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South Africa's rapid electrification programme: Policy, institutional, planning, financing and technical innovations

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ABSTRACT

This paper documents South Africa's electrification programme from the late 1980s to the present. The primary aim of the paper is to present the reader with an overview of the policy, institutional, planning, financing and technological developments and innovations that resulted in more than 5 million households receiving access to electricity between 1990 and 2007. Key aspects include the way in which a period of political change and policy disruption were essential to the programme's initiation, and the critical role played by organisations and individuals outside of national government in helping shape new electrification policies and strategies. In addition, the paper identifies the contribution of technology development in cost reduction and achieving the social aims of the programme. Several lessons may be drawn from the institutional and planning arrangements that the South African programme has developed, the significance of the development of appropriate cost-driven technical innovations and standards, and the acknowledgement of the social function of electrification and its funding from the fiscus (rather than through cross-subsidies).

1. Introduction

South Africa's electrification programme is remarkable by most measures. Prior to 1990, less than a third of the population had access to electricity. By the end of the decade, that proportion had doubled. This paper documents the programme, which had its roots in the late 1980s, was in full swing by 1994, and continues currently with the stated aim of achieving access for all households to electricity by 2012.[1] In addition, the paper reflects critically on key aspects of the programme, including policy, institutional, planning, financing and technical innovations as well as social and economic impacts.

1.1. The state of electrification by the late 1980s

The watershed event, which provided the impetus for all the policy and institutional shifts underpinning the electrification programme, was the demise of apartheid and the election of a post-apartheid government in 1994. Apartheid policies left two key legacies: first, a stark contrast between rich and poor, which was largely racially defined; and second, a history of racially determined differentiation in infrastructure provision. The UNDP's Human Development Index (HDI) for South Africa in 1988 indicated that while white South Africans ranked above average by comparison to industrialised countries, black South Africans ranked with low-income developing countries (Stats SA, 2000, p. 101); the poorest 20% of the South African population between 1987 and 1994 ranked 33% lower than the developing country average, and markedly lower than the same segment in middle-income developing countries with similar average incomes to South Africa (Stats SA, 2000, p. 103).

A disparity was also seen in access to basic services and infrastructure, including electricity. The 1996 census, the first census in South Africa that surveyed the whole population, indicated only 58% of the country's population had access to electricity, and only one in four non-urban black South African households was electrified, as opposed to 97% of non-urban white households (Stats SA, 2000, p. 90).[2]

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[1] This aim is referred to as 'Universal Access', and was stated as a policy goal for 2012 by President Mbeki in 2004 in his State of the Nation address; however, what exactly 'Universal Access' implies varies between stakeholders, as discussed briefly in Section 2.3.2.

[2] Although not representing the whole population, surveys were carried out before the 1996 census, with the following findings. At the beginning of the electrification programme, in 1990, the situation was much worse: by comparison to countries with similar income levels (Argentina—88%, Venezuela—86%, Costa Rica—85%, Thailand—75%, Brazil—65%), the estimated proportion of households with access to electricity in South Africa was only 35% (Eberhard and Van Horen, 1995, p. 48).

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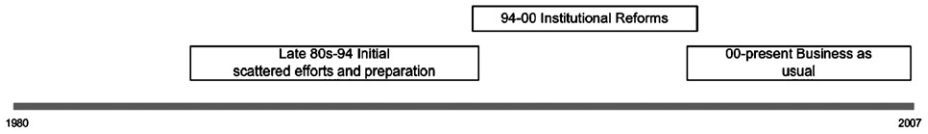

Fig. 1. Policy and institutional phases.

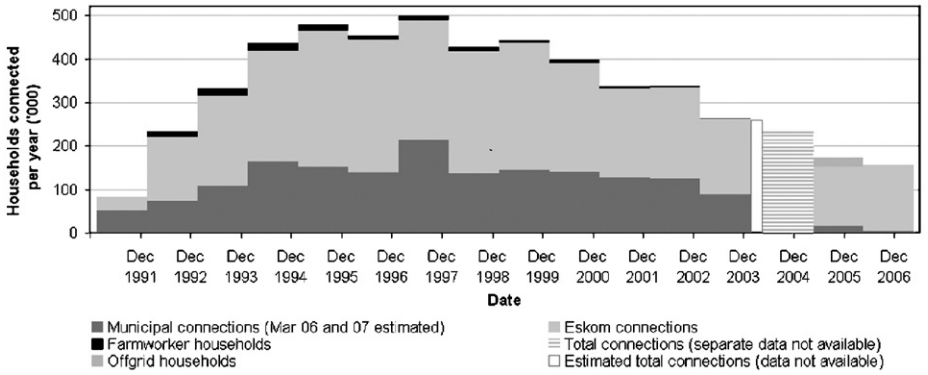

Fig. 2. Annual new household electricity connections in South Africa (Bekker et al., 2006).

2. Policy, institutions and planning

Although challenges were many, in 1990, at the beginning of the electrification programme, South Africa possessed an extremely energy-intensive economy, a world-class electricity supply industry in the form of the state utility Eskom, and a 55% reserve margin due to overbuilding in the 1980s; moreover, the same utility had been involved (albeit on a small scale) in a programme to electrify rural white farmhouses since the 1940s.

Thus, the electricity sector faced few of the usual barriers to electrification in developing countries, viz. lack of access to capital, lack of skills and lack of supply infrastructure. In addition, much of the initial demand was for urban electrification, a process far less costly and labour intensive than rural electrification.

The main barriers to widened access to electricity in the late 1980s were institutional and political. Both barriers were swept away by the democratic transition in the early 1990s, which provided not only a fundamental shift in the political landscape, but also an unusual institutional environment for policymaking. During the initial negotiation process, much policymaking moved from the state to stakeholder forums, as anti-apartheid political groupings began to change the content and scope of the policy agenda significantly.

The process that led from initial scattered efforts to the strong appearance of the electrification programme on the policy agenda, with associated firm political backing, may be defined as the first of three policy, institutional and planning phases within the context of the electrification programme, as shown in Fig. 1.

From a policy and an institutional point of view, the period from 1994 to 1999[3] may be regarded as a transitional period, during which apartheid frameworks and policies were dismantled or reformed, a new constitution was adopted, new government institutions were created at national, regional and local levels, and other institutional reforms were carried out in many areas of government. This period may be represented as the second policy and institutional development phase in Fig. 1.

From around 2000 onwards, these institutions began to function effectively (in most cases), and policymaking and governance returned to 'business as usual' (phase three). Annual connection rates dropped to lower levels (as shown in Fig. 2) and the programme was formally institutionalised in government.

In delineating the key policy, institutional and planning events and decision moments of the programme, the most coherent approach follows these three phases.

2.1. Phase 1: initial scattered efforts and preparation

2.1.1. Defining the problem of electrification in South Africa

The 'first wave' of electrification policy usually involves the electrification of the economy as a whole, with the associated establishment of institutions to regulate and facilitate the orderly expansion of electricity systems. A 'second wave' of electrification policies may be identified that responds to the problem of including areas of national economies, which do not meet criteria for electrification under existing institutional arrangements (most often expressed as financial criteria), generally leading to various forms of institutional innovation. One of the primary motivations for second-wave electrification is developmental, as electrification has the potential to promote local economic development, and may resolve problems of 'energy poverty'—economic penalties paid by low-income households for using low-quality energy carriers.

From a policy perspective, the development of second-wave electrification policies requires the establishment of electrification as a public problem,[4] which, as alluded to above, depends on the

[3] The African National Congress (ANC) won the 1994 elections by a large margin, and consolidated its majority in the next two elections in 1999 and 2004, thus providing a high degree of political continuity in the immediate post-apartheid era.

[4] The theoretical approach, which has been taken here to policy agenda-setting, involves treating policy problems as socially constructed rather than as a reflection of existing 'troubles' (see for instance Kingdon (1995) for a more extensive exegesis). While the members of a specific society are beset by many troubles, only a small number of these get onto the policy agenda. Policy problems are thus the outcome of a specific policy environment rather than a mere reflection of a societal problem.

portrayal of existing institutional arrangements as inadequate in relation to national goals. In most instances in developing countries, this is brought about by the disparity between narrow economic criteria within the electricity system and broader development goals.[5]

In the South African context, the fact that apartheid excluded most of the population, including almost all of the poor, from electoral politics, in turn meant that energy poverty remained off the policy agenda. Interest in energy poverty problems in state agencies began to emerge in the 1980s, but was marginalised in key decision-making structures.

The first significant attempts to quantify energy use in low-income households were documented by Eberhard (1984, 1986); this work was influential in the work of Dingley (1987, 1990), who proposed the idea of a national electrification programme. The social crisis faced by the apartheid state at the end of the 1980s, coupled with the dramatic political changes occurring with the beginning of the negotiation process, resulted in the rapid formulation of electrification as a definable problem in the beginning of the 1990s.

The electrification problem existed in two different frames, which would later compete for institutional and policy dominance. The first frame, pioneered by the work of socially oriented policy analysts like the Energy and Development Research Centre (EDRC) in the late 1980s and early 1990s, was based on an analysis of low-income household energy use: electrification was seen as one (and probably the most important) of a range of co-ordinated interventions to ameliorate energy poverty (Eberhard and Van Horen, 1995), and thus electrification policy was a subset of energy policy, and should be integrated into a complete energy policy framework.

The second frame, inherent in the approach of Eskom, local authorities[6] and to a certain extent, the African National Congress' (ANC) Restructuring and Development Programme (RDP),[7] was based on the understanding of electrification as infrastructure development; it should thus be integrated with other service-oriented infrastructure development processes, and located institutionally in the same place as other forms of infrastructure development.

2.1.2. Institutional structure in the late 1980s

One of the key factors determining the form of the programme, as well as its ultimate outcome, was the institutional structure of the electricity industry in the late 1980s. Historically, the industry had been divided into two main spheres of influence, with Eskom,[8] the state electricity utility, responsible for generation and transmission, and distribution undertaken by both Eskom and local authorities.

Because of the local and regional government institutions of the apartheid era, development of electricity distribution infrastructure was highly uneven. Under the 'grand apartheid' policies of the 1960s and 1970s, a significant proportion of the rural population were hived off into 'independent' or 'self-governing' territories, and independent electricity distribution authorities were set up. At the time, these were some of the most economically marginalised areas of the country, and almost no infrastructure development took place, among other reasons due to poor load profiles, financial mismanagement and lack of industrial customers (Davis, 1997). Urban areas were segregated and placed under a succession of unsuccessful governance structures, culminating in 'Black Local Authorities' (BLAs) in 1982. The BLAs suffered from similar problems: a lack of political legitimacy, maladministration, and a very poor potential customer base (whereas 'white' areas included central business districts and most industrial areas of major towns, the potential customer base of BLAs consisted largely of low-income households).

Another key development preceding the electrification programme was the crisis culminating in the De Villiers Commission in the mid-1980s. The crisis was prompted by the impact of steep Escom tariff increases on the cost structure and competitiveness of the South African economy (De Villiers, 1984). The commission's recommendations led to a number of important developments. Escom was restructured as Eskom. It slowed down its capacity expansion programme, having accumulated significant surplus capacity. Over time, these investments were amortised so that by the late 1980s and early 1990s Eskom was in a good position, both in terms of capacity and a healthy balance sheet, to launch an ambitious electrification programme. Through the restructuring, Eskom was freed from its previous prohibition on making a profit or a loss,[9] which allowed it crucial leeway in determining the viability threshold for electrification projects. These changes created a political opportunity for Eskom to establish itself as a national champion in the eyes of the new government.[10]

The final significant institutional factor was that most of the institutional capacity built in the government's complex of energy agencies in the 1970s and 1980s concerned the nexus between coal, liquid fuels and energy security, resulting in the electricity sector remaining almost entirely autonomous.[11] Whereas there was a nascent strategic concern with electricity supply during this period, electricity distribution (and electrification) was regarded as the sole sphere of local authorities, which also reflected the supply-side emphasis of energy policy during this period.

2.1.3. Setting electrification targets in an unusual policy space

Electrification policy and other policy spheres linked to it (notably energy policy), like other policy processes leading up to the 1994 elections, moved out of a formal government context and into a less formally structured negotiation process. At this time, some of the primary actors in defining electrification policy were

[5] Gaunt (2005) makes the distinction among economic, socio-economic, and socially motivated electrification. The first (viz. economic) represents 'business as usual'.

[6] For simplicity, local authorities are included in this second frame, although their contribution may easily be defined as a third frame, based on an understanding of electrification as service provision.

[7] Nedcor and Old Mutual launched an influential economic scenario exercise, 'Change of gears', in the transition period, including recommendations on low-cost housing, social investment and an accelerated electrification programme (Segal, 2007). Charles Dingley, based at the University of Cape Town's (UCT) Electrical Engineering Department, contributed to these scenarios, which were influential in shaping some of the thinking in the ANC's Reconstruction and Development Programme that sought to stimulate economic activity through redistributive investments such as electrification. The Chairman of Nedcor at the time was Johan Maree, who was also Chairman of Eskom, and so these scenarios also reinforced Eskom's commitment to accelerate its electrification programme.

[8] The utility was initially established as the Electricity Supply Commission and known as Escom or Evkom, but was restructured and named Eskom in 1987. 'Escom' is the designation used by authors for all references to the utility before 1987, and 'Eskom' for all references thereafter.

[9] This provision effectively prohibited cross-subsidisation between 'undertakings', and was a significant obstacle to subsidising the electrification of white farmhouses before the 1980s (which eventually required a parliamentary amendment).

[10] Much of Eskom's strategic behaviour after 1985 was intended to ward off further government intervention, or as the CEO at the time famously put it, "to keep government out of the engine room" (McRae, 2006), which involved a range of measures including improving financial performance, reducing real prices, international benchmarking, and aligning itself strongly with the new government's social goals.

[11] There were two underlying reasons for this: (1) the national status of Escom, and its sheer size, and (2) the dominance of coal-fired power, which decoupled the electricity system from the direct effects of the 1970s oil crises; South African electricity prices did not, and still do not, react to international oil (or gas) price movements.

Eskom and a group of primarily EDRC-based 'energy policy activists' involved in several ANC policy development groups. Other actors, such as the trade unions and local authorities, played a secondary role, and the line department, the Department of Minerals and Energy Affairs (DMEA), was marginalised.

The concept of electrification found a natural ideological home inside the ANC, and ANC leaders were immediately receptive to the idea of an accelerated programme. There were two contexts for this. The first was the Freedom Charter, a manifesto of basic political rights drafted in the 1950s at a national convention of anti-apartheid organisations, which included socio-economic rights to 'houses, security and comfort', and which thereafter became a basis for the ANC and its political allies' political programmes.[12] The second was the context of the 1980s anti-apartheid movement's struggle for the provision of basic services. These two streams were merged in the ANC's RDP, which aimed, amongst other things, to provide a wide range of basic services, including water, electricity, housing, education and health. The role of the policy analysts was to elaborate these political principles into electrification policy.

Eskom's increased role in low-income electrification began in the late 1980s with a few small projects undertaken with local partners. At the same time, Eskom's leadership, in view of the changing political environment, began to see involvement in electrification as an essential strategy to maintain organisational autonomy.[13] To this end, Eskom adopted the slogan 'Electricity for All' in 1987. Given that Eskom had limited access to non-electrified households in urban areas, a key development in the late 1980s was the takeover of several areas of supply from crisis-ridden BLAs, as well as the mostly bankrupt distribution authorities of the 'independent states' and 'self-governing territories', which were re-incorporated into South Africa in the run-up to the 1994 elections. Thus, whereas in 1991 Eskom had only 142,746 domestic and street lighting customers (Eskom, 1991), by 1994 Eskom had 1,053,725 of this category of customers (Eskom, 1994).

Eskom began electrification at a relatively low level from 1990, but the watershed event of this first phase was the organisation of a National Electrification Conference[14] in 1992, which led directly to the establishment of a National Electrification Forum (NELF), a broad-based stakeholder body with participants from Eskom, municipalities, the DMEA, unions and others. NELF's main achievement was to combine technical and financial capabilities with political legitimacy and support, and it formed an arena where stakeholders could negotiate the shape of an electrification programme, which would be both politically acceptable and practically implementable.

There were several key outcomes from NELF that set the pattern for electrification policy until the late-1990s. The first was a significant degree of technical work on the feasibility of electrification, which established the viability of, and built a consensus around, a much faster programme; the second was the establishment of a National Electricity Regulator (NER), which became the institutional focus of the programme until 2002. The final outcome was the adoption of the proposals for restructuring the electricity industry. The key motivation for this was that the fragmented nature of the distribution industry was seen as an obstacle to electrification, since many local authorities were perceived as lacking capacity to carry out electrification projects.

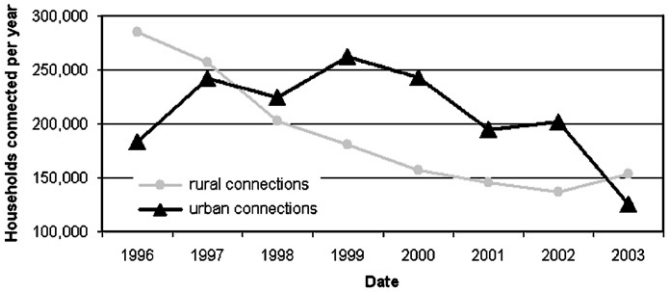

Fig. 3. Annual number of urban and rural connections (NER, 2003).

The discussions in NELF culminated in an agreement between Eskom and the ANC to electrify 2.5 million houses between 1994 and 1999, which was codified both in the ANC's RDP, the party's blueprint for social and economic policy during the transition, and in a 'compact' between Eskom and government,[15] which contained commitments on price and employment equity. Thus, the policy outcomes of phase one established addressing the electrification backlog as the principal aim, allocated significant societal resources to this end, and placed Eskom in a central role in the unfolding programme.

2.2. Phase 2: institutional reforms

During the period 1994–1999, the emphasis was almost solely on achieving the high connection rates outlined in the RDP, and creative ways were found to lower costs dramatically and overcome institutional barriers to achieve this.

Due to the fact that rural areas were part of its licensed area of supply and had the largest backlog of electrification, Eskom took on the majority of the RDP targets (66% or 300,000 new connections per year), and the local authorities assumed the rest. As a result, it may be argued that a higher proportion of rural connections were made during the initial stages of the programme than might have been the case in a 'unitary' programme, as evident from Fig. 3.

Given that ex-Eskom personnel ran the NER[16] for its first few years,[17] it is fair to conclude that the electrification programme was co-ordinated during this phase by a NER–Eskom nexus. The NER licensed all distributors and audited the electrification activity of local authorities. In addition, it provided an overall reporting framework for the programme including setting up a basic model to track electrification progress in the country as a

[12] So much so that the ANC and its allies were known as 'charterists', to distinguish them from other anti-apartheid groupings with different ideological roots.

[13] Much of Eskom's commitment was also associated with the personal moral vision of its late-1980s management (who later described this period as "the years when Eskom found its moral purpose" [interview with Alan Morgan, ex CEO of Eskom]), but the strategic view (highlighted in the text above) was primarily the way in which Eskom's early commitment was rationalised within the organisation, and was indispensable in persuading other elements in Eskom's leadership that it should commit resources to the programme.

[14] The conference was organised and hosted by the EDRC under the auspices of the ANC at the University of Cape Town.

[15] In 1991 Eskom undertook to reduce the real price of electricity by 20% over a 5-year period effective from 1992 (Eskom, 1992).

[16] The NER was established by amending the Electricity Act (Electricity Amendment Act 46/1994), which (a) changed the name of the regulatory authority that had existed previously (the Electricity Control Board), (b) expanded the authority from a board of 5 and 1.5 personnel to an organisation which currently has over 100 personnel, (c) imposed a dedicated levy on electricity sales to fund the NER, and most importantly, (d) placed *all* electricity undertakings under the regulatory authority of the NER. Previously, local authorities within their municipal areas, and Eskom (between 1987 and 1994) had not been subject to licensing or price controls by any regulatory authority.

[17] In addition to a large movement of staff from Eskom to the new regulator, Ian McRae, CEO of Eskom from 1985 to 1994, who was a strong supporter of electrification, and had been instrumental in steering Eskom into the programme, headed the NER for its initial years.

whole, and from 1995 to 2003, NER published a report on the programme.[18] National electrification planning functions during this period were located within Eskom.

Two other developments of note occurred during this time. First, due to the withdrawal of the National Party from the Government of National Unity in June 1996,[19] an ANC Minister of Minerals and Energy was appointed. This in turn led to the replacement of the old-guard leadership within the Department of Minerals and Energy (DME) and internal reorganisation, which resulted in less capacity being devoted specifically to household energy problems and more being allocated to supply-side policy issues. Second, a post-apartheid energy policy framework was drafted, a process that began in 1995 with work commissioned by the University of Cape Town (UCT) and culminated in December 1998 with the White Paper on Energy Policy. The White Paper placed significant emphasis on an integrated approach to household energy problems, while emphasising the imperative of electrification: "Government recognises that household access to adequate energy services for cooking, heating, lighting and communication is a basic need. Whilst these needs can be met by various fuel-appliance combinations, government recognises that without access to electricity, a clean, convenient and desirable fuel, human development potential is ultimately constrained" (DME, 1998) .

To this end the White Paper proposed the integration of another programme in the DME, which involved the installation of photovoltaic systems in households too remote to be electrified. A partial subsidy of the capital cost of connection, to be derived from a levy on electricity sales and routed via the fiscus, was outlined in the White Paper. However, this was subject to resolving the question of the corporatisation of Eskom, which would require the utility to pay taxes and dividends to the state, and was unprecedented.

An additional complication emerged with the imminent expiry of the compact between the state and the utility, which would expose Eskom to price regulation by the NER and thus make it more difficult to cross-subsidise the programme without an explicit policy by the state and/or ruling by the NER. Thus, the main challenge facing government after the White Paper in terms of electrification was how to set up appropriate institutional arrangements to plan and manage the electrification programme within government.

2.3. Phase 3: business as usual

While there were a high number of rural connections in the mid-1990s, the programme was dominated by urban electrification until 2002. At this time, the programme shifted to a mainly rural focus,[20] which increased average costs and necessitated the funding of bulk infrastructure to strengthen and extend transmission networks and transformers. Phase three, therefore, has been characterised by a slowing in the connection rate, the formalisation of electrification policy and institutions, and the integration of the programme with other policies and development processes.

The period 2000–2001 saw the confluence of a number of different developments that resulted in policy shifts that significantly changed the institutional basis of the electrification programme. This involved the post-transition development of policy frameworks in a number of spheres, including energy policy, public enterprises (key policy framework published in 2000), local government (restructured in 2000), and spatial development (the Integral Sustainable Rural Development Programme and Urban Renewal Programme were announced in 2001, and the Integrated Development Plan (IDP) framework implemented in 2001).

An additional factor that influenced the institutional basis of the electrification programme was the restructuring of the electricity industry as anticipated in the Energy Policy White Paper. This restructured industry was to include a number of independent regional distributors, an independent transmission company and system operator, and a number of independent (and eventually privatised) generation companies.

The obvious dilemma that government faced, given the restructuring plans and its desire to implement a more policy-driven electrification programme, was where to situate the programme, and what form it would take after the initial targets had been met. To this end, the National Electrification Coordinating Committee (NECC) was set up by ministerial directive in April 1999, consisting of representatives of Eskom, the DME, the NER and others. Its mandate was to resolve a number of policy questions, including those related to the integration of the programme with other development processes, and the institutional form which the programme ought to take. The NECC reported after about a year that the DME would be the most suitable institutional home for the programme. Furthermore, a National Electrification Programme Management Unit (MU) should be set up under the auspices of the DME, supported by a stakeholder-based National Electrification Advisory Council, which in practice was a continuation of the NECC. The MU would have a national perspective on planning and approving electrification projects, and control and disburse funds and local agencies.

After 2000, however, the Department of Provincial and Local Government (DPLG) became the primary locus for the delivery of basic services to low-income households, which led to DPLG contesting DME's oversight of electrification. This delayed the establishment of the new (from 2002) Integrated National Electrification Programme (INEP) in the DME for several years. It was only in March 2005 that the planning, funding and coordination of the INEP was established in the DME on a permanent basis.

Other noteworthy steps include the conversion of Eskom into a corporation in 2001, as preparation for the electricity industry restructuring process (via the Eskom Conversion Act). In operational terms, it meant that Eskom would adopt the same institutional structure as a private company, with a board of directors (replacing the stakeholder-based Electricity Council), and a sole shareholder (the state, via the Department of Public Enterprises), and would henceforth pay tax.

It is important to reiterate here that Eskom's relationship with the electrification programme is closely related to the restructuring process. The high level of capital funding that Eskom provided in the first stage of the electrification programme was effectively a cross-subsidy from other electricity users. Eskom was not, however, willing to continue funding the programme after its corporatisation (especially since it would now be obliged to pay taxes and dividends to the state). At the same time its price compact with government expired, which coincided with the introduction of a more transparent wholesale pricing regime by the NER. From 2001 the state funded electrification directly from the fiscus, and subsidised the entire capital cost of connection.

[18] See Lighting Up South Africa, published by the NER in most years from 1995 to 2003.

[19] In terms of the interim constitution in force when the 1994 elections were held, although the majority party/coalition formed the government, minority parties were offered cabinet seats in proportion to their share of the vote—under this arrangement, the Minerals and Energy portfolio was allocated by the ANC to the National Party, the governing party that had implemented apartheid. Pik Botha, the ex Foreign Minister in the apartheid government, became the first Minister of Minerals and Energy Affairs in Mandela's cabinet in the period 1994–1996.

[20] Current estimates are that most of the existing backlog remains in rural areas.

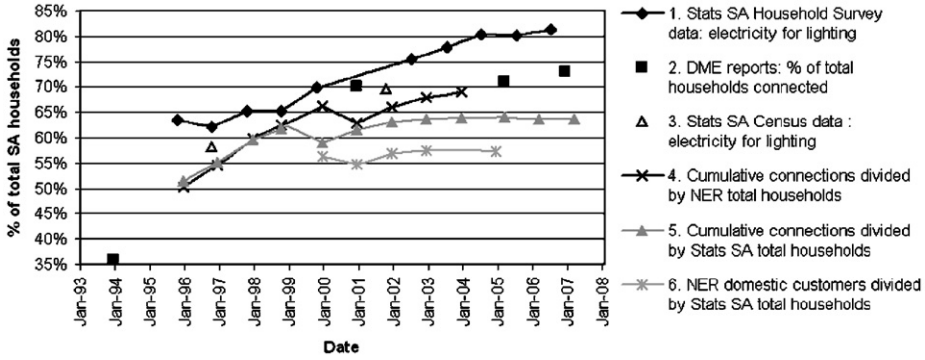

Fig. 4. Different estimates, derived from published data, of the percentage of total South African households that are electrified (Bekker et al., 2008).

Plans to restructure the electricity supply industry were abandoned at the end of 2004. Currently there are no plans to unbundle Eskom or to sell off some of its generators.

Two other significant developments in phase three were the implementation of the concession-based off-grid photovoltaic programme for remote rural areas, and the introduction of free basic electricity (FBE) for poor households (i.e. the first 50 units consumed each month are free). Since the capital cost of electrification and FBE are both funded from the fiscus, and the tariff for small customers is an energy-based charge without a minimum monthly component and is effectively subsidised by larger customers, the cost of service for low-income customers and the technology of implementation are now regulated only by the government's electrification plans.

2.3.1. *Electrification programme policy shifts*

There are several key shifts that have occurred in the execution of the programme between the 1990s and the establishment of the INEP. The first of these has been the form of the planning process. Whereas during the RDP programme, electrification projects, particularly those in Eskom, occurred without reference to other local developments, under the INEP framework all implementers, including Eskom, are required to situate electrification projects within the applicable Integrated Development Plan, developed by local government. This process seems to result in slower and less efficient implementation, but on a more sustainable basis, i.e. the programme shifted from a fairly narrow focus on connection targets to a broader set of development criteria. There has been a division in responses to the new framework between technocrats and planners: the former have been critical of the new system because it is slower, more bureaucratic, and has undermined potential economies of scale, whereas the latter have criticised many of the 1990s projects as unsustainable.[21]

The second key shift has been that from a programme with a significant urban component to a primarily rural programme, which has raised the problem of bulk infrastructure. While the electrification programme did not previously deal with the lack of bulk infrastructure (it was assumed that implementing authorities would bear the associated costs), the DME determined in 2004 that lack of bulk infrastructure was becoming a major obstacle to electrification, and began to fund infrastructure development that met certain criteria.

[21] These criticisms were mainly aimed at Eskom, for (a) not consulting local communities, (b) electrifying 'unproclaimed' areas (where particularly urban residents were settled illegally, and sometime moved shortly afterwards) and (c) 'cherry-picking' by avoiding or abandoning 'complicated' projects (where there were challenging local physical, social or political conditions, or severe limitations on the network).

The final policy shift in the electrification programme occurred from 2004, and focused on the date 2012. During the 1990s the dominant planning assumption was that 80% of households would be electrified by 2012; however, in his 2004 State of the Nation Address, President Mbeki stated that "…with a strengthened local government working with our state enterprise, Eskom, we will, within the next eight years, ensure that each household has access to electricity" (Mbeki, 2004).

2.3.2. *The likelihood of universal access to electricity by 2012*

Current estimates of the proportion of total households in South Africa with access to electricity vary quite widely, from around 64% to over 80%, as shown in Fig. 4.

If it is assumed that data set five in Fig. 4 represents the current situation most accurately, an estimated 6.9 million additional households will need to be electrified by March 2013 to achieve universal access, as shown in Fig. 5. This means that around 1.15 million households will need to be connected per year, which is almost double the roughly 575,000 households targeted per year by the DME's Universal Access Plan (DME, 2007) (data set 4 in Fig. 5). It appears from the DME's targets that the department's definition of universal access does not take into account any growth in the total number of households since the goal was announced in 2004.

Furthermore, achieving the Universal Access Plan's targets will require between five and six billion rand per year (the INEP grant for 2007/2008 was only R1.4 billion), and a dramatic increase in capacity (which will be challenging given the current generation crisis in South Africa).

These financial and capacity obstacles lead to the conclusion that access to electricity by 100% of South Africa's households by March 2013 is practically impossible at this stage. Ultimately, a more realistic and achievable set of planning targets will need to be developed.

3. Financing

A key challenge for the electrification programme in South Africa has been to resolve the problem of funding the cost of electrification while at the same time designing affordable tariff structures. This dilemma resulted in a gradual process of introducing, raising and making more transparent subsidies from the late 1980s to the present. Simultaneously, a process of technical and procedural innovation was undertaken, which reduced costs per connection significantly, that is, until costs began to rise as the programme started to electrify more remote areas from 2003.

Three phases may be identified in the evolution of the financing of the electrification programme: self-funding, funded

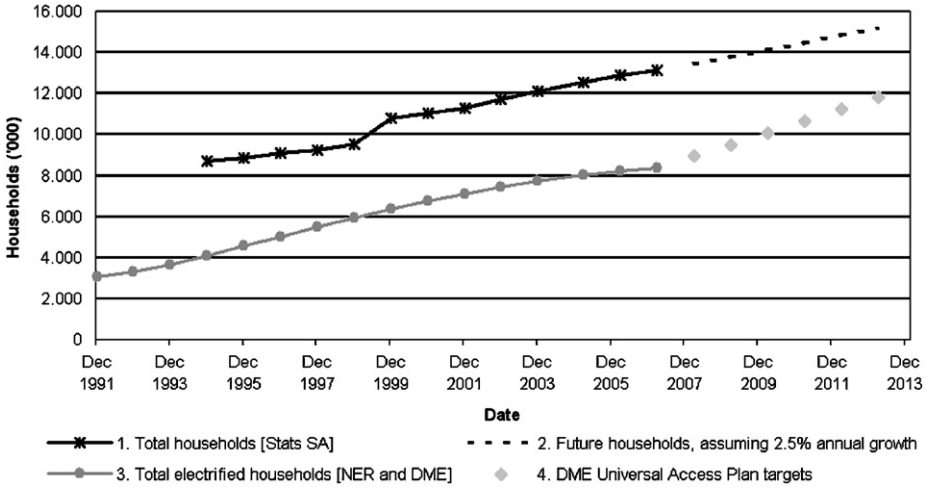

Fig. 5. Total households versus total electricity connections since 1991, and DME future connection targets (adapted from Bekker et al., 2008).

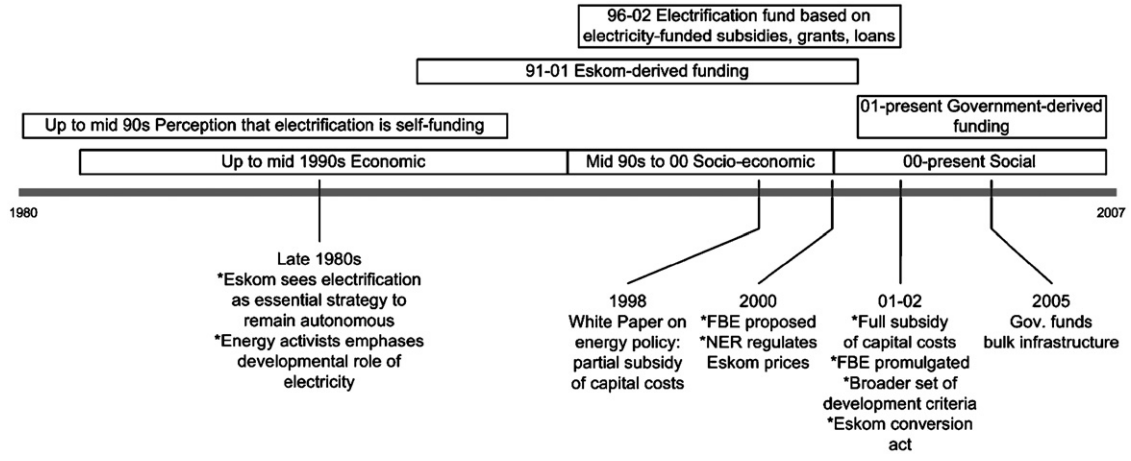

Fig. 6. Financing phases during the electrification programme, and the corresponding changes in motivation for electrification. Significant financing events are also shown.

by Eskom and funded by government. These phases correspond closely to changes in the motivation for electrification, namely from economic between the late 1980s and mid 1990s, to socio-economic until around 2000, and finally to social at present (Gaunt, 2003), as shown in Fig. 6. The phases are similar to the institutional phases of Fig. 1 but arise from different characteristics.

In the first phase, from the 1980s to the mid-1990s, there was an influential but diminishing belief that electrification could be self-funding. Although there was increasingly strong evidence that this was not the case, initial forays into electrification by Eskom were partly based on the assumption that consumption by electrified households would rise to an average level where operational and capital costs could be recovered. This in turn would create a new market for Eskom's overbuilt generation sector. Although it became apparent that such was not true, it was almost certainly politically important at the time for those within Eskom (including the CEO) who needed to persuade the more economically and politically conservative leadership to involve the organisation in electrification. Since in most cases only a nominal connection charge was paid, the capital cost was theoretically to be recovered through energy charges. In addition, prepayment metering was introduced, usually coupled with a simple tariff based only on energy consumption (no fixed charge).

By the mid-1990s, it became unavoidably apparent that electrification was not going to be self-funding—a reality exacerbated by the emergence of 'non-technical losses' (electricity theft through illegal connections and/or bypassing the meter). Given tariff levels and capital costs, consumption levels of 350 kilowatt-h (kWh)/month were required, whereas average consumption in newly electrified households was only around 100 kWh/month (Davis, 1995).

The realisation that electrification could not be self-funding introduced a second phase of programme financing, from 1995 to around 2000. During this period Eskom, played the lead role in financing the programme. Finance was accessed from various sources. These included electrification bonds, or Electrification Participatory Notes, raised from private capital markets in the early days of the programme, the returns on which were linked to consumption growth. Most funding, however, was in the form of a cross-subsidy from industrial users, bulk sales to municipalities, as well as myriad (relatively small) hidden cross-subsidies in the form of various organisational capacities (secondment of staff to the DME, etc.).

Since Eskom's electrification programme was effectively funded from a non-transparent, internal levy on electricity sales (which, as noted above, included bulk sales to local authorities), local authorities lobbied to receive a grant from Eskom to subsidise their electrification programmes. Eskom agreed in

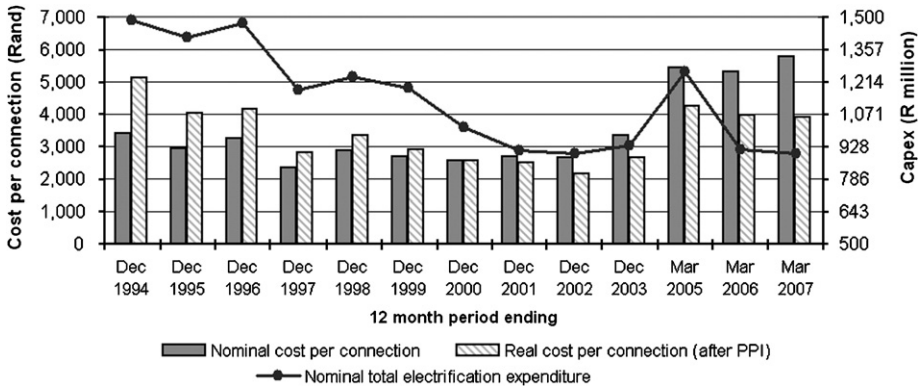

Fig. 7. Average annual cost per connection and total electrification capital expenditure (Bekker et al., 2008).

1996 to provide an amount of R300 million annually for a period of 5 years, escalated annually by the average annual tariff increase, which would be distributed to local authorities via an Electrification Fund administered by the NER (NER, 1998, p. 11).[22]

In the late 1990s, the state took the decision to fund the capital cost of the programme entirely from the fiscus, through a National Electrification Fund (Eskom, 2001), but the funding details subsequently changed. This corresponds with the time that the legal status of Eskom was changed, and the utility had to pay tax and dividends for the first time. The effect of these changes was to make electrification funding more transparent. At the same time, the state decided to introduce FBE, also to be funded from the fiscus, and targeted at low-income households.

The state's FBE policy was first announced in 2000, promulgated in 2002, and only effectively launched in September 2004 (DME, 2005, p. 2). It specified the provision of a 'self-targeted' subsidy consisting of 50 kWh/month of free electricity to poor households, identified either by the willingness of these households to accept a limited supply capacity of 10 A (households have to apply), or by a very low consumption level (in which case the subsidy is automatically allocated) (SA Government, 2002). The policy was drafted by the DME's electricity policy section, but was transferred to the DPLG, where it is implemented along with a basket of other free basic services.

By 2005, the state was also funding bulk infrastructure development. In addition, it was announced that, from 2006/2007, funds allocated to the INEP would flow through the DPLG (DME, 2005, p. 37).

3.1. Electrification capital expenditure

While connection rates remained high until 2001 (as first depicted in Fig. 2) total programme expenditure declined over this period due to reductions in the real connection costs, as shown in Fig. 7. Most innovation took place in the 1990s; after this period, costs began to rise again in the early 2000s because of two factors: first, the programme had by then become focused largely on more sparsely populated rural areas (some of which required significant additional infrastructure), and second, the prices of basic commodities required by the programme (steel, copper, aluminium) began to increase significantly above the Producer Price Index (PPI).[23]

[22] The NER continued to administer the Electrification Fund until it was exhausted in around 2003.

[23] The Producer Price Index (PPI) is published monthly by Stats SA and taken as 100 in 2000.

4. Technology development

Technological development during the electrification programme was mainly driven and facilitated by the requirement to reduce costs, an aim it succeeded in as illustrated by the declining real cost per connection until the early 2000s (Fig. 7). Given the political difficulties of lowering connection targets or altering tariff structures, the cost per connection was one of the few areas in which the financial performance of the electrification programme could be improved.

Four broad technology development phases may be identified, as shown in Fig. 8, and offer a structure to analyse the development of technology preceding and during the electrification programme.[24] It is interesting to note the interaction between these four phases and the previously identified policy and institutional and financing phases.

4.1. Phase 1: supply quality-driven optimisation

During the pre-electrification programme of the 1980s, primarily customers that could afford to pay in full were connected to the electricity supply network. The emphasis was on providing high quality and reliable supply, with connection cost only a secondary criterion in most utilities. This led to supply-quality-driven optimisation of technology, through, for example, substantial research into the impact of lightning on distribution lines by Escom and the Council for Scientific and Industrial Research (CSIR), and through constantly improved medium-voltage (MV) line designs.

4.2. Phases 2 and 3: cost-driven optimisation and standardisation

Optimisation of technology design and performance was not, however, able to offer significant additional cost benefits by the time the 'Electricity for All' programme was initiated in the late 1980s, and more radical changes were needed.

First, it became evident that significant cost-savings could be realised by changing conservative design specifications to those more suited to the requirements of typical customers. This realisation led to changes in both quality of supply and domestic load model specifications. Second, innovative technologies like prepayment electricity meters and the broader adoption of single-phase lines significantly reduced both capital and ongoing costs per connection. Finally, electrification programme implementation

[24] See Gaunt (2003) for a more in-depth analysis of technology developments during the electrification process.

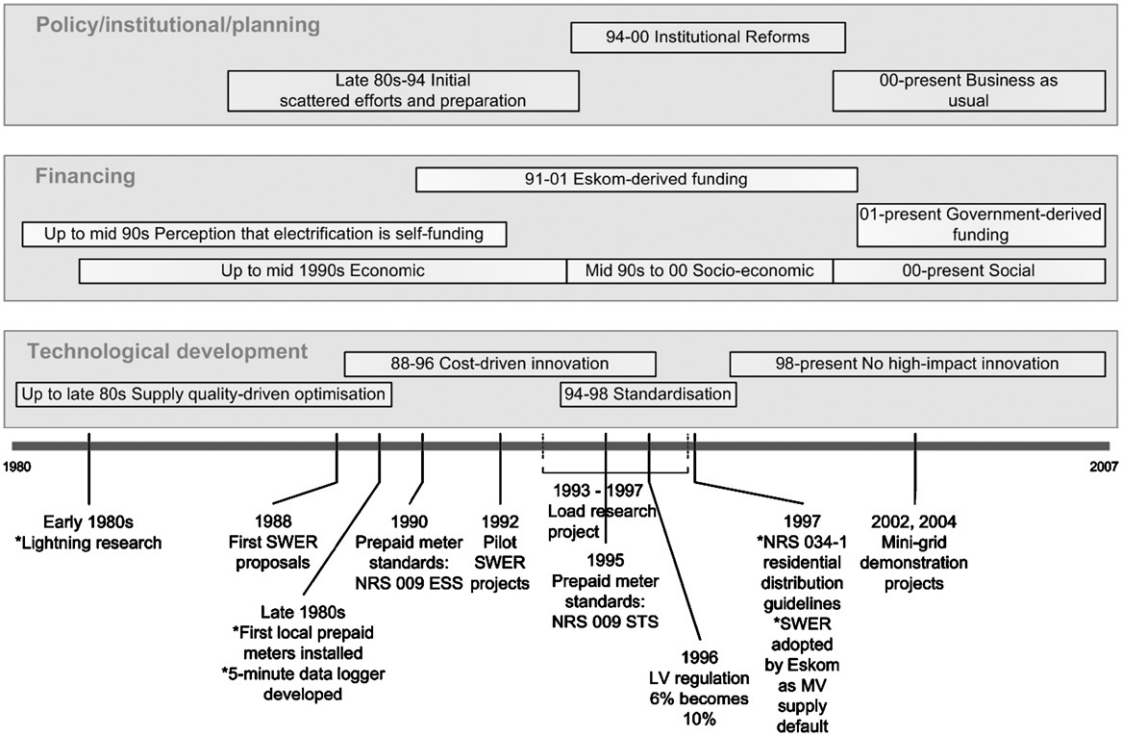

Fig. 8. Technology development phases shown with policy/institutional and financing phases and significant technology development events.

processes were optimised. These three different changes are explored in more detail below.

4.2.1. Design specification changes

4.2.1.1. Domestic load research. In the late 1980s, Herman and Gaunt (1991) developed data loggers that could make continuous time-synchronised measurements of individual customer loads averaged over short periods (of typically 5 min). Data could be downloaded every several weeks. These data loggers were used to collect electricity consumption data from communities in a Load Research Project from 1993, which informed the development of new design parameters. More conservative parameters, in use during the 1980s, had been mostly based on the work of American and European researchers in the 1940s and 1950s, and UK guidelines. The new parameters were standardised in the national design guideline for the design of residential distribution systems in 1997.

The impact of load research is seen through the change in design load specifications over time. Urban design loads dropped from up to 7 kilovolt-ampere (kVA) per household during the 1980s, to around 3 kVA in the early 1990s, and down to around 1.5 kVA in 2003. Rural design standards dropped from around 2.5 kVA per household initially, to 0.4 kVA in 2003, with significant associated savings in distribution infrastructure.

4.2.1.2. Quality of supply specifications. Additional changes in the quality of supply also had an impact. Customers with continuous production systems and sophisticated machinery are generally known to be financially sensitive to supply quality problems, while for most domestic customers these problems are more a nuisance than a cost. In the light of this, the allowable voltage regulation on low-voltage (LV) systems in South Africa was increased from $\pm 6\%$ of nominal voltage to $\pm 10\%$ in 1996. This relaxation of LV quality of supply specifications in association with other network design specification changes allowed network designers to specify a 'light' rather than a robust MV and LV network, with associated reduction in investment costs.

4.2.2. Innovative technologies

The adoption of innovative technologies often paralleled the development of new design specification parameters: for example, the introduction of single-phase lines would not have occurred if system planners were forced to specify unnecessarily high line capacities due to conservative design load specifications.

4.2.2.1. Single-phase lines. Until 1990, nearly all MV distribution lines in Southern Africa were three-wire, three-phase lines, because they allowed subsequent extension of the lines to other loads. Omitting the third phase for supplies to small loads, i.e. using two-wire, two-phase conductors, allowed a substantial savings in conductor and structure costs. The logical next step was to omit another phase conductor, adopting single wire, earth return (SWER) technology with only one-phase conductor instead of three. The obstacle of motor loads that normally require three-phase supplies was overcome by the local development of a single-phase motor and power electronic single-to-three-phase converters.

The adoption of single-phase technology in turn contributed significantly to reducing the rural cost per connection during the electrification programme. For the cost of a three-phase line, almost three SWER lines may be built, reaching more customers for the same cost.

4.2.2.2. Prepayment metering. The first locally developed prepayment meters were introduced during the late 1980s. The objectives were to remove the need for postal delivery addresses for billing, reduce the costs of reading meters, and reduce non-payment by helping customers not to incur unaffordable

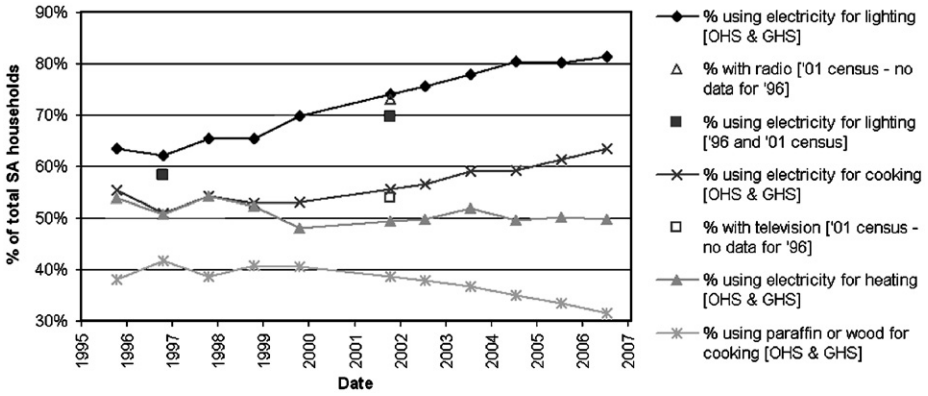

Fig. 9. South African households access to services (StatsSA OHS, GHS and Census).

consumption costs, which was already a problem in many township areas (Tewaria and Shahb, 2003).

Eskom and most municipalities adopted prepaid metering on a large scale after 1990, with the meters usually installed in households with 'readyboards', a distribution board placed in a central location in a house or shack, which contained one or two plug sockets and a light, facilitating electricity use without further house wiring.

By the mid-1990s, a number of prepayment meter standards were adopted that solved initial problems like the incompatibility of proprietary meter and vending station systems.

4.2.3. *Implementation processes*

Innovative technologies and design specification changes alone are, however, insufficient to explain the changes that occurred during the electrification programme. New and improved implementation processes played a crucial role, including greater use of decision-aiding techniques and tools, adoption of new financial evaluation methods (e.g. the modified Internal Rate of Return method used by Eskom), computer-based asset management, and software for feeder design.

Research activity by a cohort of specialists prior to commencement of the NEP was crucial to the success of the electrification programme (Dwolatzky, 2001), as was the ongoing development of skilled designers to implement the programme. Knowledge sharing and transfer also occurred across all spheres related to electrification, encouraged by a number of workshops and conferences.

The decision by Eskom after 1995 to use a blanket electrification approach (i.e. provide supply to all potential customers in an area, also known as area coverage) instead of selective electrification (i.e. connect only the customers applying and paying for connections) allowed for long term rather than ad hoc planning, and removed cumbersome quoting and payment procedures (Dingley, 1988). In addition, blanket electrification reduced perceptions of unfairness as everyone in the area receives access to electricity. A higher proportion of poor households were reached, which, through tariff subsidies, established the potential for subsequent poverty alleviation. Drawbacks included the lower average consumption of customers and higher total operating costs than with selective electrification.

4.3. *Phase 4: no high-impact innovation*

Although much progress was made up until the late 1990s, thereafter no technology innovations had a significant impact on the electrification programme in terms of cost per connection or increased annual connections.

A potentially innovative off-grid network arrangement, the mini-grid, was tested through two demonstration projects in the Eastern Cape, commissioned between 2002 and 2004. Instead of individual off-grid household installations, a mini-grid distributes energy from a local generation source, e.g. photo-voltaics and/or wind, to several households located close to each other and the source. The demonstration mini-grid systems were, however, both non-functional by the end of 2006, due mainly to social and institutional problems.

5. Social and economic impacts

One of the fundamental problems with measuring outcomes of the electrification programme is the availability of data. National data is limited, with no accurate public data on complex phenomena such as disconnections, illegal and informal connections[25] (which are apparently widespread).

The main source of national data is Stats SA, which measures household access to services through annual household surveys and national censuses. A selection of surveyed indicators are shown in Fig. 9, based on data from the October Household Survey (OHS) (conducted from 1995 to 1999), the July General Household Survey (GHS) (from 2002 until the present) and 1996 and 2001 October Census data.

Significant base-line studies were done as part of a DME review on the RDP stage of the electrification programme (DME, 2001), and as part of a pilot research project into options for a basic electricity support tariff (UCT, 2003), which culminated in the implementation of FBE.

Numerous impact studies (see Karekezi et al. (2003) for a bibliography) provide a brief national picture but important qualitative information on the complexities of the effect of electrification on low-income households and communities are absent. A major problem in impact studies is the high cost of collecting useful data from a representatively large sample of the population.

5.1. *Electrification's impact on household energy use*

The trends in household electricity usage apparent from the survey data shown in Fig. 9 indicate an increasing use of electricity for lighting, a far slower rate of increase for cooking,

[25] Informal connections are extensions of electricity supply from one household to another by householders (thus the electricity is still metered), whereas illegal connections, as noted in Section 3, comprise connections to the distribution grid by householders or their agents that bypass metering systems.

a static and even slightly declining use for heating, and a steady reduction in the use of paraffin or wood for cooking.

However, the way in which the Stats SA surveys are structured has some limitations. To begin with, the indication by a specific household of the main energy carrier per energy service is likely to mask a more complex and dynamic pattern of use. Research in South Africa and elsewhere during the 1990s, e.g. Mehlwana and Qase (1998), identified multiple fuel use[26] in households as the norm in low-income households, for a variety of budgetary and other reasons.

Furthermore, the data in Fig. 9 does not differentiate between households with different income levels. Yet "…it appears as though many of the effects of electrification are themselves related to income levels, with many effects found to be present or stronger in higher income groups. Low-income electrified households appear to have fuel choice patterns similar to those of unelectrified households, and electricity appears to be an additional fuel and an additional expense for those households" (Davis and Ward, 1995, p. 14). The quoted study further notes that the use of candles and thermal fuels persists even after electrification in these low-income households.

Although use of electricity for lighting and media is widespread, the limited impact of electrification on thermal applications undermines the total utility of the electrification programme, since the majority of negative externalities of particularly paraffin, wood and coal use stem from cooking and heating applications. Madubansi and Shackleton (2006) indicates that the slow but steady migration of households towards using electricity for thermal applications reported by Stats SA does not necessary apply in rural areas: "…for thermal needs, most notably cooking, fuelwood has remained the most widespread fuel, and the amount used per month has not changed, despite increasing scarcity of wood in the local environment". Reasons for the non-use of electricity for thermal applications are complex, and vary from cultural inertia to change (Sebitosi and Pillay, 2005) to the perceived lack of affordability of electricity.[27]

5.1.1. The impact of free basic electricity

The introduction of FBE was partly in response to the realisation that electrification is not synonymous with a migration by low-income households to electricity.

Case studies reported in UCT (2003) have shown that the introduction of FBE has increased the use of electricity for lighting, and that the use of other energy carriers for cooking and heating has fallen significantly. However, the authors note that "it is unlikely that poor households will abandon multiple fuel use even in the long term" (UCT, 2003, p. 18).

The fact that by March 2007 only 65% of households reconfigured by Eskom for FBE consume their full FBE allocation (Eskom, 2007) indicates that the FBE programme is also not entirely successful in one of its other goals: addressing the impact of income disparities on household energy use. This might partly be due to a number of reasons reported by UCT (2003), including that the recipients of FBE do not understand how it works, and that vendors are unwilling to supply the recipients with FBE credits without some form of compensation.

Howells et al. (2006) raises the question of whether electricity is the best energy carrier for thermal use in low-income households, given that methane or LPG are safe, clean, easy to use and in most cases affordable alternatives. DME's 2006/2007 strategic plan gives an indication of future policy in this regard: "… (the) provision of LPG … to households will be intensified. It is envisaged that these energy carriers will in future be included in the basket of free basic energy provision" (DME, 2006b, p. 5).

5.2. Other impacts

Studies on whether electrification stimulates economic growth, e.g. Borchers and Hofmeyer (1997) and Rogerson, (1997), have concluded that electrification does stimulate the establishment and growth of local businesses, although inputs like market access and financing play a more important role. The DME (2001, p. 21) report lists anecdotal evidence that electrification led to significant opportunities for entrepreneurial activity.

The jobs created by the electrification programme appear to be largely temporary (197 permanent and 2390 temporary jobs are reported in DME (2003)), and although the number of jobs appears to be increasing (5255 in 2006/2007), it is still low when viewed in the light of the DME's strategic target of creating one new informal job for every R100000 of INEP capital expenditure (DME, 2004, p. 32), which translate into 8970 informal jobs for the R897 million spend in the INEP in 2006/2007.

6. Conclusion

Despite the unorthodox way in which South Africa's electrification programme emerged, several patterns of institutional and policy development are evident. First, the policy uncertainty associated with the transition, far from being a negative influence on the programme, was essential to its success, since electrification was placed suddenly and strongly on the agenda, and did not encounter obstacles from traditional state agencies, which were partly or completely marginalised; it is unlikely that a less extreme 'policy window' would have led to the same outcome. Furthermore, a programme on a smaller scale would have been a dismal failure with household growth outstripping electrification.

While government institutions were sidelined, three other groups played an essential role. First, Eskom's role was crucial, for a number of reasons. It could mobilise unique resources (managerial–technical skills, financial, economies of scale), largely due to the De Villiers Commission instigated reforms in the 1980s and Eskom's low capital requirements at the time. To have attempted to fund the programme from the fiscus would probably have delayed its implementation for years. In addition, Eskom acted as a significant resource to central government in facilitating the development of organisational capacity within government (both in the NER and the DME).

The second important group was local government. While this sector was highly fragmented and faced many challenges, a few of the better managed municipal distributors made a significant contribution to the overall electrification effort.

A third group, which was vital to the programme were the university-based electricity researchers who participated in the Old Mutual/Nedcor scenarios and the energy policy analysts/activists in the EDRC/ANC, who facilitated the political legitimacy of the programme essential to its sustainability, and who, with NELF, were the architects of the accelerated programme. Independent policy research capacity on this scale in developing countries is not often present, and was probably a unique ingredient of the transition.

A notable feature of the programme was the length of time it took to develop an electrification policy and implementation system

[26] I.e. using several energy carriers/appliances for the same energy service, as well as using different energy carriers for different services.

[27] Unlike paraffin, electricity use is not easy to budget for on a daily basis, and appliances are much more expensive. However, most analyses indicate that electricity is usually cheaper in the long term than alternatives, except firewood when it is available for collection and low value is attached to the labour.

in government—approximately 12 years from the inception of the programme. However, the INEP is now a substantial agency, with a budget of R1.4 billion and an extensive planning system. The emergence of INEP in the DME in its present form was in turn dependent on (a) existing organisational resources (Eskom, the NER) being placed at its disposal for a significant period of time, and (b) the development of a range of accompanying institutions during the transition, including a new local government regime, a new spatial planning system, and significant reforms in central government, all of which took several years in most instances to begin operating effectively. It is tempting to suggest that an alternative model, a truly national utility (such as Electricite de France) would have been more efficient; however, the current structure of Eskom and the municipal utilities allows for a substantial degree of institutional diversity in implementation, which was identified in the 2001 review of the national electrification programme as one of the programme's strengths (DME, 2001, p. v).

Technology development played an essential role in reducing the real cost per connection (through innovations like SWER lines and leaner, more flexible design specifications) and reaching the social aims of the electrification programme (through innovations like prepayment metering and processes like blanket electrification). Strong research activity and knowledge sharing was a crucial component in this process.

The last notable trend was the interesting transition of electrification from a socially desirable (but economically limited) activity to an imperative, brought about broadly by a powerful democratic drive and commitment to service delivery (including the electoral significance of achieving RDP targets). As a result, the programme as a whole has extended its scope of activities, funding the whole capital cost of connection, providing bulk infrastructure, and providing various forms of capacity support to local authorities, as well as the separate FBE programme.

However, despite this, there are several side effects of the success of the programme, the main one being, ironically, the neglect of other aspects of household energy provision. There has been a lack of sustained political interest in developing the DME's capacity to draft and implement an integrated household energy policy, which on paper is an important policy goal, but in reality has not been pursued. Another significant side effect may be termed 'policy creep'—the tendency of the programme's prestige and success to result in it addressing a wider range of problems that might be better addressed elsewhere, such as capacity problems in local distributors, the persistence of which is partly the outcome of the failure of policy initiatives in other areas, specifically the electricity distribution industry restructuring process. On the whole, however, it is difficult to underestimate the significance of the electrification programme on the welfare of South Africans.

The replication of the South African experience elsewhere may be limited due to a number of reasons: first, the nature of the political transition; second, the presence of a strong national utility, in many respects unencumbered by the kinds of problems usually faced by developing country utilities; and third, a dominant industrial load base, which absorbed various forms of cross-subsidies when the programme was initiated.

However, several lessons may be drawn. One of the most interesting is probably the institutional and planning arrangements that the South African programme has developed; another is the significance of the development of appropriate cost-driven technical innovations and standards, and the third, proposed by Gaunt (2005), is the clear acknowledgement of the social function of electrification and its funding from the fiscus (rather than through cross-subsidies).

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