Peak shaving utilising batteries in commercial and retail properties

by Ian Burger, David Stubbs, Tiffany Woodley and Dom Wills, Sola Future Energy

Peak shaving battery systems operating in conjunction with grid-tied solar photovoltaic (PV) to improve demand savings and reduce stress on the national grid at retail and commercial properties with internal rate of returns (IRRs) of 18% possible due to decrease in lithium-ion battery costs and increasing electricity tariffs.

Given the increasing contribution of utility scale and small scale embedded generation (SSEG) renewable energy to the grid in South Africa, coupled with a rapidly decreasing cost of energy generation, more stress is placed on the grid to supply power during peak periods. Due to the fact that consumption often peaks at times when PV does not contribute significantly to power generation, and can fluctuate due to changing weather, utilities need to compensate with large, underutilised, infrastructure which will lead to further increases in demand charges to compensate for the high cost of energy from peaking power plants.

Commercial and retail properties with grid-tied solar systems typically have narrow peaks in their load, before and after noon, as depicted in Fig. 1. This is due to the solar generation peaking during the middle of the day, thus reducing the load during this time, while the load in commercial and retail properties increases more rapidly from base load to peak than solar production in the morning and remains high for longer than solar in the afternoon, new peaks are created during mid-morning and late afternoon. Cloud cover may also reduce the amount of solar power generated at any given time and when the reduction in solar power occurs during times of high load, local peaks in power flow can occur. In addition to placing pressure on the grid to ramp up generation capacity by employing expensive energy from peaking plants, the power surges can also reduce the building owner's peak demand savings typically associated with grid-tied PV.

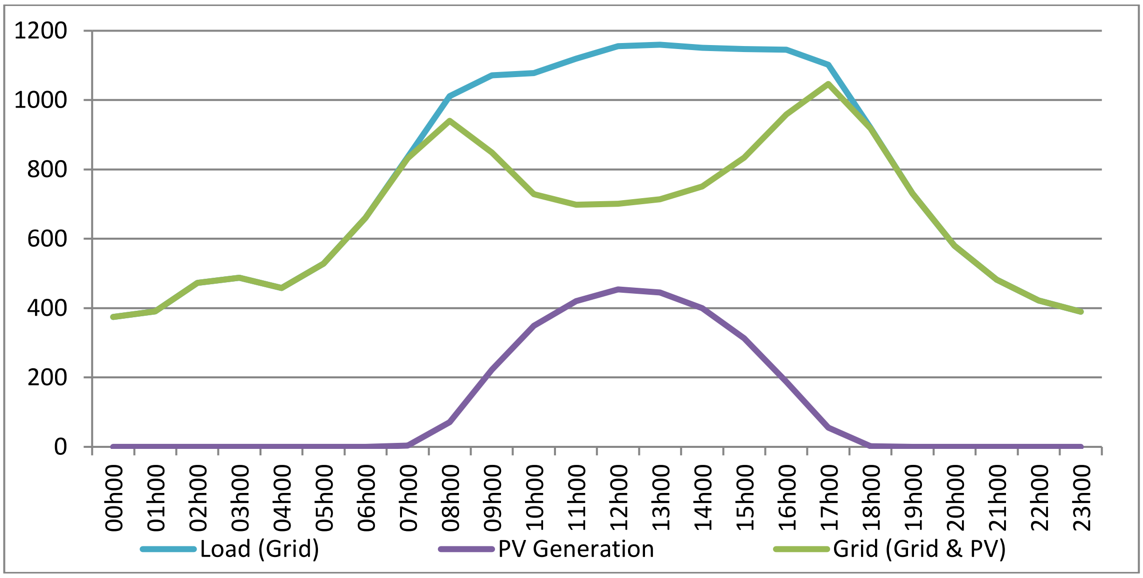

Fig. 1: The load of a selected retail facility, and the contributions of grid, solar PV.

A peak-shaving battery system is designed to charge the batteries during low demand time (during the night and while PV is at peak) and discharge during the peak demand times to reduce the peak drawn from the grid. The narrower the peaks, the smaller the battery capacity required to decrease the peak by a given amount, thus reducing the cost of the system. Fig. 2 shows the load of a retail property with and without a solar PV system integrated for one day. The respective peaks are at 1159,7 kVA and 1046,6 kVA. The PV system peaks at 454,1 kVA and reduces the peak demand for this day by 113,1 kVA. Assuming a 350 kVA battery system is installed, the amount of energy required to maximise the peak shaving is 1646,5 kWh for the case where PV is installed and 3180,1 kWh for the one without. The 48,2% reduction in battery storage capacity required to achieve the same demand saving in the case where the PV is included clearly indicates the advantage of coupling a peak shaving battery system with a grid-tied PV plant.

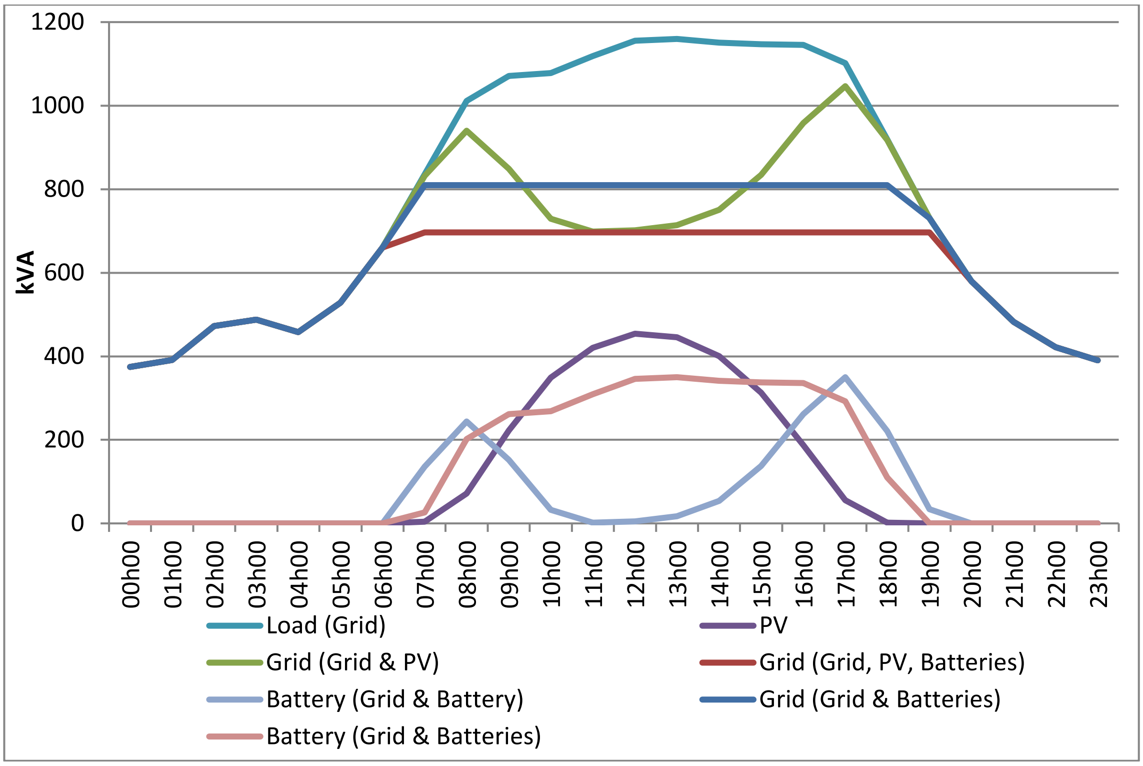

Fig. 2: The load of a selected retail facility, and the contributions of grid, solar PV and batteries in four cases (grid, grid and solar, grid and batteries and grid, solar and batteries).

In the current South African market retail property owners target returns in the range of 18% to 25% for solar PV installations. An investment into solar PV has a similar profile to that of property investments with long term yields, and battery storage technology could be seen in a similar investment category.

Assessing the rapidly reducing cost of lithium-ion batteries, at improved efficiencies (~90%) compared to lead acid and flow batteries (~80%) [1], and the increasing demand and energy tariffs, the business case is improving annually. The cost of lithium-ion batteries has decreased by 73% since 2010, dropping from $1000/kWh in 2010 to $273/kWh in 2016, with further reduction of 16,9% by 2018, 11,3% by 2019 and 10,8% by 2020 expected according to Bloomberg New Energy Finance [2]. This is mainly attributed to capacity driven by the electric car industry. Tariff increases are predicted to be in the region of 13% each year for the next four years and 8% thereafter for the next 20. It is further predicted that the cost of energy will reduce or plateau in future due to an abundance of utility scale and distributed renewable generation sources, while the cost of power (demand) will increase significantly. This is due to unpredictability of renewables, forcing expensive peaking power plant to operate more frequently and produce more power to supply the load during the lulls.

By optimally sizing the batteries and battery inverter, the cost of the installation can be kept at a minimum while maximising the saving incurred. A model has been developed that calculates the battery inverter (max power) size and battery capacity (energy) that maximises financial returns for a given property. The model requires the following information; the cost of the respective components of the battery system (batteries, inverter, controller, balance of system (BoS)), the current demand and energy tariffs for the property, forecasted tariff increase and component price decrease, battery degradation and expected lifetime, and a full year empirical load, incomer and PV generation data for the property.

The following values were used in the application of the model to a number of properties, identified as suitable candidates for peak shaving systems due to the post PV load profile, with the optimal size and IRR of one of the retail properties.

		Current	Jul 2018	Jul 2019	Jul 2020
Input	Batteries (R/kWh)	R3735	R4047	R4414	R4796
	Inverters (R/kWp)	R1200	R1200	R1200	R1200
	Control and BoS (fixed)	R990 000	R990 000	R990 000	R990 000
	CoCT LPU MV Energy (c/kWh)	72,4c	81,8c	92,5c	104,5c
	CoCT LPU MV Demand (R/kVA)	R204,70	R231,31	R261,38	R295,36
	O&M	R18 000	R19 080	R20 225	R21 438
Output	Inverter size (kVA)	150	150	150	150
	Battery capacity (kWh)	300	300	300	300
	IRR (%)	16%	18,5%	21,3%	24,4%

Table 1: Values used to model properties and the optimal size and capacity battery system and IRR.

Fig. 3 shows the profile of the consumption from the grid, without battery contribution, and with battery contribution and the battery contribution/consumption for a 150 kVA and 300 kWh battery system. The peak consumption from the grid is reduced from 1070,4 kVA to 930,2 kVA resulting in a 140,2 kVA demand reduction for this month.

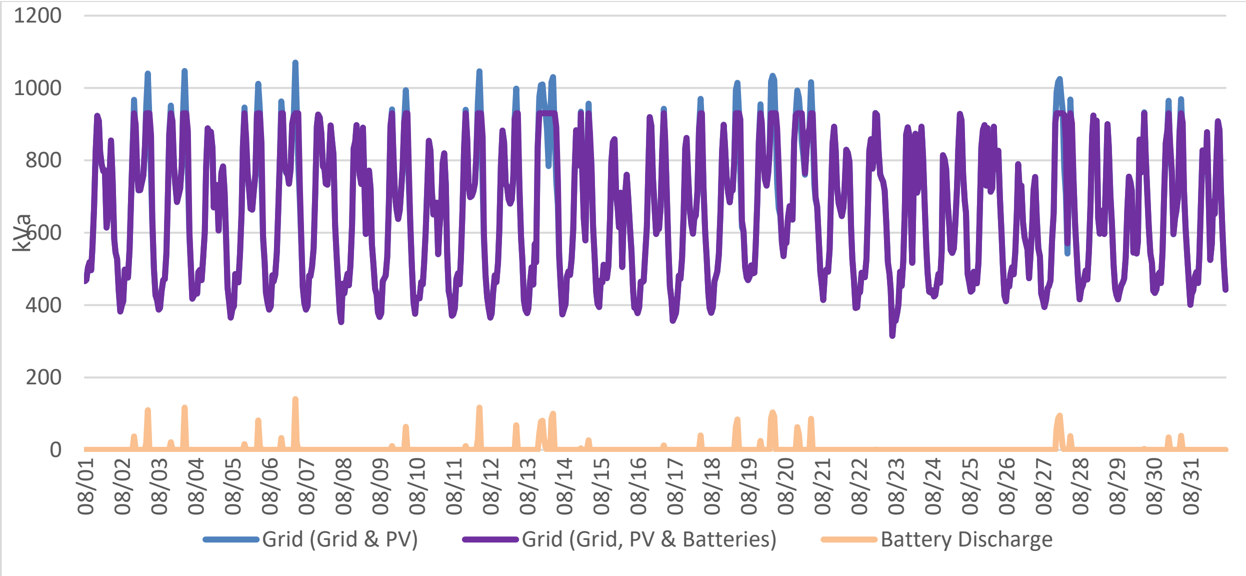

Fig. 3: The load of a selected retail facility, and the contributions of grid and batteries in two cases (grid and PV, grid, PV and Batteries) for a 150 kVA and 300 kWh battery system.

The output of the optimisation curves for the inverter size and battery capacity (kVA) are displayed in Figs. 4 and 5 respectively for 2018. The inverter curve peaks at 150 kVA with an IRR of 18,5%. For smaller sizes the fixed cost pushes the returns down, where the larger sizes have diminishing returns with increasing battery size. The battery optimisation IRRs are highest for peaks with short duration as is depicted in Fig. 5.

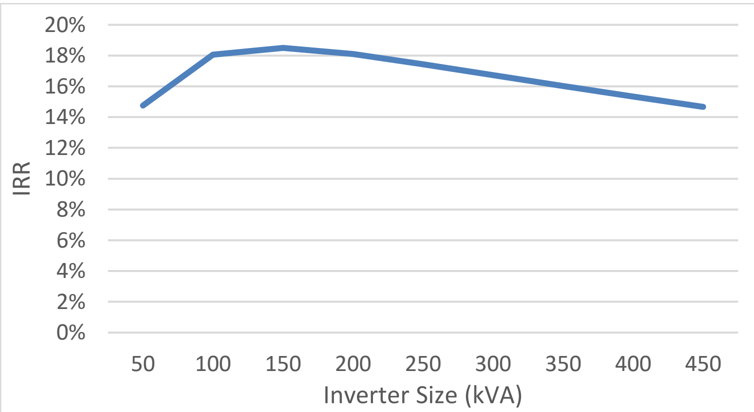

Fig. 4: Optimisation curves for battery inverter size (kVA) for 2018.

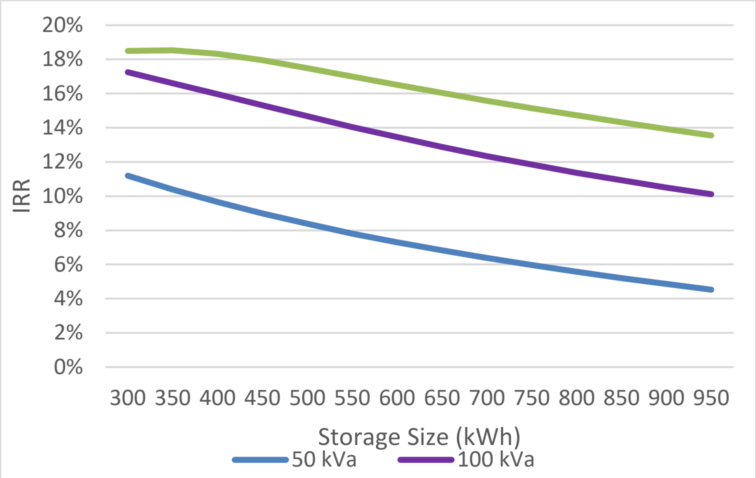

Fig. 5: Optimisation curves for battery capacity (kWh) for 2018.

In addition to demand savings; the system allows ancillary services, including; frequency regulation; voltage support and reactive power correction [2], which have not been quantified and included in the savings. By limiting the peak demand of properties with grid-tied PV, peak demand pressure is taken off the utilities as we see increasing renewable energy penetration on the grid. By adding stability to the grid, the hybrid PV battery systems should incentivise the regulator to encourage more of these systems to the grid.

The battery system can be retrofitted to existing PV plant or be installed as a hybrid with new PV plants at properties with load profiles that are suited to maximise returns. Demand savings are not considered as a guaranteed saving by some as there is an aspect of risk involved, since the load and weather impacts the demand savings, which cannot be controlled and are often not included in financial modelling. There are however numerus properties, where PV systems have been in operation for over several years, where the demand savings contribute to over 40% of total financial savings generated by PV systems. By integrating a peak shaving battery system with a PV plant demand savings are much more of a certainty. It is believed that hybrid PV battery systems will become an essential part of commercial and retail SSEG plants in the near future.

References

[1] A. Eller and D. Gauntlett: "Energy Storage Trends and Opportunities in Emerging Markets", *IFC Energy Report*, 2017.

[2] G.H. Muller and C.F. Landy: "Lithium Ion Battery costs and market", *Bloomberg new energy finance*, July 2017.

Contact Ian Burger, Sola Future Energy, Tel (021) 421-9764, ian@solafuture.co.za