Optimal Solar and Battery Allocation (Sezibwa)

> [!info] Conservative, bank-facing basis. Tariff: UEDCL Code 10.2 **Q3 2026** (Peak 666.5 / Shoulder 562.1 / Off-Peak 429.7 UGX/kWh). The schedule is a configurable model input for future ERA/UEDCL revisions. Turnkey capex, real weather. Reproducible from `nfe_solar_model.py`.

Headline

Sweeping both dimensions (solar size and battery capacity) to find the best 20-year return gives a clear, slightly counterintuitive answer:

The most business-optimal allocation is solar-heavy and battery-light. Put the money into panels on the battery already owned. Adding battery capacity lowers the return at today's battery price.

- Sezibwa zero-export-value base case: about **5 kWp** on the existing 8.9 kWh battery. Turnkey capex about **6.3M UGX**, **IRR about 42 percent**, simple payback about **2.3 years**, discounted payback about **3.1 years**, 20-year NPV about **9.8M at 15 percent**.
- With a usable export arrangement: about **8 kWp** on the same battery. Capex about **10.1M**, IRR about **46 percent**, NPV about **18.5M**. (This scenario assumes surplus is credited at **343 UGX/kWh** — a deliberately conservative, below-retail rate consistent with how net-metering credits typically pay; the real credit value under ERA's 2024 regulations is unconfirmed for this site.)
- In both, buying a second or third battery unit **lowers** NPV.

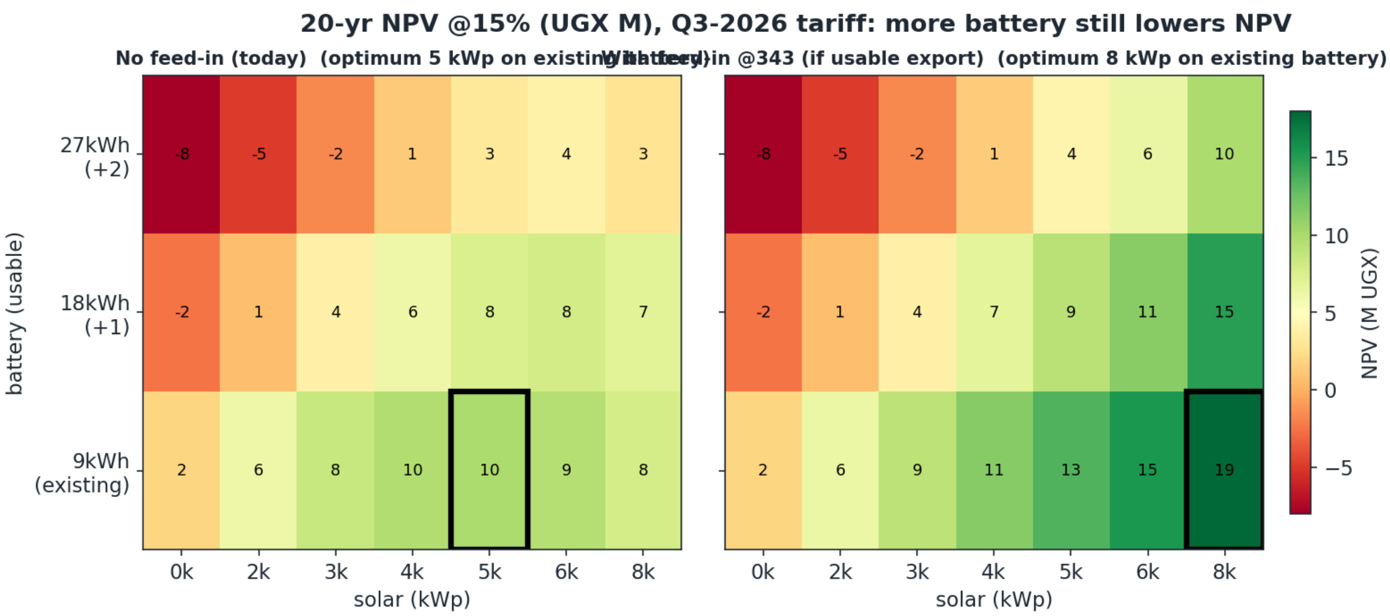
Method

A 2-D sweep over solar (0 to 8 kWp) and battery (existing one unit, or plus one or two SR-SE10B units). For each combination the model runs the real load through 20 years and computes discounted savings minus turnkey capex.

Assumption	Value

Tariff	UEDCL Code 10.2 Q3 2026: Peak 666.5 / Shoulder 562.1 / Off-Peak 429.7 UGX/kWh (configurable schedule)
Horizon	20 years
Battery aging	usable capacity fades linearly to 50 percent by year 20
Weather	seeded variable-irradiance year
Discount rate	shown at 10 / 15 / 20 / 25 percent
Solar capex	about 1.26M UGX per kWp turnkey
Extra battery capex	5.568M UGX per SR-SE10B (8.9 kWh usable)
Existing inverter + 1 battery	sunk (9.4M already spent)

Result



The greenest cells sit on the bottom row, the battery NFE already owns. Moving up (more battery) turns the map redder at every solar size.

> [!note] 4 kWp versus 5 kWp **4 kWp is the low-spill efficiency sweet spot:** it captures most of the available bill reduction with almost no curtailed solar. **5 kWp is the maximum-NPV optimum:** the fifth kWp introduces some spill, but its remaining useful generation is still worth slightly more than its marginal installed cost. The two sizes optimize different objectives.

Investment metrics and sensitivity

NPV shown across discount rates so you can see which allocation survives expensive capital (metrics ranked NPV, IRR, discounted payback, simple payback, then cumulative ROI):

Allocation	Capex	IRR	Simple / disc. payback	NPV @10%	@15%	@20%	@25%
5 kWp (no export, today)	6.3M	42%	2.3 / 3.1 yr	15.4M	9.8M	6.4M	4.1M
8 kWp (with usable export)	10.1M	46%	2.1 / 2.8 yr	28.5M	18.5M	12.3M	8.2M

Both survive a 25 percent cost of capital comfortably. (The undiscounted 20-year cumulative ROI is large, ~680 to 780 percent, but it is not a decision metric; NPV and IRR carry the case.)

Findings

1. **Do not buy more battery for return.** At the 5 kWp anchor, adding even the first battery unit lowers 20-year NPV by about 2.3M UGX; a second and third are progressively more negative (about −6.6M and −11.5M). The battery capex is not recovered within the horizon at today's ~626,000 UGX/kWh.
2. **Solar income is resilient to battery aging;** battery-only savings halve over 20 years, the solar cases decline far less.
3. **Value, not penetration.** Beyond ~4 to 5 kWp, extra panels spill and returns diminish unless storage gets cheaper or export becomes usable.

Battery replacement strategy

The model conservatively assumes the battery simply fades to 50 percent over 20 years. A real long-horizon plan should choose one of three strategies, and the economics differ:

- **Operate the original battery for all 20 years** (what the model assumes — the pessimistic bound; usable capacity, and so the evening-shift slice, keeps shrinking).
- **Replace once** when usable capacity hits a chosen threshold (say ~70 percent around year 10 to 12): restores capacity at the cost of a fresh battery, worth it only if battery prices have fallen (see the break-even case).
- **Augment gradually** by adding cells as load grows rather than replacing.

Importantly, the recommended allocation (solar-heavy, existing battery) is the least exposed to this: solar self-consumption does not depend on the battery, so battery replacement is a **reliability/backup** decision, not a driver of the solar return.

The caveat for the bank case

This prices energy savings only. It does not price the battery's real job, backup and reliability during outages. Solar is the **return** story; additional battery is a **resilience** decision justified separately.

Recommendation

Fund about **5 kWp of solar on the existing battery** to maximize NPV (about 6.3M turnkey, IRR about 42 percent); choose 4 kWp instead where the priority is the low-spill efficiency sweet spot. If a usable export arrangement materialises, scaling to about 8 kWp becomes better. For how cheap battery must get before expanding it pays, see Battery Price Break-Even. Companion cases: Battery Arbitrage, Solar Plus Battery.

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