Technical note

Evaluation of an integrated asset life-cycle management (ALCM) model and assessment of practices in the water utility sector

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Abstract

The water utility sector in South Africa is presently facing numerous challenges. Amongst the most urgent and important priorities is ageing infrastructure, which has the potential to end in failures with detrimental impacts on local communities and the natural environment. Furthermore, to manage the majority of strategic assets in terms of total performance, i.e. environmental, financial, social and technical, is often difficult as a large portion of assets, such as buried pipelines, cannot be easily accessed. These issues highlight the need for a generic asset life-cycle management model for the water utility sector. Such an integrated model is introduced; it was evaluated in the largest water utility in South Africa. Although it was found to have relevance, practicability, applicability, and usability, the model still needs rigorous testing amongst other water utilities in South Africa, and in other countries. The perceptions of the water utility sector were also assessed in terms of the practices of the principles of integrated life-cycle asset management. The results indicate a fairly good understanding of the concept of asset life-cycle management, but allude to challenges with fully implementing all the principles when it comes to asset performance measurements; particular attention must be given to develop mechanisms to measure environmental and social aspects. Nevertheless, it is highlighted that for strategic assets, the practices and principles of ALCM have many benefits, including better maintenance management, infrastructural planning, risk management, and sustainable development.

Keywords: life-cycle management, asset management, sustainable development, South Africa

Introduction

The water utility sector in South Africa is presently facing numerous challenges. Amongst the most urgent and important priorities is ageing infrastructure that must be replaced (Schwellnus, 2005), and the previous lack of formal knowledge management systems prior to modernisation in the later part of the 1980s (Rand Water, 2004). In terms of the latter the consequence has been a gross underestimation of the total value of physical assets under the control of organisations in the water utility sector in the first instance. Secondly, this caused a very reactive approach to asset replacement as the exact location and condition of the assets, especially buried pipelines, was not fully known. While there is available technology, such as eddy current scanning, that can detect pipe leaks for example, there is no technology that can detect impending leaks. Thirdly, because the landscape, i.e. natural environmental factors, and communities, i.e. social factors, around the infrastructure often change significantly from the time of the initial installation of infrastructure, the potential impacts on the communities and the natural environment in the event of failures of assets is a considerable risk, which increases each year.

Schwellnus (2005) emphasises that factors, other than financial, increasingly need to be considered in making decisions, including risks to current operations. Furthermore, the status of the large majority of strategic assets is often unknown in terms of total environmental, financial, social and technical performances, which are subsequently not addressed adequately in most asset management practices (Botha and Brent, 2005). These parameters impact the triple bottom line of an organisation, and need to be actively managed to ensure sustainable growth of the company into the future (UNEP, 2006). To this end some asset management approaches do have a total life-cycle process perspective, i.e. the 'cradle to grave' principle (Schuman and Brent, 2005). However, the 'triple bottom line' must further be contextualised within the life cycle and value chain concept of the product, namely potable water, from extraction and purification to distribution to the end users (Landu and Brent, 2006). The whole-system value chain must be scrutinised in view of the fact that the water utility sector is a key driver in enhancing socio-economic growth within South Africa, and in all countries.

Objectives of the paper

The aforementioned challenges that are posed by intense pressures from stakeholders, together with legislation such as the Public Finance Management Act (PFMA) and the Municipal Finance Management Act, are giving impetus to the concept of integrated asset life-cycle management (ALCM) in the water utility sector. This paper introduces such an integrated ALCM model, conceptualised for physical and strategic assets in the water utility sector of South Africa. The paper then summarises the evaluation of the model in the largest water utility of South Africa, and further assesses the current status in the water utility sector, in general, as to the practices of the principles of integrated ALCM.

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Overview of the current theories and models

The conventional view of physical asset management (PAM) is derived from maintenance (Amadi-Echendu, 2004). Amadi-Echendu states that PAM is much wider than the normal maintenance function. He further adds that PAM is about creating value, i.e. it includes the life-cycle processes of creating, establishing, exploiting, i.e. operating and maintaining, and divesting a physical asset in a manner that satisfies the constraints imposed by economics, ergonomics, technical integrity and business performance. Figure 1 depicts the definition of PAM. While Campbell (1995) did not profess to offer a discourse on asset management *per se*, the nine-step asset management process depicted in Fig. 2 does go a little further in expounding the fundamentals of the asset management process.

Kostic (2003) quotes the definition of asset management given by the Government of Victoria, Australia, which defines utility asset management as 'the process of guiding the acquisition, use and disposal of assets to make the most of their future economic benefit and manage the related risk and costs over the entire life cycle'. From a South African perspective, Fig. 3 illustrates the basic asset life-cycle management model depicted in the National Treasury Guideline (2004). The life cycle of an asset can be defined as that period that an entity can foresee itself utilising an asset on an economically effective and efficient basis for the furtherance of the entity's trade or service deliverance (National Treasury, 2004). The National Treasury Guideline (2004) further states that the period covers all the phases in the life of an asset, namely the procurement, the use and maintenance, and eventual disposal thereof. This period is described as the useful life of the asset to the entity and it may be different to the physical life of the asset. The National Treasury Guideline is applicable to all state-owned entities such as water utilities, and therefore has relevance.

A definite shortcoming in these conceptual models is that the economic, environmental, social and technical dimensions of asset management are not explicitly depicted in the models. There is also no mention in the models of data collection and the concept of an integrated platform of asset information such as an asset register. However, as will be discussed later in the paper, asset management practitioners that were interviewed point out that this aspect is fundamental to good asset management.

Life-cycle management (LCM) has appeared as a new managerial approach in response to increasing concern about the influence that modern industrial activities have on the environment (Sanchez et al., 2004). In general terms, LCM can be understood as a way for business to manage an approach to sustainable development; some authors have even affirmed that it is the precondition for sustainability (Westkämper et al., 2000).

LCM is the application of life-cycle thinking to modern business practice, with the aim of managing the total life cycle of an organisation's products and services towards more sustainable consumption and production. LCM is not a single tool or methodology, but a flexible integrated management framework of concepts, techniques and procedures incorporating environmental, economic, and social aspects of products, processes and organisations (UNEP, 2006).

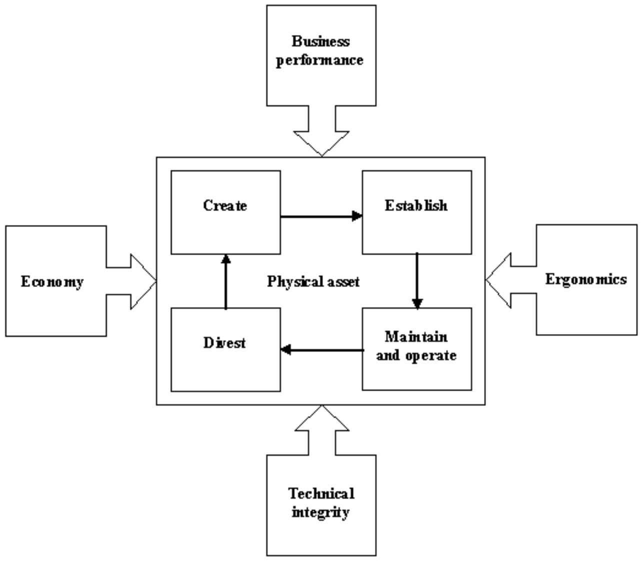

Figure 1
Physical asset management (Source: Amadi-Echendu, 2004)

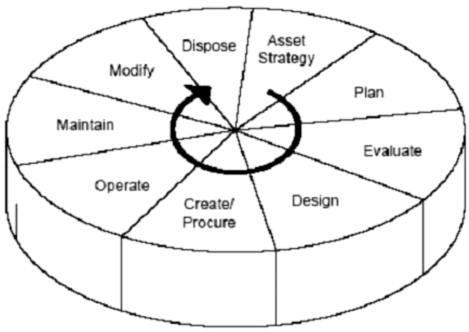

Figure 2
Asset management process (Source: Campbell, 1995)

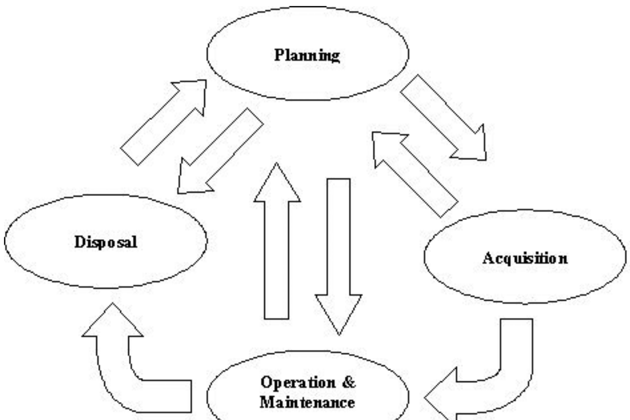

Figure 3
Asset life-cycle management (Source: National Treasury, 2004)

Proposed conceptual model

The proposed integrated ALCM model (see Fig. 4) is derived from an amalgamation of LCM and asset management theories; at present these theories and models are not captured on a common platform (Haffejee, 2006). For the purposes of this paper, integrated ALCM refers to the management of assets over their complete life cycle, from before acquisition to disposal, taking into account economic, environmental, social and technical factors and performances. Furthermore, 'assets' refer to strategic assets. For the purposes of consistency, strategic assets are those assets that play a direct role in the production of potable water and/or the distribution of potable water to the organisation's customers. Failure of a strategic asset would result in either of the following happening:

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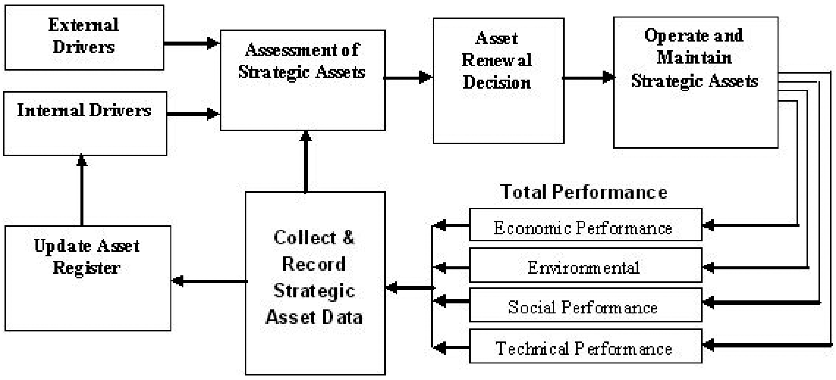

Figure 4
Proposed integrated ALCM model

- Water would not be delivered to the customer
- Water of the incorrect quality and/or less than the required quantity of water would be delivered to the customer.

It is noted that strategic assets may include non-physical assets such as intellectual capital, but in terms of the proposed ALCM model strategic assets refer to physical assets only.

External drivers of change

The external drivers of change are defined as those factors that emanate from outside the organisation, but cause changes within the organisation. These factors include, *inter alia*: communities, i.e. social and/or environmental concerns; competition; consumers, i.e. social and/or economic concerns; cost of raw water; cost of electricity; cost of chemicals; environmental lobby groups; government, e.g. legislation; increased or decreased water demand; and scarcity of skills and experience.

Internal drivers of change

The internal drivers of change are defined as those factors that are driven from within the organisation and that cause changes within the same organisation. These factors include, *inter alia*: cost-reduction initiatives; lack of system capacity; loss of skilled personnel; obsolescence, i.e. high maintenance costs; redundancy, e.g. need for interconnectivity and additional water storage facilities; process efficiency; and safety.

Assessment of strategic assets

Performance assessment is done in terms of:
- Economic or financial impacts, i.e. life-cycle costing or total cost of ownership
- Environmental impact/s, i.e. environmental incursions in terms of chemical spillages, land refills, etc.
- Social impact/s, i.e. disasters that affect people in anyway
- Technical impacts, i.e. efficiency and effectiveness
- Technical losses.

These assessments would be initiated by the water utilities themselves, e.g. risk assessments for chemical spillages and disaster prediction and management, or it could be as the result of an interaction with affected or interested parties who may be impacted by the environmental and/or social performance of the asset, e.g. the mandatory and regulated environmental impact assessment (EIA) process for new developments. The ALCM model assists in organising existing information and identifying gaps for information that is not available and which has to be gathered.

Some of the relevant concerns during this phase are assessing the performance of the asset over its design life cycle as follows:
- Are there new technologies that can perform the same (or more functions) at a better price or in a safer and more efficient manner?
- Has the performance deteriorated to a point, even before the predicted design life span, that necessitates the modification of the asset?

Asset renewal decision

The asset renewal decision refers to a decision that needs to be made regarding the future of the asset. A sound business case, unless there are safety and/or legislative reasons for asset renewal, needs to be compiled to support the asset renewal decision. The decision could include maintaining the status quo, i.e. run the asset to failure as part of the maintenance tactics, but it is ensured that a complete risk assessment is conducted to support this decision. The asset renewal decision can, therefore, include any one or a combination of the following:
- Leave as is – run to failure strategy – risk assessment completed
- Leave as is – operate and maintain as usual – future assessment to be made
- Retrofit
- Refurbishment
- Replacement of component parts
- Overhaul
- Complete asset replacement.

Operate and maintain strategic assets

The strategic assets are operated and maintained in accordance with predetermined guidelines, standards and specifications in such a manner so as to try and achieve the design life with the least possible costs, and minimal (preferably zero) social and environmental impacts.

Total performance (of assets)

The assets are monitored and managed in terms of predetermined standards and specifications with regards to the economic, environmental, social and technical performances.

Collect and record asset data

Total performance data of the strategic assets are collected, verified/validated and recorded. The data are verified against design performance parameters, but moderated for actual application conditions. A data trend and historic usage information are established. Set points are determined for the data to flag the system if the asset performance deteriorates to an unacceptable level.

Update asset register

A detailed asset register is kept, and updated regularly to reflect the performance of the strategic assets. An integrated software system incorporating an interactive database management system will be essential to the successful implementation of an asset register.

The asset register clearly identifies the asset; its geographic location; primary data such as technical ratings and design life span; secondary data such as operational performance, maintenance history, technical performance, total cost of ownership – to date, social impacts, and environmental impacts; and any background activities such as asset renewal decision(s) in process linked to the asset.

Information from the asset register could serve as an internal driver of change. For example, the condition of an asset could be such that it is clear that the design life of the asset will not be reached, thus necessitating an asset renewal decision to be taken.

Key attributes of the proposed ALCM model

In summary, the proposed conceptual ALCM model attempts to provide the technical, social and environmental dimensions to a modified physical asset management model. Other key areas of asset management, not captured in other life-cycle management or asset management models, such as data collection and the recording of key data in on integrated information platform, such as an asset register, is also depicted in the model. The key attributes of the proposed model are as follows:

- External drivers such as environmental pressures and legislation
- Internal drivers such as capacity concerns, efficiency and resource management
- Data collection, which is a key aspect of proper physical asset management
- Asset register, which forms a pivotal role in linking the asset to the financial statements of the business.

Evaluation of the conceptual model

The integrated ALCM model was evaluated within the largest South African water utility, i.e. Rand Water. The aspects that were evaluated included:

- Relevance to strategic asset management
- Applicability to the relevant business processes
- Practicability in terms of issues identified within the model
- Usability in terms of process flow, and impact on business.

Three large projects, which included assets worth over ZAR 300 m. (1 South African rand = 0.129 USD) were selected for the evaluation. Senior managers that were involved in the three projects were interviewed, and their comments collated. The following important observations were made:

- It was quite evident that the need for an assessment of the strategic assets, the first step towards the asset renewal decision, can be driven from outside the business or inside the business; at times there are a combination of external and internal factors that drive the need for asset assessment. This highlights the importance of the external and internal drivers' focus of the model.
- It was noted that each component of the model constitutes a process in its own right. These processes may take a relatively long time to conclude. All the components of the ALCM model are therefore applicable to relevant business processes, but the model does not address the scheduling of these internal business processes.
- Performance measurement was done by default, and generally on a principle of exception reporting. In other words, there were no formal mechanisms in place to monitor total financial, environmental, social and technical performances of the assets against predetermined standards and specifications. Therefore, the practicability of gathering the necessary information is still a weakness of the conceptual model.
- The process of operating and maintaining the strategic asset is, generally, the longest (time-based) process in the model. Some assets in the water utility sector were originally installed between seventy and eighty years ago, and are still in working condition and presently in operation.
- The recording of key strategic asset data, including total performance of the assets, in an integrated platform or asset register is still in its infancy stage.

The latter two bullets highlight that the actual usability of such a conceptual model in practice, has yet to be demonstrated over the long term in the water utility sector.

Revised integrated ALCM model

Based on the feedback that was received, the integrated ALCM model was revised (see Fig. 5), to reflect two more feedback loops that were identified as part of integrated ALCM processes. Since the conceptual model is intended to be a generic one, it is anticipated that the model would find utility in other sectors where the function of strategic asset management takes place.

Current status of ALCM practices in the water utility sector

A questionnaire was framed around the practices of the ALCM principles in the water utility sector (Haffejee, 2006). The questionnaire had qualitative and quantitative dimensions. The questionnaire also contained questions relating to decision-making criteria when replacing or modifying assets, and the issue of total performance monitoring of assets, i.e. the monitoring of the financial, environmental, technical and social performances of the asset.

There are a limited number of bulk water utilities in South Africa; only two are roughly comparable in terms of their total

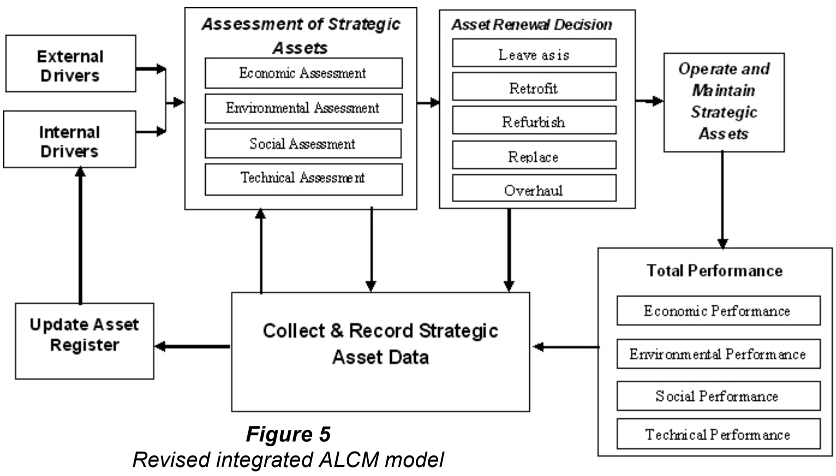

Figure 5
Revised integrated ALCM model

TABLE 1 **Summary of the main survey questions and responses (Haffejee, 2006)**	
Category / questions	**Responses**
1. Asset acquisition/modification *Questions focused on the factors considered when making decisions regarding asset acquisition/modification.*	• The Australian water utility can be considered 'best in class'. When making decisions on asset acquisition/modification, the Australian water sector considers financial, environmental, social and technical impacts of the, although not integrated into one model. • While the EIA process in South Africa caters for both the environmental and social impact assessment before major infrastructural acquisitions/modifications, three of the South African respondents did not realise this. This led to them indicating that the social impacts may, at times, not be formally considered during the acquisition/modification of strategic assets.
2. Decision making regarding assets *Questions related to the use of a ALCM plan or model when making decisions regarding assets.*	• The Australian water utility 'almost always' uses an ALCM plan or model to make decisions regarding assets. • The responses from the South African responses ranged from 'unsure' to 'very often'. This was quite interesting given that almost all the South African water utilities in the sample, indicated that they did have an asset management system or an asset management plan.
3. The use of a ALCM model/plan *Questions related to whether the use of an ALCM plan or model would result in better management of assets, better maintenance management, improved planning, and improved risk and financial management of assets.*	• There was a strong perception amongst respondents that a good ALCM plan or model would result in better and more efficient management of strategic assets.
4. Asset disposal *Questions focused on factors that were considered when phasing out or disposing of old or unwanted assets.*	• The respondent from Australian water utility indicated that the financial, environmental, social and technical impacts were considered when disposing of assets. • Only one respondent from the largest water utility in South Africa indicated that all impacts were considered during asset disposal. All other respondents from the South African water utilities indicated that the focus was primarily on financial and technical impacts during asset disposal. However, it must be noted that disposal of assets in South Africa are affected by various pieces of legislation (such as the Occupational Health and Safety Act) and the environmental and social impact assessments are often prescribed.
5. Asset failures *Questions focused on whether respondents believed that their organisations were in a 'state of readiness' to deal with any failure of its strategic assets, including dealing with the environmental and social impacts of such failures.*	• Only one respondent from a South African water utility was of the opinion that his organisation was not fully prepared to deal with any failure of its strategic assets. However, only the respondent from the Australian water utility indicated that they were 'definitely ready', and alluded to advanced risk models used to simulate various failure scenarios.
6. Asset performance *Questions related to the monitoring, measurement and evaluation of each of the dimensions of total asset performance, namely financial, environmental, social and technical performance.*	• Only the respondent from the Australian water utility indicated that all the above dimensions of asset performance were monitored, measured and evaluated. Responses from South African water utilities indicated a strong focus on technical performance monitoring, measurement and evaluation. • The two larger South African water utilities had a reasonable correlation between their responses, indicating that at least three of the four dimensions of total asset performance were monitored and evaluated.

supply value chain being similar. Nonetheless, the questionnaire was sent to a selected sample of six water utilities. The selection was based on the following criteria:

- Assets under the direct management of the water utility and which could have an impact on the environment and society (if failure occurred).
- Annual capital expenditure.
- The size of the utility in terms of the volume of water supplied annually.

The questionnaires were sent to senior managers within the sample of water utilities, mainly from the Financial, Engineering, Operations and Maintenance, and Planning departments. It was noted that all questionnaires sent to financial managers were re-routed by themselves to either their engineering or operations counterparts. By deduction, then, it is clear that the financial managers do not see asset life-cycle management as falling within their ambit of responsibility. This was also supported by the questionnaire responses; not a single respondent felt that the financial department should be the custodian of the asset register.

From personal interviews with some of the senior managers in Rand Water, which were structured around the abovementioned questionnaire, it was ascertained that Australian water utilities were perceived to be amongst the world leaders in terms of ALCM practices. Hence, three of the leading Australian water utilities were also selected to distribute the questionnaire to. While it is noted that benchmarking is not a stated objective of the paper, the Australian water utilities do introduce an inter-national dimension to the assessment.

The two largest South African water utilities provided responses to the complete questionnaires. Of the three selected Australian water utilities, only one responded.

Main findings

The questions can be broadly categorised into six main categories covering elements of integrated ALCM practice (see Table 1). The main survey questions and associated responses from these six categories are summarised in Table 1. Further details can be found elsewhere (Haffejee, 2006).

It was noted from the responses to the questions assessing the understanding of ALCM, that senior managers at all the water utilities had a good general understanding of the concepts of ALCM. For example, one such response was:

> *'The planning, acquisition, operation and maintenance of strategic assets over their life cycle (from birth to disposal) such that they achieve their intended objectives at the lowest possible life-cycle cost. This includes evaluations of performance, condition, and the risk of failure, and a continuous evaluation of when to renovate, replace or dispose of an asset'.*

However, from the responses of the South African water utilities, it is clear that there is not a full appreciation of the concept of total asset performance. Little attention is especially given in the current management practices as to the disposal phase of assets. More specifically, the social and environmental performances of assets were not always explicitly mentioned in their responses. This may well be because the concepts of environmental and social performance were not defined in the questionnaire, and may have resulted in different interpretations of these questions.

Conclusions

The evaluation and assessment, in the South African context, showed that:

- Role players within the water utility sector are of the opinion that there is a need for a generic ALCM model.
- The proposed integrated ALCM model is relevant, applicable and practicable, at least to the largest South African water utility.
- There is a good general understanding of ALCM concepts amongst senior managers in the South African water utility sector.
- The environmental and social performance of assets is not adequately monitored in the water utility sector. This is a definite concern given that failure of strategic assets would have environmental and social impacts.
- There is strong agreement between role players within the water utility sector that there is a need for usable, easy to understand tools to assist in the implementation of ALCM principles, e.g. methods to assess environmental and social performances for meaningful comparisons with financial performances.
- For strategic assets, the practices and principles of ALCM may have many benefits, including better maintenance management, infrastructural planning, risk management, and sustainable development.

To support these outcomes of the evaluation and assessment further research is required. Apart from more rigorous testing of the model in other water utilities in South Africa and beyond, attention must particularly be given to the development of formal mechanisms to measure total sustainability performances of strategic assets, i.e. appropriate indicators that can assist decision-making processes in the water utility sector of South Africa.

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