THE POTENTIAL IMPACT OF EFFICIENCY MEASURES AND DISTRIBUTED GENERATION ON MUNICIPAL ELECTRICITY REVENUE: DOUBLE WHAMMIES AND DEATH SPIRALS

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1. Background and Introduction

A range of national and local policies and strategies promote energy efficiency and renewable energy in response to the electricity crisis and national climate change commitments. This trend is not only local, but global. In South Africa this is taking place in the context of rapidly decreasing renewable energy costs and simultaneous rapidly increasing grid electricity costs resulting from the new build programme.

Electricity revenue and city financial survival is closely linked in many South African municipalities, due to our particular history of municipalities operating as electricity distributors. Typically 10% of annual electricity revenue generated is fed into city coffers, subsidising a range of other important municipal services. In addition, revenue from 'high-end' users (larger residential and other consumers) is routinely used to cross subsidise 'losses' from providing power to poor households which are not fully covered by the national Equitable Share grant.

In the past, the threat of revenue loss linked to reduced sales from energy efficiency and solar water heating programmes has often resulted in some resistance by electricity departments to such initiatives. However, today it is widely accepted that such changes are inevitable, even if just as a consumer response to the high electricity prices and increasing availability of cheaper alternatives (e.g. solar PV), and a managed response is therefore called for.

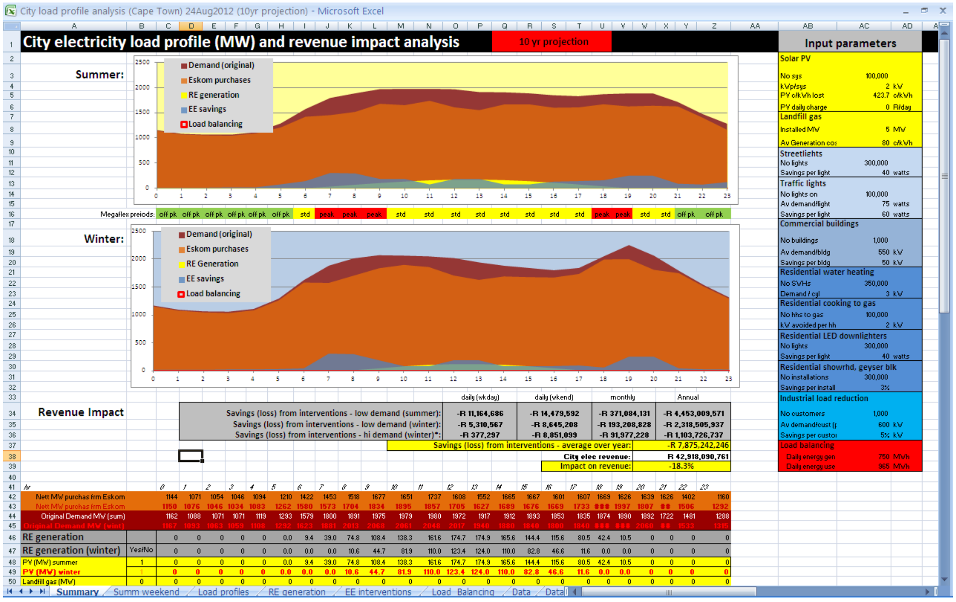
However the threats to electricity revenue remain real, and only recently has work started to assess this situation in detail. What will the impact be of high-end customers becoming more efficient and installing solar PV systems for own-use because it makes financial sense - as is expected within a few years?[1] These customers are key revenue generators for cities, and important for enabling cross-subsidisation of the ever increasing proportions of poor households. This paper presents results from a modelling exercise to estimate this revenue impact of efficiency and small embedded generation over the next 10 years, flags the potential for an impending revenue 'death spiral' associated with expected trends, and suggests what needs to be done to avoid likely serious negative revenue consequences while still enabling economically desirable efficiency and renewable options.

2. Hourly load profile impact modelling

Discussions with municipal electricity staff indicate that general models projecting potential electricity and revenue savings and losses were not particularly useful, but rather hourly load profile impact analysis was required mainly because bulk purchase costs vary significantly at different times of the day

[1] This is illustrated in a detailed paper by Trollip H, Walsh V, Mahomed S and Jones B (2012): *Potential impact on municipal revenue of small scale own generation and energy efficiency* (Submitted to the South African Economic Regulators Conference, August 2012)

and year. An immediate challenge to undertaking this exercise was that often cities don't know what their overall load profile is. To undertake the modelling detailed half-hourly data was gathered for six intake points for the City of Cape Town and for key eThekwini intake points[2] for a full year. Load profiles included week and weekend demand.



Screen grab of load profile and revenue impact analysis spreadsheet model used

Projections for uptake of various efficiency and renewable alternative energy services were developed. These concentrated on the residential sector (for which more detailed information was available, and which forms the focus of this paper), with some estimations for commercial building efficiency and broad estimates for industrial efficiency. Projections were developed based on 'real life' data as far as possible:

1. Residential uptake of efficient water heating based on market analysis undertaken for Cape Town City rollout programmes
2. Commercial building efficiency impact based on data taken from the real-time monitoring of eThekwini municipal buildings pre- and post-efficiency retrofits
3. Residential PV uptake based on a detailed analysis of customer expenditure on electricity and therefore PV financial feasibility into the future[3]
4. Solar PV generation profile based on analysis of solar radiation data, with array tilt angle selected for maximum annual output (see figure below)
5. Predicted electricity price increases and PV price decreases as reflected in the national IRP2010

[2] - only results for Cape Town are presented here, as discussions with eThekwini officials on their results had not yet taken place at the time of writing.

[3] - this and other information for the modelling exercise was drawn from the detailed paper by Trollip H, Walsh V, Mahomed S and Jones B (2012): *Potential impact on municipal revenue of small scale own generation and energy efficiency* (Submitted to the South African Economic Regulators Conference, August 2012)

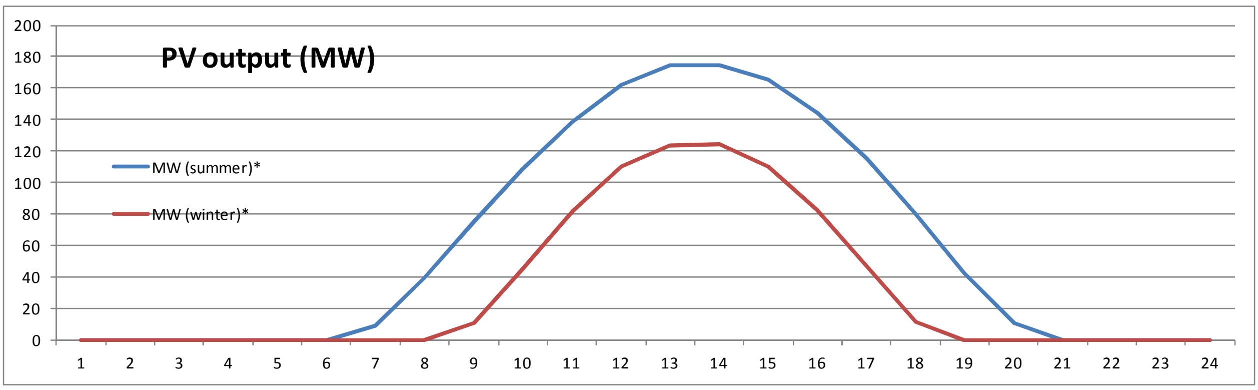
Pulling these together resulted in the following key inputs to the model:

Interventions modelled		
Solar PV (residential)		
No system	100,000	over 10 yrs
kWp/system	2	kWp
Commercial buildings		
No buildings	1,000	over 10 yrs
Av demand/bldg	550	kW
Savings per bldg (pk)	50	kW
Residential water heating*		
No. SWHs	350,000	over 10 yrs
Demand / cyl	3	kW
Residential LED downlighters		
No lights	300,000	over 10 yrs
Savings per light	40	Watts
Residential eff showerhead, geyser blanket		
No installations	300,000	over 10 yrs
Savings per install	3%	
Industrial load reduction		
No customers	1,000	over 10 yrs
Av demand/cust (pk)	600	kW
Savings per cust.	5%	kW

* - residential eff water heaters equipped with timers to avoid peak load periods (i.e. megaflex peak)

As will be shown, the most significant amongst the interventions in terms of revenue loss are the solar PV uptake of 100 000 households in 10 years, and efficient water heater uptake of 350 000 households in 10 years. Both of these penetration figures are based on substantial research, and therefore are considered credible. These interventions will be primarily adopted by high-end users who are most affected by increasing tariffs, which is compounded by the structure of the inclining block tariff (IBT) resulting in their bearing the brunt of price increases. Revenue losses from this category of customer are serious, as they are key to cross-subsidising other city functions as well as low income household electricity provision.

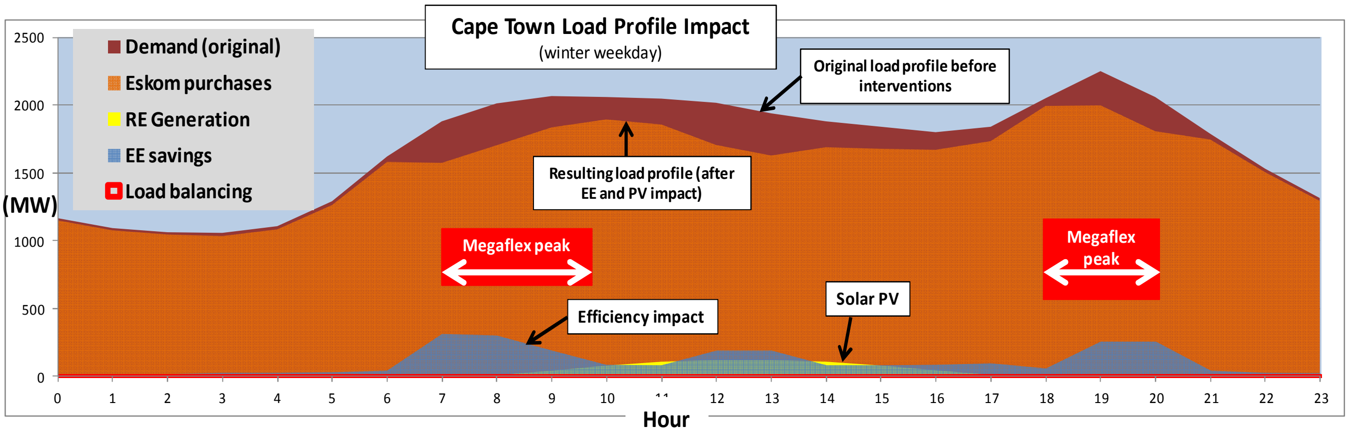
Commercial and industrial solar PV uptake, which is expected to be significant, was not modelled in this first exercise. This impact will be explored in future work.



Average generation profile (MW) of 100 000 x 2kWp solar PV systems in summer and winter (Cape Town)

3. Load profile modelling results

The graph below shows the result of the hourly load profile modelling for Cape Town for the different interventions discussed above. The major contributor to the efficiency intervention impact (shown in blue) is solar water heaters. Note that these are equipped with timers to avoid megaflex peak periods, thereby maximising their benefit for the city by smoothing the load profile. Solar PV is shown in yellow at the bottom, and while it has a small apparent impact, the revenue impact is significant (discussed later).



Load profile impact modelling results for efficiency and solar PV interventions in Cape Town (winter weekday)

Reflecting on this graph the following points are noteworthy:

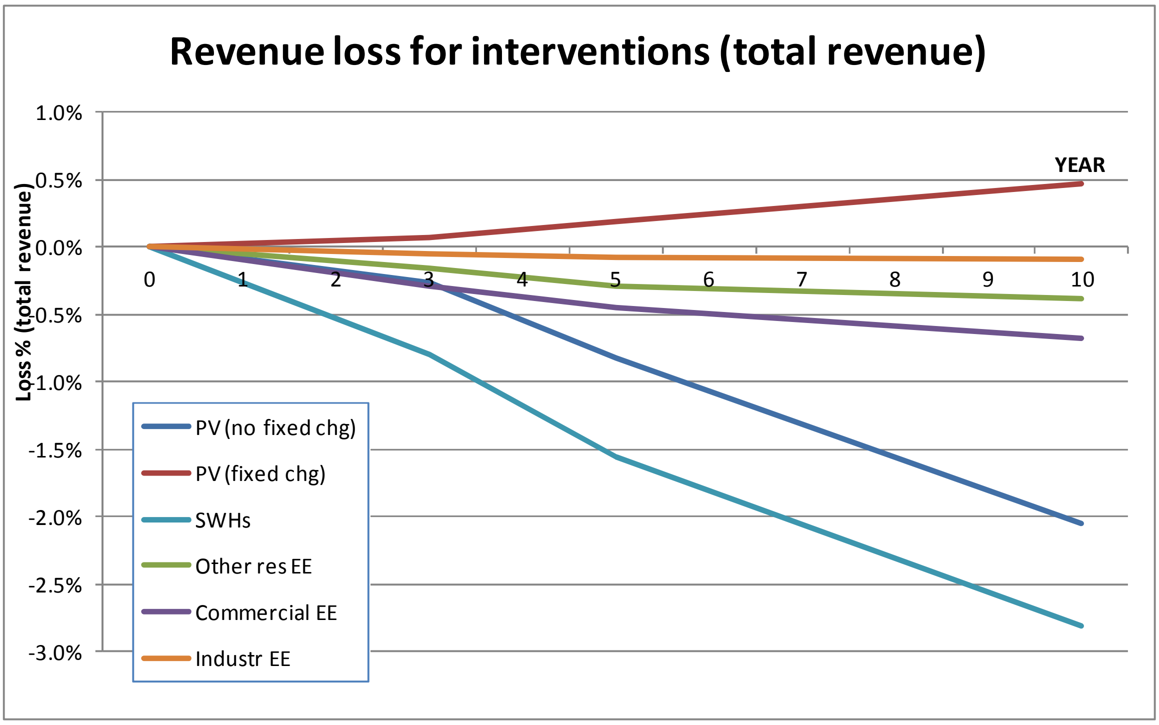
- Interventions that can hit megaflex peak periods are obviously the best. At this point the municipality is often selling electricity to the end user for less than they are purchasing it from Eskom (particularly in the residential sector) and therefore any load reductions here are potential money savers. Solar water heaters with timers to avoid peak periods are one such intervention (although they will still result in a revenue loss with current tariff systems, but this loss will at least be minimised by the use of timers).
- Solar PV systems generate most of their power during the day rather than in peak periods. At these times bulk power purchase costs are generally at standard rates, and thus the revenue losses from displaced power are more significant.

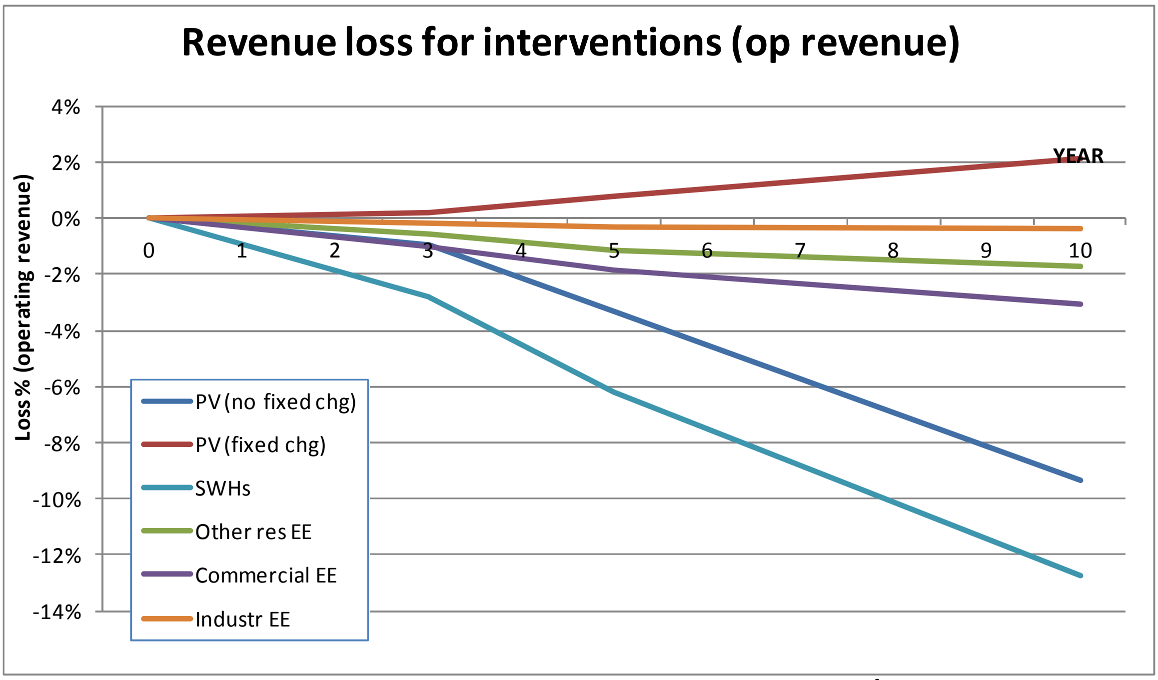
4. Electricity revenue impacts

The graphs below indicate the impact of the different interventions on electricity revenue. Of most interest are solar PV and solar water heaters. Other interventions (commercial and industrial efficiency, and other residential efficiency measures) also have important impacts, but these are not the focus of this paper. The impact shown in the graphs of solar PV and solar water heaters (SWHs) are clearly significant, particularly when net (operating) revenue is considered (i.e. where bulk purchase expenses are excluded, which are around 63% of total expenses for Cape Town at present, and are likely to escalate to over 70% as electricity prices increase faster than inflation). The net revenue impact reflects the real effect on the income available to the Electricity Department for core functions, as well as for contributions to other important city functions.

The losses indicated are clearly untenable – should current PV price trends, solar water heater rollout expectations, electricity price escalations and tariff systems persist, revenue losses are predicted to be around 4.5% of total revenue (and probably around 22% of net revenue after deducting bulk expenses) for both solar water heaters and solar PV interventions combined within 10 years.

In order to avoid this potentially crippling impact on city revenues, changes to the current modus operandi will need to be planned for and implemented over the next 5 years.





Revenue losses for solar water heater (SWH) and solar PV interventions[4]

The graph also indicates the revenue impact if households with solar PV systems are charged a fixed charge and separate energy charge, as with Cape Town's new residential net metering tariff[5]. Such a

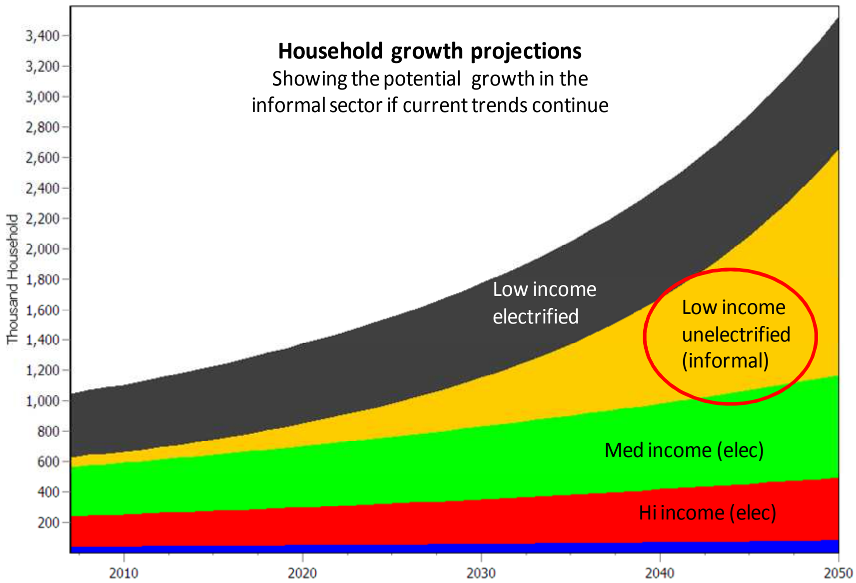
4 Other interventions are also shown here, but are not discussed in detail in this paper.
5 R9.83/day fixed charge and 91.69c/kWh energy charge

tariff is considered a reasonable approach, as net metered households need to pay for the grid availability even if they are generating most of their own energy (unless they choose to go off-grid completely of course). The graph shows that there is minimal revenue loss if such a fixed charge tariff is applied. However, such a tariff also significantly discourages the adoption of solar PV, as savings for the customer are much less than if they are charged the normal residential tariff. This is discussed later. It is important to note that such a net metering tariff may not avert a revenue crunch however, as households may well choose to still install solar PV and limit its generation to 'own use' – i.e. not feed back into the grid at any time. It is questionable whether the city would be able to charge them a net metering tariff in this case, or would even know that they have a solar PV system installed. For the high-end household this is likely to become a financially viable choice in the next few years, and the revenue impacts for the city will be significant. The large-scale adoption of solar PV systems may therefore well take place irrespective of tariffs imposed - either 'under the radar' or outside of the regulatory influence of government.

NERSA has made the point[6] that there is no provision in the 2010 Integrated Resource Plan (IRP2010) for small solar PV or other generation within municipalities, and that municipalities are not mandated to buy and sell power generated by such systems. However there is a reasonable amount of confusion around this issue, including potentially conflicting statements in other official documentation[7] and the fact that some cities are allowing net metering already. All considered, the significant future adoption of solar PV may well proceed despite the regulatory confusion and introduction of net metering tariffs.

5. Pressure on cross-subsidies for low-income electrification

In addition to the potential revenue impact of efficiency and solar PV interventions, there will be mounting pressure to increase cross subsidies for low income electricity provision. This is largely because of the escalating focus on electrification of informal settlements coupled with the high growth rates of these settlements[8].



Informal household growth rates are high, and servicing them will place an increasing burden on city finances

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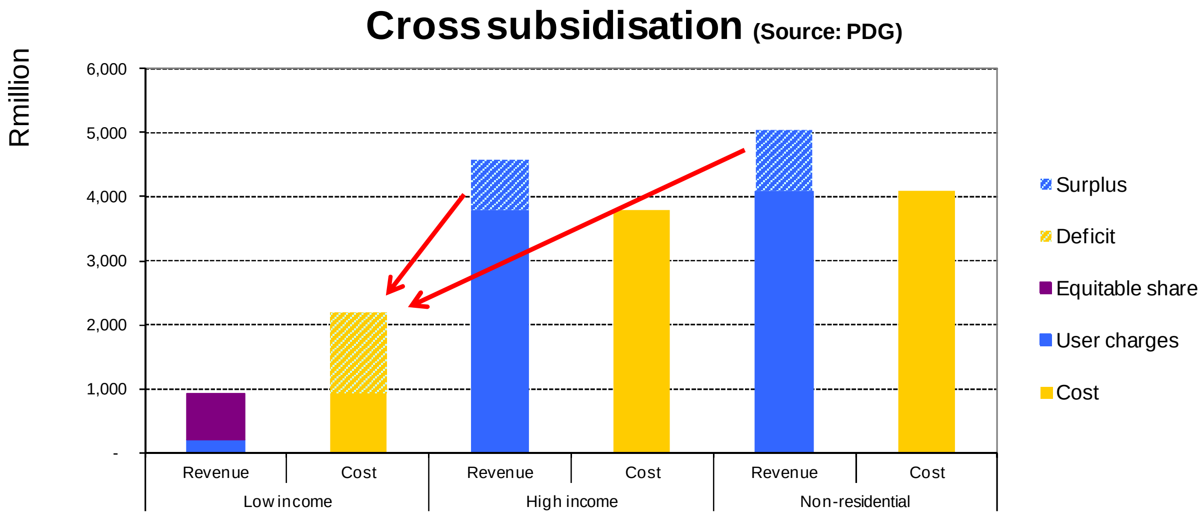
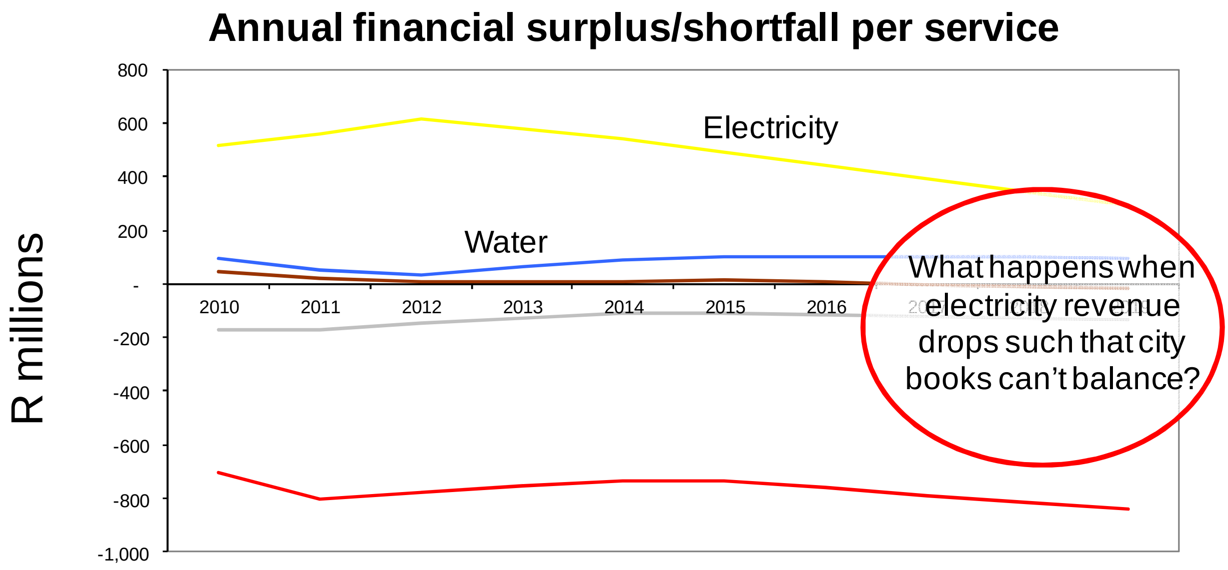
6 At a workshop with municipalities on embedded generation on 13 July 2012 at SALGA offices
7 Such as the net metering guidelines for <100kW systems issued by NERSA, which suggest that net metering can be undertaken by cities (Standard Conditions for Embedded Generation within Municipal Boundaries)
8 Different sources indicate growth rates of between 10% and 16% in Cape Town – see Energy Scenarios for Cape Town Technical Report. Sustainable Energy Africa, 2011. Cape Town.



Surpluses from high-end residential customer electricity sales and from other customers cross-subsidise poor customers (illustrative)[9]

6. Double whammy and death spiral

Cities are in an increasingly difficult position where they need to find the resources to cross-subsidise poor households, and this pressure is increasing as informal electrification becomes more of an obligation, yet electricity revenue is under strain as bulk prices increase and important surplus-generating high-end customers look for ways of spending less. Cities are under fast increasing revenue stress from two sides - a 'double whammy'. If attempts are made to alleviate this pressure and sustain adequate revenue by further loading the tariff to wealthier residential and other customers (who currently are the key surplus income generators), this just accelerates their adoption of solar PV and efficiency options to reduce their electricity expenditure, which further reduces city revenue – a 'death spiral'[10].



9 From Palmer Development Group analysis of city revenue – while this figure is provided for illustrative purposes, it is based on actual analyses of South African cities.
10 A term suggested by Gary Ross of the City of Cape Town

Declining revenue from electricity sales is predicted if current trends continue (illustrative)[11]

Continuing on the current path is therefore likely to be untenable and, and while there are longer term national government responses required to support cities in avoiding a revenue crisis and maintaining service delivery standards, municipalities may well need to initiate short term tariff changes to mitigate this looming business challenge.

7. Conclusion: issues, solutions and ideas

South Africa is being hit by a rapidly changing electricity sector financial situation due to fast rising national grid electricity prices that can't be readily absorbed by users, coinciding with rapidly decreasing costs of small solar PV, and global warming emissions pressures that accelerate energy efficiency implementation such as solar water heaters.

South Africa has the particular situation where municipalities operate as distributors and electricity sales generate revenue that is used to cross subsidise electricity costs in the low income market and feed into municipal coffers as a 'hidden tax'. On the one hand pricing has to buffer the poor from unmanageable hardship; on the other, this can run the risk of pushing the price burden on the high-end users into realms where alternatives become affordable and desirable and they withdraw from the system partially or fully - the double whammy and potential death spiral.

Current tariff systems will need to be reconsidered to respond to these challenges. Amongst other things, tariffs will need to:

- not burden high-end users excessively thereby driving them seek alternatives and reduce their contribution to revenue generation (the top IBT tariffs can unfortunately have this effect)
- generate enough surplus to cross-subsidise low income households and contribute to other city services
- ensure that net metering customers pay for grid availability in a fair manner (i.e. introduce a fixed cost component for their use of the distribution grid)

Is it possible to balance these impacts in tariff design? This is uncertain. But current tariffs are unlikely to achieve this, and the inclining block tariff in particular needs to be flagged as potentially counterproductive in this regard.

What if revised tariff systems disincentivise customers from installing net-metered solar PV and solar water heaters through the introduction of bigger fixed charges?[12]

- Solar water heater or other efficient water heater implementation is recognised as being economically valuable for the country, and thus detrimental effects on such programmes needs to be avoided. This could be achieved through continued targeted national subsidies as with the current Eskom IDM programme.
- Solar PV net metering disincentives would be unfortunate as these are entirely customer-funded green electricity generators. But is it better to have these end users putting funds towards a solar PV system or supporting the city service delivery through revenue contributions? If the country needs more green generation, could it not be more economically sensible to focus on large-scale plant? Will thousands of small PV systems feeding into the grid create huge management problems for already over-stretched electricity departments? Given questions such as these, it seems unclear whether such a disincentive would be counter to national best

11 From Palmer Development Group analysis of city revenue

12 End users will have reduced financial savings as a result of tariffs with lower energy charges and higher fixed charges

interests. But it is clear that such net-metering customers need to pay a fair contribution to grid availability and operation costs.

However, household and commercial use of solar PV with no net metering (i.e. no grid feed-in) cannot easily be regulated by government, which creates a situation of generation capacity implementation that falls outside of public planning processes. The potential for such uptake appears significant, as discussed earlier, and trends in this regard may need to be monitored closely.

The main point this paper attempts to highlight is that there are growing pressures on municipal electricity revenue, and there is evidence that current electricity and PV price trends and tariff systems may rapidly lead to a death spiral – where key revenue generating customer contributions dwindle, and cities are increasingly unable to support poor households and general service delivery standards drop. It seems appropriate that a plan is put in place urgently to address this situation.