TECHNICAL AND FINANCIAL IMPACTS OF RESIDENTIAL PV-BATTERY SYSTEMS

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Overview

• Objective of study.

• Simulation Model and Assumptions.

• Impacts on Power Flow.

• Impacts on Energy.

• Impacts on Revenue- Fixed rate vs Time of Use Tariff.

• Conclusions.
Objective of Study

The objective is to determine impact of PV only, battery only and combination thereof on MV networks for:

- **Technical**: impact on power flow profile.
- **Financial**: impact on revenue when considering time of use and fixed rate tariffs.

Important questions:

- How will battery storage and PV installations affect power flow profiles in MV networks?
- With increasing availability of battery storage, can the utility expect a reduction in revenue?
- What is the ideal tariff structure to implement that will minimise revenue loss with increased PV and storage in networks?
Simulation Model

- Network used was Flora Park in Polokwane Municipality with 87% residential and 13% commercial clients.
- The network has a total installed MV/LV transformer capacity of 13.2 MVA.
- All consumers have 60 A breakers (13.8 kVA).
- All studies were done using Digsilent PowerFactory 2018.
Load Profiles

- Assumed that network loading can reach 100% of the total MV/LV transformer capacity.
- Peak network loading occurs in winter with the summer peak approximately 40% of the winter peak.
PV Profiles

- Since all customers are on a shared feeder, as per NRS 097-2-3 PV installations are limited to 25% of the total NMD, i.e. max PV= 3.45 kVA/consumer (25% of 13.8 kVA).
- Peak PV output is achieved in summer with winter peak output approximately 80% of summer output.
Battery System

- Li-ion type, 52 V-460 Ah-24 kWh.

- The maximum charge is set to **3.64 kW**. The maximum discharge is set to **7.28 kW**.

- Controller determines battery charge/discharge logic, and therefore **3 different battery profiles** are considered:
  - Full discharge.
  - Load following.
  - Conservative discharge.
Battery Charge/Discharge Profiles

- **Full discharge**: Batteries discharge their full rated output during peak periods regardless of load demand.

- **Load following discharge**: Batteries discharge so that it matches the load value subjected to its maximum rated output limit.

- **Conservative discharge**: Batteries discharge to 50% of its maximum rated output, regardless of the load demand.
Study Assumptions

• All consumers are assumed to have PV and battery systems installed. No statistical dispatch of PV / battery systems were considered, hence:
  – 0% PV/Battery means all of the PV / battery systems are off.
  – 40% PV/Battery means the all the PV and battery systems outputs are limited to 40% of rating.
  – 100% PV/battery means the all the PV and battery systems outputs are on fully i.e. 100% of rating.

• Studies were done considering all battery profiles. Results showed very similar trends. For simplicity ONLY load following battery charge/discharge profile results are presented.
Impacts on Power Flow – PV Only

• Typical in networks with PV, **duck curve** is observed in summer and winter.
• During summer season, reverse power flow to HV network occurs.
• Adding **PV only** to the network **fails to overcome the traditional double peak.**
Impacts on Power Flow – Battery Only (load following profile)

- With 40% battery a smoothing effect is observed for the profiles.
- There is increased loading observed during traditional off peak due to charging.
- During peak times in the morning and evening, peak shaving can be observed.
Impacts on Power Flow – Battery Only (load following profile)

- When 100% Battery, there is a significant change in the power flow profile.
- There is an increased loading noted during traditional off-peak times.
- During traditional peak times in the morning and evening, dips in power flow are now observed.
Impacts on Power Flow – PV and Battery

- With 100% PV and batteries, there is a now an increased night loading.
- Midday loading observed with battery only is removed due to battery charging from PV.
- In summer, there is backfeed to the HV network.
- Peak shaving (40% case) and dips (100% case) occur at traditional morning and evening peak times respectively.
Impacts on Daily Energy Sold

- Reduction in energy sold is noted for PV scenarios.
- Batteries only cause NO reduction in energy sold. They only shift when the energy is sold.
Impacts on Revenue – Fixed Rate Tariff

- Reduction in revenue is noted for PV scenarios.
- Batteries only cause NO reduction in revenue for fixed rate tariff.
Impacts on Revenue – Time of Use Tariff

- Reduction in revenue is noted for battery only scenarios.
- Largest revenue loss is noted when PV and batteries are installed and a time of use tariff structure is in place.

https://www.ekurhuleni.gov.za/thecouncil/tariffs
Conclusions

• How will battery storage and PV installations affect power flow profiles in MV networks?
  – **PV Only:** Mid-day dips and reverse power flow in low loading cases.
  – **Battery Only:** Load shifting resulting in increased midday/midnight loading and dips with high penetration. Peak shaving achieved with balanced penetration.
  – **PV and Battery:** PV helps to reduce mid-day loading, traditional peaks now become dips for very high penetration levels.

• With increasing availability of battery storage, can the utility expect a reduction in revenue?
  – Depends on the tariff: No reduction expected for fixed rate tariff.
  – Reduction expected if on time of use tariff.

• What is the ideal tariff structure to implement that will minimise revenue loss with increased SSEG and storage in networks?
  - Networks with more PV
  - Networks with more batteries
  - Time of Use
  - Fixed rate
THANK YOU

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