Forecast-Driven BESS Scheduling in PV Plants: Intraday Updates to Maximize Arbitrage and Effective Utilization

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Introduction & Methodology

Problem

Utility-scale PV plants frequently experience **energy curtailment** when instantaneous generation exceeds the grid interconnection limit or the **dispatch instructions set by the grid operator**. This surplus energy is irrecoverably lost, reducing both renewable yield and project revenue.

Battery Energy Storage Systems (BESS) can capture this excess and redispatch it during high-value periods. However, the economic benefit depends critically on the scheduling strategy: a fixed day-ahead schedule ignores actual intraday variability of the solar resource, leaving storage capacity under-utilised.

Research question: Can simple rule-based intraday SOC corrections significantly improve curtailment capture over a fixed schedule while remaining viable for real-time operational deployment?

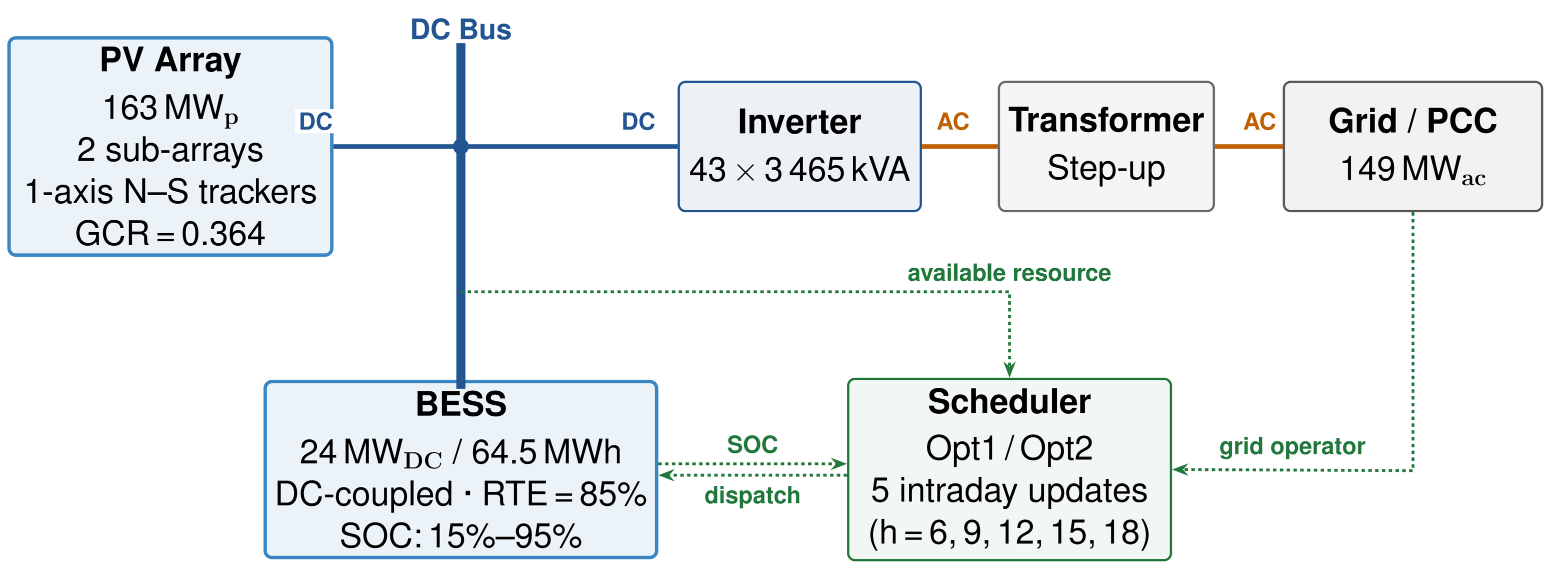
Proposed Methodology

Three scheduling algorithms are evaluated through SAM (NREL) simulation.

- **Esc0 — Fixed schedule (baseline):** charges h = 10–15, discharges h = 19–24. No forecast, no intraday corrections.
- **Opt1 — Rule-based with 5 intraday corrections:** plans the day using monthly historical PV profile; at h = 6, 9, 12, 15, 18 the real SOC is simulated and the remaining dispatch is re-optimized (gap-based greedy).
- **Opt2 — Dawn-reserve variant:** identical to Opt1 but enforces SOC $\geq$ 40% at sunrise, guaranteeing energy availability for grid obligations at the start of each day.

Analysis period: 6 months with highest curtailment (Jan–Mar & Oct–Dec). Simulation year: Year 5 (degradation included).

System Description & Performance



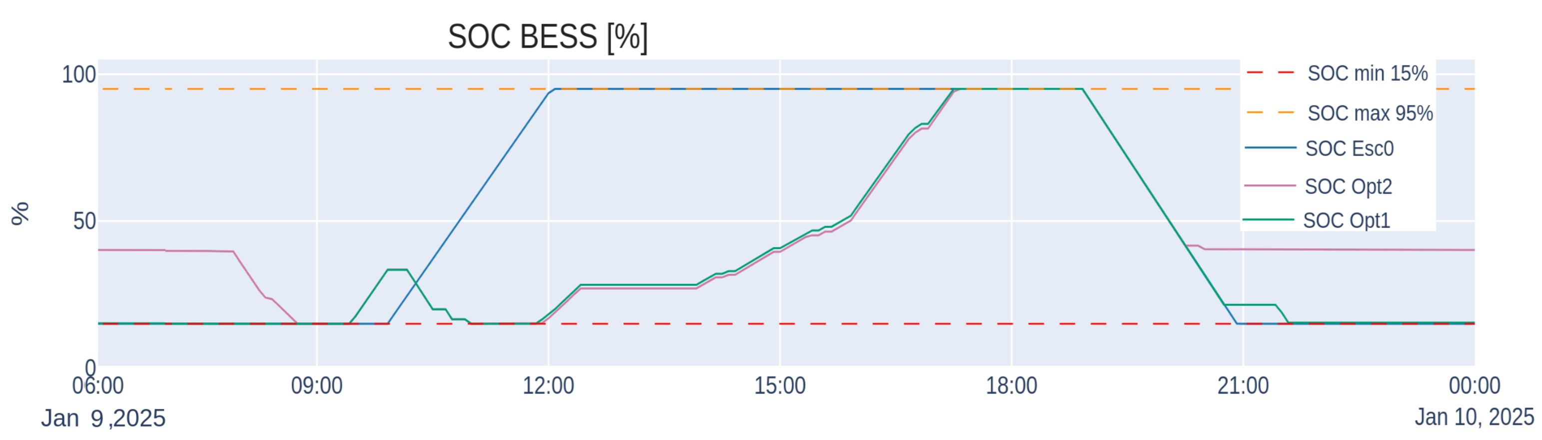


Fig. 2. 5-min time series: BESS SOC [%] — Esc0, Opt1, Opt2.

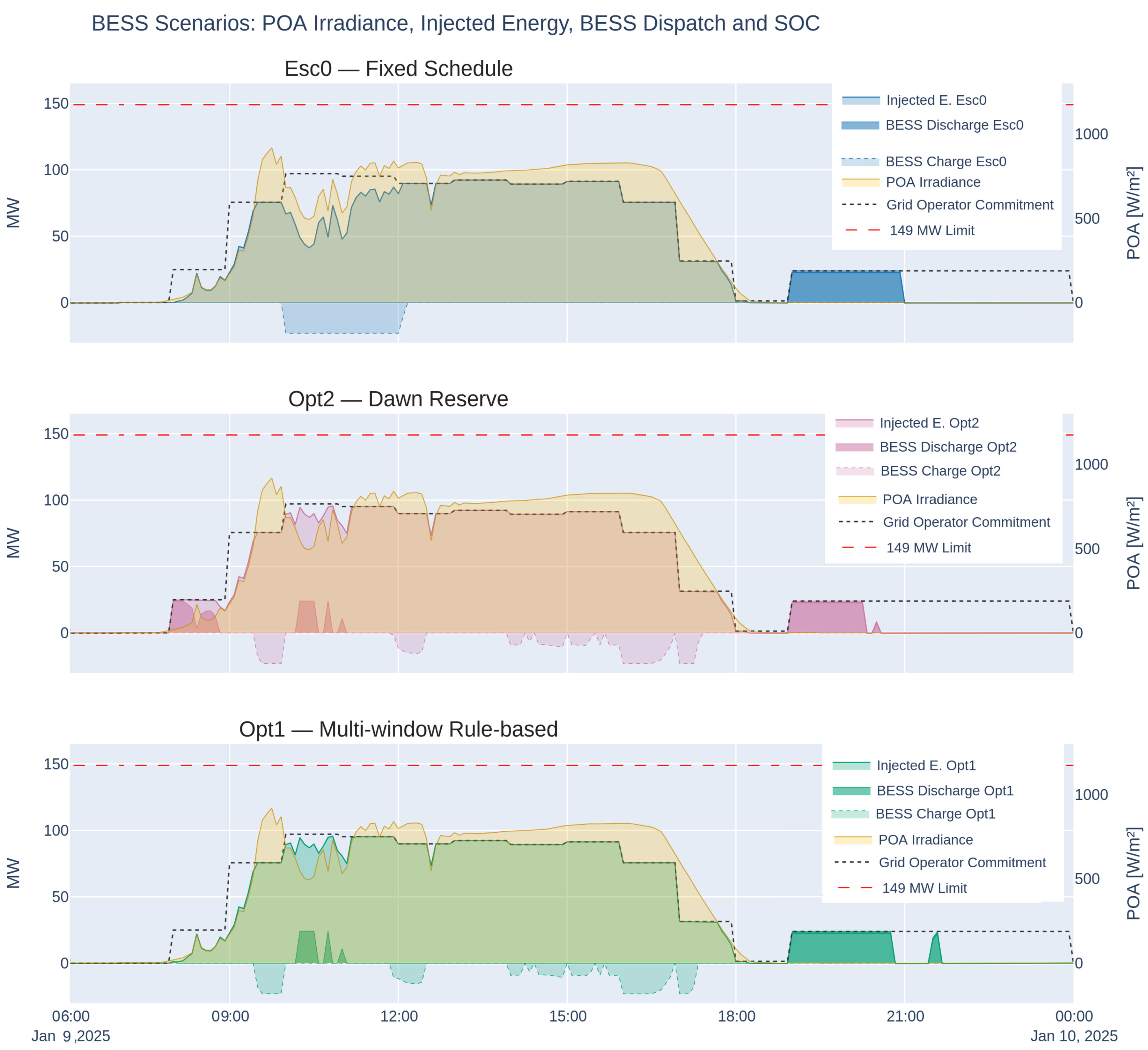


Fig. 1. 5-min time series: injected power [MW] and BESS dispatch — Esc0, Opt1, Opt2.

Energy Metrics — 6 High-Curtailment Months

Month	Esc0 [MWh]	Opt1 [MWh]	Opt2 [MWh]
January	14,770	15,360	15,169
February	11,220	11,445	11,273
March	18,924	19,313	19,157
October	14,544	14,936	14,786
November	17,161	17,620	17,474
December	17,848	18,676	18,426
Total [MWh]	**94,467**	**97,350**	**96,286**
Gain vs Esc0	—	**(+3.05%)**	**(+1.93%)**

Conclusions

1. **Intraday SOC corrections** (Opt1) increase injected energy by **+3.05%** over the fixed schedule, with no mathematical solver required (<1 ms/day computation).
2. The **dawn-reserve** variant (Opt2) provides operational security by ensuring SOC $\geq$ 40% at sunrise, at the cost of lower daily arbitrage (+1.93% total gain).
3. Updating the real SOC every 3 hours is the critical driver: it corrects the divergence between the statistical forecast and actual PV production.
4. The rule-based approach is **viable for real-time deployment**: it requires no mathematical solver, is fully interpretable, and can run on any existing plant control system.