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:

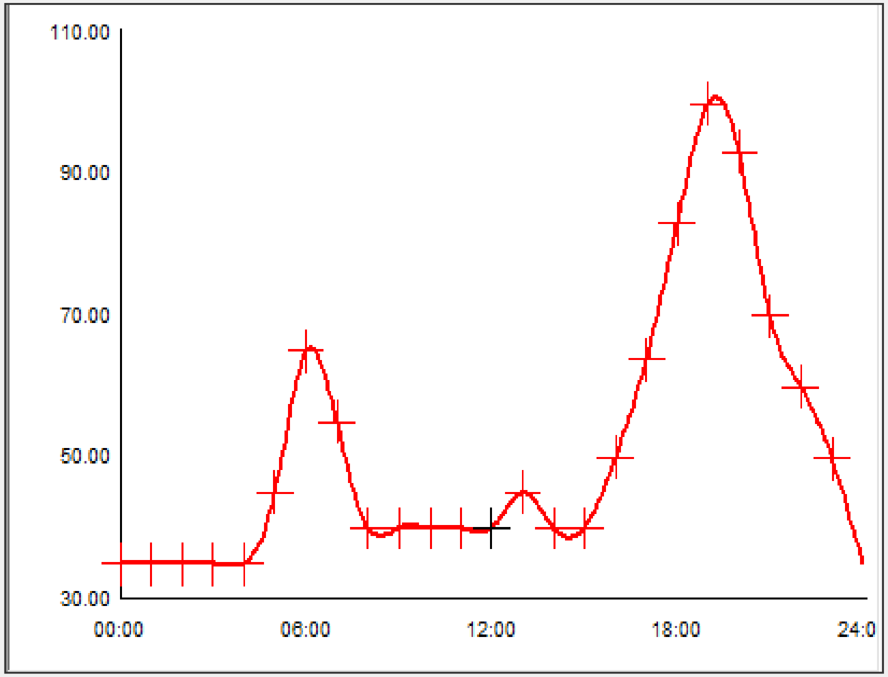
- How will battery storage and PV installations affect power flow profiles in MV networks?
- With increasing availability of battery storage, can the utility expect a reduction in revenue?
- What is the ideal tariff structure to implement that will minimise revenue loss with increased PV and storage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

Simulation Model

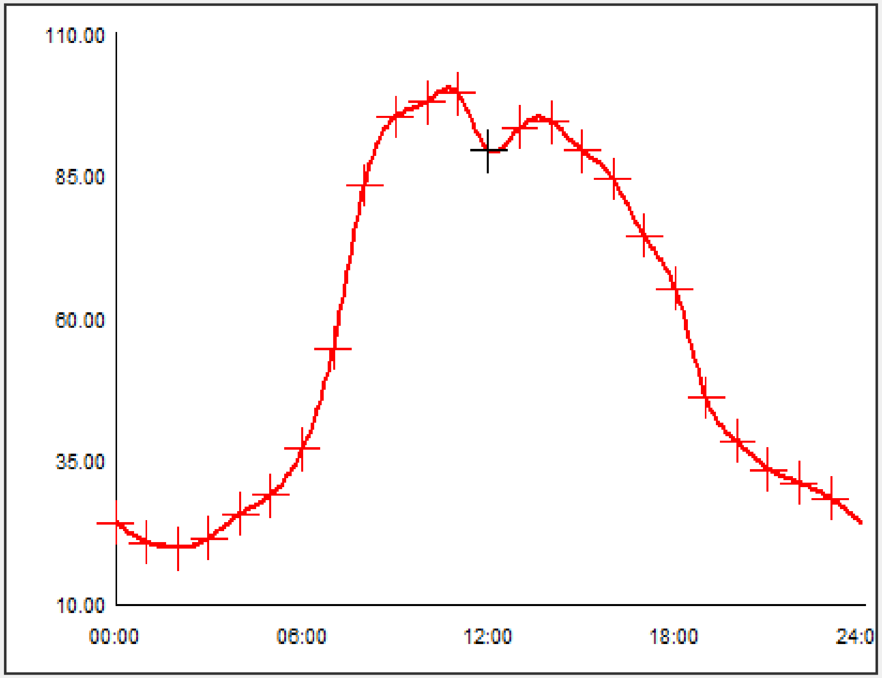
- Network used was Flora Park in Polokwane Municipality with 87% residential and 13% commercial clients.
- The network has a total installed MV/LV transformer capacity of 13.2 MVA.
- All consumers have 60 A breakers (13.8 kVA).
- All studies were done using Digsilent PowerFactory 2018.

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.



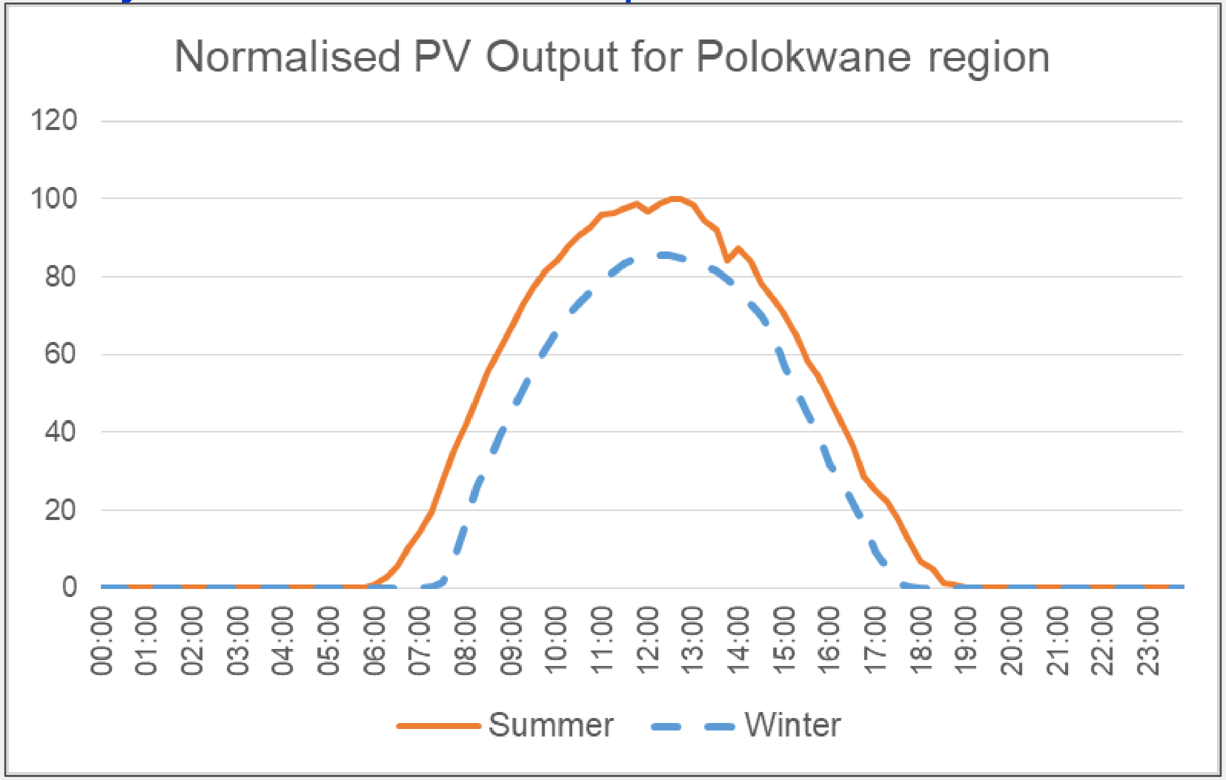
Residential Consumer



Commercial Consumer

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.

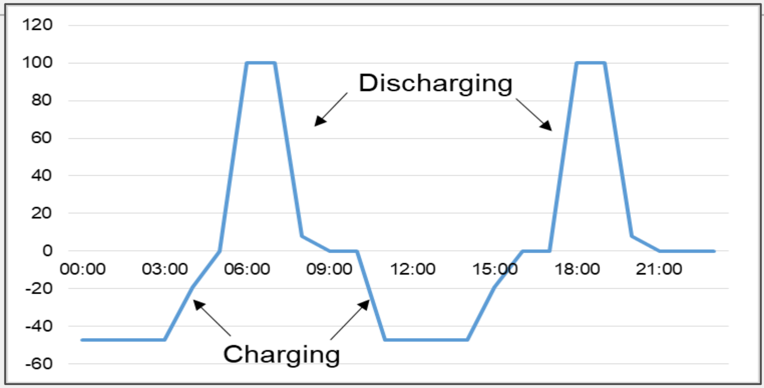


Battery System

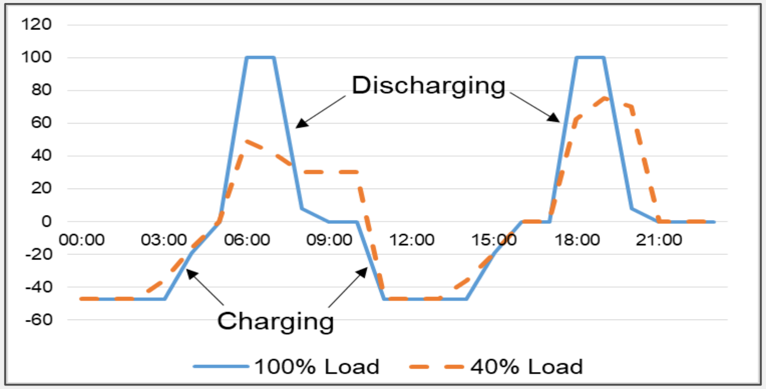
- Li-ion type, 52 V-460 Ah-24 kWh.
- The maximum charge is set to 3.64 kW. The maximum discharge is set to 7.28 kW.
- Controller determines battery charge/discharge logic, and therefore 3 different battery profiles are considered:
  - Full discharge.
  - Load following.
  - Conservative discharge.

Battery Charge/Discharge Profiles

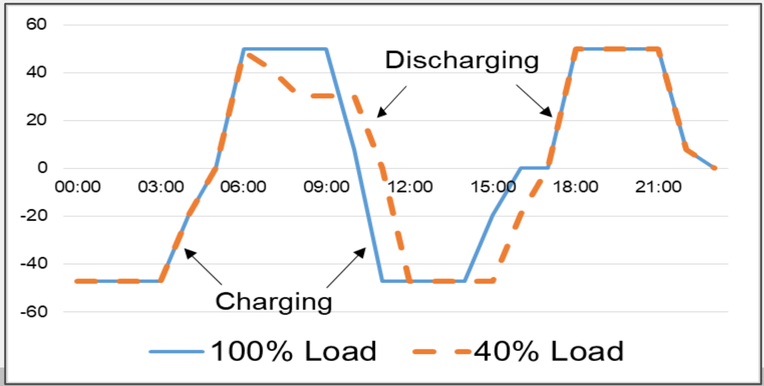
- **Full discharge:** Batteries discharge their full rated output during peak periods regardless of load demand.



- **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.

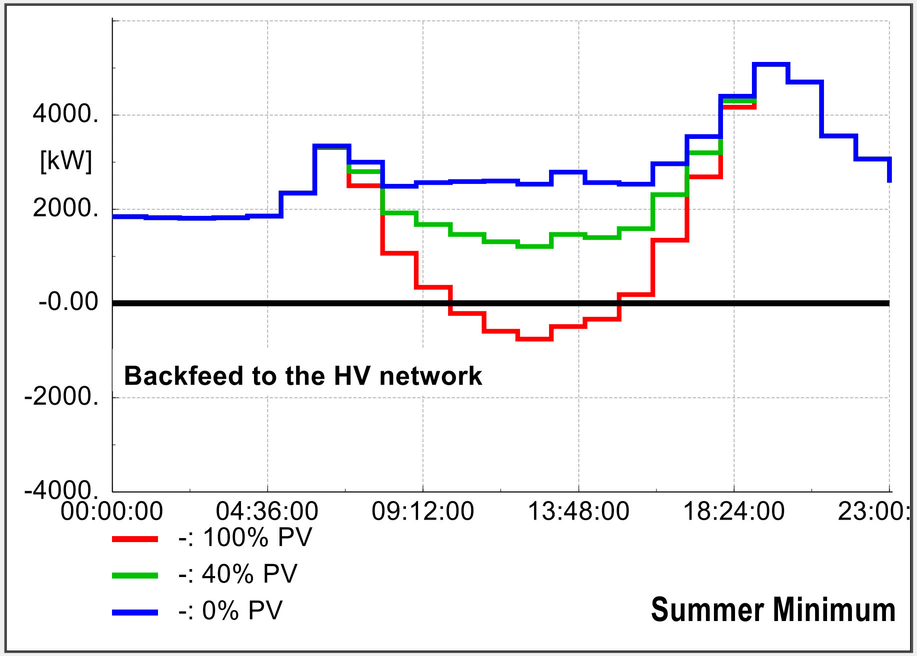


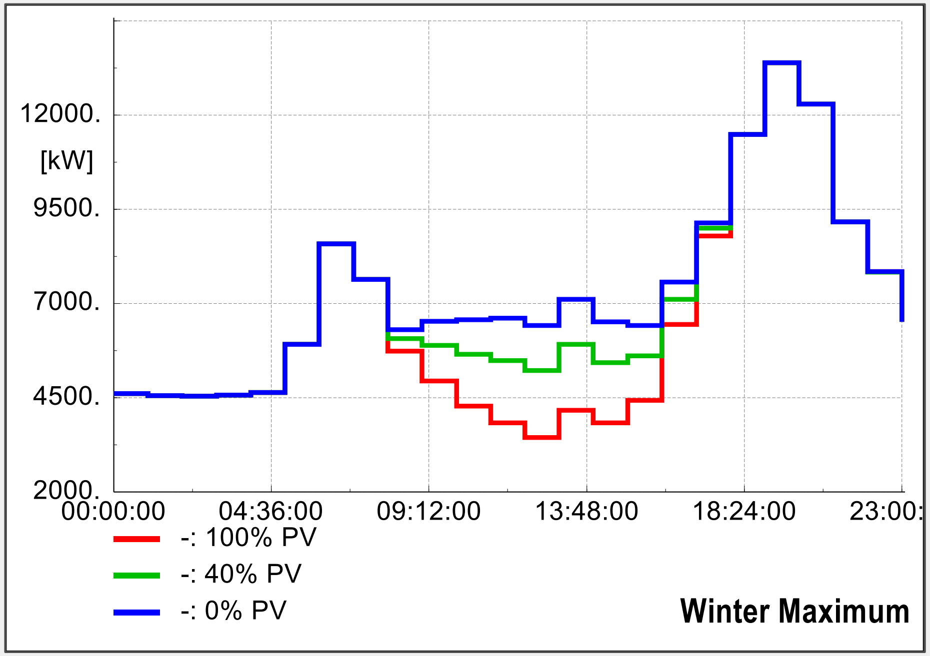
Study Assumptions

- 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.

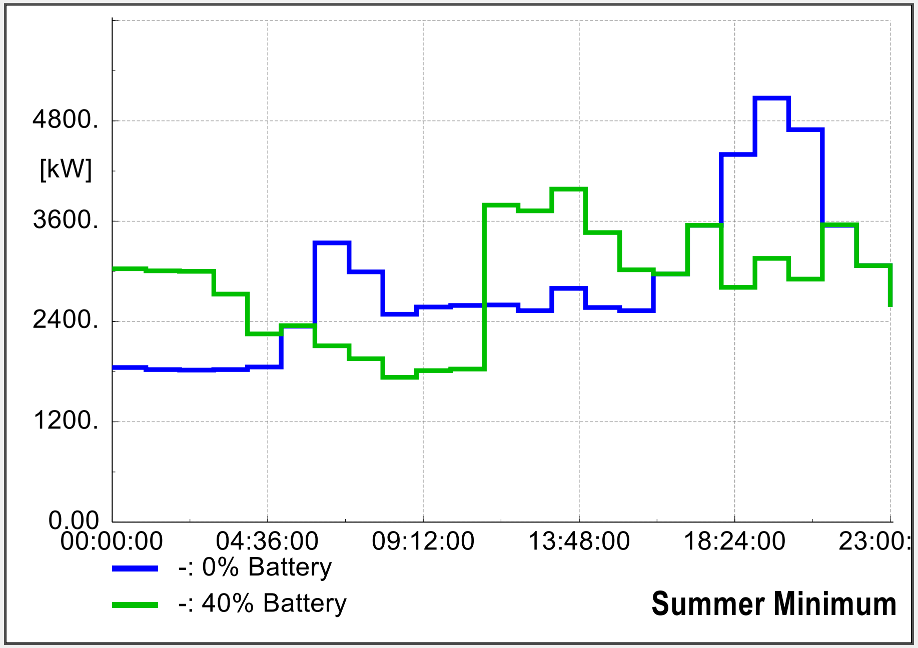
Impacts on Power Flow – PV Only

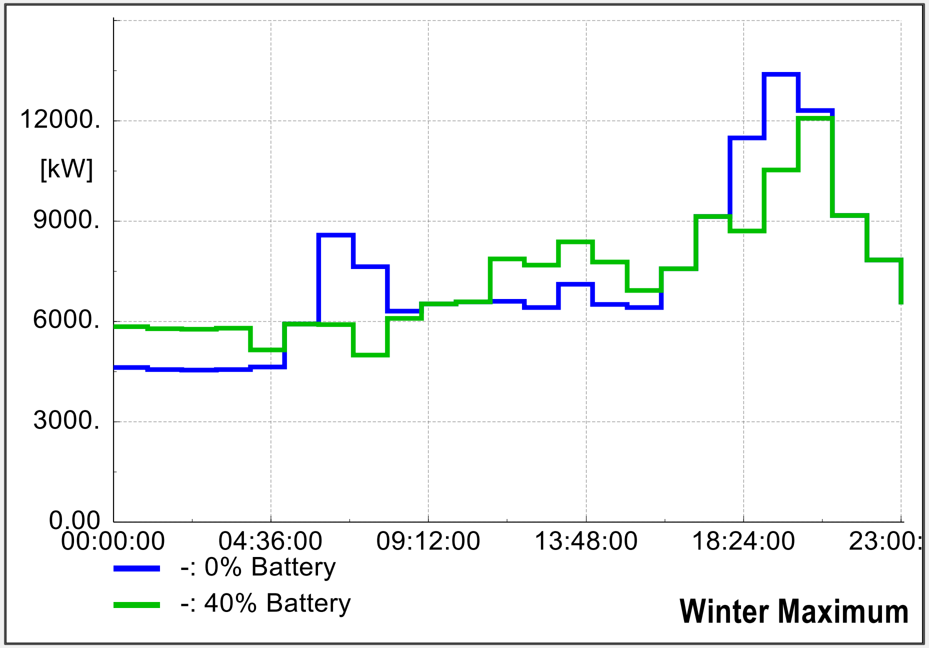




- Typical in networks with PV, duck curve is observed in summer and winter.
- During summer season, reverse power flow to HV network occurs.
- Adding PV only to the network fails to overcome the traditional double peak.

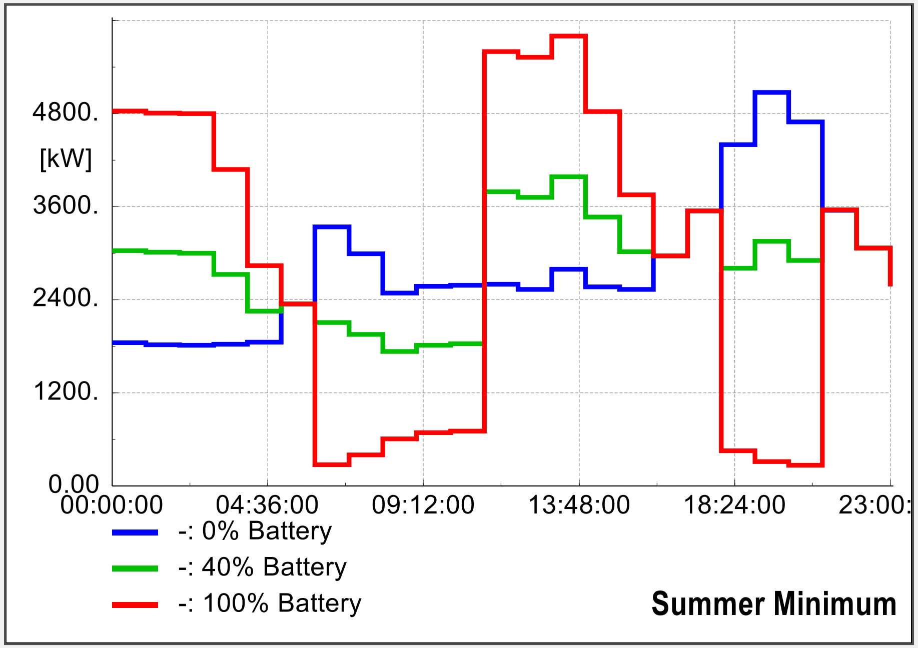
Impacts on Power Flow – Battery Only (load following profile)

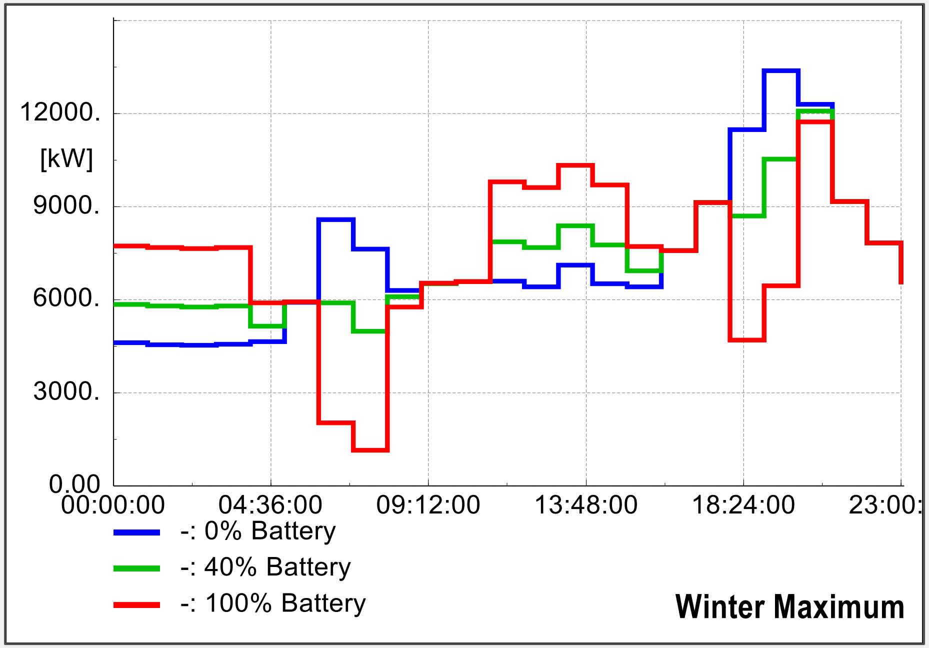




- With 40% battery a smoothing effect is observed for the profiles.
- There is increased loading observed during traditional off peak due to charging.
- During peak times in the morning and evening, peak shaving can be observed.

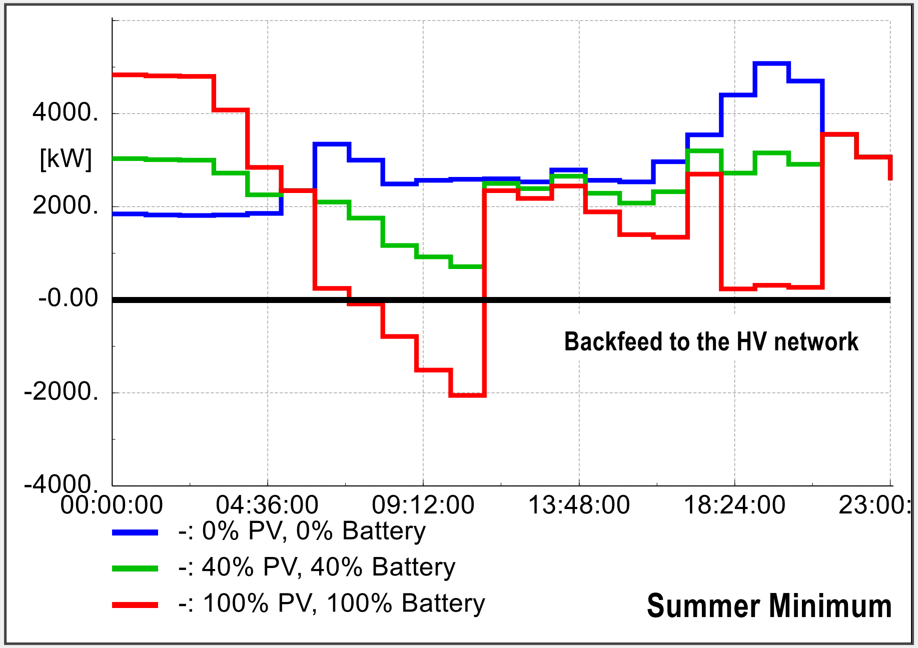
Impacts on Power Flow – Battery Only (load following profile)

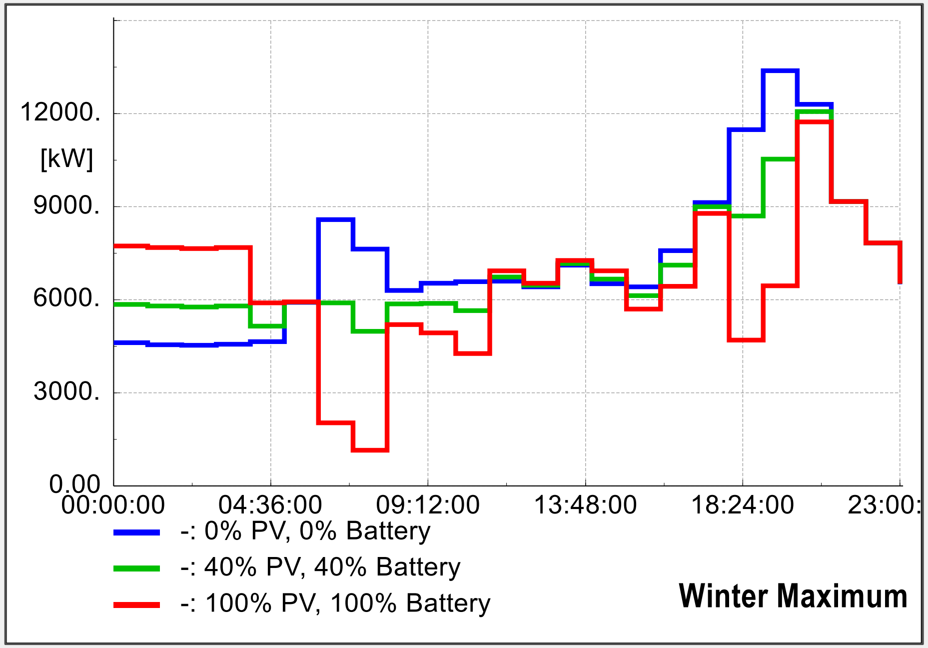




- When 100% Battery, there is a significant change in the power flow profile.
- There is a increased loading noted during traditional off-peak times.
- During traditional peak times in the morning and evening, **dips** in power flow are now observed.

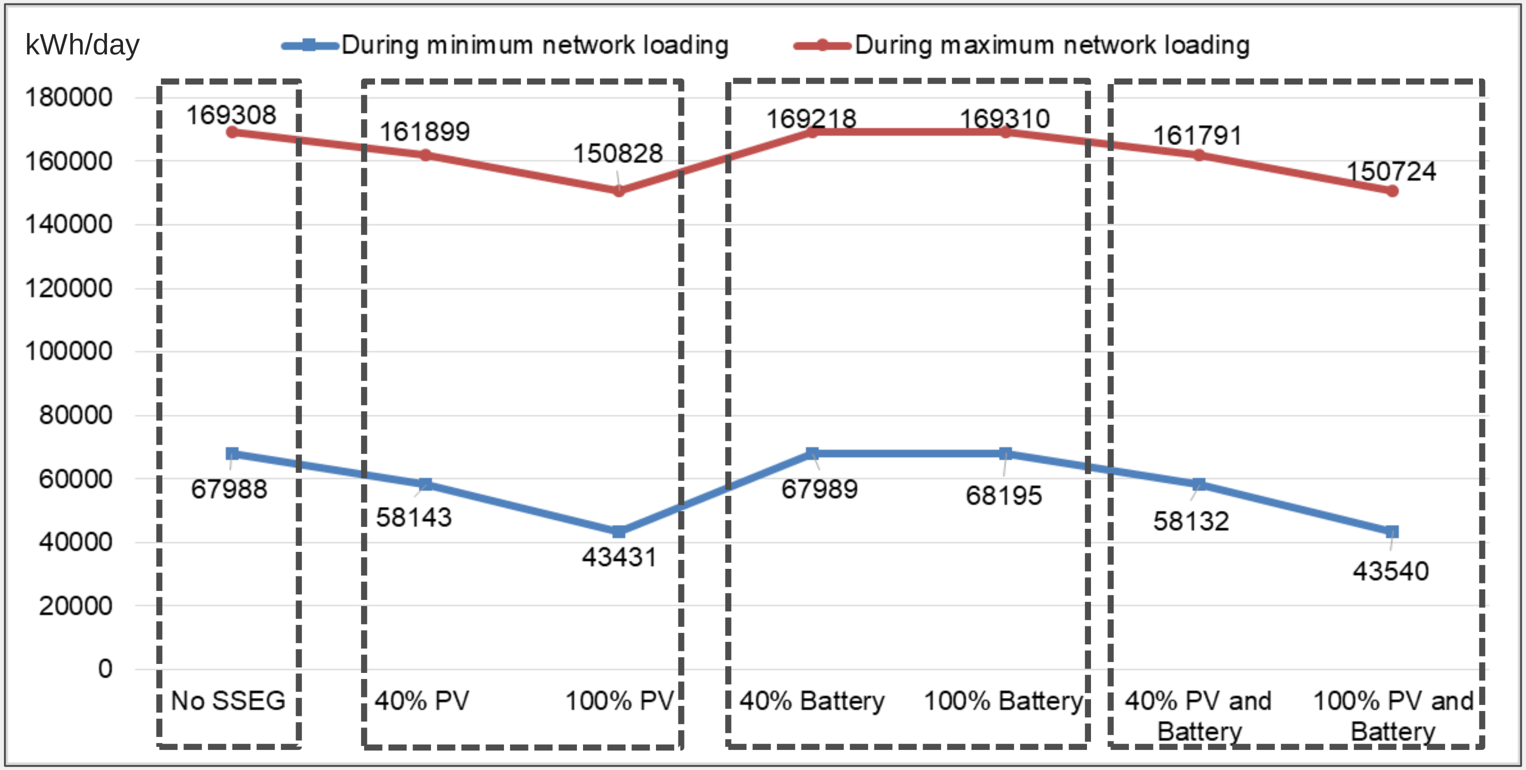
Impacts on Power Flow – PV and Battery





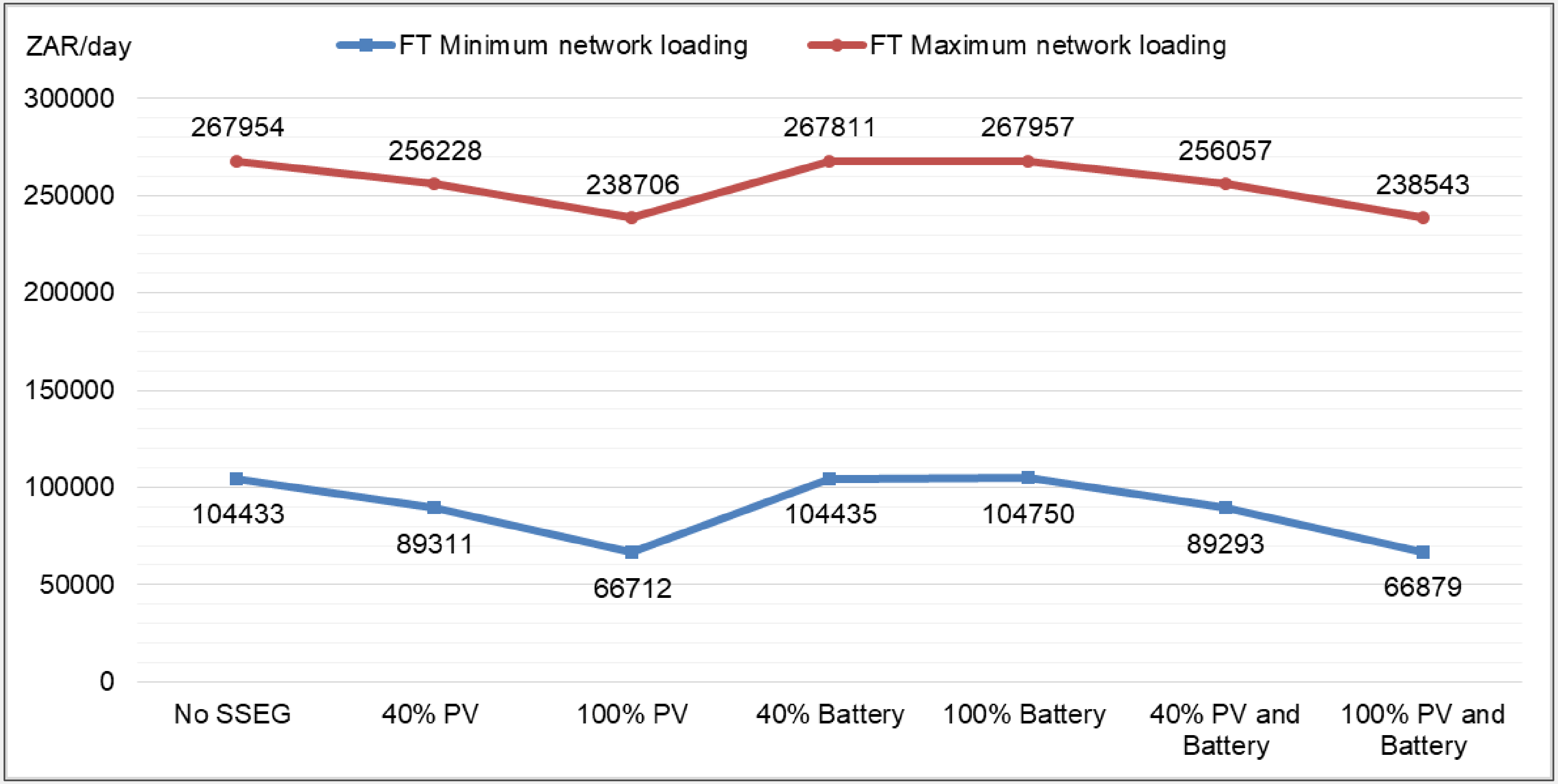
- With 100% PV and batteries, there is a now an increased night loading.
- Midday loading observed with battery only is removed due to battery charging from PV.
- In summer, there is backfeed to the HV network.
- Peak shaving (40% case) and dips (100% case) occur at traditional morning and evening peak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

Impacts on Daily Energy Sold



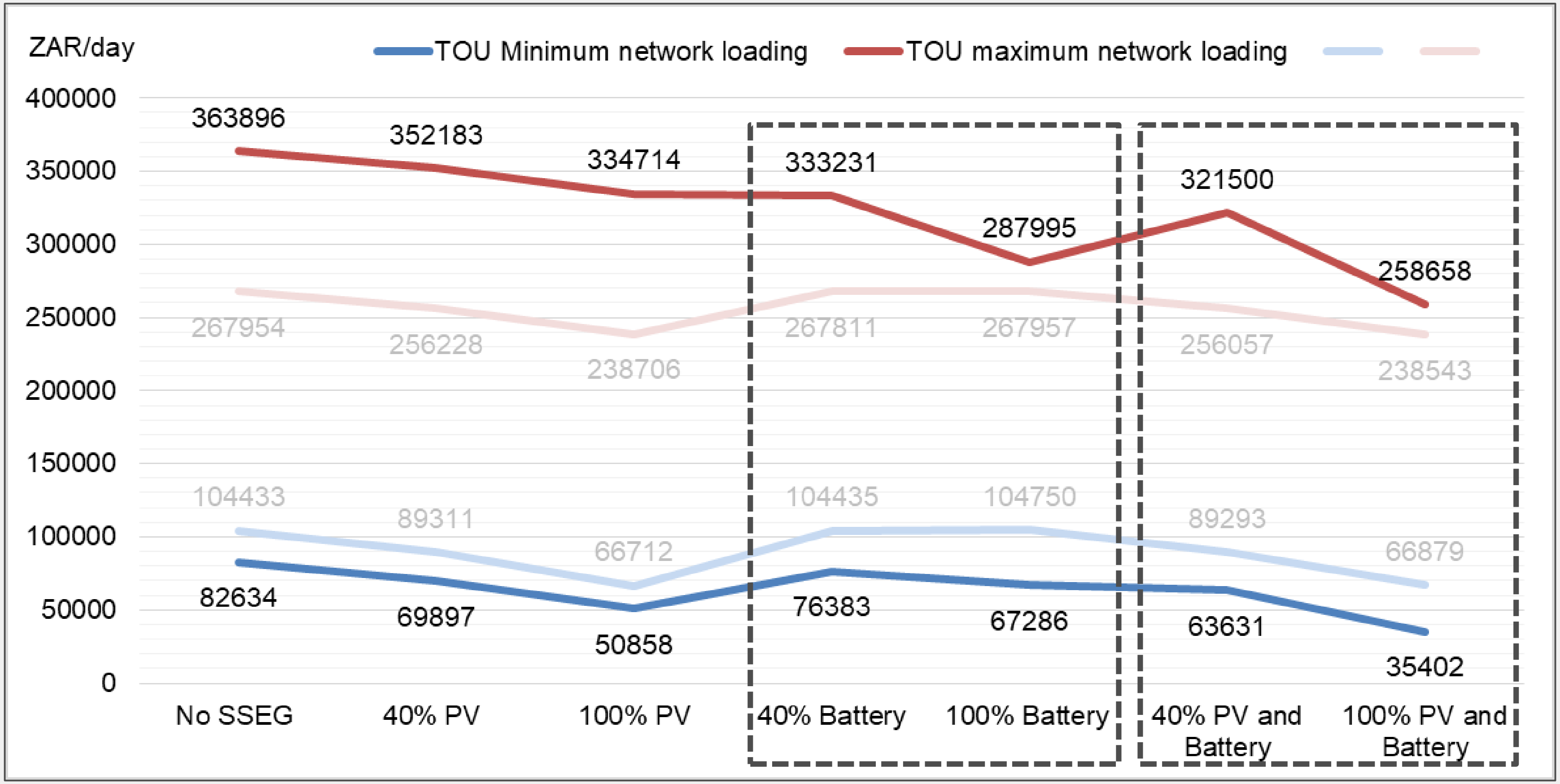
- Reduction in energy sold is noted for PV scenarios.
- Batteries only cause NO reduction in energy sold. They only shift when the energy is sold.

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.

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

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THANK YOU