Lessons Learned From Techno-Economic Analysis of Solar Photovoltaics and Battery Energy Storage at a Vietnam Industrial Park

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Introduction

Through the Clean Energy Investment Accelerator (CEIA), engineers from the U.S. National Renewable Energy Laboratory (NREL) conducted a case study analysis evaluating the techno-economic feasibility of battery energy storage systems (BESS) at an industrial park in Vietnam. The analysis uses NREL's REopt®[2] platform, a distributed energy modeling and optimization tool, to identify the cost-optimal system sizing for BESS, in conjunction with existing and future onsite renewable generation, to reduce electricity costs, improve onsite solar photovoltaic (PV) utilization, and strengthen resilience to grid outages.[3]

Key Takeaways

Based on the real-world case study inputs, CEIA's Vietnam industrial park REopt analysis suggests:

- Adding **new PV could be significantly cost effective, with or without BESS,** at the industrial park.
- **BESS begins to become cost-effective in Vietnam, if BESS all-in costs cross below approximately $200/kW + $100/kWh** (the lower end of the range of 2022 BESS costs across Southeast Asia[4]).
- Where BESS is cost-effective, the **value of combined PV plus BESS is greater than** the value of **standalone PV plus** the value of **standalone BESS.**
- These technologies could contribute to site **resilience against grid outages** as alternatives or supplements to backup diesel generation.

Site Overview

Electric loads: The case study site is an industrial park located in Vietnam, with tenants primarily in chemical processing, steel, logistics, manufacturing, and petro-logistics. The study considers current and projected future load scenarios, given high potential capacity growth planned at the park over the next 5-10 years. Current loads are approximately 138,000 MWh/year with a peak demand of approximately 30 MW; by 2029 loads are projected to stabilize around 429,000 MWh/year with a peak demand of approximately 105 MW. The park provided historical hourly interval data to capture timing of load. The future load profile projection was developed by scaling the historical interval data to the future annual consumption.

Electric utility rate tariff: The industrial park buys wholesale electricity on a time-of-use (ToU) utility rate from the state utility, Vietnam Electricity Corporation (EVN), which it sells to its tenants at the regulated retail rate, while operating the park's distribution system. The park's ToU wholesale purchase prices vary significantly based on timing of consumption; their on-peak hours' electricity costs approximately three times that of electricity during off-peak hours. This offers potential for energy arbitrage via BESS. Net metering is not available under current Vietnam regulations.

Existing onsite energy assets: The industrial park already is powered in part by 4 MW of renewable energy generation, and it plans to scale-up onsite PV to 60 MW in the future.

Methodology

The CEIA team used REopt to evaluate the cost-optimal system sizing and project economics for the following scenarios and sensitivities:

1. **Current vs. future load projections:** 138,000 MWh per year and 429,000 MWh per year, with peak demands of approximately 30 MW and 105 MW, respectively.
2. **Technology options:** (a) business-as-usual (BAU), (b) new BESS only, (c) new PV and new BESS

[1] The authors gratefully acknowledge the contributions of CEIA-Vietnam's co-leads Hang Dao and Tung Ho to this research.

[2] The NREL website for REopt is found here: https://reopt.nrel.gov.

[3] This document is a summary of the REopt case study analysis (using $6/$W_{DC}$ for PV), linked here.

[4] Colthorpe, Andy. 2021. "Analysts predict 30% reduction in Asia-Pacific region's grid battery storage costs over five years." January 19, 2021. *Energy Storage News.* https://www.energy-storage.news/analysts-predict-30-reduction-in-asia-pacific-regions-grid-battery-storage-costs-over-five-years/.

3. **BESS capital cost sensitivity study:** Due to uncertainty in costs of commercial-scale BESS in Vietnam, low ($200/kW + $100/kWh), medium ($325/kW + 163/kWh), and high ($450/kW + $225/kWh) "all in" (including equipment, balance-of-system, installation, etc.) BESS cost scenarios were evaluated.

Systems were sized to minimize the lifecycle cost of electricity, where lifecycle cost of electricity is calculated as the present value of all capital costs, operations and maintenance costs, and electric grid purchases throughout the 10-year analysis period. The analysis assumes a real discount rate of 11% and electricity grid cost escalation 3% per year.[5] The value of resilience these technologies may provide in case of utility grid outage was estimated based on the amount that some tenants currently pay for backup diesel generation.

Results

The analysis indicates that:

- **Adding new PV can be significantly cost effective**, with or without BESS, at the industrial park.
- **BESS begins to become cost-effective in Vietnam if BESS all-in costs cross below approximately $200/kW + $100/kWh** ($400/kW all-in for 2-hour BESS; $600/kW all-in for 4-hour BESS). Table 1 shows these on the low end of Southeast Asia BESS market costs.

Table 1. Results Compared to All-In Whole-System Market Costs for 2-Hour Front-Of-The-Meter BESS Costs in the Asia-Pacific Region [6]

	China	S. Korea	Australia	Vietnam case study
2020 BESS Costs	$554/kW	$821/kW	$990/kW	Cost effective at or below ~$400/kW
2025 Projected Costs	$369/kW	$578/kW	$658/kW	

- **Where BESS is cost-effective** (Table 2 shows cost-optimal systems), **the value of combined PV plus BESS is greater than the value of standalone PV plus the value of standalone BESS.**

Table 2. Cost-Optimal Sizes and Net Present Value (NPV) of PV and BESS for the 10-Year Analysis Period, With Low ($200/kW + $100/kWh) BESS Costs

	Optimal PV Capacity	Optimal BESS Capacity	NPV of PV+BESS
Current Load	14 MW_{DC}	21 MWh / 5 MW	$270,000
Projected Future Load	24 MW_{DC}	25 MWh / 6 MW	$320,000
Projected Future Load, Higher-Penetration RE	60 MW_{DC}	80 MWh / 20 MW	$313,000

- **These cost-optimal systems can provide part-load resilience as alternatives to backup diesel generation. Larger PV/BESS systems would be required to meet full load resilience requirements.**

These results suggest that as BESS capital costs decline, there is potential for them to provide value in cost savings, increasing renewable energy penetration and supporting site resilience against electric grid outage, specifically for industrial applications in Vietnam. For additional analysis details, see the complementing deck: www.nrel.gov/docs/fy23osti/84352.pdf. For more information on the CEIA, visit www.cleanenergyinvest.org.

[5] Based on Vietnam's Prime Minister's Decision No. 24/2017/QD-TTg from June 2017.
[6] Colthorpe, Andy. 2021. "Analysts predict 30% reduction in Asia-Pacific region's grid battery storage costs over five years." January 19, 2021. *Energy Storage News.* https://www.energy-storage.news/analysts-predict-30-reduction-in-asia-pacific-regions-grid-battery-storage-costs-over-five-years/; $/kW listed in reference converted to $/kWh.

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