PROPOSED DIRECTION FOR DOMESTIC CUSTOMER TARIFFS IN VIEW OF NEW CHALLENGES

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Contents.

ABSTRACT

- The challenges that face the electricity supply industry with specific reference to domestic pricing practices are as follows: Serious capacity shortages in the Cape and to lesser extent the region now and even more so in future, the increased pressure on the environment by the increased use of energy, the demand to increase electrification in South Africa, the increased cost of grid electrification, strain on resources and financial difficulties of municipalities.

- The shortcomings of the current domestic customer pricing and metering practices are as follows: Heavy cross subsidisation, no or very limited capacity pricing signals, no incentive to move loads to cheaper times of day, very limited utility load management, almost no customer load management and no ability to effectively further manage loads

- These challenges can be addressed by the application of new pricing practices: Applying the principle of limited capacity supplies for subsidised tariffs, tariff structures more closely reflecting the true cost behaviour and thereby increasing attractiveness of certain alternatives, applying capacity charges, applying Time of Use tariffs and assisting customers with technology to manage their loads

- The technical features required to implement the above can be addressed with some of the new AMR systems now being launched and tested in South Africa: Ability to measure capacity and limit the capacity on a fixed per year basis or more dynamic time basis, ability to apply time of use tariffs, option of applying peak day withdrawal tariffs where the tariff time periods can be set dynamically and assisting customer with load management.

- Finally the utility engineers and accountants should know how these practices will be beneficial to them: Although short term revenue may drop somewhat, monthly and yearly load factors will increase drastically thereby delaying massive network capital expenditure and reducing tripping and low voltage problems, and overall reduction in customers' energy bills leading to increased disposable income and increased electricity usage in cheaper times.

1 INTRODUCTION

If we were to ask any Councillor or any City Engineer if there is a problem with domestic tariffs or practices the answer would probably be negative. This really illustrates the magnitude of the problem. They say that once you identify and accept that there is a problem you can start to address it.

I will illustrate in this paper that in fact the current domestic pricing practices are far from optimal and are contributing significantly to some of the biggest problems in the industry.

2 INDICATORS OF PROBLEMS

The industry is facing many problems and challenges. It is not the objective of this paper to try and detail all these but to discuss those issues which are directly caused by the sub-optimal domestic pricing practices. Many of the other challenges will however also be addressed by the solution offered by optimal domestic pricing practices.

The following statements illustrate the high level symptoms which suggest that the industry is facing serious challenges:

- In various areas in Johannesburg, Tshwane and other municipalities, developments cannot go on because of electricity capacity shortages.
- Power interruptions on a large scale are becoming more and more common. Many of these due to overloading of equipment.
- Major capital expenditure projects are being undertaken to increase capacity in existing residential areas such as Soweto.
- Payment levels in many areas are still as low as 40% as has been the case for more than 5 years.
- Many municipalities still under serious financial constraint.
- Ongoing call for increased employment.

This is more or less common knowledge in the industry. These are indicators of the challenges that we face now and in the future:

- Serious capacity shortages in the Cape and to lesser extent the region now and even more so in future.
- Pressure on environment via increased energy use.
- Demand to increase electrification in South Africa.
- Increased cost of grid electrification and strain on resources.
- Need to reduce prices on industrial customers to stimulate industrial growth and thus economics and job creation.

3 INDUSTRY CHALLENGES

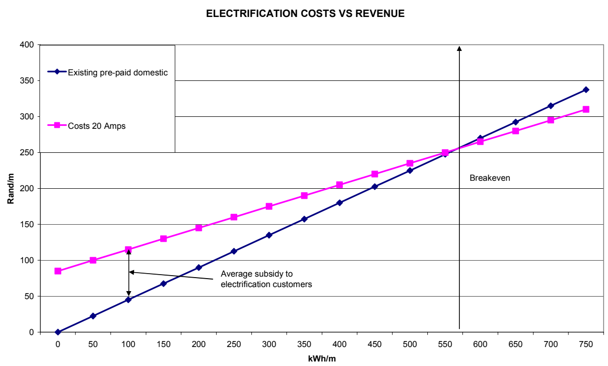
The question then is what is causing these challenges. There are many causes to these, which are being debated and addressed with many strategies. It is however feared that one of the biggest causes that hold the biggest potential to address, relates to current domestic practices that are not addressed. The following practices are the cause of a major part of the problem:

3.1 Cross subsidisation

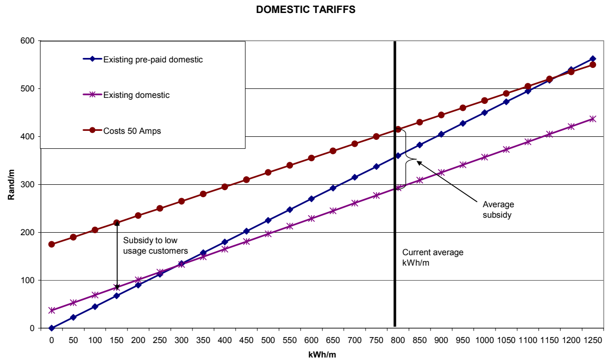
Many people will sit up when this subject is mentioned. They can all sit down. The plan that I will propose will not increase the electricity cost to the majority of customers. The domestic cross subsidies which exist in the ESI are as follows:

- Electrification customers. It is a known fact that capital costs are subsidised by government and other customers as well as operating cost to low usage customers. The current subsidy levels are considered reasonable and sustainable. With the growing base it may however become non-sustainable.

This is illustrated by the picture below. The current breakeven for electrification customers on the single energy rate of Eskom is more than 500 kWh/m which is way more than the current average consumption of about 100 kWh/m.



- Normal domestic customers. The majority of them are subsidised to the extent of about 30%. This is illustrated in the figure below. The average consumption for these customers is more than 750 kWh per month. The detailed cost breakdown will be discussed later in this paper.



The exact levels of cross subsidisation differ significantly between different utilities but the above pictures illustrate the average situation.

3.2 No capacity pricing signals

One of the biggest problems in domestic pricing is the lack of capacity pricing signals and practices. The majority of municipalities are providing 60 Amp, 1 phase or 60 Amp 3 phase supplies to customers. In various cases such as Eskom, 20 Amps are used for electrification customers.

In most cases the connection fees are differentiated between these different supplies. In the majority of cases the tariffs are however the same. Some do have a slightly higher basic charge which emulates the increased metering and administration cost of 3 phase supplies.

Before 1994 a large number of municipalities, especially in the Cape, were applying capacity charges in R/Amp per month based on installed capacity. Most of these were abandoned in the 10 years since. This was mainly driven by the ideology of having the same tariff, equity, for all.

Many of these have over the last few year discovered the problem with this strategy and has at least reintroduced a basic charge. In most cases however they are still not differentiated by capacity.

The current installation and metering methodology present some implementation problems:

- There is no warning system for the customer. When the supply capacity is exceeded, the CB will trip. The customer then has to run around to get it switched on. When the customer is not at home, damage can be incurred such as rotting of food in fridges.
- There is no assistance to help the customer in staying within the installed capacity. It is therefore simply easier to take a much bigger supply to solve the hassle for the customer.

- With pre-payment meters, the circuit breaker in the meter which is usually in the house and is therefore easy for the customer to reset. In the case of some new pre-payment meters, the meter will self reset after a while. A large number if trips will eventually decrease the circuit breaker life increasing the cost to the utility.
- In the case of many conventional meter supplies, the utility circuit breakers could be outside of the house, stand or even on a utility pole or in a utility distribution box which is inaccessible to the customer. The utility will then have to come out to reset the circuit breaker.
- In many cases the customer will have his/her own circuit breaker to limit the load. The problem with this is that in many cases these are not set by the customer at the appropriate size or the trip differentiation between the customer and utility meter is not effective thereby still causing the utility circuit breaker to trip.
- The biggest problem with this is the bypassing of pre-payment meter and self upgrading of circuit breakers being done by customers when they experience a problem with the capacity.

It is clear that the current methodology and technology does not lend itself to effective capacity management. Despite all of this some utilities are doing it to a reasonable level of effectiveness. I will however later on illustrate how these issues can be addressed.

3.3 Lack of load shift incentives

There is currently no incentive for domestic customers to shift loads to the cheaper times of the day, except for a few domestic customers on pilot projects.

The resent power problems in the Cape has clearly illustrated that there is significant load shift potential for domestic customers. The load shifting by all customers but specifically the domestic customers during evening peaks has been so extensive that the load profile for the Cape over that period almost became flat.

This load shifting by customers has caused a significant inconvenience because everything had to be dome manually as no automated equipment exists. Despite that, many customers have indicated that it was not so bad.

In France, the domestic customers on TOU tariffs, where significant load shifting assistance with technology is provided to customers, the domestic peak is outside of the normal domestic peak time. In other words the profile has been inverted. They do the following:

- They apply TOU tariff with significant differentiation in rates between the various periods.
- There TOU tariff also feature a so called peak day withdrawal tariff where for 22 days in the year, which are determined 24 hours before the time, the rates will increase as much as 10 times during the very cold spells.
- From the meter a set of contacts are provided which switch as follows:
    - On all times of the day.
    - On only during standard and off peak.
    - On only during off peak times.
- From these contacts the customers then either wire there houses to the various applications.
- Space heating is largely done with gas. During the past few year, electricity has increased in usage because of some EDF surplus capacity but in many cases these are using some form of stage devises allowing minimum usage during peak times.
- The majority of household cook with gas. The ovens are still mainly electric.

We know of the experiences and troubles that Eskom and other utilities have had in making TOU successful. Later in the paper I will show you how it can be done.

The bottom line is that the majority of domestic customers in South Africa are not applying any load management strategies.

3.4 No ability to effectively manage during crisis

There is no ability to manage loads during major power shortage crisis. The only means is the limited utility geyser control and the call on the public method used by Eskom in the Cape.

If such mechanisms do not exist the only means to reduce the demand are:

- To reduce the voltage on the domestic networks. This reduced voltage reduces the largely resistive loads of domestic customers. This however is not always possible because of:
    - low voltage problems already existing all over the network
    - because automated equipment does not exist
    - and such decreased voltages for other more inductive loads will increase thereby causing low voltage problems.
- Interrupting selected areas. This is extremely disruptive to customers, causes many other problems such as violence, accidents, lost productively, etc. It also requires a significant amount of work for utilities without the required SCADA systems.
- To call on customers in general using the media to reduce loads. The main problem with this strategy is that some customers contribute to a large extent whereas other simple don't give a dam. Those customers who go to the effort are not compensated and those who don't are not penalised. Over longer periods of time, this will become unsustainable.

Later in the paper I will illustrate how the demand can be managed effectively and fairly during times of serious capacity shortages.

3.5 Lack of use of alternatives

One of the biggest problems caused by the cross subsidisation of domestic tariffs is the fact that it makes alternative energy sources uncompetitive. The Electricity Act makes provision for the application of cost reflective tariffs which will promote the efficient applying of energy sources with due consideration for environmental considerations. Our industry is failing this requirement with distinction. Examples:

- Solar heating, which is considered as one of the most environmentally friendly methods of heating water is almost non-existent in South Africa. If electricity water heating was priced cost reflectively many more solar systems would be installed. It is however appreciated that the cost is significantly when these loads are managed from a national capacity and local network capacity point of view. These practices make electricity water heating much more competitive with solar heating.
- Cooking with gas is a much more effective and efficient way. With electricity, especially in poor households the losses are very high due to:
    - Use of old, cheap and ineffective appliances.
    - Use of old, bend and not sealing containers.
    - Bad habits such as leaving lids of pots open, always selecting then highest setting on the plates, etc.
- Space heating with electricity is one of the most wasteful applications electricity industries worldwide get involved in.
    - In a coal fired power station coal is crushed and burned to create heat.
    - Then water is heated to create steam.
    - Then steam is run through a turbine to create kinetic energy and a large portion of the energy is lost to condensate the water.
    - Then the turbine turns the generator to create electricity.
    - Then the electricity in transformed to high voltage, then over the lengths of South Africa, down to low voltage again.
    - And then in a heater, heat energy is created again.

  The total efficiency of this process is less than 20%. In other words less than 20% of the calorific value of the coal end up as useful energy in the house. This could still be accepted had there not been other alternatives. What makes this problem even more so compared with other applications such as cooking is the few number of hours required in a year.

3.6 Energy efficiency

The current low tariffs that also do not reflect the costs in a cost reflective way, is partly the cause of very limited energy efficiency practices being applied:

- With a low electricity price the cost of converting to more efficient appliances is not warranted in many cases.
- Because TOU tariffs are not applied, the applications in the peak time, such as lighting are not nearly as attractive as it should have been.

3.7 High non-technical losses.

There as still many areas where the non-technical losses are very high. This remains one of the biggest causes of the financial problems in municipalities. This is respect of electricity but also water.

- In the majority of pre-payment areas the non-technical losses are still at least 10%.
- In many of the old “townships” the payment levels are still as low as 40%.

Current technology and methodology just does not seem to be able to solve the problems.

3.8 Limited features of meters.

The current meters being used for domestic customers have very limited features for the utility or customer. Their job is to read electricity consumption or make available pre-paid electricity mainly. There shortcomings are as follows:

- They offer limited feedback to the utility:
    - The Pre-payment meters have no regular feedback. Utilities use the purchase pattern of customers but that has no direct relationship with consumption. A visit has to be made in the house to access the meter, when a cumulative consumption reading can be taken from some of the meters. Some meters will then also indicate bypassing that was done.
    - Conventional meters are at least visited by meter readers once a month or 3 months. This at least gives a regular feedback of the consumption. This does however not indicate when the consumption was made or any other information. Feedback is also flawed with human intervention.
- They offer no or very limited load management features.
- They offer limited TOU features if any.

- They are not effective vehicles to manage non-payment.

I will illustrate later in the paper how this is hindering moving forward with the application of optimal practices.

4 RECOMMENDED STRATEGY

These challenges can be addressed using the following strategies:

- Apply limited capacity supplies for subsidised domestic supplies.
- Apply highly cost reflective tariff structures and levels for all other domestic customers featuring the following.
    - Basic charges to reflect the fixed customer's service/administration type costs.
    - Capacity charges reflecting the required capacity of customers
    - Time of Use energy rates as close as possible to bulk tariffs.
    - Consider peak day withdrawal rates and reduction in capacity during major capacity shortage times.
    - Assist the customers with advise and technology to be able to:
        - Move loads to cheaper times.
        - Reduce the maximum required capacity.
        - Apply energy efficiency measures.
        - Switch to alternative energy sources.
    - Continue utility geyser load management but in line with the National control capacity requirements to maximise the value to the utility/customer. Offer incentive to customers to manage their geysers to enable the application of more aggressive switching.
- Reducing non-technical losses through better information about consumption, power outages, and losses per areas and then targeting the associated problem areas.

That sounds very easy, but there are many questions which the reader will have that first need to be answered:

- Will it really work?
- Will it really make a big difference?
- Is it practical to implement?
- What are the costs / benefits?

5 COST VS CURRENT PRICES

Many of you will probably now say that this is a pipe dream which is not possible. I will try to illustrate to you what I mean and how it is possible.

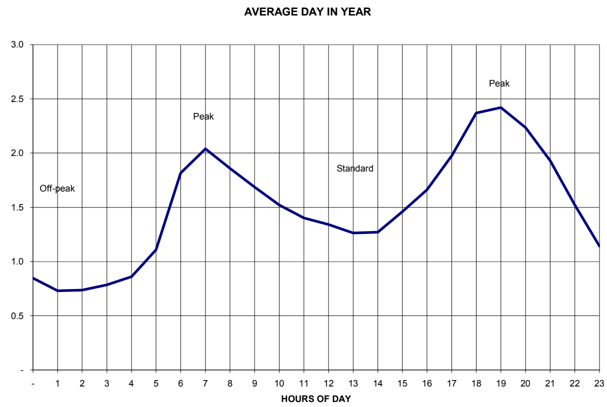
I will start with an illustration of the true cost of supply.

The whole cost analysis process will not be illustrated because of time constraint and the fact that much of the issues are known by now. The analysis of cost will focus on the analysis if the load profile. The analysis was done using half hour profiles of some individual customers and grouped domestic customers from various municipal areas in various regions of South Africa:

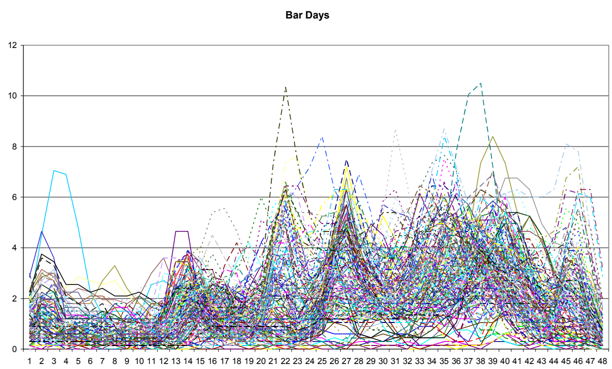
- 20 000 customers.
- 819 kWh/m.
- Annual loaf factor 30.35%
- Peak demand (ADMD) = 3.7 kVA.

It would be agreed that this represents a pretty average (non-electrification) customer. If any the consumption is on the low side.

The profile below is similar to what is usually presented at workshops and conferences. This shows an average peak demand (of 2.3 kVA ADMD.



For a typical domestic customer however, the maximum demand is much higher, typically 8 to 16 kVA as is illustrated by the individual customer load profile below. This shows a peak demand of 11 kVA.



It is well realised that this is a before diversity profile and the effect of diversity from the individual customer up to the mini-substation is very high, as much as 90% of the national wide diversity. The problems with historical tariff designs are that the annual peak ADMD is not used but an average annual peak. This means that the peak that should be used for cost allocation is understated by as much as 48%. 2.5 kVA rather than 3.7 kVA.

The table below summarises the current tariffs Vs typical costs and typical large customer tariffs.

COMPARITIVES					
Typical variables	Domestic excluding electrification				
Capacity	Amps (ADMD)	18.5	3.7	kVA	
Installed capacity	Amps	50	Capacity required not installed.		
Energy	kWh/m	819			
Current tariffs		Prices	Fixed cost	Variable cost	Total
Basic charge	R/month	37	37		
Capacity	R/KVA	0	0		
Energy	c/kWh	32		262.08	299.08
Costs		Prices	Fixed cost	Variable cost	Total
Customer service	R/month	8	8		
Administration	R/month	12	12		
Capacity	R/KVA	32	118.4		
Energy	c/kWh	30		245.7	384.1
Large customer tariffs		Prices	Fixed cost	Variable cost	Total
Customer service	R/month	37	37		
Demand	R/KVA	55	142.45		
Energy	c/kWh	25		204.75	384.2

This shows a cross subsidy of almost 30%. In this case the tariff for the same profile on the large customer tariff is almost the same. This indicates that I have been too conservative and that in fact the cross subsidy is much more, especially if the municipal tax (surplus) is taken in consideration.

6 LOAD PROFILE IMPACT

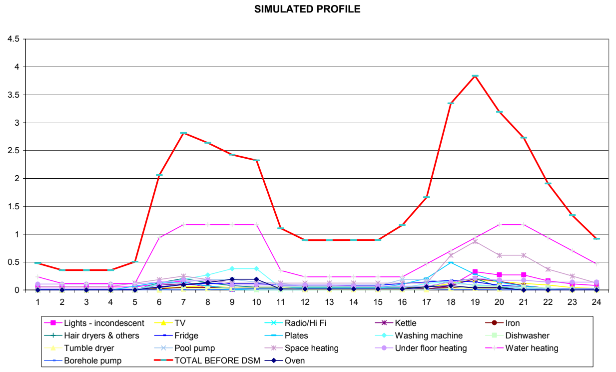
This section shows the impact on customer's load profile of the following strategies:

- effective energy efficiency
- load shifting
- and energy conversion.

The table below shows the assumptions used to simulate a load profile for a winter month.

ELECTRICITY - medium household			Winter month					
APPLICATION	% of houses	Nr	Capacity	Daily Hours	Duty cycle	kWh/m	Cumm / kWh/m
Lights - incondescent	100%	10	50	4	1	61.00	61.00
TV	100%	1	250	5	1	38.13	99.13
Radio/Hi Fi	100%	1	50	6	1	9.15	108.28
Kettle	100%	1	2000	0.5	1	30.50	138.78
Iron	100%	1	1500	1.5	0.3	20.59	159.36
Hair dryers & others	100%	2	1000	1	0.7	42.70	202.06
Fridge	100%	1	250	24	0.3	54.90	256.96
Plates	100%	1	2000	2	0.5	61.00	317.96
Oven	100%	1	2000	1	0.5	30.50	348.46
Washing machine	100%	1	2000	2	0.5	61.00	409.46
Dishwasher	50%	1	3000	0.5	0.5	11.44	420.90
Tumble dryer	50%	1	3000	0.25	0.8	9.15	430.05
Pool pump	40%	1	800	6	1	58.56	488.61
Space heating	70%	1	2000	5	0.8	170.80	659.41
Under floor heating	20%	3	500	24	0.4	87.84	747.25
Water heating	100%	1	3000	24	0.2	439.20	1186.45
Borehole pump	10%	1	700	3	1	6.41	1192.86

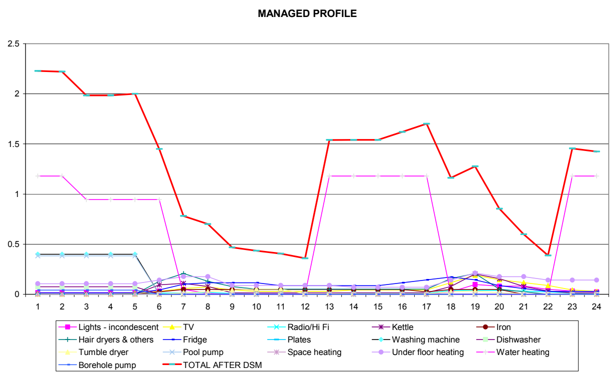
Assumptions were then made about consumption of these various appliances during different times of the day and the resultant average daily load profile for a winter month was obtained below. Note that the simulation was done to yield the same annual peak demand of 3.7 kVA.



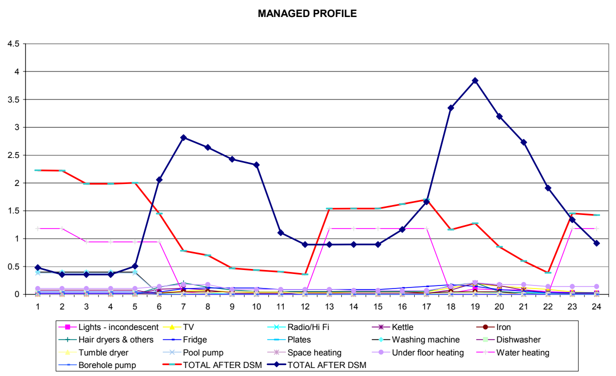
Various assumptions were then made in terms of the application of load management, efficiency and energy shifting strategies as shown below.

ASSUMPTIONS
All lighs converted to efficient.
Convert plates to gas.
Convert to alternative space heating.
The following appliances only used on off peak times:
- Washing machines, dishwashers, pool pums, bore hole pums,
Tumble dryers in standard day but some hours in morning peak.
Water heating: 0nly in off -peak times plus 4 hours standard in day.

The resultant load profile then looks like the one shown below.



The profile before and after change are compared in the picture below.



The key results from the above analysis are shown in the table below.

Key variables	Before management	After management	Diff
Ave kWh/month year	966.7928	820.3928	146.4
Ave kWh/month High	1192.855	918.355	274.5
MD at peak time	3.73584	1.275893	2.459947
MD	4.639701	3.663484	0.976218

When we view this it is clear that domestic customers still need significant capacity but that it can be at times when the networks are lightly loaded due to commercial and industrial needs. On the higher voltage networks where there is diversity with these other loads the reduction in peak demand would thus be significant.

7 CUSTOMER IMPACT SIMULATIONS

Using the analysis above the impact on customers is assessed. The impact for a winter month is shown in the table below.

SAVINGS - WINTER				Price		Revenue impact	
	kWh			Existing	New	Existing	New
To alternatives	-231.8			0.32	0.49	-R 74	-R 114
Efficiency	-42.7			0.32	0.4927	-R 14	-R 21
Energy shift	-232.9	From Peak		0.32	0.62	-R 75	-R 144
	-197.5	From Standard		0.32	0.2381	-R 63	-R 47
	195.11	Too Off peak		0.32	0.17	R 62	R 33
Capacity	-2.46			0.00	45.00	R 0	-R 111
						-R 163	-R 404
				Before shift			
Total bill	Rand / m			R 437	R 580	R 274	R 176
% change	Existing to new tariffs			R 143	32.72%		
	Shift on existing tariff			-R 163	-37.33%		
	Shift on proposed tariff			-R 404	-69.69%		
	Existing to proposed with s			-R 261	-59.77%		

During the summer months the savings is much smaller. The table below shows the average for the year.

AVERAGE / MONTH				Winter	Summer	Revenue impact	
				3	9		
	kWh			Existing	New	Existing	New
To alternatives	-231.8			0.32	0.29528	-R 47	-R 49
Efficiency	-42.7			0.32	0.30	-R 14	-R 13
Energy shift	-232.9	From Peak		0.32	0.34115	-R 54	-R 64
	-197.5	From Standard		0.32	0.20353	-R 63	-R 40
	195.11	Too Off peak		0.32	0.1664	R 77	R 40
Capacity	-2.46				45	R 0	-R 86
						-R 101	-R 212
				Before shift			
Total bill	Rand / m			R 437	R 580	R 336	R 368
% change	Existing to new tariffs			R 143	32.72%		
	Shift on existing tariff			-R 101	-23.13%		
	Shift on proposed tariff			-R 212	-36.53%		
	Existing to proposed with s			-R 69	-15.76%		

The following can be deducted from this:

- Few customers would consider the hassle and effort worth wile for about R100 per month which will be the case on the current tariffs.
- Many customers would consider a saving of about R210 per month worth while the effort.
- Many customers would participate if they know they are facing a real tariff increase of 33%. This increase we must remember is on top of any real increases facing the ESI because of Eskom major capacity increases.

I am sure that there would be acceptance for achieving effective load management if these are the kind of results that are achievable.

8 HOW?

In previous sections the many practical problems associated with these strategies were highlighted. This section will address these issues.

From a practice implementation point of view these objectives can only be achieved using Automatic Meter Reading (AMR) systems. The name in itself is misleading. We are really referring to a remote measurement, control and customer interface system because this is the features offered by the modern AMR systems.

The objective of this paper is not to advertise AMR systems but to inform you of the features which are required by these systems to allow utilities to benefit from all of the recommended strategies. If not, only a few benefits will be achieved thereby threatening the cost benefit analysis.

The general features of AMR systems such as cost, reliability, accuracy, reliability, implementability, broad base application, application for all kinds of customers, covering electricity and water, possibilities for value added services, utility network planning features, quality of supply management, etc will not be mentioned here. Only the features required to achieve the load management objectives. The features required are as follows:

- Conventional and pre-payment meter option.
- TOU tariffs such as Eskom Megaflex.
    - Basic and administration charges
    - Capacity charges (time differentiated)
    - Energy charges:
        - High and low season
        - Peak/Standard/Off-peak times
        - Weekday/weekend
        - Public holidays
- Super peak or peak day withdrawal tariff.
    - Very high rates
    - At dynamic times
- Capacity tariff management options.
    - Overall capacity
    - Capacity at peak times
- Capacity crisis management options.
    - Proportionate reduction in capacity.
- Utility load management options:
    - Utility Geyser control for local network.
    - Load control from a national perspective.

- Load management assistance to the customer:
  - Information about the Time of Use times.
  - Information about the capacity.
  - Auxiliary contacts linked with TOU periods.
  - Exceeding capacity contacts.
- Informing customers of various issues:
  - actual capacity being used
  - actual rate of consumption
  - approaching exceeding of capacity
  - remaining credit and consumption
  - relevant TOU tariff period
  - reason for trip such as exceeding capacity
  - automatic reset after trip due to overload
- Some form of tamper detection with quick feedback to the utility.
- Supply outages being incurred.
- Load profile data.
- Losses data per feeder or substation.

Most of the modern systems offer these features. Some of them however do not. One of the key design aspects is the following:

- The tariff calculations (TOU and capacity) cannot be done cost efficiently in the meter unless the tariff tables are updated very regularly. This is because of the need for dynamical tariffs where the times and rates can change on the day and thus the large memory and calculation needs required.

9 UTILITY IMPACT

Engineers and financial members of the municipalities probably fear large revenue losses and high costs that need to be incurred. The following facts to help address many of the fears:

- The cost of many of the AMR systems is not significantly more than current pre-payment meters. This is more so when retrofitting of pre-payment meters are considered for existing medium consumption customers.
- The savings in electricity bills are large matched by savings in:
  - The purchase cost from Eskom because of lower consumption levels and more at the cheaper time.
  - Massive savings in capital expenditure and reduced trips, and equipment failure due to overloading.
  - Massive increase in revenue due to reduction of losses.
  - The effective profit for the utility can be increased significantly at the current average prices levels due to the major reduction in cost.
- These strategies will make an incredible amount if capacity available which can be used to supply the large demand for new developments. (1 to 2.4 kVA per existing house).

In many cases the break-even of the capital expenditure offered by the AMR systems and using these proposed strategies is less than 1 year.

10 CONCLUSIONS

The subject covered in this paper requires a full conference to cover in depth. This paper has as objective to illustrate to Engineers and other municipal representatives that there are alternative ways to solving many of the challenges facing the ESI today.

The case for each utility is obviously different. The networks are different, the customer profiles are different, the costs are different, the types of customers are different and many more. The calculations for each would thus yield different results. My experience hints that this would be workable for all municipalities. This is so even before any of the other softer benefits have been considered.

I hope this will stimulate thought and debate and that staff will start building these kinds of issues into their strategies for the future.

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