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# KIT CARSON ELECTRIC COOPERATIVE MICROGRID COLLABORATIVE ANALYSIS PROJECT

## ESMO TOOL FOR TECHNO-ECONOMIC ANALYSIS AND OUTAGE MITIGATION IN RURAL MICROGRIDS: EL RITO WEST MICROGRID CASE STUDY

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# 1. PROJECT OVERVIEW

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- **Project Goal:** Optimize battery energy storage system (BESS) sizing and dispatch for rural community microgrids, co-maximizing tariff savings, islanding resilience, and energy market value.

- **Current Practice:** Rural cooperatives size BESSs without systematic multi-value optimization, leading to undersized systems, missed market revenue, and unquantified outage risk.

- **Why Argonne:** ANL combines deep expertise in energy storage modeling, grid optimization, and techno-economic analysis with a proven record of developing open-source decision-support tools that translate research into actionable guidance for utilities and cooperatives.

- **Innovation:** ANL's ESMO framework (Energy Storage Microgrid Optimization) transforms complex microgrid planning problems into practical, data-driven investment decisions by combining high-resolution load and generation data, least-cost dispatch optimization, and rigorous reliability analysis.

- **Impact:** Provides Kit Carson Electric Cooperative (KCEC) with a defensible, data-driven investment framework for reliable, affordable, and secure energy delivery at the El Rito West (ERW) remote microgrid. This methodology is directly transferable to other rural electric cooperatives nationwide.

- **Vertical/Investment Area – Duration:** Grid Integration and Field Validation – FY25-FY26.

- **Alignment:** Supports DOE OE's **stabilize** and **optimize** strategic pathways, strengthening grid reliability and security for remote rural communities, and enhancing grid performance through advanced modeling and data-driven decision-making.

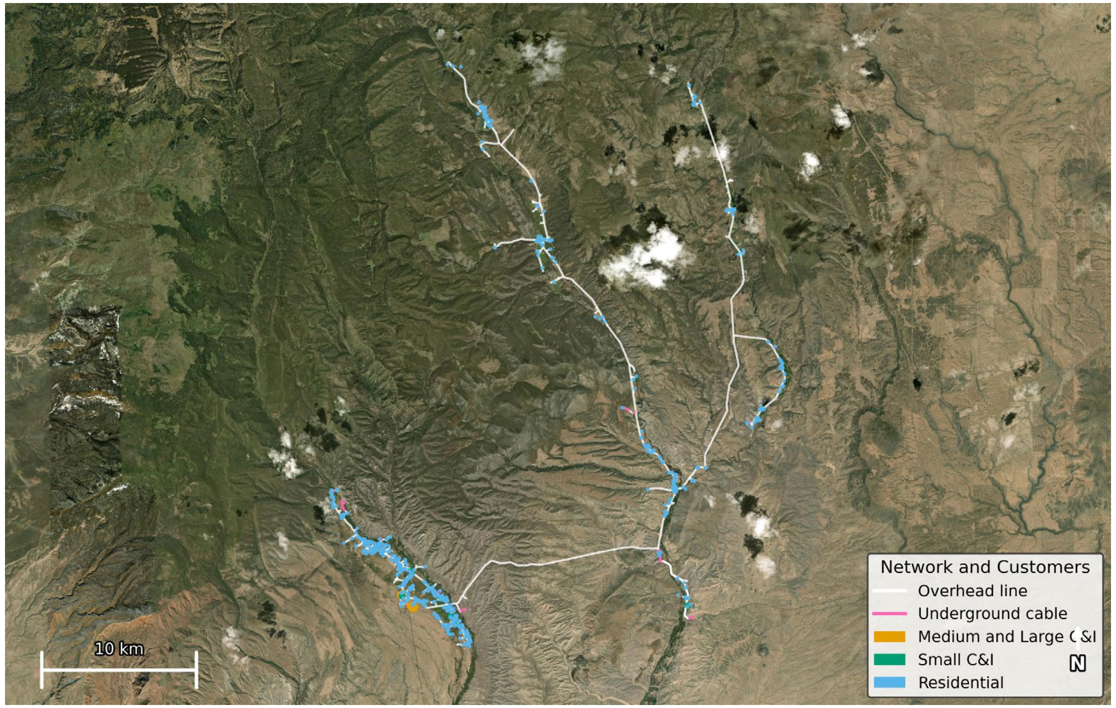
# PROJECT CONTEXT

**Background & Significance**

- KCEC serves about 30,000 customers across rural northern New Mexico → a region exposed to wildfires, extreme weather, and grid outages.
- Three community microgrids are being upgraded with BESSs to strengthen **grid reliability and security** → Focus: ERW microgrid.
- KCEC's BESSs are resilience-first assets deployed to address **wildfire-driven outage risk.**

**Objectives**

- Quantify BESS economic value: tariff savings (via **peak load shaping**) + **outage mitigation**.
- Evaluate BESS economic value across multiple sizing configurations.



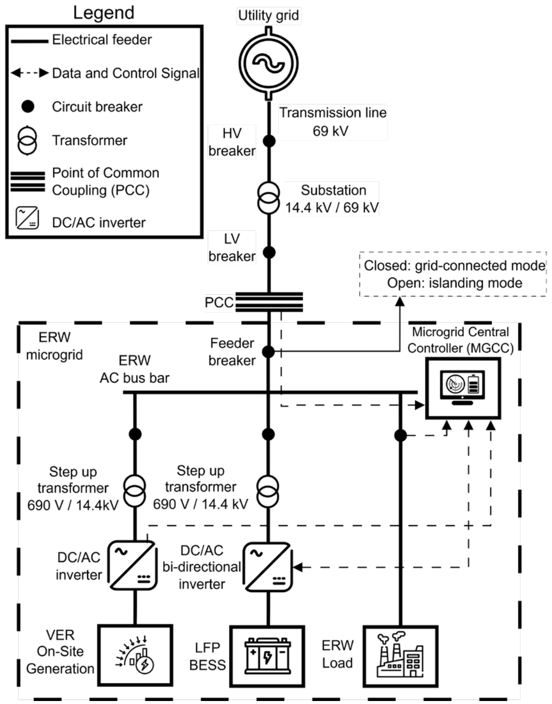




*Fig. 1. Kit Carson Electric Cooperative (KCEC) El Rito West (ERW) microgrid network: satellite view (left) and electrical layout (right).*

# 2. ESMO TOOL - OVERVIEW

# ESMO TOOL

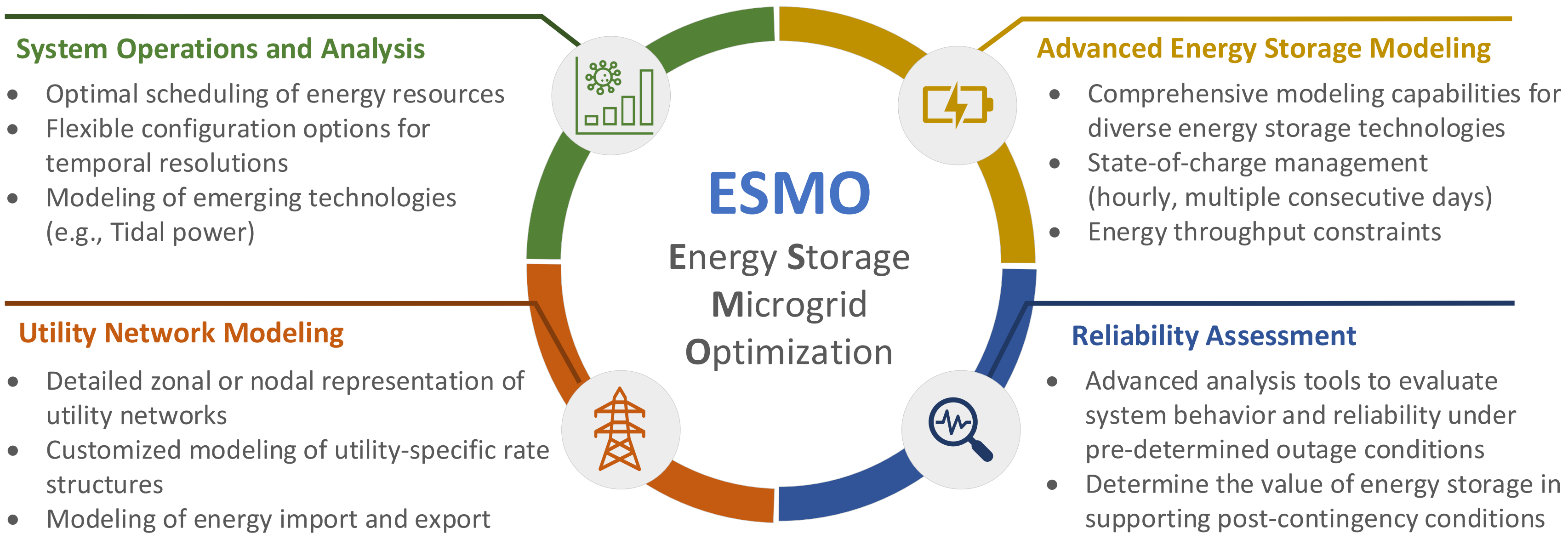



*Fig.2. Energy Storage Microgrid Optimization (ESMO) framework [1].*

1. **Operational optimization** → determines the optimal BESS dispatch schedule to minimize monthly transmission charges.

2. **Resilience quantification** → simulates BESS dispatch during each recorded outage event, quantifying the resulting energy not served (ENS).

3. **Economic assessment** → converts ENS and tariff savings into annual BESS benefit, supporting the cost-optimal investment decision.

[1] Balducci, Patrick, Kwon, Jonghwan, Nwadiaru, Vivian, et al., "Rosario Strait Tidal Energy plus Energy Storage — Preliminary Economic Assessment," (2024), https://doi.org/10.2172/2283071

# ESMO TOOL

**Model Inputs**

- ❑ 8760-hour load and on-site variable energy resources (VER) generation profiles.
- ❑ KCEC tariff structure, historical outage events, and microgrid network.
- ❑ Customer Value of Lost Load (VOLL) from ICE Calculator [2].
- ❑ Scenarios: 16 BESS configurations (0.75–1.5 MW × 2–8 h), RTE = 83%.

**Stage 1 — Optimal Dispatch**

- ❑ Microgrid modeled as islanded (VER + BESS serve all load).
- ❑ Objective: minimize monthly transmission and load-shaping charges.
- ❑ Output: hourly BESS schedule + monthly ENS.

SOC from Stage 1 determines available backup energy

**Stage 2 — Contingency Analysis**

- ❑ Input: historical outage events.
- ❑ Output: avoided outage costs monetized via VOLL.

**Final Output**

- ❑ Annual BESS benefit = Stage 1 tariff savings + Stage 2 avoided outage costs.

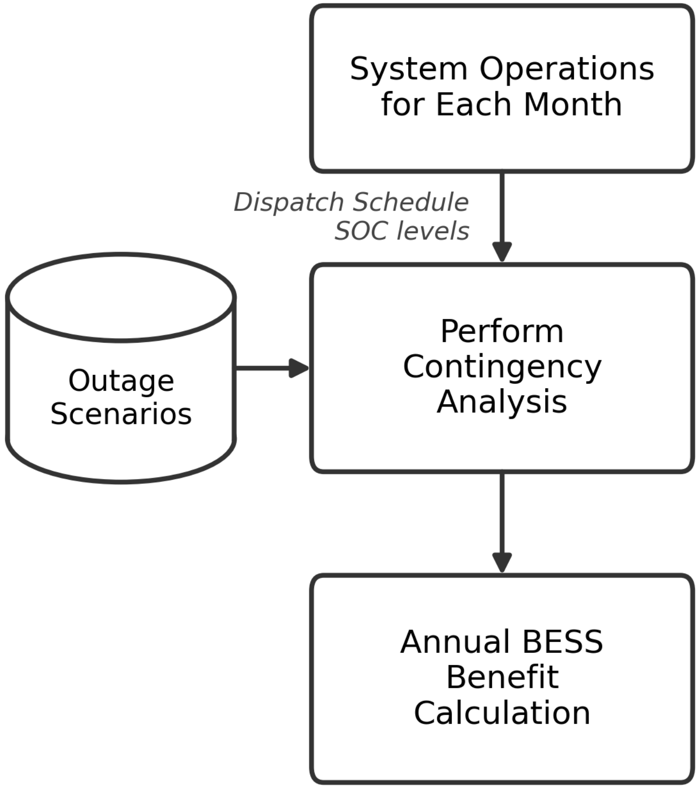



*Fig.3. ESMO two-stage structure of outage mitigation analysis [1].*

[2] Lawrence Berkeley National laboratory, “Interruption Cost Estimate Calculator (ICE) Calculator 2”, (2026), https://icecalculator.com/

# 3. EL RITO WEST (ERW) MICROGRID CASE STUDY

# BESS DAILY DUTY CYCLE

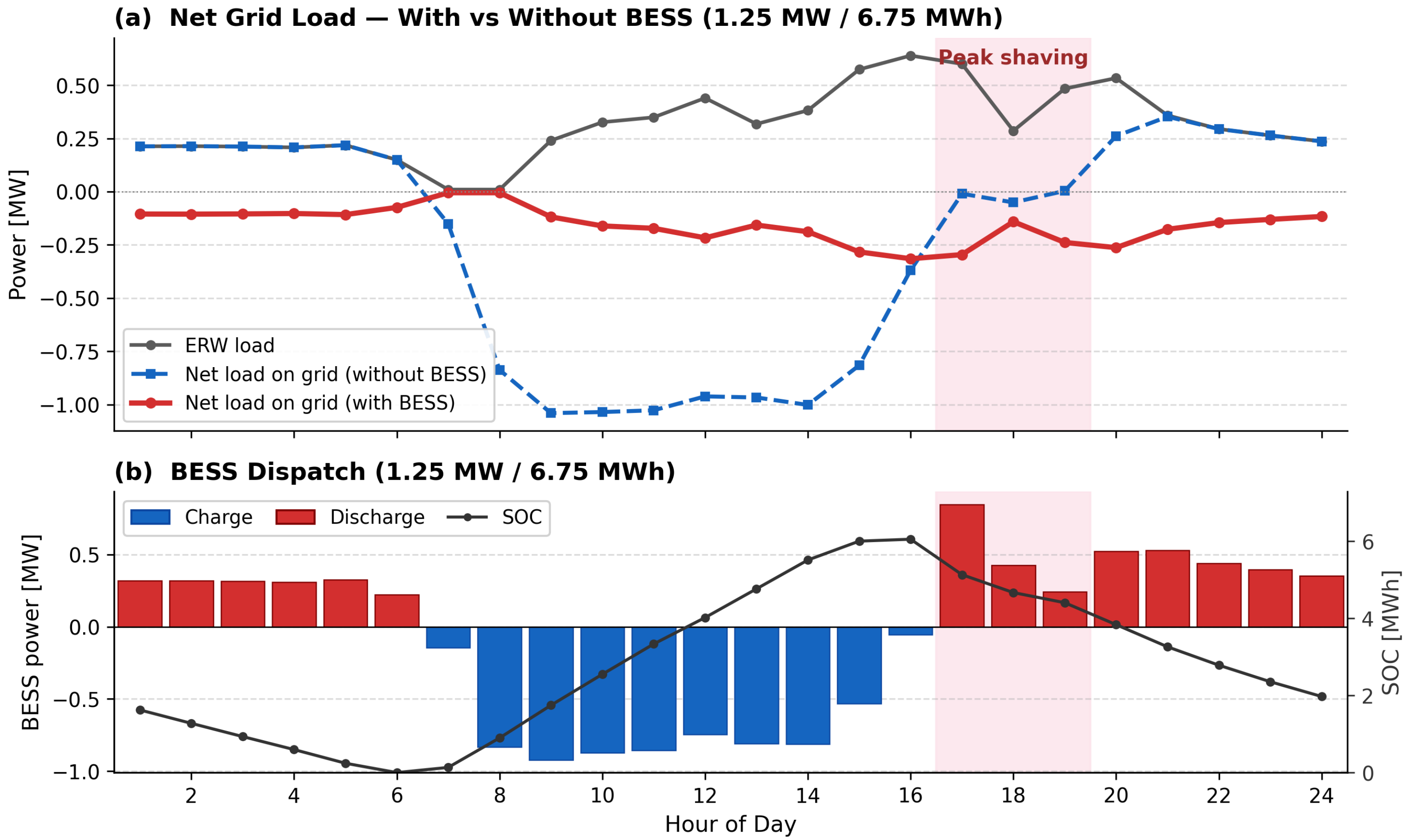



*Fig. 4. El Rito West (ERW) BESS daily duty cycle for a representative summer day (Wednesday, July 9, 2025): net load on the grid with vs without BESS (a) and hourly BESS charge/discharge profile and state-of-charge (b) for the selected configuration (1.25 MW / 6.75 MWh).*

# ERW DISTRIBUTION OUTAGES & VALUE OF LOST LOAD

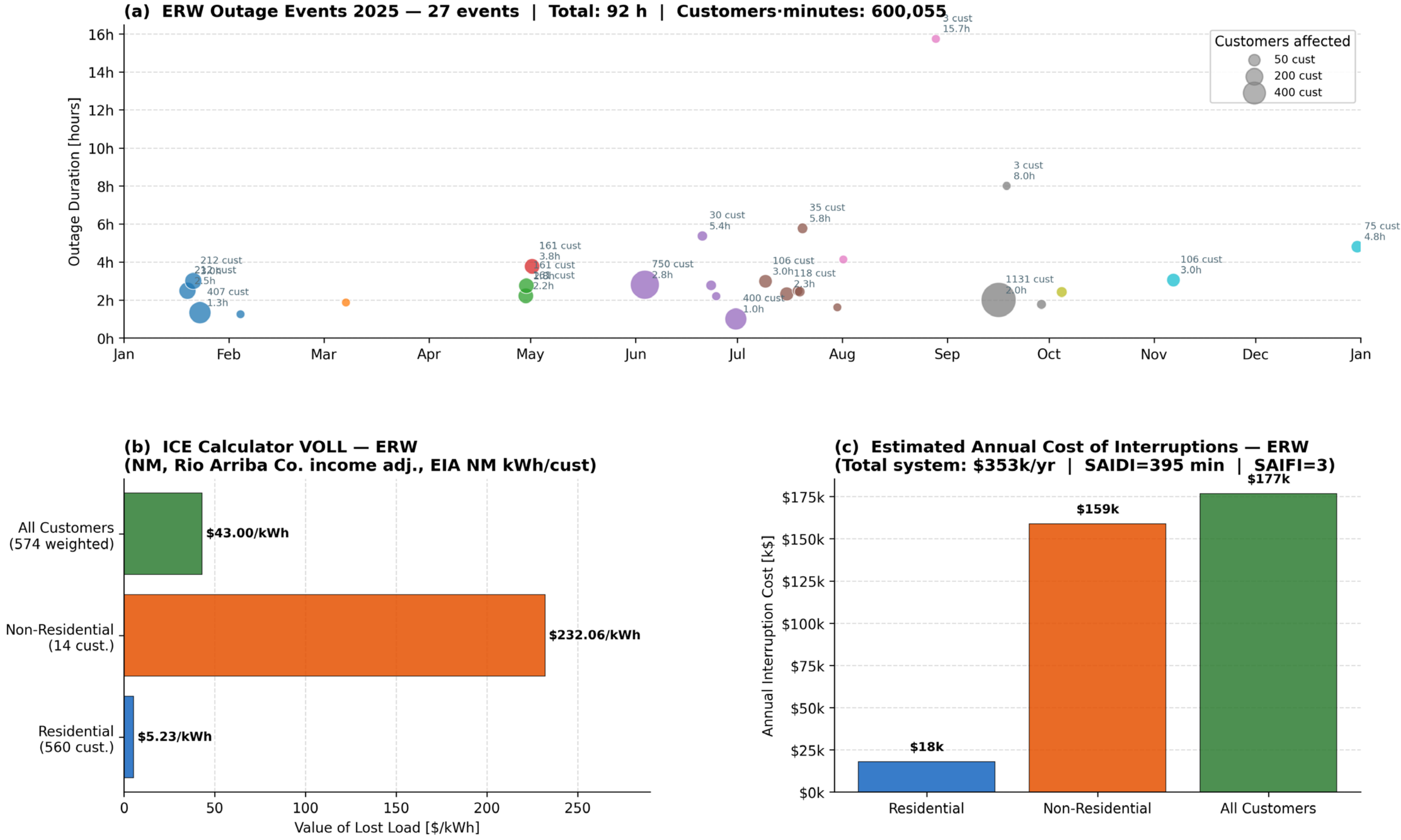



*Fig. 5. El Rito West (ERW) outage events used by ESMO Stage 2 (a).*
*ICE Calculator Value of Lost Load (VOLL) by customer class (b). Estimated annual cost of interruptions by customer class (c).*

Source: [2] calibrated with New Mexico state data, Rio Arriba County income distribution (Census ACS 2023) and EIA 2024 commercial data.


[2] Lawrence Berkeley National laboratory, “Interruption Cost Estimate Calculator (ICE) Calculator 2”, (2026), https://icecalculator.com/

# BESS SIZE SENSITIVITY

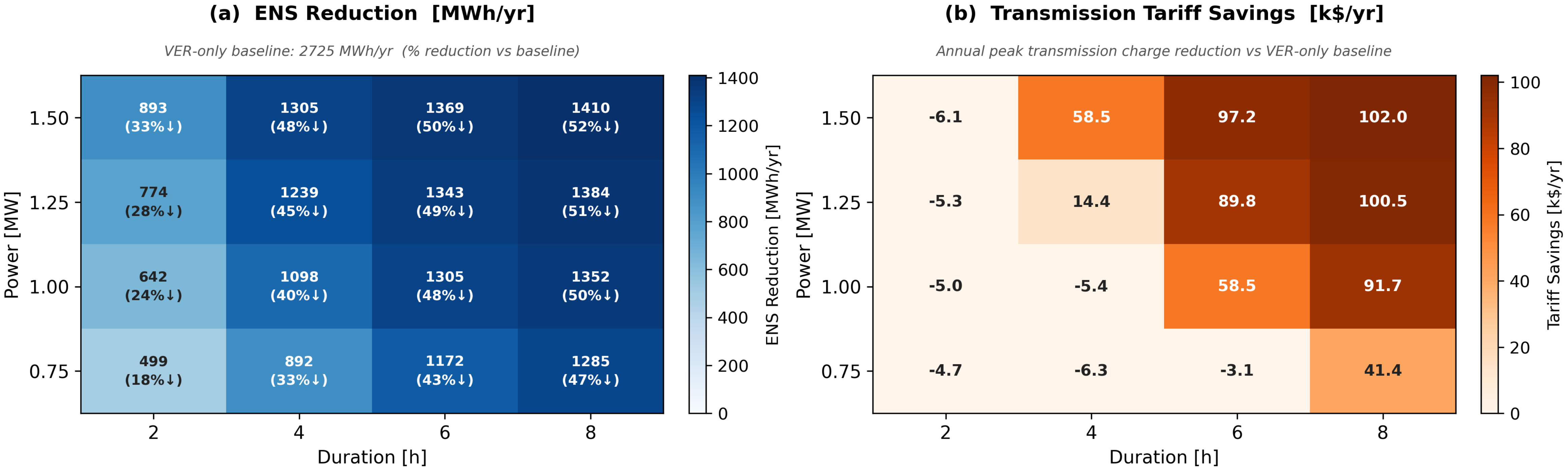



*Fig. 6. El Rito West (ERW) BESS size sensitivity: Energy Not Served (ENS) reduction in [MWh/yr] (a) and transmission tariff savings in [k$/yr] (b) compared to VER-only baseline.*

# MONTHLY PERFORMANCE WITH SELECTED BESS SIZE

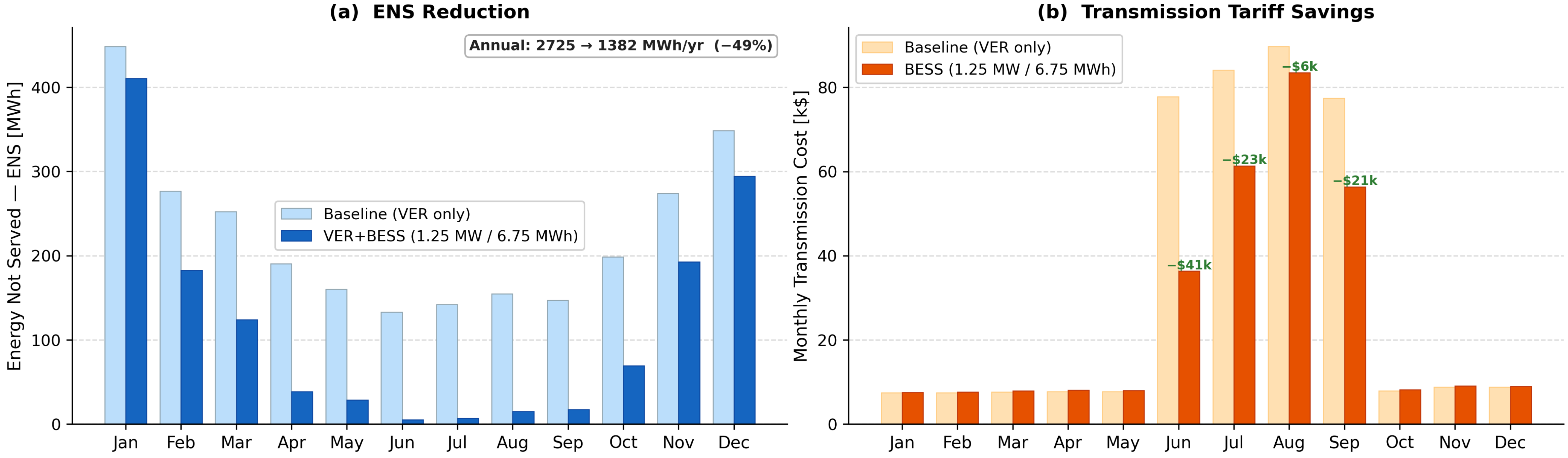



*Fig. 7. El Rito West (ERW) monthly performance: Energy Not Served (ENS) reduction in [MWh/yr] (a) and transmission tariff savings in [k$/yr] (b) compared to VER-only baseline (Stage 1 sizing scenario).*

# BESS BENEFIT DECOMPOSITION

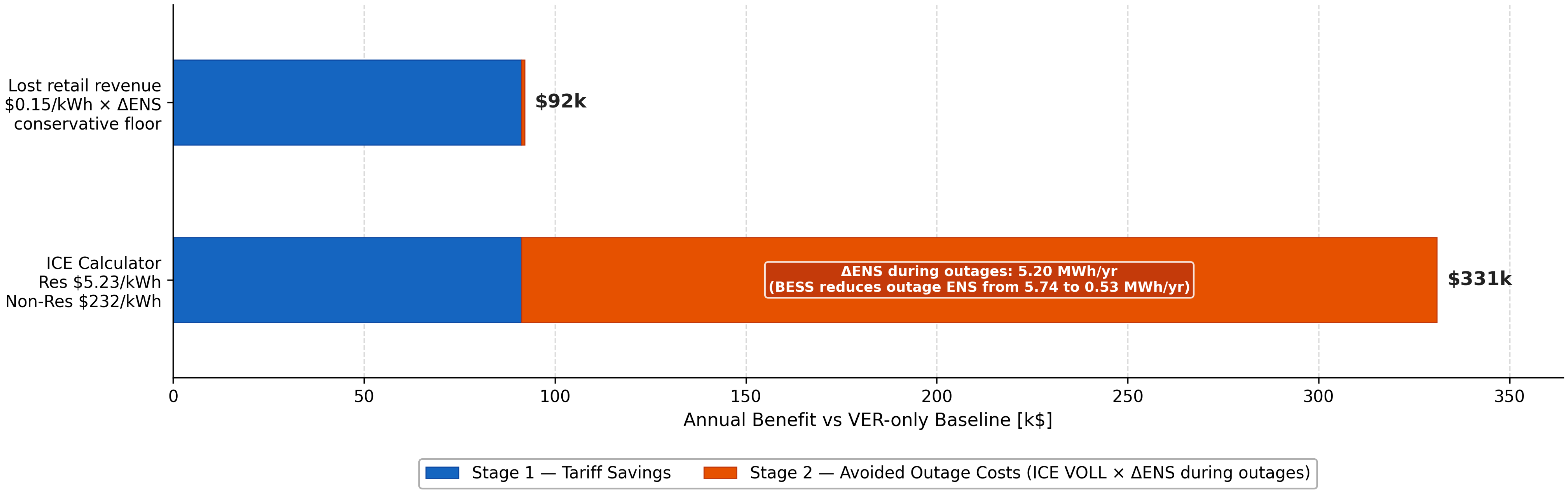



*Fig. 8. El Rito West (ERW) annual BESS benefit decomposition for the selected configuration (1.25 MW / 6.75 MWh). Stage 1 tariff savings and Stage 2 avoided outage costs (5.20 MWh/yr BESS-attributable ENS reduction during the 27 outage events), evaluated at lost retail revenue ($0.15/kWh, conservative floor) and ICE Calculator per-class VOLL (Res $5.23/kWh, Non-Res $232/kWh).*

Source: [2] calibrated with New Mexico state data, Rio Arriba County income distribution (Census ACS 2023) and EIA 2024 commercial data.

[2] Lawrence Berkeley National laboratory, “Interruption Cost Estimate Calculator (ICE) Calculator 2”, (2026), https://icecalculator.com/

# 4. CONCLUSIONS, IMPACT AND FUTURE DIRECTIONS

# CONCLUSIONS, IMPACT AND FUTURE DIRECTIONS

## CONCLUSIONS

- 1.25 MW / 6.75 MWh BESS eliminates **49%** of structural ENS and **91%** of outage-event ENS → **$91k–$331k/yr** combined benefit.
- **Storage duration**, not rated power, drives performance: 6h captures 97% of achievable ENS reduction.
- $91k/yr tariff savings are VOLL-independent → a guaranteed economic floor.

## IMPACT

- ESMO delivers a replicable, data-driven pathway to **reliable**, **affordable**, and **secure** energy for rural and underserved communities, scalable beyond KCEC to cooperatives nationwide.

## FUTURE DIRECTIONS

- Apply ESMO to remaining KCEC **microgrid sites** and scale the methodology to rural, underserved, and isolated microgrids across the U.S.
- Extend contingency analysis to transmission-level events and use multi-year historical load data to reduce uncertainty due to year-to-year variability in generation and demand patterns.
- Quantify **electricity market services** (energy arbitrage, ancillary services) as additional BESS revenue streams to improve investment viability.

# ACKNOWLEDGEMENTS

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