ELECTRICITY FOR ALL IN SOUTH AFRICA:

THE NEED AND THE MEANS

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The purpose of this paper is to provide a summarised discussion of the main issues relating to the electrification of the underdeveloped areas of South Africa. The paper starts by looking at electrification in South Africa against a global background, and then sets out the benefits of electrification. It next discusses the institutional framework of the electricity supply industry, and makes proposals for the establishment of a National Electrification Board and for the rationalisation of the structure of the electricity supply industry in South Africa. The last part of the paper deals with the resources needed for the implementation of a proposed national electrification programme.

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INTRODUCTION

Only a third of South Africa's population have electricity in their homes, a level of domestic electrification which is low even by the standards of the developing world.

Because of the needs of its mines and industries, South Africa has the world's fifteenth largest power generation capability, and Eskom is claimed to be the fifth largest generating authority in the Western world.[1,2] Eskom's generating capacity includes an unusually high level of reserve over what is needed to provide for its winter peak loads and possible plant outages, the result of its long-term planning in the early 1980's having been based on the assumption of a sustained high economic growth rate.[3] Eskom's present excess reserve capacity - equivalent to several times the capacity of Koeberg Power Station - would supply every unelectrified household in South Africa today.

The main engineering effort required in supplying electricity to all in South Africa is the building of transmission and distribution networks to take the electricity to where it is needed. The technology of these networks is mature and locally available. In many areas, however, the supply authorities which are needed to operate and maintain these systems, and to administer the service, do not exist. The problems to be tackled in the electrification of the country's underdeveloped areas are therefore primarily institutional and financial.

The purpose of this paper is to provide a summarised discussion of the main issues relating to electrification. The paper starts by looking at electrification in South Africa against a

global background, and then sets out the benefits of electrification. It next discusses the institutional framework of the electricity supply industry, and makes proposals for the establishment of a National Electrification Board and for the rationalisation of the structure of the electricity supply industry in South Africa. The last part of the paper deals with the resources needed for the implementation of a proposed national electrification programme.

This paper is based on research being done for Eskom and the National Energy Council, who the author wishes to thank for their financial and other support. This research has included a review of international and South African literature on electrification, visits to supply authorities in a number of countries and to international development agencies, surveys and case studies in several parts of South Africa, and discussions with a wide range of interested people and organisations.

ELECTRIFICATION WORLD-WIDE

The population of the world is just over 5000 million. Of this number, some 1500 million live in the industrialised countries, and virtually all have electricity in their homes. Some 3500 million live in the developing countries, mainly in Asia, Latin America, and Africa. An estimated 1500 million of these have electricity. Overall levels of electrification are thus about 60 percent globally and 40 percent in the developing world. [4,5,6]

Electrification in the urban centres of the developing world is generally at a relatively high level, averaging perhaps 70 percent of households, but in rural areas it is much lower, at around 30 percent. Levels of electrification are generally far higher in Asia and Latin America than in Africa, where it is estimated that only 5 percent of the rural population have electricity. There is some correlation between per capita GNP's and levels of electrification, with notable exceptions. For

example, Asia generally has substantially lower GNP's than Latin America, but has a comparable degree of electrification. China has a per capita GNP of only US$300, but virtually its entire urban population, and three-quarters of its rural population, have electricity.[4,5,7]

The current level of expenditure in the developing world on electrification projects in rural areas alone is estimated at US$5000 to 6000 million per annum[4], which in turn brings electricity to some 30 to 50 million more people each year.

Examples of countries which are allocating significant resources to electrification are Costa Rica, Brazil, and Thailand. All three have per capita GNP's lower than South Africa. Their programmes are briefly discussed below.[8]

Costa Rica is committed to electrification as part of its government's objective of attaining a certain minimum standard of living for all. The level of urban electrification is high, and despite its mountainous and difficult terrain, 75 percent of the country's area is served with electricity. The government's target for the year 2000 is that 90 percent of the country's area, and virtually the entire population, should have electricity.[9]

Brazil has a distribution of income which has a skew similar to that in South Africa. The World Bank comments that although a high degree of income inequality persists in Brazil, substantial progress has been achieved in poverty alleviation, and in this regard the World Bank considers Brazil's electrification programme as being of particular significance.[10] Current levels of electrification are over 90 percent in urban areas, and about 65 percent overall. Many shanty areas are being electrified as part of a policy of accepting their existence and devoting resources to upgrading them.

Virtually all urban households in Thailand, and 70 percent of rural households, have electricity. A central aim of government policy is to aid rural development through the provision of roads, irrigation facilities, and electrical services. Electrification targets and detailed project proposals have formed part of successive National Economic and Social Development Plans, and the most recent (for 1987-1991) sets a target of 95 percent of rural settlements being electrified by 1991.[11] The Provincial Electricity Authority (which covers all areas apart from Bangkok) has each year over the past decade provided supply to some 400 000 new consumers[12], which is an annual rate of four times the total number of houses electrified in Soweto.

ELECTRIFICATION IN SOUTH AFRICA

The electricity supply industry in South Africa has a plethora of licensed supply authorities. In addition to Eskom, there are more than 400 municipal electricity undertakings[1], as well as other sundry suppliers, such as the Department of Development Aid (in the "self-governing territories"), the Regional Services Councils, the Community Services sections of the Provincial Administrations, the House of Representatives (in certain "Coloured" areas), and the electricity corporations in the "independent states" of Transkei, Bophuthatswana, Ciskei, and Venda. This fragmented structure should be seen in contrast to the consolidated and rationalised structures found in almost all other countries (Britain, Brazil, Australia, Greece, and Canada being a few examples). In these countries generation is done nationally or on a regional basis, with a small number of regional distribution authorities being responsible for retailing to all users within their designated supply areas.

The low level of domestic electrification in South Africa can largely be attributed to the structure of the supply industry, and to the fact that the majority of the population have no

franchise at the national level and effectively no franchise at the local level, leaving them without conventional political influence over the supply industry. The white-controlled municipalities have fully electrified their white urban areas, but, with some exceptions (for example, Durban and Cape Town), have had neither the will nor the incentive to allocate capital to the electrification of the townships on their periphery. Eskom has historically seen its role as being that of bulk supplier to the municipalities and to other large users[13], and hence it has only some 220 000 small consumers, of which about half are farming supplies[3]. The various other licensed suppliers mentioned in the previous paragraph are generally not well equipped, in terms of either finance or skills, to make any appreciable impact. Nor, in most cases, is the supply of electricity their prime objective. The country's black population, and to a lesser extent those classified "Coloured" or "Indian", have simply been left out - no part of the supply industry structure has seen itself as having a clear responsibility or obligation to supply the disenfranchised section of the population.

Although some of the larger black urban areas are fully electrified, more than 80 percent of formal townships have little or no electricity.[14] The overall level of electrification in this sector is perhaps 30 percent.[15] In addition, some 5 million people live in unelectrified informal housing in and around the cities.[16] The "homeland" areas have a very low level of electrification, and it is confined almost entirely to the urban centres. There are, for example, only some 10 000 consumers in Transkei[17], which means that about 2 percent of households have electricity, and consumers in all other "homeland" areas (both "independent" and "self-governing") total no more than several tens of thousands. Another significant group is the more than four million farm workers and their dependants living on predominantly white-owned and

electrified farms. Only some 15 percent have electricity in their houses.[18]

In summary, South Africa has some 2,4 milliom domestic electricity consumers.[19,1,3] On the basis of an average of 5 occupants per household (which is perhaps high, given the middle-class status of the majority of these consumers), this means that some 12 million people live in electrified households. (Eskom gives an estimate of 13 million).[3] The projected mid-1990 population of South Africa (including the "homelands") is 37,7 million.[16] Thus about one third of the country's population have electricity in their homes.

THE BENEFITS OF ELECTRIFICATION

This section briefly sets out what may be considered the case for electrification. Electricity is not of course always the highest priority: an adequate and convenient supply of clean water is usually a higher priority in those areas which have neither electricity nor water.[20]

Present fuel usage patterns in unelectrified areas in South Africa range from an almost total reliance on fuelwood and dung in certain rural areas, to an almost total reliance on commercial fuels (such as coal and paraffin) in urban areas, with many intermediate combinations, dictated by local conditions. Candles and batteries are widely used throughout.[21]

The case for the electrification of urban areas is clear cut on economic grounds alone: numerous surveys, starting with that conducted by the Department of Health in 1977[22], have found that unelectrified urban households spend considerably more (around 1,5 times as much) on energy than do electrified households. These findings apply to both formal townships and informal (or shanty) areas. Survey data from various parts of the country shows that rural households spend an average of around R40 per

month on fuel, candles, and batteries.[20,21] This figure suggests that electrification would also be justified on economic grounds alone in many of the higher density and more prosperous rural settlements (such as the "commuter belt" villages around Umtata, for example).

The widespread use of fuelwood in rural areas incurs both an environmental and a social cost. The environmental cost is obvious and serious: it exacerbates the severe deforestation that is evident in many areas. The social cost is in the time and effort required for fuelwood collection, and the impact this has on family life and on the potential for economically productive activities. Several hundred million person-hours are spent on fuelwood collection in South Africa each year.[23,24]

Electricity greatly enhances the quality of domestic life. It is the most convenient, clean, versatile, safe, and, generally, the most economical, form of domestic energy. It provides access to convenient and good quality forms of lighting, heating, cooking, and refrigeration, as well as to sound systems, television, and a wide range of appliances and tools. Refrigeration, for example, offers in turn important economic and nutritional benefits, as it enables householders to switch from preserved to fresh foods.

Currently used forms of energy cause significant health-related problems in the form of respiratory ailments from the combustion of fuels in confined spaces[25], accidental burns (particularly to children), loss of life through fires (notably in shacks), eye strain from reading or studying in poor light, and wide-area atmospheric pollution.

Electricity is a prerequisite for appreciable decentralised economic growth. It will give impetus to the informal sector and allow for the spread of service industries away from the major urban centres. The setting up of light manufacturing

industries also becomes possible in economically depressed areas. Certain types of agricultural production, such as chicken farming, dairying, and the growing of crops requiring irrigation, will also benefit.

Electricity will enable schools and clinics to make use of electrically operated equipment and so function more effectively. It will also enable these facilities to be used at night.

Electrification is widely believed to have long-term socially beneficial effects, which are, however, often intuitive and not easily measurable. Literacy, for example, has been positively correlated with household electrification, although the direction of causality is not easy to determine. An improvement in the quality of rural life could encourage more people to remain on the land. (This was part of the US government's rationale in the 1930's when they embarked upon their rural electrification programme). It is also widely held that an improvement in standard of living will lead to a drop in the birth rate, and electrification will obviously contribute. Access to television will lead to a better informed rural population, with the result, it has been suggested, that they will feel a greater sense of identity with the country as a whole. And very importantly (particularly in the South African context), electrification will go some way to reducing the disparities in standards of living that exist among the various sections of the population.[4,26]

The value placed on domestic electricity is confirmed in various studies and reports. A USAID study in four countries, for example, found that, "Generally, people wanted electricity, valued it highly, and were willing to sacrifice to get it".[27]

THE NEED FOR A NATIONAL ELECTRIFICATION PROGRAMME

In 1987 Eskom stated that it planned "to intensify its efforts to assist in speeding up electrification of South Africa's developing urban and rural areas", and since then it has given prominence to the objective of "electricity for all at an affordable price".[28,29] In pursuance of this objective, Eskom has implemented a number of pilot projects, such as that at KwaNobuhle adjacent to Uitenhage, and is now involved in a total of 48 projects in various stages of progress, from negotiation to customer connections.[3] Eskom states that, "These [projects] represent a major step towards the target of one million homes which Eskom plans to electrify over the next five years [1990-94]", although Eskom adds the proviso that, "This can be achieved if the required capital is raised".[3]

It is proposed here that Eskom's initiative should now be broadened and formalised into a publicly available long-term national electrification plan, compiled in consultation with all interested parties. Such a plan is needed because of the scale of what needs to be done and the resources that will be required, because of the policy decisions which need to be made and clearly set out, and because of the importance of focussing and co-ordinating the efforts of all who will be involved. These include government, financing agencies, Eskom, municipalities, representatives of the communities concerned, equipment suppliers, the appliance industry, other infrastructural development bodies, contractors, consultants, and training institutions. Developing an electrification plan at national level in conjunction with organisations enjoying broad-based support among the communities concerned, would go a long way to overcoming what Eskom refers to as "the social and political barriers which stand in the way of electrification".[3]

This national electrification plan would form the foundation for a national electrification programme. The basic plan would need

to be supplemented by medium-term (say five-yearly) and short-term (say annual) plans setting out updated policies and objectives and specifying actual areas to be electrified. (The Thai government's five-yearly electrification plan, for example, provides detailed information of this nature).[30] The institutional framework needed for the implementation of this national electrification programme is discussed in the next section.

The following is an estimate of the scope of a comprehensive programme. As was noted earlier, only some 12 or 13 million people in South Africa currently live in electrified houses. There are therefore 25 million who do not. Surveys in various unelectrified areas have shown average household occupancies of 5 to 7 people, implying some 4 million unelectrified households in South Africa.[20,21] A programme to electrify this backlong over say 20 years would require an average of 200 000 new connections each year. Furthermore, the country's population is at present increasing at a rate of almost one million per year[16], which translates to some 150 000 new households per year. A national electrification programme aiming at virtually complete electrification within two decades must therefore provide supply to some 350 000 households per year over that period. This figure is corroborated by a study made of electrification programmes in six other countries, which in all cases showed an electrification rate of between 10 and 13 new connections per year per 1000 of population in the supply area.[8] Applying the lower figure to South Africa gives a rate of around 375 000 households per year.

A major policy issue will be the setting of priorities, both among the various sectors (formal townships, informal or shanty areas, rural areas, and farm workers), and within each sector. For example, although it may seem obvious to start by electrifying all urban areas, this could have the undesirable effect of accelerating migration to the cities. Other obvious

and important areas requiring policy decisions are financing, the organisational structure of newly established local distribution authorities, tariff structures and levels, metering and billing methods, and the allocation of responsibility for the programme among existing and newly established supply authorities. These issues are all political in the broadest sense of the word. Acceptance of these policy decisions and commitment to them by all concerned will require broad and representative participation in their formulation.

A formal national electrification programme will give direction and pace to the electrification effort. It will give coherence and commitment to the efforts of those involved in providing the supply. And it will enable the eventual users (households, businesses, and health, education, and water authorities, for example) to plan their efforts and capital expenditure in the optimum way as they prepare for electrification.

THE REQUIRED INSTITUTIONAL FRAMEWORK

This section looks at two aspects of the institutional framework required for electrification. Firstly, who should formulate and drive the national electrification programme? Secondly, who should distribute the electricity to the end user? The third role, that of bulk supplier to the distribution authorities, clearly belongs to Eskom.

The planning and co-ordination of the programme will require broad-based participation, preferably with public accountability. To achieve this, I would propose the setting up by the government of a small semi-autonomous body, called, for example, the National Electrification Board (NEB). The NEB would be responsible for policy formulation, for setting targets and priorities, and for allocating funds to distribution authorities in the form of long-term loans. Board members would be part-time and would be drawn from, among others, the

government itself, financing agencies such as the Development Bank, the unelectrified communities, the electricity supply industry, and the private sector. Full-time NEB staff would administer the programme and provide technical and managerial assistance to its borrowers.

A number of countries (for example, Jamaica, India, and Ireland) have taken this approach of setting up a separate body to give impetus to electrification (particularly of rural areas).[26] A notable example comes from the USA where the Federal Government set up the Rural Electrification Administration (REA) in 1935 to administer a programme to electrify the country's rural areas. This was done by the REA in conjunction with over a thousand rural electricity co-operatives, set up with the help of the REA and owned and run by the consumers themselves. This very successful structure is still firmly in place and covers three-quarters of the country. The REA's role has been to make long-term loans to the co-operatives (from Federal funds); to draw up standard specifications and designs for materials, equipment, and systems; to establish a standard monthly and annual financial reporting system for its borrowers; and to provide ad hoc technical and managerial assistance to the co-operatives.[31]

As noted in a previous section, the existing supply industry structure in South Africa is not geared to distributing electricity in most of the country's underdeveloped areas. This structure is defective both because it is so fragmented and because it was set up primarily to serve only the developed and enfranchised sectors.

These structural defects in the distribution section of the electricity supply industry could be remedied by rationalisation of the industry, perhaps into a structure comprising a bulk supplier (Eskom) and say 10 to 20 area distribution boards covering the whole country. Each board would be responsible for supplying all users (and would-be users) in its designated area.

Rationalisation would not only enable electrification to proceed more quickly; it would also remove the need for more than 400 municipal electricity supply departments, and lead to a more effective use of technically skilled people. An obstacle to rationalisation is that municipalities who distribute electricity have a vested interest in continuing to do so. Profit generated from electricity sales is used to subsidise rates. (In the 1988/89 financial year, for example, the electricity department of the Cape Town City Council transferred a "trading surplus" of R41 million to the city's coffers).[32] Furthermore, electricity revenue is a component in the formula used in the grading of municipalities, and hence in the determination of the salaries of senior officials.[33]

Eskom's approach to distribution in the electrification initiative that it started recently, is to set up a small local distribution authority in each area to be electrified. In KwaNobuhle, for example, Eskom, in conjunction with local industry, has set up a joint venture company called Kwanolec. Eskom and its partners have put in R4 million in the form of share capital, while R25 million has been made available in the form of a loan from the Development Bank of Southern Africa.[34] Eskom are providing management and technical personnel on a contract basis. Eskom's approach of using newly-created authorities to carry out distribution stems logically from its policy of remaining primarily a bulk supplier, but it has the disadvantage of compounding the problem of the fragmentation of South Africa's supply industry - within a decade the country could have a thousand supply authorities. The longer rationalisation is delayed, the more complex and intractable the problem will become.

As it is possible that electrification projects will continue for some time to be implemented by means of newly-created local distribution authorities, careful consideration needs to be given to the form of their organisational structures. Two

guidelines are offered here. Firstly, the structure should not be such as to subsequently complicate or impede rationalisation. This could be the case, for example, with privately owned organisations, as share-holders would be looking for long-term profitability. Secondly, consumers should have constitutional participation in the control (and perhaps ownership) of the organisations. A model based on the USA rural electric co-operatives could be successful.

In summary, the existing structure of the electricity supply industry in South Africa is unsatisfactory and deficient. It not only represents a major obstacle to the electrification of underdeveloped areas, but also results in the sub-optimal use of national financial and human resources. The government is urged to address these issues.

THE COST OF A NATIONAL ELECTRIFICATION PROGRAMME

The following estimates (in current Rand values) cover the costs of the required distribution networks, from the incoming bulk supply point for each area up to and including the consumers' meters. House-wiring is normally the consumer's responsibility (although utilities do sometimes make loans available for wiring and the purchase of appliances). Wiring costs can vary from around R150 for a board equipped with an incoming breaker and several socket outlets (the "Rediboard"), to conventional permanent installations costing upwards of R1000.

Distribution costs are normally estimated in terms of the cost per household served. This will vary with the density of the housing, the type of installation (for example, underground cable or overhead wires), and the level of load per household for which the system is designed. There will, in addition to long-term inflationary trends, also be short-term fluctuations in material and contracting costs.

Current distribution costs are generally in the range R1500 to R2500 per household, where the higher figure reflects the cost of electrifying rural settlements in an area such as Ciskei. For the present purpose I shall use the mid-point value of R2000 per household to allow for a mix of urban and rural electrification.

As indicated earlier, electrification would need to proceed at a rate of around 350 000 households per year if virtually full electrification is to be achieved in two decades. At that rate, electrification would thus require capital expenditure of around R700 million per year.

To put that figure into perspective, it is equivalent to 18 percent of Eskom's current level of capital expenditure of R4000 million per year.[3] It is also just 1 percent of the government's 1990 budgetted expenditure figure of R70 billion.

Virtually all of the required equipment and material is manufactured in South Africa. A relatively small amount of foreign curency will, however, be required to cover the cost of certain imported components and raw materials.

GENERATION IMPLICATIONS

In virtually all cases, even in rural areas, the technically and economically optimum energy source will be centrally generated power distributed through the grid, and the figures given in this section are formulated on that premise. However attractive the notion of using renewable sources, such as sun or wind, may be, the problem is that these technologies are at present not nearly economically competitive. Small hydro schemes may be attractive in certain areas, but they carry heavy engineering and project management overheads. Diesel generation may sometimes provide a short-term solution pending grid extension,

after which the same generating set may again be used as a temporary source elsewhere.

Domestic load levels are usually given in terms of the "after diversity maximum demand" (ADMD) per household, which is defined as the maximum power demand of a group of households divided by the number of households in the group. The ADMD figure takes into account the fact that individual households in a group impose their individual peaks on the system at different times, so that the ADMD per household is considerably less than the maximum demand of individual households. The larger the number of households, and the greater their geographical spread, the lower will be the ADMD per household, because of the diversity in their domestic routines.

On a country-wide basis, a safe maximum figure on which to base estimates would be an ultimate ADMD of 1,5 kW (kilowatts) per household (that is, at the end of a transition period of several years during which the major household appliances would be installed). On that basis, the electrification of some 7 million households over twenty years would produce an ultimate combined load of some 10 500 MW (megawatts), which is coincidentally just equal to Eskom's present reserve generating capacity (as shown in the next paragraph). The net additional generating capacity required would, however, be less than this amount, because of a diversity (different time of occurrence) between the day-time industrial peaks and the early evening domestic peaks. In other words, although some extra capacity will be required for the small increase in the day-time peaks brought about by the additional low-level day-time domestic load, the total capacity required for the day-time load may well be close to, or even exceed, that required for the early evening when the domestic load is at its peak. Therefore the additional capacity required would be somewhat less than the newly-created domestic peak load of 10 500 MW taken on its own. Composite load curve projections of this type are, however, difficult to

make, particularly in view of Eskom's proposed introduction of a time-of-use tariff for large users, which is likely to affect current usage patterns.[35]

At the end of 1989 Eskom's generating capacity was 32 400 MW (excluding Cahora Bassa), as compared with the 1989 peak demand on its system of 21 900 MW, which means that its reserve capacity is some 10 500 MW.[3] Eskom is delaying the completion of partially completed power stations for as long as is contractually possible, and current projections are that its generating capacity (including sets on order and Cahora Bassa) will be fully used only by the turn of the century. Additional domestic electrification will therefore have little impact on generation capacity for the next decade.

The additional electrical energy consumption in the domestic sector at end of the projected 20-year electrification period would be some 35 x 10^9 kWh (kilowatt hours) per annum (based on a total of 7 million households using an average of 5000 kWh per annum), which is a quarter of the country's current consumption and 12 percent of projected total national consumption in the year 2010 (based on the present annual growth rate in Eskom's sales of about 4 percent).[3]

EMPLOYMENT IMPLICATIONS

Electrification will have employment and economic implications in four main sectors: power systems equipment suppliers, the appliance industry, contracting, and the supply industry itself.

The cost of electrifying 350 000 households per year will be about R700 million. Wiring and appliances will cost households on average perhaps R2000 each, or a further R700 million per year (although individual households will probably spread this expenditure over a number of years). Thus equipment and appliance suppliers, their associated commercial sectors, and

the contracting industry, will benefit from a combined total annual injection of some R1,4 billion. If half of this amount goes into wages for semi-skilled and unskilled workers, it will result in the creation of some 50 000 jobs in those sectors.

Electricity distribution authorities normally have consumer to employee ratios ranging from 100 to 1 in the less developed countries to 250 to 1 in the developed countries.[8,26] Ratios in South Africa tend at present to be at the lower end of this range. Electrification at the proposed rate would thus require an increase in the number of people employed in the supply industry of up to 3500 per year, or a total of 70 000 over a 20-year period (which is about the number employed in the industry at present). Perhaps a thousand of these would be professionals (mainly engineers and accountants), with support from several thousand technicians and artisans. A large proportion of the rest would require in-house training for system operation and administrative functions.

A perception in the supply industry in South Africa is that human resources are not always used in the most efficient manner. Rationalisation of the structure of the industry, together with improved training and management, is needed to contain the growth in employee numbers as the electrification programme proceeds. The estimates given in the previous paragraph could then be significantly reduced.

FINANCING THE PROGRAMME

Are electrification programmes in underdeveloped areas able to pay for themselves? For any particular scheme this will obviously depend on a number of factors, but, in general, urban schemes will usually pay for themselves in the long run, while rural electrification will usually need subsidisation.

The following is an illustrative cash flow projection for a "typical" urban case. Assume a system cost of R2000 per household served, an interest rate of 15% p.a., an inflation rate of 10% p.a., a level of usage of 4000 kWh per household per year (reached in year 5 after equal annual load increments), and a tariff which initally provides for a loan repayment component of 5 cents per kWh (implying a tariff of about 15 cents per kWh), with annual increases in line with inflation. Under these conditions, the total outstanding debt per household served will rise initially, peaking at about R3600 in year 11, after which it will decrease to zero in year 20. In present value terms (as seen from the beginning of the loan period), the total outstanding debt will remain approximately constant (at around R2000) during the first four years, after which it will decrease steadily to zero. (The interest and inflation rates used here are lower than current rates in South Africa, but similar cash flow projections would be obtained using rates of say 20% and 15% respectively).

This cash flow projection shows that urban electrification schemes can pay for themselves, but with two important provisos: firstly, that the loan finance is structured so as to carry the build-up of additional debt during the first ten years or so; and, secondly, that annual tariff increases approximately in line with inflation would be politically acceptable.

Rural electrification schemes, by comparison, will be more expensive, because of lower consumer densities. Electricity consumption levels will moreover be lower, because of lower household income levels and the availability of a certain amount of free fuel from natural sources. These schemes will therefore require long-term (although not necessarily permanent) subsidisation.

The World Bank experience is that rural electrification projects have always required subsidisation.[36] Furthermore, this has

been true not only in the developing world. Rural electrification has been (and is still) subsidised even in the USA, where the rural electric co-operatives built their systems with 100 percent financing from Federal loans repayable over 35 years at an interest rate of 2% p.a.[37]

Thus, in general, electrification schemes in underdeveloped areas have long pay-back periods and hence need long-term financing. Load and revenue build-up is slow, and loans must therefore be structured with grace periods before repayments commence, or with provision for additional shorter-term financing to cater for the initial increase in the amount owing. Schemes in rural areas, and possibly in some urban areas, will require subsidisation.

TARIFFS, METERING AND BILLING

The domestic tariff in the newly-electrified black urban areas (such as KwaNobuhle) is being set at a slightly subsidised rate of around 16 cents per unit of energy (kWh). This subsidy is in the form of loans (to cover the capital cost of the systems) which are at a rate of interest several percentage points below the commercial rate. The current domestic tariff in the large established municipalities is, however, much lower, at around 10 cents per unit. There are two reasons for the lower rate in these areas. Firstly, the distribution networks have been built up over several decades and are now substantially paid for, so that the loan repayment component in the tariff is low. Secondly, the established municipalities supply to a mix of consumer types (industrial, commercial, and domestic), whereas the consumers in the newly-electrified areas are predominantly domestic. The greater variety of consumer types means that the established municipalities have a more even demand pattern, and hence a higher "load factor". In terms of Eskom's current two-part tariff, the average cost per unit falls significantly as the load factor increases.

Thus, although there may well be sound economic justification in each case for the tariff levels set by the individual supply authorities, this multiplicity of suppliers is leading to widely differing rates being applied in adjacent areas. The residents of Khayelitsha and KwaNobuhle, for example, pay some 50 percent more for their electricity than their counterparts in Cape Town and Uitenhage. Seen from a wider regional perspective this disparity could be considered economically indefensible and politically unacceptable. To avoid predictable and understandable conflict on this issue, urgent steps are needed to bring about an equalisation of tariffs on a regional, if not a national, basis. The long-term solution lies in the rationalisation of the structure of the electricity supply industry, with the application of uniform regional or national tariffs. This is the practice in almost every country in the world.

Metering and billing of domestic consumers in South Africa has traditionally been based on monthly meter readings and accounts. The recent development of economically priced pre-payment meters using credit-card type magnetically encoded tokens, has, however, provided an alternative with many advantages over the existing system. The main benefits of pre-payment metering are reduced administrative costs, earlier receipt of revenue, elimination of bad debt, and the ability consumers have to budget their electricity usage (by means of an indication on the meter of the remaining credit). These meters have successfully been introduced in a number of new projects, and consideration is being given to their replacing traditional meters in certain long-electrified areas, particularly where bad debt is a problem. It is likely, therefore, that pre-payment metering will be the norm in newly electrified areas, and that it will moreover gradually replace existing conventional metering and billing systems.

CONCLUSIONS

The main conclusions to be drawn are as follows:

1. The level of domestic electrification in South Africa is about 33 percent. This is just over half the average global level and somewhat less than the average level in the developing world.

2. The low level of domestic electrification in South Africa can largely be attributed to the fragmented structure of the electricity supply industry, with no part of the existing structure having a clear responsibility to supply the disenfranchised section of the population.

3. A case for the electrification of urban households can be made on economic grounds alone: unelectrified urban households spend some 50 percent more on energy than do electrified households.

4. Electrification offers many further immediate and long-term benefits in terms of quality of life, health, reduced deforestation, and economic and social development.

5. The current electrification initiative should be broadened and formalised into a long-term national electrification programme, with stated policies, targets, and priorities.

6. A national programme aiming at virtually complete electrification within two decades must provide supply to some 350 000 households per year over that period. This will require capital expenditure of about R700 million per year.

7. The national electrification programme should be formulated, driven, and co-ordinated by a National

Electrification Board, with widely representative membership.

8. Urgent attention needs to be given to rationalising the structure of the electricity supply industry, both to optimise the use of resources and to facilitate the electrification programme.

9. Because of Eskom's present high level of reserve generating capacity, additional domestic electrification will not affect Eskom's plant requirements for the next decade. At the completion of the projected 20-year electrification programme, the additional domestic consumption of electrical energy will be 12 percent of projected total national consumption.

10. The electrification programme will create some 50 000 jobs in the electrical manufacturing and contracting industries, and ultimately up to 70 000 new jobs in the electricity supply industry.

11. Urban electrification schemes will be able to pay for themselves in the long-term provided that the losses in the initial stages can be carried and that tariff increases in line with the inflation rate will be acceptable. Rural schemes will, however, require subsidisation.

12. Tariffs in newly electrified areas are some 50 percent higher than in adjacent established municipal supply areas. This is likely to prove politically unacceptable. Urgent steps are needed to bring about an equalisation of tariffs on a regional or national basis.

13. Recently developed pre-payment meters offer significant advantages over traditional metering and billing systems. Their widespread use is likely both in newly electrified

areas and, ultimately, in areas which are already electrified.

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