The financial impact of residential rooftop PV on local governments in South Africa

A case study into Stellenbosch Municipality

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Contents

What is the research about?
• Research question
• Research Process

Pre-analysis (provides context and assess municipality’s argument)
Analysis and results
1) Grid capacity for EG
2) Impact in kW on electricity load profile
3) Impact in financial terms

Discussion: what should be the role of municipalities
Municipality’s Concern

- South African municipalities serve historically as electricity distributors and many rely on electricity revenue.

- Around 30 percent of total revenue comes from electricity sales. In some cases it can go up to 70% percent of the total income (Tusan & MacDonald 2014). The surplus is partly used to cross finance departments that run on losses. Rooftop PV forms a potential threat on this income from electricity sales as people’s purchases diminish from municipality. Electricity is for many (larger) municipalities seen as the cash cow or the golden egg.

- This does not count for every municipality, there are also many (mainly small and rural) municipalities that are in debt and owe Eskom money.
Research question

• What will be the impact on Stellenbosch Municipality’s electricity revenue if households in high-user suburbs are occupying the maximum capacity for EG according to NRS standard to feedback electricity produced by residential rooftop PV to the grid?
Methodology

- Single case study
- Mixed method but quantitative analyses is dominant
- Secondary data from Stellenbosch Municipality is being used
- An extreme case scenario has been used to project a possible future impact.
Research Process & Tools

- Identification high user suburbs
  - Potential investment areas for rooftop PV

- Electricity Grid Map
  - Analyses of maximum grid capacity in kW for channeling EG back to electricity grid based on NRS 097-2-series

- Record solar PV system
  - Hourly solar PV generation Profile for a municipal financial year 2013/2014

- Municipality’s electricity profile
  - Zimele technology: hourly electricity output Stellenbsch Main and Cloetesville substation
Contextualising research

- Provides context
- Assesses municipality’s argument
Assessment of Municipality’s argument

Revenue by source 2011/2012

- Property rates: 31%
- Property rates - penalties & collection charges: 22%
- Service charges - electricity revenue: 18%
- Service charges - water revenue: 9%
- Service charges - sanitation revenue: 5%
- Service charges - refuse revenue: 3%
- Service charges - other: 3%
- Rental of facilities and equip: 0%
- Interest earned - external investments: 2%
- Interest earned - outstanding debtors: 1%
- Fines: 1%
- Licenses and permits: 1%
- Agency services: 0%
- Transfers recognised - operational: 0%
- Other revenue: 1%
Assessment of Municipality’s argument

Relationship between electricity revenue and expenditure.
Why focus on residential sector?

Revenue per category consumer 2012/2013

- Domestic Pre-paid: 24%
- Domestic Conventional: 8%
- Agriculture: 4%
- Manufacturing/Industry: 2%
- Commercial: 2%
- Street Lighting: 1%
- Municipality Departments: 35%
Why focus on residential sector?

- 60% of the electricity revenue comes from the residential sector in Stellenbosch
- Residential sector responsible for most fluctuations in load profile
- Add the most during peak hours
  - During peak hours electricity is more costly for municipality: municipality pays in certain circumstances (Winter) more to Eskom per unit than citizens pay per unit to the municipality
Identified High User Suburbs
Average electricity usage per suburb

• **Highest user suburbs**
  • Uniepark 1130 (Pre-paid) 1105 (credit)
  • Dalsig 960 (Pre-paid) 1050 (credit)

• With exceptional high users of over 10,000kWh a month

• **Lowest user suburbs**
  • Kayamandi 156 (pre-paid) 420 (credit)
  • Cloetesville 570 (Credit)
Analysis 1) Grid capacity for Embedded Generation

• How much consumer-generated electricity can go onto the grid according to South African standards?

• NRS 097-2-series

• Two steps taken:
  • 1) From MV/LV Transformer
  • 2) From MV feeder level
Analysis of grid capacity for receiving EG according to NRS 097-2-series
## Conclusion

<table>
<thead>
<tr>
<th>Step 2 Max. Transformer</th>
<th>kVA (kVA (25% NMD))</th>
<th>kW PF= 0,95</th>
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<tbody>
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<td>Total</td>
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<table>
<thead>
<tr>
<th>Step 3 Max. MV Feeder</th>
<th>kVA (kVA (15% NMD))</th>
<th>kW PF= 0,95</th>
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<tr>
<td></td>
<td>7656,0</td>
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| Difference between totals | 1841,0 | -305,4 |
|                          |        | -290,1 |
Overall max Transformer

<table>
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<tr>
<th>Substation</th>
<th>Area</th>
<th>Transformer kVA</th>
<th>kVA (25% NMD)</th>
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<td>Uniepark &amp; Karindal</td>
<td>3925,0</td>
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<td>Cloetesville</td>
<td>Welgevonden</td>
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<td>4945,0</td>
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<td><strong>Total</strong></td>
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<td><strong>30765,0</strong></td>
<td><strong>7455,0</strong></td>
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Overall max MV Feeder

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<th>Substation</th>
<th>Area</th>
<th>MV Feeder kVA</th>
<th>kVA (15% NMD)</th>
<th>kW PF=0,95</th>
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<td><strong>54098,0</strong></td>
<td><strong>8114,7</strong></td>
<td><strong>7709,0</strong></td>
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</table>
Sub-conclusion

• Maximum EG that can be put back onto the grid is between 7 and 7.7 MW for the identified high user suburbs

• Safest approach is to take the lowest value as point of departure for further measurement
Analysis 2) Impact on load profile

- Impact in kW on electricity output profile of municipality for the identified high-user suburbs
Electricity load output profile
Stellenbosch

Account ID: 1686

Legend:
- Abnormal/Interpolated value
- Gap in data

Consumption:
- Peak - low demand
- Peak - high demand
- Off Peak - low demand
- Off Peak - high demand
- Standard - high demand
- Standard - low demand

Demand:
- Demand Charge

Refresh Graph
Choose Dates

Tue Jul 09 2013 00:00 to Wed Jul 10 2013 00:00
Impact on Electricity Usage in kW

- The next slides present the impact on the electricity usage by rooftop solar PV in the areas Welgevonden, Paradyskloof, Dalsig, Uniepark and Onder Papegaaiberg.
- The data is given in graphs that show the electricity output for the Cloetesville and Stellenbosch substation. Welgevonden is connected to Cloetesville and the remaining areas are connected to Stellenbosch substation.
- The graphs show the impact from July 2013 till June 2014 which is the municipal financial year 2013/2014
- Typical days for season are used to plot PV output for the particular month
- Note: the impact of rooftop PV is given without considering the rebound effect of people increasing electricity usage since they reduce costs by generating own electricity
- This research also does not look at the position of the rooftops:
Tuesday 9 July 2013

Welgevonden

- Losses
- PV Production (Welgevonden max)
- Electricity use less PV production (so = new use)
Tuesday 9 July 2013
Onder Papegaaiberg, Paradyskloof, Dalsig, Uniepark

- Total losses
- PV Production (Unipark and karindal max)
- PV Production (dalsig and brandwacht max)
- PV Production (paradyskloof and die boord max)
- PV Production (Onder Papegaaiberg max)
- Electricity use less PV production (so= new use)
Monday 18 November 2013

Welgevonden

- Losses
- PV Production (Welgevonden max)
- Electricity use less PV production (so = new use)
Monday 18 November 2013
Onder Papegaaiberg, Paradyskloof, Dalsig, Uniepark

Total losses
PV Production (Unipark and karindal max)
PV Production (dalsig and brandwacht max)
PV Production (paradyskloof and die boord max)
PV Production (Onder Papegaaiberg max)
Electricity use less PV production (so= new use)
Wednesday 5 February 2014
Onder Papegaaiberg, Paradyskloof, Dalsig, Uniepark

- Total losses
- PV Production (Unipark and karindal max)
- PV Production (dalsig and brandwacht max)
- PV Production (paradyskloof and die boord max)
- PV Production (Onder Papegaaiberg max)
- Electricity use less PV production (so= new use)
Analysis 3) Financial Impact

• What is the benefit as a result of rooftop pv?
• What is the loss as a result of rooftop pv?
• Difference between the two outcomes is the actual financial impact
Financial Impact

• Electricity consumption data used from municipality for pre-paid and credit for whole of Stellenbosch for every month in the past 5 years.

• Filtered out the domestic users in identified high user suburbs
Financial Impact

• Eskom charges the municipality different tariffs at different hours: Off-peak, Standard and Peak
• Therefore we need to know what solar electricity is produced during which hours.
• This needs to be put into relative proportion according to max capacity of the grid in the different suburbs.
• The tariffs Eskom charges need to be multiplied by the amount of EG solar energy.
• This would show how much it would affect the municipality’s bill to Eskom.
Solar generated in high-low season
Savings for municipality

<table>
<thead>
<tr>
<th>High Season</th>
<th>Tariff Hour</th>
<th>Tariff</th>
<th>Maximum PV in Stellenbosch sample system</th>
<th>Electricity produced per kWp</th>
<th>EG produced for kWp</th>
<th>Proportion EG produced per tariff hour</th>
<th>Savings on Eskom bill for municipality in Rand</th>
<th>Proportion of savings</th>
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</thead>
<tbody>
<tr>
<td>Week</td>
<td>Off Peak</td>
<td>0,3383</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0%</td>
<td>0,0</td>
<td>0,0%</td>
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<tr>
<td></td>
<td>Standard</td>
<td>0,623</td>
<td>313574,1</td>
<td>186,7</td>
<td>1262721,9</td>
<td>11,3%</td>
<td>786675,7</td>
<td>14,4%</td>
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<tr>
<td></td>
<td>Peak</td>
<td>2,0566</td>
<td>41430,9</td>
<td>24,7</td>
<td>166836,7</td>
<td>1,5%</td>
<td>343116,3</td>
<td>6,3%</td>
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<tr>
<td>Saturday</td>
<td>Off Peak</td>
<td>0,3383</td>
<td>41631,9</td>
<td>24,8</td>
<td>167646,3</td>
<td>1,5%</td>
<td>56714,7</td>
<td>1,0%</td>
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<tr>
<td></td>
<td>Standard</td>
<td>0,623</td>
<td>26345,3</td>
<td>15,7</td>
<td>106089,1</td>
<td>1,0%</td>
<td>66093,5</td>
<td>1,2%</td>
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<tr>
<td>Sunday</td>
<td>Off Peak</td>
<td>0,3383</td>
<td>75560,4</td>
<td>45,0</td>
<td>304271,8</td>
<td>2,7%</td>
<td>102935,1</td>
<td>1,9%</td>
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<tr>
<td>Low Season</td>
<td>Off Peak</td>
<td>0,2929</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0%</td>
<td>0,0</td>
<td>0,0%</td>
</tr>
<tr>
<td></td>
<td>Standard</td>
<td>0,4617</td>
<td>1340990,6</td>
<td>798,2</td>
<td>5399993,4</td>
<td>48,5%</td>
<td>2493176,9</td>
<td>45,6%</td>
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<tr>
<td></td>
<td>Peak</td>
<td>0,6708</td>
<td>282819,5</td>
<td>168,3</td>
<td>1138876,9</td>
<td>10,2%</td>
<td>763958,6</td>
<td>14,0%</td>
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<tr>
<td>Saturday</td>
<td>Off Peak</td>
<td>0,2929</td>
<td>182136,3</td>
<td>108,4</td>
<td>733439,1</td>
<td>6,6%</td>
<td>214824,3</td>
<td>3,9%</td>
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<td>Standard</td>
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<td>541561,2</td>
<td>4,9%</td>
<td>250038,8</td>
<td>4,6%</td>
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<tr>
<td>Sunday</td>
<td>Off Peak</td>
<td>0,2929</td>
<td>328662,5</td>
<td>195,6</td>
<td>1323480,9</td>
<td>11,9%</td>
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<td>100,0%</td>
<td>5465181,7</td>
<td>100,0%</td>
</tr>
</tbody>
</table>
Saving for municipality

- Appr. 5.5 Mln
- R 808 per kWp installed
Costs for Municipality: From household side

- What are households putting up?
- Maximum grid capacity/ installation capacity: $6765.14/ \ 3 \ kWp = 2255 \ installations$
- Depending on in which tariff block the top usage of households fall into and what will be taken off by PV
- Use PV planner: EG produce in winter: eg 300 average electricity usage: 1000
## Average consumption per high user suburb

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<tbody>
<tr>
<td><strong>Credit meters</strong></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Uniepark &amp; Karindal</td>
<td>951,3</td>
<td>904,3</td>
<td>985,8</td>
<td>1418,9</td>
<td>1508,2</td>
<td>1418,2</td>
<td>1424,6</td>
<td>1249,3</td>
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<td>Die Boord &amp; Paradyskloof</td>
<td>808,0</td>
<td>743,6</td>
<td>759,0</td>
<td>972,1</td>
<td>1095,1</td>
<td>1150,2</td>
<td>721,8</td>
<td>1195,6</td>
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<td>Dalsig &amp; Brandwacht</td>
<td>952,2</td>
<td>907,2</td>
<td>915,7</td>
<td>1201,7</td>
<td>1365,9</td>
<td>1300,4</td>
<td>1035,4</td>
<td>1212,3</td>
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<tr>
<td>Onder Papegaaiberg</td>
<td>651,1</td>
<td>834,8</td>
<td>924,6</td>
<td>865,2</td>
<td>804,2</td>
<td>794,3</td>
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<tr>
<td><strong>Total Credit</strong></td>
<td>793,9</td>
<td>827,9</td>
<td>1106,9</td>
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<td>1183,5</td>
<td>951,5</td>
<td>1110,4</td>
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<td>Uniepark &amp; Karindal</td>
<td>912,7</td>
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<td>626,8</td>
<td>657,4</td>
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<td>697,8</td>
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<td>Welgevonden</td>
<td>431,0</td>
<td>433,7</td>
<td>462,2</td>
<td>514,9</td>
<td>579,8</td>
<td>638,3</td>
<td>568,4</td>
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<td><strong>Total Pre Paid</strong></td>
<td>705,2</td>
<td>673,3</td>
<td>650,8</td>
<td>662,5</td>
<td>687,0</td>
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<td><strong>Pre Paid and Total Credit</strong></td>
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<td>759,5</td>
<td>787,5</td>
<td>743,5</td>
<td>776,0</td>
<td>931,5</td>
<td>1010,0</td>
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<td>1009,3</td>
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</table>

Average consumption kWh per high income suburb Stellenbosch
Sub- conclusion

• Average credit meters: 940 kWh month
• Average pre-paid meters: 750 kWh month
• Total Average: 885 kWh

• **Problem**: individuals don’t invest because of average usage

• **New direction needed**: filter out the households in the high-user suburbs for whom it makes financially sense to invest
Discussion

• Is the argument of the municipality legitimate?

• What should be the role of the municipality regarding rooftop PV?
  – Resist because of fear for impact?
  – Active role: Embrace and collaborate, regulate to keep track
  – Passive: lessaiz-faire
Discussion

• Should electricity be fully cost recovery?
• If the surplus on electricity would be lost, should other departments not source funding from somewhere else or be cost reflective and sustain themselves?
Discussion

• Questionable if it makes sense for households to invest in rooftop PV
• If reduction of costs would be the reason would be the reason there are other more affective ways
• If you have a usage profile of 10,000 kWh a month: rather invest in SWH or other EE measurements or reduce electricity usage by switching off jacuzi
• It is also questionable that when somebody can afford these amounts of electricity a month if they really care about reducing costs
Discussion

• If the reason would be as a response to Eskom’s unreliable supply of electricity:
• You will still need the grid as a battery/ back up system, which does not work during load shedding
• Or you need to invest in batteries (which are costly to replace and unsustainable)
Thank you