Energy-efficient lighting in an imperfect market: Preliminary thoughts for South Africa

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1. Introduction

The role of demand-side management (DSM) in newly created competitive electricity markets is not clear. Some have hailed this type of market transformation as a new opportunity for DSM. Although the last decade has revealed substantial potentials for reducing the use of energy by implementing more efficient technology, only a small fraction of this technology has been implemented; introducing competition into electricity markets could result in more of these savings being captured. Others see the sector's transformation as the beginning of the demise of DSM. Certainly, the result of more competition in the electricity industry in both Norway and England has been reduced interest and activity by the governments and utilities in DSM. And in the United States major reductions in DSM programme budgets have been proposed as utilities respond to the potential for a competitive market structure (Haaland 1995).

This paper seeks first to detail some of the theoretical and general aspects of the electricity industry and DSM, and then to apply these aspects to a real world context – energy-efficient lighting for low-income households in South Africa. The purpose of the paper is to contribute to the growing discussion concerning DSM and increased competition in the electricity industry in South Africa.

2. Assumptions and definitions

While it should be noted that these may not apply to all schools of thought and contexts, the following assumptions and definitions have been employed in this paper.

- The *electricity industry* comprises four sectors: generation, distribution (also referred to here as the electricity distribution industry (EDI)), transmission and retail. In most instances these sectors have been refered to specifically. Otherwise, the term `electricity industry' has been used to refer to the industry as a whole.
- *Generation* is defined as the process used to create electricity. *Transmission* is the process of conducting the flow of electricity at high voltages from the points of generation to the locations of groups of electricity users, such as residential neighbourhoods, industrial parks, or commercial centres. *Distribution* of electricity is the process of transforming high-voltage electricity to lower voltages and then physically delivering it to households, industrial facilities, commercial establishments, government offices, and other electricity users. *Retail sale* of electricity is the process of marketing electricity to the ultimate customers (Brennan et al 1996).
- Some literature, especially that from the US, uses the term *deregulation* to describe the process in which the electricity industry is introduced to (more) market competition. This term is somewhat misleading: it is indicative of a relaxation of regulations on the electricity industry. In many countries, including South Africa, the process of bringing more competition to the electricity industry might, in fact, result in a need for *more* regulation than is required of a less competitive electricity industry. In this paper the term is avoided. Instead, more neutral phrases such as `reform in' or `restructuring of' the electricity industry are used.
- Where the electricity industry is not competitive, the term *utility* is used to refer to the institution undertaking generation, distribution and transmission activities. Where competition has been introduced within the industry, the term `utility' is again used in its generic form – though here referring to a specific sector of the electricity industry.
- *Economic efficiency,* or Pareto Optimality, refers to a state in which no entity can be made better off without making another entity worse off. In general, *energy efficiency* refers to a state in which less energy is used to produce the

same amount of services or useful output. Essential to this paper, economic efficiency does not necessarily imply energy efficiency; neither does energy efficiency imply economic efficiency.

- Although, in theory, demand-side management (DSM) activities can refer to any measure taken by an individual, household, or firm to change the end-use of energy towards a specific objective, DSM in this paper refers, unless otherwise stated, to activities initiated by *utilities*. Such activities are designed to influence customer use of electricity in ways that will produce desired changes in a utility's load shape (that is, changes in the time pattern and magnitude of a utility's load). Utility programmes falling under this umbrella of DSM include: load management, new uses of electricity, energy conservation, electrification, customer generation adjustments in market share and innovative rates (Pye 1994).
- More competition in the electricity industry is meaningful, as long as the barriers to entry into the market are not too significant. This is to say, a leaning towards market forces (more competition) is regarded in this paper as a social good in that it is likely that it will lead to improved economic efficiency.
- DSM is a social good; that is, society benefits from more DSM activity. This assumption is based on:
    - the numerous environmental benefits associated with utilising less resources to generate (at least) an equivalent amount of energy output;
    - the savings utilities implicitly derive in avoiding significant capital outlays required to build new power plants;
    - the savings on utility bills to users utilising less energy for the same service.

3. The trend towards reform in the electricity industry

Historically, large natural monopolies have dominated electricity industries around the world. Until relatively recently these monopolies were justified within the context of an understanding that the generation, transmission and distribution of electricity is best undertaken on a large-scale. Accordingly, it was thought that the nature of the electricity industry is such that over a range of output – for any or all of the aforementioned activities – long-run average costs fall. In other words, by expanding activity, costs per unit of output decline. Due to the scale and scope of investment, particularly to enter the industry, and operations required, public sector support (even ownership) has often been relied upon. By definition, competition in such economies is precluded: a single firm can supply the entire service at lower cost than could two or more firms, and, given its cost structure, an established utility can undercut its rivals and drive them from the market (Moorhouse 1996). Secure from competition, natural monopolies could exploit the consumer were it not for regulation or state ownership.

Since the early 1980s, there has been a shift in the nature of this thinking and practice. In fact, consensus has now been reached that the natural monopoly structure is *not* necessarily the most appropriate structure for *all* sectors of the electricity industry. Certainly, in the generation sector, a growing body of empirical evidence, primarily from the United States, shows that smaller generation units are more economically efficient than one-firm structures. High-efficiency gas turbines and combined cycle turbines tend, for instance, to have lower capital and operating costs per megawatt-hour of electricity produced than new coal-fired generators, and they also have comparable reliability in generating performance (Brennan et al 1996). Moreover, the former are generally quicker and easier to bring into operation. At the other end of the scale, electricity transmission involves substantial fixed costs (for instance, transmission lines and right-of-way agreements), and therefore continues to be a natural monopoly. It is less clear what organisational form is best suited to distribution and retail sale. Traditionally, these services have been provided as joint products. On the one hand, this arrangement could continue to make sense if it is cheaper for one entity to be both the electricity distributor and the seller (that is, there are economies of scope). On the other hand, the retail sale of electricity does not require large fixed costs for capital equipment that the physical distribution of electricity involves, and may therefore be amenable to competition (Brennan et al 1996).

Current thinking is that even if economies of scale and scope do exist, they are neither necessary nor sufficient for a natural monopoly to exist. In this regard, technical and economic efficiency, though seen as vital drivers of the design and development of electricity facilities, are now not viewed as the only deciding factors: *reliability* also plays a major role in such processes. As Berlin, Cicchetti and Gillen (1974) note, '[t]he contingency to be guarded against is that a particular unit will not be available when needed. If generating capacity consists of a large number of small units, risk is spread over each of the units.' It has also become clearer that the efficient use of resources to produce and distribute electricity requires information about relative valuations that can only be generated by voluntary market exchange (Moorhouse 1996).

Few governments argue today that electricity industries are most effective or efficient as vertically integrated natural monopolies requiring government support. Several nations, including the United Kingdom, Norway, New Zealand, Chile and Argentina, have already restructured their electric utility systems. Similar initiatives are being implemented or considered in other parts of the world including Sweden and some parts of the United States (Haaland 1995).

There are several degrees to which an electricity industry can be introduced to competition. In general, competition in wholesaling is sought before competition in retailing. In fact, competition in retail is meaningless if the wholesale industry is not liberalised. Wholesale competition essentially entails separating the transmission, generation and distribution sectors, in an effort to open up the market so that all generators can sell power to local distributor utilities and other wholesale customers, such as power marketers. Under this scenario, electricity users would continue to purchase electricity from local utilities. Retail competition entails the separation of local distribution from retail sales. Users – including residential customers – would purchase electricity from the generator or marketer of their choice. There would be a number of electricity retailers to chose from, each potentially offering different packages of services and prices. Generating companies would resemble those under wholesale competition, except that they would be in a position to sell power to electricity retailers or directly to customers, instead of just to local distributors with a monopoly franchise for selling power (Brennan et al 1996).

To date, the electricity industry in South Africa has been dominated by Eskom, a vertically integrated and state-owned utility, and in most respects a good example of the type of traditional monopoly referred to above. Over the last four years, the industry has been carefully scrutinised with a view to it potentially being reformed. While many issues have been raised and demands specified, universal agreement on how to proceed has not been attained. Consensus has, however, been reached that (i) competition in the wholesale market will precede competition in retail, and (ii) the EDI will be targeted for reform first.

The EDI is highly fragmented – over 400 separate distributors are currently responsible for distributing electricity to customers around the country – with Eskom being by far the largest player in terms of energy sales for final consumption and number of customers. Moreover, roughly one third of the municipalities acting as electricity distributors currently cannot consistently provide adequate, reliable, and acceptable quality service (Galen 1997). It is expected that restructuring in the EDI will entail activity that primarily seeks to rationalise these distributors, or in other words to consolidate the EDI. Early on in the debate, the Electricity Working Group (EWG)[1] recommended that the fragmented EDI be consolidated into one single national electricity distributor. Later, this recommendation was withdrawn and replaced by one that suggested the EDI be consolidated into between five and 17 regional electricity distributors (REDs), to be formed by merging the electricity distribution functions of Eskom and local authorities in specific areas.[2] It was suggested that, if managed correctly, these REDs will be placed in a strong position to apply more effective credit control measures as well as boost the government's electrification programme (*Business Day* 7/3/97). More recently there have been calls for extending the number of REDs even more (*Business Day* 8/7/97).

While the reason for the EWG backtracking on its initial recommendation is unclear, it is interesting, and informative to this paper and to the wider debate that the recommendation was altered. At first glance, rationalising the EDI from more than 400 local distributors to about five is not indicative of a move towards a greater reliance on market forces and competition. Placing restrictions on the number and nature of the players in the EDI certainly limits the stage for competition and competitive behaviour. It could be otherwise argued. Though 400 and more institutions are currently taking the responsibility for distributing electricity, the EDI is not operating within a competitive environment. This is because Eskom is dominating the EDI, a third of the others are financially unviable, and Eskom has a monopoly on electricity generation. In essence the conditions for competition in the industry are not present with the EDI in its current form. Consolidating the EDI such that distributors (though limited) are able to compete on a more equal basis (in terms of financial, size and capacity), is surely indicative of a move towards creating the conditions for broad-based competition within the entire industry at later stages of reform – that is, moving from wholesale to retail competition in the longer term. This argument makes some sense in the light of the overall nature of the electricity industry: that sectors of the electricity industry are integrally linked, and more specific to this argument, that change in one sector might only have full impact once other sectors have also been reformed. In essence it can be said that the creation of the REDs lays the ground for future broad-based competition in the entire industry. That there will always be some market power in distribution has not gone undisputed though: it is envisaged that the functions of the National Electricity Regulator (NER) will attempt to protect electricity users from potential collusive or other monopoly-related activity.

Following international trends, recognition of the need to introduce competition into the South African electricity distribution is also beginning to emerge. How or when this will be done is currently undecided. Recent actions and stipulations of the NER clearly lean towards preparing the electricity industry for more competition in generation. The NER now requires, for instance, that Eskom ringfence its accounts for each of its generation units, and is attempting to create conditions such that the next major investment in power production is not an Eskom-driven initiative. Furthermore, there has been some debate on the potential role that independent power producers (IPPs) might begin to play.[3]

As elsewhere, the short-term potential for introducing competition into high-voltage transmission is limited in South Africa. It continues to make economic and organisational sense for this service to be operated and managed by one firm: indeed, substantial economies of scale and scope *can* be attained from operating in this way.

Currently retail sale of electricity falls within the activities of the EDI. It is likely that retail and distribution will now be separated, but not within the next five

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1 The EWG was the result of one of the National Electricity Regulator's first at overseeing and licensing electricity distribution authorities (Galen 1997).

2 In doing so, Eskom's distribution functions will be separated from generation.

3 IPPs are non-utility generators able to compete in selling generation capacity.

years. Through reform in other sectors of the industry, conditions for this to occur will gradually be created.

4. Theoretical aspects of DSM in more competitive markets

4.1 Introduction

As explained in the previous section, competition will be introduced into the generation and retail sale of electricity in South Africa, and this will be facilitated by a consolidation of the distribution industry. This section looks at the theoretical aspects of competition that underpin this process.

4.2 Restructuring and market forces

In a fully competitive electricity industry (that is, one in which competition has extended to retail sale of electricity), any electricity consumer (residential, commercial or industrial) would be able to purchase kilowatt-hours from any supplier, but still through regulated distribution utilities. This situation would invite an era of fierce price competition (Mills 1993). An example of the type of activity that could result from this form of deregulation is *retail wheeling* whereby customers can shop around for the least-cost electricity supply and have it 'wheeled' across existing local electric utility lines. The customer pays the local utility a retail wheeling rate for transmission and distribution services and buys electricity generation services (capacity and energy) from a different supplier. The supplier could be a neighbouring electricity generator, a non-utility generator, an electricity broker or a customer's own co-generation facility located at a different site (Pye 1994).

In many countries it is neither possible nor feasible in the short-to-medium term to introduce full-fledged competition into the electricity industries, and thus more moderate means of liberalising them might be favoured. In South Africa, for instance, the conditions for competition of the nature described above do not exist. There is currently no competition, for example, in the generation of electricity. Conditions for competition need to be created. Nevertheless, the trend in South Africa as elsewhere is towards a greater reliance on customer choice and market forces, and away from monopoly control. This approach is based on a classical or neo-classical theory of markets.

4.3 Neo-classical economics and perfect competition

The central tenant of classical and neo-classical theory is the proposition that agents operate in an environment of perfect competition, in which markets costlessly adjust to maintain the supply and demand for every good and service in constant equilibrium. The early theorists placed full confidence in the 'invisible hand' of the market to bring about a competitive equilibrium.[4] In the light of emerging levels of unemployment and inflation in the late 1960s – clear indications of market disequilibrium – Keynesians rejected the early claims of the classical economists. The proclaimed instead that, as the automatic adjustment mechanism of competition cannot be relied upon to achieve full employment and price stability, public sector intervention is necessary if such disequilibria were to be avoided. Market-based theories emerged again, as evidence mounted that government intervention is not the panacea either. The neo-classical competitive model differs from classical theorists' traditional treatments of perfectly competitive economics inasmuch as agents in it do not have full information about the structure of economy in which they operate. Instead, they make decisions based on their rational expectation of what will happen. Mistakes are made only to the extent that the economy is subjected to random and exogenous shocks, either in the form of policy surprises or fluctuations in technology (Laidler 1986; Fischer 1987; Hoover 1988). Today, most economists are in agreement that 'market failure', or 'barriers'

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4 A competitive equilibrium results when demand equals supply.

to entry into the market do exist. They disagree, however, as to how effective government is at dealing with this.

Economists define market `failure', as the *inability* of a system of private markets to provide certain goods either at all or at the most optimal level (Pearce 1992). In other words, market failure does not mean that nothing good has happened, but that the best attainable outcome has not been achieved (Lipsey et al 1993). Market `barriers'are factors that *inhibit* market agents from purchasing goods and services where benefits exceed costs.

4.4 Market failures and barriers

There is no single market for energy services: instead there are many energy services and many different markets for them. Furthermore, there are many cross-cutting distinctions within each of these markets. It helps, when defining and discussing market failures and barriers, to be more specific about the kind of service. Noting the large number of market barriers that can occur in energy markets, this narrowing-down process is particularly important. Energy efficiency, the focus of this discussion, is an example of a cross-cutting distinction in the markets for energy services. It is not a `stand-alone product' but one that has implication for energy demand at the one extreme and energy supply at the other (Golove & Eto 1996). Thus, the following examples and explanations of market failures and market barriers refer specifically to energy efficiency related concerns.

Sutherland (1991) suggests that market failures in energy markets are due to several factors:

- *Environmental externalities*

The term *externality* refers to a situation where the activity of one economic agent causes a change in the utility of another agent, and this change is not compensated or appropriated (van Horen 1996). Externalities can be positive or negative, although attention is usually given to the latter. In energy markets, externalities normally relate to the costs associated with usage of, or damage done to, environmental resources which are then not included in costs of production.

- *Energy conservation research as a public good*

The total cost of undertaking energy conservation research does not increase as the number of users of the research increases. Because agents potentially interested in the research know that it will be undertaken anyway, they do not see a need for, or economic benefit in, providing this service of their own accord.

- *National security aspects of energy supply*

All agents in a given environment know that the public sector will ensure that energy supply remains secure, and again see no reason to provide it of their own accord.

Market barriers, or imperfections in the market that prevent investment in energy efficiency include the following:

- *Imperfect information*

Customers may not have access to reliable information concerning their energy use and the costs and benefits of DSM technologies (Levine et al 1994; Golove & Eto 1996; Haaland 1995). Alternatively, customers may not be directly responsible for their energy-use behaviour if another party bears responsibility for paying their energy bills (Levine et al 1994). Golove and Eto (1996) describe this as being a problem of `misplaced or split incentives'.

- *Imperfect decision-making*

Customers may lack the expertise necessary to solve complex resource and utility optimization problems such as life-cycle costs and benefits of energy-using technologies and energy-efficiency options. Rather, customers may rely on `bounded rationality' that yields generally imperfect results (Simon 1987; Levine et al 1994; Haaland 1995).

- *Capital market accessibility and imperfections*

Some customers may have limited access to capital, and are frequently unable to borrow from capital markets (due to any number of constraints, such as income, equity, or risk). This then prevents then from making investments in energy-efficient equipment even though they are aware that this equipment could be beneficial to them (Levine et al 1994; Haaland 1995; Golove & Eto).

Customers may also use discount rates to guide their purchase decisions that are much higher than a utility's cost of capital. This can result in under-investment in DSM and over-investment in new utility generation (Levine et al 1994).

- *Transaction or hidden costs*

Consumers may find that the costs of gathering and processing information, making decisions, and designing and enforcing contracts may be too high to invest in energy efficiency (Golove & Eto).

- *Market structure*

The market structure barrier refers to product supply decisions made by manufacturers of energy-efficient devices. Certain firms might be able to inhibit their competitors from introducing energy-efficient and cost-effective products on to the market (Golove & Eto 1996; Haddad 1994).

- *Pricing*

Electricity is often subsdised to levels below the average cost of supply, and virtually always below the long-run marginal cost (LRMC). While these are justified in terms of reducing the cost of electricity to, for example, low-income users, the effect can be counterproductive. At low energy prices, the energy user invests too little in energy efficiency and electric utilities have to invest far more, increasing society's overall costs for providing electricity (Dutt & Mills 1994).

- *Gold plating*

'Gold plating' refers to the notion that energy efficiency frequently entails the purchase of other costly features and is not available separately. Thus, consumers are required to make an investment in compact fluorescent lamps in order to partake in energy-efficient lighting practices (Golove & Eto 1996; Pye 1994).[5]

Market `failures' and market `barriers' prevent users from purchasing economically efficient levels of DSM. It seems logical, then, to ask whether some form of DSM intervention into this particular market is appropriate. The section to follow explains why this would indeed be appropriate.

4.5 Energy efficiency in economically efficient markets

A utility must operate economically efficiently to remain competitive in this sector. It may engage in DSM or not, depending on the economics. Economic efficiency does not imply that energy efficiency will or will not be adopted. On the face of it, DSM related activities are expensive for distributors and retailers. For one thing, programme costs must be recovered.[6] In addition, and in line with the nature of DSM, there is a tendency for DSM to adopt true social costs of generation (as opposed to private costs). Again, these costs must be recovered. This usually implies the need for a tariff increase. If, in this perhaps oversimplistic scenario, *all* distributors and retailers in a market-driven electricity industry engage in DSM activities and, if necessary, increase tariffs concurrently, DSM will be justified.

If distributors and retailers deem DSM cost-ineffective, the spin-off effects for electricity industries could be far-reaching. Reduced spending on DSM undoubtedly impacts upon utility-funded research and development initiatives. In addition to this, a trend to treat data on customer energy patterns and conservation programmes as confidential or proprietary information is likely to develop. Mills

[5] A compact fluorescent lamp (CFL) is the energy saving device most often disseminated by utilities and their energy efficiency programmes. For more details see Clark (1997).

[6] In some countries, regulators allow utilities to recover programme costs in tariff structures.

(1995), for instance, warns of `serious departure from the relatively open and sharing environment of recent years', where it is `extremely difficult to conduct independent evaluations of DSM programmes' and spread best practice information to the market.

Thus, if retailers and distributors choose not to engage in DSM activities, and the resultant impacts are as above, it might be that a national regulator would find it within society's interests to require them to undertake a certain amount of DSM (or DSM-related activity such as research and development). This could be achieved by, for example, (i) a condition of the license agreements distributed by regulators to utilities, or (ii) a financial (or other) incentive provided by the regulator or generator to distributors and retailers.

As competition is introduced, utilities might, on the other hand, independently chose to engage in, or re-evaluate the approach afforded to, DSM. Utilities might find it cost-effective to market DSM as an integral part of a unique service to customers, as opposed to merely selling the product. In this regard, Mills (1995) suggests that energy efficiency could be promoted as a *value-added* service. Indeed, he argues, `there is good reason to believe that some customers would rather pay a little more for the electricity from a utility offering such a service as opposed to getting cheaper electricity from a competitor that does not offer any energy efficiency support'. Examples of utility DSM services, which could include financial services with the potential to provide much higher leverage than ordinary rebates, as well as various forms of technical assistance, are as follows:

- *Financial services*

i. provision of financing for efficient technologies

ii. leasing of efficient equipment

iii. acquisition of efficiency-focused technology

iv. direct sales of energy services (for example, illumination, comfort)

- *Technical services*

i. energy audits

ii. operation, maintenance, and commissioning

iii. design and project management

iv. training of facility operators

v. emphasis on non-energy benefits (i.e. socio-economic and environmental benefits).

How, in turn, these services are managed will in turn have impact on the economic viability of the utility.

4.6 Conclusion

The preceding section serves as an introduction to the section to follow. It has been noted that in a market environment DSM activities are costly and usually entail more risk. Given market failure and very apparent market entry barriers, it is highly unlikely that electricity users would invest in such activities of their own accord. Some form of public and/or utility intervention to reduce barriers is an essential prerequisite for customer participation. On the face of it, it does not make sense either for utilities to initiate or continue DSM activity, for generally such activity is also both costly and risky. Utility DSM activity in competitive markets is only worthwhile if it is viewed as a cost-effective business opportunity. This could possibly be achieved by utilities offering to provide a series of unique or customised DSM-related financial and technical services to potential customers.

5. Energy efficiency in South Africa

5.1 Introduction

The aim of this section of the paper is to contribute to the debate regarding the current role of DSM, and prospects for it in restructured electricity markets in South Africa. The discussion looks at DSM and energy efficiency broadly, and then focuses on one specific aspect of DSM: energy-efficient lighting for low-income households. The rationale for using this example is that (i) efficient lighting offers significant opportunity to utilities to alter their demand profiles, and; (ii) the barriers faced by the low-income sector are perhaps most pronounced and thus useful for illustrative purposes.

It is not the intention of this paper to suggest types of cost-effective and competitive DSM interventions for Eskom in its present form, and for the electricity industry during the various stages of its liberalisation: it is too soon to do the latter anyway. Instead, it seems worthwhile to take a step back and to consider some of the driving forces behind DSM in less and more competitive electricity industries. The remainder of this paper identifies some of the barriers to entry in the energy-efficient lighting market for low-income households, and how Eskom, in the light of its current priorities is planning to assist the low-income sector in overcoming some of these barriers. Barriers facing Eskom are then outlined, followed by a commentary on DSM initiatives in more competitive markets is given, and overall conclusions.

5.2 Low-income households and energy-efficient lighting

5.2.1 Socio-economic indicators

Tables 1, 2, and 3 below give a broad indication of the average monthly income and expenditure (nominal) of selected poor[7] households in Johannesburg, Port Elizabeth, Durban and Cape Town. Rural income and expenditures are likely to be even lower than these figures presented for urban areas.

	Johannesburg	*Port Elizabeth*	*Durban*	*Cape Town*
Av. Income (R)	945	828	1 119	1 277
Av. Expenditure (R)	706	553	1072	?

Table 1: Average household income and expenditure: all surveyed households (low-income or poor)
Source: Hoets & Golding (1992); Rossouw & van Wyk (1993); Mazur & Qangule (1995) as cited in Simmonds & Mammon (1996)

	Johannesburg	*Port Elizabeth*	*Durban*	*Cape Town*
Av. Income (R)	1 458	996	1 342	1 550
Av. Expenditure (R)	981	672	1 263	?

Table 2: Average household income and expenditure: formal surveyed housing
Source: Hoets & Golding (1992); Rossouw & van Wyk (1993); Mazur & Qangule (1995) as cited in Simmonds & Mammon (1996)

[7] 'Poor' is defined as the poorest 40 per cent of households; and 'ultra-poor' as the poorest 20 per cent of households. 'Fifty-three percent of South Africa's population lives in the poorest 40 per cent of households and are thus classified as poor. Twenty-nine per cent of the population live in the poorest 20 per cent of households and are therefore classified as ultra-poor' (SALDRU 1995).

	Johannesburg		Port Elizabeth			Durban	Cape Town	
	PI	UI	PI	UI	B/Y	I	I	B/Y
Av. Income (R)	829	782	688	570	595	914	914	923
Av. Expenditure (R)	646	616	463	356	345	896	?	?

Note: P: planned; U: unplanned; I: informal housing; B/Y: backyard shacks

Table 3: Average household income and expenditure in selected areas
Source: Hoets & Golding (1992); Rossouw & van Wyk (1993); Mazur & Qangule (1995) as cited in Simmonds & Mammon (1996)

Living conditions and access to services varies tremendously between the poor and the rest of the population. Table 4 details these disparities between different consumption groups in terms of their access to electricity. As is shown, the vast majority of the poor do not have access to electricity.

		Households ranked by consumption groups of 20% (quintiles)					
	All SA	Quintile 1	Quintile 2	Poorest 40% (poor)	Quintile 3	Quintile 4	Quintile 5 (richest)
% with elec.	53,4	15,1	27,7	21,4	49,4	77,3	97,5

Table 4: Access to electricity by consumption group
Source: SALDRU (1995)

Finally, an indication of urban electrification by housing type is presented in Table 5. Formal housing is well electrified whereas informal and backyard shacks are not.

Housing type	Houses	Electrified	Not electrified	% electrified
Formal	3 500 000	2 700 000	800 000	77
Informal	724 000	224 000	490 000	31
Backyard shack	147 000	36 000	111 000	25
Total	4 361 000	2 960 000	1 401 000	68

Note: figures are rounded to nearest 1 000

Table 5: Access to electricity by dwelling type in the urban areas of South Africa
Source: Davis (1995)

5.2.2 *Barriers to entry for low income households*

The types of barriers faced particularly by low-income households, as opposed to other income sectors, into the energy-efficient lighting market illustrate why the potential energy savings have not yet been captured. Some of the main barriers include the following:

- *Access to electricity*

Electricity provides a superior source of lighting, and is among the cheapest options for the provision of this service. Tables 4 and 5 show, however, that the vast majority of poor households in South Africa do not have access to this service. This immediately precludes these households from entering into the energy-efficient lighting market.

- *Cost of energy-efficient lighting and access to capital*

In situations where no DSM utility activity is available, access to capital to purchase energy-efficient lighting is perhaps the severest market barrier faced by low income households. Even though households can expect a financial saving over time from an investment in energy-efficient lighting, current consumption generally takes precedence over future savings or consumption. This is the same as saying that low-income households have a high discount rate for future savings and investment in energy-efficient lighting.

The average cost of a CFL in South Africa is approximately R50. There are no local manufacturers and all units must be imported. Monthly income and expenditures (shown in Tables 1, 2, and 3) suggest that this additional expense is unaffordable to many households if lump sum payments are required, and still hard to afford if payment by installment are acceptable. In addition to investing in CFLs, households might find it necessary to invest in some form of luminaire (a lamp shade, or covering) and other equipment – for example, households with only one lamp each might need extension cords. These additional expenditures make entry even more difficult.

If opportunities for capital market borrowing do exist, low-income households are frequently unaware of it. Although word-of-mouth is usually the main mechanism for low-income households gaining access to this type of information, it is highly susceptible to distortion and break down.

- *Price of electricity*

Generally, the low consumer cost of subsidised electricity in South Africa makes energy-efficient activities less cost-effective. Since the startup costs of utilising electricity for lighting efficiently (that is, the price of a CFL and associated equipment) are significant, it generally does not make sense for poor households to make this type of investment: households' payback time increases as the cost of electricity falls. With the electricity industry restructuring pending, and pledges to drop prices even further, this constraint will become increasingly evident.

- *Information and support*

As noted above, households' access to credit might be impeded by informational constraints. This problem extends to information detailing technical, economic, social and other aspects of CFLs. Without utility intervention, low-income households are unlikely to come across satisfactory amounts of information about CFLs and support for their usage. This is because CFLs' share in the lighting market in South Africa is still very small, largely because there are presently no local manufacturers of CFLs.

5.3 Utilities and energy-efficient lighting

5.3.1 Eskom's energy-efficient lighting programme

The National Electricity Regulator (NER) has committed the EDI to targeting 450 000 new connections annually. In doing so, it aims to raise the percentage of electrified households in South Africa from 35 per cent in 1992 to 70 per cent by 2000 (NER 1995). Eskom currently has sufficient capacity until 2007, given this committed construction plan (IEP5). Energy efficiency is thus not an immediate priority from an Eskom generation-capacity perspective (Eskom 1996a).[8] A study of 32 potential energy-efficiency programmes suggests, however, that a reduction in peak load of 2 500 MW is achievable by 2015 at a life cycle cost which is considerably lower than that of an equivalent power station. Furthermore, customers participating in the programme could realise an R8 billion benefit through reduced electricity costs. At least 80 per cent of the cost of the energy efficiency programme (R3.5 million) would be recoverable from participating customers (Eskom 1996b). In this regard, it has made sense for Eskom to phase in the programme slowly.

Eskom's immediate focus is on the residential sector. In fact, energy-efficiency programmes in this sector are the first energy efficiency programmes to be designed and implemented by Eskom. In essence, the residential sector has been targeted because of the nature of its consumption: residential load (demand) constitutes 75 percent of the total national variable load (demand) and is on the increase due to the impact of electrification (Eskom 1997a). Efficiency improvements in this sector could clearly contribute to a reduction in peak demand. These residential efficiency programmes are now housed in the

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[8] Eskom defines *energy efficiency* as 'the effective conversion and utilisation of energy in meeting customers' energy service needs in a manner which results in reduced life cycle costs for both Eskom and its customers' (Eskom 1996a).

Residential Demand Side Management (RDSM) Programme and include water-heating load control, time-of-use tariffs, thermal efficiency, appliance labelling, energy-efficient behaviour, limited supply capacity tariff options (for electrification) and energy-efficient lighting.

The main objective of the energy-efficient lighting (EEL) programme is to introduce cost-effective energy-efficient lighting schemes into all residential sectors, to reduce the evening peak by at least 770 MW by the year 2015, dependent on the developing balance between system supply and demand. The reason that the residential sector has been targeted is that it is largely responsible for the peaky nature of the national load profile. Other objectives of EEL include the following:

- making CFLs widely available at affordable prices;
- improving customer service by reducing lighting cost in the household;
- contributing to environmental conservation; and
- supporting the macro-economic development of the country (Eskom 1996b).

The programme allows for a range of specific DSM activities to be initiated in the low-, middle-, and upper-income sectors. In each of these sectors, the programme will consider the initial price per lamp that customers pay, awareness of CFLs and customer benefits, customer acceptance of CFLs, and CFL availability.

Eskom expects that EEL can achieve the following MW peak demand reductions in all three market segmentations, and reports impressive potential savings (net present values) to both its participants and to the utility.

Sector	*MW - 2000*	*MW - 2015*
High-income	90	500
Middle-income	30	90
Low-income	20	90
TOTAL	140	680

Table 6: Projected peak demand reductions
Source: Eskom 1996b

	Household	*Utility*
Sector	*Net financial benefits (R millions)*	*Net cost savings (R millions)*
High income	556.17	913.76
Middle income	51.86	72.94
Low income	58.51	94.77

Table 7: Projected utility and households savings
Source: Eskom 1996b.

EEL is in its developmental phase, and thus it is too early to describe its activities in detail. Personal communication with programme staff and draft project documentation reveals, though, that Eskom is considering the following for the low-income sector:

- launching the programme as a continuing initiative – that is, Eskom will attempt to promote and sustain the use of CFLs;
- launching a series of pilot projects to test utility impact and customer acceptance;
- launching an energy-efficient lighting programme;
- targeting newly electrified and previously electrified low-income households;
- targeting all lights in low-income sectors, since the houses are generally small;

- using the same technology in the low-income sector as for middle- and high-income sectors;
- liaising with local councils and social organisations in low-income areas when distributing the lighting devices;
- issuing CFLs free of charge in some areas, offering others at reduced prices in other areas;
- requesting payment be made through the tariff in some areas, requesting payment by installment in other areas.

5.3.2 Eskom and DSM in the electricity industry today

Eskom's EEL for the low-income sector is geared towards altering the load profile of electricity demanded by this sector. The programme aims to assist the low-income sector in overcoming some of the barriers to entry into the energy-efficient lighting market. Like users of electricity, utilities also face barriers to entry into the DSM market. These barriers vary in significance and include the following:

- *Cost of DSM programme*

DSM programmes are generally costly; Eskom estimates, for instance, that its energy-efficient lighting programme alone could cost over R4 million per annum (Eskom 1996c) and success is not assured.

- *Access to information*

For the energy-efficient lighting programme to take effect, further research is needed. Currently, relatively little is known about energy for lighting usage patterns in low-income households (for example, the number of lamps used in individual low-income households or the number of hours that these lamps are used for each day). This type of information is essential for the programme to be successful.

- *Availability of technology*

CFLs are not readily available in South Africa, and Eskom needs to rely on imported CFLs. Currently there is an overall shortage of such lighting devices in the international market, and so each time Eskom requires CFLs they must be ordered. Lag times between ordering and receiving can be quite significant and have the potential to undermine programme processes. This has not been a problem in South Africa yet, but once Eskom's energy-efficient lighting programme gains momentum and the pilot projects are implemented, CFL availability could pose an obstacle to the programme.

- *Price of CFLs*

Eskom, as noted, depends on imported CFLs. The cost of these devices is dependent on the rate of exchange of the Rand. Given the limited means of poor households, Eskom will potentially need to bear a proportion of the financial burden. In the light of low electricity prices, and Eskom's commitments to lowering them even further, this cost might be hard to justify.

- *Uncertainty in electricity industry*

Though it is too soon to say, the pending restructuring of the electricity industry in the country could have significant impact on the RDSM programme. If, for instance it is decided that RDSM programme costs and lost revenues cannot be recovered through tariffs, RDSM activities could potentially be reduced.[9] This, in turn, would hurt the energy-efficient lighting programme. Concerns such as these hinder the natural progression of the programme.

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[9] In Britain, electric utilities have yet to become active in promoting energy efficiency for this very reason.

- *Current excess capacity*

As noted, energy efficiency activities are not *yet* a priority for Eskom. Until South Africa begins to run short of its excess installed capacity, it is unlikely that this will change. In this regard, the programme will continue to face internal debate.

Because these barriers may prevent utilities from engaging in DSM, regulators often find it in society's interests to regulate that utilities undertake a certain amount of DSM. In South Africa, this has not been the case. Clearly Eskom sees enough benefit in DSM that they are willing to tackle such barriers. Indeed, it is in Eskom's interests to investigate the consumer market for DSM in South Africa. The reason for this have been explained: Eskom needs to start designing and implementing ways of altering the residential electricity demand profile. At current rates of consumption, South Africa will soon begin to run short of installed capacity, and new investment in additional power plants might be necessary. Energy-efficient lighting is one of the areas Eskom has chosen to target in an attempt to alter the demand profile.

The adoption of DSM appears cost-effective to Eskom in its current form. From both a financial and an institutional point of view, it is relatively easy for Eskom, as a vertically integrated utility, to engage in such activities. Altering the demand profile is a task that the generation and distribution components of Eskom would oversee. Similarly, investing in new power plants is also the responsibility of Eskom generation. Because generation and distribution activities, though separate, both currently fall under Eskom, DSM activity is easier to undertake. As will be shown next, when competition is introduced, however and if generation and distribution are separated, the decision to adopt DSM activities is not clear cut. A danger exists that DSM might be in the interests of generation, but not necessarily in the interests of distribution or transmission, or vice versa.

5.3.3 *DSM in a more competitive electricity industry*[10]

The South African electricity industry is waiting for a vision. Other than Cabinet's recent commitment to rationalising the EDI, few other definite steps have been made towards the restructuring process. As such, uncertainty regarding the future form of the industry abounds. The role of DSM in these more competitive markets is even less clear. In this light, the commentary below can only be based on what *might* happen.

Various stages towards introducing more competition into the electricity industry in South Africa have been proposed. The first, as noted, is for the EDI to be rationalised into approximately five regional electricity distributors (REDs). When this happens, and it is expected that it will be relatively soon, the EDI will be completely separated from generation and transmission. In effect, this means that Eskom's market power in distribution will be reduced, while its market power in generation will remain roughly the same.

What are the implications of this for DSM? Rationally, the REDs would strive to sell as many units of electricity as possible. As electricity prices must be competitive, engaging in DSM activity might not necessarily be economically efficient – unless, as was described in section 4.5, REDs combine the electricity product with a service too. REDs would purchase electricity from Eskom's generation sector (at this early stage in the process still a monopoly), and would pay for its transmission. Given that Eskom generation will face similar pressures on demand during peak hours and on installed capacity, it might be in its interests to encourage these distributors to support DSM. This could be achieved by Eskom generation offering financial or other incentives to REDs to carry out DSM initiatives. Pricing structures could be set such that is would be in the REDs' interests to purchase an increasing amount of

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10 With perhaps the exception of the barrier resulting from *uncertainty in the electricity industry*, the barriers to entry into the energy efficient lighting market as described in the previous section still apply.

electricity out of peak hours. Eskom generation might also chose to enter into long-term agreements with customers with a high demand for electricity such that electricity is transmitted directly to the user, and where the role of the distributor is only nominal. Small, fixed fees (the structures of which could be determined by the NER), could be paid to the transmission sector by the customer for usage of the transmission wires. Conditions of the contact between Eskom generation and the customer might be that the customer engage in energy-saving activity. In fact, it might not even be necessary for energy-saving conditions to be attached to such a contract: long-term users may engage in energy-efficient measures of their own accord if the peak/off-peak pricing structures signal the benefits of a change in energy-use behaviour.

It is unlikely that Eskom generation will directly drive DSM activities targeted at the residential sector. It is more likely that until the way is paved for the establishment of a retail industry, residential DSM programmes will be driven by, and administered within, the EDI. It is unlikely in the short-to-medium term that distributors (and other utilities) will compete with each other to provide either products or services to low-income households. Similarly to the way electrification initiatives are seen today, it is likely that the offer of DSM support to low-income households will be seen more as a social responsibility than a business opportunity for the utilities.[11] Perhaps it will be in the interests of the individual REDs to offer DSM support to the low-income sector now, with a view to preparing to capture a future consumer base. Perhaps by providing DSM support to the low-income sector, the REDs will be in a position to manage peak demand better, thus minimising the purchase of expensive peak-hour electricity from Eskom generation.

The next major phase of the process will probably involve the introduction of competition in the generation sector. The NER may foster the creation and development of a number of independent power producers (IPPs). For installed capacity and load management reasons, newly created IPPs might again need to carefully manage electricity usage during peak hours. Perhaps the NER will further simulate competition in energy markets by requiring that all power produced is sent to a common national electricity pool. As has been done in other parts of the world (the UK especially), the REDs could acquire electricity from this pool by bidding on a regular basis for it. The regulator (or generators) might in turn require that the REDs include in bids an illustration of their predicted demand profile. It could be in the interests of the REDs to adopt some DSM activity in an attempt to submit the winning bid. The REDs may also chose to engage in DSM irrespective of the bidding processes. If a common electricity pool is not established, then competition between the various generators to sell electricity to the distributors will be more transparent, which will imply less scope for generators to attach conditions to the sale of electricity. Distributors will always choose the cheapest source of electricity, and therefore there is less scope for DSM initiatives. If DSM is deemed socially desirable, a role for the NER might develop here. As described above, IPPs could engage in long-term agreements with high-demand electricity customers. Incentives could be offered, or stipulation made requiring that the customer engage in load management exercises, or energy-saving activities.

It is currently difficult to envisage how competition in a retail industry in South Africa would work. Perhaps, though, the retail industry, or even energy service companies, could become the natural home for DSM and particularly that which is targeted at the residential sector. Indeed DSM is about a service and not just a product. In this type of environment, it is most likely that DSM (in general) will take the form of a value-added service, with benefits paid for by individual customers. If this is the case, then, keeping other barriers to entry into the market in mind, it is unlikely that low-income households, in particular, will be able to

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11 In fact, there are indications that this is the case already. It is widely accepted that the 'real' energy savings gains during peak hours come, not from the low-income household sector, but rather the middle-to-upper income sector.

participate to the extent to which they would perhaps like to. This might be another role for the regulator.

6. Conclusion

As is clear from the uncertainties presented in this paper, and in particular in the preceding section, it is difficult to predict the implications of reform in the electricity industry on DSM in general. One of the reasons for this is that different degrees and models of competition can be introduced. A very limited description has been given of some of the possible outcomes in South Africa. Clearly, other outcomes are also possible.

By exploring some of the theoretical and historical aspects of the electricity industry and DSM and then focusing in on energy-efficient lighting to the low-income sector, this paper has attempted to draw out some of the issues that will be requiring thought and debate in the next few years in South Africa.

It is unclear if DSM is worthwhile in competitive electricity industries. Three scenarios could, in this regard, be considered. First, DSM might be deemed worthwhile by the regulator, but not by the main players in the electricity industry. In the event of this, distributors and retailers will undertake DSM according to the regulations imposed on the industry. The Regulator might require that distributors or retailers dedicate a percentage of sales to DSM-related activity. Futhermore, distributors or retailers might be required to bid for amounts of electricity (either directly from Eskom, or from a common electricity pool if there is competition in generation) with mandatory DSM-related activity being an integral component of the bid.

The second scenario is perhaps the more interesting: players in the industry might undertake DSM activities of their own accord; this is to say, engagment in DSM related activity is determined by the market. In this case, intersectoral linkages between generation, distribution, transmission and eventually, retail will develop. These linkages might be catalysed by the introduction, for example, of time-of-use tariffs. It will then be in the interests of distributors and retailers to undertake DSM activities in order for less expensive electricity to be purchased from the generation sector. The extent to which DSM-related activity is engaged in will also depend on whether or not the regulator allows DSM programme costs to be recovered in tariff structures.

The third scenario, the most unlikely, is that neither the regulator nor the other players in the industry consider DSM worthwhile, in which case DSM programme activity will be discontinued.

Finally, the paper has suggested that DSM activity targeted at the residential sector will most likely be driven by the EDI and, eventually, energy service companies or the retail sector. For low-income households it becomes even less clear what form DSM activity will take. For distributors and retailers in competition, the returns probably do not justify their engagement in this sector. It might be that the motivation for involvement be related more to the distributor or retailer's social responsibility towards this sector.

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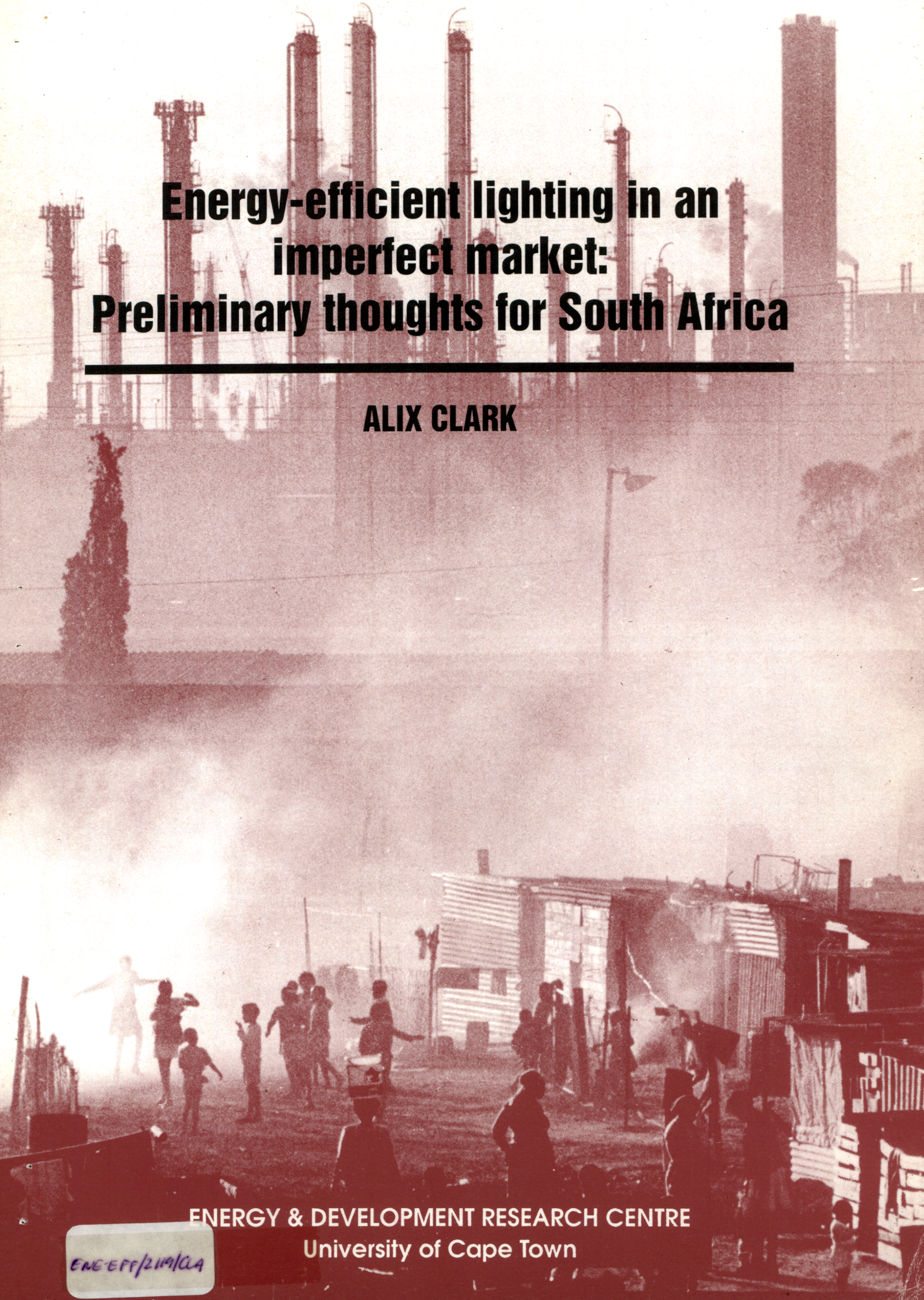

Energy-efficient lighting in an imperfect market: Preliminary thoughts for South Africa

ALIX CLARK

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