Analysis of energy metering effectiveness in rural municipalities – a case study

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ABSTRACT

Management of any aspect of life remains the single determining factor for success, wealth, growth and prosperity – this is a general truth. Without an effective management system, nothing will have direction and no milestone can be achieved.

The most important management section of any organization is the management on ground level. If ground level management of an organization is defective, the organization will not function and will soon only serve as a reference to a valuable lesson.

The sustainability of local government is determined by the same principle, with the success thereof ascribed to the management of infrastructure and processes within a municipality. One such functioning aspect of municipalities is the electrical energy metering system. A well-managed and maintained electrical energy management system is one of the few capital resources of any municipality. The electrical supply system can however also be one of many constraints, impeding development if mismanaged.

This research study shows the effects of management, or the lack thereof, on selected rural municipalities. Research was done to determine the current state of technology and the associated financial impact on these municipalities. Although it is not possible to generalize, it is evident from this research study that an underlying problem is the lack of proper ground level management.

Design science research was used to add value in the form of a capability maturity model for rural municipalities. Such a model can be used to score a municipality in terms of its capability maturity at national level. When applied correctly, this model can be used as a management tool.

By the implementation of certain management strategies based on technical principles, the impact of an electrical energy metering management system was also illustrated by this research study. This research study also covers the applied method and results as implemented by several municipalities within the Republic of South Africa.

Keywords: Energy metering, rural municipality, capability maturity, effectiveness

Analisering van die effektiwiteit van energie metering in landelike munisipaliteite – ‘n gevallestudie

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OPSOMMING

Die sukses van alle aspekte van die lewe hang grotendeels af van die bestuur daarvan – dit is ‘n welbekende feit. Sonder ‘n effektiewe bestuursisteem sal geen doelwit bereik word nie en sal sukses, voorspoed, groei en welstand in gebreke bly.

Grondvlakbestuur is die belangrikste deel van enige organisasie. Sonder effektiewe grondvlakbestuur sal ‘n organisasie agteruitgaan en spoedig slegs bestaan as ‘n verwysing na ‘n waardevolle les van tipiese foute wat nie gemaak moet word nie

Die volhoubaarheid van die plaaslike regering word deur dieselfde beginsels bepaal. Die sukses van ‘n munisipaliteit word toegeskryf aan die manier wat infrastruktuur en prosesse binne die munisipaliteit bestuur word. Binne ‘n tipiese munisipaliteit is daar weinig kapitale hulpbronne. Een so ‘n hulpbron is die bestuur van die elektriese energie metering stelsels. Die bestuursisteem wat hierby geïmpliseer word kan voordelig wees vir die munisipaliteit, maar dit kan ook aanleiding gee tot groot verliese asook ‘n struikelblok in die ontwikkeling van die plaaslike ekonomie.

Hierdie studie toon die effek van bestuur op geselekteerde landelike munisipaliteite aan. Navorsing is gedoen om die huidige toetstand van tegnologie, asook die finansiële impak daarvan, te bepaal. Dit is nie moontlik om te veralgemeen nie, maar dit is duidelik uit die studie dat die onderliggende probleem die gebrek aan grondvlakbestuur is.

Ontwerpswetenskaplike navorsing (“design science research”) was gebruik om waarde toe te voeg in die vorm van ‘n bevoegdheidsmodel (“capability maturity model”) vir landelike munisipaliteite. So ‘n bevoegdheidsmodel kan gebruik word om ‘n bevoegdheidstelling op te stel vir munisipaliteite op nasionale vlak. Wanneer die model korrek aangewend word, kan dit effektief as ‘n bestuursmeganisme aangewend word.

Wanneer basiese tegniese beginsels toegepas word in die vorm van ‘n bestuurstrategie, sal dit ‘n definitiewe impak hê op die energie metering en ‘n direkte uitkringeffek op die inkomste van die munisipaliteit. Hierdie studie toon die toepassing hiervan aan en sluit ook toegepaste metodes en resultate in nadat sekere voorstelle by verskeie munisipaliteite in die Republiek van Suid-Afrika geïmplimenteer is.

Sleutelwoorde: Energiemetering, landelike munisipaliteit, bevoegdheid volwassenheid, effektiwiteit

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LIST OF ABBREVIATIONS, TERMS AND SYMBOLS

A	Ampére
AC	Alternating Current
AMP	Ampére
ASCII	American Standard Code for Information Interchange
Bits	Contraction of binary digit
CBI	Circuit Breaker Industries
CMMI	Capability maturity model integration
CONVENTIONAL METERS	Used to meter energy consumption of less than 60A.
CPUT	Cape Peninsula University of Technology
CRCED	Centre for Research and Continued Engineering Development
CT	Current Transformer
DC	Direct current
ESKOM	Largest supplier of energy in the Republic of South Africa
HD	High demand seasons (March to August)
Hz	Hertz
ID	Identification number
IT	Information Technology
ITIL	Information technology infrastructure library
Kb	Kilobits
LD	Low demand seasons (September to February)
kHz	Kilohertz
kV	Kilovolt
kVA	Kilovolt-Ampére
kWh	Kilowatt-hour
k Ω	kilo-ohm
MVA	Megavolt-Ampére
MW	Megawatt

NER	National Energy Regulator
NERSA	National Energy Regulator of South Africa
NMD	Notified maximum demand
NRS	National Regulatory Standards
NWU	North West University
MD	Maximum demand
MD Meter	Meters used for the energy metering of bulk consumers.
OPM3	Organizational Project Management Maturity Model
OSIMM	Open Group Service Integration Maturity Model
P3M3	Portfolio, Programme and Project Management Maturity Model
R	South African Rand
RDG	Indication of the resolution and accuracy of meters
RMS	Root mean square
s	seconds
SABS	South African Bureau of Standards
SANS	South African National Standard
SOA	Service orientated architecture
V	Volt
VAT	Value added tax
Ω	Ohm

1 INTRODUCTION AND AIM OF STUDY

This chapter provides an introduction to the research that was done on the effectiveness of energy metering on local rural municipalities. An overview of the underlying problem is presented, after which the research objectives and methodology are provided. Finally, an outline of this dissertation is given.

1.1 Background

Local government (in the form of rural municipalities for the purpose of this research study) functions as the ground level management of national government. When the principle of management on ground level is applied to government management, it implies that the national government fails if local government is not managed effectively.

Currently there are 237 local municipalities registered as service providers in the Republic of South Africa. According to Auditor-General Terence November only 7 of the 237 local municipalities received a positive audit during the 2010/2011 financial year and 85% of all local municipalities are under administration (Downing, 2011). This figure is disturbing, especially since local government is the core financial accumulator of public revenue and the originator of domestic infrastructure. This clearly indicates a high level of mismanagement at ground level and the state of services in domestic and rural areas is evidence of this.

Corrective measures are critical at this stage for the survival of local municipalities and eventually the meaningful functioning of national government. There are many aspects of management of local municipalities that need consideration. The aim of this research study is to perform an analysis of the electrical infrastructure on the current state of affairs from a technical perspective, and then to propose an engineering solution to the technical management of basic electrical infrastructure. In addition to an analysis, a maturity model for electrical energy metering (as part of a larger system) is derived and proposed from a literature search and pragmatic results from a case study. The proposed engineering solution includes the electrical energy metering of business, industrial and domestic connections as well as the management of public lighting systems.

The study follows a *design science research methodology* - a research methodology that generates knowledge from a design of a process, method, or a useful artefact. In our case, we wish to derive a capability model from knowledge that was gained from a literature study and a case study. The literature study provided a framework for capability maturity measurement while the case study validated individual criteria (or capabilities) of the capability maturity model, and thus provided a method with which to validate the overall framework.

More specifically, design science research is outcomes-based research that has the following characteristics applicable to our research:

- Identification of the problem: namely that rural municipalities are not measured on a common scale and do, therefore, not perform up to standard;
- Demonstration that a capability maturity model for energy metering does not exist in rural municipalities;
- Synthesis of a capability maturity model applicable to rural municipalities - this is done by using information obtained from a literature study as well as a case study;
- Evaluation of the maturity model is done on the basis that specific interventions from the case study caused significant improvement in capability maturity;

Validation of the capability maturity model follows from the fact that (i) the capability maturity model that was used, Carnegie Mellon's CMMI, is an ad-hoc standard, and (ii) the case study's improvements validate the inclusion of specific criteria (or Process Areas) since those criteria were shown to improve service delivery at selected municipalities. The combination, and verification of validated criteria thus validates the model by design.

Although the importance of the above aspects relative to demand side management was not part of this research study, its importance should not be ignored and will therefore be highlighted as a basis for future study.

From a previous investigation, conducted on behalf of Ingplan Consulting Engineers with regards to network losses in smaller municipalities, it became clear that some management factors, such as discussed below, contribute largely to network losses in municipalities (Kotzé, Master Design Report - Smaller municipalities within the North West Province of the Republic of South Africa, 2008).

The first aspect of management to be considered is the electrical energy metering system. Of all energy distributed by local municipalities, over 30% of the energy is not being metered or not metered accurately and of the energy metered only 55% of the distribution costs are recovered. The mismanagement of the electrical energy metering systems is imposing a severe financial burden on local municipalities and is contributing extensively to the bankruptcy of local governments. With the looming increase in electricity usage cost, the actual rand value of losses is amplified to levels that cannot be left unnoticed.

The second aspect identified involves the management of public lighting systems. According to the "*SA Distribution Quality of Service Template*" there are currently 2,43 million street lights and 457 000 high mast lights installed in South Africa. At any given time during daytime, 15% of all public lighting installations are switched on, resulting in a massive wasteful expenditure (25 Degrees in Africa, 2011).

Figure 1: Kokosi – High mast lighting switched on during daytime (22 March 2010)

If the 15% can be reduced to below 5%, more revenue will be available for maintenance and providing of infrastructure and the alarming burden on ESKOM's electricity supply will be substantially reduced. One must bear in mind that all energy that is saved from spillage and waste, reduces a municipality's basic expenditure and could contribute to productivity.

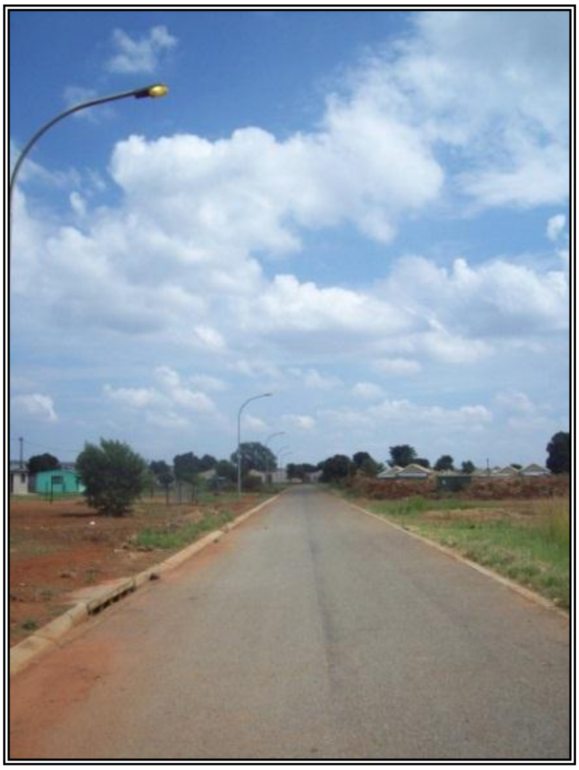

Figure 2: Blybank – Street lighting switched on during daytime (25 March 2010)

Figure 3: Khutsong - Street lighting switched on during daytime (28 March 2010)

A well-managed switching policy of medium and low voltage distribution systems after power failures may further result in some savings for any local municipality. These savings will mainly be as a result of minimizing the actual maximum demand of the municipality connection. The fact that street lights are burning during the day is indicative of a lack of management. Should energy metering be done correctly, these losses would become visible and manageable.

1.2 Hypothesis

The formal hypothesis is therefore stated as follows:

There is significant spillage and wastage in the electricity consumption of local municipalities due to negligence in energy metering.

Operations management includes (amongst other important focus areas) the following important areas, namely (i) economics such as billing and tariff control, (ii) technological aspects such as metering and technology management, (iii) continued maintenance of metering equipment, and (vi) operations management for optimal effectiveness and efficiency. It is known that good operations management is a requirement to ensure operational effectiveness. However, the impact of not performing operations management relative to energy metering has not been published in available reports or academic journals. This can only be determined by measuring losses before and after management structures have been put in place. Since this is a cause-effect case study, the results can validate the maturity model for energy metering.

"Significant spillage and wastage" needs to be defined since limited measured values were available at the onset of this research study – hence, an opportunity arose for a study to determine the actual cost saving that can be achieved by eliminating waste. Such a case study was performed in the North-West Province - in selected municipalities - to make a case in point. Due to cost and time constraints for this research study, it was deemed not sensible or feasible to perform a detailed study on more than one local municipality (comprising a number of towns). It is acknowledged that this municipality may not be representative of the precise state of affairs in other municipalities, but a study had to be performed so that measured data could be obtained, which could serve as a reference point for further studies. In the spirit of design science research, it is expected that the results from the analysis done in this research study will lead to further studies.

1.3 Objectives of this research study

The main, unanswered questions that this research addresses are:

- What are the capital losses in a typical rural municipality in the North-West Province due to ineffective energy metering?
- What are the specific contributions from different elements of the metering system in terms of losses?
- What steps could be taken to minimize these financial losses in the form of engineering and operations management?
- Is there a capability maturity model that will cover all critical energy metering functions, including management functions, and what are the factors that determine capability?

1.4 Overview of methodology

As discussed previously, this research study follows a design science research approach [10] (Vaishnavi & Kuechler, 2004). This includes the analysis of the existing state of low voltage networks in a specific local municipality with its associated lack of controls, and a literature study of existing methods for capability maturity measures.

A case study is performed of the Maquassi Hills municipality for four reasons, namely (i) to find the current state of affairs - the "as is" and its associated lack of operational controls, (ii) to improve the energy metering system and measure the "to be" including operational controls, and (iii) to learn from this case study which critical elements are required for such an energy metering system, (iv) to identify operations management functions that can be linked to a capability maturity framework. The case study thus serves as input to the design science research, as well as validation of the operational controls from a cause-effect point of view.

The case study as well as the results from literature are used to propose a capability maturity model for energy metering in rural municipalities. Thus, after the implementation of corrective measures, the results were carefully monitored and combined to form the basis of a proposed management structure and its associated capability measures.

The case study was done in the form of a technical as well as a financial audit with corrective action, using a scientific and systematic approach, each facet including the following:

- Technical audit: Technical investigation of all electrical energy meters to create a technical baseline;
- Financial audit: Investigation of consumer's accounts, focussing on applied tariffs and tariff structures - to create a financial baseline;
- Technical and financial controls were put in place;
- Operational controls were put in place;
- Similar studies were conducted on other municipalities (not included in this report);
- An audit was done to determine the impact of the controls - this is the improvement on the baseline.

The case study was conducted in 4 phases, as outlined below:

- Phase 1 – Data collection
- Phase 2 – On-site investigations
- Phase 3 – Account analyses
- Phase 4 – Implementation of corrective measures

Chapter 4 provides a detailed discussion of the methodology followed while this research study was conducted.

In our approach to this research, the following process definition was used to define this research as a process:

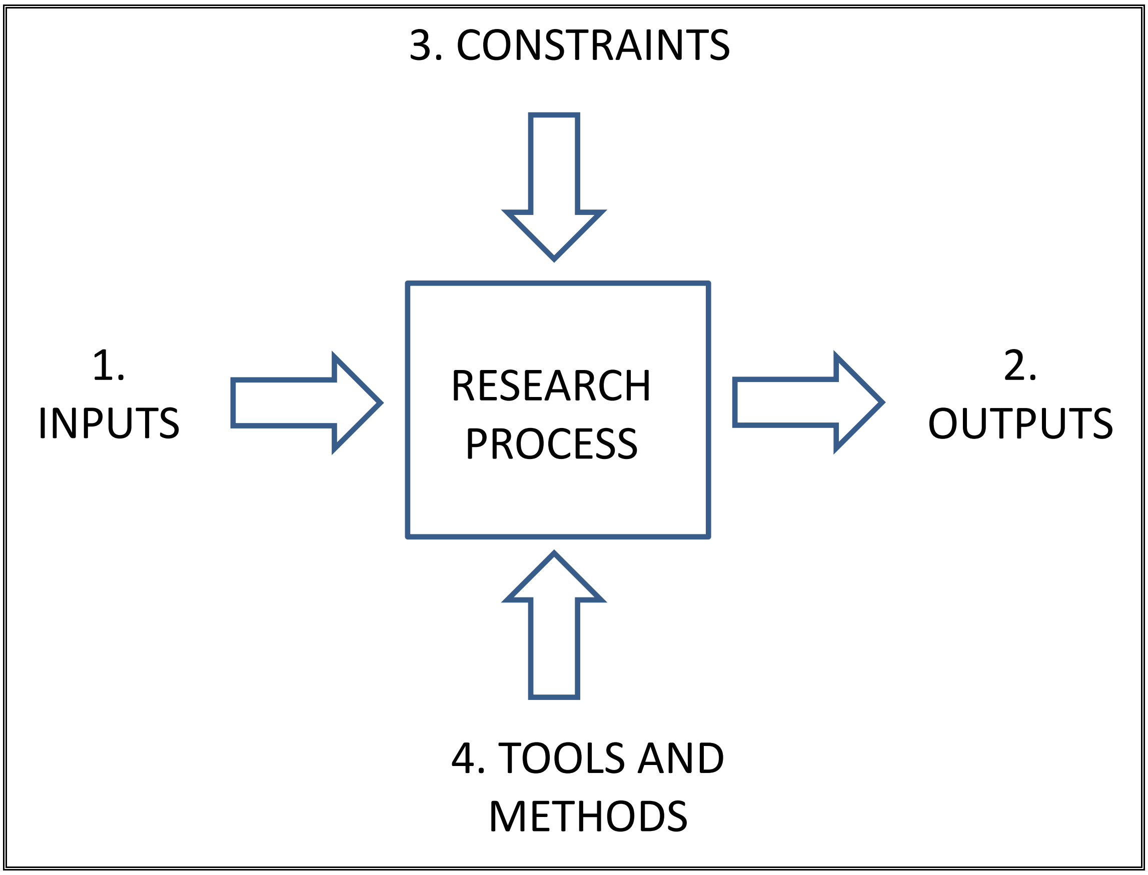

Figure 4: Approach to research study

1.4.1 Inputs

Inputs to this research include:

- Documents (drawings, configurations, laws, equipment manuals, standards and other **data**) used to define the AS IS of the energy metering system;
- Actual, **physical** sites that were visited and physical inspection results and
- The energy metering case study as part of a real-world problem.

1.4.2 Outputs

The results of this research study are:

- Results from an operations audit (as part of the “research process”) in the form of technical and financial shortfalls;
- An improved system to provide evidence that specific actions resulted in improvement, together with measured improvements;
- A derived capability maturity model for energy metering (applicable to rural municipalities);

Note that technical shortfalls are **verified** by means of measurements (from site visits) while financial shortfalls are **verified** by means of audited accounts. Both technical and financial shortfalls are **validated** when the verified shortfalls are rectified by corrective action (which, in turn, has been verified). This also provides sufficient evidence that the derived capability maturity model is applicable (all management processes that were implemented are contained in this model framework).

1.4.3 Constraints

The constraints of this research study include:

- Time of the case study and literature research;
- Cost of implementation of an improved energy metering system;
- The limited number of municipalities that were studied due to time and cost (as a result);

It is acknowledged that all municipalities in South Africa cannot be studied in one study, but a general understanding of the effectiveness of energy metering can be obtained and evidence can be provided that supports a case for good management.

1.4.4 Tools and methods

The tools and methods used in this research study include:

- Existing literature on design science research, capability maturity, and studies done on maturity models;
- Existing capability reference frameworks (in use);
- Measurement equipment;
- The design science research methodology that was followed.

1.4.5 Validation and verification

Verification of this research will be achieved when:

- The metering equipment shows significant evidence of neglect of maintenance;
- The actual value of losses can be determined from audits;

Validation will be achieved when:

- Proven references were used from which to derive a theoretical capability maturity model framework - thus following a method of induction;

- The method that was implemented to address the management shortfalls actually reduced losses.

1.5 Contribution

Our contribution to the research community from our own research includes the following:

- Analysis of a real-world problem in the form of a case study of energy metering improvement in a rural municipality, in which the author took part;
- A literature study on capability maturity models, including Carnegie Mellon's CMMI, the World Bank service delivery indicators, and other less relevant maturity models;
- Synthesis of a capability maturity framework, specifically applicable to energy metering, from the literature and case study;
- A causal link to World Bank service delivery indicators to show that the capability maturity model does have an effect on an accepted measurement framework.

1.6 Dissertation overview

Chapter 2 of this research study provides a literature study and a discussion on the equipment used for the study. Chapter 3 explains the state of the mentioned municipality's electrical energy metering systems before the implementation of the proposed management system – the ***AS IS*** status. The approach and methodology to the mentioned engineering solution follow in Chapter 4. Chapter 5 provides a detailed breakdown of the shortcomings of the existing electrical energy metering system of the Maquassi Hills municipality as well as an evaluation of the initial level of maturity of the municipality while Chapter 6 introduces corrective actions as well as a discussion of the results obtained after the implementation of the corrective actions. Chapter 7 provides a summary of the findings is given and technical suggestions for further study are presented. In Appendix A, a theoretical study is presented to show the effects of public lighting on energy wastage – this is presented not as part of the main focus of this research study, but rather due to its importance.

The statement: "*One can't manage which one can't measure"*, remains the modus operand for this research study. Finally, it is the purpose of this work to introduce a practical and cost effective management system that can be implemented on ground level at local municipalities to result in an improved future for South Africa.

1.7 Conclusion

This chapter provided background to the research problem, a framework for the research that was done, as well as an overview of the dissertation. The primary research objective is to provide a capability maturity model for municipalities, and to show, beyond doubt, that there is significant wastage and spillage of electricity (and cost) due to negligence in energy metering - this is a pragmatic and applicable result. The process that will be followed is defined by 4 phases, namely (i) data collection, (ii) on-site investigations, (iii) financial account analysis, and (iv) corrective action.

From the results of the case study and literature research, a model is derived and proposed by means of inductive reasoning (if it works in practice, it should be included in the model, together with other best practice standards from a literature study), verification of shortfalls will be achieved by means of measurement and analyses, while validation will be achieved when the corrective actions actually address the identified shortfalls.

2 LITERATURE STUDY

2.1 Introduction

This chapter discusses literature on energy metering and equipment used for metering, literature on operations management, and literature on capability maturity.

2.2 Literature overview

2.2.1 Literature

Several resources were considered during the search for information on previous studies done in this particular field. These resources include:

i.) Academic Institutions - CPUT (Prof Uken & Mr Wheeler)

- CRCED - Pretoria (Prof Kleyngeld)

ii.) Supply Authorities - ESKOM Measurement and Verification (Southern Region)

iii.) Literature - NWU Nexus Search:

a. "Energy saving techniques/tactics and municipalities or local government"

b. "Electrical metering and engineering management and municipalities"

c. "Electrical metering and engineering management or management"

d. "Electrical metering and financial implication or sustainability and municipalities"

e. "Electrical metering and demand side management and municipalities"

f. Literature on capability maturity.

Although no indication could be obtained on previous studies relative to this research study (that is, energy metering), information could be obtained for several core concepts such as demand side management. From the research it also became clear that a gap existed in previous studies done relative to wastage and spillage on municipality electricity networks - this gap will be addressed in this research study.

The literature study first addresses equipment used during the technical audits, followed by a study of capability maturity models.

2.3 Equipment

2.3.1 External metering equipment used for on-site metering

The following metering equipment was used for on-site metering, as described below.

2.3.1.1 NETLOG II energy analyser from NETELEK

The Netlog II is a combination of a data recorder and an electrical transducer. Figure 5 provides an image of the used NETLOG II energy analyser.

The meter records the single/three phase voltages together with the single/three phase currents and power parameters. Additionally, two auxiliary inputs for recording two process parameters such as temperature, pressure, flow rate, etc. are provided.

Figure 5: NETLOG II energy analyser

A PC is used to transfer the recorded data from the Netlog II data memory onto a computer hard drive. The data on the computer can be analysed using the Netlog software. The Netlog software provides statistical and graphing facilities.

All data can be converted to ASCII format using the Netlog software. This data can then be exported to any spreadsheet package for further graphical display and analysis as may be required.

Before the on-site study was conducted, the mentioned Netlog II Energy Analyser was serviced by a technician to ensure accurate data collection. Table 1 provides the technical specifications of the Netlog II Energy Analyser.

NETLOG II TECHNICAL SPECIFICATIONS			
Characteristic	**Specification**	**Characteristic**	**Specification**
Baud Rate	9600 (Default)	**Sampling Rate**	420 samples/s
Communication Protocol	RS232	**Clock Drift**	< 30 s/month
Number of Voltage inputs	One 3-Phase Set	**Resolution**	12-Bits
Number of Current inputs	4 Sets of 3-phase	**Accuracy 1 Amp, 100 Volt**	Class 1
Number Of Auxiliary inputs	2	**Accuracy 5 Amp, 380 Volt**	Class 0,5
Voltage input range (Phase to Neutral)	0-499 ac RMS	**Supply Voltage**	* 230 V ac 50 Hz
Current input range	0-6 Amp ac RMS		* 110 V AC 50 Hz
Auxiliary input range	+/- 10 V	**Averaging interval**	1 s - 1 hour
Input offset drift	+/- 2 bits	**Memory**	256 kb – 512 kb

Table 1: Technical Specifications of the NETLOG II energy analyser

2.3.1.2 FLUKE 355 digital clamp meters

The FLUKE 355 digital clamp meter was used during the study to collect instantaneous energy readings for spot checking the accuracy of the connected NETLOG II energy analyser.

The FLUKE 355 digital clamp meter can successfully collect electrical data of connections up to 2000 A. Accurate peak measurements were also taken using the in-rush current mode, especially for motors and inductive load applications.

Figure 6: FLUKE 533 digital clamp meter

Table 2 provides the technical specifications of the FLUKE 355 digital clamp meter.

FLUKE 533 TECHNICAL SPECIFICATIONS	
Current measurement dc and ac 10 Hz to 100 Hz	Range : 2000 A; 1400 ac rms Resolution: 1 A Accuracy, A: 1.5 % rdg + 5 digits Trigger Level for Inrush: 5 A Trigger Level for Hz Filter OFF: 8 A Trigger Level for Hz Filter ON: 8 A

Crest Factor (50/60)	**Range : 2000 A; 1400 ac rms** Crest Factor* : 2 @ 1000 A, 2,4 @ 833 A
Voltage measurement (355 only) dc and ac 10 Hz to 100 Hz (600 V and 1000 V ranges have 10 % over range to 660 V and 1100 V respectively.)	**Range : 4 V** Resolution: 1 mV Accuracy: 1 % rdg + 10 digits Trigger Level for Hz Filter OFF: 0,050 V Trigger Level for Hz Filter ON: 0,050 V **Range : 40 V** Resolution: 10 mV Accuracy: 1 % rdg + 5 digits Trigger Level for Hz Filter OFF: 0,25 V Trigger Level for Hz Filter ON: 0,25 V **Range : 400 V** Resolution: 100 mV Accuracy: 1 % rdg + 5 digits Trigger Level for Hz Filter OFF: 6 V Trigger Level for Hz Filter ON: 6 V Range : 600 V ac rms Resolution: 1 V Accuracy: 1 % rdg + 5 digits Trigger Level for Hz Filter OFF: 6 V Trigger Level for Hz Filter ON: 6 V Range : 1000 V dc Resolution: 1 V Accuracy: 1 % rdg + 5 digits
Ohms measurement (355 only)	**Range: 400** Ω Resolution: 0,1 Ω Accuracy: 1,5 % + 5 digits **Range: 4 k**Ω Resolution: 1 Ω Accuracy: 1,5 % + 5 digits **Range: 40 k**Ω Resolution: 10 Ω Accuracy: 1,5 % + 5 digits **Range: 400 k**Ω Resolution: 100 Ω Accuracy: 1,5 % + 5 digits

Continuity beeper (355 only)	On at ≤ 30 Ω Off at ≥ 100 Ω
Frequency measurement	Measurement range 5,0 Hz to 1 kHz **Resolution** 0,1 Hz (15 Hz to 399,9 Hz); 1 Hz (400 Hz to 1 kHz) Accuracy – 5,0 Hz to 100 Hz 0,2 % + 2 counts Accuracy – 100,1 Hz to 1kHz 0,5 % + 5 counts **Trigger level** Refer to current and voltage tables

Table 2: Technical Specifications of the FLUKE 355 digital clamp meter

2.4 Capability and maturity

Effective operations management is typically applied to a specific type of operation in order to be meaningful. The core objective of any municipality is to supply services to the community (Municipality, Maquassi Hills, 2008). Different types of operations management exist in practice (in the services industry), but since a performance measurement framework was required, a suitable maturity model was selected to provide such a framework.

Several models were investigated to determine if the application thereof would be applicable for the measuring of capability maturity of metering systems in local municipalities. During the literature review for this study, it became clear that no developed maturity model could be applied unconditionally for measuring the maturity of metering systems in local municipalities.

From the study it was found that important generic principles could be applied to measure local municipalities' ability to manage the effectiveness of electrical metering systems in municipalities and to provide a roadmap for increased effectiveness in this regard. Based on the underlying generic factors contained within capability maturity models, three models were chosen and compared on its functionality and maturity criteria. The following list provides an indication of the capability maturity models that were reviewed:

- CMMI – Capability Maturity Model Integrated
- ITIL – Information Technology Infrastructure Library
- OSIMM – Open Service Integration Maturity Model
- OPM3 – Organizational Project Management Maturity Model

- P3M3 – Portfolio, Program and Project Management Maturity Model

ITIL and OSIMM focus extensively on maturity within the information technology and for this reason was excluded from the comparison discussed below.

As indicated in the title of this dissertation, this study reflects on the effectiveness of the energy metering systems for a particular municipality – the Maquassi Hills municipality. The remaining three maturity models mentioned above (CMMI, OPM3 and P3M3) were compared within this isolated context, concentrating on the maturity model's ability to assess the following aspects relative to electrical energy metering systems:

- Evaluation of existing systems & recommendation for improvements
- Decision-making
    - Recommendations
    - Programs
    - Procurement policies
    - Budgets
- Implementation
    - Standardised equipment
    - Technical installation
    - Financial Management
- Maintenance
    - Maintenance Plans
    - Reaction time on breakdowns
    - Record keeping
- Measurement and improvement
    - Yearly auditing
    - On-going training

The three maturity models were compared on the basis of the following:

- Maturity Criteria
- Functional Criteria

A comparison done by mosaic projects, (Bourne & Tuffley, 2007), was adopted for this study. The following tables provide the comparison as reconstructed to be relevant to this study.

CRITERIA	**CMMI**	**OPM3**	**P3M3**
Background	Exists	Exists	Exists

Explanation of Model Architecture	Exists	Exists	Exists
Explanatory Text	Exists	Exists	Exists
Assessment	Partially exists	Exists	Exists
Improvement	Exists	Exists	Exists
Multiple Representations	Exists	Exists	Exists
Compatibility	Does not exist	Does not exist	Does not exist
References	Exists	Exists	Exists
Sample Case Study	Exists	Partially exists	Does not exist
Content Amplification	Exists	Does not exist	Does not exist

Table 3: Maturity Criteria

From Table 3 it is clear that based on the maturity criteria, no single model is more advanced than the others and when applied to the scope of this study there is no advantage in considering these criteria. (Bourne & Tuffley, 2007)

FUNCTION CRITERIA	**CMMI**	**OPM3**	**P3M3**
Link to Strategy	Exists	Partially exists	Exists
Program Management	Partially exists	Exists	Exists
Project v. Program	Partially exists	Exists	Exists
Manage Related Projects	Exists	Partially exists	Exists
Program Management Processes	Exists	Exists	Exists
Role of the Project Manager	Exists	Exists	Exists
Program Management	Partially exists	Does not exist	Does not exist

in Context of General Management			
Organizational Management Processes	Exists	Exists	Exists

Table 4: Function Criteria

From the table above, the criteria under consideration that are key to effective management of energy metering systems within local municipalities are included under the provisions of CMMI only. Energy metering systems are a critical part of the functioning of a municipality as an organization with its main goal to provide a measuring tool to the municipality for revenue management.

Energy metering systems are considered to be part of the operations management of local municipalities. Between the maturity models reviewed, the Capability Maturity Model Integration (CMMI®) (Carnegie Mellon, 2010) approach was identified to be the most suitable for assessment during this research study as it focuses on all aspects of operations. This is mainly due to the fact that the remaining two models have rather specific information technology focuses, while CMMI is generic in nature.

In the context of energy metering, operations management comprises the following architecture and principal functional areas, as described below:

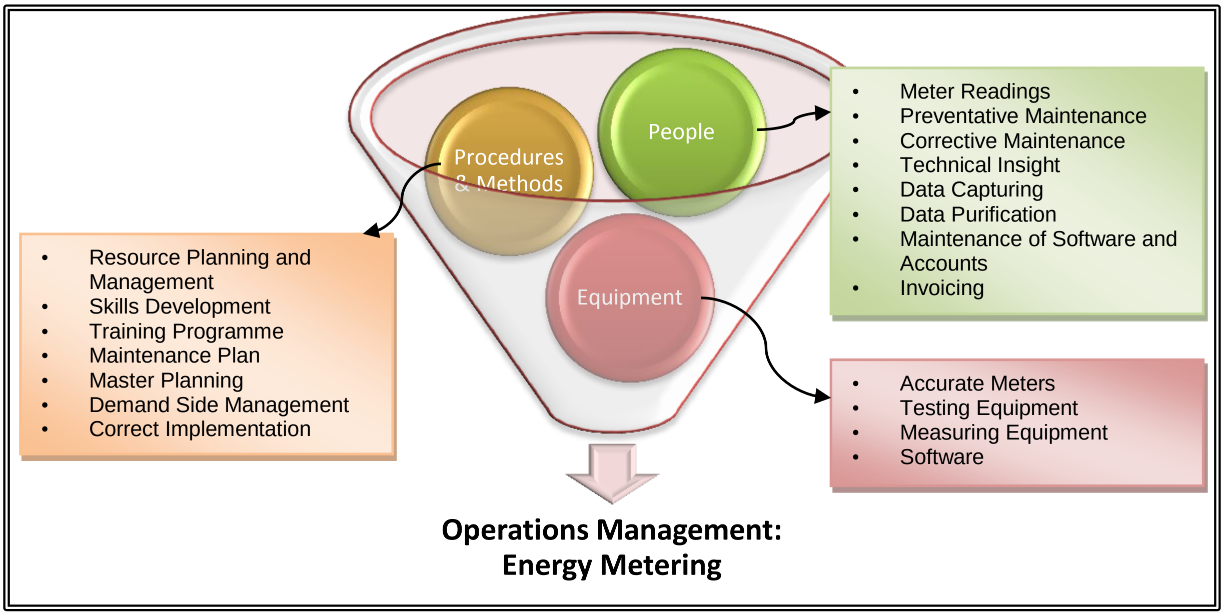

Figure 7: Architecture and principal functional areas of operations management

The procedures and methods implemented in a municipality allow it to refine the manner in which service delivery is being achieved. It allows a municipality to address scalability and provides a way to incorporate knowledge of how to do things better and to leverage resources.

A focus on process provides the infrastructure and stability necessary to deal with the demand from the community and to maximize the productivity of people.
People remain the most important asset in the management strategy of any municipality. Without committed people who have the necessary skill to implement best practices, the management strategies will fall short of its objectives and all procedures and methods will deteriorate as a result.

Integrated with the processes and methods is the equipment used to achieve the required objectives. Although, the correct equipment is not the main determent of successful management, it contributes largely to the overall ease by which this is achieved – that is, equipment is considered to be resources of a larger system aimed at improving effectiveness and efficiency.

Today, many organizations in manufacturing and service industries recognize the importance of quality operations management. Operations management helps an organization's workforce to meet business objectives by helping them to work smarter, not harder, and with improved consistency. Effective operations management also provide a vehicle for introducing and using new technology in a way that best meets the business objectives of the organization (Carnegie Mellon, 2010).

For this research study, the CMMI for services manual (CMMI-SVC V 1.3), refer to (Carnegie Mellon University, 2010), was used as a guide to develop a maturity model relative to energy metering systems within rural municipalities. Within the CMMI framework for services, the capability and maturity of all processes or grouping of processes within an organization is determined and measured against a set of predefined levels. These levels are used to measure the stage within an improvement path for processes used to provide services.

Two improvement paths are supported by CMMI namely:

- The improvement of processes associated with individual process areas;
- The improvement of a set of processes by incrementally addressing successive groups of process areas.

Each of the two improvement paths is associated with two types of levels namely:

- Capability levels;
- Maturity levels.

In turn, these levels correspond with two approaches (referred to as "representations") to improve processes within an organisation namely:

- Continuous approach;
- Staged approach.

The continuous representation enables the organisation to achieve individual capability levels and the staged representation enables the achievement of maturity levels. When all goals of the targeted process area or set of targeted process areas have been satisfied, a particular level is reached.

Capability levels apply to an organization's process improvement achievement in individual process areas and maturity levels to an organization's process improvement achievement across multiple process areas. The different levels achievable are as follows:

- Capability levels: 0 to 3;
- Maturity levels: 1 to 5.

The following table from (Carnegie Mellon University, 2010) provides an indication of the different levels within the capability and maturity representations:

Level	**Continuous Representation Capability Levels**	**Staged Representation Maturity Levels**
Level 0	Incomplete	
Level 1	Performed	Initial
Level 2	Managed	Managed
Level 3	Defined	Defined
Level 4		Quantitatively Managed
Level 5		Optimizing

Table 5: Comparison of capability and maturity levels

The description of the levels can be summarized as follows:

- Capability levels:
  - Incomplete – Process is either not preformed or partially performed;
  - Performed – Process is performed in such a manner that work products are produced;
  - Managed – Performed process, planned and executed in accordance with policy;

  - Defined - Managed process that is tailored from the organization's set of standard processes according to the organization's tailoring guidelines; has a maintained process description; and contributes process related assets to the organizational process assets.
- Maturity levels:
  - Initial – Organization does not provide a stable environment to support processes. Processes are usually ad hoc and chaotic;
  - Managed – Establishment of a foundation for an organization to become an effective service provider by institutionalizing selected project and work management, support, and service establishment and delivery processes;
  - Defined – Service providers use defined processes for managing work;
  - Quantitatively Managed - Service providers establish quantitative objectives for quality and process performance and use them as criteria in managing processes;
  - Optimizing – A continues improvement of an organization's processes based on a quantitative understanding of its business objectives and performance needs.

As mentioned previously, either the continuous approach or the staged approach can be used to determine the levels of capability and maturity of an organization. It is however also possible to compare results from these two approaches. This is called equivalent staging. Equivalent staging enables an organization using the continuous representation to convert a capability level profile to the associated maturity level rating. Although for this research study, the full guide relative to equivalent staging wasn't applied, the following rules relative to equivalent staging are worth mentioning to indicate the correlation between the continuous representation and the staged representation:

- To achieve maturity level 2, all process areas assigned to maturity level 2 must achieve capability level 2 or 3;
- To achieve maturity level 3, all process areas assigned to maturity levels 2 and 3 must achieve capability level 3;
- To achieve maturity level 4, all process areas assigned to maturity levels 2, 3, and 4 must achieve capability level 3;
- To achieve maturity level 5, all process areas must achieve capability level 3.

The following table provides a description of the different process areas grouped under the different maturity levels (Carnegie Mellon University, 2010):

CMMI PROCESS AREA	DESCRIPTION OF THE PROCESS AREA
THIS COLUMN PROVIDES A LIST OF ALL PROCESS AREAS IN CMMI.	***THIS COLUMN PROVIDES AN EXTRACT FROM THE V1.3 CMMI FOR SERVICES STANDARD*** (Carnegie Mellon University, 2010)***.***
Maturity Level 2 - Managed	
Configuration Management (CM)	The purpose of Configuration Management (CM) is to establish and maintain the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.
Measurement and Analysis (MA)	The purpose of Measurement and Analysis (MA) is to develop and sustain a measurement capability used to support management information needs.
Process and Product Quality Assurance (PPQA)	The purpose of Process and Product Quality Assurance (PPQA) is to provide staff and management with objective insight into processes and associated work products
Requirements Management (REQM)	The purpose of Requirements Management (REQM) is to manage requirements of products and product components and to ensure alignment between those requirements and the work plans and work products.
Supplier Agreement Management (SAM)	The purpose of Supplier Agreement Management (SAM) is to manage the acquisition of products and services from suppliers.
Service Delivery (SD)	The purpose of Service Delivery (SD) is to deliver services in accordance with service agreements.
Work Monitoring and Control (WMC)	The purpose of Work Monitoring and Control (WMC) is to provide an understanding of the ongoing work so that appropriate corrective actions can be taken when the performance deviates significantly from the plan.
Work Planning (WP)	The purpose of Work Planning (WP) is to establish and maintain plans that define work activities.
Maturity Level 3 - Defined	
Capacity and Availability Management (CAM)	The purpose of Capacity and Availability Management (CAM) is to ensure effective service system performance and ensure that resources are provided and used effectively to support service requirements.
Decision Analysis and Resolution (DAR)	The purpose of Decision Analysis and Resolution (DAR) is to analyse possible decisions using a formal evaluation process that evaluates identified alternatives against established criteria.

Incident Resolution and Prevention (IRP)	The purpose of Incident Resolution and Prevention (IRP) is to ensure timely and effective resolution of service incidents and prevention of service incidents as appropriate
Integrated Work Management (IWM)	The purpose of Integrated Work Management (IWM) is to establish and manage the work and the involvement of relevant stakeholders according to an integrated and defined process that is tailored from the organization's set of standard processes.
Organizational Process Definition (OPD)	The purpose of Organizational Process Definition (OPD) is to establish and maintain a usable set of organizational process assets, work environment standards, and rules and guidelines for teams.
Organizational Process Focus (OPF)	The purpose of Organizational Process Focus (OPF) is to plan, implement, and deploy organizational process improvements based on a thorough understanding of current strengths and weaknesses of the organization's processes and process assets
Organizational Training (OT)	The purpose of Organizational Training (OT) is to develop skills and knowledge of people so they can perform their roles effectively and efficiently.
Risk Management (RSKM)	The purpose of Risk Management (RSKM) is to identify potential problems before they occur so that risk handling activities can be planned and invoked as needed across the life of the product or work to mitigate adverse impacts on achieving objectives.
Service Continuity (SCON)	The purpose of Service Continuity (SCON) is to establish and maintain plans to ensure continuity of services during and following any significant disruption of normal operations.
Service System Development (SSD)	The purpose of Service System Development (SSD) is to analyze, design, develop, integrate, verify, and validate service systems, including service system components, to satisfy existing or anticipated service agreements.
Service System Transition (SST)	The purpose of Service System Transition (SST) is to deploy new or significantly changed service system components while managing their effect on ongoing service delivery.
Strategic Service Management (STSM)	The purpose of Strategic Service Management (STSM) is to establish and maintain standard services in concert with strategic needs and plans.

Maturity Level 4 - Quantitatively Managed	
Organizational Process Performance (OPP)	The purpose of Organizational Process Performance (OPP) is to establish and maintain a quantitative understanding of the performance of selected processes in the organization's set of standard processes in support of achieving quality and process performance objectives, and to provide process performance data, baselines, and models to quantitatively manage the organization's work.
Quantitative Work Management (QWM)	The purpose of Quantitative Work Management (QWM) is to quantitatively manage the work to achieve the established quality and process performance objectives for the work.
Maturity Level 5 - Optimizing	
Causal Analysis and Resolution (CAR)	The purpose of Causal Analysis and Resolution (CAR) is to identify causes of selected outcomes and take action to improve process performance.
Organizational Performance Management (OPM)	The purpose of Organizational Performance Management (OPM) is to proactively manage the organization's performance to meet its business objectives.

Table 6: Description of process areas

Generic predefined goals are used to determine the capability and maturity levels for each process area or group of process areas and by reaching the capability level 3 for each generic goal, that particular process area is considered to be defined. Once the set of process areas within a maturity level grouping has achieved the "defined" level (3), that maturity level is reached and the organization can focus on the following set of process areas to progress to the subsequent maturity level.

These generic predefined goals can be summarized as follows (Carnegie Mellon University, 2010):

GENERIC GOAL (GG)	DESCRIPTION GG	GENERIC PRACTICE (GP)	DESCRIPTION OF GP	APPLICABLE TO WHICH PROCESS AREAS?
GG 1: Achieve specific goals	The process supports and enables achievement of the specific goals of the process area by transforming identifiable input work products to produce identifiable	GP 1.1: Perform specific practices	Perform the specific practices of the process to develop work products and provide services to achieve the specific goals of the process area.	All

	output work products.			
GG 2: Institutionalize a managed policy	***The process is institutionalized as a managed process.***	GP 2.1: Establish an organizational policy	Establish and maintain an organizational policy for planning and performing the process.	All
		GP 2.2: Plan the process	Establish and maintain the plan for performing the process.	All except: WP, OPD, OPF, OT, OPP, OPM
		GP 2.3: Provide resources	Provide adequate resources for performing the process, developing the work products, and providing the services of the process.	All except: WP(initially), OPD, OPF, OT, OPP, OPM
		GP 2.4: Assign responsibility	Assign responsibility and authority for performing the process, developing the work products, and providing the services of the process.	All except: WP(initially), OPD, OPF, OT, OPP, OPM
		GP 2.5: Train people	Train the people performing or supporting the process as needed.	All
		GP 2.6: Control work products	Place selected work products of the process under appropriate levels of control.	All
		GP 2.7: Identify and involve relevant stakeholders	Identify and involve the relevant stakeholders as planned.	All except: OPD, OPF, OT, OPP, OPM
		GP 2.8: Monitor and control the process	Monitor and control the process against the plan for performing the process and take appropriate corrective action.	All except: OPD, OPF, OT, OPP, OPM
		GP 2.9: Objectively evaluate adherence	Objectively evaluate adherence of the process against its process description, standards, and procedures, and address noncompliance.	All except: PPQA

		GP 2.10: Review status of higher level management	Review the activities, status, and results of the process with higher level management and resolve issues.	All except: OPD, OPF, OT, OPP, OPM
GG 3	***The process is institutionalized as a defined process.***	GP 3.1: Establish a defined process	Establish and maintain the description of a defined process.	All except: OPD, OPF, OT, OPP, OPM
		GP3.2: Collect process related experience	Collect work products, measures, measurement results, and improvement information derived from planning and performing the process to support the future use and improvement of the organization's processes and process assets.	All

Table 7: Description of generic goals

2.5 World Bank service indicators

The application of CMMI on the efficiency of energy metering processes within a municipality has been extended by adopting the philosophy described for measuring of service delivery by the World Bank.

The measurement of the service delivery of the electrical segment of the operations of a municipality, provides a first order impression of the status thereof and by doing so identify if there is a need for the implementation of corrective actions.

This philosophy was used to develop a service delivery index (Van der Walt, 2003). The service delivery index developed measures the quality of service delivery and focus on the following dimensions of service delivery:

- Electricity infrastructure service quality;
- Electricity infrastructure delivery efficiency;
- Affordability of electricity services;
- Access to electricity services.

On each of the dimensions mentioned above, the category of service is measured using the following levels:

- Level of service 1 – Minimal or absent;
- Level of service 2 – Basic;
- Level of service 3 – Intermediate;
- Level of service 4 – Full.

For each of the dimensions of service delivery mentioned above, the following evaluation scale has been used to determine the level of service:

- Electricity infrastructure service quality

LEVEL OF SERVICE	DESCRIPTION	VALUE
1	No electricity	1
2	Some house connections	2
3	Restricted house connections	3
4	Unrestricted metered house connections	4

Table 8: Electricity infrastructure service quality – Level of service scale

The numerical values allocated to each of the categories are similar to each particular level of service i.e. Level of service 1 has a value of 1; Level of service 2 has a value of 2, etc.

- Electricity infrastructure delivery efficiency

  The National Electricity Regulator (NER) will enforce the NRS 048 quality of supply standards, which will in future become a precondition for continued licensing. In terms of efficiency of supply, two indicators need to be monitored namely: unplanned interruptions and the power unaccounted for, where unplanned interruptions are expressed as a percentage of days per year and the power unaccounted for (including line losses) as a percentage of the total supplied.

  As indicated later on in this study, inaccurate energy metering contributes largely to the power unaccounted and therefore negatively affects the efficiency of the supply.

CATEGORY	DESCRIPTION	RATING

1	Unplanned interruptions	%
2	Power unaccounted for	%

Table 9: Electricity service supply efficiency categories

AVERAGE RATING OF THE TWO CATEGORIES	DESCRIPTION	VALUE
Higher than 15%	No service	1
10% to 15%	Major problems	2
5% to 10%	Minor problems	3
Less than 5%	No problems	4

Table 10: Electricity infrastructure delivery efficiency – Level of service scale

If any of the categories score higher than 15% individually, the service must be considered inefficient.

- Affordability of electricity services

  Other aspects of the electricity sector that raise concern are the areas of financial management and sustainability. Non-technical losses (or non-payment for electricity) present a problem.

CATEGORY	DESCRIPTION	RATING
1	Percentage ratio of electricity cost per month to household income	%
2	Non-payment levels	%

Table 11: Electricity service affordability categories

AVERAGE RATING OF THE TWO CATEGORIES	DESCRIPTION	VALUE
Less than 1%	Cheap	4
1% to 5%	Affordable	3
5% to 10%	Expensive	2
More than 10%	Unaffordable	1

Table 12: Electricity services affordability values – Level of service scale

- Access to electricity services

  Access to electricity services are presented as a percentage of households connected to the service and evaluated according to the following table.

AVERAGE RATING	DESCRIPTION	VALUE
More than 95%	Full access	4
95% to 90%	Part access	3
89% to 85%	Limited	2
Less than 85%	No access	1

Table 13: Electricity services accessibility values – Level of service scale

After values for all four dimensions have been determined, the service delivery index is determined by calculating the average of the levels of the four dimensions.

Without doubt, energy metering systems affects all four dimensions mentioned above. Some of the dimensions get affected indirectly such as the quality of service and access to services, mainly through loss of revenue. The other two dimensions get affected directly through malfunctioning or power unaccounted for.

The relevance of energy metering systems within local municipalities to the dimensions mentioned above is illustrated later on in this dissertation. After the service delivery index had been determined, the necessary measures were implemented to raise the service delivery index with respect to energy metering systems. The implementation has been evaluated against CMMI.

2.6 Conclusion

A survey amongst South African firms and universities showed that limited studies have been conducted on the effectiveness of metering on rural municipalities, as such. As a result, this research study will contribute to the body of knowledge in this regard.

Different measurement equipment was used with which to conduct field measurements. A technology study was conducted to understand the technical and functional capabilities of verification equipment.

It was deemed critical to refer to an existing, proven performance framework in the form of the Capability Maturity Model Integration (CMMI®) structure to use as a framework for energy metering capability maturity. This research used the CMMI framework to show how a fundamental management structure can improve by using the CMMI performance framework.

3 MAQUASSI HILLS MUNICIPALITY - OVERVIEW

3.1 Introduction

No recent research information could be obtained regarding the impact that operations management has on losses incurred by municipalities or more specifically, the impact of management of electrical energy metering systems. This chapter is therefore included in this research study as a case study to indicate the relevance of this specific facet to the sustainable management by local government. The mentioned case study forms the basis of this research study. The case study of the Maquassi Hills municipality – done in 2007/8 - will clearly indicate the processes followed to obtain the results and will provide insight on the effect that a well-organized and maintained management system has on the revenue. Furthermore, it will also indicate the contribution that a management system of electrical energy metering systems has on demand side management.

3.2 Analysis

The Maquassi Hills municipality is part of the Southern District of the North West Province of the Republic of South-Africa. Its mandate ranges over three units: Wolmaransstad, Leeudoringstad and Makwassie. Figure 8 provides a locality plan of the distribution area of the Maquassi Hills municipality (Frith, 2006).

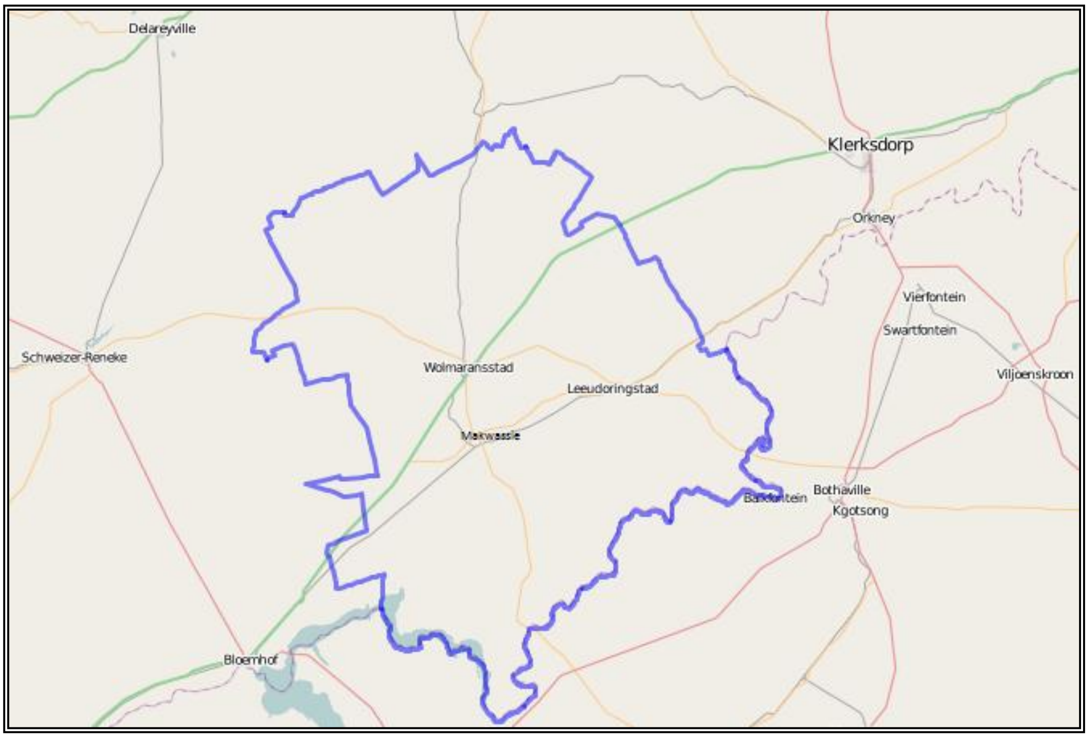

Figure 8: Maquassi Hills municipality – Locality Plan

Table 14 provides an indication of the total population of Maquassi Hills municipality as at 2007 as well as a population breakdown with respect to the official South African languages (SA, 2008).

LANGUAGE	**POPULATION**
Setswana	48697
Afrikaans	7678
Sesotho	6379
IsiXhoza	4513
IsiZulu	534
Sepedi	341
English	245
IsiNdebele	214
Xitsonga	160
Other	159
Siswati	79
Tshivenda	44
TOTAL	**69042**

Table 14: Maquassi Hills municipality – 2007 Population Breakdown

3.3 Total electricity consumers

As indicated in Table 14, the total population in the Maquassi Hills municipality district, was 69 042 at the end of 2007. It should be noted that these numbers increased from the time the study was started to the time this document was submitted. Keeping in mind the unknown population growth from 2007 until 2011 when the results are reviewed in Chapter 5 of this document, the importance of the implementation of a similar operations management system at other local municipalities in South Africa becomes even more significant.

From the population of 69 042 people in the Maquassi Hills municipality at the time, only the electricity consumers serviced by the Maquassi Hills municipality electrical Infrastructure were included in the study. Consumers of other supply authorities (ESKOM) were excluded. The breakdown of consumers is detailed below:

3.4 Wolmaransstad

	EXISTING CONNECTIONS	**ESTIMATED FUTURE MORE CONNECTIONS**
Domestic Metering Points	1012	100
Business Metering Points	377	10
Industrial Metering Points	13	1
Departmental Metering Points	37	
SUB-TOTALS	1439	111
TOTAL	**1550**	

Table 15: Electricity Consumers List – Wolmaransstad

3.4.1 Leeudoringstad

	EXISTING CONNECTIONS	**ESTIMATED FUTURE MORE CONNECTIONS**
Domestic Metering Points	478	185
Business Metering Points	76	10
Industrial Metering Points	8	1

Departmental Metering Points	14	
SUB-TOTALS	576	196
TOTAL	**722**	

Table 16: Electricity Consumers List - Leeudoringstad

3.4.2 Makwassie

	EXISTING CONNECTIONS	**ESTIMATED FUTURE MORE CONNECTIONS**
Domestic Metering Points	285	20
Business Metering Points	54	5
Industrial Metering Points	5	1
Departmental Metering Points	16	
SUB-TOTALS	360	26
TOTAL	**386**	

Table 17: Electricity Consumers List - Makwassie

The Maquassi Hills municipality is currently servicing the above mentioned consumers with a distributed power system rated at 11 kV.

3.5 Source of the electrical supply

3.5.1 General

ESKOM can be considered to be the wholesaler of the electricity supply and restrictions have been placed on local authorities for erecting and extending their own generating facilities, except where generators are installed for peaking conditions.

3.5.2 Bulk Supply

The bulk electricity supply of the Maquassi Hills municipality is distributed with high voltage cables from their 88/11kV substation to the Wolmaransstad and Leeudoringstad main intake substations. There is an 11 kV bulk supply to Makwassie.

Electrical medium voltage metering is installed in the municipal substations at each unit and calibrated using ABB/Rayrolle VT/CT metering equipment.

3.5.3 Notified Maximum Demand

ESKOM require from all local municipalities to inform ESKOM of their expected annual maximum demand, called the NOTIFIED MAXIMUM DEMAND (NMD). Local municipalities are further required to respect the NMD or will be held liable for additional national electricity network (grid) stress by means of implemented monthly fines. This aspect of network management further emphasizes the value of effective ground level management.

If all units in the Maquassi Hills municipality are fully developed and built up as proposed, and if all the houses are equipped as described, a total load can be calculated as follows - the calculated values will serve as a basis for the supply of electricity from the Maquassi Hills municipality:

i.) Wolmaransstad:

Domestic Consumers:	1470 X 1,61 kVA	=	2,36 MVA
Other Consumers:			3,88 MVA
Hospital:			0,40 MVA
Prison:			0,63 MVA
TOTAL NMD (Domestic and Other Consumers):			7 ,27 MVA

ii.) Leeudoringstad:

Domestic Consumers:	601 x 1,85 kVA	=	1,11 MVA
Other Consumers:			2,31 MVA
Farms:			1,20 MVA
Silo:			0,80 MVA
TOTAL NMD (Domestic and Other Consumers):			5,42 MVA

iii.) Makwassie:

Domestic Consumers:	350 x 1,89 kVA	=	0,66 MVA
Other Consumers:			1,01 MVA
Silo:			0,50 MVA
TOTAL NMD (Domestic and Other Consumers):			2,17 MVA

iv.) Total NMD – Maquassi Hills municipality:

The total notified maximum demand as communicated with ESKOM is the sum of the three totals above:

$$NMD_T = 7{,}27\ MVA + 5{,}42\ MVA + 2{,}17\ MVA$$
$$= 14{,}86\ MVA$$

This detail and the significance of this figure will be further explained under the expanded result discussions in Chapter 5 of this research study.

For the Maquassi Hills municipality, only 55% of the metered distributed electrical energy was being recovered in terms of debited accounts during 2008. Further to the loss of 45% of distributed electricity not recovered, network fines were implemented against the Maquassi Hills municipality for exceeding the above NMD on a monthly basis (Kotzé, Energy Analysis Report - Maquassi Hills Local Municipality, 2008).

3.6 Current state of electrical energy metering system

While conducting this research study, distinction was continually made between the main two different metering types: 24 maximum demand (kWh/kVA) and 2478 conventional (kWh) meters constituted the electricity income base of the Maquassi Hills municipality. No pre-paid metering equipment existed under the distribution region of the Maquassi Hills municipality.

Table 18 below tabulate the occurrence of the different electrical energy metering equipment in the Maquassi Hills municipality.

TOWN	TOTAL KWH CONSUMERS	TOTAL KWH/kVA CONSUMERS
Wolmaransstad	1503	14
Leeudoringstad	616	7
Makwassie	359	3
TOTAL	**2478**	**24**

Table 18: Existing electricity meters - Maquassi Hills municipality (2008)

3.6.1 Maximum demand meters (kWh/kVA)

In Table 19, a list of the 24 existing maximum demand meters (Bulk Consumers) (2008) is provided.

ACCOUNT NUMBER	ERF NR	NAME	LOCATION
100001506	150/02	Dept of Public Works	Wolmaransstad
100002264	150/19	Nic Bodenstein Hospital	Wolmaransstad
100003939	2277	Basfour	Wolmaransstad
100000081	1090/01RG	Dept of Public Works	Wolmaransstad
100002466	150/88	Wolmaransstad High School	Wolmaransstad
100001246	236	Telkom	Wolmaransstad
100000928	888	Retirement Home	Wolmaransstad
100001474	150/83	Suidwes Landbou	Wolmaransstad
100001475	150/83	Westra Nywerhede	Wolmaransstad
100002380	150/65	Daedraad School	Wolmaransstad

100001426	150/79	Dept of Education	Wolmaransstad
100003769	882/04	Shoprite	Wolmaransstad
200002474	341	Foodzone	Wolmaransstad
100001150	2206	Central Spar	Wolmaransstad
200002166	466	Tau Mills	Leeudoringstad
200001055	60RI	Sedibeng Water	Leeudoringstad
200001548	1976	Tau Mills	Leeudoringstad
200000965	2LO	Suidwes Landbou	Leeudoringstad
200000334	940	Telkom	Leeudoringstad
200001956	956	Suidwes Landbou	Leeudoringstad
200001044	64RI	NW Secondary School of Deaf	Leeudoringstad
300001050	641	A.J Petorius	Makwassie
301000813	661	Suidwes Landbou	Makwassie
301000814	661	Suidwes Landbou	Makwassie

Table 19: 24 Maximum demand meters of the Maquassi Hills municipality

Figure 9 below provides photographs of the different types of maximum demand meters used for the recovery of the energy consumption of the above mentioned bulk consumers. *(The number of meters indicated in* Table 19 *does not add up to 24. The explanation of this is given under Chapter 5 of this research study.)*

Figure 9: Types of maximum demand energy meters

All of the existing maximum demand meters of the Maquassi Hills municipality were calibrated for accurate metering through phase current transformers (CT's). The purpose of the CT's are to down scale the current flowing through feeder cables to a similar yet proportional value measurable by the energy meter. If the CT's were underrated, inaccurate, non-existent or connected in reverse run, it would have contributed to inaccurate electrical energy consumption metering.

Figure 10 to Figure 12 indicate the existing state of several of the CT's installed in the energy metering system of the Maquassi Hills municipality (2008).

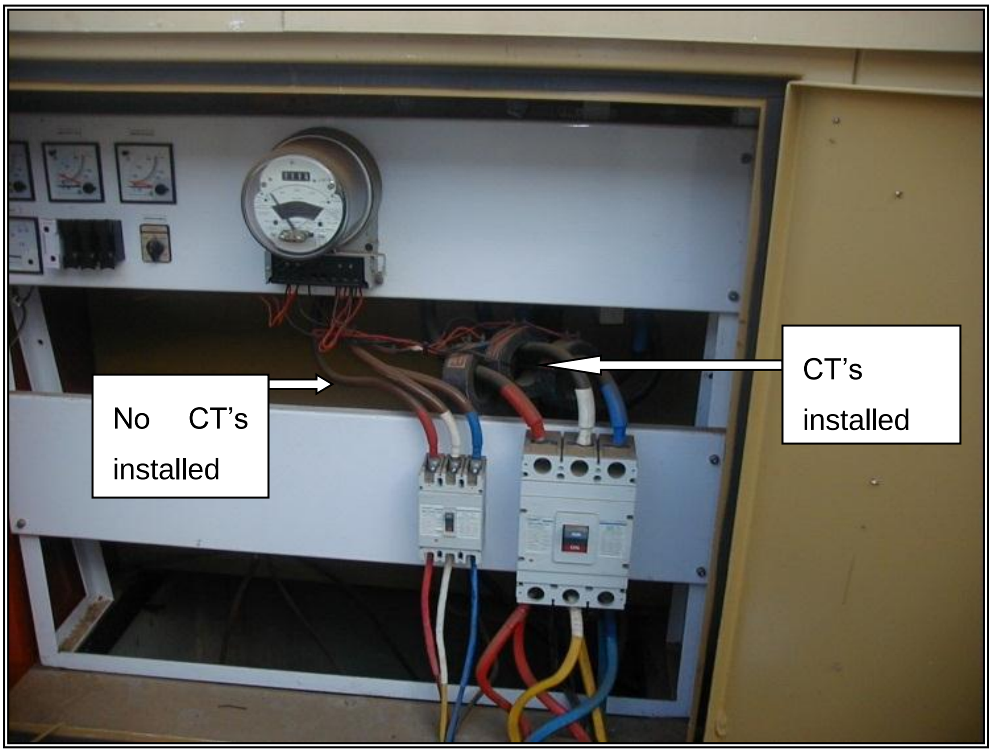

Figure 10: CT's only on some feeders

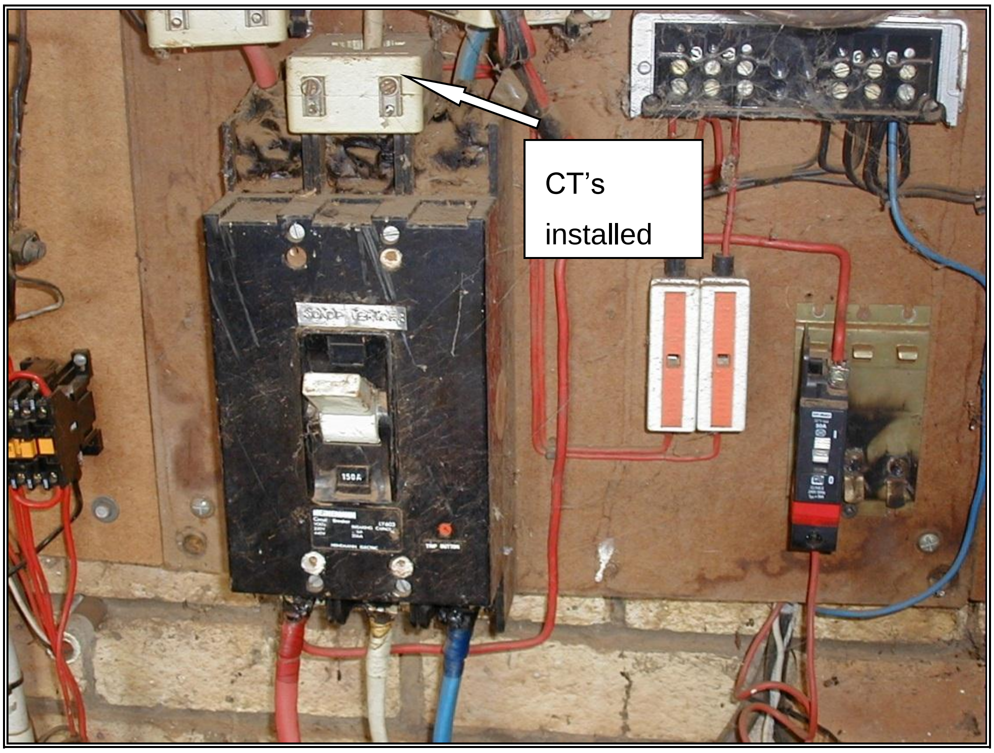

Figure 11: CT's installed but not connected

Figure 12: CT's burned

The extent and contribution of the above and similar errors in the Maquassi Hills electrical energy metering system is discussed in detail in Chapter 5.

3.6.2 Conventional meters (kWh)

All other electrical energy consumers' consumptions, not listed under maximum demand recovery above, were recovered using a conventional (kWh) electrical energy meter.

The full list of conventional electrical energy consumers is provided in Appendix B, included on the CD.

In general, conventional electrical energy metering is implemented when a consumer connection does not exceed 100 A. The conventional electrical energy meter is metering energy consumption without the calibration of CT's.

Several different types of conventional energy meters were found as part of the Maquassi Hills municipality electrical energy metering system, namely: Siemens, Voltex, CBI, GEC ALSTOM, and Schlumberger.

The type of meters used should always comply to the SANS regulation and should carry the SABS mark of approval to ensure accuracy.

Other factors influencing the accuracy of the electrical energy metering systems of local municipalities are (i) lifetime of meters, (ii) unsealed and bridged meters, and (ii) meters not installed technically correct.

Figure 13 to Figure 15 provide an indication of the status of the electrical energy metering system in the Maquassi Hills municipality before the implementation of certain corrective measures as discussed in Chapter 5.

Figure 13: State of conventional energy meters – Wolmaransstad

Figure 14: State of conventional energy meters - Leeudoringstad

Figure 15: State of conventional energy meters - Makwassie

3.7 Summary

A case study on energy metering was done on Maquassi Hills municipality in 2007/8. This research study is based on a total connection of 2478 conventional consumers and 24 maximum demand consumers distributed over a total of 3 towns namely Wolmaransstad, Leeudoringstad and Makwassie in the North-West Province. The combined notified maximum demand of the Maquassi Hills municipality was 14,86 MVA with the bulk of the demand incurred by Wolmaransstad.

The connections mentioned were metered by a wide variety of brand meters. Several different shortcomings resulted in the malfunctioning of meters. The above analysis shows the following:

- Meters were not maintained properly;
- Additional connections were being made without any adjustments to metering equipment such as CT's;

- Networks were overloaded by adding connections without developing infrastructure;
- Installation of meters of improper standards;
- Stealing of electricity was a problem and was not monitored;
- The life expectancy of metering equipment was not considered when maintenance was done on existing metering systems;
- Knowledgeable staff and good workmanship of operation and maintenance staff was lacking significantly.

The above results clearly show that knowledge and skills associated with technology are critical for the management of an energy metering system. In addition, fundamental issues such as lack of basic management (maintenance and operations) and site security were identified. Technology management would have provided a long-term view of technology and would have prevented the use of metering technology at end-of-life, amongst other advantages. This clearly indicates the need for a professional person (or persons) to provide operations management of this deeply technological system.

4 CASE STUDY: APPROACH AND METHODOLOGY

4.1 Introduction

As part of the Southern District of the North-West Province of the Republic of South-Africa, the Maquassi Hills municipality contributes to the wealth of the surrounding community particularly towards the development of infrastructure, continuous economic growth, and maintenance of existing services.

However, the management of the local authority has limited means of securing funds for the successful provision of the abovementioned services. The main method of harvesting funds for the mentioned duties of any local authority remains the selling of basic services such as water, sewage and electricity.

For this research study, particular attention was given to the distribution of electricity within the distribution area of the Maquassi Hills municipality, the accuracy of the existing electrical energy metering system and the effectiveness of the existing electrical energy billing system.

The following was done in preparation for the research:

- Assistance was provided by the Maquassi Hills municipality technical and financial staff in the collection of data for this research study;
- Existing maintenance manuals and manufacturer's guides were studied to determine the technical perimeters of all metering equipment;
- Suppliers' drawings and single line diagrams were examined to determine the correct implementation of the recommended installation criteria;
- SANS installation and manufacturing regulations were considered to obtain insight in the current state of the metering equipment; and
- NERSA legislation was used as evaluation criteria for the existing electrical billing system.

Following the above, the financial impact of each factor mentioned above was determined and is discussed in this chapter.

4.2 Investigation

The execution of this research study was done in four phases and distinction was made between the maximum demand (kWh/kVA) electrical energy meters and the conventional (kWh) electrical energy meters. The phases are discussed in the sections that follow.

4.3 Phase 1 – Data collection

The following was done with respect to data collection:

- Before starting with the analysis into the existing electrical energy metering system, all data was collected from the technical staff of the Maquassi Hills municipality;
- A database was developed indicating account numbers, addresses and names, meter ID's, manufacturers, - serial numbers and last meter readings;
- A technical inspection checklist was also developed with checkboxes for technical parameters to be evaluated. The technical inspection checklist included visual inspection, seals, connections, installations according to the specific single line diagram, CT ratings where applicable, feeder circuit breaker ratings, mechanical soundness of meters, and current and voltage ratings;
- Geographical lay-out drawings were also developed indicating the street names and erf numbers and each town was divided into different block-zones for ease of reference.

4.4 Phase 2 – Site investigations

After all required documentation had been prepared for conducting the proposed study, phase 2 of the study was undertaken. For site investigations, the following was done:

- Phase 2 of the study involved a technical on-site inspection of the existing electrical energy metering system of the Maquassi Hills municipality, as mentioned, continually distinguishing between the maximum demand– and conventional type of electrical energy metering equipment. The execution of the study was performed using the block-zone lay-out drawings and the progress of the on-site investigations was thoroughly monitored;
- During the on-site investigations of the existing state of the electrical energy metering systems, attention was given to the technical parameters of metering equipment; focusing on the items as mentioned in Chapter 2. Several technical errors were identified and the financial impact of these errors was determined. The magnitude of this is further expanded on in Chapter 5;
- Subsequent to the on-site investigation checklists and the lay-out zone drawings, accurate external energy metering equipment was used as a method to determine the accuracy of the existing electrical energy metering equipment. It is important to note that this formed part of the verification of the AS IS status. The external energy metering equipment was connected to the complete existing electrical energy metering system of

the Maquassi Hills municipality at every individual interface point. The following external metering equipment was used:

  - NETLOG II energy analyser
  - FLUKE 355 digital clamp meters

- After an extensive data collection process, all collected data was captured in Excel and converted to workable spreadsheet. Results and technical recommendations were developed from the workable data. The full extent of the technical findings is discussed in Chapter 5.

The on-site investigation of the current state of the Maquassi Hills Local Municipalities electrical energy metering system ranged over a period of 4 months.

4.5 Phase 3 – Account analysis

After the completion of all data capturing mentioned in 4.4, an intensive analysis was launched of the existing billing system for electrical energy of the Maquassi Hills municipality.

The focus of the account analysis was to determine:

- The effectiveness of the existing billing system;
- The correct implementation of new and escalated electricity tariffs;
- The successful recovery of consumption debts;
- Application of correct CT ratio's;
- The accuracy of the existing client database, and;
- The occurrence of numeric calculation errors.

The following steps were taken with regard to account (financial) analysis:

- The account analysis took on the form of an account audit, but differed from an account audit in the sense that a technical background was relied upon to determine certain technical corrective measures;
- During phase 3 of the study, every electricity account issued by the Maquassi Hills municipality was reviewed, again distinguishing between the maximum demand- and the conventional type electrical energy meters;
- A record was developed indicating the effectiveness of the existing billing system by taking into account dates meter readings were taken, time spent in capturing the collected

electrical energy meter readings, dates accounts were issued, recovery of debt and correct account information displayed on accounts;

- Further to the above, current and previous electricity tariffs were reviewed and compared to the approved NERSA increased electricity tariffs;
- Electricity accounts were also reviewed for the occurrence of numerical calculation errors such as cross-readings between consumers, wrong tariff types applied to certain consumers, and also including wrong CT ratio's used in the determination of the electricity consumption of end users;
- Lastly, the Maquassi Hills municipality's income generated from the electrical energy consumers was compared to the electricity wholesaler's (ESKOM) monthly account to determine if power in the Maquassi Hills municipality distribution area was supplied at a gain or a loss to the Maquassi Hills municipality.

The account analysis was conducted in 1.5 months reaching from October 2010 to December 2010. For the maximum demand electrical energy meter accounts (kWh/kVA), a total period of 7 months' accounts were reviewed including November 2007 to May 2008. For the conventional electrical energy meter accounts (kWh) a total period of 3 months' accounts were reviewed including May 2009 to July 2009. The results of the study are elaborated upon in Chapter 5.

4.6 Phase 4 – Implementation of corrective measures

Based on the outcomes from the technical on-site investigation and the electrical accounts analysis, certain corrective measures were recommended and implemented. The implementation of the proposed corrective measures was conducted over a period of 2 months.

After the implementation of the corrective measures, a completion investigation was done based on a spot check inspection to evaluate the application of the proposed engineering principle and the contribution of an effective electrical energy metering system towards a Local Authorities' sustainability.

4.7 Conclusion

This chapter provided an overview of the methodology followed in the study. It is clear from the methodology that this case study was comprehensive and scientific in nature since a cause-effect could clearly be established. This was possible seeing that an AS IS analysis was done. Afterwards, the effects of corrective action were monitored for a period of 24 months. Part of the corrective measures implemented was a follow-up program during which certain connections were spot checked every three months to determine whether the maintenance of the management system was implemented.

5 CASE STUDY: RESULTS

5.1 Introduction

All results were carefully reviewed and evaluated using a technical background based on engineering principles. The results from the on-site investigation and account analysis of the electrical energy metering system of the Maquassi Hills municipality are presented in this chapter. The implementation of the proposed corrective measures were combined into an operations management system and implemented as a corrective measure for the sustainability of the Maquassi Hills municipality.

The results are discussed in two main sections, namely 5.2, the on-site technical investigation, and 5.3, the electrical energy account analysis. As stated, the two types of electrical energy metering equipment (maximum demand and conventional) are reviewed separately under the two main sections.

5.2 On-site technical investigation

5.2.1 Maximum demand metering equipment (kWh/kVA):

The overall physical installation of the existing maximum demand electrical energy metering equipment was in an acceptable state and when compared with the wiring diagrams, no technical errors were found.

The main installation error identified was the non-existence of the Sedibeng maximum demand electrical energy meter. This meter was removed after lighting damage and had not been re-installed and re-commissioned.

Figure 16 & Figure 17 provides photographs, indicating the existing state of the installation of the maximum demand electrical energy metering equipment of the Maquassi Hills municipality.

Figure 16: Meter burned in 2007 and never replaced. Industrial consumer has been using electricity for 22 months without any charge

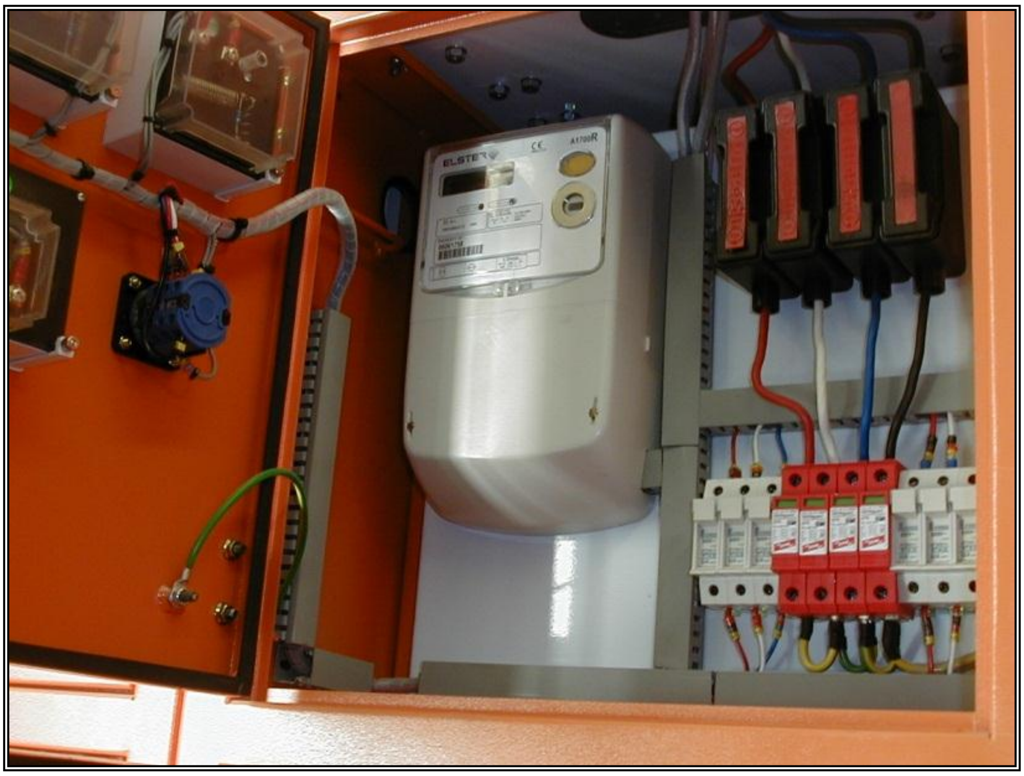

Figure 17: New meter installed. Installation is technically correct

In Appendix C, the results of the on-site technical investigation are listed. The nominal voltages for these connections are 420 V (3-phase).

Rows marked in red indicate that installed CT's and circuit breaker sizes were not corresponding. Columns in orange give an indication of inaccurate energy meters based on the energy readings from the NETLOG II Energy Analyser.

Recall that four types of bulk meters were found, namely Sangamo, Elster, Enermax, and Autometers.

From the results in Appendix C, it is clear that of the 24 Bulk Meters, 3 were installed with CT's that did not correspond with the main feeder circuit breaker (Acc. 100001474, 100001475 & 200000965). If the CT installed is lower than the circuit breaker size, the electrical energy consumption can be more than the rated CT value and all energy usage above that value will be unaccounted for. In all three cases the comparison between the existing electrical energy meter reading and the NETLOG II Energy Analyser provided information indicating the existing saturated CT's which contributed to an overall monthly loss of R 9 142.75. Table 22 provides a summary of the financial impact resulting from the saturated CT's.

To determine the financial impact of the errors found on the existing electrical energy metering system reflected in Appendix C on the included CD, the following tariffs were used as published in the Maquassi Hills municipality notice 12/2007:

- Industrial Tariff Structure:

	2007/2008 Tariff (incl 14% VAT)
Basic	R 532.38
kVA	R 58.6074
kWh	R 0.2555

Table 20: 2007/2008 Industrial tariff structures – Maquassi Hills municipality

- Time of Use Tariff Structure:

	2007/2008 Tariff (incl 14% VAT)
Basic	R 532.38
Peak HD	R 0.8585
Standard HD	R 0.3190
Off Peak HD	R 0.1848
Peak LD	R 0.8226
Standard LD	R 0.2864
Off Peak LD	R 0.1593
Reactive	R 0.0302

Table 21: 2007/2008 Time of use tariff structure - Maquassi Hills municipality

The financial impact was obviously affected by the pricing structure, which had increased significantly on an annual basis. This had to be considered when losses were calculated since the financial impact has grown at a rate significantly higher than inflation due to the ESKOM increases.

Account Number	CT Ratio	Feeder Circuit Breaker Size (A)	Maximum Demand based on existing CT's (kVA)	Maximum Demand as per the NETLOG II Energy Analyser (kVA)	Rand Value for the loss in income (R)
100001474	300/5	750	218	263	2637.33
100001475	300/5	800	218	305	5098.84
200000965	500/5	630	364	388	1406.58
TOTAL					**9142.75**

Table 22: Results from technical investigation for MD electrical energy metering equipment

The above errors were corrected by downgrading the feeder circuit breakers to the consumer requested sizes and upgrading the CT's to corresponding ratios.

5 Bulk Meters were installed with circuit breaker sizes smaller than the available transformer capacity (Acc. 300001050, 100001506, 100000081, 200001956 & 200000965). In these cases, there was a total combined capacity of 1,4 MVA available on the Maquassi Hills Electrical Energy Network, which could not be utilized due to incorrect circuit breaker sizes. Taking into account the network surcharge for the Notified Maximum Demand (NMD), the Maquassi Hills municipality's incurs a monthly operating expenditure for a total of 1,4 MVA not utilized. The total loss of possible monthly income was calculated as follows:

1 400 kVA x R 58.6074 = R 82 050.36

Although the above number was not taken into consideration in the calculation of the final financial impact, it is worth taking note of when taking into account that new developments demand strengthening of networks which result in fruitless expenditure should all capacity not be utilized first.

Another factor which influenced correct energy consumption was the type of meter used. From the 24 investigated bulk meters, 70,8% (17) of the meters were Sangamo type meters, 16,6% (4) were Elster type meters, 4,2% (1) was an Enermax type meter and 4,2% (1) was an Autometer type meter.

The National Energy Regulator allows 5% diversity for the supplied voltage. This 5% diversity was taken into account during the site investigation. During the site investigation, 11 of the 17 Sangamo type meters (64,7%) were found to be inaccurate when the kVA reading from the meter was compared to instantaneous Ampére readings from the external FLUKE 355 digital clamp meter. Out of the 4 Elster type meters, 1 (25%) were found to be inaccurate and all the other types were found to be accurate. It must be kept in mind that for the 1 Elster meter that is incorrect, the installed CT's for this particular meter was smaller than the expected CT value. From this finding it is clear that the Sangamo type meters were not accurate and had a financial implication for the Maquassi Hills municipality.

The extent of the loss due to inaccurate maximum demand electrical energy meters could only be determined once all corrective measures had been put in place. After metering it, the impact was taken into account in the determination of the final financial impact to the Maquassi Hills municipality's loss of income.

The Elster A1700 was considered to be the most accurate in its range and all maximum demand meters were changed to Elster A1700 maximum demand meters as a corrective measurement.

5.2.2 Conventional metering equipment (kWh):

During the on-site investigation of the existing conventional electrical energy metering equipment, different types of electrical energy meters were found, namely: Siemens, Voltex, CBI, GEC ALSTOM, and Schlumberger.

Figure 18: General Maintenance of metering equipment is non-existent. In some cases the meter reading could not be taken due to windows overgrown with weed and spider webs

Figure 19: Metering kiosk broken and meters stolen

Figure 20: Certain phases not metered

Figure 21: Meter not operational due to expired life

Figure 22: Tampered meter

Figure 23: No meter installed

Several of the conventional electrical energy meters proved to be inaccurate when compared to the NETLOG II Energy Analyser readings. The inconsistency was identified and could be summarized under the following main categories:

- Expired lifetime of meters,
- Bridging of conventional meters by consumers,
- Conventional meters not connected as per the wiring diagram.

Another factor which influenced correct energy consumption was the type of meter used. Not all existing conventional electrical energy meters complied with the SANS regulations for electrical energy metering equipment and also did not carry the SABS mark of approval.

Table 23 below tabulates the error results, the corrective measures taken and the financial implication towards the monthly income for the Maquassi Hills municipality.

Town	**Electrical Energy Meters**					**Losses - Rand Value/ Month (excl. 14% VAT)**
	Total Consumers	**Meters Changed**	**Newly Sealed**	**Readings Unknown**	**% Meters Incorrect**	
Wolmaransstad	1503	82	779	191	18%	R 25,785.00

Leeudoringstad	616	18	151	63	13%	R 6,899.00
Makwassie	359	15	71	68	23%	R 7,820.00
Total	**2478**	**115**	**1001**	**322**	**18%**	**R 40,504.00**

Table 23: Results from technical investigation for conventional electrical energy metering equipment

From Table 23, it is clear that the Maquassi Hills municipality experienced an R 40,504.00 (excl. 14% VAT) loss per month, due to technical errors in the physical installation of the conventional electrical energy metering equipment.

The following figures provide an indication of the percentage errors per town under the distribution area of the Maquassi Hills municipality.

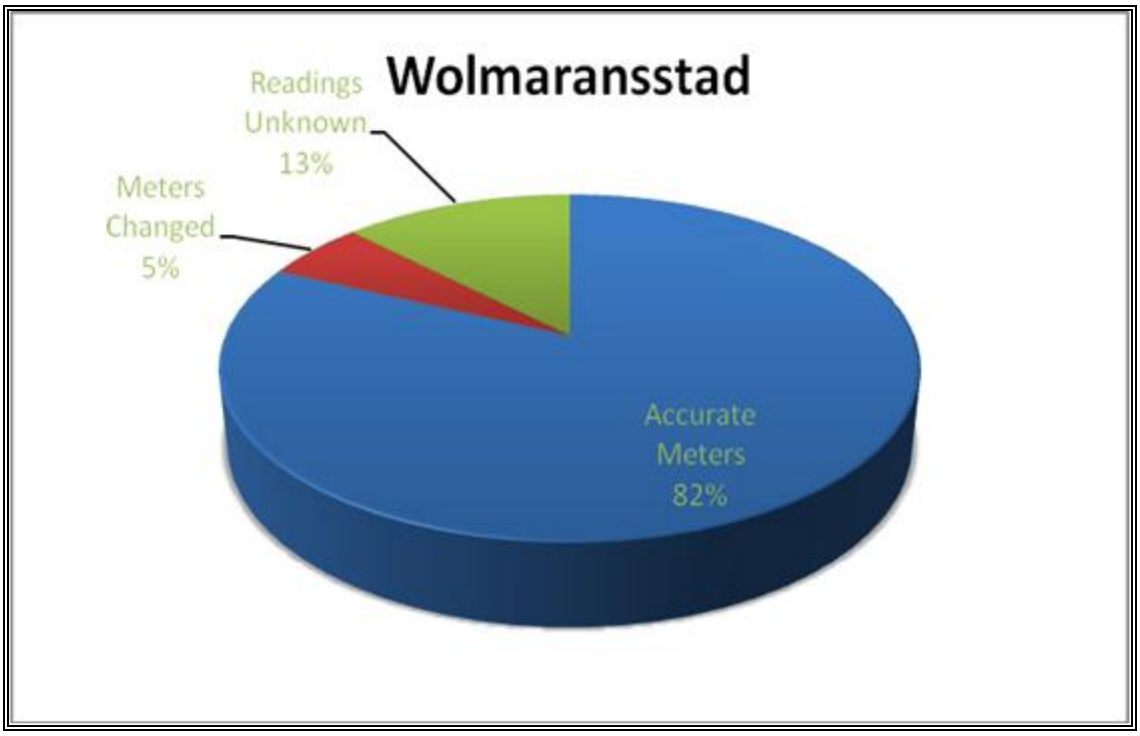

Figure 24: Accuracy of the conventional electrical energy metering equipment - Wolmaransstad

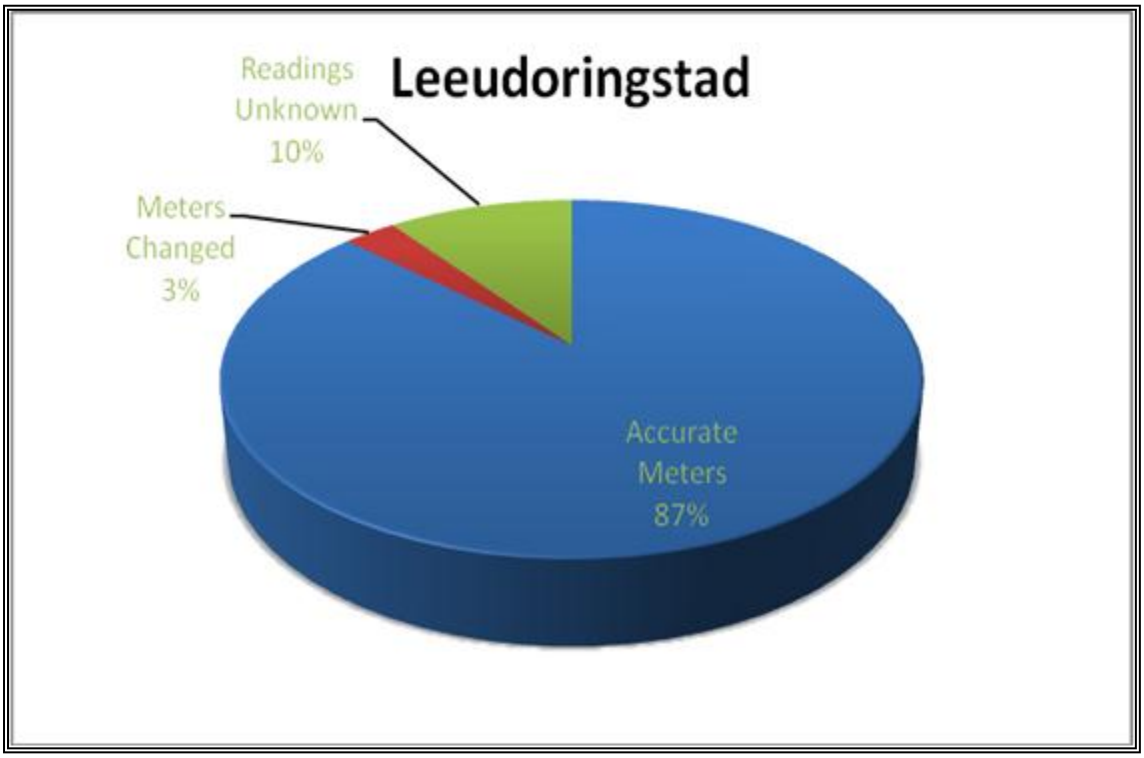

Figure 25: Accuracy of the conventional electrical energy metering equipment of Leeudoringstad

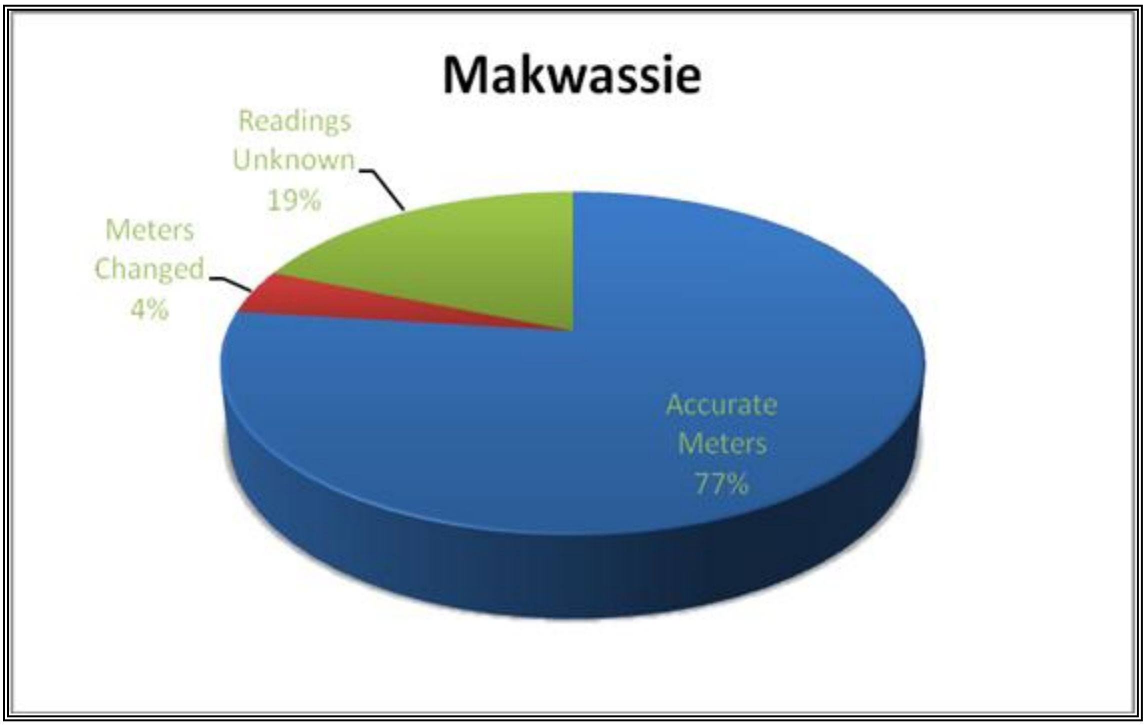

Figure 26: Accuracy of the conventional electrical energy metering equipment of Makwassie

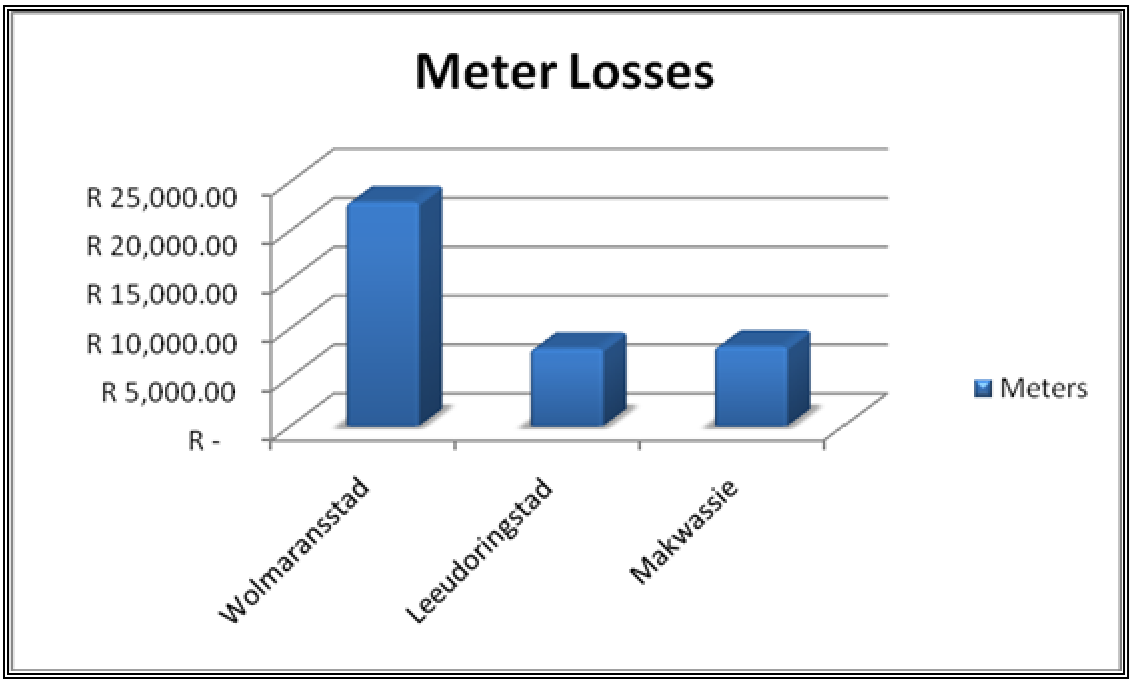

Figure 27: Conventional electrical energy meter losses of the Maquassi Hills municipality

All corrective measures were put in place during phase 4 of the study and the loss of income due to the impact of technical errors on both maximum demand- and conventional type electrical energy metering equipment was taken into account in calculating the final financial impact of technical shortcomings towards the loss of income of the Maquassi Hills municipality.

The main shortcoming that resulted in the technical errors mentioned above was identified to be a lack of maintenance. The reasons for the lack of maintenance were not investigated, but the problem could be ascribed due to a shortfall in management.

5.3 Account analysis

5.3.1 Maximum demand metering equipment (kWh/kVA):

A thorough account analysis was done on the Maquassi Hills municipality billing system for the abovementioned maximum demand electrical energy metering equipment. As stated previously, the account analysis covered a 7 month period from November 2007 to May 2008. The results of the account analysis for the maximum demand electrical energy metering equipment are discussed below.

All the cost values in the following discussions exclude 14% value added tax (VAT).

Three different invoicing items on the electrical consumption were analysed (kVA, kWh and the basic electricity fee).

From the 24 electricity accounts, tariffs on 12 (50%) were found to be correctly implemented. The difference in figures on the other 12 accounts has a serious financial implication for the Maquassi Hills Municipality; some accounts have a negative implication and some have a positive implication.

The tariff structures as mentioned under Section 5.2 were used in the evaluation and account analysis of the maximum demand electrical energy account analysis.

Of all accounts, only the 12 inaccurate accounts will be discussed in this section. In the Appendices attached to this document, full schedules of all 24 meters for the period of 7 months are provided. For all of the electrical energy accounts, the account information received by the Maquassi Hills municipality on the 27th May 2008 was used.

i.) Account Nr 100001150:

Table 24 shows the data for this account (Central Supermarket)

DATE			BASIC	BASIC FEE AS PER MAQUASSI HILLS TARIFF STRUCTURE	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - Basic Fee
11/07			R 532.38	R 532.38	R -	R -
12/07			R 532.38	R 532.38	R -	
01/08			R 532.38	R 532.38	R -	
02/08			R 532.38	R 532.38	R -	
03/08			R 532.38	R 532.38	R -	
04/08			R 532.38	R 532.38	R -	

05/08			R 532.38	R 532.38	R -	
DATE	**VA - Reading**	**kVA**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kVA**
11/07	0	206	R 12,073.12	R 12,073.12	R -	R -0.02
12/07	0	202	R 11,838.69	R 11,838.69	R -	
01/08	0	206	R 12,073.12	R 12,073.12	R -	
02/08	0	211	R 12,366.16	R 12,366.16	R -	
03/08	0	203	R 11,897.30	R 11,897.30	R -	
04/08	0	209	R 12,248.95	R 12,248.95	R -	
05/08	0	212	R 12,424.77	R 12,424.77	R -	
DATE	**kWh - Reading**	**kWh - With meter factor**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kWh**
11/07	76124	76124	R 30,260.66	R 19,447.70	R 10,812.96	R 44,919.73
12/07	69707	69707	R 27,709.79	R 17,808.33	R 9,901.46	
01/08	77396	77396	R 30,766.31	R 19,772.67	R 10,993.64	
02/08	93011	93011	R 36,973.55	R 23,761.89	R 13,211.66	
03/08	87785	87785	R 22,426.79	R 22,426.79	R -	
04/08	72393	72393	R 18,494.53	R 18,494.53	R -	
05/08	67980	67980	R 17,367.12	R 17,367.12	R -	

Table 24: Account analysis for account 100001150

From the data above it is clear that the tariffs for the kWh charge were wrongly implemented. This resulted in an over recovery of R 44 919.73.

ii.) Account Nr 100003939:

Table 25 shows the data for this account (Basfour)

DATE			BASIC	BASIC FEE AS PER MAQUASSI HILLS TARIFF STRUCTURE	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - Basic Fee
11/07			R 84.80	R 532.38	R -447.58	R - 3,133.06
12/07			R 84.80	R 532.38	R -447.58	
01/08			R 84.80	R 532.38	R -447.58	
02/08			R 84.80	R 532.38	R -447.58	
03/08			R 84.80	R 532.38	R -447.58	
04/08			R 84.80	R 532.38	R -447.58	
05/08			R 84.80	R 532.38	R -447.58	
DATE	**VA - Reading**	**kVA**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kVA**
11/07	260	31	R 1,828.55	R 1,828.55	R -	R -
12/07	250	30	R 1,758.22	R 1,758.22	R -	
01/08	200	24	R 1,406.58	R 1,406.58	R -	
02/08	260	31	R 1,828.55	R 1,828.55	R -	
03/08	280	34	R 1,969.21	R 1,969.21	R -	
04/08	260	31	R 1,828.55	R 1,828.55	R -	
05/08	260	31	R 1,828.55	R 1,828.55	R -	
DATE	**kWh - Reading**	**kWh - With meter factor**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kWh**

11/07	35	4200	R 1,659.04	R 1,072.99	R 586.05	R 4,286.56
12/07	32	3840	R 1,516.84	R 981.02	R 535.82	
01/08	34	4080	R 1,611.64	R 1,042.33	R 569.31	
02/08	38	4560	R 1,801.25	R 1,164.96	R 636.29	
03/08	46	5520	R 2,180.46	R 1,410.22	R 770.24	
04/08	33	3960	R 1,564.24	R 1,011.68	R 552.56	
05/08	38	4560	R 1,801.25	R 1,164.96	R 636.29	

Table 25: Account analysis for account 100003939

Although this account was on an industrial tariff structure, the basic fee recovered from the consumer was for the domestic high tariff structure and is R 447.58 less than what it should be. For the unit charge, the wrong tariffs have also been applied. The result of these errors is a net over recovery of R 1 153.50.

iii.) Account Nr 100002264:

Table 26 shows the data for this account (Nic Bodenstein Hospital)

DATE			BASIC	BASIC FEE AS PER MAQUASSI HILLS TARIFF STRUCTURE	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - Basic Fee
11/07			R 532.38	R 532.38	R -	R -
12/07			R 532.38	R 532.38	R -	
01/08			R 532.38	R 532.38	R -	
02/08			R 532.38	R 532.38	R -	
03/08			R 532.38	R 532.38	R -	
04/08			R 532.38	R 532.38	R -	
05/08			R 532.38	R 532.38	R -	

DATE	VA - Reading	kVA	RAND VALUE AS PER ACCOUNT	RAND VALUE AS PER CALCULATIONS	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - kVA
11/07	360	86	R 10,549.33	R 6,063.68	R 4,485.65	R 20,275.89
12/07	360	86	R 10,549.33	R 6,063.68	R 4,485.65	
01/08	340	82	R 9,963.26	R 5,782.36	R 4,180.90	
02/08	370	89	R 10,842.37	R 6,204.34	R 4,638.03	
03/08	340	82	R 9,963.26	R 5,782.36	R 4,180.90	
04/08	360	86	R -	R 6,485.65	R -6,485.65	
05/08	380	91	R 11,135.41	R 6,344.99	R 4,790.42	
DATE	**kWh - Reading**	**kWh - With meter factor**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kWh**
11/07	102	24480	R 13,029.17	R 7,254.00	R 5,775.17	R 47,467.05
12/07	106	25440	R 13,540.12	R 7,499.26	R 6,040.86	
01/08	108	25920	R 13,795.60	R 7,621.89	R 6,173.71	
02/08	136	32640	R 17,372.23	R 9,338.67	R 8,033.56	
03/08	132	31680	R 16,861.28	R 9,093.42	R 7,767.86	
04/08	114	27360	R 14,562.02	R 7,989.77	R 6,572.25	
05/08	122	29280	R 15,583.91	R 6,480.28	R 7,103.63	

Table 26: Account analysis for account 100002264

For the above consumer, the implemented tariffs for both maximum demand and unit charge were wrong. In the case of the maximum demand, kVA is currently charged at R 122/kVA and should be R 58.6074/kVA. The rate for kWh should have been R 0.2547 but was implemented at R 0.5322/kWh. This resulted in an overall over recovery of R 67,742.94 over a period of 7 months.

iv.) Account Nr 100001474:

Table 27 shows the data for this account (Suidwes Landbou Wolmaransstad)

DATE			BASIC	BASIC FEE AS PER MAQUASSI HILLS TARIFF STRUCTURE	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - Basic Fee
11/07			R 532.38	R 532.38	R -	R -
12/07			R 532.38	R 532.38	R -	
01/08			R 532.38	R 532.38	R -	
02/08			R 532.38	R 532.38	R -	
03/08			R 532.38	R 532.38	R -	
04/08			R 532.38	R 532.38	R -	
05/08			R 532.38	R 532.38	R -	
DATE	**VA - Reading**	**kVA**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE – kVA**
11/07	2100	252	R 9,846.04	R 14,769.06	R -4,923.02	R -21,333.10
12/07	2100	252	R 9,846.04	R 14,769.06	R -4,923.02	
01/08	1680	202	R 7,876.83	R 11,815.25	R -3,938.42	
02/08	1460	175	R 6,845.35	R 10,268.02	R -3,422.67	
03/08	1440	173	R 6,751.57	R 10,127.36	R -3,375.79	
04/08	1600	192	R 7,501.75	R 11,252.62	R 3,750.87	
05/08	1920	230	R 9,002.10	R 13,503.14	R -4,501.04	

DATE	kWh - Reading	kWh - With meter factor	RAND VALUE AS PER ACCOUNT	RAND VALUE AS PER CALCULATIONS	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - kWh
11/07	299	35880	R 6,110.94	R 9,166.41	R -3,055.47	R -17,413.10
12/07	264	31680	R 5,395.61	R 8,093.42	R -2,697.81	
01/08	196	23520	R 4,005.83	R 6,008.75	R -2,002.92	
02/08	206	24720	R 4,210.21	R 6,315.32	R -2,105.11	
03/08	237	28440	R 4,843.79	R 7,265.68	R -2,421.89	
04/08	201	24120	R 4,108.02	R 6,162.03	R -2,054.01	
05/08	301	36120	R 6,151.82	R 9,227.72	R -3,075.90	

Table 27: Account analysis for account 100001474

For the Suidwes Landbou Wolmaransstad Silo's, wrong tariffs had been implemented on both maximum demand and unit charge. The resulting loss calculates to R 38 746.20.

v.) Account Nr 100001055:

Table 28 shows the data for this account (Sedibeng)

DATE			BASIC	BASIC FEE AS PER MAQUASSI HILLS TARIFF STRUCTURE	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - Basic Fee
11/07			R 208.22	R 532.00	R -323.78	R 1,460.20
			R 532.38		R 532.38	
12/07			R 208.22	R 532.00	R -323.78	
			R 532.38		R 532.38	
01/08			R 208.22	R 532.00	R -323.78	
			R 532.38		R 532.38	

02/08			R 208.22	R 532.00	R -323.78	
			R 532.38		R 532.38	
03/08			R 208.22	R 532.00	R -323.78	
			R 532.38		R 532.38	
04/08			R 208.22	R 532.00	R -323.78	
			R 532.38		R 532.38	
05/08			R 208.22	R 532.00	R -323.78	
			R 532.38		R 532.38	

DATE	**kWh - Reading**	**kWh - With meter factor**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kWh**
11/07	57271	57271	R 9,936.98	R 9,936.98	R -	
	7996	7996	R 6,691.64	R 6,691.64	R -	
	6991	6991	R 211.20	R 211.20	R -	
	24617	24617	R 7,400.31	R 7,400.31	R -	
12/07	57271	57271	R 9,936.98	R 9,936.98	R -	
	7996	7996	R 6,691.64	R 6,691.64	R -	R -0.02
	6991	6991	R 211.20	R 211.20	R -	
	24617	24617	R 7,400.31	R 7,400.31	R -	
01/08	57271	57271	R 9,936.98	R 9,936.98	R -	
	7996	7996	R 6,691.64	R 6,691.64	R -	
	6991	6991	R 211.20	R 211.20	R -	
	24617	24617	R 7,400.31	R 7,400.31	R -	

02/08	57271	57271	R 9,936.98	R 9,936.98	R -	
	7996	7996	R 6,691.64	R 6,691.64	R -	
	6991	6991	R 211.20	R 211.20	R -	
	24617	24617	R 7,400.31	R 7,400.31	R -	
03/08	57271	57271	R 9,936.98	R 9,936.98	R -	
	7996	7996	R 6,691.64	R 6,691.64	R -	
	6991	6991	R 211.20	R 211.20	R -	
	24617	24617	R 7,400.31	R 7,400.31	R -	
04/08	57271	57271	R 9,936.98	R 9,936.98	R -	
	7996	7996	R 6,691.64	R 6,691.64	R -	
	6991	6991	R 211.20	R 211.20	R -	
	24617	24617	R 7,400.31	R 7,400.31	R -	
05/08	57271	57271	R 9,936.98	R 9,936.98	R -	
	7996	7996	R 6,691.64	R 6,691.64	R -	
	6991	6991	R 211.20	R 211.20	R -	
	24617	24617	R 7,400.31	R 7,400.31	R -	

Table 28: Account analysis for account 100001055

As shown in Table 28, two basic fees were recovered from the consumer, one amount being R 532.38 and another amount of R 208.22. This resulted in a total over recovery of R 1 460.20. When the unit charge was reviewed, it became clear that the energy units consumed from November 2007 to May 2008 did not change and the same rates were recovered for the previous 7 months.

As indicated previously, this meter was not installed and the applied rates were based on average consumption from previous measurements taken. The financial impact of this could not be determined because no measure existed to obtain previous consumption.

vi.) Account Nr 100002166:

Table 29 shows the data for this account (TAU Mills Leeudoringstad)

DATE			BASIC	BASIC FEE AS PER MAQUASSI HILLS TARIFF STRUCTURE	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - Basic Fee
11/07				R 532.00	R -532.00	R -3,724.00
12/07				R 532.00	R -532.00	
01/08				R 532.00	R -532.00	
02/08				R 532.00	R -532.00	
03/08				R 532.00	R -532.00	
04/08				R 532.00	R -532.00	
05/08				R 532.00	R -532.00	
DATE	**kWh - Reading**	**kWh - With meter factor**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kWh**
11/07	11093	11093	R 1,766.65	R 1,766.65	R -	R -1,467.11
	6500	6500	R 5,347.06	R 5,347.06	R -	
	47061	47061	R 1,421.72	R 1,421.71	R 0.01	
	13298	13298	R 3,614.07	R 3,808.12	R -194.05	
12/07	16001	16001	R 2,548.29	R 2,548.29	R -	
	5913	5913	R 4,864.17	R 4,864.18	R -0.01	
	57305	57305	R 1,731.18	R 1,731.18	R -	
	14728	14728	R 4,002.72	R 4,217.63	R -214.91	

01/08	11939	11939	R 1,901.38	R 1,901.38	R -	
	6260	6260	R 5,149.63	R 5,149.63	R -	
	45831	45831	R 1,384.55	R 1,384.55	R -	
	12430	12430	R 3,378.17	R 3,559.55	R -181.38	
02/08	14551	14551	R 2,317.36	R 2,317.36	R -	
	6449	6449	R 5,305.10	R 5,305.10	R -	
	58093	58093	R 1,754.98	R 1,754.99	R -0.01	
	13609	13609	R 3,698.60	R 3,897.18	R -198.58	
03/08	13052	13052	R 2,078.63	R 2,078.64	R -0.01	
	6707	6707	R 5,517.34	R 5,517.34	R -	
	55880	55880	R 1,688.13	R 1,688.13	R -	
	13037	13037	R 3,543.14	R 3,733.38	R -190.24	
04/08	12869	12869	R 2,049.49	R 2,049.49	R -	
	6375	6375	R 5,244.23	R 5,244.23	R -	
	51223	51223	R 1,547.45	R 1,547.45	R -	
	12209	12209	R 3,318.12	R 3,496.27	R -178.15	
05/08	22116	22116	R 3,522.16	R 3,522.15	R 0.01	
	8391	8391	R 6,902.64	R 6,902.64	R -	
	81610	81610	R 2,465.44	R 2,465.44	R -	
	21230	21230	R 5,769.80	R 6,079.59	R -309.79	

Table 29: Account analysis for account 100002166

For this connection no basic fee was charged for the electrical connection. The tariff for the standard unit charge during low season was recovered using 2006/2007 tariffs which resulted in a debit. The total income loss for this account for the past 7 months was found to be R 5,191.11.

vii.) Account Nr 100001548:

Table 30 shows the data for this account (TAU Mills Leeudoringstad).

DATE			BASIC	BASIC FEE AS PER MAQUASSI HILLS TARIFF STRUCTURE	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - Basic Fee
11/07			R 532.38	R 532.00	R -	R 1,599.42
12/07			R 532.38	R 532.00	R -	
01/08			R 532.38	R 532.00	R -	
02/08			R 532.38	R 532.00	R -	
03/08			R 532.38	R 532.00	R 0.38	
			R 532.38		R 532.38	
04/08			R 532.38	R 532.00	R 0.38	
			R 532.38		R 532.38	
05/08			R 532.38	R 532.38	R -	
			R 532.38		R 532.38	
DATE	**VA - Reading**	**kVA**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE – kVA**
03/08	0	329	R 19,281.83	R 19,281.83	R -	R 0.00
04/08	0	332	R 19,457.66	R 19,457.66	R -	
05/08	0	336	R 19,692.09	R 19,692.09	R -	
DATE	**kWh - Reading**	**kWh - With meter**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER**	**DIFFERENCE IN RAND**	**TOTAL DIFFERENCE**

		factor		CALCULATIONS	VALUE	– kWh
11/07	68701	68701	R 10,941.18	R 10,941.18	R -	R – 18 360.15
	34582	34582	R 28,447.98	R 28,447.98	R -	
	168136	168136	R 3,555.57	R 5,079.39	R -1,523.82	
	74924	74924	R 20,362.54	R 21,455.84	R -1,093.30	
12/07	66733	66733	R 10,627.76	R 10,627.76	R -	
	33951	33951	R 27,928.91	R 27,928.91	R -	
	161860	161860	R 3,422.85	R 4,889.79	R -1,466.94	
	73507	73507	R 19,977.44	R 21,050.05	R -1,072.61	
01/08	74134	74134	R 11,806.43	R 11,806.43	R -	
	28016	28016	R 23,046.64	R 23,046.63	R 0.01	
	153474	153474	R 3,245.51	R 4,636.45	R -1,390.94	
	61373	61373	R 16,679.70	R 17,575.26	R -895.56	
02/08	83520	83520	R 13,301.22	R 13,301.23	R -0.01	
	34813	34813	R 28,628.01	R 28,638.01	R -10.00	
	182310	182310	R 3,855.31	R 5,507.59	R -1,652.28	
	77675	77675	R 21,110.20	R 22,243.63	R -1,133.43	
03/08	143513	143513	R 36,663.84	R 36,663.84	R -	
	91036	91036	R 14,498.21	R 14,498.21	R -	
	33813	33813	R 27,815.38	R 27,815.39	R -0.01	
	186826	186826	R 3,950.81	R 5,644.01	R -1,693.20	
	78330	78330	R 21,288.21	R 22,431.21	R -1,143.00	

04/08	291911	291911	R 74,575.68	R 74,575.68	R -	
	84773	84773	R 13,500.78	R 13,500.78	R -	
	32776	32776	R 26,962.32	R 26,962.32	R -	
	177313	177313	R 3,749.64	R 5,356.63	R -1,606.99	
	76904	76904	R 20,900.66	R 22,022.84	R -1,122.18	
	0	0	R -	R -	R -	
05/08	167087	167087	R 42,686.39	R 42,686.39	R -	
	112711	112711	R 17,950.13	R 17,950.13	R -	
	32312	32312	R 26,580.63	R 26,580.63	R -	
	149859	149859	R 3,169.06	R 4,527.24	R -1,358.18	
	82080	82080	R 22,307.37	R 23,505.09	R -1,197.72	

Table 30: Account analysis for account 100001548

For April, May and June 2008 two basic fees of R 532.00 were recovered. This resulted in an over recovery of R 1,467.11. Even though this was an account with time of use tariffs, there was an amount of R 58,431.58 that was recovered for maximum demand. The unit charge shows a loss of income of R 18,360.15. This loss is mainly due to 2006/2007 tariffs applied to 2007/2008 units.

viii.) Account Nr 301000814:

Table 31 shows the data for this account (Suidwes Landbou -Makwassie)

DATE			BASIC	BASIC FEE AS PER MAQUASSI HILLS TARIFF STRUCTURE	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - Basic Fee
11/07			R 532.38	R 532.38	R -	R 1,064.76
12/07			R 532.38	R 532.38	R -	
01/08			R 532.38	R 532.38	R -	

02/08			R 532.38	R 532.38	R -	
03/08			R 532.38	R 532.38	R -	
04/08			R 532.38	R -	R 532.38	
05/08			R 532.38	R -	R 532.38	
DATE	**VA - Reading**	**kVA**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kVA**
11/07	220	44	R 2,578.73	R 2,578.73	R -	R 4,454.16
12/07	560	112	R 6,564.03	R 6,564.03	R -	
01/08	220	44	R 2,578.73	R 2,578.73	R -	
02/08	220	44	R 2,578.73	R 2,578.73	R -	
03/08	380	76	R 4,454.16	R -	R 4,454.16	
04/08	0	0	R -	R -	R -	
05/08	0	0	R -	R -	R -	
DATE	**kWh - Reading**	**kWh - With meter factor**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kWh**
11/07	33	6600	R 1.01	R 1,686.13	R -1,685.12	R -7,710.67
12/07	40	8000	R 1.23	R 2,043.79	R -2,042.56	
01/08	39	7800	R 1.20	R 1,992.70	R -1,991.50	
02/08	39	7800	R 1.20	R 1,992.70	R -1,991.50	
03/08	0	0	R -	R -	R -	
04/08	0	0	R -	R -	R -	
05/08	0	0	R -	R -	R -	

Table 31: Account analysis for account 301000814

The above account was for one of the previous connections for the Makwassie Silos of the Suidwes Landbou. Wrong tariffs were applied to the unit charge which resulted in a total loss of R 7,710.67 for the past 7 months and an over recovery of R 4,454.16 for the same period. This account should be discontinued.

ix.) Account Nr 301000813:

Table 32 shows the data for this account (Suidwes Landbou Makwassie).

DATE			**BASIC**	**BASIC FEE AS PER MAQUASSI HILLS TARIFF STRUCTURE**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - Basic Fee**
11/07			R 532.38	R 532.38	R -	R -
12/07			R 532.38	R 532.38	R -	
01/08			R 532.38	R 532.38	R -	
02/08			R 532.38	R 532.38	R -	
03/08			R 532.38	R 532.38	R -	
04/08			R 532.38	R 532.38	R -	
05/08			R 532.38	R 532.38	R -	
DATE	**VA - Reading**	**kVA**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kVA**
11/07	500	100	R 9,377.18	R 5,860.74	R 3,516.44	R 16,878.94
12/07	500	100	R 9,377.18	R 5,860.74	R 3,516.44	
01/08	440	88	R 8,251.92	R 5,157.45	R 3,094.47	
02/08	147	29	R 2,756.90	R 1,723.06	R 1,033.84	
03/08	813	163	R 15,247.31	R 9,529.56	R 5,717.75	
04/08	600	192	R 11,252.62	R 11,252.62	R -	

05/08	640	205	R 12,002.80	R 12,002.80	R -	

DATE	kWh - Reading	kWh - With meter factor	RAND VALUE AS PER ACCOUNT	RAND VALUE AS PER CALCULATIONS	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - kWh
11/07	93	18600	R 7,602.91	R 4,751.82	R 2,851.09	R 8,491.96
12/07	53	10600	R 4,332.84	R 2,708.02	R 1,624.82	
01/08	62	12400	R 5,068.60	R 3,167.88	R 1,900.72	
02/08	69	13800	R 5,640.87	R 3,525.54	R 2,115.33	
03/08	0	0	R -	R -	R -	
04/08	114	36480	R 9,319.69	R 9,319.69	R -	
05/08	104	33280	R 8,502.18	R 8,502.17	R 0.01	

Table 32: Account analysis for account 301000813

What applied to account 301000814, also applies here. The total over recovery for the 7 month period was found to be R 25,370.90.

x.) Account Nr 200001044:

Table 33 shows the data for this account (School of Deaf)

DATE			BASIC	BASIC FEE AS PER MAQUASSI HILLS TARIFF STRUCTURE	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - Basic Fee
11/07			R -	R 532.38	R -532.38	R -2,129.52
12/07			R -	R 532.38	R -532.38	
01/08			R -	R 532.38	R -532.38	
02/08			R -	R 532.38	R -532.38	
03/08			R 532.38	R 532.38	R -	
04/08			R 532.38	R 532.38	R -	

05/08			R 532.38	R 532.38	R -	
DATE	**VA - Reading**	**kVA**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kVA**
11/07	720	86	R 5,063.67	R 5,063.68	R -0.01	R -0.01
12/07	640	77	R 4,501.05	R 4,501.05	R -	
01/08	140	17	R 984.61	R 984.60	R 0.01	
02/08	640	77	R 4,501.05	R 4,501.05	R -	
03/08	520	62	R 3,657.10	R 3,657.10	R -	
04/08	520	62	R 3,657.10	R 3,657.10	R -	
05/08	660	79	R 4,641.70	R 4,641.71	R -0.01	
DATE	**kWh - Reading**	**kWh - With meter factor**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kWh**
11/07	204	24480	R 6,254.01	R 6,254.00	R 0.01	R -
12/07	193	23160	R 5,916.78	R 5,916.78	R -	
01/08	27	3240	R 827.73	R 827.74	R -0.01	
02/08	176	21120	R 5,395.61	R 5,395.61	R -	
03/08	175	21000	R 5,364.95	R 5,364.95	R -	
04/08	119	14280	R 3,648.17	R 3,648.17	R -	
05/08	189	22680	R 5,794.15	R 5,794.15	R -	

Table 33: Account analysis for account 200001044

No basic fee was recovered for 4 months for this account, which resulted in a loss of income of R 2,129.52.

xi.) Account Nr 200000965:

Table 34 shows the data for this account (Suidwes Landbou Makwassie)

DATE			BASIC	BASIC FEE AS PER MAQUASSI HILLS TARIFF STRUCTURE	DIFFERENCE IN RAND VALUE	TOTAL DIFFERENCE - Basic Fee
11/07			R 532.38	R 532.38	R -	R -
12/07			R 532.38	R 532.38	R -	
01/08			R 532.38	R 532.38	R -	
02/08			R 532.38	R 532.38	R -	
03/08			R 532.38	R 532.38	R -	
04/08			R 532.38	R 532.38	R -	
05/08			R 532.38	R 532.38	R -	
DATE	**VA - Reading**	**kVA**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kVA**
11/07	520	104	R 7,314.21	R 6,095.17	R 1,219.04	R 6,721.11
12/07	760	152	R 10,689.99	R 8,908.32	R 1,781.67	
01/08	800	160	R 11,252.62	R 9,377.18	R 1,875.44	
02/08	267	53	R 3,755.56	R 3,129.64	R 625.92	
03/08	520	104	R 7,314.21	R 6,095.17	R 1,219.04	
04/08	217	217	R 12,717.81	R 12,717.81	R -	
05/08	199	199	R 11,662.87	R 11,662.87	R -	
DATE	**kWh - Reading**	**kWh - With meter**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kWh**

		factor				
11/07	79	15800	R 4,843.79	R 4,036.49	R 807.30	R 9,534.28
12/07	143	28600	R 8,767.87	R 7,306.56	R 1,461.31	
01/08	163	32600	R 9,994.14	R 8,328.45	R 1,665.69	
02/08	128	25600	R 7,848.16	R 6,540.13	R 1,308.03	
03/08	-84	-16800	R -	R -4,291.96	R 4,291.96	
04/08	28622	28622	R 7,312.18	R 7,312.18	R -	
05/08	27784	27784	R 7,098.08	R 7,098.09	R -0.01	

Table 34: Account analysis for account 200000965

For this account, a total amount of R 16,255.39 had been over recovered from the consumer. This resulted because incorrect formulas were used in the calculation.

xii.) Account Nr 200000334:

Table 35 shows the data for this account (Telkom LDS)

DATE			**BASIC**	**BASIC FEE AS PER MAQUASSI HILLS TARIFF STRUCTURE**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - Basic Fee**
11/07			R 532.38	R 532.38	R -	R -
12/07			R 532.38	R 532.38	R -	
01/08			R 532.38	R 532.38	R -	
02/08			R 532.38	R 532.38	R -	
03/08			R 532.38	R 532.38	R -	
04/08			R 532.38	R 532.38	R -	

05/08			R 532.38	R 532.38	R -	
DATE	**VA - Reading**	**kVA**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kVA**
11/07	200	16	R 937.72	R 937.72	R -	R 16,878.93
12/07	220	18	R 1,031.49	R 1,031.49	R -	
01/08	180	14	R 843.94	R 843.95	R -0.01	
02/08	200	16	R 937.72	R 937.72	R -	
03/08	220	18	R 10,314.90	R 1,031.49	R 9,283.41	
04/08	180	14	R 8,439.47	R 843.95	R 7,595.52	
05/08	200	16	R 937.72	R 937.72	R -	
DATE	**kWh - Reading**	**kWh - With meter factor applied**	**RAND VALUE AS PER ACCOUNT**	**RAND VALUE AS PER CALCULATIONS**	**DIFFERENCE IN RAND VALUE**	**TOTAL DIFFERENCE - kWh**
11/07	84	6720	R 1,716.78	R 1,716.79	R -0.01	R -0.01
12/07	108	8640	R 2,207.29	R 2,207.30	R -0.01	
01/08	101	8080	R 2,064.23	R 2,064.23	R -	
02/08	121	9680	R 2,472.99	R 2,472.99	R -	
03/08	109	8720	R 2,227.73	R 2,227.73	R -	
04/08	95	7600	R 1,941.60	R 1,941.60	R -	
05/08	120	9600	R 2,452.55	R 2,452.55	R -	

Table 35: Account analysis for account 200000334

The maximum demand for this account had been wrongly calculated which resulted in an over recovery of R 16,878.93.

During the accounting investigation a total loss of income of R 65 019.31 was discovered and a total over recovery of R 173 781.59. This resulted mainly from calculation errors, tariffs being wrongly applied and tariffs not escalated on a year to year basis.

5.3.2 Conventional metering equipment (kWh):

A thorough analysis was done on the Maquassi Hills municipality billing system for the Business & Domestic Electrical Energy Accounts. This account analysis covered a 3 month period from May 2009 to July 2009. The procedure followed for the conventional type accounts was the same as for the maximum demand electrical accounts, where the invoicing amount was compared to the calculated amount as per the Maquassi Hills 2009 tariff schedule.

All the values in the following discussions exclude 14% VAT.

Two different items on the invoices were analysed (kWh and the basic electricity fee).

Of the 2478 electricity accounts, tariffs on only 2225 were found to be correctly implemented. The difference in figures on the other 253 accounts had serious financial implications for the Maquassi Hills Municipality; some accounts negative and some positive.

The following NERSA approved tariffs were being applied for electrical energy consumption in the Maquassi Hills municipality distribution area:

- Business

	Before July 2009	**After July 2009**
Basic Fee	R 355.75	R 391.33
kWh Tariff	R 0.5192	R 0.6957

- Domestic HIGH

	Before July 2009	**After July 2009**
Basic Fee	R 144.89	R 159.35
kWh Tariff	R 0.5308	R 0.7236

- Domestic LOW

	Before July 2009	After July 2009
Basic Fee	R 144.89	R 159.35
kWh Tariff	R 0.6588	R 0.4104

i.) Wolmaransstad

The analysis of the electricity accounts of Wolmaransstad showed the following:

Electrical energy metering readings were taken **correctly**.

13% of the accounts tariffs were **implemented inaccurately**.

The oversights constitute a **R 19,426.00 loss of income** per month.

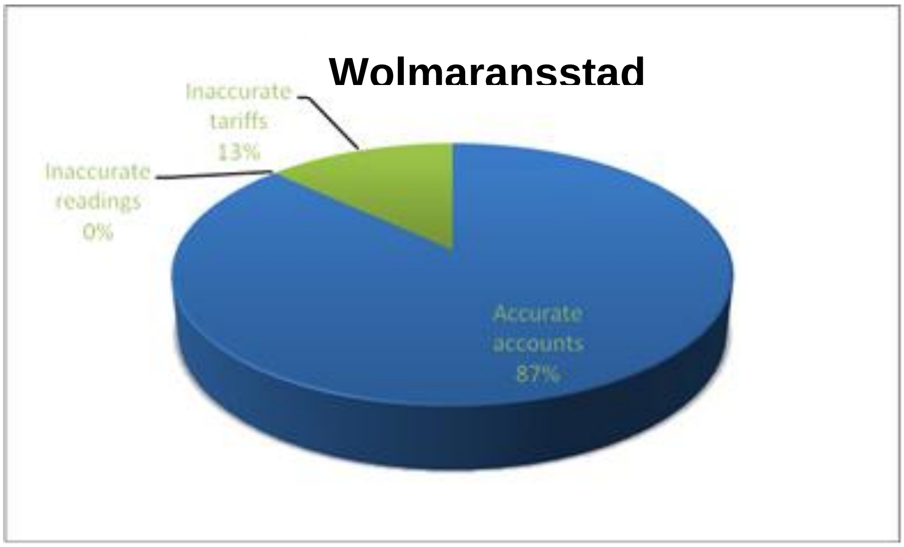

Figure 28: Account analysis of Wolmaransstad

ii.) Leeudoringstad

The analysis on the accounts of Leeudoringstad showed the following:

5% of the electrical energy metering readings was taken **incorrectly**.

7% of the accounts tariffs were **implemented inaccurately**.

The oversights of these problems constituted a **R 2,319.00 over recovery** per month.

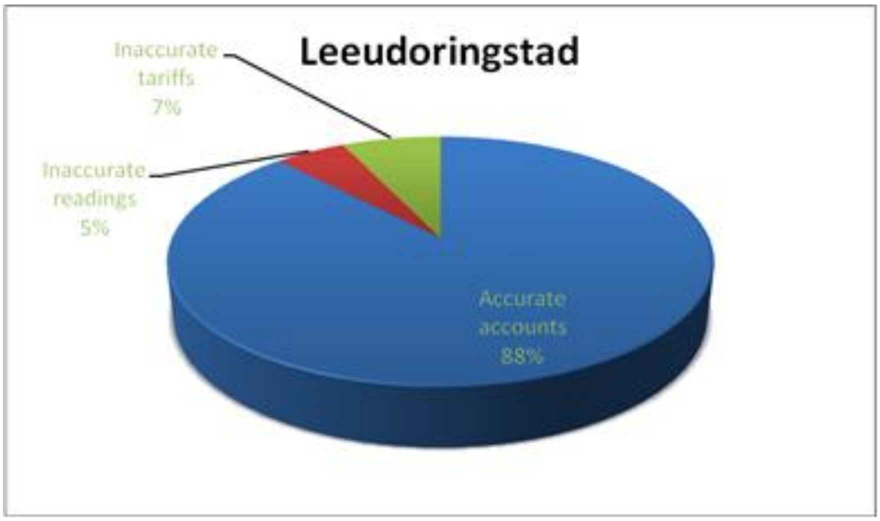

Figure 29: Account analysis of Leeudoringstad

iii.) Makwassie

The analysis on the accounts of Makwassie showed the following:

9% of the electrical energy metering readings was taken **incorrectly**.

12% of the accounts tariffs were **implemented inaccurately**.

The oversights of these problems constituted a **R 3,744.00 loss of income** per month.

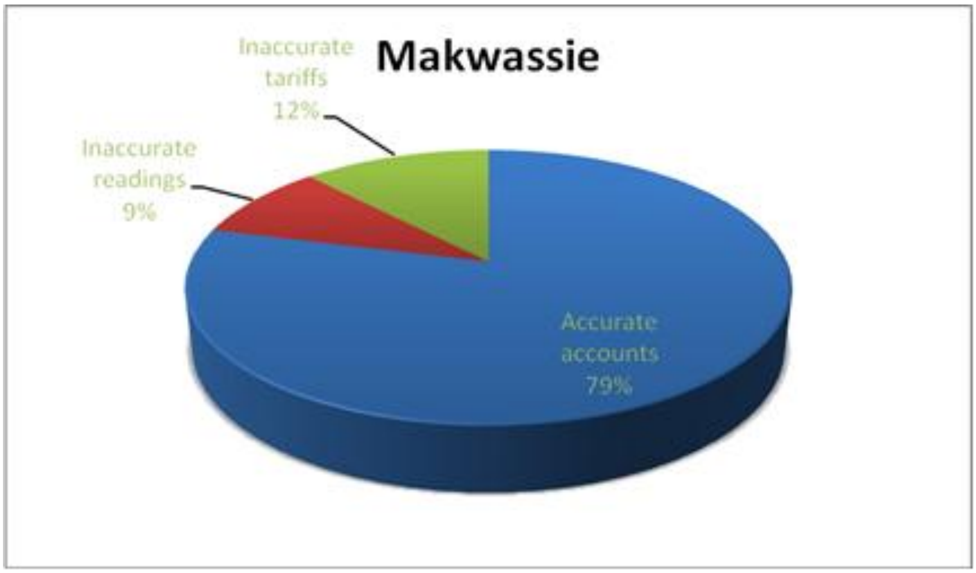

Figure 30: Account analysis of Makwassie

While analysing the conventional electrical energy accounts, it was discovered that the Maquassi Hills municipality had a total loss of income of R 15 851.00 per month. The main reason for this was because of incorrect tariffs being used for invoicing**.**

Figure 31 provides a comparison of the losses in the three different towns in the distribution area of the Maquassi Hills municipality.

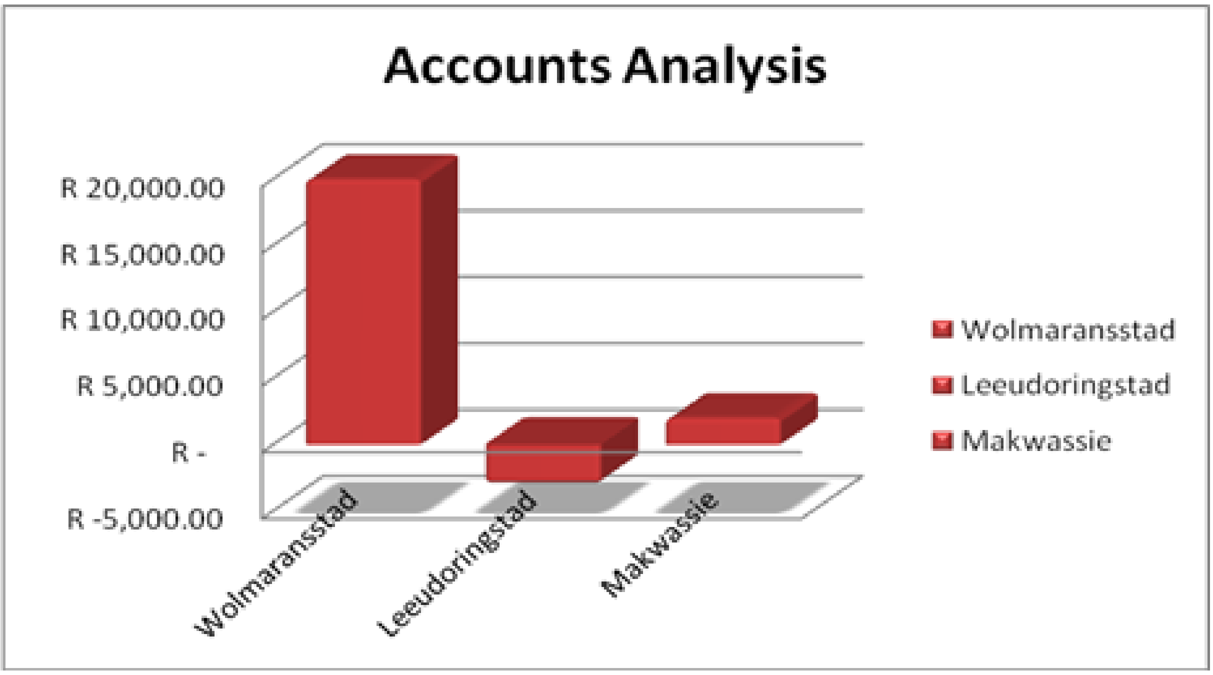

Figure 31: Energy account losses of Maquassi Hills municipality

5.4 Impact

After the results in the previous sections had been carefully examined, the financial impact of the electrical energy management system was determined and compared to other losses on the electrical energy distribution system of the Maquassi Hills municipality.

Other losses discovered on the electrical energy distribution system of the Maquassi Hills municipality include the following:

- Medium Voltage Distribution Losses
- Low Voltage Distribution Losses
- Transformer Distribution Losses

The extent of the above losses was discovered in a different study. The study mentioned was conducted on behalf of Ingplan Consulting Engineers in 2008. For this particular study, only comparison with the electrical energy metering system will be relevant.

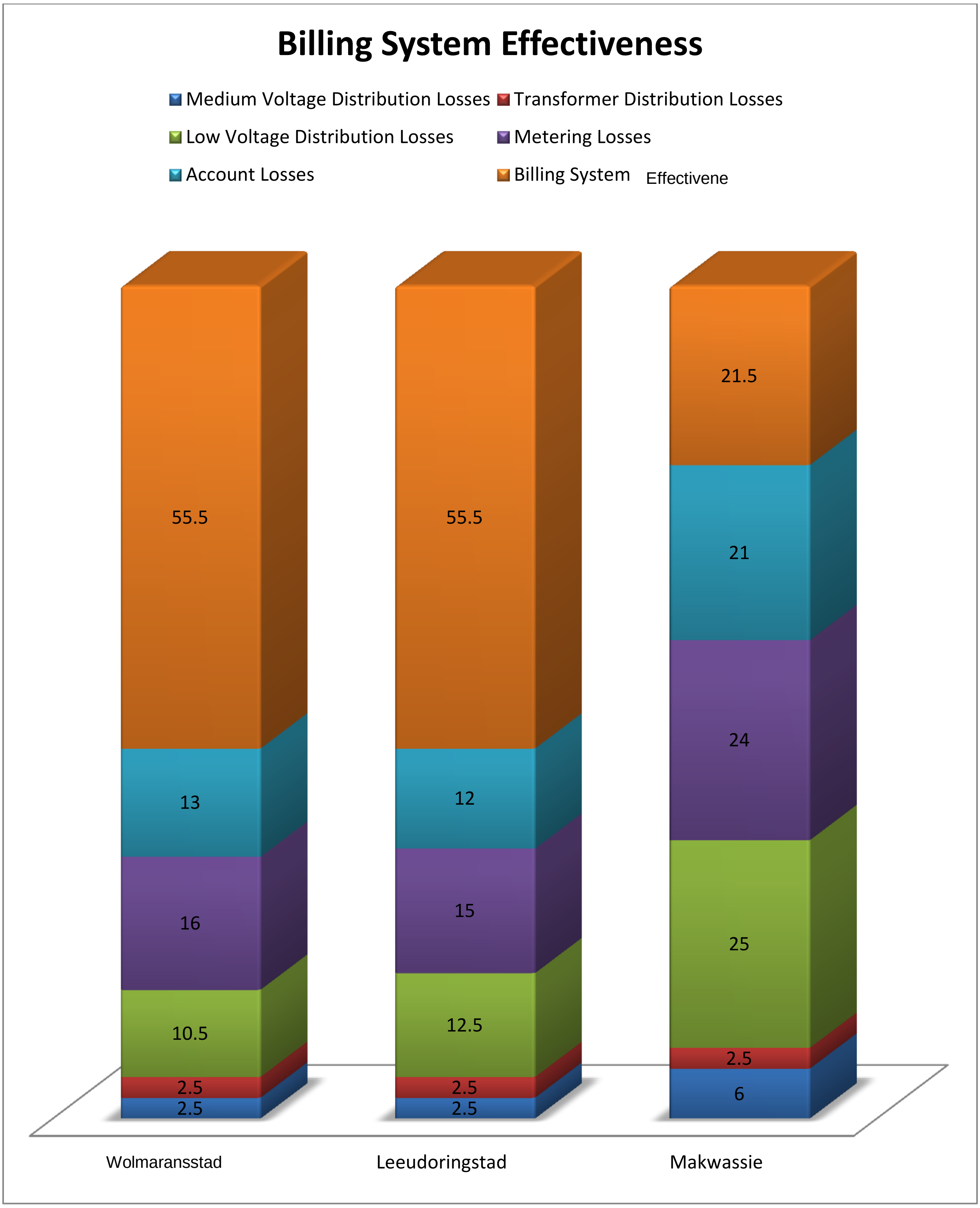

Figure 32: Municipality electrical network losses

From Figure 32 it is clear that the bulk of the electrical energy losses for the Maquassi Hills municipality were the result of an inaccurate electrical energy metering system.

Of the 2478 consumers, 675 (27%) accounts for electrical energy consumption were incorrectly recovered.

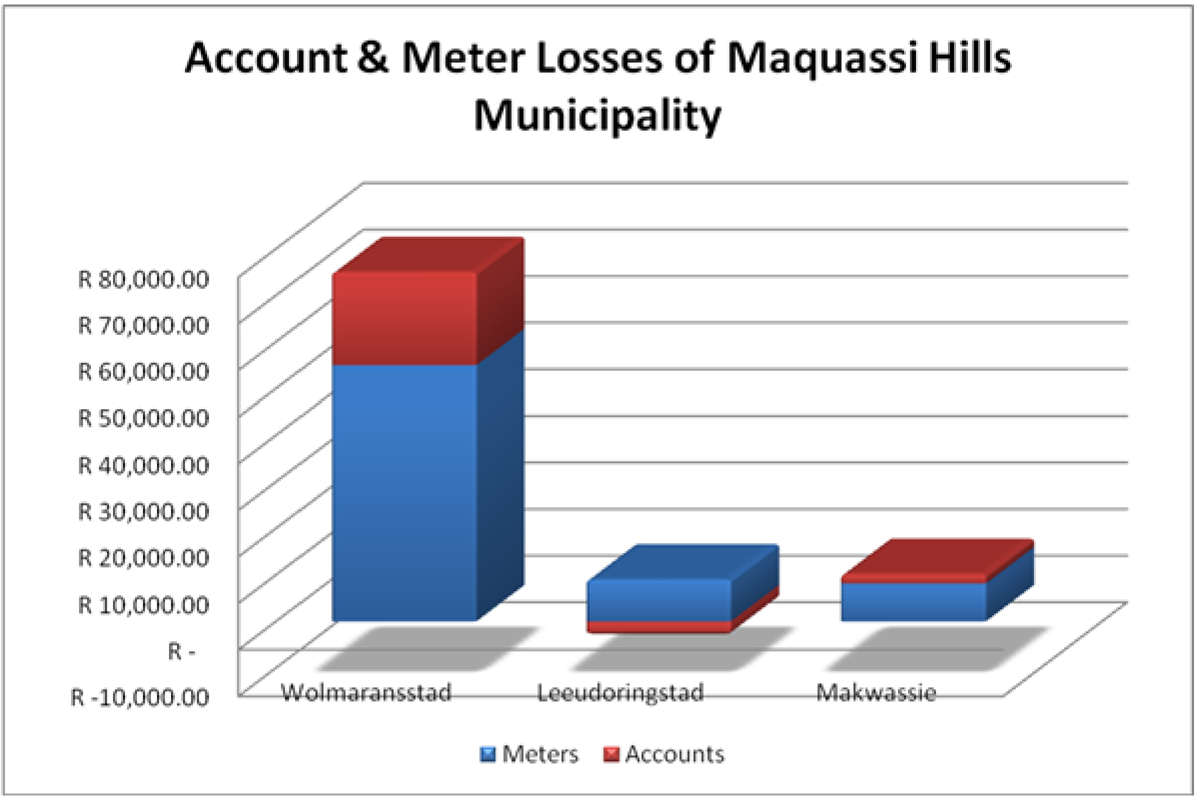

Figure 33: Electrical energy metering system losses of the Maquassi Hills municipality

The combined total monthly losses (in Rand value) of the electrical energy metering system of the Maquassi Hills municipality due to mismanagement can be calculated as follows:

i.) TECHNICAL INVESTIGATIONS:

Max Demand Energy Meters (kVA/kWh):	Loss	–	R 9 142.75	(1)
Conventional Energy Meters (kWh):	Loss	–	R 40 504.00	(2)

Excluding potential monthly loss of R 82 050.36 as discussed under Section 5.2 of this chapter.

ii.) ACCOUNT ANALYSIS:

Max Demand Energy Meters (kVA/kWh):	Over recovery	–	R 15 148.38	(3)
Conventional Energy Meters (kWh):	Loss	–	R 20 851.00	(4)

iii.) TOTAL MONTHLY LOSS OF INCOME:

$LOSS_T = (1) + (2) – (3) + (4)$

$= R\ 55\ 349.37$

If this amount is normalised to the number of consumers in the Maquassi Hills municipality (*2502, refer to Chapter 1*), the total monthly loss of income is R 22.12 per consumer per month.

A similar study was done for the Lekwa Teemane local municipality on behalf of Ingplan Consulting Engineers in 2009/2010. The results from this particular study were similar to the results discussed above and (Carnegie Mellon - Institute for Software Engineering, 2010) served as a good verification of the results discussed above (Du Toit & Kotzé, 2009).

5.5 Conclusion

The effect of mismanagement of the electrical energy metering system by the Maquassi Hills municipality has been clearly illustrated with reference to the losses incurred as outlined in this chapter. The results shown do not include wastage on other services such as water and other utilities. The positive effect that maintenance will have on metering systems has thus been illustrated.

6 CAPABILITY MATURITY AND CORRECTIVE ACTION

6.1 Introduction

A number of shortfalls have been identified from the study – these are listed in this chapter. In addition, corrective actions were taken to address the listed shortfalls, also listed in this chapter. The focus of this research study was on the analysis of energy metering and not particularly on the implementation of corrective actions. However, the study would be validated when the corrective actions actually address the shortfalls. Hence, the corrective actions and its effectiveness are given in this chapter to validate the results from the operations research.

This chapter also provides a capability maturity framework based on the CMMI model with reference to the World Bank service level indicators. A matrix of process areas, links to World Bank service level indicators, generic goals, and case study interventions is also provided.

6.2 Summary of shortfalls

From the study, the following shortfalls were identified:

i.) Technical Installation:

- General maintenance of metering equipment was non-existent;
- CT's did not correspond with connection sizes, resulting in saturated meter readings;
- CT's not operational, contributing to inaccurate metering;
- Meters broken;
- Meters not sealed;
- Bridging of meters;
- Meters not programmed according to connection electrical characteristics;
- Meters not installed as per the wiring diagrams;
- Certain phases of connections not metered;
- Meters not calibrated;
- Lifetime of meters expired;
- Certain meters completely disconnected.

ii.) Accounts

- Tariffs applied were tariffs from previous financial years and had therefore expired;
- Tariffs applied did not correspond to meter programming;
- No basic fee charge on certain accounts although applied tariff structure required it;
- Accounts not issued;
- Calculation errors on accounts.

From the above analyses, the following becomes evident as general shortfalls:

- It is clear that the management of the electrical energy metering system has a substantial financial impact on the monthly income of the Maquassi Hills municipality;
- The nature of the corrective technical actions implemented is mostly maintenance related and it is clear that the lack of general maintenance has an effect on the accuracy of the metering equipment;
- There is a component of technical shortfall that relates to standards and by-laws, such as incorrect technology and calibration;
- The nature of the corrective administrative actions implemented is mostly management related. The lack of management is obvious from the elementary errors found on the accounts system of the Maquassi Hills municipality;
- Training of staff is imperative and the lack of skills of staff influences the monthly revenue of the municipality negatively. In turn the lack of revenue has a substantial impact on the development of infrastructure and providing of services to the local community;
- From studies in other similar size municipalities, similar results were obtained. If all smaller local municipalities have the same lack of management skills of the electrical energy metering systems it can be a contributor to the insolvency of municipalities;
- There is an indirect impact on the demand side management of the municipality, especially when it comes to load flow, measuring and verification. This information is usually used for planning purposes by local municipalities.

6.3 Corrective actions

Corrective actions were taken to address the shortfalls found in the study. Although not the focus of this research study, the actions are listed below to validate the results of this research study:

- Repairs and replacements were done on meters to ensure functional capability of installed equipment;
- Adherence to relevant standards, laws and by-laws and to ensure effective technical installations of equipment to the electrical metering system was ensured;
- Further to the corrective actions, a maintenance plan was developed that allowed for on-going maintenance;
- Incorrect accounts were corrected;
- A six month operating and training programme was implemented to ensure the sustainability of corrective measures implemented and prolonged results;
- Follow-up audits were conducted to ensure quality and good corporate governance.

In terms of **technical** maintenance (details), the following corrective actions were taken:

- Replacement of inaccurate energy meters;
- Repair of installations;
- Resealing of energy meters;
- Upgrading of current transformers;
- Cleaning of metering panels.

In terms of **financial** corrections (details), the following was done:

- Review of applied tariffs;
- Balancing of account statements;
- Calculation of financial losses.

6.3.1 Maintenance Plan

As part of the proposed operations management program for electrical energy metering equipment, a thorough maintenance plan was developed and implemented for the on-going maintenance at the Maquassi Hills municipality. The maintenance plan included the management of the energy metering equipment which addressed the factors mentioned above in the following manner:

- All metering equipment were to be investigated with specific attention given to correctness of the installation;
- All metering equipment were to be checked for tampering;
- All metering equipment were to be tested for accuracy;

- The lifetime of all metering equipment was to be determined as well as the time lapsed during which the equipment had been operational;
- Metering equipment, current transformers and supply circuit breakers had to correspond with regard to their electrical attributes;
- A thorough asset register had to be developed for all metering equipment;
- After all corrective measures had been implemented and the metering system of the municipality was precise, the system needed to be maintained;
- Spot checks needed to be done at previously discovered tampered meters on a monthly basis;
- Spot checks had to be done with regards to technical installation quarterly;
- Spot checks had to be done with regards to accuracy of meters on a 6 month basis;
- A complete meter investigation needed to be conducted once every 3 years.

6.4 Evaluation of interventions

Six months after all corrective measures had been implemented, a follow-up audit was done to determine if the implementation actions were maintained. The follow-up audit was done on the following basis:

- 15% of the metering accounts and equipment were randomly selected for spot checking;
- The same methodology was followed as described in Chapter 4 to conduct a technical and financial audit on the selected 15%;
- All results were captured and compared with projected figures and savings;
- The results from the follow-up audit indicated a deviation of less than 6% with respect to the projected figures and savings.

The results clearly showed that the results from the study were valid in that the corrective actions had addressed the shortfalls effectively to within a margin of 6%. That is, the corrective actions effectively reduced losses because the identified shortfalls were the underlying cause of the losses.

Currently, the impact that the implementation - as described in this research study – has on the Maquassi Hills municipality's financial situation, is being monitored on a monthly basis by the Chief Financial Officer of the municipality.

6.5 Capability maturity

Up to this point, the focus has been on the case study and the improvements that were implemented and measured. The focus now shifts towards the definition of a capability maturity model for rural municipalities.

Our approach to a capability maturity model is to define such a model based on the CMMI approach, as the CMMI framework is comprehensive. In addition, the World Bank service level indicators are used to show causality between CMMI and a model that is actually in use in the energy environment. The World Bank model is a broad model, while the CMMI model will be focused specifically on energy metering and the links between CMMI and the World Bank model are interesting. However, the main result will be the capability maturity model based on CMMI.

The discussion starts with an overview of the World Bank service delivery index (to show that interventions did indeed cause improvement in the overall service delivery). This discussion is followed by a matrix that provides a capability framework for rural municipalities, with each process area linked to the World Bank service level indicators.

6.5.1 World Bank service delivery indicator – before intervention

The following section provides the calculated World Bank service delivery index applicable to this research study. Again, it should be highlighted that the index was applied in an isolated context to the area of electrical energy metering only and should not be regarded as an all-inclusive indication of service delivery within the Maquassi Hills municipality.

The capability maturity index is equally important and follows later in this document. There exists causality between the CMMI process areas and the World Bank service level indicators - this causality is provided in a capability maturity matrix presented in the following section.

- Electricity infrastructure service quality

  Under this dimension of the service level index, the quality of infrastructure is being measured in terms of house connections and whether they are metered or not. From the discussions above it is clear that not all connections are metered and therefore result in a level of service 3 with a contributing value of 3.

LEVEL OF SERVICE	DESCRIPTION	VALUE
3	Restricted house connections	3

Table 36: Electricity infrastructure service quality – Energy metering systems

- Electricity infrastructure delivery efficiency

CATEGORY	DESCRIPTION	RATING
1	Unplanned interruptions	%
2	Power unaccounted for	%

Table 37: Electricity service supply efficiency categories

Electrical energy metering contributes largely to the second category. From the discussions above, it is clear that the losses due the electrical energy metering systems are higher than 15%. From the evaluating criteria for the 2 categories within this dimension, if one of the categories obtains a value of higher than 15%, the service level should be regarded as inefficient and a value of 1 must be allocated to the dimension.

AVERAGE RATING OF THE TWO CATEGORIES	DESCRIPTION	VALUE
Higher than 15%	No service	1

Table 38: Electricity infrastructure delivery efficiency – Electrical energy metering

- Affordability of electricity services

The same principle as for the previous dimension applies to the evaluation of the affordability of this particular portion of the electrical infrastructure. Category 1 below does not get affected by energy metering system effectiveness. Energy metering systems contribute however largely to category 2 and in the case of the Maquassi Hills municipality, Non-payment levels are as high as 55%.

CATEGORY	DESCRIPTION	RATING
1	Percentage ratio of electricity cost per month to household income	%
2	Non-payment levels	%

Table 39: Electricity service affordability categories

When evaluating the affordability of electrical infrastructure within the Maquassi Hills municipality, this dimension gets allocated a value of 1. This implies that the electrical infrastructure is unaffordable.

AVERAGE RATING OF THE TWO CATEGORIES	**DESCRIPTION**	**VALUE**
More than 10%	Unaffordable	1

Table 40: Electricity services affordability values – Electrical energy metering

- Access to electricity services

This dimension contributes indirectly to the effectiveness of energy metering systems within the Maquassi Hills municipality. Accurate metering of the electrical consumption within a municipality will provide detailed records and will form the basis of better revenue collection. Higher collection of revenue will provide a funding opportunity for capital projects, including electrical infrastructure and better access to electricity.

From the municipal IDP (Municipality, Maquassi Hills, 2008) a total of 86.2% of the community in the Maquassi Hills municipality does not have access to electricity. This figure was used to determine the contributing value for this dimension and is indicated below.

AVERAGE RATING	**DESCRIPTION**	**VALUE**
89% to 85%	Limited	2

Table 41: Electricity services accessibility values – Electrical energy metering

The average value obtained from the four dimensions above is therefore: 1.75.

When the following scale is applied using the average value:

- Level of service 1 – Minimal or absent;
- Level of service 2 – Basic;
- Level of service 3 – Intermediate;
- Level of service 4 – Full.

the energy metering systems of the Maquassi Hills municipality is considered to be between level of service 1 and level of service 2 and confirm that a corrective strategy is indeed required.

As a result of the audit and corrective actions, this particular municipality recovered losses of up to R 85 646.13 per month. The recovered loss did not only have an impact on the monthly finances of the local municipality, but it also affected development of infrastructure and demand side management. Furthermore, the cumulative negative effect of the lack of maintenance was halted and turned around.

6.5.2 CMMI level of maturity

The generic goals described in Table 7, Chapter 2 were used to determine the level of capability for each process area relative to the electrical metering systems of the Maquassi Hills municipality. For this research study, this particular section of operation with the municipality, the energy metering system was viewed in isolation from the other operational sections in the municipality and the level of maturity for this section only was determined before and after implementation of the corrective actions.

For each goal (including the generic practices thereunder) a capability level of 0 to 3 was allocated. As described under Table 5, Chapter 2 the levels can be interpreted as follows:

- 0 – Incomplete
- 1 – Performed
- 2 – Managed
- 3 – Defined

The following table provides a breakdown of the different process areas within the CMMI framework and includes references to interventions taken during this particular research study. It also lists the maturity level reached after the implementation of these interventions.

“EXCEL TABEL”

CMMI process area	CMMI description	Translation to energy metering	Link to World Bank service delivery indicator (BEFORE:AFTER)				Level of generic goals and practices (0, 1, 2 or 3) (BEFORE:AFTER)														Capability level derived from generic goals (BEFORE:AFTER)	Interventions provided during case study
This column provides a list of all Process Areas in CMMI.	*This column provides an extract from the V1.3 CMMI for Services standard. These process areas are generic for all types of service industries.*	*This column has been derived from the case study in this research and provides a CMMI context specifically applicable to electricity metering in municipalities.*	Electricity infrastructure service quality	Electricity infrastructure delivery efficiency	Affordability of electricity services	Access to electricity services	GG1	GG2										GG3		Lowest level achieved before : Lowest level achieved after intervention.	*This column provides the actions that were taken / improvements that were made during the case study. Since the improvements led to an increase in effectiveness, these actions also serve to validate the selection of process areas that make up CMMI for electricity metering.*
							GP1.1	GP2.1	GP2.2	GP2.3	GP2.4	GP2.5	GP2.6	GP2.7	GP2.8	GP2.9	GP2.10	GP3.1	GP3.2		
Maturity Level 2 - Managed																					
Configuration Management (CM)	The purpose of Configuration Management (CM) is to establish and maintain the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.	Logical and physical configurations must be managed by using drawings, physical inspections and audits against baseline drawings and other technical support data.		Yes (1:3)	Yes (1:3)		(0 : 3)	(1 :3)	(0 : 2)	(0 : 1)	(1 : 3)	(0 : 2)	(1 : 3)	(1 : 2)	(0 : 2)	(0 : 2)	(0 : 3)	(0 : 2)	(0 : 1)	(0 : 1)	Development of a database of existing services. Database to be maintained on an ongoing basis. Technology selection guide developed to standardize all equipment.
Measurement and Analysis (MA)	The purpose of Measurement and Analysis (MA) is to develop and sustain a measurement capability used to support management information needs.	MIS and related measurement systems that provide information in management format. Technical performance data and financial performance data are examples. May include, for example, central control room with SCADA and alarm functions.	Yes (3:4)	Yes (1:3)			(0 : 3)	(0 : 2)	(0 : 3)	(1 : 3)	(0 : 2)	(0 : 2)	(0 : 2)	(1 : 2)	(0 : 2)	(0 : 2)	(1 : 2)	(0 : 2)	(0 : 2)	(0 : 2)	A set of checklists and spreadsheets were developed to measure and analyse data relative to the metering losses (strategic metering), accuracy of meter readings, history of performance of different equipment types, billing system and bad debts relative to the metering systems. Results from these checklists and spreadsheets can be presented to management in various formats such as graphs etc. This area need to be optimized to intigrate real-time data into automated software presenting data in generic or user specific reports.
Process and Product Quality Assurance (PPQA)	The purpose of Process and Product Quality Assurance (PPQA) is to provide staff and management with objective insight into processes and associated work products	Process quality assurance by means of a developed quality management system prescribing quality policies relative to measurement, analysis and improvement of the existing energy metering systems, staff responsibilities, infrastructure roll-out, technology selection etc. It also dictates procedures relative to the quality of maintenance of infrastructure.	Yes (3:4)				(1 : 3)	(1 : 3)	(1 : 3)	(1 : 1)	(1 : 2)	(0 : 2)	(1 : 2)	(1 : 2)	(0 : 2)	N/A	(1 : 2)	(0 : 3)	(0 : 2)	(0 : 1)	Quality management system for the metering systems forms part of the overall quality management system for all functions within the municipality. This system was adopted to govern the functionality within the electricity department and includes the following: consumer satisfaction with regards to correct billing, network losses attributed to metering systems, billing system effectiveness, management review of processes, regular consumer needs assessment, recovery of bad debt etc.
Requirements Management (REQM)	The purpose of Requirements Management (REQM) is to manage requirements of products and product components and to ensure alignment between those requirements and the work plans and work products.	Requirement management linked to the regulations set out by NERSA, ESKOM and key performance indicator's of top and middle management staff.		Yes (1:3)	Yes (1:3)		(2 : 3)	(1 : 3)	(0 : 3)	(1 : 3)	(1 : 3)	(0 : 2)	(1 : 3)	(1 : 2)	(0 : 2)	(2 : 3)	(1 : 3)	(1 : 2)	(2 : 3)	(0 : 2)	Requirement management linked to the regulations set out by NERSA, ESKOM and key performance indicator's of top and middle management staff. On the list of approved equipment, all standards and certification requirements were taken into account to evaluate and qualify products.
Supplier Agreement Management (SAM)	The purpose of Supplier Agreement Management (SAM) is to manage the acquisition of products and services from suppliers.	Supplier agreements must exist in conjunction with a list of approved / qualified equipment and materials. For municipalities, the list must include electrical metering and other support equipment and IT hardware and software. Such an agreement must be aligned with approved procurement policies.	Yes (3:4)	Yes (1:3)			(0 : 3)	(0 : 2)	(0 : 2)	(2 : 3)	(2 : 2)	(0 : 2)	(2 : 2)	(1 : 2)	(0 : 2)	(1 : 2)	(1 : 3)	(1 : 2)	(0 : 2)	(0 : 2)	A database of approved manufacturers for certain technology was developed via a tendering process. The database consists of circuit breakers/isolators, energy meters, CT's, cables, conductors etc as part of a standard list of approved equipment. The procurement of products is included in the procurement policy of the municipality and prescribed by national treasury.
Service Delivery (SD)	The purpose of Service Delivery (SD) is to deliver services in accordance with service agreements.	Service levels must exist between the municipality and the electricity users. Service delivery agreements <u>*relative to rural municipalities do not exist*</u> and is not agreed upon between the community (customers) and the management of a municipality (supplier). Service delivery are measured by individuals' key performance indicaters dictated by the council. A customer relationship management system (CRM) should be put in place.	Not included in initial intervention.(1:1)																		The development of service level agreements for internal resources as well as external resources was not included in this study. It is however necessary to develop such agreements for the successful implementation of the processes and should be developed upon further study.
Work Monitoring and Control (WMC)	The purpose of Work Monitoring and Control (WMC) is to provide an understanding of the ongoing work so that appropriate corrective actions can be taken when the performance deviates significantly from the plan.	Time management, administrative management, technical inspections, system auditing, fault reporting and monitoring of work as set out in the work management system.	Yes (3:4)	Yes (2:3)	Yes (2:3)	Yes (1:2)	(1 : 3)	(1 : 3)	(1 : 3)	(2 : 3)	(1: 2)	(0 : 2)	(1: 2)	(1 : 2)	(0 : 2)	(1 : 1)	(0 : 2)	(0 : 2)	(0 : 2)	(0 : 1)	Time management, admin management, technical inspections, auditing, fault reporting and monitoring of work as set out in the developed work excecution plan. The focus of this section of the work execution plan is to provide management with a tool to monitor and control the work activities within there description of responsibilities.
Work Planning (WP)	The purpose of Work Planning (WP) is to establish and maintain plans that define work activities.	Monthly, weekly, and daily work plans must be available as schedules according to a high-level policy. This includes new installations, meter reading, scheduled and unscheduled maintenance and repairs, testing, and other support functions.	Yes (3:4)	Yes (1:3)		Yes (1:2)	(1 : 3)	(1 : 3)	N/A	N/A	N/A	(0 : 2)	(1 : 2)	(1 : 2)	(0 : 2)	(1 : 1)	(0 : 2)	(0 : 2)	(0 : 2)	(0 : 1)	A work execution plan was developed focusing on several activities such as infrastructure roll-out, planned maintenance, new connections, administrative functions etc. Time sheets were developed where staff activities are recorded. A generic timing tool was also derived to indicate the average time per activity under normal circuimstances. Emergency breakdown are prioritised based on the provisions within the risk management plan and attended to accordingly. The work execution plan also prescribes the conducting of technical inspections and monitoring of quality of work by the line managers. This plan need to be optimised further to adapt to the management style of the specific management team at any given time.
Maturity Level 3 - Defined																					
Capacity and Availability Management (CAM)	The purpose of Capacity and Availability Management (CAM) is to ensure effective service system performance and ensure that resources are provided and used effectively to support service requirements.	Correct metering and support technology such as CT's must be defined and installed. A system must be in place to measure and report on meter readings. All core metering services and technology must be functional and available.	Yes (3:4)	Yes (1:3)		Yes (1:2)	(1 : 3)	(1 : 3)	(1 : 3)	(1 : 1)	(1 : 2)	(0 : 2)	(1 : 2)	(1 : 2)	(0 : 2)	(1 : 1)	(0 : 2)	(0 : 2)	(0 : 2)	(0 :1)	As part of the case study certain measures were developed to adress the necessary resource and support functions. These measures includes management of infrastructure plan, regular scheduled technical inspections, infrastructure selection rules and installation specifications. The implementation of the measures are controlled through a management workflow.
Decision Analysis and Resolution (DAR)	The purpose of Decision Analysis and Resolution (DAR) is to analyze possible decisions using a formal evaluation process that evaluates identified alternatives against established criteria.	Decision support for technical and financial issues. Technical decisions supported by specialists and "fit for purpose" analyses. Financial decisions supported by specialists and financial analyses.		Yes (2:3)			(0 : 3)	(1 :3)	(0 : 2)	(0 : 1)	(1 : 3)	(0 : 2)	(1 : 3)	(1 : 2)	(0 : 2)	(0 : 2)	(1 : 2)	(0 : 2)	(0 : 2)	(0 : 1)	A decision making support system was developed focusing on processes and procedures relative to the operational, technical and more detailed functioning of the metering systems. The decision making support includes the development of an equipment selection guide, the improvement of the procurement policy for minor projects, development of a policy for applying of tariff structures. The decision support relative to the detail functioning of the metering systems are to be outsourced through the appointment of a suitable field specialist. This approach is not sustainable due to the mindset it creates amongst municipal officials to avoid the making of important real time decisions and rather transferring this responsibility to consultant firms. Subsequently, this increases the cost of electricity. A more suitable solution need to be developed with regards to the decision making support system relative to detailed functioning of metering systems such as programming of maximum demand meters.
Incident Resolution and Prevention (IRP)	The purpose of Incident Resolution and Prevention (IRP) is to ensure timely and effective resolution of service incidents and prevention of service incidents as appropriate	Identification of electricity-related incidents such as faulty or incorrect individual metering or distribution network failures. Financial failures include incorrect billing, billing failure, or metering bypasses (fraud and theft). Resolution implies predictive action and planning.	Yes (3:4)	Yes (1:3)	Yes (1:3)	Yes (1:2)	(0 : 2)	(1 : 3)	(1 : 3)	(1 : 2)	(1 : 2)	(0 : 2)	(1 : 2)	(1 : 2)	(0 : 2)	(0 : 2)	(1 : 2)	(0 : 2)	(0 : 2)	(0 : 2)	A technical and financial auditing guideline was developed strategically focused to prevent the occurance of electricity related incidents relative to the physical installation of meters, the correct functioning of meters, accurate meter reading, accurate applied tariffs and accurate billing system. Further to the above, a maintenance plan was developed adressing emergency breakdown repairs. This section of the maintenance plan focus on procedures relative to the resolution of certain incidents. Different aspects of incident resoltution such as response times, risk profiles, implementation and reporting are dictated. One area that still needs to be adressed are the recovery of bad debt relative to the consumption of electricity within the municipality. This incident needs urgent attention as it contains high risks for a rural municipality.A procedure for the management of server downtime also need to be developed.
Integrated Work Management (IWM)	The purpose of Integrated Work Management (IWM) is to establish and manage the work and the involvement of relevant stakeholders according to an integrated and defined process that is tailored from the organization's set of standard processes.	Technical planning and coordination (for new installations, maintenance, equipment provision etc). Contract and contractor management (vendor management) and service level management according to standard. Implies the existence and maintenance of standards.		Yes (1:3)	Yes (2:3)		(2 : 3)	(1 : 3)	(0 : 3)	(1 : 3)	(1 : 3)	(0 : 2)	(1 : 3)	(1 : 2)	(0 : 2)	(1 : 1)	(0 : 2)	(0 : 2)	(0 : 2)	(0 : 1)	As part of the management policy that was developed for the municipality, the communication channel for the electrical department was formalised. The roles and responsibilities of all stakeholders were defined. A guideline was developed focusing on the execution and approval of different activities relative to the metering systems. One such activity is the interfacing between the meter readers and the account clerks. A formal application and complaints procedure was also developed to assist with the liasion between the consumers and the municipality. Although the aim is the promotion of interaction between all stake-holders including the supply authority (ESKOM), the regulatory body (NERSA), external service providers, internal municipal resources and consumers, the sustainability of the measures put in place is determined by the maintenance thereoff. In this particular study, this area wasn't maintained after the external consultant's appointment ended and decayed to its initial level.
Organizational Process Definition (OPD)	The purpose of Organizational Process Definition (OPD) is to establish and maintain a usable set of organizational process assets, work environment standards, and rules and guidelines for teams.	Definition of standard operating procedures for meter installation, measurement, maintenance and incident handling. Standards of work to control quality of installations, maintenance etc are examples.		Yes (1:3)			(1 :2)	(1 : 2)	N/A	N/A	N/A	(0 : 2)	(1 : 1)	N/A	N/A	(0 : 2))	N/A	N/A	(0 : 1)	(0 : 1)	The core business processes defined for the metering systems of the municipality includes the following: management responsibility, management of the application for new connections, infrastructure roll-out, fault reporting and progress monitoring, selection of technology, upgrading and maintenance of infrastructure, procurement rules, auditing approach, network loss management etc.
Organizational Process Focus (OPF)	The purpose of Organizational Process Focus (OPF) is to plan, implement, and deploy organizational process improvements based on a thorough understanding of current strengths and weaknesses of the organization's processes and process assets	Once the metering system has been completed, improvements are possible from actual measurement and analysis as well as strategic planning and execution. Optimization is in place for reduction of losses and costs, increase of service levels etc.	Yes (3:4)	Yes (1:3)			(1 :2)	(1 : 2)	N/A	N/A	N/A	(0 : 2)	(1 : 1)	N/A	N/A	(0 : 2))	N/A	N/A	(0 : 1)	(0 : 1)	The newly defined core business processes were expanded to dictate procedural implementation of each process. Successful implementation is measured against the prescribed outcomes and also the quality of the outcomes. Each procedure describes the roles and responsibiliteis of all roleplayers including top management, technical and administrative staff, service providers etc.
Organizational Training (OT)	The purpose of Organizational Training (OT) is to develop skills and knowledge of people so they can perform their roles effectively and efficiently.	Training programme for technical personnel, financial personnel, and support personnel. Establishing and maintaining training programmes.	Not included in initial intervention.(1:1)																		Training program recommended, but not yet implemented.
Risk Management (RSKM)	The purpose of Risk Management (RSKM) is to identify potential problems before they occur so that risk handling activities can be planned and invoked as needed across the life of the product or work to mitigate adverse impacts on achieving objectives.	A risk management system must identify possible areas of failures in the metering network. Failures in this case include all failures pertaining to electricity metering, including electricity meters, support equipment such as current transformers (CT's), IT hardware and software, and failures of humans in procedures.	Yes (3:4)	Yes (1:3)	Yes (1:3)	Yes (1:2)	(0 : 3)	(0 : 2)	(0 : 3)	(1 : 3)	(0 : 2)	(0 : 2)	(0 : 2)	(1 : 2)	(0 : 2)	(0 : 2)	(1 : 2)	(0 : 2)	(0 : 2)	(0 : 2)	A Risk management plan was developed, focusing on potential sector specific risks such as saturation of CT's, overcurrent, unearthed systems etc were identified. The risk management plan focus on business continuity plans, impact of occurances (i.e. financial, safety etc), risk factors etc.The risk management plan only focused on potential risks within the metering sector and can be opimised to include risks linked to other sectors within the municipality such as IT malfunctioning. Another aspect that needs to be adressed is the risk involved in the municipalities inability to recover bad debt. A risk management plan need to be developed specificaly for this aspect due to complex nature of this aspect.
Service Continuity (SCON)	The purpose of Service Continuity (SCON) is to establish and maintain plans to ensure continuity of services during and following any significant disruption of normal operations.	Existence of a maintenance plan which includes procedures for planned and emergency maintenance. Service continuity should be established through the development of a back-up and archiving system describing the procedures for securing and retrieving of network relevant information during emergency/disaster occurances.	Yes (3:4)			Yes (1:2)	(0 : 3)	(1 :3)	(0 : 2)	(0 : 1)	(1 : 3)	(0 : 2)	(1 : 3)	(1 : 2)	(0 : 2)	(0 : 2)	(1 : 2)	(0 : 2)	(0 : 2)	(0 : 1)	Implementation of new infrastructure against a generic project execution plan. Infrastructure upgrading model and maintenance plan developed. The focus of the maintenance plan is to manage emergency breakdown and planned maintenance in order to establish a continued service with minimum disruptions.

“EXCEL TABEL”

Table 42: CMMI Model of maturity for the Maquassi Hills Municipality

CMMI process area	CMMI description	Translation to energy metering	Link to World Bank service delivery indicator (BEFORE:AFTER)				Level of generic goals and practices (0, 1, 2 or 3) (BEFORE:AFTER)													Capability level derived from generic goals (BEFORE:AFTER)	Interventions provided during case study
This column provides a list of all Process Areas in CMMI.	***This column provides an extract from the V1.3 CMMI for Services standard. These process areas are generic for all types of service industries.***	***This column has been derived from the case study in this research and provides a CMMI context specifically applicable to electricity metering in municipalities.***	**Electricity infrastructure service quality**	**Electricity infrastructure delivery efficiency**	**Affordability of electricity services**	**Access to electricity services**	**GG1**	**GG2**										**GG3**		**Lowest level achieved before : Lowest level achieved after intervention.**	***This column provides the actions that were taken / improvements that were made during the case study. Since the improvements led to an increase in effectiveness, these actions also serve to validate the selection of process areas that make up CMMI for electricity metering.***
Service System Development (SSD)	The purpose of Service System Development (SSD) is to analyze, design, develop, integrate, verify, and validate service systems, including service system components, to satisfy existing or anticipated service agreements.	In cases where a capability does not exist to define system processes, consulting firms should be contracted to provide specialized services. This should be performed by experts in metering and engineers who specialize in electrical systems, such as the municipal electrical engineer.	Yes (3:4)	Yes (1:3)	Yes (1:3)	Yes (1:2)	(0 : 2)	(1 : 3)	(0 : 3)	(1 : 3)	(1 : 3)	(0 : 2)	(1 : 3)	(1 : 2)	(0 : 2)	(1 : 2)	(1 : 3)	(1 : 2)	(1 : 2)	(0 : 2)	A guideline was developed describing the procedure for implementation of newly invented technology, systems or processes such as finance software. In certain instances, the implementation of new technology, systems or processes can be complex and the responsible official (in this particular municipality, the technical manager) will need to take an informed decision to obtain the services of experts in such instances. This area wasn't well developed within this study as the optimising thereoff will affect the operation of the municipality as a whole and can't be isolated to this sector only.
Service System Transition (SST)	The purpose of Service System Transition (SST) is to deploy new or significantly changed service system components while managing their effect on ongoing service delivery.	Whenever service definitions change due to new metering technology, new services must be integrated by following as system transition (freeze, analyze, design, implement, test, unfreeze). A change management process is followed. This should be facilitated by experts in metering systems and engineering management.	Not included in initial intervention.(1:1)																		Not included in the initial intervention, but should be adressed in a further study.
Strategic Service Management (STSM)	The purpose of Strategic Service Management (STSM) is to establish and maintain standard services in concert with strategic needs and plans.	The management of service in concert with strategic needs and plans are included under the provisions of the municipal integrated development plan (IDP). The IDP incorporates area specific master planning such as energy metering systems to allow for future growth etc.		Yes (1:3)		Yes (1:2)	(0 : 2)	(1 : 3)	(1 : 3)	(1 : 2)	(1 : 2)	(0 : 2)	(1 : 2)	(1 : 2)	(0 : 2)	(0 : 2)	(1 : 2)	(0 : 2)	(0 : 2)	(0 : 2)	The current approach with regards to the management of services in concert with strategic needs and plans is to outsource the strategic planning to external service providers. Should the procedures developed during this study be maintained (example: network loss monitoring), the municipality will be in a position to internally develop the strategic planning of the municipality. It will be beneficial to the muncipality if this aspect of their service can be conducted internally because the responsible person will have readily access to the required information, be familiar with the municipal specific operational dynamics and will have a good knowledge of the community needs.
Maturity Level 4 - Quantitatively Managed																					
Organizational Process Performance (OPP)	The purpose of Organizational Process Performance (OPP) is to establish and maintain a quantitative understanding of the performance of selected processes in the organization's set of standard processes in support of achieving quality and process performance objectives, and to provide process performance data, baselines, and models to quantitatively manage the organization's work.	Identification of core business processes for management. Measurement of those processes and procedures that have direct and material impact on system effectiveness or cost. These include the defintion of technical and financial processes (including quality assurance processes such as audits and client-related processes).	Not included in initial intervention.(1:1)																		As part of the performance management program developed, the impact of performance measuring relative to an organization's goals and quality of service delivery were described. The performance management program is to be further developed to determine and optimise the collective performance of this sector within the municipality.
Quantitative Work Management (QWM)	The purpose of Quantitative Work Management (QWM) is to quantitatively manage the work to achieve the established quality and process performance objectives for the work.	Development of a set of defined processes relative to key aspects with the metering systems such as fault reporting, implementation of technology and selection of equipment, upgrading of infrastructure, maintenance, monitoring of processes etc.		Yes (1:3)		(1 : 3)	(1 : 3)	(1 : 3)	(1 : 1)	(1 : 2)	(0 : 2)	(1 : 2)	(1 : 2)	(0 : 2)	N/A	(1 : 2)	(0 : 3)	(0 : 2)	(0 : 1)	(0 : 1)	Defenition of staff roles and responsibilities, implementation of different guidelines for different policies and establishment of clear reporting lines to motivate better communication between all roleplayers. As part of the operational procedures contained within the developed management policy, the measuring of staff performance is stipulated. The performance of external service providers are also monitored against deliverables such as reaction times, installation procedures, programming, cost controll etc. This area can be optimised to further to encorporate the municipal human resource management policies for metering specific staff operation.
Maturity Level 5 - Optimizing																					
Causal Analysis and Resolution (CAR)	The purpose of Causal Analysis and Resolution (CAR) is to identify causes of selected outcomes and take action to improve process performance.	Detecting technical fault conditions. Detecting financial defaults or irregularities in electricity use. Systems in place to remove causes of faults such as technical repairs. Financial data analysis (billing data). Improvements to future processes.		Yes (2:3)		(0 : 1)	(0 : 2)	(0 : 1)	(1 : 2)	(0 : 2)	(0 : 2)	(0 : 2)	(1 : 2)	(0 : 2)	(0 : 2)	(1 : 1)	(0 : 2)	(0 : 2)	(0 : 2)	(0 : 1)	The key faults/errors relative to the metering systems were identified and grouped into two categories namely operational and technical. The impact of these faults were determined and a strategic plan developed to achieve lower occurances of faults and errors. Included under the developed plans are a maintenance plan, process for detection of faults, procedure for logging of faults, implementation of a auditing policy for the billing system. A recommendation was made for the founding of a call centre with the relevant operational planning. This was however not implemented.
Organizational Performance Management (OPM)	The purpose of Organizational Performance Management (OPM) is to proactively manage the organization's performance to meet its business objectives.	Measure and control performance by means of management systems. Technical management includes measurement of availabilty, quality, and cost-effectiveness, while financial management reduces cost and losses. Customer satisfaction, equipment and service supply, and technology trends are managed.		Yes (1:3)		(1 : 2)	(1 : 2)	(1 : 2)	N/A	N/A	N/A	(0 : 2)	(0 : 1)	N/A	N/A	(1 : 1)	N/A	N/A	(1 : 1)	(0 : 1)	The existing performance measuring tool within the municipality was used and the processes defined incorporated therein to measure the perormance of this sector within the municipality. The measuring tool referred to is the monitoring of key performance indicators against specific objectives. Although, the key performance indicators are specific to individuals and there roles within the municipality, the performance of processes can be measured on this basis due to the clear roles and responsibilities defined for each process. This system of organizational performance management should be optimized to measure the collective performance of the energy metering systems within a municipality.

Table 42: CMMI Model of maturity for the Maquassi Hills Municipality

From the table above, it is clear that although the organisation's maturity level didn't increase from a level 1 to a level 2 by the implementation of the interventions, the capability levels of several process areas increased substantially, in some cases with 2 levels. The CMMI therefore provides a definite direction with regards to the increase in service delivery of rural municipalities and if applied rigidly, provides a roadmap in increasing the ultimate efficiency of rural municipalities.

6.5.3 World Bank service delivery indicator – after intervention

Upon finalization of this research study and the results obtained from following the paths described by the CMMI for services, the service delivery of the Maquassi Hills municipality was scored to provide an indication of progress in this regard.

After the measures, described in the preceding sections of this chapter, were implemented, the service delivery of the Maquassi Hills municipality was scored against the indicators as prescribed by the World Bank. The following sections provide the revised level of service as evaluated by the World Bank service delivery indicators:

- Electricity infrastructure service quality

  By installing new meters to connections that wasn't metered before and replacing broken meters, the value of this dimension was raised from a 3 to a 4 as indicated below:

LEVEL OF SERVICE	DESCRIPTION	VALUE
4	Unrestricted metered house connections	4

Table 43: Electricity infrastructure service quality – Energy metering systems

- Electricity infrastructure delivery efficiency

  By the implementation of the corrective measures to attend to the shortcomings discussed under Chapter 5 above, the value for the relevant category (category 2) for this dimension was raised from a 1 to 3 as indicated below:

CATEGORY	DESCRIPTION	RATING
1	Unplanned interruptions	%
2	Power unaccounted for	%

Table 44: Electricity service supply efficiency categories

AVERAGE RATING OF THE TWO CATEGORIES	DESCRIPTION	VALUE
5% to 10%	Minor problems	3

Table 45: Electricity infrastructure delivery efficiency – Electrical energy metering

- Affordability of electricity services

CATEGORY	DESCRIPTION	RATING
1	Percentage ratio of electricity cost per month to household income	%
2	Non-payment levels	%

Table 46: Electricity service affordability categories

The on-going control and monitoring of the applied techniques has resulted, in only 6 months, in raising the level of service for this dimension from an original 1 to a contributing value of 3.

AVERAGE RATING OF THE TWO CATEGORIES	DESCRIPTION	VALUE
1% to 5%	Affordable	3

Table 47: Electricity services affordability values – Electrical energy metering

- Access to electricity services

This dimension could not be verified during the course of this research study. A verification cycle of at least 18 months is anticipated, before this dimension could be re-evaluated. For the revised evaluation, no progress in this dimension has been assumed and again a value of 2 has been allocated to this dimension.

AVERAGE RATING	DESCRIPTION	VALUE
89% to 85%	Limited	2

Table 48: Electricity services accessibility values – Electrical energy metering

The average value obtained from the four dimensions above is therefore: 3.

When the following scale is applied using the average value:

- Level of service 1 – Minimal or absent
- Level of service 2 – Basic
- Level of service 3 – Intermediate
- Level of service 4 – Full

The energy metering systems of the Maquassi Hills municipality is considered to be at a service level 3. This is an indication of the improvement in the level of service relevant to the electrical energy metering systems only.

6.6 Conclusion

This chapter described the shortfalls and corrective actions that were identified from this research study. The shortfalls relate to maintenance, implementation of standards, training, and management.

Corrective actions were put in place to address the shortfalls. A follow-up audit showed a deviation of within 6% with respect to the measured losses. This resulted in a saving of almost R86,000 per month.

A capability maturity model was proposed for energy metering in rural municipalities. This model is fully based on the well-known CMMI model from Carnegie Mellon, with specific adaptations for energy metering systems.

Process areas of this CMMI model were linked to the World Bank service delivery indicators to show the validity of the CMMI process areas - if a CMMI process area contributes to service delivery, it is clearly validated in the case study. For specific process areas, such as Organizational Training (OT), Service System Transition (SST), and Organizational Process Performance (OPP), there was no intervention in practice. However, it is clear that these process areas are to be included in future interventions.

The overall maturity of the municipality did not increase in the case study (from a staged perspective), but individual process areas improved significantly (in a continuous sense). From the World Bank service level indicators, it is clear that an improvement was achieved. The scale of the World Bank index is perhaps somewhat optimistic as it shows a significant increase (from 1.75 to 3) where there was no movement on the maturity levels of CMMI.

The difference in values between the World Bank service index and the CMMI maturity level clearly shows that CMMI is a more comprehensive measurement tool that highlights shortfalls of the underlying system. It is clear that a capability maturity model based on CMMI for energy metering is highly applicable and useful for service improvement and planning.

In conclusion, the case study showed that there are significant spillage and wastage in energy metering systems in rural municipalities - this addresses the first research goal. Secondly, a capability maturity model for rural communities has been proposed and was linked to a widely used World Bank model. The CMMI model is valid since it is based sound best practice standards and each process area was found to be relevant and applicable to energy metering. With the exception of three process areas, the CMMI model was linked to interventions that all increased capability.

7 SUMMARY AND CONCLUSION

This research addressed two main topics, namely (i) the need for intervention in rural municipalities with respect to energy metering losses and ineffectiveness, and (ii) the need for a measurement tool with which to measure energy metering effectiveness.

This case study focused on the contribution of losses incurred by the electrical energy metering systems of local government and was based on a case study of a local municipality in the North West Province. The Maquassi Hills municipality consists of 3 towns namely Wolmaransstad, Leeudoringstad and Makwassie with a total consumer connection of 24 maximum demand and 2478 conventional type electrical energy meters.

The study was conducted in 4 phases, namely:

- Phase 1 – Data collection
- Phase 2 – On-site investigations
- Phase 3 – Account analyses
- Phase 4 – Implementation of corrective measures

An electrical metering audit was performed on all the metering equipment in the Maquassi Hills municipality. The purpose of this audit was to identify contributing factors to the monthly losses relative to the electrical energy metering system of the municipality. The audit was performed on both the technical portion as well as the accounts portion of the metering system.

It was found that losses of up to R 85 646.13 per month were evident from the investigation in this research study. The recovered loss did not only have an impact on the monthly finances of the local municipality, but it also affected development of infrastructure and demand side management. These losses have escalated since 2007/8 due to the significant increase in electricity cost.

The following general shortfalls were identified from the study:

- Operations management (in terms of metering) was inadequate;
- Mostly maintenance related shortfalls were identified;
- Standards, laws, and by-laws were not fully addressed;
- Administrative shortfalls were mostly management related;

- Personnel were not empowered with knowledge and skills;
- There is an indirect effect on demand-side management.

Corrective actions were taken to address the shortfalls found in the study. Although not the focus of this research study, the actions are listed below for the sake of completeness (this is not a comprehensive list, but rather a summarized overview):

- A maintenance plan was drawn up and functionally incapable equipment was repaired or replaced;
- Relevant standards, laws, and by-laws were adhered to;
- Incorrect accounts were corrected;
- Staff were trained (ad hoc training relative to specific processes);
- Quality control was put in place.

Capability maturity models were investigated by means of a literature study. A number of different models were considered, with Carnegie Mellon's CMMI being the most applicable to our research.

In addition, a World Bank service level index was investigated and used in conjunction with the CMMI model for the sake of interest. Links between the CMMI process areas and the World Bank service level index were established and showed a causal effect between process areas in energy metering and electricity service delivery in general. Lastly, scores were assigned to find an index of the "as is" scenario before intervention and the "to be" scenario after intervention.

A matrix was drawn up to provide a framework for electricity / energy metering in a rural municipality. This model may be extended to cover larger municipalities due to the generalization provided by the CMMI framework. The matrix clearly shows how process areas are applicable to energy metering process areas and how process areas are linked to World Bank service level indicators. As part of the matrix, generic goals were considered relative to the case study - that is, a capability maturity analysis was done based on the case study.

The results indicate that, even with interventions from the case study, the maturity level of the municipality remained at a low level, while the World Bank index raised from 1.75 to 3 on average. The difference is explained in the comprehensiveness of CMMI as opposed to the rather vague / broad index of the World Bank index. CMMI thus highlights underlying shortfalls that will affect service delivery in the long run.

The validation of the capability maturity framework lies in the fact that (i) a proven model was used as obtained from a literature study, and (ii) the interventions that were clearly linked to CMMI process areas showed measurable improvement - thus validating the inclusion of those process areas in the model.

Thus, by following the improvement paths described by CMMI for services, a definite and directive strategy can be followed for increasing the levels of capability and subsequently the levels of maturity within rural municipalities. By doing so, municipalities will be able to increase their level of service delivery and ensure sustainable operations within different sectors of a community.

7.1 Further study

The study of the metering system and the operations management system in local government was followed by a study of the public lighting systems (please refer to Appendix A: Review of public lighting systems). Public and area lighting systems that are powered during daytime contribute largely to a wasteful expenditure of local government and constitutes an unnecessary demand on the national electricity grid.

Theoretical calculations indicate that public and area lights powered in daytime could lead to losses of up to 62,81 MW per hour. This, calculated over a month at 10 hours per day results in a projected loss of R 14 132 250.00. These losses can be minimized using strategies such as continuous monthly maintenance where control equipment is checked monthly and circuits are tested regularly. This strategy had been implemented in local municipalities, but results are not yet available to validate the implementation. This could form part of further formal studies.

After auditing of the electrical metering system, implementation of the corrective measures, observation of results and validating results with results from other projects, the conclusion was made that local municipalities and especially their technical departments suffer from lack of management. The reasons for this shortcoming were not investigated but it can possibly be ascribed to:

- Lack of management skills and an associated training and empowerment programme;
- Lack of experience and human capital in terms of experienced personnel and mentorship;
- Shortage of trained staff.

The reasons for the shortcomings in the management in local government should be further investigated in a separate study and should contribute to a large extent to the sustainable functioning of municipalities.

7.2 Conclusion

The initial goal of this research study was reached in that a concrete, measured value was attached to define the current state of energy metering in selected rural municipalities, specifically in the Maquassi Hills district. This knowledge adds actual value since it allows other rural municipalities to use this research study as a framework for studies in other municipalities. It is a commonly known fact that many municipalities are in need of support.

This research study thus provides sufficient evidence that energy metering is one of the important local management functions that suffers from lack of operations management. In addition, common problems were identified – these will assist other municipalities in locating their problem areas and addressing these problems with basic elements of operations management in the energy metering context.

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8 APPENDIX A: Review of public lighting systems

8.1 Introduction

Other than the management of electrical energy metering systems as discussed in the previous chapters, ineffective public lighting systems also contribute significantly to spillage and wastage on municipality networks and form an integral part of demand side management. Currently area lighting in the Republic of South Africa is provided by 2 430 000 street lights and 457 000 high mast lights. The lamps used in these luminaires vary between 57 W, 125 W, 150 W, 250 W and 400 W. At any given time during daytime, 15% of all public lighting installations are switched on, contributing to a massive monthly fruitless expenditure and increasing monthly demand. It is believed that through effective management and continuous maintenance, the 15% can be reduced to below 5% (25 Degrees in Africa, 2011).

This chapter discusses a theoretical analysis to public lighting systems and illustrates the possible decrease in wasteful expenditure of local government. Although this aspect of the management system has been implemented, the results could not be verified due to time and cost constrains, but the information is interesting and relevant and is thus presented.

8.2 Theoretical approach

As mentioned above, 15% of all public or area lighting constitutes a fruitless expenditure of local government and an unnecessary additional load on the national grid. Table 49 indicates the total luminaires powered during daytime.

Luminaire Type	**National Total**	**15%(waste) of Total**
Streetlights	2 430 000	364 500
High Mast Lights	457 000	68 550

Table 49: Total estimated luminaires powered nationally during daytime

The lamps installed per luminaire type for the 15% mentioned above, differs with regards to dissipation and are tabulated as follows:

	Streetlights	High Mast Lights
57 W	127 575	-
125 W	164 025	-
150 W	54 675	-
250 W	18 225	34 275
400 W	-	34 275
Total	**364 500**	**68 550**

Table 50: Luminaires powered nationally during daytime per lamps size

It was assumed that the different lamp types did not affect the wastage and therefore no distinction was made between mercury vapour, metal halide or high pressure sodium lamps.

The total hours considered to be daytime is 10 hours.

The following table provides an indication of the theoretical wastage due to luminaires powered unnecessary during daytime.

Lamp Size	**Total Lamps**	**Wasted time per day (Hour)**	**Wasted time per 30 day month (Hour)**	**Wasted electricity per hour (MW)**	**Approximate cost of 1 unit of electricity (R/MWh)**	**Approximate wasted national capital per month (R)**
57w	127 575	10	300	7.27	750	1,635,750
125w	164 025	10	300	20.50	750	4,612,500
150w	54 675	10	300	8.20	750	1,845,000
250w	52 500	10	300	13.13	750	2,954,250
400w	34 275	10	300	13.71	750	3,084,750
Total	**433050**	**10**	**300**	**62.81**	**750**	**14,132,250**

Table 51: Estimated wasted capital due to luminaires powered nationally during daytime

As indicated, public lighting systems significantly influence the increase in demand as well as capital expenditure. Several aspects were identified that contribute to the problems mentioned above. These aspects include:

- Day-light switches broken and not replaced;
- Reserve batteries on time-switches expired, which result in timers not keeping time;
- No control gear;
- Lack of maintenance.

Only a few means exist to counter the losses mentioned above.

The first possible solution to the problems would be up-to-date and sustainable maintenance. If maintenance is being done on a monthly basis, where all timers, day-light switches and other control gear is checked and tested, the effect of wastage can be minimized. The maintenance plan of every municipality should include the maintenance of public and area lighting and the implementation of the maintenance plan is of utmost importance. This will reduce the network losses for the particular municipality and will decrease the demand. This will have a positive effect on ESKOM's load and will surely release some of the saved capacity on the national grid. A program can be developed where municipalities are being reimbursed for electricity saved on public or area lighting.

The second possible solution could be the centralisation of all public or area lighting. A program could be developed based on four components, namely, installation of new technology, maintenance of existing infrastructure, communication to a base station and software application.

The proposed program will mean that all public and area lighting would be monitored remotely from a centralized station (base station) with radio frequency technology such as telemetry. Signals would then be transmitted from each luminaire to the base station to indicate switching times, open and closed circuits etc. When errors are reported to the base station, the local municipality could be notified via sms to investigate. This option will not only include the benefits of the first option mentioned, but it will also decrease the general maintenance cost because of the real-time monitoring of infrastructure. The initial capital outlay for this technology will be very high, but over a number of years the system will pay for itself.

A further initiative that can be implemented either under option 1 or option 2 above is the intelligent switching of streetlights. At certain times during evenings, streetlights are switched off to save energy. Between 01h00 and 04h00, one third of streetlights can be switched of. With the total streetlights being 2 340 000, one third is 780 000. The following table provides an indication of the possible saving.

Lamp Size	Total Lamps	Wasted time per day (Hour)	Wasted time per 30 day month (Hour)	Wasted electricity per hour (MW)	Approximate cost of 1 unit of electricity (R/MWh)	Approximate wasted national capital per month (R)
57w	273 000	3	90	15.56	750	1,050,300
125w	351 000	3	90	43.88	750	2,961,900
150w	117 000	3	90	17.55	750	1,184,625
250w	39 000	3	90	9.75	750	658,125
Total	**364 500**	**3**	**90**	**86.74**	**750**	**5,854,950**

Table 52: Estimated monthly saving due to intelligent switching techniques

As mentioned previously, the result from the above theoretical approach has not been verified due to time and cost constraints. Option 1 above has however been implemented in several local municipalities such as the Lekwa Teemane local municipality in the North West province and the Camdeboo local municipality in the Eastern Cape.

8.3 Summary

Public lighting systems contribute largely to the demand on the national supply grid. The wastage due to unnecessary powering of public or area lighting contributes extensively to the loss of public revenue. These losses and wastages can be minimized with the application of several strategies.

Although the strategies are different, they have one dimension in common, namely management. Each strategy can be summarized as an aspect of management. It is believed that the wastage because of public lighting discussed in this chapter results from poor management.

9 APPENDIX B: Detailed account analysis

Refer to the included CD

10 APPENDIX C: Site inspection reports

Refer to the included CD

11 APPENDIX D: Schedule of meters after corrective action

Refer to the included CD