry responded with more suitable technology, bringing down the cost/connection as illustrated in Figure 1.

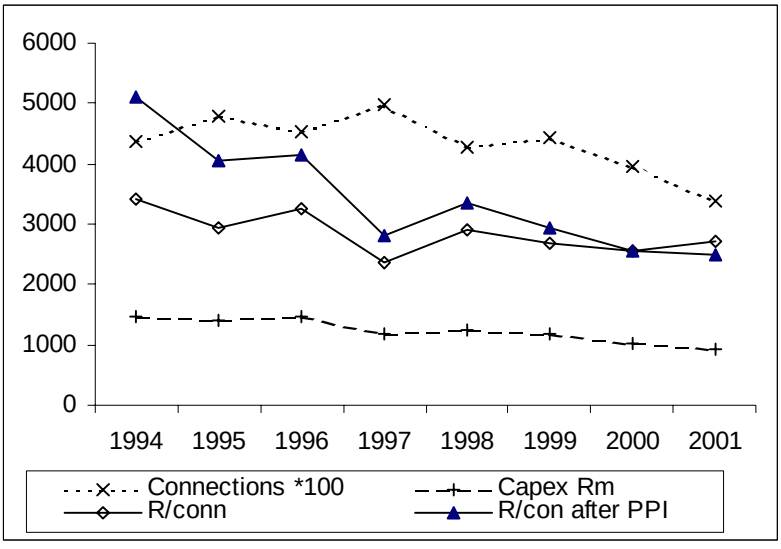

Figure 1: Cost/connection: 1994-2001

The scale of the change was such that it challenges several conventional ideas of electrification. It was generally accepted that capital investment costs per customer in rural electrification are high, but the evidence indicates that appropriately planned rural systems may be no more expensive than urban systems. The national average costs per connection

for urban and rural electrification in 1995 and 2001 are shown in Table 3. The average cost of urban electrification appears to have increased by about 15% in current terms but decreased by 20% after allowing for inflation (PPI). At the same time, the average cost of rural electrification decreased by 40% in current terms and a massive 70% after inflation. The savings were achieved by adopting designs that match the network technology and capacity to the needs of the customers. Designs are based on information about customers' needs derived from an extensive load research project in which several AMEU members participate.

Table 3: Average cost per connection, 1995 and 2001

National average cost/connection [Rand current]	Year 1995	Year 2001
Urban	2170	2674
Rural	3568	2622

Derived from NER reports

Technology improvement is not unique to South Africa. Its importance in the context of this electrification is that it was stimulated by an awareness of costs that was symptomatic of new needs in distribution and electrification, even if the nature of the change was not clearly understood. The technological achievements of the electrification programme also created opportunities to extend further the benefits of electrification.

The financial constraints and customer needs that forced down the costs of electrification also challenge the standards, technologies and approaches to non-grid electrification so widely supported by some development assistance agencies. The National Research Foundation reported recently: "*Over a third of the population is still not connected to Eskom's power grid and the cost of doing so seems prohibitive. Renewable energies, particularly solar power, offer viable, sustainable solutions*." [7]. However, the costs of PV appear to still be much more expensive than grid-supplied energy, as shown in Table 4.

Table 4: Investment costs of PV and grid related to energy capacity [8]

	International data		South African data	
	PV	Light grid	PV	Grid
Investment cost	US$750	Not given	R5900 each	R2541/customer + R2000 for capacity
Energy delivery [kWh/year]	100	1000	100	1000
Investment cost/kWh/year	US$7.5	US$1.9	R60	R4.60

It appears that PV systems are only viable:

- where comparisons of the costs of renewable systems are made against high costs of grid electrification, distorted by high energy capacity and possibly inefficient procedures,
- with aid support and aid subsidies, or where conventional electricity utilities fail, and
- when the authority and financial power of government officials dominates individual choice by customers with limited means.

In Southern Africa, the large pit-head power stations using low grade coal, and the large hydro stations with the capacity to regulate the uneven seasonal water flow have economies of scale that are not yet matched by small electricity generating technologies. Technology might have the potential to develop future renewable energy and isolated power supplies without the disadvantages of small scale, but this is not yet achieved. Because PV systems as presently conceived are limited by the small energy available, they represent a poverty trap for customers because of the high further cost of moving to the next level. Until the limitations of low energy capacity and high costs change, renewable energy and non-grid supplies must be considered generally irrelevant to large scale electrification.

5 An ethical basis

Analysis of the ethics supporting electrification has identified religious obligations to help the needy, a philosophical principle of giving equal consideration to the interests of all, and political or pragmatic reasons to help the poor. From all perspectives, electrification to alleviate poverty is justifiable and even desirable.

The world does not lack the resources for social development and poverty alleviation through electrification, but the mechanisms for using the resources are insufficient. African countries, particularly, do not have a good reputation for efficiency and integrity. Financiers need to be confident that the institutions can identify suitable objectives, and use funds and technology effectively, without resource waste and benefit leakage through corruption and inefficiency. There is still a need and a role for aid and subsidies for social electrification, but they must be assessed in terms of the objectives and management.

Economic and financial studies are inappropriate for assessing social development plans because of the long term of the development and the difficulty of expressing the benefits in economic values. Instead, a social model leads to a specification for a social tariff:

> *A social tariff will be one in which a subsidy reduces the cost to customers of a fully cost-reflective tariff, including the profits of a privatised utility. The subsidy will not be so large as to damage the economy and will be derived from a source that can sustain it. Geographic uniformity will promote perceptions of fair pricing, but the subsidised tariff may be restricted in terms of the service provided. However, a social tariff should be substantial enough to make a difference in respect of the purpose for which it is intended, and must not put the beneficiaries into a poverty trap that restricts them to a limited benefit. Of course, the benefits should reach a clearly identified group of beneficiaries (the target group), with as little as possible leakage to those outside the group. A simple tariff structure will assist understanding and reduce the costs of implementing the tariff.*

Recent research into a subsidy of electricity consumption for poor customers in South Africa produced a novel self-targeted tariff consistent with the specification [8].

6 Implications

Technological, financial, social and tariff subsidy analysis lead to conclusions that …

- Social benefits cannot be delivered to households that have not been connected. Blanket electrification is appropriate to social electrification, rather than restricting supply to those customers that can best afford it. Also, a basic electricity support tariff cannot help the 30% of South African households not yet electrified. They comprise mostly poor households and consumption subsidies must be accompanied by continued expenditure on electrification.
- A specific institutional structure is relatively unimportant to success in electrification, as long as a few basic requirements are met, including having a clear understanding of objectives that are realistic, and a technological core that can meet the needs to develop and maintain networks at minimum cost. It also appears that efforts and expenditure on restructuring may not show much benefit in the long run, and in the short term could damage the efforts for electrification. Learning organisations are more effective than specific structures. Further, there may be significant value in having or retaining diversity of utility structures and sizes.
- Electricity utilities have been widely used for socio-economic and social interventions, and in developing countries this is not an unexpected role for them. However, social responsibilities complicate the utilities' more obvious goals of delivering electricity efficiently and profitably. Having established national policy, government must accept the utilities' objectives and activities. Similarly, utilities must understand that electricity supply cannot be separated from politics.
- In an electricity distribution system supplying economic customers, loss of supply arising from rationing or black-outs caused by under-design will be costly. An electrification system implemented for social objectives will have a lower penalty associated with under-design. Obviously, the optimum capacity is that which is just right, as illustrated in Figure 2, but under-design will be preferred to over-design where the costs of under-performance are relatively low. Minimum cost solutions are needed for socially directed electrification.

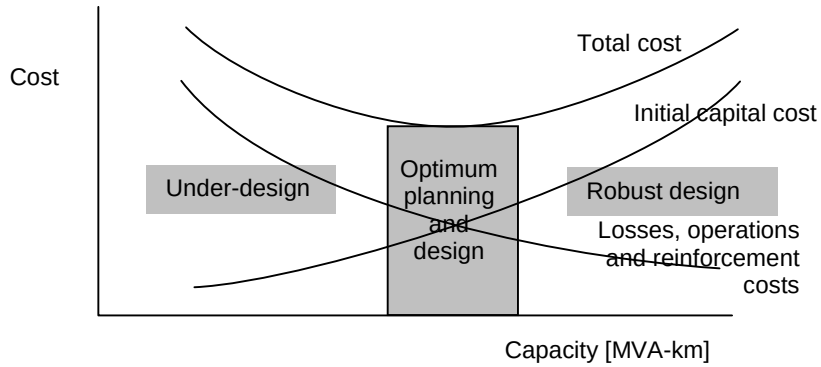

Figure 2: Variation of cost with capacity

7 Conclusions

All the decision-makers in the process of electrification need to be aware of the differences between economic, socio-economic and social objectives. Their understanding of electrification shapes the objectives, plans, and evaluations of achievements. Non-technical people need to understand the contributions that different technologies can make to meeting their objectives, and technical people need to be aware that different outcomes are required in different circumstances, and that the technologies must be correctly selected and applied.

The benefits initially expected of electrification investment in South Africa are unlikely to be achieved quickly, because they were expressed in terms of economic and socio-economic objectives. However, substantial benefits are derived from the electrification programme through its contribution to social and poverty alleviation objectives. Hindsight indicates that the confusion of objectives prevented the optimum systems being implemented at the start of the programme, but financial constraints and changes in development thinking have led to the adoption of more appropriate technologies and processes.

In future, the planning, approval, implementation and post-project evaluation is more likely to be appropriate if the objectives are identified correctly. Also, differentiating between economic and social objectives suggests an approach to defining subsidies needed from government to support non-profitable electrification, and instead of defining the boundaries of six regional distributors to obscure the differences between viable and non-viable electricity supply, an industry structure compatible with strategies of efficiency and effectiveness might be adopted.

Electricity in Africa will continue to have both economic and social impacts. Understanding the differences, and applying them to electrification, electricity tariffs and the electricity distribution industry, should contribute to better decision-making and greater effectiveness. Research to inform these processes and improve electricity distribution will continue.

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9 References

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