Energy, Efficiency, Tariffs, and New Technology – what are the links?

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BACKGROUND

South Africa’s Traditional Energy Environment.
South Africans have traditionally been divided between a first world and a third world community. As far as energy is concerned the first world community primarily made use of electricity for residential, commercial and industrial purposes. They used petrol and, to a certain extent, diesel for private transport and mostly diesel for farming, commercial and industrial transport. There was always some sensitivity regarding a vehicle’s fuel consumption. The 1973 fuel crisis dramatically reduced the number of V-8 cars on the South African roads. However, electricity stayed “cheap” and nothing really dampened the increasing consumption of this commodity.

For the bigger part of South Africa’s population, energy consisted of whatever will burn. Energy from fires for cooking and water heating was the norm. Travel was on foot, bicycle, train or Taxi. In rural areas fires were made from wood or animal dung. In urban areas wood, paraffin, coal and some LP-gas was used. Electricity was generally a luxury. This has all changed.

Cheap Eskom energy
For many years South Africans have been told that Eskom’s electrical energy is one of the cheapest in the world. When using the standard exchange rates for different countries this view could be supported. However using the very well-known “Big Mac” rate, a different picture emerges. Notwithstanding, electricity in South Africa was perceived by the first world community to be “cheap” and plentiful.

The rest of South Africa just kept on wishing to share in this commodity.

Energy Crunch
In 1992 NELF came into existence. Electrification of South Africa became a government priority. In 1994 a new political dispensation came in place. With it came large changes and the focus on Eskom’s long term energy plan became blurred. REDS and the privatisation of part of South Africa’s generating needs failed to mature. This added to Eskom’s woes and led to mass shortages of electricity in 2008. This in turn led to mass rolling blackouts causing incalculable damages to the South African economy and the electricity infrastructure.
Tariff Focus
National Government accepted a new electricity strategy and although challenges were many, in 1990, at the beginning of the electrification programme, South Africa possessed an extremely energy-intensive economy. Eskom was a world-class electricity supply industry with a 55% generating reserve margin due to overbuilding in the 1980s. This changed to the extent that South Africa experienced rolling blackouts in 2008. What did this do to the electricity tariffs?

Graph 1
Comparing the accounts for a typical 1,1 MVA industrial consumer with a MegaFlex tariff, a HomePower Basic 4 consumer, and the CPI leads to the result shown in Graph 1. From this it is clear that Eskom’s electricity price for Industrial and residential consumers respectively increased 2,5 and 2,7 times faster than the average consumer price index.

This graph depicts the Eskom situation but as MegaFlex is the supply tariff for most municipalities, one can safely assume that a very similar trend will be applicable for Municipal consumers.

Metering
Pre electrification, all residential consumers were metered with a single phase electromechanical meter. These meters have basically stayed the same for almost a century. In South Africa, the introduction of the electricity-for-all program meant that many premises with non-banking consumers were electrified. Credit metering was obviously not the solution for this new consumer group. This led to the local design of pre-payment meters. Most of these started off as proprietary, but with the lead of Eskom and the AMEU through the NRS a set of standards were developed. The STS standard was even adopted internationally as IEC 62055-41: ELECTRICITY METERING - PAYMENT SYSTEMS - Part 41: Standard transfer specification (STS) - Application layer protocol for one-way token carrier systems.

The electronic device market exploded since the late nineties. It was led by the cellular phone industry. Real time information and contact became very important. Labour became more and more expensive and alternative and better ways of service delivery became a major focus. Utilities also felt the pinch and meter manufacturers saw the opportunity for introducing remotely readable meters. More for less! Initially this was done through drive by systems. But once this wave started there was no stopping it and Smart Metering is alive and well. ‘Drive by’ is now seen as archaic!
The Smart Metering industry worldwide is a fast expanding industry. The money budgeted and spent on this technology is mind boggling! Graph 2 gives an indication of the history and expectation of smart meter shipments to the major regions of the world. Again the Middle East/ Africa region seem to be lagging behind!

**Graph 2**

*Smart Meter Shipment by Region, World Markets: 2008-2015*

![Graph Image](image)

(Source: Pike Research)

**Billing**

Because of the traditional use of credit metering, billing had to follow suit. Monthly meter reads led to monthly bills. Meter reading is phased throughout the month and leads to so-called billing cycles. This meant that bill payment dates also fell on all the workday of the month. This is very convenient for the utility but mostly frustrating for the salaried consumers that got their pay regularly on a single day of the month.

**Control**

The bulk of current day electricity meters are still electromechanical, non-intelligent, non-controllable pieces of equipment. The meters can only be read on site by meter-readers actually visiting the meter. No control either by the utility or the user is possible. Connect, disconnect happens manually through an external supply circuit breaker.

The exception to this is the use of pre-payment meters. Here the consumer “feeds” the meter with credits and the meter deducts from these credits as the consumer uses energy. Once the credit is depleted the meter automatically disconnects the user’s supply. This limited control is generally preferred by users with strained financial capabilities. With pre-
payment metering, the consumer feels in control and do not get “surprises” a month after the event.

**WHAT CHANGED?**

**The Green Factor**

The “Greenies” have been with us for a few decades. Initially they were generally seen as a small crazy group of radicals primarily concerned with stopping whale hunting and nuclear activities. Unfortunately as time passed, social networking became freely available and “serious” scientists became verbal, the general public started to take note. It became clear to all of us that our environment was changing. The change in world weather patterns was the most obvious.

**Awareness**

Former United States Vice President Al Gore's campaign to educate world citizens about global warming via a comprehensive slide show that, by his own estimate, he has given more than a thousand times and the 2006 documentary film “An inconvenient truth” directed by Davis Guggenheim about this presentation, must be one of the most influential individual sensitising actions to date.

The world media, with heart breaking visuals on natural world disasters added to the general public’s awareness on the issue of global warming.

At the same time most governments of the world have already promulgated some form of legislation regulating the environment within. They also participate in world summits like the upcoming “Earth Summit 2011”. The Environment Agency - Abu Dhabi (EAD) will host the ‘Eye on Earth Summit’ on December 12-15, 2011 in Abu Dhabi, in partnership with the United Nations Environment Programme (UNEP).

An expected outcome of the summit will be a clear statement on ways and means to strengthen existing initiatives and fill gaps towards informed policy making in support of a sustainable future. In addition, it is anticipated that a number of special initiatives to strengthen capacities in developing countries will be formulated with commitments form the donor community.
Global warming
Most of the “green” focus today is on global warming, what causes it and how to prevent it.

Internationally the effects of global warming are clearly visible. The average temperature of the world is increasing. The effect is that great ice masses are reseeding with increasing speed. Great glaciers have already disappeared. The pictures above are of the Parstese Glacier in Austria taken in 1875 and 2004! This glacier is gone and will not reappear soon!

The global impact since 1970 is shown in Figure 1 below:

Figure 1: Glacier change 1970 to 2010

Mountain Glacier Changes Since 1970

Other effects that are just as devastating but not always as visible are changes in weather patterns, crop yields, biodiversity changes, re-appearance of illnesses like malaria, and a general increase in the frequency and severity of adverse weather conditions like tornados.
The Cost Factor
South Africa has a mix of primary energy resources. Graph 3 depicts the energy mix and it is clear that Coal at 69% is still the dominant source, followed by crude oil and renewables at a small 16% and 10% respectively.

Graph 3: South African Energy Sources

An international study was carried out by an ad hoc group of officially appointed national US experts. Cost data provided by the experts for 27 coal-fired power plants were compiled and used by the joint IEA/NEA Secretariat to calculate generation cost. Construction times are around four years for most plants. At a 5% discount rate, the levelled generation costs over 40 years of nearly all coal-fired power plants range between 25 and 50 USD/MWh. The more important metric is the relationship between costs. Investment costs represented around 35%, O&M cost accounted for some 20%, and fuel costs for some 45% of the total. An unstable coal price will therefore have a visible impact on the generating cost of electricity. Establishing a plant lifetime coal contract will be the only way to alleviate this threat.

Coal
The US International Energy Agency ranked South Africa the country with the sixth largest coal reserves and fifth largest coal producer in 2011 (See Table 1). The perceived abundance of coal in South Africa made this the energy source of choice. However, international coal prices seem to attract more coal exports and the local cost of coal to Eskom suffers accordingly.

Table 1

| Top Ten Hard Coal Producers (2010e) |
|-------------------------------|------------------------|-------------------|
| PR China                      | 3162Mt                 | Russia            | 248Mt             |
| USA                           | 932Mt                  | Indonesia         | 173Mt             |
| India                         | 538Mt                  | Kazakhstan        | 105Mt             |
| Australia                     | 353Mt                  | Poland            | 77Mt              |
| South Africa                  | 255Mt                  | Colombia          | 74Mt              |

Source: International Energy Agency 2011
The availability of the South African coal price is limited to 2008. As a comparison the Australian coal price history as published by the US Energy Information Administration is shown in Graph 5. The trend up to 2008 is very similar to that of the South African trend. The price escalation over the last ten years is approximately 4.6 to 1. This is even higher than the price escalation of Eskom.

Graph 5: Ten year Australian coal price

With so much coal available in South Africa, it is understandable that Eskom’s major power generation expansions would be coal based.

In 2006, Eskom received a licence to build the first new coal-fired power station in more than 20 years being Medupi power station in Lephalale, Limpopo Province. An official sod turning took place on 14 August 2007 and to date terracing is approximately 60% complete and slip columns construction on the first two units is near complete.

On 29 February 2008 Eskom awarded contracts worth about R31.5 billion for its "Kusile Project", a coal-fired power station being built near Emalahleni in Mpumalanga. This station is expected to be completed in late 2016. Terracing work begun in middle 2008 and the first unit is planned to be online by 2013.

Efficiency

Technologies

The evolution of technologies is happening at an ever increasing speed. The current generation must be known as the technology generation. When we as parents and grandparents want some electronic gismo sorted out, we only have to give it to a teenager. In a wiz it will be up and running. Almost all urban children have a cellular phone of their own. These phones are generally mini computers in their own right and enable the user to communicate verbally, by texting, tweeting, twittering, surfing and/or face-booking with any other phone or even computers anywhere in the world! This is the visible environment. To enable this and many other functionalities, that we seem to take for granted, a mired of “invisible” technological infrastructures exist.
Data handling

In the “good old days” almost everything was based on analogue values with its major limitations. Today almost everything is digital and with that everything can be sped up and condensed. Relatively secure and reliable data transfers at thousands of millions of bits per second are commonplace. To enable this, millions of kilometres of copper wire and optical fibre cables have been put in place. The number of dedicated radio frequency links is unknown. Figure 2: Satellites around the globe, gives a graphical interpretation of the number and placement of satellites currently orbiting earth in order to send or repeat data back to earth. These satellites perform weather monitoring, data repeater, Global Positioning and many other functions.

Earth-orbiting satellites can cover remote areas out of reach of wired networks or where construction of a cellular network is uneconomical. The Inmarsat satellite telephone system, originally developed in 1979 for safety of life at sea, is now also useful for areas out of reach of landline, conventional cellular or marine VHF radio stations. In 1998 the Iridium satellite system was set up, and although the initial operating company went bankrupt due to high initial expenses, the service is available today.

Cellular phone technologies

Dr. Martin Cooper of Motorola, made the first US analogue mobile phone call on a larger prototype model in 1973. The picture to the left is a reenactment in 2007.

Cellular technologies have come a long way since then. The smart phone with 3G, internet, multi megapixel photography, and much more is freely available and comes free with data and voice bundles from service providers like Vodacom, MTN and Cell-C. The iPad3 is on the horizon and promises to outperform its older brother the iPad2 dramatically. The iPad2’s spec sheet already reads like something impossible! It is a phone, camera, modem, computer, library, diary, television, and much more. The iPad includes Wi-Fi connectivity as well as 3G connectivity. 3G uses cellular signals — the same signals your cell phone uses — to connect to the Internet and is very useful if you’ll be spending time in places without Wi-Fi hotspots, such as outdoors or on your morning commute. The Wi-Fi facility on the other hand, makes connectivity easy and fast in widely available Wi-Fi hot spots.
By 2009, it had already become clear that, at some point, 3G networks would be overwhelmed by the growth of bandwidth-intensive applications like streaming media. Consequently, the industry began looking to data-optimized 4th-generation technologies, with the promise of speed improvements up to 10-fold over existing 3G technologies. The first two commercially available technologies billed as 4G were the WiMAX standard (offered in the U.S. by Sprint) and the LTE standard, first offered in Scandinavia by TeliaSonera.

One of the main ways in which 4G differs technologically from 3G is in its elimination of circuit switching, instead employing an all-IP network. Thus, 4G ushered in a treatment of voice calls just like any other type of streaming audio media, utilizing packet switching over internet, LAN or WAN networks via VoIP.

**Software**

Computer software, or just software, is a collection of computer programs and related data that provide the instructions for telling a computer what to do and how to do it. In other words, software is a conceptual entity which is a set of computer programs, procedures, and associated documentation concerned with the operation of a data processing system. We can also say software refers to one or more computer programs and data held in the storage of the computer for some purposes. In other words software is a set of programs, procedures, algorithms and its documentation. Program software performs the function of the program it implements, either by directly providing instructions to the computer hardware or by serving as input to another piece of software. The term was coined to contrast to the old term hardware (meaning physical devices). In contrast to hardware, software is intangible, meaning it "cannot be touched". Software is also sometimes used in a more narrow sense, meaning application software only.

**Apps**

Application software, also known as an application or an "app", is computer software designed to help the user to perform specific tasks. Examples include enterprise software, accounting software, office suites, graphics software and media players.

In the electricity environment we are more concerned with utility applications. These will range from Automated Meter Reading (AMR) to very sophisticated Network System Design and operations. The latest focus worldwide is on the so called “SMART GRID”.

Applications for this environment include but are not limited to Smart Metering, Smart Communications, Energy Management, Outage Management, Smart Billing, Loss Control,
Load management and Meter Management. Within each of these applications you will find numerous different strategies, developments and “standards”.

**Metering**

The traditional role of the utility meter has changed dramatically from an accumulating unit counter to an intelligent interface device. Unit counting, or metering as it is known, has just become one of the functions of the “meter”. Meters increasingly function as part of an integrated power system - the Smart Grid. Its role has become an interface between the customer, the environment and the utility.

A typical smart meter, shown below, will enable the utility to:

- Do remote meter reading at very short intervals – typically 15 minutes;
- Monitor near-real-time energy consumption;
- Do data storage of billing data and load profiles;
- Do load limiting by limiting the main contactor or activating appliance control devices;
- Monitor tampering;
- Monitor quality of supply;
- Do energy balancing;
- Do remote connect and disconnects;
- Communicate with the customer via a customer interface;
- Remotely change tariffs;
- Apply time-of-use, block-interval and pre-payment tariffs;
- Do load profiling; and even
- Monitor local temperatures.

In short, the smart meter will be the utility’s grass roots “nerve point” and interface with its environment and customer.

**Billing**

With extremely reliable electronic remote meter reading at programmable dates, or all on the last minute of the last day of the month, billing becomes a breeze provided the communication infrastructure/technology supports it. Human intervention is reduced to managing the exceptions reported by the system. Remote meter reading enables the clarification and rectification of any exception prior to the bill actually being sent out. ‘Move-ins’ and ‘move-outs’ can happen in almost real time and with the electronic history in hand, Customer Support Services will be able to solve most queries from the customer without having to refer it to field personnel, meter specialists or accountants.
Payment
By having billing information available within 24 hours after the end of the month, the customer can have the bill in hand by the tenth day of each month and payment should be in the bank by the end of the month. This will reduce average credit days to around 30 compared to the national average of between 45 and 90 days.

In addition, by linking the meter and its associated CIU with the billing system, it will be possible for the utility to inform the customer within hours of unpaid accounts. If the customer does not respond the utility can disconnect the supply remotely. This period is however governed by NERSA and will be seven days minimum. In the meantime however, the current capacity to the premises can be limited remotely, limiting losses by the utility, should the account go south.

Efficiencies
Efficiencies can be defined and measured in many spheres of the electricity industry. It includes efficiencies in energy consumption, capital deployment, system usage, operations, and many more. The Smart Grid focuses on improving most of these efficiencies, but energy efficiency and capital optimisation are at the top of the list.

By definition a Smart grid is a type of electrical grid which attempts to predict and intelligently respond to the behavior and actions of all electric power users connected to it - suppliers, consumers and those that do both – in order to efficiently deliver reliable, economic, and sustainable electricity services.

In Europe, the smart grid is conceived of as employing innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies in order to:

- Better facilitate the connection and operation of generators of all sizes and technologies;
- Allow consumers to play a part in optimising the operation of the system;
- Provide consumers with greater information and options for choice of supply;
- Significantly reduce the environmental impact of the whole electricity supply system;
- Maintain or even improve the existing high levels of system reliability, quality and security of supply;
- Maintain and improve the existing services efficiently.

To underscore the importance of energy efficiency, the South African National Energy Efficiency Agency (NEEA) was officially established in March 2006 through a directive issued by the Minister of Minerals and Energy. Located within CEF (Pty) Ltd as a wholly incorporated division, the Agency commenced operations on 3 April 2006 and will be subject to review in three-year intervals, in line with the national Energy Efficiency Strategy, which was approved by the Minister of Minerals and Energy in 2005.
It is envisaged that the NEEA will initially oversee the implementation of DSM and Energy Efficiency projects undertaken by Eskom and other entities in the country. The Demand Side Management (DSM) funds however, will in the interim remain with Eskom as the main implementing agency, who will continue to manage these funds with the oversight of the NEEA governance body.

As part of the DSM a national solar water heater project is underway. This technology can save up to 40% of a household’s energy consumption. Blanket roll out in to-be-electrified areas will reduce the household ADMD with between 0.8 and 1.2 kW. This has a huge impact on the distribution design and results in major savings.

**Best practices**
Evaluating what is happening throughout the world, it is clear that there is no one best practices yet. There are no common standard for smart grids, smart metering or smart communications. The world is still a haze of proprietary actions.

However, not all is lost because there are already many task and working teams actively pursuing standardisation and interoperability. Technological changes have also made it possible to start picking low hanging energy fruit.

The most obvious solution has already been mentioned: solar energy. The solar water heating technology is quite mature and very well established. The photo voltaic (PV) technology on the other hand is still developing rapidly. It is still a rather expensive solution towards energy supply. Solar farms with different technologies to generate electricity are also run as pilots.

The lighting industry is another arena where the energy efficiency envelope has been pushed hard. The compact fluorescent lamp (CFL) is fast replacing the traditional incandescent lamp. Light emitting diodes (LEDs) have developed to the level that they are now starting to challenge CFLs. In South Africa, local authorities and to a greater extend Eskom, have been very active in promoting the replacement of standard incandescent lamps with CFLs.

**Legislation**
The legislative environment in South Africa is one of the fastest changing in the world! It seems impossible to keep up with new Acts. For the utility environment some legislation needs elevating but will not be discussed further. Regulations published in terms of the
acts are also very important as the regulations normally set the boundaries of legal activities and responsibilities.

These acts are:

- The Public Services act
- Electricity Regulation Act, 2006. (No. 4 of 2006)

Government Notice, R. 773 Electricity Regulation Act (412006): Electricity Regulations for Compulsory norms and Standards for Reticulation Services needs special mention.

The following is a quote from that regulation:

“2. In order to maintain good quality of supply, to ensure stability of the electricity network, to minimise electricity load shedding and to avoid blackouts, the following norms and standards for reticulation services must be maintained in an area of jurisdiction:

(a)...

(d) An end user or customer with a monthly consumption of 1000kWh and above must have smart system and be on time of use tariff not later than 01 January 2012;

(e) Sub-regulations (b) and (c) do not apply in an event where the licensee can remotely reduce or increase the supply of electricity to the building using a smart system.”

From this it is clear that all electricity utilities must have smart systems in place by 1 January 2012. No information to the contrary seems to exist!

QUO VADIS
It is very important to know where to! But it is as important to know where from! Without these two references there is no possibility of planning the route. Other factors to consider must be how soon/fast and obviously what will it cost?

Status Quo
The status quo for any utility is normally perceived to be very well known. However once a structured due diligence study is started the anomalies, unknowns, errors and wrong perceptions soon show itself.
What to benchmark to?
Utilities are normally ill equipped to do their own due diligence studies. However external facilitators of due diligence studies are normally well equipped to lead the utility through the information gathering process. Once completed the results are moderated and reported on with clear reference to national or international benchmarks. These results must lead the utility into the next phase of the process, i.e. the SWOT analysis.

SWOT
The SWOT analysis is a very well-known exercise and again an independent facilitator should lead the top structure of the utility through this process. The SWOT analysis is a group exercise and cannot be done in the Bosses office!

Strengths
During this phase of the process all the utilities related strong points are listed – not discussed!

Weaknesses
Here the utilities weak points are listed.

Opportunities
Here the utilities opportunities are listed.

Threats
Now the threats are listed.

Once this is done each of the SWOT elements are analysed by the group. Similar issues are grouped together to eventually get a few representative generic issues within each element.

Cross Analysis
Finally, the cross-analysis is done. Here the weaknesses are countered with strengths and the treats with opportunities. Unmatched elements get special attention and strategies are developed to address each and every weak point and threat.

These strategies must be communicated to and accepted by the utility as a whole!

SO... WHAT ARE THE LINKS?
In short: A well developed and integrated business system with supporting communications. The SMART GRID! Is this too bold a statement?

Apparently not! All the elements are already there. The challenge lies in deciding on the appropriate elements, then integrating them into an architecture that supports the vision of the utility. However, the communication and data handling elements are of key importance.
With the smart grid, energy consumption will be monitored and controlled via the smart meter and smart customer interfaces. The customer will be able to manage own consumption. The correct tariff structures will give the financial signals and motivation for the customer to want to manage consumption. The smart meter will also enable the customer to be aware of supply constraint, and to participate in load reduction rather than to be totally without power. Those consumers not playing ball, will be warned individually by the meter via the customer interface unit and will eventually experience a power outage. Smart communication systems will be up and running, as these systems like customers on life support systems, hospitals, schools and the like will be identified and each treated according to an agreed upon supply plan. With the communication intact, repenting customers will be able to get back on line through a phone call, SMS or the like.

By having reliable data on consumption, tampering and energy balancing, non-technical losses can be reduced to almost zero. These losses currently run into Billions of Rand for the South African electricity distribution industry. If reduced, the savings can be used to alleviate the tariff burden. Alternatively it can be used towards obtaining the universal electrification goal. In the same vain, technical losses will also become transparent through a proper energy balancing system and here those inefficient grid elements will show themselves very quickly, leading to more efficient maintenance and replacement plans.

Finally, through the smart metering system, it will become possible to monitor and determine which elements like transformers, cables, power lines and generating plant in the system are over- or under-utilised and system operational adjustments can be made. This will reduce outages, I²R loses and ensure a better rate of return on capital when an optimised, just-in-time build program is established.

**CONCLUSION**

This paper set out to sensitisise the reader on a wide spectrum of energy, environmental, customer and technology issues. What is clear is that the world as we knew it ten, fifteen years ago is no more. We live in a global village made possible by communications, travel and freedom of our minds.

Unfortunately, being part of this global village means that you enjoy its privileges but you can also not escape its horrors. Global warming, the depletion of the ozone layer, escalating energy costs and dwindling clean water resources are some of the challenges that can turn into global horrors.

With this in mind, governments have joined hands and are formulating and implementing interventions and strategies to counter these threats. Electricity generation is seen as one of the bigger ‘culprits’ contributing to CO2 emissions through coal fired plant. Unabated and unmanaged energy consumption by consumers is adding to the problem. Through many
years of development, the definition of Smart Grids, there advantages and the technologies to create and support these smart grids are finally here. The standards are still not finalised and the interoperability might only be possible on paper, but there is very little time to waste. Every utility must make a decision of some sort towards a smart solution plan, funding and implementing it. This is a matter of utmost urgency.

If the SMART GRID is not deployed soon, the next generation might not have a next generation!