Towards a Smart Grid in Drakenstein Municipality

Building a Smart Grid Roadmap and Business Case

2013-2014

Report Prepared for:
The British High Commission &
Department of Economic Development and Tourism
Western Cape Government

Prepared by:
Smart Grid project team
GreenCape Sector Development Agency
31 March, 2014

Contact:
Smart Grids team
44A Bloem St, 2nd floor
Cape Town, 8001
Tel no. 021 811 0250
smartgrids@green-cape.co.za
ACKNOWLEDGEMENTS

The contribution of the Project Steering Committee throughout the study and to this report is much appreciated. Members of the Steering Committee:

<table>
<thead>
<tr>
<th>Names of People</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deon Louw</td>
<td>AMEU / Drakenstein Municipality</td>
</tr>
<tr>
<td>Suzanne Carter</td>
<td>British High Commission</td>
</tr>
<tr>
<td>Leslie Recontre</td>
<td>City of Cape Town</td>
</tr>
<tr>
<td>Neil Ballantyne</td>
<td>City of Cape Town</td>
</tr>
<tr>
<td>Matthew Kempthorne</td>
<td>City of Cape Town (Councillor)</td>
</tr>
<tr>
<td>Lize Jennings</td>
<td>Department of Environmental Affairs &amp; Development Planning</td>
</tr>
<tr>
<td>Leon Eksteen</td>
<td>Department of Local Government</td>
</tr>
<tr>
<td>Joe Renney</td>
<td>Department of Local Government</td>
</tr>
<tr>
<td>Sally Levesque</td>
<td>Eskom</td>
</tr>
<tr>
<td>Naniki Lukhele</td>
<td>Eskom</td>
</tr>
<tr>
<td>Lucky Ngidi</td>
<td>NERSA</td>
</tr>
<tr>
<td>Minnesh Bipath (replacing Willie De Beer)</td>
<td>SANEDI/SASGI</td>
</tr>
<tr>
<td>Jan Coetzee</td>
<td>Stellenbosch Municipality</td>
</tr>
<tr>
<td>Trevor Gaunt</td>
<td>UCT</td>
</tr>
<tr>
<td>Ron Herman</td>
<td>UCT</td>
</tr>
<tr>
<td>Francois du Plessis</td>
<td>GreenCape MD</td>
</tr>
<tr>
<td>Lauren Basson</td>
<td>GreenCape Project Manager</td>
</tr>
<tr>
<td>Mike Mulcahy</td>
<td>GreenCape Operations Manager</td>
</tr>
</tbody>
</table>

* All members attended at least one meeting
The contributions of the Smart Grids project team are gratefully noted. Members of the Project Team:

<table>
<thead>
<tr>
<th>Names of People</th>
<th>Organisation</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bernard Bekker</td>
<td>GreenCape</td>
<td>Project Manager</td>
</tr>
<tr>
<td>Peter Atkins</td>
<td>GreenCape</td>
<td>Project Officer</td>
</tr>
<tr>
<td>Maloba Tshehla</td>
<td>GreenCape</td>
<td>Researcher</td>
</tr>
<tr>
<td>Bruce Raw</td>
<td>GreenCape</td>
<td>Researcher</td>
</tr>
</tbody>
</table>

The following organisations made resources available to the project:

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Contact person</th>
</tr>
</thead>
<tbody>
<tr>
<td>British High Commission</td>
<td>Suzanne Carter</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:suzanne.carter@fco.gov.uk">suzanne.carter@fco.gov.uk</a></td>
</tr>
<tr>
<td>Western Cape Provincial Department of Economic Development and Tourism</td>
<td>Charline Mouton</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:charline.mouton@pgwc.gov.za">charline.mouton@pgwc.gov.za</a></td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

Project motivation

The concept of a smart grid

In today’s rapidly changing, technology-driven world, electrical utilities are faced with new and sometimes daunting challenges. Along with these new challenges have risen technologies to address these issues and improve the operations of an electricity distributor. These technologies are bundled under the term “smart grids” and generally share one key component; communication. Some of the challenges faced by utilities include: increasing energy demand, rising energy costs, distributed generation and environmental concerns. These challenges call upon the utility to: automate its grid and supporting systems, implement technologies that reduce outages, improve on customer services and improve asset management, amongst other opportunities.

International implementation

There are both international and local implementations of what can be classified as “smart grid” technologies, ranging from pilot projects of a few hundred smart meter installations, to metro-wide installations as seen in the City of Tshwane, South Africa. What is certain from all this is that there is no one-size-fits-all approach to smart grids; rather a customized solution is required for each utility.

Principles of smart grid technologies

A literature review of lessons learnt from smart grid development and implementation was done and the insights gained from this provide a theoretical baseline against which later practical experiences in the selected case study municipalities could be compared. This allows for an iterative process where the lesson learned in literature can be adjusted to fit the specific South African context, also avoiding time wasted ‘re-inventing the wheel’. The general principles of a smart grid can be summarised as:

- The benefits of a smart grid can only really be leveraged when projects are implemented as part of a clear, long term strategy/vision/roadmap
Utilities, in this case municipalities, should embrace the need for innovation, rather than shy away from it.

Although Smart Grid implementations bring benefits in several areas not easily quantifiable financially, the economic viability of a Smart Grid project to all parties including the customer is usually a critical indicator of ultimate success.

The gathering of data through smart grid technologies is pointless without systems in place to understand and make meaningful use of said data.

**Documented benefits of smart grid implementation**

As mentioned, there are numerous implementations of smart grids around the world and the documented benefits of implementing these technologies include, but are not limited to: improvements in power quality, reductions in transmission losses, reduction in system interruptions, potential savings in electricity purchases and reduction in power use. These benefits, it must be reiterated, are not to be expected all from every intervention, but will vary from project to project. However, what is known is that as part of a clear vision and strategy, the smart grid brings about large overall improvements in the operation of the electricity grid.

**Aims and methodology**

**Project goals**

The British High Commission (BHC), under its “Prosperity Fund” has asked GreenCape to execute a study that seeks to increase municipal uptake of “smart grid interventions to improve electricity provision efficiency and enable uptake of electricity from renewable sources”. In line with GreenCape’s facilitation of the growth of all aspects of the Green Economy in the Western Cape, and especially the uptake of renewable energy technologies, this project aims to:

- Identify where smart grids can play a role in increasing the sustainability of the electricity business in a variety of municipalities
- Identify and remove barriers to the implementation of smart grid technologies
- Generate knowledge from experiences in the Western Cape with regards to Smart Grids, that can then be disseminated to the rest of the country
- Help municipalities avoid costly errors that are a result of, amongst other, tying into specific technologies and vendors
Above and beyond these project goals, this study seeks to influence decision making within municipalities with regards to future plans for infrastructure upgrades, increase knowledge and awareness of smart grid technologies at the municipal level and thereby create a conducive environment for the uptake of these technologies.

Methodology:

This project, consisting of case studies of three selected municipalities in the Western Cape, was developed following a generic 5-step process outlined shortly. As emphasised earlier, the development and implementation of smart grid projects is very case specific, and so the outlines to follow merely describes the process followed. The 5 step process is summarised in the following diagram.

Diagrammatic representation of business case development process

Information gathered

As a means of getting acquainted with the project, the project researchers sought to gain an understanding of Drakenstein municipality’s electricity grid. Drakenstein is already on the way towards a smarter grid and has several smart grid related components in place or in the process of being implemented:

- SCADA: this was initially set up as a stand-alone system, but is now being integrated with other grid systems at Drakenstein. The SCADA controls and monitors the main
substations with respect to current, maximum demand, oil pressures and switching status. This SCADA system is not currently used for remote network control, because of safety concerns.

- Back-end management systems: Drakenstein is using the Maximo asset management system, which includes asset registers, maintenance scheduling and work records. However, Maximo is not yet integrated with the Finance asset register (using the Venus system), because of the differing levels of detail in the two systems (Maximo is aimed at the more detailed level required by the engineers). Having two asset registers results in duplication of work and difficulties in reconciling the two systems. Because no one system gives the municipality what it needs, large Excel spreadsheets have been developed, which are now starting to have stability problems.

- Metering: Domestic customers are mainly on inclined block tariffs (with one knee point) and the intention is to migrate domestic customers to Time of Use (TOU) tariffs in order to encourage them in energy conservation and peak shifting behavioural change. The meter population consists of prepaid and conventional meters, with 35% of the meters being manually read.

- Demand Side Management: the Drakenstein DSM systems allow the municipality to remotely switch customer hot water geysers on and off. However there are ongoing problems with the communications to the geyser controllers and Drakenstein is in the process of trying out different communications solutions. The communications problems also affect remote meter reading.

- AMR: Drakenstein has been working with Automatic Meter Reading for five years, but has experienced problems with the communication platforms (required for remote meter reading and management)

- Smart meters: these have been installed for some of Drakenstein’s large power users (> 1 000 kWh/month) plus some smaller (>500 kWh/month) and some of the larger commercial customers. These total about 250 smart meters. Drakenstein has received funding from Eskom for an additional 750 smart meters. These are being installed without communications facilities until the communications problems mentioned above have been resolved.

- Theft management: this is being done through energy-balancing over a ring-fenced area. Analysis of energy usage over a six month period can then be done to identify suspicious energy usage which can then be investigate further. These efforts are constrained by a lack manpower and the fact that the process is not yet fully
automated. This lack of people capacity will be addressed through the creation of a Revenue Protection Unit.

- Maintenance: currently done by weekly site visits and manual checks, with the result that sometimes critical conditions are missed. Automated sub-station condition monitoring would help with these problems.
  - Renewable energy integration into the grid: there are few known renewable energy systems connected into the Drakenstein grid, in fact, it is illegal at present to connect, for instance, rooftop solar PV systems to the grid. New legislation, due in July 2014, will provide the regulation mechanisms for embedded, small scale generation sources.
  - Outages – there is a need to improve outage recovery response times, this will be done through extending the fault-detection facilities from the current 20% of substations to a fuller coverage. Note that although the costs to customers through outages are not measured, nevertheless customer satisfaction is an important performance criterion.
  - Grid loading – The Drakenstein grid is approaching its maximum loading in certain sections.
- Capital expenditure plans – mainly aimed at providing for additional electricity requirements of new residential and commercial developments.

**Proposed roadmap & solutions**

*Long term vision and short term implementation*

The proposed solution is based on user requirements; analysis of the information gathered from the case study process was used to map out user requirements and link them to possible solutions. The long term vision was developed to plan the progress of smart grid upgrades to the municipal distribution grid. The proposed short term project is a smaller implementation that fits within the framework of the longer term vision, serving as a first step in the along the journey.

The long term vision proposed is summarised in Figure 1. The vision is broken into an initial implementation, a continuation development and a longer term development.

The business case is focussed on getting a reliable smart meter communications platform in place, then proceeding with the smart meter pilot (750 smart meters) with communications fully enabled, then extending the pilot to include more customers.
Implementation details

This section of the report developed functional specifications for the project and its sub-systems, without delving into technical specifications. These functional specifications are then be used as a basis for the cost-benefit analysis.

The installation requirements for the initial development described above are categorised into: hardware requirements (such as smart meter communications platform choice and implementation), system requirements (such as the integration of the smart meter data into Drakenstein’s other information systems), and alignment with the municipal IDP and budget cycle.

Implementation and monitoring plan

Due to budget restrictions a smart grid project cannot always be implemented in a single step. The purpose of this plan is to give a guideline for an effective and manageable project implementation. Thus, the project implementation and monitoring are split into the following seven step plan:

1. Selection of an appropriate communications platform for smart meters
2. Select metering technology (already done – using the 750 pilot meters)
3. Customer engagement to encourage beneficial behaviour change (to the customer and the municipality)
4. Design of an appropriate tariff
5. Select location for the pilot meters installations
6. Continued monitoring and evaluation so as to learn from the pilot so that decisions for an extended smart meter roll out can be based on the pilot experience
7. Full scale roll out of smart meters.

Approach to the cost benefit analysis

The cost benefit analysis appraises both the economic and non-economic benefits accrued by the municipality and its customers. Taking cognizance of the fact that the municipality does not operate solely as a profit-making body, this analysis considers the tangible benefits and the softer benefits. Tools such as the benefit-cost ratio, net present value, and payback period calculations were used to economically approach the initial implementation. Customer satisfaction and issues of sustainability are then gauged, as a means of a non-economic appraisal.

Results of cost benefit analysis

The cost benefit modelling of the project for Drakenstein showed that is it possible under the right conditions for smart metering to pay itself off over its lifespan when all the municipal benefits are taken into account and customer benefits excluded. The cumulative net benefits of the project result in a payback period of just under 15 years and a net present value of R76 000. This business case is not particularly strong when only municipal financial benefits are considered. The business case changes drastically when customer savings are factored in, with the payback period being just under two years, while the net present value soars to R36 million. When compared to the capital outlay of R1 million this project does not give a particularly high financial rate of return if customer savings are not included; however the project is also justified strongly by benefits which do not give direct financial value. Benefits such as customer satisfaction, reduced carbon emissions, decreased pressure on national energy demands, alignment with national policy and customer savings all provide strong motivation for the project.
Risk & sensitivity analysis

Additional to the cost benefit analysis, a Strengths Weakness Opportunities and Threats (SWOT) and a sensitivity analysis was done on the proposed interventions.

The sensitivity analysis for the smart meter project looked at the following parameters:

- Load shift (i.e. how the TOU tariffs will causes customers to shift their loads out of peak)
- Discount rate (8% was the base rate chosen – the lower the rate the more profitable the investment looks, based on net present value)
- Capital shift (i.e. how much peak and load reduction reduces future capital expenditure)
- Tariff design – the more the tariff benefits the customers, the less it benefits the municipality, so the financial benefits of the project to the municipality depend strongly on the tariff design

Recommendations and conclusions

The process of developing this business case, from the selection of suitable case study municipalities to the developing of the specific project and its business case has brought to light various main lessons and recommendations that the project team puts forward to all stakeholders. Firstly, the selection of a municipal champion to ensure the longevity of the smart grid development process is of paramount importance to project success as it ensures the longevity of the project. Secondly, the notion of a smart grid must be included into the municipality’s development plans, namely: the Integrated Development Plan (IDP) and the budget, to ensure that municipal processes occur unhindered and that current development decisions are informed by this longer term vision.

Smart metering in Drakenstein offers the municipality an opportunity to enable municipal customers to achieve significant savings on their bills, the ability to reduce stress on its grid, the ability to reduce demand from Eskom, help the environment- through reduced demand and a flatter load profile, and gather valuable information on happenings in the grid. The proper execution of the planned smart metering pilot project will unlock these benefits at a relatively low cost over the long term. Additional to this pilot project and a phase-by-phase approach, a thorough customer engagement process is strongly recommended as the technology solutions alone will not achieve the desired behavior changes. Finally, it has been found that a suitable communications platform is crucial to the long term success of a smart
grid and so the municipality is strongly recommended to make strategic decisions in the selection of a communications platform on which all future smart grid developments will be based.
## LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMR</td>
<td>Automatic meter reading</td>
</tr>
<tr>
<td>CIC</td>
<td>Customer Interruption Cost</td>
</tr>
<tr>
<td>DG</td>
<td>Distributed generation</td>
</tr>
<tr>
<td>DSM</td>
<td>Demand side Management</td>
</tr>
<tr>
<td>IDP</td>
<td>Integrated development Plan</td>
</tr>
<tr>
<td>PV</td>
<td>Photovoltaic</td>
</tr>
<tr>
<td>SASGI</td>
<td>South African Smart Grid Initiative</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control And Data Acquisition</td>
</tr>
<tr>
<td>SCM</td>
<td>Supply chain management</td>
</tr>
<tr>
<td>SCMP</td>
<td>Supply chain management policy</td>
</tr>
<tr>
<td>SG</td>
<td>Smart grid</td>
</tr>
<tr>
<td>SM</td>
<td>Smart meter</td>
</tr>
<tr>
<td>TOU</td>
<td>Time of use (electricity tariff)</td>
</tr>
<tr>
<td>T&amp;D</td>
<td>Transmission and distribution (electrical)</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS

**SIGNATURE PAGE**

**ACKNOWLEDGEMENTS**

**EXECUTIVE SUMMARY**

- Project motivation .......................................................... 4
- Aims and methodology ....................................................... 5
- Information gathered ......................................................... 6
- Proposed roadmap & solutions ............................................ 8
- Implementation and monitoring plan .................................. 9
- Approach to the cost benefit analysis ................................. 10
- Results of cost benefit analysis ......................................... 10
- Risk & sensitivity analysis ................................................. 11
- Recommendations and conclusions .................................. 11

**LIST OF ABBREVIATIONS** .................................................. 13

**TABLE OF CONTENTS** ...................................................... 14

**LIST OF TABLES** ............................................................ 19

**LIST OF FIGURES** .......................................................... 20

**GLOSSARY** ........................................................................ 21

1. **PROJECT MOTIVATION** .................................................. 23

   1.1 What is the Smart Grid? ............................................... 23

   1.2 Current implementation status: international .................. 25
1.3 Current implementation status: South Africa ........................................ 26

Regulation 773 ........................................................................................ 26

Smart grid implementations in South Africa: ............................................. 26

1.4 Principles from literature that inform this study ................................ 29

1.5 Documented benefits gained from Smart Grid Implementations ....... 33

2. AIMS & METHODOLOGY ..................................................................... 36

2.1 Motivation for study ........................................................................ 36

2.2 Goals ............................................................................................... 36

2.3 Methodology .................................................................................... 37

Step 1: Understand ................................................................................ 38

Step 2: Identify an area of focus ............................................................. 38

Step 3: Develop Smart Grid roadmap .................................................... 39

Step 4: Defining a specific project .......................................................... 39

Step 5: Build a business case ................................................................. 40

3. INFORMATION GATHERED .................................................................. 41

3.1 Smart Grid related systems already installed ................................. 41

SCADA .................................................................................................. 41

3.2 Other operation improvement systems in place .............................. 43

Maintenance .......................................................................................... 44

3.3 Capital expenditure plans ................................................................. 44

3.4 Known Problems ............................................................................... 45

Outages .................................................................................................. 45
4. PROPOSED ROADMAP & SOLUTIONS................................................................. 47

4.1 Long term roadmap vs short term implementation ......................... 47

4.2 Long Term Vision/ Road Map................................................................. 49

Initial Development...................................................................................... 49

Continuation Development .......................................................................... 50

Long Term Development.............................................................................. 50

Road Map Explanation - Initial development............................................. 51

Road Map Explanation – Continuation development.................................. 53

Road Map Explanation – Long term development....................................... 53

4.3 Suggested Short Term Implementation.................................................. 54

5. IMPLEMENTATION DETAILS..................................................................... 55

5.1 Developing functional specifications...................................................... 55

5.2 Implementation Requirements............................................................... 55

5.3 Implementation plan.............................................................................. 55

Step one – Select Communications Platform.............................................. 56

Step Two – Select Metering Technology...................................................... 56

Step Three – Customer Engagement.......................................................... 58

Step 4 – Tariff Design.................................................................................. 59

Step 5 – Select location for Pilot Project...................................................... 60

Step 6 – Pilot Project.................................................................................... 60

Step 7 – Pilot Evaluation.............................................................................. 61

Step 8 – Full scale rollout........................................................................... 61
6. COST-BENEFIT ANALYSIS APPROACH

6.1 Economic appraisal

Benefit-cost ratio

Net present value

Payback period

6.2 Non-economic appraisal

Sustainability

Customer satisfaction

7. COST BENEFIT ANALYSIS

7.1 Benefits

7.2 Costs

7.3 Assumptions

7.4 Tariff Generation

7.5 Results

No customer savings included

Customer savings included

7.6 Additional Benefits

Customer satisfaction and savings

Reduced carbon emissions

Decreased pressure on national energy demands

Alignment with national policy

Loss Reduction
8. RISK & SENSITIVITY ANALYSES

8.1 Sensitivity Analysis

Variables:

8.2 SWOT

Strengths

Weaknesses

Opportunities

Threats

9. CONCLUSIONS & RECOMMENDATIONS

9.1 Selection of a ‘municipal champion’

9.2 Following the municipal budget and Integrated Development Plan (IDP) cycle

9.3 Lessons learnt

Managing stakeholder expectations

Communications best practice

Municipal business constraints

Case study candidate selection

Data collection issues

9.4 Conclusions

10. REFERENCES
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Cost Benefit Analysis</td>
<td>70</td>
</tr>
<tr>
<td>Table 2</td>
<td>Cost Benefit Analysis with Customer Savings</td>
<td>72</td>
</tr>
<tr>
<td>Table 3</td>
<td>Municipal budget revision yearly schedule</td>
<td>81</td>
</tr>
<tr>
<td>Table 4</td>
<td>IDP process</td>
<td>82</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Long term vision roadmap</td>
<td>9</td>
</tr>
<tr>
<td>Figure 2</td>
<td>200 Smart Grid projects identified by VaasaETT’s 2013 Global Impact Report</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>(vaasaETT, 2013:2)</td>
<td></td>
</tr>
<tr>
<td>Figure 3</td>
<td>Smart metering benefits</td>
<td>31</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Five pillars for benchmarking smart grids</td>
<td>33</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Diagrammatic representation of business case development process</td>
<td>37</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Example of user need - functionality mapping</td>
<td>40</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Full User needs-to-technology mapping for Drakenstein municipality</td>
<td>48</td>
</tr>
<tr>
<td>Figure 8</td>
<td>Long Term Vision Roadmap</td>
<td>51</td>
</tr>
<tr>
<td>Figure 9</td>
<td>Cumulative net benefit of project</td>
<td>69</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Cumulative net benefit of project with customer savings included</td>
<td>71</td>
</tr>
</tbody>
</table>
**GLOSSARY**

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced metering infrastructure (AMI)</td>
<td>AMI is a composite technology composed of several elements: consumption meters, a two-way communications channel and a data repository (meter data management). Jointly, they support all phases of the meter data life cycle — from data acquisition to final provisioning of energy consumption information to end customers (for example, for load profile presentment) or an IT application (such as revenue protection, demand response or outage management) (Gartner, 2014).</td>
</tr>
<tr>
<td>Asset management</td>
<td>In the context of electrical infrastructure, this is the process of recording data in an asset accounting system about an electrical asset. The level of detail depends on the requirements – it could include: asset description, age, value, geographical position (GPS coordinates), address, associated business name and contact details, service history, fault history etc.</td>
</tr>
<tr>
<td>Automated meter reading (AMR)</td>
<td>The capability of reading meters remotely and automatically using smart meter telecommunications and storing this data in a billing or accounting system.</td>
</tr>
<tr>
<td>Condition monitoring</td>
<td>As applied to electricity grid infrastructure, condition monitoring includes monitoring and recording of equipment operating conditions such as temperature, voltage, current, vibrations, operational changes (e.g. switch operations, tap-change operations).</td>
</tr>
<tr>
<td>Conventional or non-smart meters</td>
<td>These are meters that are essentially stand-alone and can’t be read or updated remotely. That is they have to be physically read and updated.</td>
</tr>
<tr>
<td>Demand side management</td>
<td>Demand side management or DSM is the process of seeking to manage electricity consumers load profile, usually to flatten out load profiles and reduce peak loads, but also to achieve an overall reduction in energy consumption (e.g. through remote control of consumer hot water geysers and other energy-intensive devices, encouraging the use of solar water heaters etc.)</td>
</tr>
</tbody>
</table>
Distributed generation

Distributed generation (DG), often also called embedded generation, refers to decentralised generation sources (e.g. solar PV, wind turbines, biogas generators, co-generation etc.) as opposed to large, centralised power stations. Often DG has a more restricted usage and refers to small, private or commercial generation sources such as photovoltaic (PV) rooftop systems or small wind turbines.

Energy balancing

The process of measuring the energy supplied and consumed within a defined area so as to identify missing energy (e.g. due to electrical losses, theft or incorrect metering).
1. PROJECT MOTIVATION

This initial chapter introduces the smart grid project, highlighting the motivation behind the conducting of this study and brief and simplified overview of the concept of a smart grid.

1.1 What is the Smart Grid?

In today’s rapidly changing and technology-driven world, electrical utilities are faced with new and sometimes daunting challenges. Along with these new challenges have risen technologies to address these issues and improve the operations of an electricity distributor. These technologies are bundled under the term “smart grids” and generally share one key component; communication.

Challenges:

- Increasing energy demand (stressing existing infrastructure)
- Rising energy costs (necessitating improved energy efficiency and loss control)
- Distributed generation (such as residential PV; how to regulate it, municipal revenue implications)
- Environmental concerns
- Uncertainty with regards to national policy (e.g. with respect to small-scale distributed renewable energy generation)
- Regulatory barriers
- Possible consumer resistance
- An ageing existing electricity infrastructure with a large maintenance and refurbishment backlog which needs to be addressed, thus constraining the capital available for other projects
- Municipal electricity planning which does not yet reflect smart grid interventions
- A lack of shared service planning with the result that each service is treated on its own instead of exploiting possible synergies (e.g. electricity and water smart metering sharing infrastructure and therefore reducing costs)
- Constraints on capital and cash flow for smart grid investments
- Shortage of municipality staff with the required knowledge, skills and experience required for smart grid project development, implementation and ongoing operations, this is aggravated by the difficulties in recruiting and retaining such staff
- Phased implementations of smart grids, required because of various constraints (e.g. finance and people), can make it difficult to justify initial phases because the benefits might only be realised in later phases
- Problems with having to integrate old and new technology and systems (e.g. billing systems having to integrate data from different types of meter, such as prepaid and smart meters, SCADA systems accessing old and new technology)
- Data management
- A lack of standards which could lead to interoperability problems
- Grid stability and complexity in the face of multiple and potentially unmanaged sources of intermittent, distributed generation
- Having to work within the municipal procurement processes and timing (e.g. smart grid technology typically has a life span of decades, whereas the contracts and paybacks are often limited to a few years)
- Provision for electric vehicles (EV) (impact on load profile, regulating fast battery chargers, exploiting storage capability of EV batteries – the impact in South Africa is likely to be small for the foreseeable future)
- Theft of infrastructure

(Enerweb, 2011:15)

Opportunities:

- System automation
- Reduced outage times (e.g. self-healing grids)
- Reduced theft and technical losses
- More efficient utility operation (e.g. peak load reduction)
- Improved asset management and asset life
- Improved customer service
- Improved customer billing and more tariff flexibility
- Improved municipal electricity net revenue performance
- Replacing end of life hardware
- Allows the integration of different generation and energy storage options
- Enables energy markets
– Fulfil the NERSA requirement to report on KPIs such as SAIDI, SAIFI, DSLI and RSLI

1.2 Current implementation status: international

VaasaETT’s Smart Grid Global Impact Report provides a good overview of the status of smart grids internationally (vaasaETT, 2013). It identified 200 projects globally that could be defined as contributing to the smart grid, as shown in Figure 2. Note that most of these projects are still pilots or roll-outs confined to specific areas in cities. Only a handful represent wide-spread implementations, notably: OG&E Positive Energy Smart Grid Project (USA); Townsville Queensland Solar City (Australia); Smart Grid Smart City (Australia); a leading utility (USA); Yokohama Smart City Project (Japan), Buzios Smart City Project (Brazil).

Figure 2: 200 Smart Grid projects identified by VaasaETT’s 2013 Global Impact Report (vaasaETT, 2013:2)

What is clear is that there is no one-size-fits-all methodology available to implement smart grids. The smart grid in 2013/14 is still an evolving concept, with every new completed project informing and sometimes realigning our understanding of the challenges and opportunities of smart grids, and the best ways of implementing these.
1.3 **Current implementation status: South Africa**

In general the smart grid in South Africa is still in its infancy and is growing opportunistically, on a case by case basis, rather than as a result of a concerted, policy-driven drive.

**Regulation 773**

There is one smart grid policy intervention in effect: Regulation 773: and this is aimed at managing consumer demand and encouraging energy efficiency. In the smart grid context, this regulation requires the supplying agent (e.g. Eskom or a municipality) to provide the facilities to individually manage consumer demand by remotely disconnecting electric geysers, swimming pool pumps, and space heating and cooling and ventilation systems. It also requires that electricity supply to consumers using more than 1 000 kWh per month “have a smart” system and be on a time-of-use tariff. All this was required by 1 January 2012. In practice this regulation has largely been ignored; mainly because of municipal capacity constraints (money and suitably skilled people) and because it is too vague and no appropriate metering standards have yet been adopted in South Africa. Currently, most municipalities are either ignoring 773 or they have applied for temporary exemption from 773. At the time of writing, it was not clear what the future holds for Regulation 773.

**Smart grid implementations in South Africa:**

*Eskom’s Load Management Pilot Project (Enerweb, 2011:20)*

This was an Eskom pilot project, started in 2009, in Fourways, Gauteng. It consisted of a smart grid network, with energy monitoring and display devices installed in volunteer customer households. The main aims of the project were to help customers become more energy aware and to review Eskom’s load-limiting technology options. The pilot was later extended to selected customers in other municipalities.

*Tshwane Smart pre-paid meter project (Pretoria)*

The smart pre-paid meter roll-out in Tshwane started in October, 2013. The stated objectives of the project were:

- Improve revenue collection
- Maximise operational efficiencies
- Shift load as part of national demand management
- Change customer behaviour
- Comply with National Regulation 773
Towards a Smart Grid in Drakenstein Municipality 2013-2014

(Tshwane, 2013)

The prepaid smart meter tender was awarded to Peu Capital Partners and Tshwane Utility Management Services Ltd (TUMS, a subsidiary of Peu) amidst controversy about the tender process. At the time of writing, a court case brought against the City of Tshwane by Afriforum was in progress – the case was about the validity or otherwise of the procurement process rather than the merits of smart pre-paid meters (IOL News, 2014). The project was estimated to involve 800 000 smart pre-paid meters to be installed over a period of 10 years, with an initial roll-out of 7 000 meters to large power users. The project’s capital cost would be funded by Peu, who would supply the equipment and install it, and manage it. In return Peu, through TUMS, would receive a service fee of 19.5% - 25% of electricity related proceeds over an eight year contract (City of Tswane, 2013).

City Power Smart Meter project (Johannesburg)

This has been another contentious and expensive smart meter project, although, legally, it now appears to be in the clear. The tender was issued to Edison Power Group. The project started in 2013, with a pilot roll-out of 2 500 smart meters (pre and post paid). The first phase intends to install 50 000 smart meters by mid-2014. The roll-out into 50 suburbs will start with Ferndale, Franklin Roosevelt Park, Langlaagte, Berario, Linden, Glenvista, Crown Gardens, Fairland, Sandringham, Brixton and Parkhurst (Jansen, 2013).

City Power offered an incentive to their (paid up) customers to switch to prepaid (smart) meters in the form of reduced tariff increases in 2013/14 (1.4% compared to the average 7.85%) (Stone, 2013).

City of Cape Town smart grid activities

Smart metering pilot: In early 2012, the City of Cape Town (CoCT) started a three household pilot project involving PV panels, smart meters and a grid-connected invertor. The purpose of the pilot project was to “test the technical, operational and administrative feasibility of the project with the intent to possibly implement grid tie on a larger scale” (Sustainable Energy, 2013).

Looking beyond this pilot described above, the CoCT had not yet, at the time of writing, finalised its net metering tariffs, processes and specifications, with the result that PV panel owners who are tied to the grid at present are effectively acting illegally and cannot export surplus energy back into the grid. Black River Park, currently Cape Town’s largest rooftop PV installation (700 kWp), is connected legally, but cannot export its surplus energy back into
the grid because the CoCT has not yet got the required processes, tariffs and regulations in place. Neither can it use the energy from one of its building’s PV panels to supply another on an adjacent erf (i.e. wheel its energy from one of its offices to another), because the two offices have separate grid connections and the current regulations don’t allow for wheeling (Ramayia, 2014). The Vodacom Century City PV installation suffers from the same problems. These are examples of regulatory problems getting in the way of smart grid implementations and their benefits.

The City of Cape Town, is also actively engaged in the South African Smart Grid Initiative smart meter working group, which is developing smart meter standards for smart pre-paid meters for households and businesses (CTES, n.d.; SABS, 2008).

_Geyser control in the Western Cape_

Water heating has long been recognised as an energy service where significant reductions in grid energy consumption can be made; both in peak load shifting (e.g. by using geyser time switches or remote geyser control as envisaged in Regulation 773) and in total electricity consumption (e.g. by installing solar water heating systems and/or by improving the geyser insulation and lowering the thermostat settings). An example of a water geyser intervention is the Residential Load Management (RLM) project in the Drakenstein Municipality – this involves installing ripple relays, which can remotely connect and disconnect geysers in response to a signal sent over the normal electricity supply systems. The project started in 2011 and the aim was to install 17 000 ripple relays in Paarl and Wellington (Beyers, 2011).

In the City of Cape Town area, a pilot project of 600 split prepayment meters with the associated communications equipment, including geyser control relays, was completed recently, although without two-way communications capability (City-of-Cape-Town, 2014).

_Ethekwini smart grid projects_

eThwkweni embarked on its smart grid journey a few years ago, the key aspects of which are:

- Investment in a smart grid communications infrastructure (e.g. a fibre network, supporting multiplexor facilities and IP, as well as interim GPRS services), connecting high voltage substations and major installations
- Integrated Control and Protection Schemes (e.g. SCADA)
Outage Management System (OMS acquisition and installation and integration with other systems ongoing, the tender closing date was March 2012)

Fault detection facilities

Business case development for AMI

Staffing to support the smart grid initiatives

In the Ethekwini 2011/2012 Annual Report (Ethekwini Electricity Department, 2012), progress on the above can be seen on various smart grid related activities. For instance, following were set as delivery milestones by end 2013:

- the Wireless Distribution Area Network for distribution automation and smart metering
- All new equipment to be intelligent and have communications capabilities
- Following an AMI feasibility study, continue working on AMI implementation
- Continue working with Eskom on load control facilities

The Ethekwini Medium Term Revenue and Framework for 2013/2014 to 2015/2016 (three years) also shows considerable capital investments being made in the electricity infrastructure (R1.9 billion). The words “smart grid” don’t appear in this document, although it can be seen that investments are being made in smart grid related equipment and systems (e.g. R4.5 million per year on the OMS) (Ethekwini Municipality, 2013).

The Ethekwini Energy Office has recently released a tool, jointly developed with GIZ, to help potential PV investors assess the economics of their projects by calculating the lifetime cost of the electricity generated (in R/kWh over the life of the PV system). This cost can then be compared to the cost of the municipal electricity (under current and future tariffs). The purpose of this initiative, according to Derek Morgan of the Ethekwini Energy Office: “is to provide financial planning assistance for renewable energy project developers, both in the private and public sector. We think it will help people to better account for the cost of financing renewable energy projects” (Mckenzie, 2013).

1.4 Principles from literature that inform this study

Several case studies, reports and other literature have been published to date on the best ways to approach the implementation of smart grid related technologies. The authors of this report conducted a literature study focusing on the conclusions and lessons learned from these publications, to try and compile a list of lessons learned that would inform the rest of
the report. Identifying this list of lessons learned before embarking on the report has several advantages:

- it avoids wasted time spend reinventing the wheel
- the understanding gained from the literature review provides a theoretical baseline against which later practical experiences in the selected municipalities could be compared. This allows for an iterative process where the lesson learned in literature can be adjusted to fit the specific South African context etc…

In no particular order of importance:

**Only when a smart grid project forms part of a long-term smart grid vision / roadmap, can real leveraging of its benefits be realised.**

"The financial benefits are real. Customers are finally benefiting from smart grid, but only where a clear customer journey is identified." (vaasaETT, 2013:53)

**Don't be afraid to innovate.**

Innovation is one of the five pillars for benchmarking smart grids according to VaasaETT (2013).

“Leading projects deploy innovation across many elements of their projects because they understand that modernisation of one area exposes other areas for improvement. Projects which avoided innovation due to perceived risk tended to rank lower overall.”

“Economically focused projects should not be conservative about innovation, or see it as a risk. Innovation should not be engaged in for the sake of innovation, but is an important driver of positive economic returns.”

“The more innovative a project, as long as it is focused on a broad array of smart grid elements and benefits, the more cost-effective the outcome will tend to be.”

(vaasaETT, 2013)

**The smart grid solution’s economic viability is context specific.**

"It may seem somewhat incongruous that smart grid projects can and maybe should be done without smart meters. Yet, this point was highlighted in a study commissioned by Germany’s ministry of economics…It suggested Germany should rather design its rollout of smart
metering systems in a targeted fashion… Lewis (of vaasaETT) says that overall there probably is a benefit from smart meters: ‘… it is increasingly the view that you don’t replace meters that are perfectly good and you don’t put them everywhere. The big bang approach is questionable in terms of resource, revenue and cost management.” (ESI Africa, 2013:53).

The German study mentioned in the quotation above was done by Ernst & Young for GIZ and titled Cost-benefit analysis for the comprehensive use of smart metering systems (Ernst & Young, 2013). This study clearly shows that the higher the household electricity consumption, the bigger the smart metering benefits.

<table>
<thead>
<tr>
<th>Consumption classes</th>
<th>Potential savings in %</th>
<th>Potential load shifting in %</th>
<th>Cost savings in € p.a. and meter (rounded values)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Average</td>
</tr>
<tr>
<td>&lt; 2,000 kWh/a</td>
<td>0.5</td>
<td>0.25 - 5</td>
<td>2.50</td>
</tr>
<tr>
<td>2,000 - 3,000 kWh/a</td>
<td>-1.0</td>
<td>0.50 - 10</td>
<td>10</td>
</tr>
<tr>
<td>3,000 - 4,000 kWh/a</td>
<td>-1.5</td>
<td>0.75 - 15</td>
<td>20</td>
</tr>
<tr>
<td>4,000 - 6,000 kWh/a</td>
<td>-2.0</td>
<td>1.0 - 20</td>
<td>39</td>
</tr>
<tr>
<td>&gt; 6,000 kWh/a</td>
<td>-2.5</td>
<td>1.25 - 25</td>
<td>75</td>
</tr>
</tbody>
</table>

Source: Ernst & Young based on the pilot projects, experiences of other countries and studies

**Figure 3: Smart metering benefits**

Source: (Ernst & Young, 2013:15)

These savings can be compared to the estimated costs of smart meters and the required infrastructure of at least Euro 57/meter per year (discounted over 15 years at 5% p.a.) (Ernst & Young, 2013:18).

**Although smart grid implementations bring benefits in several areas not easily quantifiable financially, the economic viability of a smart grid project to all parties including the customer is usually a critical indicator of ultimate success.**

The central view of our report was captured in this statement: "Economic return on investment (ROI) is becoming a key commercial, public and political issue for smart grid projects and plans around the world. It is simply not enough to promise benefits for society. If the smart grid is going to deliver results – if it is going to win approval from customers and politicians who have become frustrated by energy price rises – it must ultimately pay its own way. Clear evidence of the potential for a positive economic business case is essential" (vaasaETT, 2013:50).
"Projects with only economic goals deliver less positive economic results than those with broader objectives. Projects without clear economic goals and without a clear strategy to track and maximise cost-effectiveness rarely achieve a positive economic outcome." (vaasaETT, 2013:53).

**It is important to differentiate between smart grid and Smart Metering - the latter is only one (not necessarily compulsory) part of the smart grid**

"Many projects defined as ‘smart grid’ are actually focused on smart meters. True smart grid projects are deploying a much broader mix of components and in the leading 30 smart grid projects analysed, grid-side technology that insulates the customer from significant impact - such as network intelligence and control - tends to dominate." (vaasaETT, 2013:18).

**Smart grids are not antidotes for ageing infrastructure**

Whilst smart grids will not magically fix ageing infrastructure problems, they do allow the life of existing assets to be prolonged. Also, the fact that replacement equipment is increasingly more smart capable can accelerate smart grid readiness (Vadari, 2013).

**Data means nothing without understanding**

“The analysis suggests that, beyond the initial focus on smart metering, most current smart grid projects are focused on grid sensing, monitoring, control and automation technologies, which will create large volumes and varieties of real-time and near real-time data. Utilities must plan now for how they will turn this data into actionable insights which address business challenges such as asset reliability, outage response and the integration of distributed and renewable energy resources.” (vaasaETT, 2013:18).

“IT provides nothing if there is no understanding of the relationships between different elements of the smart grid. Data on its own are insufficient if this provides no understanding.” (ESI Africa, 2013:54).

**Intentional (i.e. planned) roll-outs offer the most benefits**

"While the smart grid concept gains maturity, only projects with clear economic and consumer goals at the outset can achieve strong results. Successful projects have solid objectives-based management and a strategy framework that enables decisions that lead to better results" (vaasaETT, 2013:61).
"Smart grids cannot succeed if developed through isolated ad-hoc projects in the absence of a clear sense of direction." (vaasaETT, 2013:61).

"Another key driver is getting the investment criteria right. Don’t assume you need scale to be successful." (ESI Africa, 2013:54).

"From the results of the study Lewis is able to summarise the key drivers for smart grid projects. ‘They must be inclusive and holistic – the best projects tend to be more holistic and integrate well. The projects have to innovate and interconnect information technology with operational technology.’” (ESI Africa, 2013:54).

1.5 Documented benefits gained from Smart Grid Implementations

The focus in this section is the long-term benefits that can be gained from a well-planned roadmap towards a smart grid, and is informed by the literature review. Some of the benefits international projects found from smart grid implementations are listed here.

Generally smart grid implementations impact one or more of the five pillars as shown in Figure 4.

![Five pillars for benchmarking smart grids](source)

**Figure 4: Five pillars for benchmarking smart grids**

Source: (vaasaETT, 2013:7).

As mentioned earlier in this report, benefits of implementing these technologies include: improvements in voltage quality, reductions in technical and non-technical losses, reduction in system interruptions, potential savings in electricity purchases and reduction in overall power use.
Here are some specific references to these:

"The vast majority of these utilities indicate that they expect voltage quality, transmission losses and system interruptions to achieve up to 9% improvement. This is a significant achievement, given that this level of improvement typically occurs in grids that are already highly reliable" (vaasaETT, 2013:9).

"In Holland, IBM works with energy company Nuon on just such a project. In a pilot test of smart meter-based energy management systems in 500 households, energy use is monitored, targets set and usage patterns influenced by various beyond-the-meter-services. The next phase of the pilot will also include switching off unnecessary appliances. Anticipated savings average 14% on electricity and 9% on gas – that’s around £200 a year for an average household. In another study, participants who responded to real-time prices reduced peak power use by 15%." (IBM, 2013).

Loss reduction:

“Higher technical losses are due to less efficient and poorly maintained equipment” “Increasing the efficiency of European distribution transformers by 0.33% would have reduced losses by more than 100 TWh in 2000 and would result in savings of 200 TWh in 2030 (IEA 2003). For a sense of scale, the electricity generation of Australia in 2009 was 232 TWh” (Bazilian et al., 2010:11).

“Non-technical losses such as power theft can be partially addressed with the help of smart metering infrastructure” “This was reported as one of the reasons for Italy’s initiative to fit smart meters in 85% of Italian homes (M. Scott 2009). The Italian utility Enel reports annual cost savings of USD 750 million from their investments in the smart meter technologies, which were characterised by a payback period of technology, allowing it to recoup the infrastructure investment in just four years. Additionally, monitoring of transformer loading and third party assessments of potential misuse will help tackle such power theft, which is often difficult to determine in developing countries as it can involve collusion with linesmen and meter readers.” (Bazilian et al., 2010:11).

Peak demand reduction:

“Active management of consumer demand through smart appliances and equipment will reduce the need for spinning reserve and expensive electricity supply to satisfy peak demand. This could be achieved using demand response programmes. A reduction of 1% in
peak demand could result in cost reductions of 4%, equalling billions of dollars at system level.” (Bazilian et al., 2010:12).

Quality of supply:

“Smart Grids can significantly contribute to reducing costs of grid congestion, power outages and power quality disturbances." “3 In the U.S., these costs are estimated to be in the range from USD 25–80 billion annually.” (Bazilian et al., 2010:12).

Climate change mitigation:

“Direct and indirect benefits of Smart Grids offer the potential for yearly emission reductions of 0.9–2.2 Gt CO2 per year by 2050”

Customer satisfaction:

This is difficult to quantify in monetary terms, nevertheless, there are many mentions of increased customer satisfaction in the literature, resulting, for instance from more secure and higher quality power and improved energy billing. For instance:

“Customer satisfaction has increased as more meters were installed, providing greater access to more accurate data to manage consumption, with fewer billing errors” (vaasaETT, 2013:62).

“For circuit-level outages, CenterPoint Energy will use the intelligent grid’s “self-healing” capability to switch around the fault to restore power to the maximum number of consumers. As a result, where the automated switches have been used to restore circuit-level outages, “CenterPoint Energy has seen significant improvement in the service restoration process, with many affected customers experiencing an outage of just a few minutes rather than at least half an hour.” (vaasaETT, 2013:40).

---

1 Note that the in-text references from Brazilian have been omitted here for better readability.
2. AIMS & METHODOLOGY

This chapter describes the motivation and aims of this smart grid project and the methodology used in building a business case for a smart grid technology intervention.

2.1 Motivation for study

The British High Commission (BHC), under its “Prosperity Fund” – which seeks to assist governments drive changes that will encourage, amongst others, growth in renewable energy and energy efficiency – commissioned GreenCape to execute a study that seeks to increase municipal uptake of “smart grid interventions to improve electricity provision efficiency and enable uptake of electricity from renewable sources”.

This smart grids study aligns well with GreenCape’s wider vision of enabling the growth of the green economy in the Western Cape, by focussing on more efficient operation of municipal electricity grids, the enabling of renewable energy uptake, and potentially significant savings as a result of more informed decision making in municipal electricity departments and therefore more effective service delivery.

2.2 Goals

Informed by the above motivation, the study aims to build smart grid roadmaps and business cases within three selected municipalities in the Western Cape. This process has the following general aims:

- Identify where smart grids can play a role in increasing the sustainability of the electricity business in a variety of municipalities
- Identify and remove barriers to the implementation of smart grid technologies
- Generate knowledge from experiences in the Western Cape with regards to smart grids, that can then be disseminated to the rest of the country
- Help municipalities avoid costly errors that are a result of, amongst others, tying into specific technologies and vendors

Additional to the above, there were some specific project goals, namely:
- Influence the municipalities’ thinking with respect to electricity planning, through lessons learned from tailored smart grid roadmaps in the case studies
- Develop guideline/informative documents to assist municipal engineers in motivating the inclusion of smart grid implementations into municipal development plans – i.e. inclusion of smart grid projects in municipal Integrated Development Plans (IDPs), and the municipal budget
- Engage with key municipal stakeholders to create a conducive environment within municipal decision-making structures, for the implementation of smart grids technologies

2.3 Methodology

This section describes the approach taken by the project researchers to identify a viable project to be developed for the municipality. This was after suitable municipalities had been selected and their cooperation obtained, as described in the Guidelines to developing Smart Grid Projects (GreenCape, 2014b:4).

A 5-step process was followed, with iterations between the different steps. These steps are summarised in Figure 5 and described below.

Figure 5: Diagrammatic representation of business case development process
**Step 1: Understand**

This stage involved initial meetings with the municipality to align the researchers’ and municipality’s perspectives of the concept of a smart grid and how it relates to the current operation of the municipality’s electricity grid. Additionally, this stage sought to give the project researchers insight into the municipality’s electricity grid and its operation.

Typically, these meetings involved discussions with the municipality’s head of technical services, head of electricity/electro-technical services, the head of Finance, officers from the budget and revenue office and the Integrated Development Plan (IDP) manager. The participation of the Municipal Manager was also deemed key to ensuring that the municipality’s executive agreed with the direction the project was taking. These stakeholders provide insight into:

- the municipality’s strategic development objectives,
- the technical details of the electricity grid and its functioning,
- a breakdown of the municipality’s customer base,
- the financials of the electricity business, and
- specific development goals within the electrical department.

Guided by a set of detailed questions about the technical, financial and social aspects of the running of the municipality’s electricity grid, the project researchers discussed the municipality’s electricity grid and the electricity business in general with relevant municipal staff, leading to Step 2.

**Step 2: Identify an area of focus**

Guided by the municipality’s electricity department manager, the project researchers sought to identify particular areas of concern and possible areas for improvement within the electricity business. This was informed by engagements with the stakeholders described in Step 1 and to a large extent by the electricity department manager.

Having identified areas of concern, possible smart grid interventions were discussed, using suggestions from both the project researchers and from the department managers. These discussions were intentionally conducted interactively, to ensure that the project remained in alignment with the municipality’s own goals, and also so that there was adequate buy-in by the electricity department. Furthermore, through constant engagement with the electricity department staff throughout the rest of the project stages, the project researchers sought to maintain smooth project development and avoid the need for lengthy feedback sessions.
The choice of a ‘viable’ smart grid intervention to investigate was based on several factors, including:

- Benefits that would be accrued from the technology implemented
- The practicality of the proposed project, given the time available for the research and business case development
- The current state of the municipality’s grid and future plans
- The technology solution that was best aligned with the electricity department manager’s biggest concerns

Again, in recognising that various stakeholders in the municipality have different motivators, the project researchers ensured that the chosen project also spoke to the non-economic value and benefits accrued by stakeholders beyond the municipality. This considered the impact of the intervention on factors such as service delivery and customer satisfaction (sometimes referred to as ‘soft benefits’). Later chapters describe the cost benefit analyses performed on the project, and this more clearly described the economic and non-economic aspects of project benefits.

**Step 3: Develop Smart Grid roadmap**

Recognising that the smart grid is still a concept in development, the project researchers sought to develop a tailored roadmap of what a smart grid in the specific municipality would mean and what benefits it should provide – always with the understanding that ultimately it must be benefit driven. Under the South African National Energy Development Institute (SANEDI) is the South African Smart Grid Initiative (SASGI), which has developed a higher level vision for what the future South African electricity grid should look like (Bipath, 2014). Guided by this document, the project researchers sought to develop a tailored roadmap aligned with this national vision.

**Step 4: Defining a specific project**

Having identified an area of focus in Step 2 and a future roadmap for smart grids in Step 3, Step 4 now sought to develop a more defined project for implementation through an iterative process especially with Step 2. This step developed the specific functionality of the technologies proposed to address these concerns identified in Step 1. This functionality definition linked user needs to technologies, and is a useful tool in future smart grid undertakings – both in this municipality and in other municipalities – guiding the thought process from challenges to suitable interventions. An example of this mapping is provided in Figure 6.
Figure 6: Example of user need - functionality mapping

Through several iterations of the user needs-functionality-technology mapping process, this stage determined a specific technology as subset of the larger smart grid roadmap for which Step 5 developed a business case.

**Step 5: Build a business case**

The approach taken to the business case was to compare the cost of ‘doing nothing’ – represented by continuing with current operations and associated losses – with the potential benefits from smart grid interventions. Taking into consideration that the municipality functions differently from a conventional business, the business case sought to evaluate both the economic and non-economic benefits possible from a smart grid intervention. Future projects are evaluated in terms of losses – from current operation practices, and benefits – from smart grids. Additionally, the potential for further benefits, resulting from the ability to implement further smart grid technologies, was emphasised. The basic premise being that smart grid technology benefits are increasingly realised with the installation of more systems with wider reaching impacts on the operation of the municipal grid. The details of the cost-benefit analysis done on the project were further elaborated in Chapter 5.2.
3. INFORMATION GATHERED

This chapter describes the information gathered during the project team’s interactions with the municipality and the lessons learnt through the exercise of developing this business case. The information and lessons described below are specific to Drakenstein municipality, although some of these might be usefully applied to other municipalities.

This is a summary of the information gathered at the municipality and the lessons learnt. Here we include anything that we learnt from doing the case study, both the information our case was built on as well as anything that would benefit other municipalities.

This section aims to allow other municipalities to judge how relevant the proposed solutions are as well as learn from past projects within Drakenstein.

3.1 Smart Grid related systems already installed

Drakenstein has already taken the first steps on the path towards a smarter grid, with a few systems and projects already being implemented.

**SCADA**

Drakenstein has implemented a SCADA system that controls and monitors all the main network substations. Along with current and maximum demand metering, oil pressure and switching status are also monitored. The SCADA system is capable of some level of control over the network, but due to safety concerns this control is not often utilised.

The SCADA system was initially implemented as a stand-alone monitoring system; however systems are starting to be integrated.

**Back-end data management system**

Drakenstein has recently installed Maximo asset management software; to handle maintenance scheduling, asset registers, and work records. The asset register in Maximo is not currently integrated with the asset register in the finance department, despite this integration being flagged as a requirement for the installation of the Maximo system. This means that they have two asset registers; one at a high level used by the finance department and the other at a lower, more detailed level used by the engineering department.
The finance department uses a Venus-based system called Solar, which has its own asset registers. The asset registers stored by the finance department are at a much higher level of abstraction to those stored by Maximo; the Maximo system will generally store information on every component of a device, the financial asset register stores it as a single device. This differentiation in the levels of abstraction is useful because financial records do not require the same level of detail on specific parts; but the lack of integration between the systems leads to duplication of data entry, errors and wasteful reconciliation effort.

System reports are based on very large Excel spreadsheets which have become unstable, because of this they want to move to database-based systems.

**Metering**

Domestic customers are currently on an Inclined Block Tariff (with one knee point) and Drakenstein plans to move them onto a time-of-use (TOU) tariff. It is believed that customers will change their habits to exploit the TOU tariffs, as many customers have already proven to be pro-active in energy conservation through the use of geyser timers. The meters being used in the municipality primarily consist of pre-paid and conventional meters, with roughly 35% of the meters being manually read.

Drakenstein has been working with Automatic Meter Reading (AMR) for 5 years, and have had various issues with their implementation over this time. The majority of the problems they have experienced can be attributed to the communications platform being used. The initial AMR systems used simple cell communications through SIM cards on the meters, this was later updated to include a private APN. They were unhappy with the use of third party communications (i.e. Cell Networks) as they found them to be problem prone; their Demand Side Management (DSM) systems were installed using Zigbee for communications. The DSM system is in the form of geyser controls, which allow the municipality to control the customer’s geysers. They ran into issues when trying to extend the area of coverage of the Zigbee mesh because the topography of the area does not allow for the Zigbee network to provide the desired coverage. A radio frequency (RF) wireless system has been suggested for implementation to provide the communications protocol for metering and DSM.

Smart meters have been installed for Drakenstein’s large power users and these are automatically read into their metering system; minisubs are equipped with meters that are also linked to the system. Large power users on the smart metering system include all users on the 11kV network with consumptions over 1000kWh per month, and some above 500kWh per month, as well as some large commercial users. There are about 250 users on the
system and the meters installed are capable of time-of-use metering with remote tariff adjustment. Drakenstein has received funding from Eskom for an additional 750 meters for use in a pilot smart metering project.

Future plans for metering include a change in communications platform and meter data management system for both smart metering and DSM. There are also plans to implement quality of supply logging and telemetry. New meter installations are going ahead with smart-capable meters that currently have no communications attached.

3.2 Other operation improvement systems in place

This section describes other systems in place in Drakenstein, that may not necessarily fall into the category of smart grids, but introduce operations that pave the way towards a smart grid and so are worthy of mention.

Theft management

Drakenstein believes that most of its non-technical system losses are caused by theft; power is most often stolen through direct connections to poles. Drakenstein currently has some systems already in place to attempt to combat the threat of theft to their electricity business. A ring-fenced area has been setup in which energy balancing is conducted. The energy balancing is done manually with help from the Itron prepaid metering system which runs purchase history over a 6 month period. This data is then analysed for any suspicious drops in electricity purchases. This is not fully automated and is subject to the availability of manpower to run the programme, analyse the data and then take action.

A revenue protection unit is planned for Drakenstein to help manage non-technical losses.

Demand Management

Drakenstein has been retro-fitting hot water controllers using outsourced contractors and this is causing big problems because of bad quality work. Also they had some initial problems with the algorithms controlling the hot water system DSM. Many of these problems were related to issues in the communication platform being used. The municipality can force their customers to allow load control on their hot water systems. Funding was received from NERSA for their geyser load control system. Geyser control, i.e. remote geyser switching, is useful for controlled “switching-on” of the grid, to avoid a huge surge as all geysers come online after a power outage.
Maintenance

Maintenance is carried out according to a schedule prescribed for municipal grid maintenance by the NRS- National Rationalized Specifications. Workers conduct weekly inspections of each substation and confirm the state of all equipment using a prescribed checklist. This process unfortunately occasionally fails due to human error, and a worker overlooking an aspect of the checklist or misreading something can cause issues where the state of an asset is not properly tracked.

Drakenstein does not currently have any installed condition monitoring in its substations, although it has been identified as a possible useful addition to their network. Transformers are infrequently taken offline for maintenance; this occurs approximately once every five years.

Copper theft has been identified as a cause of maintenance problems; when copper grounding cables are stolen the issue may not be detected before damage is done to the substation.

Renewable energy

Renewable energy has yet to see large scale penetration into the Drakenstein municipality. One of the few known installations is a large photovoltaic installation at the Imperial sub- headquarters. In terms of current municipal legislation, it is illegal for anyone other than NERSA-licensed generators (e.g. Eskom) to connect into the grid. This legislation is being changed in Drakenstein and the deadline is 1 July 2014 for the revised laws to be in place. The Drakenstein legislation on self-generation will become the SA model (previously the CT Metro legislation was the model). Nevertheless, some self-generators do have wheeling agreements with Eskom which allow them to feed power into the grid and sell it to Eskom (this requires a tri-partite agreement between the generator, Eskom and the municipal. An example is EB Steam).

3.3 Capital expenditure plans

The primary focus of capital expenditure for the municipal electricity department appears to be the electrification of new developments. These new developments require increased grid capacity and new hardware. Substation extensions have been planned in order to deal with the increasing load on the grid, as the existing infrastructure is not suited for its current loading.
Other proposed capital expenditure projects on the grid include:

- The addition of another 66 kV feed into the grid
- Network upgrades to increase network robustness in cases where there are no back-up feeds
- Replacement of substations which are past their end-of-life

### 3.4 Known Problems

During the course of our case studies several issues were highlighted by the municipality as areas in which it believes problems lie. These problems are described below.

**Outages**

The first steps towards a smart outage management system have been taken in the form of fault indication on some of the newer mini-substations. Around 20% of the municipality’s mini-substations currently have fault indication and all new mini-substations being installed will have fault detection. Outage response time in the municipality is not always up to NERSA standards, with some faults taking longer to repair than the prescribed guideline times. The revenue lost through outages is currently not being quantified (neither customer losses nor municipality losses are calculated and tracked).

**Customer service**

Customer losses caused by outages are not quantified by the municipality as they can’t be easily determined and don’t affect the municipality’s revenue. The municipal manager made it clear that he will measure the value of any smart-grid business case not only by financial savings, but also by how it strengthens the more long-term vision in terms of “soft” issues like customer satisfaction, improvement of business intelligence etc.

Other issues that were highlighted throughout engagements with the municipality include:

**Multiple asset registers**

- Finance and Engineering use different asset management systems
- Having two asset registers leads to duplication of data entry, errors and wasteful reconciliation effort
Communications

- Communications platforms for smart metering and demand side management are not performing as desired
- Various communication methods have been tested and no suitable solution has been found
- More communications platforms are currently being tested

Reactive power

- Drakenstein has a problem with reactive power and has introduced a kVAR tariff based on Eskom’s tariff

Staff resignations

- Recently staff involved with smart grid interventions have resigned
- Gaps have formed in Drakenstein smart grids project team due to resignations causing reshuffling of the electricity department

Grid Loading

- The Drakenstein grid is approaching its maximum loading
4. PROPOSED ROADMAP & SOLUTIONS

This chapter outlines the proposed smart grid solution for the municipality. It builds both a long term road map, as well as a shorter term project implementation. The shorter term project is a single project on the journey to a complete smart grid that we recommend as a solid first step. The project is chosen to be a small implementation while still aiming towards sustainability within itself; while the project will gain greater benefits from having other smart grid implementations it should also be sufficient to justify itself alone.

4.1 Long term roadmap vs short term implementation

Based on the process outlined in Figure 5, a technology solution was developed for the municipality, guided by the user needs expressed by the municipality. These user requirements were then mapped to appropriate smart grid technologies solutions. The specific user needs-to-technology mapping exercise for Drakenstein municipality is show in Figure 7. A simplification of the map is represented in Figure 6.
Figure 7: Full User needs-to-technology mapping for Drakenstein municipality
The long term vision was developed to plan the progress of smart grid upgrades to the municipal distribution grid. Developed in order to ensure that smart grid initiatives align with the SASGI vision as well as make sure that future developments are considered when making decisions on current systems and implementations. The specific proposed project is a smaller implantation that fits within the framework of the longer term vision. It serves as a first step along the smart grid journey; as a project that is viable to run alone, but gains incremental benefit as future projects are added.

4.2 Long Term Vision/ Road Map

The long term vision for the municipality is often referred to as a smart grid road map. It acts as a guide for the utility on their journey towards a smart grid. The journey is based on the user needs identified as well as the SASGI smart grid vision.

Initial Development

Start with Communications Platform

- Solid communications platform is key
- Allows systems to share infrastructure and become integrated
- Allows efficient and integrated system management
- Helps ensure the desired functionality is extracted from installed smart technology

Domestic Smart Meter Pilot program

- Encourages customers to shift peak loads
- Empowers customers to save on electricity bills
- Allows automated energy balancing to reduce theft when combined with substation metering
- Pilot provides learning experience for larger scale roll-out

Expand Smart meter pilot to rollout to domestic customers

- Encourages customers to shift peak loads
- Empowers customers to save on electricity bills
- Allows automated energy balancing to reduce theft when combined with substation metering
Continue expanding substation metering

- Allows automated energy balancing to reduce theft when combined with substation metering
- All substations should be metered for accurate information

Continuation Development

Asset Register Integration

- Prevents duplication of data entry, errors and wasteful reconciliation effort.

Link geyser control to AMI

- Greater system integration
- Improved system control.

Condition Monitoring on Substations

- Improved asset maintenance
- Reduces unplanned maintenance
- Reduces failure

Long Term Development

Automated Fault Detection

- Faster outage recovery

Network Automation

- Faster outage recovery
- Fewer customers impacted for shorter periods
- Optimised network management
- Grid can “self heal”
The initial development stage of the smart grid is the stage that has the highest relative costs, as the communications platform must be installed; it also has the lowest returns, as smart grid implementations gain exponential value with each new implementation. The initial implementations are chosen as projects which will be able to carry the costs of installing the communications platform, allowing future projects to be possible.

Communications platform

The foundation of a smart grid is its communications platform: a poorly chosen communications platform will cause issues for all aspects of the smart grid. All smart grid technology relies on two-way communications in order to deliver its services; if the communications platform fails, so will the technology that is relying on it.

While it is obvious that communications are required with any initial smart grid implementation, it is important that the communications platform is not treated as something that is just put in to make each smart grid implementation work. By considering the communications platform for your grid as a whole, you can choose a platform that will support not only current implementations, but future implementations as well.
It important to note that despite being a core component of the smart grid, the communications platform does not provide any benefits alone. This means that the cost of the communications platform must be sunk into the costs of other implementations. The more implementations that use the communications platform the greater its value will be, so it should be chosen to suit the long term plans of smart grid.

The choice of communications platform is not an easy one and there is no solution that will suite all utilities. Finding the correct communications platform for the utility is a key part of ensuring a strong smart grid.

**Domestic Smart Metering Pilot**

Smart metering can provide the utility with a range of benefits such as reduced peak load, improved system efficiency, and reduced theft. The smart metering pilot is suggested as an early implementation for Drakenstein as many of the costs have already been sunk, with the municipality already having smart meters purchased and sitting in a warehouse.

The reason for implementing a pilot program before rolling out smart meters comes from the need for customer data. Currently the municipality does not have accurate data on the usage patterns of customers, as conventional meters do not record this. By implementing smart meters in a pilot program, the usage of customers can be monitored, as well as their response to time-of-use billing, and customer interaction programs. This information will help to make sure that larger scale smart meter rollouts are as effective as possible.

**Expand Smart Meter Pilot**

Once information has been gathered from the smart metering pilot, the municipality will be in a strong position to evaluate the best path to move ahead with smart metering. By expanding the smart metering program based on information from the pilot project the municipality will be able to spread the beneficial aspects of the pilot program onto a much larger scale.

**Substation metering**

Drakenstein has already begun installing meters on its substations and mini substations. When combined with metering information given by other systems, such as domestic smart metering, this can provide valuable insight into the grid. By continuing to install meters on all new substation equipment Drakenstein will be greatly increasing their vision into the grid.
**Road Map Explanation – Continuation development**

The continuation development extends on the platform built by the initial implementation. These implementations can make use of the infrastructure in place from the initial development, allowing them to deliver greater value at lower cost than if they were run alone.

*Asset Register Integration*

Drakenstein currently has discrepancies between financial asset registers and the asset registers of the Maximo system. Integration of systems becomes vital once the smart grid starts feeding information in automatically.

*Condition Monitoring on Substations*

Condition monitoring for substation is currently done manually via inspections and checklists. Upgrading the process to an automated system allows improved asset maintenance. The removal of human error, combined with automatic alerts and decision support allow utilities to reduce maintenance based downtime and increase asset life.

**Road Map Explanation – Long term development**

The long term development gives an idea of future goals for the smart grid. Having an idea of the long term goal allows for more informed decisions in the short term. The implementations here are outside the current capabilities and budget of the municipality, but should be considered when choosing technology for shorter term implementation.

*Automatic fault detection and location*

Fault detection allows the municipality to easily locate faults. This results in much faster outage recovery times as it removes the time taken to find the fault. It also serves as a precursor to a self-healing grid.

*Network Automation*

Network automation allows the grid to manage itself. The grid can use the measurement devices installed on the grid to determine its optimal state, allowing for increased energy efficiency. When combined with automated fault detection it can allow for the grid to isolate the fault within seconds, and re-configure the network, ensuring that the number of clients affected by a fault is kept to a minimum.
4.3 Suggested Short Term Implementation

The suggested short term implementation for the Drakenstein municipality is a smart metering project to implement a time-of-use tariff for domestic customers. The project covers the first three points mentioned in the long term plan, namely; communications platform, smart metering pilot and the extension of the smart metering pilot.

Smart Metering project steps:

- Select an appropriate communications platform
- Design appropriate tariff
- Roll out smart metering project to identified pilot area
- Engage with customers to aid beneficial behaviour change growth
- Learn from the pilot project and base decisions for a larger scale rollout on the pilot.

The implementation of these steps is explained in more detail in the next chapter.
5. IMPLEMENTATION DETAILS

This chapter describes the requirements for implementation of the initial project described in chapter 4, and provides functional specifications wherever possible. It also gives a suggested implementation and monitoring plan designed to aid the municipality in implementing and managing the project.

5.1 Developing functional specifications

The aim of this chapter is partly to develop functional specifications for the project and its sub-systems, without restricting the project unnecessarily through more specific technical specifications which risks becoming product or protocol specific. These functional specifications will then be used as a basis for the cost-benefit analysis.

The functional specifications developed here are kept quite high-level; adequate for development of an indicative cost/benefit analysis, but not sufficient to cut-and-paste into e.g. a project tender document. This reason for this is mainly that a significant amount of detailed knowledge is required of the existing systems with which the proposed system will interact, before the proposed system can be functionally defined in some detail. Due to the limited time during which three business cases had to be developed within three different municipalities, this knowledge was mostly not available to the project team.

5.2 Implementation Requirements

- Add to IDP
- Add to Budget
- Apply for funding

5.3 Implementation plan

Due to budget restrictions a smart grid project cannot always be implemented in a single step. The purpose of this plan is to give a guideline for project implementation in a fashion that is both effective as well as manageable by the municipality.

The project is divided into simple steps for an effective meter metering rollout.
Step one – Select Communications Platform

The suggested first step for smart metering is to determine the best communications platform for the municipality’s smart grid. It is important to select the platform that is best for the full smart grid vision and not just what works best for the first project. The communications platform represents a significant investment by the municipality and if selected properly can greatly decrease the cost of future smart grid projects. If no consideration is given to future projects the municipality may well find itself in a situation where a large investment has gone into a communications that is not suitable for their needs.

When deciding upon a communications platform there are several important factors that should influence the decision.

These factors include:

- Cost
- Coverage
- Latency
- Bandwidth
- Security
- Interoperability
- Existing Infrastructure

Communications Functionality:

The communication platform’s core functionality is to allow communications between all of the devices on the network.

- Data transfer rates should be sufficient to meet functional requirements for all projects in the long term vision.
- Communications should allow at least daily polling of meters.
- Communications platform must use an open standard.
- Security should be sufficient to ensure privacy of customers.
- Communications platform must be able to cover entire network

Step Two – Select Metering Technology

In addition to communications hardware, implementing a residential time-of-use tariff and smart metering program requires metering hardware. While smart meters themselves are an
obvious requirement, the choice of metering hardware should not be looked at as a choice of what meter to use, but rather what Advanced Metering Infrastructure (AMI) to use.

The selected communications platform forms the basis of the AMI system, and depending on the choice of communications devices such as concentrators and aggregators are needed to make sure that information gets from the meter to the Meter Data Management (MDM system). The other two core components of the AMI system are the smart meters and the MDM system.

_Selecing Meters_

The choice of meter for the project is a decision that will have a large impact on the success of the AMI. With smart metering still a relatively new field in South Africa, smart metering standards are incomplete and this makes the choice of meter more difficult.

Without a clearly defined standard smart meters from various vendors are not easily interchangeable, but with careful selection of the MDM, meters and communications hardware on the meter it is possible to minimize the impact of meters that are not interchangeable.

Some factors to consider when selecting meters include:

- Cost
- Security
- Interoperability
- Existing Infrastructure

_Smart Meter Functionality:_

- National specifications of smart meters are still currently under development
- Meters should meet requirements that will be outlined in NRS049-1 and NRS049-2

As Drakenstein already has meters available for the smart meter program, the selection process for this is not as important, but will become relevant as the project continues.

_Selecting MDM system_

The MDM system acts as the interface into the AMI system, without an effective MDM system few of the expected benefits of the project are likely to be realised. Data needs to be
available in a useful fashion, and must be compatible with other systems such as the accounting system.

The MDM system should not be limited to receiving data from the meters currently being installed, otherwise meter choices in the future are restricted.

Some factors to consider when selecting the MDM system include:

- Cost
- Interfaces made available to the customer
- Security
- Interoperability (both with other systems and with various meter types)
- Support available
- Existing Infrastructure

**MDM Functionality**

- MDM system should be compatible with meters from multiple local vendors.
- MDM system should be able to compile energy balancing reports and interface with GIS
- MDM system must interface with municipal financial and billing system
- Should provide a feedback interface for customers.

**Step Three – Customer Engagement**

The smart metering project relies fairly heavily on the customers’ response to the system. If the customers embrace the system and shift their loads out of peak times, both the municipality and the customer will benefit and the project will be seen as a success. If customers do not shift their loads the municipality loses out on possible benefits such as reducing grid loading and reduced capital expenditure.

The customers’ perception of the project plays a key role in how they will react to the system. If the project is seen as a money making scheme for the municipality, or a way to increase the customers’ bill, the customers are less likely to change their behaviour, and more likely to complain about the system. The municipality should engage with the customers before the smart meter project is implemented so that the customers feel they have been included in the process and not like they are having smart meters forced upon them.
It is important to create the impression that the time-of-use tariff is an opportunity for the customer rather than a punishment for using electricity in peak times. For this reason it is suggest that when tariffs are designed that they be designed in such a way that when implemented the customers’ bill will not rise, this will be discussed in more detail in step 4.

Programs to incentivise behaviour change can help to increase the customers’ uptake in load shifting.

Some examples of customer engagement programs include:

- Usage feedback – Showing customers exactly what they are spending and when, will help them to see how they can shift their loads.
- Informing the customer of the money they could be saving by shifting load on a personal basis. It should be very easy for customers to see how much they are saving
- Comparison of usage between members of the community.

Customer engagement is an ongoing process, if the engagement stops the benefits it created will slowly fade over time.

Some customer engagement key points:

- Educate Customers Before Deployment
- Anticipate and Answer Questions Before Customers Ask Them
- Facilitate Community Engagement
- Communicate Ways to Shift Usage Off-Peak
- Deploy User-Friendly Web Portal
- Continue engagement programs

**Step 4 – Tariff Design**

A large part of the project is the implementation of a time-of-use tariff. This tariff needs to be designed to suit both the needs of the municipality and the customers.

As mentioned in Step 3 the customers’ perception of smart metering needs to be a positive one. One of the ways to prevent negative sentiment towards the project is to ensure that the customers’ bills are not increased when they are moved onto the new tariff. This can be accomplished by designing the tariff with the constraint that when it is applied to a typical usage pattern the bill remains the same.
The tariff also needs to incentivise load shifting, customers will not shift their loads unless they are given reason to do so. This is done by having reduced off peak pricing and ensuring that this is clearly and repeatedly communicated to customers.

The final aspect of the tariff is to make sure that municipal profit is maximized after load shifting. The criteria that says the customers’ bill must not change at implementation ensures that the municipal revenue is not affected by the tariff before the load is shifted, but once customers loads start shifting, municipal revenue will be affected.

Thus an optimal tariff tries to meet three primary criteria:

- Not increase customers’ bills
- Incentivise load shifting
- Protect municipal revenue

A large challenge designing a tariff properly is predicting the load shift from the customers, because the amount the customer shifts his load varies with the tariff. For example if we put an extremely high mark-up on peak times, and low mark-up off peak, the customers will be very incentivized to move his load, but when he does so the municipalities income will be significantly reduced. In the opposite case, if the municipality does not make the difference between peak and off-peak high enough, the customer will not shift load, and despite the fact that this system gives increased profits for the municipality is load is shifted, the profits will never be realised as the customer is not incentivized. A possible solution to this may be add incentives for load shifting from outside of the tariff.

**Step 5 – Select location for Pilot Project**

The pilot project will be the first members of the community to have smart meters installed, and thus it is very important that it is seen to be a success. If the people involved in the pilot are happy with the project it promotes a good customer view of smart metering. The pilot site should be chosen in an area that is likely to embrace the project, this is most likely the higher consumption users as they have more flexibility in their loads.

**Step 6 – Pilot Project**

Once the first 5 steps have been completed the municipality should be ready to roll out a smart meter pilot project. If the planning and preparation have been done well the pilot should be as easy to run as possible.
Step 7 – Pilot Evaluation

Information gained from the pilot project can be used to inform decisions for the full scale rollout. Data recorded from the pilot can be used to re-evaluate decisions for the full rollout.

Step 8 – Full scale rollout

Once enough information has been gathered, the full scale rollout can begin. This rollout will follow similar steps to those taken in the pilot project, but this time they are informed by experience and data.
6. COST-BENEFIT ANALYSIS APPROACH

This chapter describes the techniques used in the cost-benefit analysis of the proposed interventions. What was essential in the cost-benefit analysis was ensuring that the traditional business approach to benefit evaluation was not strictly stuck to, but rather that consideration was taken of the fact that the municipality’s core function is the provision of services to its citizenry. Thus, non-economic benefits also needed to be included in such an analysis.

It is important to consider that a cost-benefit analysis for a municipal project will differ from that performed, perhaps, for a private sector company. What is most notably different about the municipality in this regard is that the municipality gets money “for free”, in that it does not pay interest and therefore does not make spending decisions based on possible internal rates of return (IRRs) values. Rather, the municipality considers a whole array of benefits that must accrue from the proposed project, including both economic and non-economic benefits.

The project researchers were aware that the smart grid will bring about both economic (reasonably simple to quantify) and non-economic (more difficult to quantify) benefits, and so have attempted to perform a multi-criteria analysis that took this into consideration, focusing on the following:

- financial impact
- environmental sustainability
- customer satisfaction
- safe working conditions for staff.

6.1 Economic appraisal

The main focus of the economic appraisal was on the financial benefits accrued by the municipality. This section describes the criteria used to appraise the financial benefits of the proposed projects. Where the benefits resulting from a proposed smart grid technology solution were also accrued by the customers – and not only the municipality – this was clearly stated in the analysis.
The following concepts / indicators were used for the financial appraisal of benefits, and are elaborated below: benefit-cost ratio, net present value, and payback period.

**Benefit-cost ratio**

For the economic benefits of a smart grid intervention, the first step was to investigate the savings or ‘reduced losses’ achieved through the proposed technology solution. Based on the typical lifetime of the smart grid technology proposed, projections of losses and savings are made into the future (assumptions made in the modelling exercise will be elaborated on in Chapter 7). These values are then discounted back to a present value, with a similar calculation performed for the cost of implementation. A benefit-cost ratio is determined, giving an indication of the economic value gained from the intervention. Each intervention would, of course, involve various costs and would provide value in different ways.

**Net present value**

Another economic appraisal technique used was the net present value. Following on from the discounting of future costs and benefits, the total ‘value’ of the project was determined each year - done by subtracting costs from benefits. These yearly values were discounted to a present value and then totalled, to give a single present value of the whole intervention over its lifetime - a net present value.

**Payback period**

To indicate how soon a municipality could expect an intervention to have paid itself off, a payback period calculation was also done. In this calculation the cost of intervention was subtracted from the benefits realised, giving a yearly ‘total benefit’ figure. This figure was then accumulated over the project lifetime. The point at which the cumulative sum was greater than zero determined the payback period.

### 6.2 Non-economic appraisal

This section describes appraisal techniques used for the non-economic elements/benefits accrued from the proposed technology solutions.

The importance of including a non-economic appraisal section derives from the fact that the municipality is a service deliverer to the public, and so a significant indicator of whether a municipality is meeting its service delivery objectives is customer satisfaction.
Another aspect of development which is becoming increasingly important is the notion of sustainability, specifically in the environmental sense. Development in the 21st century must now consider the environmental impacts, better still benefits, of proposed projects.

**Sustainability**

The notion of sustainability, for the purposes of this analysis refers to environmental and social sustainability. The indicators that were used to gauge the ‘sustainability’ of the proposed technology solutions included:

- uptake of distributed generation facilitated by the project
- reduction in municipal peak demand – which is understood to have the cumulative effect of reducing the required generation capacity and therefore emissions
- employment generation
- energy efficiency improvements

Though some of these indicators could be translated into economic terms, this was purposefully not done, as a means of maintaining transparency.

**Customer satisfaction**

As a service deliverer, the municipality must ensure that its customer base is at the core of all developments, and so it is essential to appraise the customer impact of the proposed smart grid implementations. For the municipality itself, customer satisfaction is a significant criteria as this directly affects the municipality’s council- voted for by the public, which takes executive decisions on the operation of the municipality.

The indicators that could be used to appraise customer impact vary and depend very much on the nature of the technology intervention and its purpose. The municipality would also be able to report on official performance indicators such as the SAIDI and SAIFI figures which speak directly to customer service.
7. COST BENEFIT ANALYSIS

This chapter details the results of the cost benefit analysis (CBA) performed for the smart grid technology solutions proposed for Drakenstein municipality. As described in Chapter 6, this appraisal considers both the economic and non-economic benefits accrued from the proposed projects. While chapter 4 described the proposed vision and initial project, this chapter will focus specifically on the two suggested short term implementations- herein referred to as ‘projects’- namely: substation metering to enable energy balancing, and fault detection to reduce outage times.

In this analysis the present value of the costs to implement and run the project are compared to the present value of the benefits to determine the net present value of the project. The net present value represents the value of the project discounted to its present value.

In this analysis we will look at the viability of an implementation of adding 750 meters on high end residential customers to the smart metering system. The model takes expected consumption of these users and compares the municipal earnings before and after the implementation to determine the net benefit of implementing meters.

7.1 Benefits

Benefits in this analysis are limited to financially quantifiable benefits; the project may also include benefits that are not easily quantifiable, such as customer satisfaction, but these are not included in this analysis. The reason for not including these benefits is that municipality has very limited funds, and if the project to be successful it must be able to pay itself off through direct financial means.

The benefits that have been included in this analysis are:

Avoided Capital expenditure

- This represents the capital purchases that are avoided by implementing the project
- Calculated using municipal capital budget and planning.

Avoided Operational Expenditure

- All day to day costs that are currently required, but not required for smart metering
Reduced Maintenance Spending from reduced peak demand

*Increased Sales Revenue*

- Based on difference in monthly income for modelled data.

### 7.2 Costs

The costs that have been included are:

*Installation/Implementation costs*

- Purchasing of meters
- Installing of meters
- Purchasing of communications
- Installation of communications

*Additional Operational Expenditure*

- All day to day costs that are not currently required, but required for smart metering

### 7.3 Assumptions

In order to build the model for the cost benefit analysis certain assumptions were required to be made. These values should be readjusted after a pilot project has been conducted to get a more accurate prediction.

The first of these was the expected behavioural shift of customers being put onto a time-of-use tariff. This behaviour shift is the primary goal of a time-of-use tariff as well a leading motivator for the implementation of smart metering. Moving load out of peak times is a key to the success of smart metering, as it reduces the maximum loading on the grid and decreases required capital expenditure. This shift is assumed to be a 15% load shift from peak hours into standard hours, this estimation is based on estimates of 15% seen in other case studies when customers are given the opportunity to save 10% on their bills.

Customer savings and other benefits that do not financially help the municipality are not included as a financial benefit in this model. The savings were not included as they skew the cost of
A discount rate was used to translate all future amounts into present day values. The rate used for the modelling of this case was 8% per annum, based on the discount rate used by municipalities.

Loss reduction (both technical and non-technical) is not a factor which is included in the financial savings for this project. While smart meters can greatly reduce theft or decrease technical losses, smart meters alone do not prevent theft and losses. When combined with bulk meters and a theft prevention unit these meters can reduce theft but this is taken as an extra benefit rather than a direct financial gain.

The final predictions are the capex and opex savings created by the shift of load. For this project we assume that capital that would spent infrastructure capacity upgrades is reduced by decreasing the maximum loading on the system and similarly with reduced peak load opex is reduced primarily through maintenance. We have taken the reduction in capital expenditure to be 20%. Other case studies have had predicted capex reductions of 80%, but we felt this estimate is over optimistic for the South African market as there are upgrades such as redundancy upgrades that cannot be avoided through peak load reduction. Opex savings are predicted at 10% based on the portion of opex we predict can be reduced. Capex is only budgeted for a period of 5 years, capex after this time is taken to increase by 10% per annum for future unbudgeted years.

The effects of these assumptions, as well as the choice of their values are discussed further in our sensitivity analysis.

### 7.4 Tariff Generation

Due to the fact that Drakenstein does not currently have an active residential time of use tariff used in this modelling was calculated in order to fit certain requirements. The tariff was optimized in order to create the maximum revenue for the municipality within the constraints given. This optimization was done to ensure that the municipality does not lose money when customers shift their loads from peak times.

The main constraints used to generate the tariff were:

**Minimal increase in average customer bill**

- Customers should not experience large increase in bills when being shifted onto time of use. (This was enforced with a maximum of 1% on average)
To ensure this the tariff was calculated ensuring that the amount billed by the municipality does not change when shifting onto time of use.

**Incentive to shift loads**

- The tariff needs to ensure that customers are incentivized to shift loads. A tariff which charges more in standard time ensures high profit when customers shift load, but this will not occur without incentive.
- The incentive is ensured by enforcing a possible saving of 10% on bills when shifting peak loads in winter periods.

**Rational tariff**

- The tariff should not bill an extremely high or extremely low amount at any point.
- Optimization may find that billing extremely low amounts at certain times and high amounts at others offers an optimal solution. This does not work in reality, as customers’ behaviour changes dramatically when approaching extreme prices.
- To ensure the tariff does not become irrational the tariff is forced to charge at least the cost price from Eskom in all periods.

This optimization scheme produces a tariff that should offer the customer a chance to save money, and save the municipality money at the same time. This means that load shifting is beneficial for all parties involved.

### 7.5 Results

**No customer savings included**

The cost benefit modelling of the project for Drakenstein showed that is it possible under the right conditions for smart metering to pay itself off over its lifespan when all the municipal benefits are taken into account.

A graph of the cumulative net benefit of the proposed project can be seen in Figure 9: Cumulative net benefit of project, showing a payback period of just under 15 years giving the project a net present value of R76000.
Figure 9: Cumulative net benefit of project

This graph is based on a model created for the municipal electricity business, the output of this model can be seen in Table 1. From these results we can see that there is a net benefit – cost ratio of 1.03:1 and the project has an estimated net present value of R76000. Such a low over 15 years does not look like a particularly good investment, however there are also financial benefits for the municipality’s customers. These benefits will be looked at in the next section.
Table 1. Cost Benefit Analysis

<table>
<thead>
<tr>
<th>Year</th>
<th>Benefits</th>
<th>Costs</th>
<th>Total Benefit</th>
<th>Net Benefit</th>
<th>Cost vs Benefit (BCR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capex savings</td>
<td>Opex Savings</td>
<td>Meter Installation</td>
<td>Decreased Energy</td>
<td>Opex Costs</td>
</tr>
<tr>
<td>1.00</td>
<td>204897.51</td>
<td>95441.48</td>
<td>300338.99</td>
<td>1125000.00</td>
<td>164487.06</td>
</tr>
<tr>
<td>2.00</td>
<td>117599.02</td>
<td>93674.05</td>
<td>511612.07</td>
<td>143165.01</td>
<td>44166.67</td>
</tr>
<tr>
<td>3.00</td>
<td>292933.99</td>
<td>90236.76</td>
<td>894782.82</td>
<td>137911.70</td>
<td>43348.77</td>
</tr>
<tr>
<td>4.00</td>
<td>102053.51</td>
<td>88565.71</td>
<td>1085402.04</td>
<td>130390.55</td>
<td>41758.12</td>
</tr>
<tr>
<td>5.00</td>
<td>103943.39</td>
<td>83735.55</td>
<td>1273081.38</td>
<td>120997.36</td>
<td>40225.84</td>
</tr>
<tr>
<td>6.00</td>
<td>105868.27</td>
<td>80663.33</td>
<td>1459612.99</td>
<td>116201.23</td>
<td>38032.20</td>
</tr>
<tr>
<td>7.00</td>
<td>107828.79</td>
<td>74852.21</td>
<td>1642293.99</td>
<td>98509.72</td>
<td>35958.19</td>
</tr>
<tr>
<td>8.00</td>
<td>109825.62</td>
<td>70770.28</td>
<td>1822889.89</td>
<td>86427.88</td>
<td>33367.70</td>
</tr>
<tr>
<td>9.00</td>
<td>111859.43</td>
<td>64455.72</td>
<td>1999205.05</td>
<td>74423.61</td>
<td>30963.82</td>
</tr>
<tr>
<td>10.00</td>
<td>113930.90</td>
<td>59812.22</td>
<td>2172948.17</td>
<td>62899.87</td>
<td>28201.05</td>
</tr>
<tr>
<td>11.00</td>
<td>116040.73</td>
<td>53466.60</td>
<td>2342455.50</td>
<td>52176.01</td>
<td>25684.78</td>
</tr>
<tr>
<td>12.00</td>
<td>118189.63</td>
<td>48695.98</td>
<td>2509341.12</td>
<td>42478.98</td>
<td>22959.82</td>
</tr>
<tr>
<td>13.00</td>
<td>120378.33</td>
<td>42723.61</td>
<td>2672443.06</td>
<td>33943.71</td>
<td>20523.95</td>
</tr>
<tr>
<td>14.00</td>
<td>122507.56</td>
<td>38190.96</td>
<td>2833241.58</td>
<td>26621.15</td>
<td>18066.77</td>
</tr>
<tr>
<td>15.00</td>
<td>124878.07</td>
<td>32886.48</td>
<td>2991006.13</td>
<td>20491.62</td>
<td>15798.31</td>
</tr>
</tbody>
</table>

Towards a Smart Grid in Drakenstein Municipality 2013-2014
Customer savings included

The business case for smart metering is not particularly strong if you consider only the financial benefit for the municipality. While the project should pay itself off, it does not offer a large return on investment as the meters lifespan ends shortly after they pay themselves off. However when the customer savings are taken into account the result is dramatically improved.

Figure 10: Cumulative net benefit of project with customer savings included

This graph is based a model created for the municipal electricity business, the output of this model can be seen in Table 2. From these results we can see that there is a net benefit – cost ratio of 2.23:1 and the project has an estimated net present value of R 36 million. This is a much more appealing business case, but still does not cover the full range of smart grid benefits. In the next chapter some of the other benefits available will be discussed.
## Table 2. Cost Benefit Analysis with Customer Savings

<table>
<thead>
<tr>
<th>Year</th>
<th>Benefits</th>
<th>Capex savings</th>
<th>Opex Savings</th>
<th>Total Benefit</th>
<th>Costs</th>
<th>Decreased Energy</th>
<th>Opex Costs</th>
<th>Total costs</th>
<th>Net Benefit</th>
<th>Cost vs Benefit (BCR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>654356.62</td>
<td>204975.71</td>
<td>9541.48</td>
<td>940095.61</td>
<td>1125000.00</td>
<td>164487.46</td>
<td>45000.00</td>
<td>133487.46</td>
<td>-170391.85</td>
<td>0.35</td>
</tr>
<tr>
<td>2</td>
<td>651464.83</td>
<td>117599.02</td>
<td>93745.35</td>
<td>126835.52</td>
<td>143165.01</td>
<td>41610.67</td>
<td>152189.14</td>
<td>305014.38</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>592037.65</td>
<td>292933.95</td>
<td>96236.75</td>
<td>2802041.92</td>
<td>137911.70</td>
<td>43358.77</td>
<td>1703079.61</td>
<td>1098962.32</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>498177.29</td>
<td>102053.51</td>
<td>85865.71</td>
<td>4900983.44</td>
<td>130390.95</td>
<td>41758.12</td>
<td>1875278.68</td>
<td>1515809.76</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>388145.69</td>
<td>109343.59</td>
<td>83775.55</td>
<td>4066661.47</td>
<td>120937.36</td>
<td>40225.84</td>
<td>2036451.88</td>
<td>2030211.60</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>280015.36</td>
<td>105868.27</td>
<td>86663.33</td>
<td>4533210.44</td>
<td>110201.23</td>
<td>38032.20</td>
<td>2184685.31</td>
<td>2348505.13</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>187044.61</td>
<td>107828.79</td>
<td>74582.21</td>
<td>4902936.05</td>
<td>93509.72</td>
<td>35958.19</td>
<td>2319153.22</td>
<td>2583782.82</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>115870.05</td>
<td>109825.62</td>
<td>70770.28</td>
<td>5199219.01</td>
<td>86427.88</td>
<td>33857.70</td>
<td>2438948.80</td>
<td>2760270.21</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>66252.24</td>
<td>118953.43</td>
<td>64455.72</td>
<td>5441786.41</td>
<td>74423.61</td>
<td>30693.83</td>
<td>2544316.25</td>
<td>2897450.16</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>35131.77</td>
<td>113850.50</td>
<td>59812.12</td>
<td>5050060.70</td>
<td>62899.87</td>
<td>28201.05</td>
<td>2635437.16</td>
<td>3015223.54</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>17248.88</td>
<td>116040.73</td>
<td>53466.60</td>
<td>5837416.92</td>
<td>52176.01</td>
<td>25684.78</td>
<td>2713297.94</td>
<td>3124118.97</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>7841.62</td>
<td>118189.63</td>
<td>48695.98</td>
<td>6012144.15</td>
<td>42478.98</td>
<td>22959.82</td>
<td>2778736.74</td>
<td>3233407.41</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>3000.85</td>
<td>120378.33</td>
<td>42723.61</td>
<td>6178546.94</td>
<td>33943.71</td>
<td>20523.96</td>
<td>2833204.41</td>
<td>3345342.53</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1286.54</td>
<td>122607.56</td>
<td>38190.96</td>
<td>6340362.00</td>
<td>26621.15</td>
<td>18006.77</td>
<td>2877832.33</td>
<td>3462799.67</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>464.30</td>
<td>124876.07</td>
<td>32884.48</td>
<td>6498860.85</td>
<td>20491.62</td>
<td>15788.31</td>
<td>2914122.26</td>
<td>3584738.59</td>
<td>0.06</td>
<td></td>
</tr>
</tbody>
</table>

| 3507854.72 | 1972834.77 | 1018171.36 | 6898860.85 | 1125000.00 | 1305126.25 | 483996.01 | 2914122.26 | 3584738.59 | 2.23 |
7.6 Additional Benefits

When compared to the capital outlay of R1 Million this project does not give a particularly high financial rate of return if customer savings are not included; however the project is also justified heavily by benefits which do not give direct financial value. Benefits such as customer satisfaction, reduced carbon emissions, decreased pressure on national energy demands, alignment with national policy and customer savings all provide strong motivation for the project.

**Customer satisfaction and savings**

Time of use billing gives the customer the opportunity to save money on their electricity bill as well as giving them the ability to see how they use energy. With correct customer engagement customers should feel that they are receiving a great new technology that can help improve their lives.

As mentioned previously, customer service is a performance indicator, and improvements in this area serve as a direct benefit to the municipality.

**Reduced carbon emissions**

Reducing loads reduces carbon emission and creating a flatter energy use profile reduces the need for generation capacity that can handle peaking loads. This creates an environment which is more suited to renewable generation, as technologies like PV generation do not generally produce power in peak times.

**Decreased pressure on national energy demands**

Reducing peak loads decreased the need for Eskom to run extremely expensive diesel gas turbine generators. Reducing the cost of energy production for Eskom should serve the best interests of the country as a whole going into the future, and reduces the need for electricity tariff increases from Eskom.

**Alignment with national policy**

NERSA regulation 773 requires municipalities to have all customers using above 1000 kWh per month to be put on smart metering. While currently municipalities can get an exemption from this, national policy is clearly heading towards this.
Loss Reduction

While not included in the cost benefit due to the requirement of implementations outside the scope of the suggested project, smart meters do provide the opportunity for loss reduction projects.

Smart Grid Vision – Communications network

This project serves as a good way to spread a communications network, getting the municipality closer to the full smart grid vision, and all the benefits it brings. While many of the benefits of smart grids require more than one technology, it is impossible to implement them all at once. Moving closer to the full envisioned smart grid will provide long term benefits for the municipality.
8. RISK & SENSITIVITY ANALYSES

In this chapter we do a SWOT (Strength, Weaknesses, Opportunities and Threats) analysis of the suggested project, as well as a sensitivity analysis to see how variation in certain assumptions impact the CBA results found in the previous chapter.

8.1 Sensitivity Analysis

There were several assumptions and variables in the cost benefit analysis that can influence the outcome of the business case. These factors will be discussed here this chapter covers both the values we selected, the reason for their selection and the effect of changing them.

Variables:

Load shift

The expected behavioural shift of customers being put onto a time-of-use tariff plays a large role in determining the viability of the project. Without load shifting almost none of the benefits of smart metering can be achieved. The amount that load is shifted by effects both the capital savings that can be seem as well as increased profit margins. This shift is assumed to be a 15% load shift from peak hours into standard hours; based on predictions of expected load shifts from other case studies. Drakenstein municipality believes it is likely their users will shift their loads.

If the load shift is reduced the profitability of the project will decrease, and if no load shift is seen the project will fail to achieve any benefits. If the load shift is greater than expected the project will pay itself off much faster and earn the municipality more money.

In order to reduce the risk involved a pilot project is suggested. By monitoring the pilot project a better prediction of load shifting can be done, inputting that back into the model will provide more accurate information on which to decide a further course of action.

As Drakenstein already has the meters for the pilot project, the initial investment is low, and thus the risk is low. If the pilot project reveals that load shifting is unlikely future investments can be reconsidered.
Discount Rate

A discount rate was used to translate all future amounts into present day values. The rate used for the modelling of this case was 8% per annum. Increasing the discount rate will decrease the net present value of the project, while decreasing it will increase the net present value.

Capital Shift

For this project we assume that capital that would spent on infrastructure capacity upgrades is reduced by decreasing the maximum loading on the system. The capital savings created by the shift of load is assumed to be 20% as described above.

This assumption affects the profitability of the project as capital savings are used as a benefit, and thus increases and decreases have a direct effect on the value of the project.

If these savings are not reached it would require approximately 1.5% increase in tariff to recover the lost revenue.

Tariff Design

The tariff is designed with a single controllable variable, the incentive rate. The incentive rate represents the savings the customer can make for shifting their load. Increasing the incentive rate increases the incentive for customers to shift load and increasing their savings when doing so. By increasing customer savings municipal profits are decreased. The rate was set at 10% savings for a load shift of 15%. The value of this incentive shifts the benefit gained from load shifting towards the customer. If this value is reduced, the municipality would benefit more from load shifting, but the customers will be less likely to shift loads.

Risk here exists in the fact that it may require increased incentive rates to get the load shift required.

Tied closely with the risk of reduced customer load shift this risk is reduced through the pilot program, which should help the municipality determine the optimum incentive rate.

8.2 SWOT

Strengths

The strengths are the internal factors that give the project advantages over other options.
Strengths

1. Time of Use billing can be implemented to encourage peak shifting and energy efficiency.
2. Demand response technologies for customers:
   Available end uses for demand response:
   - Space heating and cooling systems;
   - Geyser control;
   - Regulating the lighting sources;
   - Managing electric appliances with adjustable time of operation (washing machines, dishwashers etc.);
   - Available remote and automatic load control devices;
   - Can share communications and backend with existing geyser control units.
3. Available commercial, off-the-shelf hardware and software for customizable feedback options on individual appliances monitoring and consumption data aggregation. Smart appliances are emerging on the market.
4. Available domestic communications (WiFi, Bluetooth, Wireless M-Bus, ZigBee, PLC/ HomePlug, and Ethernet) for data exchange between different smart metering elements inside individual household (Energy Meters, Appliances, IHD2, PC, Load control devices) for feedback and demand response purposes.
5. Available customer feedback mediums:
   - Internet and existing mobile networks;
   - Utilities billing system.
6. Municipality no longer makes a loss in peak times.
7. Customers get an opportunity to save on their bills.
8. Enables future distributed generation.
9. Enables municipality to manage non-technical losses (e.g. theft) better, through advanced tamper detection and energy reconciliation between minisub output and customer consumption.

Weaknesses

The weaknesses are the internal factors that give the project disadvantages over other options

Weaknesses

1. Customer Acceptance:
   - Integration of domestic consumers who are less motivated by purely economic concerns (minimal gains);
   - Domestic consumers are generally unable to make precise predictions on their available load flexibilities; therefore it is difficult for them to offer services in the classical sense;
   - Demand Response:
   - The benefits of demand response alone are in general not enough to justify large scale smart metering investments.
2. Change of tenants or occupants waters down effect of information campaigns and analysis of long term savings.

---

2 IHD: In home display
3. Remote or automatic load control devices and programs are not fully integrated (interoperability) to take full advantage of time varying and dynamic pricing algorithms including available end uses of demand response.

4. Non-availability of data:
   Historical data for past comparison (Historical feedback);
   Data for comparative benchmarking (Normative feedback).

5. Insufficient modularity and flexibility of present mass market smart metering products and lack of full interoperability among available commercial AMI3 systems. (Lacking Standards)

6. Compatibility and costs of emerging and available commercial off-the-shelf hardware and software for different smart metering elements inside individual household (Energy Meters, individual appliances consumption monitoring, IHDs, PC, Load control devices) used for feedback and demand response purposes.

7. Interoperability issues for third-party participation in offering remote or automatic load control devices and programs (Energy management devices).

8. In order to best capitalize on smart metering benefits the whole system needs to be in place.

9. Benefits for the supply side are mostly explored in ongoing smart metering projects.

10. The cost of installation.

11. Savings opportunities of TOU pricing requires customer and municipality co-operation.

12. Poor choice of communication can cause project to fail. Careful consideration is required in selecting communications platform.

Opportunities

The opportunities are the external factors that the project can exploit

Opportunities

1. Smart metering is a first and essential building brick of Smart Grids.

2. NERSA Regulation 773.


4. Leading role of electricity applications in Smart metering – Electricity meter can have “data concentrator” role for other metering (eg. water)

5. Third-party participation in information campaigns accompanying smart metering installation and the introduction of additional stimulation which will incite consumers to take the desired actions - Promoting “Green” attitude.

6. Use of existing billing to upgrade towards informative billing.

7. Savings opportunities
   Dynamic pricing for consumers;
   Elimination of meter reading costs;
   Reduction of power frauds (thefts);
   Remote activation and deactivation of service;

———

3 AMI: Advanced metering infrastructure
8. Emerging feedback technologies (new web and mobile applications, IHDs etc.)
9. Gaining consumers trust and participation.

Threats

The threats are the external factors that can cause trouble for the project.

<table>
<thead>
<tr>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Leading role of electricity in smart metering can lead to neglect of other energy (heat, gas) and water feedback options.</td>
</tr>
<tr>
<td>2. Interest and benefits for domestic consumers have the second priority as benefits for the supply side are mostly explored in ongoing smart metering projects. Utilities may see investments in consumer feedback programs non-profitable.</td>
</tr>
<tr>
<td>3. Too high expectations of smart meters - without consumer participation and additional services the meter itself is simply an &quot;enabler&quot; of energy savings.</td>
</tr>
<tr>
<td>4. The effect of more cautious energy use may erode over time without constant motivation.</td>
</tr>
<tr>
<td>5. Losing consumers’ trust and participation.</td>
</tr>
<tr>
<td>6. Security of personal information (safety and anonymity of the data transfer).</td>
</tr>
<tr>
<td>7. Partial implementation will not return anticipated results.</td>
</tr>
<tr>
<td>8. Benefits of smart metering may accrue to other parties than those that bear the costs of implementation.</td>
</tr>
<tr>
<td>9. Financial incentives may have to be introduced to make energy saving measures more attractive in economic terms.</td>
</tr>
<tr>
<td>10. If third party communications are used, poor service from the third party passes on to poor service to the customer, and possibly lost information.</td>
</tr>
</tbody>
</table>
9. CONCLUSIONS & RECOMMENDATIONS

This section of the business case seeks to outline what is to happen after the initial smart grid technology implementation phase. This describes the mid to long term steps that will finally lead to the smart grid envisioned for the municipality. To ensure that the vision described and the benefits realised for the smart grid are aligned with the municipality’s IDP and other development plans, such as the electro-technical service department’s Masterplan, this section outlines critical after-steps which must be taken.

9.1 Selection of a ‘municipal champion’

From the onset of the project it was recognised that the selection of a suitable ‘smart grid champion’ within the municipality was a key step towards successful implementation. The core function of this champion would be to ensure the realisation of the smart grid implementation process. Given that GreenCape’s role goes only so far as producing this business case and providing feedback and guidelines on the process of developing smart grid roadmaps, the champion must drive the continued success of the project.

Ideally the selected candidate will be intimately involved in the municipality’s electricity business and will know enough to contribute to the development of the smart grid vision, however technical knowledge is not a prerequisite, rather an understanding of areas of opportunity within the business is desirable, e.g. a senior staff member from the municipality’s finance department or the electro-technical services department.

9.2 Following the municipal budget and Integrated Development Plan (IDP) cycle

From the information gathered from the municipality’s finance department, the municipal budget cycle is very tight and highly structured, requiring any capital expenditure by the municipality to be on projects included in the municipality’s IDP.

To ensure that capital can be budgeted for the proposed project, it is important to identify strategic objectives of the municipality that the project addresses. This will improve chances of the project being accepted into the municipality’s budget. Beyond targeting access to the budget, to obtain overall acceptance of the project and support from decision making
structures within the municipality. The project researchers have developed a document titled *Municipal Procurement Processes* (GreenCape, 2014c), which outlines the legislation around municipal finance management, especially the procurement process and also the need for projects to align themselves with the budget and IDP. A general outline of the yearly budget review process is provided in the table below.

**Table 3: Municipal budget revision yearly schedule**

<table>
<thead>
<tr>
<th>Event</th>
<th>Estimated date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning and budgeting phase</td>
<td>July of previous year</td>
</tr>
<tr>
<td>Review of public engagement comments from IDP process</td>
<td>August - September</td>
</tr>
<tr>
<td>Municipal Directorates submit project plans for inclusion into the IDP</td>
<td>September - October</td>
</tr>
<tr>
<td>1st draft of budget for next year due</td>
<td>September of previous year</td>
</tr>
<tr>
<td>Finalised IDP and draft budgets for council approval</td>
<td>Midway through previous financial year</td>
</tr>
</tbody>
</table>

Having identified the relevant strategic objectives of the municipality’s IDP, which the proposed project talks to, it is important to align the project proposal and implementation schedule with the municipality’s budget cycle. Given that a 1st draft of the budget for the following year is prepared by September of the current budget cycle, this current project can only aim to be included in the budget for 2015/2016. This is for the case where funding for the project is channelled through government avenues and must therefore go through the municipality’s budget. This applies irrespective of whether the funding source is government, private sector, local or international – more of this in the document titled *Municipal Procurement Processes*. 
The table below details the basic schedule of the IDP process.

### Table 4 IDP process

<table>
<thead>
<tr>
<th>Event</th>
<th>Estimated date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1: Analysis- departments to submit performance reports</td>
<td>August-September</td>
</tr>
<tr>
<td>Stage 2: Strategy- public participation and input from community groups</td>
<td>September - October</td>
</tr>
<tr>
<td>Stage 3: Project (runs parallel to stages 2 and 4)- departments finalise their operation budgets and Mayoral council develop 1st draft of municipal budget</td>
<td>Can extend until January</td>
</tr>
<tr>
<td>Stage 4: Integration phase (runs parallel to stage 3)- involves quarterly performance reports, ward projects and other progress indicators and preparation of final IDP draft</td>
<td>January until launch of new IDP</td>
</tr>
<tr>
<td>Stage 5: Council approval of IDP</td>
<td>Approximately mid-year, in line with budget cycle</td>
</tr>
</tbody>
</table>

### 9.3 Lessons learnt

Incorporating a long-term vision as part of a business case for a short-term smart grid component, allows the leveraged value of the component to become apparent, changing what might have been a non-viable component into something that will be viable once it leverages as part of larger smart grid implementation. This long term vision strategy – when included in the municipality’s IDP, and therefore the yearly budget considerations – ensures that the development of the smart grid is well integrated into the municipality’s own development plans.

Through the case study process, the project team has gained some valuable insights into key issues that need to be considered when executing projects in and with municipalities.
Ensuring that these are considered and well thought out contributes to ensuring the success of any suggested projects. These are: managing stakeholder expectations, communications best practice, municipal business constraints, case study candidate selection, and data collection issues.

**Managing stakeholder expectations**

Municipalities are often overwhelmed with basic municipal service requirements and so are wary of taking on further projects that may not seem to speak directly to these requirements. It is thus important that the benefits of the proposed project be communicated very early on to the municipality. Furthermore it is important to communicate how the project will be aligned to the municipality’s current development plan as outlined in the IDP and budget.

The role the municipality is to play, what is expected of municipal staff and what the municipality expects of the project researchers and the project itself must all be clearly defined. For instance, if the bulk of work is to be done by the project researchers, with the municipality offering minimum guidance and information, this must be made clear, so that the project is not too daunting to the municipality.

**Communications best practice**

*Establish solid communication lines*

It is crucial, from the very beginning, to establish good communications with the relevant staff members of the municipality. The approach used in this project was to try and get a meeting with the Municipal Manager, the Chief Finance Officer (CFO) and the Head of Technical services/ Head of electricity department early on in the project. This ensured that key decision makers were on board – if this was not the case, chances of project success are slim to none. Agreement with these key stakeholders ensured that the acquisition of data and co-operation from other staff members was simpler.

*Strive for live meetings*

It was noted that meetings in person with relevant staff members were always far more productive than long email conversations. It is thus highly recommended that as far as possible, regular meetings in person be held with the municipality to share information, clarify matters and maintain good working relations.
Municipal business constraints

It is very important that any project team (external to municipal workings) very quickly
familiarises itself with the numerous processes involved in municipal decision making,
especially around procurement. The municipal IDP and budgets are paramount to municipal
operation and so new projects must find their way into these documents, not only as a
means of securing funds, but also ensuring their continuity beyond just the implementation
phase. Municipal procurement processes are succinctly highlighted in the GreenCape
document Municipal Procurement Processes (GreenCape, 2014c).

Case study candidate selection

The selection of appropriate case study candidates is crucial to the success of the project in
terms of ensuring that the selected municipalities are likely to co-operate and participate in
the project, and ultimately are likely to gain value from the project. Thus, it is important to
develop thorough selection criteria, adjusted to the envisioned case studies and what
information the project seeks to extract and disseminate from the work done. The selection
criteria used to pick this municipality is outlined in GreenCape’s Criteria for selecting case
study municipalities (GreenCape, 2014a).

Data collection issues

Often data is central to the case study, both easy access to it and its relevance – in the way
of format and specific detail – to the proposed case study methodology. Thus, ensuring, at
the beginning of the project, as far as possible, that the case study methodology aligns well
with data that is readily available in the municipality is crucial to the timeous completion of
projects. Alternatively, as often it takes time and resources to extract the requisite data,
sufficient resources may be allocated to the acquisition of data from the onset of the project.
Whatever the case may be, it is essential that the flow of data from the municipality into the
project and vice versus is secured, to ensure that a useful, relevant and complete project is
achieved.

9.4 Conclusions

Smart metering in Drakenstein provides an opportunity for the municipality to offer its
customers large savings, reduce the stress on their grid and on Eskom, help the
environment, align with national policy and gain valuable information on their grid. These
benefits can potentially come at a relatively low long term cost and risk to the municipality if a
pilot project is properly executed and evaluated. To ensure the success of the smart
metering project, it is essential that the municipality develop and adopt a thorough customer engagement campaign, as the success of the intervention largely relies on changes in customer behaviour. Furthermore, it is strongly recommended that the municipality engage in this current intervention and all future smart grid implementations, via a phase-by-phase approach. Not only does such an approach hold many benefits, such as allowing for extensive and effective monitoring and evaluation, allowing for lowered capital costs for each project phase, and enabling the municipality to implement said project phases with its in-house capacity, but it also allows the municipality the opportunity to feed in lessons from each experience into the longer term smart grid vision.

As mentioned, the core of a smart grid is the communications platform installed, and so it is re-emphasised here that the municipality makes a concerted effort to select an appropriate communications platform. The platform should be selected taking into consideration future interventions that will rely on a communications platform – and therefore future needs for increased data handling capabilities, data security, and integration with multiple systems.
10. REFERENCES


Ernst & Young. (2013). *Cost-benefit analysis for the comprehensive use of smart metering systems* (pp. 1–68).


IBM. (2013). Smart meters for a smarter planet.


Stone, S. (2013). Drive for prepaid power or smart meters. BDLive.

