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Data-Driven Techno-Economic Analysis of Community Energy Storage

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Abstract: The Pueblo of Picuris, located in northern New Mexico, is home to over 300 tribal members. This tribal reservation is the state's smallest with very limited resources and limited economic development opportunities. The tribe currently experiences relatively high costs of electricity and frequent power interruptions. The Pueblo has successfully constructed a 1MW photovoltaic (PV) project in 2018 and is selling its energy to the local electric utility. This revenue provides return on investment and partial subsidy the electricity bills of the tribal households. The tribe has successfully secured another grant to fund a second grid-tied solar project. The tribe also expressed interest in evaluating whether the addition of an energy storage system (ESS) to this project could provide additional benefit. Sandia has evaluated different technical solutions that couple ESS with solar PV on Picuris Pueblo.

Pueblo of Picuris Facts

- Tribal members: ~300 enrolled members
- Location: in Sangre de Cristo Mountains, Taos County, Northern New Mexico
- Above-average electricity rates
  - Electric heating is considered costly and gas infrastructure does not exist
  - Many members burn wood, with possible health consequences
- 1 MW solar PV operational since Jan. 2018
  - Funded though DoE grant and loan
  - Power Purchase Agreement (PPA) to sell power to the local utility
  - Revenue from PPA pays back loan and subsidizes tribal members' electric bills
- Funding secured for another project
  - Microgrid with another solar PV array

Project Goals:

- Evaluate alternative electrical service scenarios
  - How can a Battery Energy Storage System (BESS) support tribe's energy sovereignty?
- Evaluation of different solutions to couple large scale energy storage and solar
  - Analysis of reduction of electricity costs with energy storage and solar power

Applications of Energy Storage at Picuris

Reliability:

- Problem: restoration time is relatively long due to location
  - New solar project presents opportunity for a microgrid with the addition of energy storage
  - Power interruptions of over 1 hour are common
  - Communications, local economy and well-being of people are affected
  - Local sensitive loads need backup power
  - Pollution of diesel-powered backup is undesirable

Energy arbitrage:

- Sell excess energy from PV to utility and buy energy when battery is depleted
- PPAs for *buying* and *selling* power with BESS
  - Sell and store power when there is excess solar
  - Buy and discharge BESS when no solar power is available
- What are the best sizes of new PV array and BESS?
- Maximize net present value of investment
  - Capital costs: purchase new PV and BESS under budget constraints
  - Revenue stream: cost-savings from arbitrage and revenue from solar PV
- Net load estimated using meter data from the local utility, load profiles from similar buildings[1] and estimated solar PV generation[2]

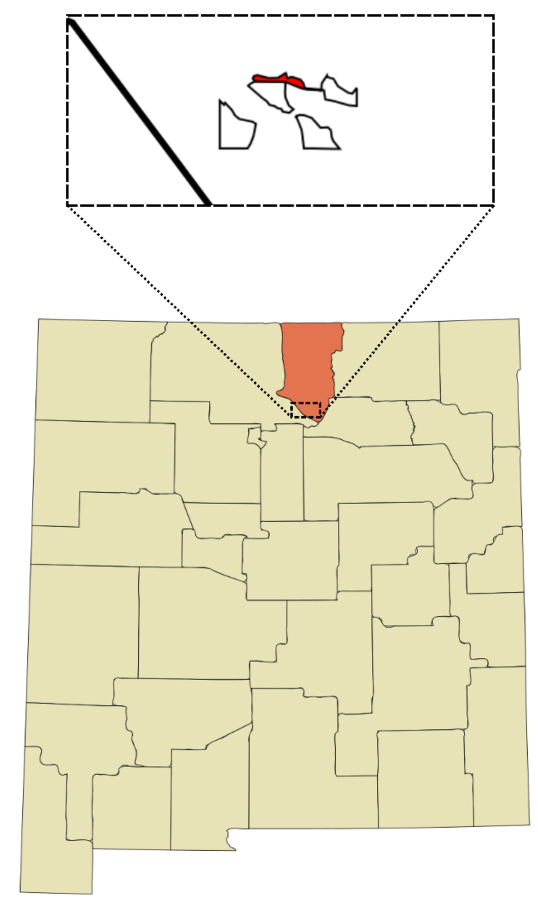

Fig. 1. Location of the Pueblo of Picuris.

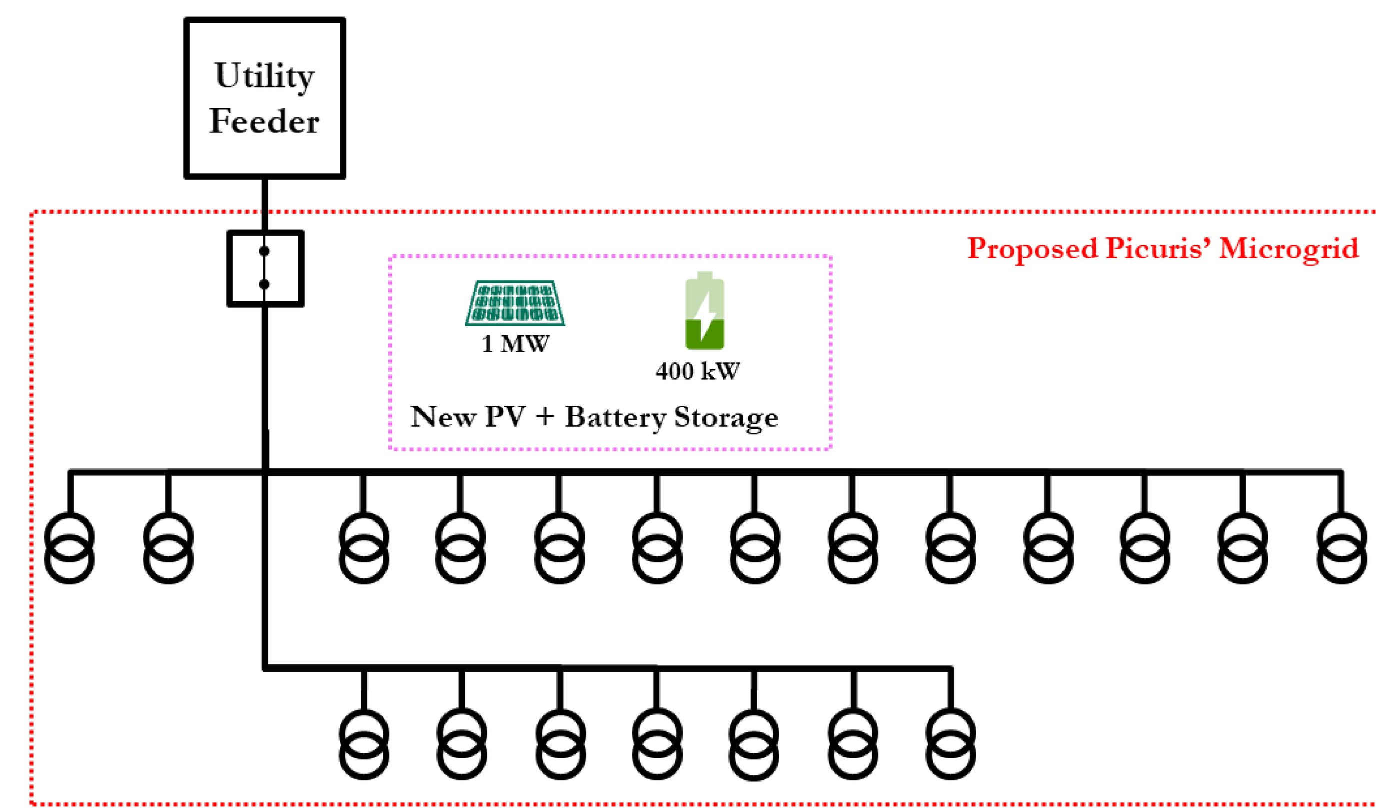

Fig. 2. Notional diagram of the proposed microgrid with local solar PV generation and BESS.

Energy Arbitrage Application

- Goal: maximize cost savings
- Cost savings sensitive to difference between prices of selling and buying power
- Price of buying energy is expected to be higher than price of selling excess solar PV energy
- Two scenarios:
- $p_{buy} - p_{sell} = \$0.14/\text{kWh}$ or $\$0.125/\text{kWh}$

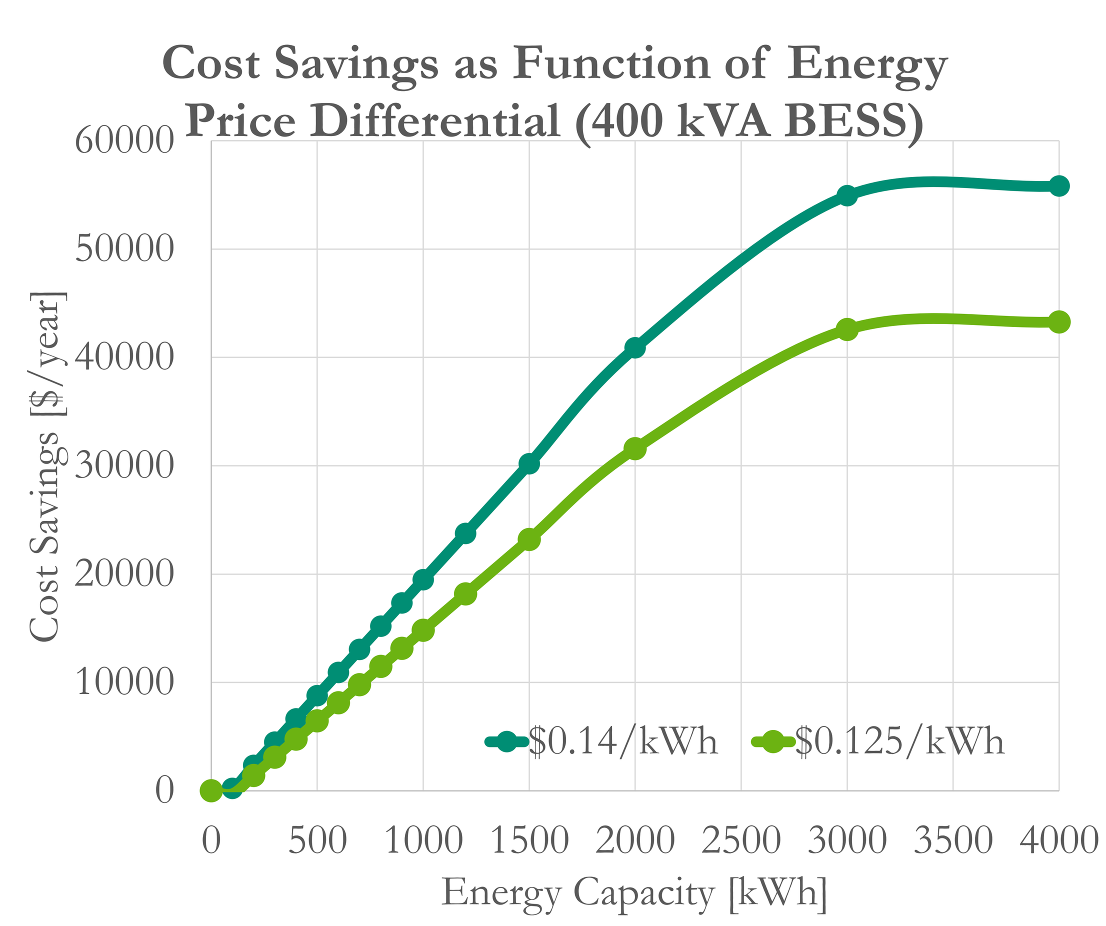

Fig. 3. Marginal cost savings start to decrease after the energy capacity is larger than 1,500 kWh.

Reliability Application

- Consider 1 MW solar PV system within microgrid
- **Power Capacity: 400kVA**
  - Estimated current net peak load of 169 kW
  - Considering 7% annual peak load growth, 3% losses and 0.85 power factor
- **Energy Capacity**: function of required runtime and scope of backup power:
  - **Full load**: microgrid backs up estimated net load
  - **Partial load**: decrease estimated load by 50%

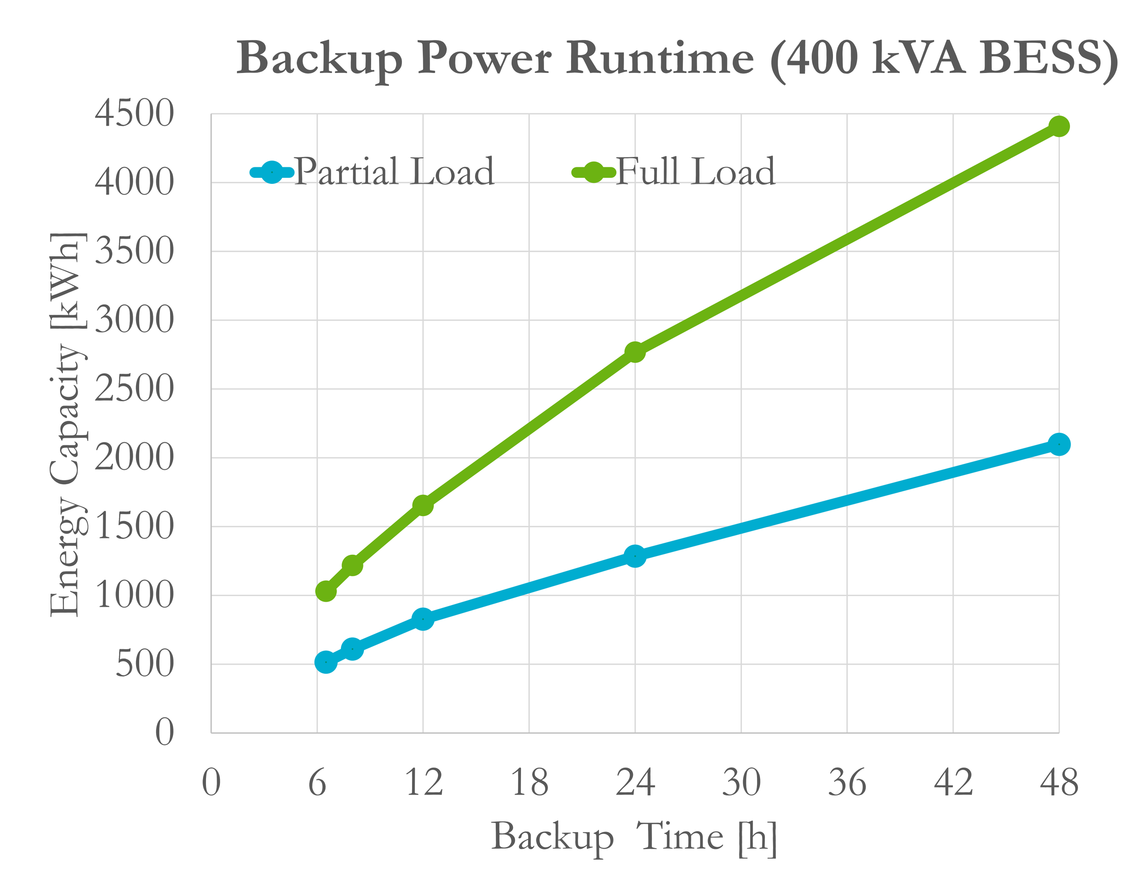

Fig. 4. Energy capacity can be sized as a function of desired backup time.

Considering a limited budget, stacking both applications would require a tradeoff between desired reliability level achieved by emergency backup power and energy cost savings obtained by buying and selling energy to the local utility

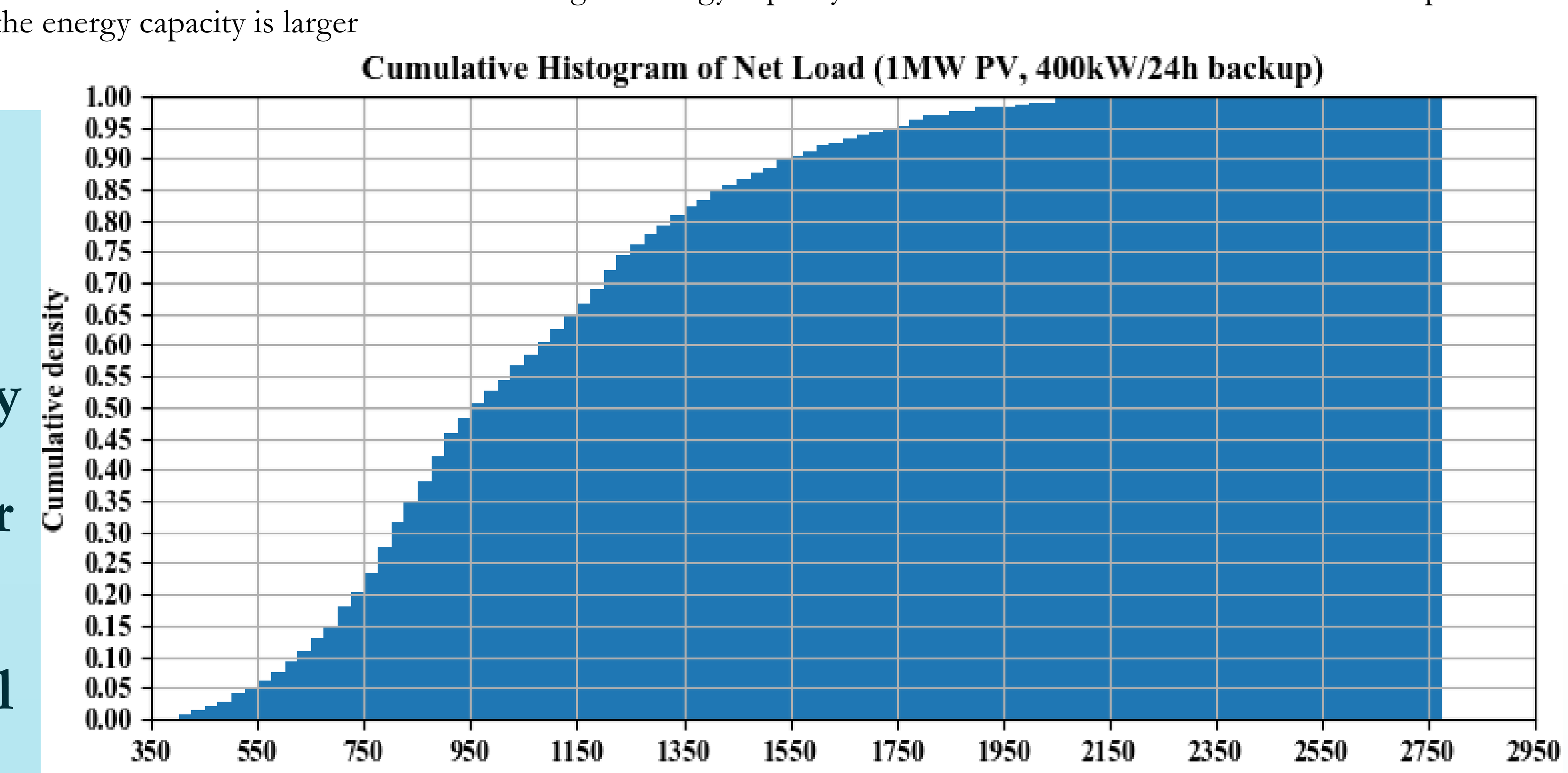

Fig. 5. Cumulative distribution of energy necessary for backing up net load over 24 hours.

Conclusion

- BESS can reduce energy costs to the Pueblo by minimizing the use of energy bought from the local utility because the price of electricity
- Marginal benefits of energy arbitrage tend to decrease for BESS with energy capacities larger than 1,500 kWh
- BESS and solar PV can support the loads of the Pueblo during a power interruption for several hours
- There is a tradeoff level of reliability obtained by energy capacity reserved for backup power and economic benefit from buying and selling energy

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2. Dobos, A. P. *PVWatts version 5 manual.* No. NREL/TP-6A20-62641. National Renewable Energy Lab.(NREL), Golden, CO (United States), 2014.