Impact of localised Energy Efficiency (EE) and Renewable Energy (RE) on Ekurhuleni's finances over the next 10 years – Report

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Sustainable Energy Africa

Introduction

Over the past few years, there has been an increasing interest in Renewable Energy (RE) and Energy Efficiency (EE) products amongst the residential, commercial and industrial sectors of the urban economy. Although this shift has been good for the customer (reduced electricity bill) and the environment (reduced greenhouse gas and particulate emissions), it has also resulted in losses in municipal electricity sales. Since electricity sales are the biggest source of income for a municipality outside of national government funding, a decrease in revenue from electricity can have a major impact on the effective functioning of the municipality. Further to this, since it is the mid-high income residential sector that is most likely to install RE and EE, reduced sales to this sector results in reduced funds to cross subsidize electricity for indigent households. Since the market for PV and EE is increasing, increased revenue losses into the future could be potentially substantial.

Aim of the project

To this end, Sustainable Energy Africa, with funding from the Renewable Energy and Energy Efficiency Partnership (REEEP), has undertaken a study to determine the impact of energy efficiency (EE) and renewable energy (RE) on a municipality's revenue over the next ten years. The findings from this study will not only inform municipalities, and the country as a whole, as to the losses they can expect, but also looks to provide contingency options which can be instituted over a period of time to protect the city's revenue. This report is the final output of the project, showing the results achieved and options decided on.

Methodology

In consultation with Ekurhuleni, Sustainable Energy Africa (SEA) has developed tools to determine the uptake of PV and EE interventions for each sector, and the impact each of these interventions would have on electricity consumption and revenue in the municipality over a 10 year period. The revenue impact tool developed by SEA is the most detailed one currently available in the country.

Due to municipalities' paying Eskom different rates at different times of the day and year, revenue loss from EE and RE will depend on when in the day, week and year the energy sale is lost. The tool bases its calculations from this perspective, and as such provides an accurate reflection of revenue lost. The tool includes hourly electricity load profiles for winter and summer, weekdays and weekends for each sector, the projected decrease in load profiles due to the penetration of RE and various EE interventions over the next 10 years, Eskom purchases, alternate municipal energy sources and load balancing, net metering, consumption growth, tariffs and price increases and distribution losses etc. (Refer to appendix for assumptions).

Both tools are available at no cost.

Results

The first step in determining the impact of EE and RE interventions over the next ten years is to determine the financial feasibility of these interventions within this period. Interventions need to be affordable to make them attractive to the market, and as such uptake will be directly linked to a strong financial case. Energy efficiency interventions (efficient lights, water heaters, motors, HVAC etc) are mostly financially feasible already, and uptake is expected to be rapid over the next 10 years. However, the financial feasibility of PV is not clear as prices are expected to reduce in future as global demand increases.

To clarify this, a market related analysis was undertaken to determine the potential rate of uptake of PV for each economic sector over ten years.

> To see how calculations were done, refer to spreadsheet 'PV cost benefit analysis – uptake scenarios (BAU)' and accompanying 'Instruction sheet'. The spreadsheet is able to calculate the break even points for PV installations in the residential, commercial and industrial sectors if installed now, in 5 years' time or 10 years' time. These can be downloaded from http://www.cityenergy.org.za/category.php?id=3#1 (Solar PV cost benefit analysis tool; and Guide on municipal revenue impact from renewable and energy efficiency tools).

The table below summarises the outputs from the PV tool for Ekurhuleni. The yellow table represents pay back periods for PV if installed now. The orange table represents pay back periods for PV if installed in 5 years' time. The red table represents pay back periods for PV if installed in 10 years' time. Two sets of tables are presented for each time period– one which assumes a real PV price drop of 4% per annum, and one which assumes 8%. Payback is also calculated for 3 different financing options:

i. Cash up front (0% on the table)
ii. 18% loan repayed over 5 years (retail bank loan)
iii. 8.5% loan repayed over 10 years (access bond type loan)

It is assumed that an intervention which should enjoy market uptake is either:

i. one which breaks even in under 3 years or,
ii. one where the monthly loss is less than R100. This is the difference between the repayment amount and the amount saved from not purchasing electricity

Conditions under which market uptake would be favourable have been highlighted in grey in the table below.

4% drop in PV

Financing arrangement		0%	18% over 5yrs	8.5% over 10 yrs
		Install now		
Resid	PBP (year)	11	16	15
	Max annual loss	R 50,463.81	R 13,731.81	R 4,693.83
	Monthly loss	R 4,205.32	R 1,144.32	R 391.15
Comm	PBP (year)	9	13	12
	Max annual loss	R 45,621.86	R 11,610.75	R 3,242.25
	Monthly loss	3802	968	270
Industrial	PBP (year)	10	14	13
	Max annual loss	R 35,043.82	R 9,195.38	R 2,835.31
	Monthly loss	2920	766	236

Financing arrangement		0%	18% over 5yrs	8.5% over 10yrs
		Install in 5 years		
Resid	PBP (year)	10	13	13
	Max annual loss	R 52,860.57	R 13,667.34	R 4,023.76
	Monthly loss in 2013 ZAR	R 3,529	R 912	R 269
Comm	PBP (year)	8	11	11
	Max annual loss	R 47,459.76	R 11,169.73	2240.487705
	Monthly loss in 2013 ZAR	R 3,168	R 746	R 150
Industrial	PBP (year)	9	12	12
	Max annual loss	R 36,568.85	R 8,988.43	R 2,202.20
	Monthly loss in 2013 ZAR	R 2,441	R 600	R 147

Financing arrangement		0%	18% over 5yrs	8.5% over 10 yrs
		Install in 10 years		
Resid	PBP (year)	8	11	11
	Max annual loss	R 55,589.88	R 13,086.90	R 2,628.95
	Monthly loss in 2013 ZAR	R 2,813	R 662	R 133
Comm	PBP (year)	6	9	2
	Max annual loss	R 49,319.99	R 9,965.38	R 282.09
	Monthly loss in 2013 ZAR	R 2,496	R 504	R 14
Industrial	PBP (year)	7	10	6
	Max annual loss	R 38,206.89	R 8,297.38	R 938.08
	Monthly loss in 2013 ZAR	R 1,933	R 420	R 47

8% drop in PV

Financing arrangement		0%	18% over 5yrs	8.5% over 10 yrs
		Install now		
Resid	PBP (year)	11	16	15
	Max annual loss	R 50,463.81	R 13,731.81	R 4,693.83
	Monthly loss	R 4,205.32	R 1,144.32	R 391.15
Comm	PBP (year)	9	13	12
	Max annual loss	R 45,621.86	R 11,610.75	R 3,242.25
	Monthly loss	3802	968	270
Industrial	PBP (year)	10	14	13
	Max annual loss	R 35,043.82	R 9,195.38	R 2,835.31
	Monthly loss	2920	766	236

Financing arrangement		0%	18% over 5yrs	8.5% over 10yrs
		Install in 5 years		
Resid	PBP (year)	9	12	12
	Max annual loss	R 44,787.15	R 11,085.64	R 2,793.31
	Monthly loss in 2013 ZAR	R 2,990	R 740	R 186
Comm	PBP (year)	7	10	7
	Max annual loss	R 39,984.37	R 8,779.27	1101.180989
	Monthly loss in 2013 ZAR	R 2,669	R 586	R 74
Industrial	PBP (year)	8	11	10
	Max annual loss	R 30,887.56	R 7,171.68	R 1,336.33
	Monthly loss in 2013 ZAR	R 2,062	R 479	R 89

Financing arrangement		0%	18% over 5yrs	8.5% over 10 yrs
		Install in 10 years		
Resid	PBP (year)	6	9	1
	Max annual loss	R 37,595.14	R 7,332.58	-R 113.59
	Monthly loss in 2013 ZAR	R 1,902	R 371	-R 6
Comm	PBP (year)	5	7	1
	Max annual loss	R 32,658.19	R 4,637.30	-R 2,257.30
	Monthly loss in 2013 ZAR	R 1,652	R 235	-R 114
Industrial	PBP (year)	5	8	1
	Max annual loss	R 25,543.92	R 4,248.05	-R 991.85
	Monthly loss in 2013 ZAR	R 1,293	R 215	-R 50

Figure 1: Cost benefit analysis for PV installation in Ekurhuleni: now, in 5 years' time and 10 years' time

In summary then, the tables show that PV only becomes financially feasible and attractive to the market in the following time frames by sector:

- Residential – more than 10 years from today
- Small commercial – 10 years from today
- Industrial sector – 10 years from today

Intervention Uptake

Once an intervention becomes financially feasible, it is assumed, using the Rogers Distribution Curve as a basis, that 2.5%-15% of the market will already have implemented the intervention.

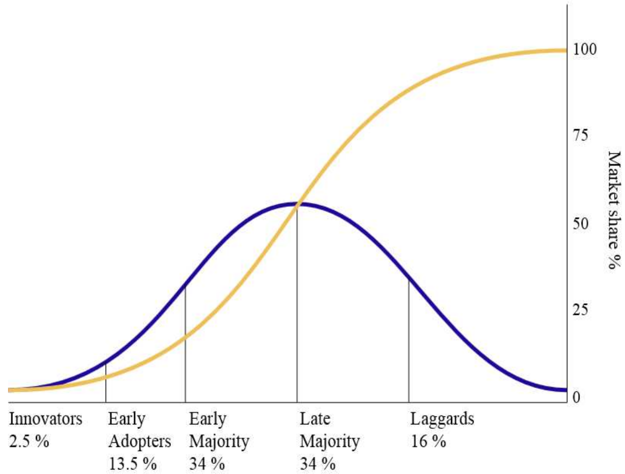

Figure 2: Rogers Distribution Curve showing typical intervention uptake

Mainstreamed interventions are assumed to have penetrated 15%-50% of the market, having been financially feasible for 5 years, while mature interventions are assumed to have penetrated 50%-85% of the market having been financially feasible for 10 years or more.

For PV therefore it is assumed that with the exception of small commercial buildings, between 2.5%-15% of the electricity customers will have installed PV in 10 years' time. As small commercial PV will be financially viable in 5 years, in 10 years' time it will have penetrated 15%-50% of the market. Energy efficiency interventions which are currently financially viable are assumed to be mature in 10 years' time and to have penetrated 50%-85% of the market.

Following this reasoning the uptake rates and total amount of all interventions modelled by year 10 are as follows:

Intervention	Low Penetration (%)	High Penetration (%)	Low Penetration	High Penetration
Res PV	2.5%	15%	4000	24000
SWHs	50%	85%	80000	136000
Res EE	50%	85%	80000	136000
Small comm PV	15%	50%	3000	10000
Small comm EE	50%	85%	10000	17000
Indus PV	15%	50%	900	3000
Indus EE LV	50%	85%	0	0
Indus EE MV	50%	85%	0	0
Indus EE MV TOU	50%	85%	0	0
Indus EE HV TOU	50%	85%	3000	5100

Figure 3: RE and EE Intervention penetration rates for Ekurhuleni by intervention and sector in 10 years' time

<u>Impact on city revenue</u>

The penetration information presented above was then fed into the City revenue impact model to determine the extent of the losses on municipal finances over the next 10 years. The losses to the city revenue were calculated using the assumptions listed in the appendix of this document.

> To see how calculations were done, refer to spreadsheet 'City revenue from RE and EE tool Oct 2013'and accompanying 'Instruction sheet'. These can be downloaded from http://www.cityenergy.org.za/category.php?id=3#1 (Impact of renewable energy and energy efficiency on municipal revenue spreadsheet tool; and Guide on municipal revenue impact from renewable and energy efficiency tools).
>
> The spreadsheet accurately calculates the impact of RE and EE interventions on City finances over 10 years.

It is important to understand how the losses are calculated in order to be clear what the percentage losses mean. Of the total electricity revenue received by the City, some 67% is passed on to Eskom as repayment for electricity purchased. The remaining 33% is for the operation of the Electricity Department. Sales losses can then be represented as a percentage of the total revenue figure (total losses), or as a percentage of the operational figure (operational losses). Essentially, percentage wise, operational losses are 3.3 times higher than overall losses, but total wise the losses are the same.

For example:

- A City has a total annual revenue of R10bn
- R6.7bn is paid to Eskom, leaving R3.3bn for operational revenue (use by electricity dept to function, cross subsidising other City functions)
- A 1% loss on total revenue from EE and RE would be R100 million
- The operational revenue loss would equate to 100milion/3.3bn = 3.3%

For the electricity department, the operational losses are a more useful way of looking at the impact, as these are the real internal losses experienced as a business.

The operational revenue losses for Ekurhuleni are presented in the tables below. The model was run using two input scenarios. The first is the low penetration scenario, based on the 'Low penetration (%)' column of Figure 3 above. The second is the high penetration scenario based on the 'High penetration (%)' column of Figure 3 above. These two scenarios create an upper and lower limit of potential impact from EE and RE into the future. The tables indicate the impact now (grey), impact in 3 years (yellow), impact in 5 years (orange) and impact in 10 years (red) by intervention and sector.

	Residential			Commercial		Industrial		Street & Traffic lights	All interv. (no fixed Charge)
year	Res PV	SWHs	Other res EE*	Comm PV	Commercial EE	Ind PV	Industr EE		
0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.79%	0.79%
3	-0.01%	-0.22%	-0.11%	-0.03%	-0.05%	-0.23%	-0.08%	0.79%	0.07%
5	-0.03%	-0.77%	-0.37%	-0.11%	-0.17%	-0.77%	-0.26%	0.82%	-1.66%
10	-0.07%	-2.10%	-1.00%	-0.31%	-0.45%	-2.26%	-0.71%	0.88%	-5.91%

Figure 4: Revenue loss (of operational revenue) %- Low Penetration

	Residential			Commercial		Industrial		Street & Traffic lights	All interv. (no fixed Charge)
year	Res PV	SWHs	Other res EE*	Comm PV	Commercial EE	Ind PV	Industr EE		
0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.79%	0.79%
3	-0.05%	-0.38%	-0.18%	-0.11%	-0.08%	-0.75%	-0.13%	0.79%	-0.89%
5	-0.16%	-1.31%	-0.62%	-0.38%	-0.28%	-2.79%	-0.44%	0.82%	-5.13%
10	-0.44%	-3.58%	-1.71%	-1.04%	-0.77%	-7.74%	-1.20%	0.88%	-15.51%

Figure 5: Revenue loss (of operational revenue) %- High Penetration

The model shows that:

- If there is low penetration, the residential sector will be the largest contributor to revenue losses up to year 10 with industrial and commercial following.
- If there is high penetration, the largest losses will be from the industrial sector installing PV.
- The city's own interventions such as EE street lights and traffic lights help to save a small amount.
- From year 3, the city will start experiencing declines in total electricity sales.
- In year 10, the city will experience losses ranging from 5-15% of operational revenue i.e. 5-15% less than business as usual.

Three other sub-scenarios were also investigated as follows:

1. Load shifting at various levels in the residential sector
2. 5% customer growth from 2017
3. Optimising PV system sizes

The results of these alternative scenarios investigated are not presented as it was found not to have a significantly different impact from the results shown in this report. The model demonstrated that city revenue was **most affected by market penetration of interventions (high vs low penetration).**

Revenue Protection Options

There are various options to mitigate these losses. Typically the municipality increases electricity tariffs to meet budget, however, this adversely affects the poor. High electricity prices also make the financial case for RE and EE more attractive. Therefore other measures need to be explored.

i. Decoupling

The most sensible option is to protect revenue using a decoupled tariff which is composed of a fixed charge and energy charge. This is the most transparent tariff as it shows the cost of the service i.e. having access to the grid, and then the actual price of electricity. For example a residential customer would pay 55c/kWh, which would be passed on directly to Eskom by the municipality, and the municipality would charge a monthly fee of R400 to cover the cost of supplying that customer with electricity. In this way the municipality protects its revenue, no matter how much electricity is sold. In many ways it will encourage the electricity department to support energy saving, as this will reduce the demand placed on their network. The reduction of the energy charge however will have the effect of making the business case for EE and RE interventions less attractive, and would slow down the uptake for a period. However, this model will allow a fair and equitable tariff structure to develop, protect municipal finances, and promote more stable EE and RE business models into the future.

ii. NETFIT

The NETFIT business case proposed by Eskom describes a mechanism to compensate municipalities for monetary losses as a result of PV. This is gathering support and could well be implemented nationally. NETFIT, if implemented correctly, would solve the revenue loss problem from PV generation. However, this model does not take into account revenue loss from EE interventions and behaviour change, which are expected to be substantially greater than PV. This solution would therefore only be partially beneficial to municipalities.

This decoupled option where it is only offered to households with PV was evaluated and the results shown below.

iii. Decoupled tariff for PV users only

This option applies a partially decoupled tariff to PV customers only – energy and service charge. Once again this mechanism will only improve losses from PV sales.

This scenario was modelled and the results presented in figure 6 below. Using only households with PV on the decoupled tariff, using a fixed charge (R5/kWp/day) and an energy charge (88c/kWh), the municipality is able to mitigate losses.

year	Res PV decoupled
0	0.00%
3	0.25%
5	0.84%
10	2.39%

Figure 6: Revenue gain (of operational revenue) %

The results show an increasing surplus therefore, these rates would need to be adjusted every year so that the municipality remains profit neutral.

A compulsory decoupled tariff for only those customers who have PV encourages illegal connections as they would benefit from the higher energy charge on their old tariff. In other words, their savings from generating PV would be greater due to the higher energy charge. For example a PV generator which generates 5kWhs in a day will save R7.50 from an energy tariff of R1.50/kWh, and only R2.50 from an energy tariff of 50c/kWh. Therefore if implemented in this way, it would need to be closely monitored.

On the whole though, it is unlikely that this tariff will be successful, and will once again only avoid a small component of the revenue losses is enforced correctly. A full decoupled option as described in Option i above is a far better solution.

iv. Customer growth and improved business efficiency

It also stands to reason that increasing customers and reducing operational costs within the electricity department will provide additional income and offset any losses from EE and RE.

Conclusion-Ekurhuleni

The results from this study have shown that large scale installation of PV in all sectors is only expected to occur in Ekurhuleni 10 years from now as it becomes financially feasible for customers to install. The operational revenue losses for the electricity department are projected to be between 5%-15% lower than business as usual in 10 years' time. The main areas where these losses will occur are residential solar water heating, and industrial PV.

In order to ensure the functionality of the municipality, these losses need to be either absorbed or protected. The various strategies discussed with the Ekurhuleni electricity department point towards

i. Decoupling the electricity tariff into an energy charge (to cover Eskom charges) and a fixed charge (to cover distribution costs). This will secure the municipal business model and encourage EE and RE within a municipality
ii. A NETFIT funded by the REIPPP and managed by Eskom as a component of the national strategy to grow the renewable sector. This which will compensate the City for lost revenue from PV and recompensate any excess generation from PV customers.
iii. More efficient business processes and working hard towards customer growth will assist in absorbing revenue losses

As a final summary of this work, it is clear that a workable solution to the growing implementation of EE and RE can be found, and that Ekurhuleni has 3-5 years to implement these changes. In so doing, a paradigm shift in the perception of EE and RE can be achieved within the elements of the municipality which is concerned with revenue, which will result in a more sustainable energy future being encouraged and not resisted. Decoupling lies at the heart of this change, where without it, the long term sustainability of the electricity distribution business within a municipality is at risk.

Appendix

The following assumptions were used for the Revenue impact from EE and RE model:

- EE interventions include:
    - Residential: solar water heaters; showerhead; geyser blanket; lights and fuel switching for cooking
    - Commercial: Lights and HVAC
    - Industrial: motors etc (5% per customer)
- Full installed cost of PV (Residential = R27 000/kWp; small commercial = R25 000/kWp; Industrial = R19 000/kWp).
- Financing options: cash up front repayment; bond repayment (8.5% interest over 10 years); retail bank loans (18% over 5 yrs)
- No subsidy included
- Potential market/ customer base only includes those who consume more than 600kWh per month[1].
- PV, SWH and EE penetration rates are linked to market uptake scenarios developed for this report
- The Roger's Distribution Curve was applied to the uptake projections. An S curve with 10% uptake of the total 10 year market potential by year 5, and 35% by year 10 was used.
- PV size – Residential = 2kWp; Small Commercial = 4.5kWp; Industrial = 400kWp
- Radiation based on Eberhard, 1990[2]
- Load demands are based on averages of half hourly intervals taken over the last 12 months measured at the municipal intake points
- Hourly residential consumption profiles based on Davis, S. 2011[3].
- Hourly commercial and industrial profiles based on data supplied by eThekwini
- Landfill gas data based on data supplied by municipality
- Winter load demand - June to August months
- 0% load shifting (a probable 30% load shift in the residential sector shows negligible differences)
- 30% residential PV exported during the day
- Streetlights: current = 65 000; future = 75 000
- Traffic lights: current = 75 000; future = 120 000
- Purchase of exported PV energy at Megaflex rates (net metering)
- 0% growth in sales up to 2017, 1% growth in sales from 2017 onwards

[1] Any customer consuming lower than this amount is considered to be a very small user of electricity, either due to budget constraints or existing EE. This customer will in all likelihood not install RE and EE due to delayed return on investment time frames or due to the additional upfront costs.

[2] Eberhard, A., A Solar Radiation Data Handbook for Southern Africa. Elan Press, Cape Town, 1990

[3] Measuring the rebound effect of energy efficiency initiatives for the future: A South African case study. Energy Research Centre, UCT Research Paper. Available at: http://www.erc.uct.ac.za/Research/publications/11-Davis-etal-Rebound_Effect_Addendum.pdf

- 7.7% operational cost growth rate annually
- Eskom electricity increases of 6% (year1), and 8% thereafter
- CPI scenarios included 6.5% and 7.5%
- Distribution loss = 5.7%

Several other scenarios were investigated:

1. Load shifting at various levels in the residential sector
2. 5% customer growth from 2017
3. Optimising PV system sizes