Economic Evaluation of Behind-The-Meter Battery Storage for Residential Customers with PV Systems in the Regional Market Environment

Yahia Baghzouz
Department of Electrical and Computer Engineering
University of Nevada
Las Vegas, NV (USA)

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Overview

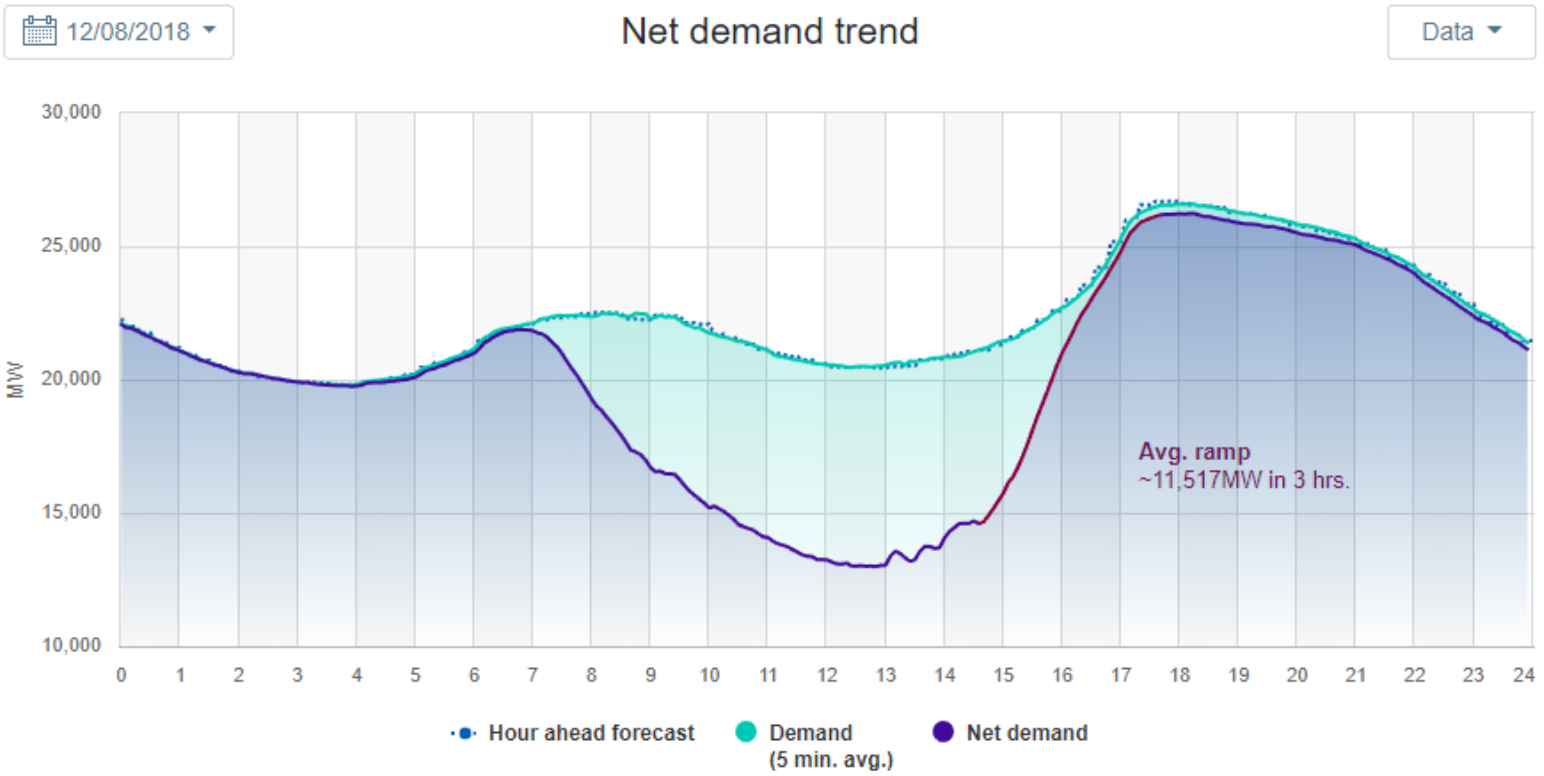
- Background/Introduction
- Current Regional Utility Rates and Rebates
- System Description
- Numerical Analysis
- Conclusions

Background

- Over the past decade, the proliferation of electric power generation from photovoltaic (PV) systems has surged dramatically throughout the world.
- In some regions of the U.S., solar energy already represents up to 15% of total annual electricity generation, and instantaneous solar generation can reach up to 40% in some cases.
- The state of California now requires all new home constructions to have built-in PV systems.

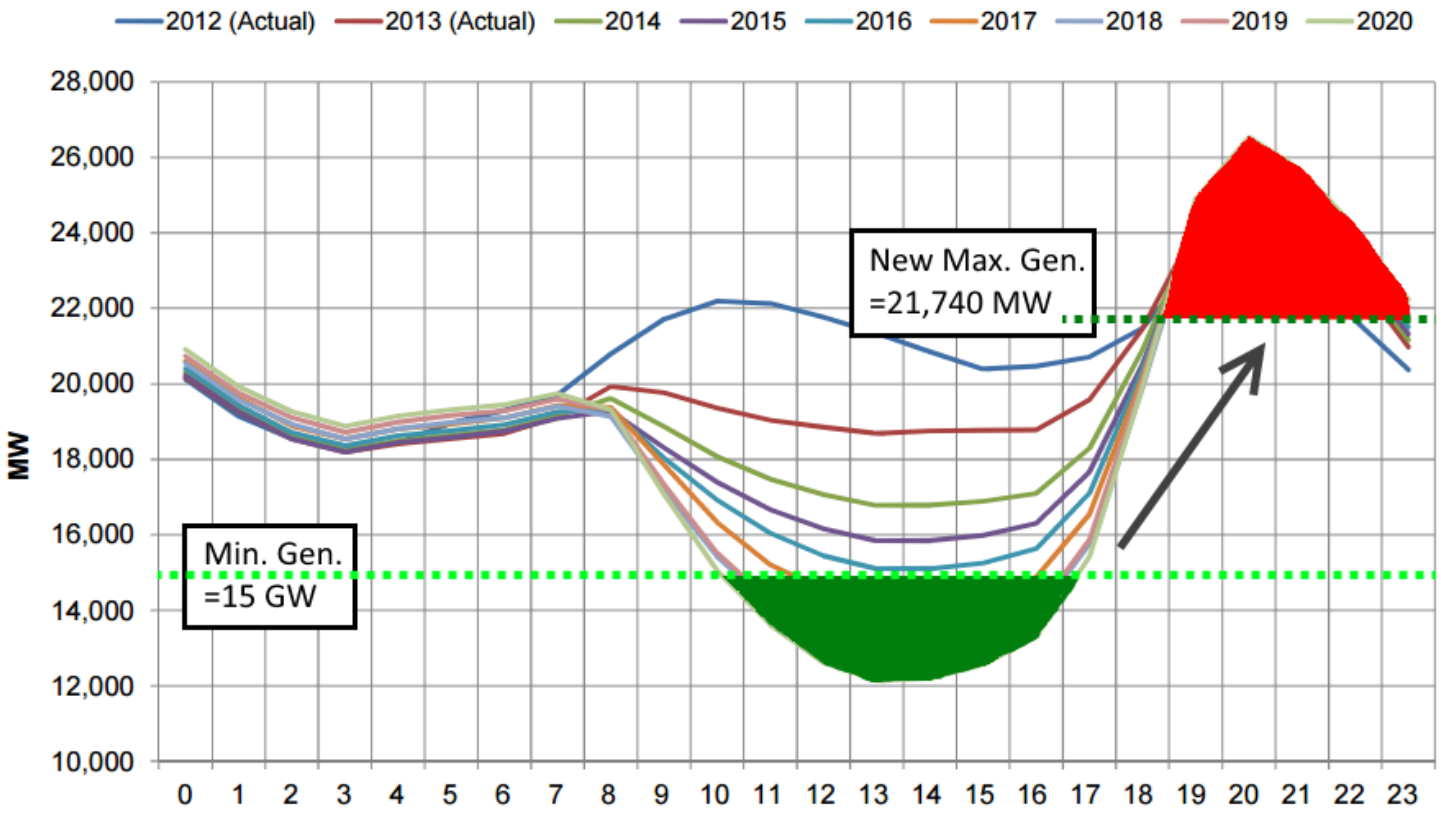
Background

- As PV penetration into the grid continues to increase, so does the complexity in regulating the system voltage and frequency, and in economic scheduling of conventional power plants.
- These technical challenges are mainly caused by the mismatch between electricity consumption and PV generation.



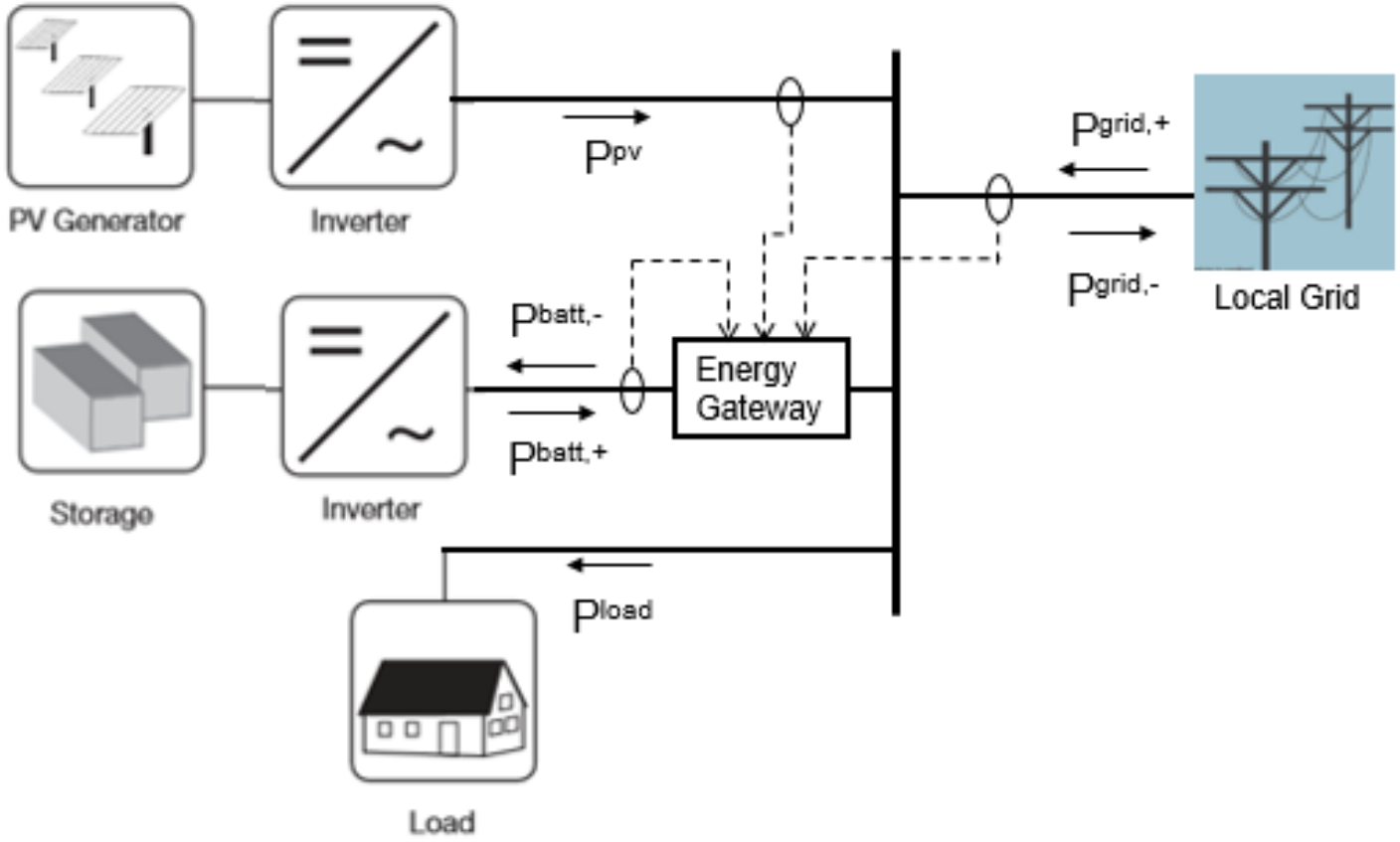
Background

- New policy incentives that support PV self-consumption (e.g., limiting the amount of PV power that is fed into the grid by installing battery energy storage systems - BESS) are being advocated in many countries.



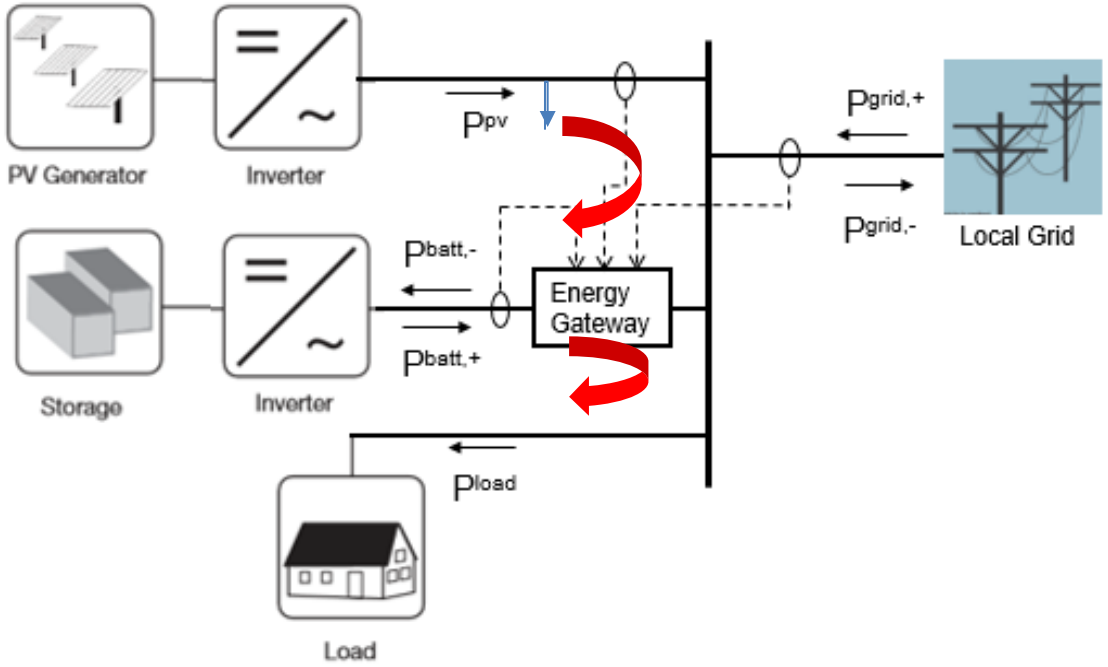
Scope

- This article investigates the economic viability of installing a BESS at a local residential customer, who is equipped with a PV system, under new local incentive schemes and policies.



Local BESS Incentives & Policies

- State of Nevada RPS:25% by 2025 (new ballot initiative: 50% by 2030).
- BESS incentive rebate: up to $3,000.
- Federal Investment Tax Credit: 30% of BESS cost.
- Requirement – BESS can only charge from the PV system and discharge into local load.
- Enroll in ToU rate.

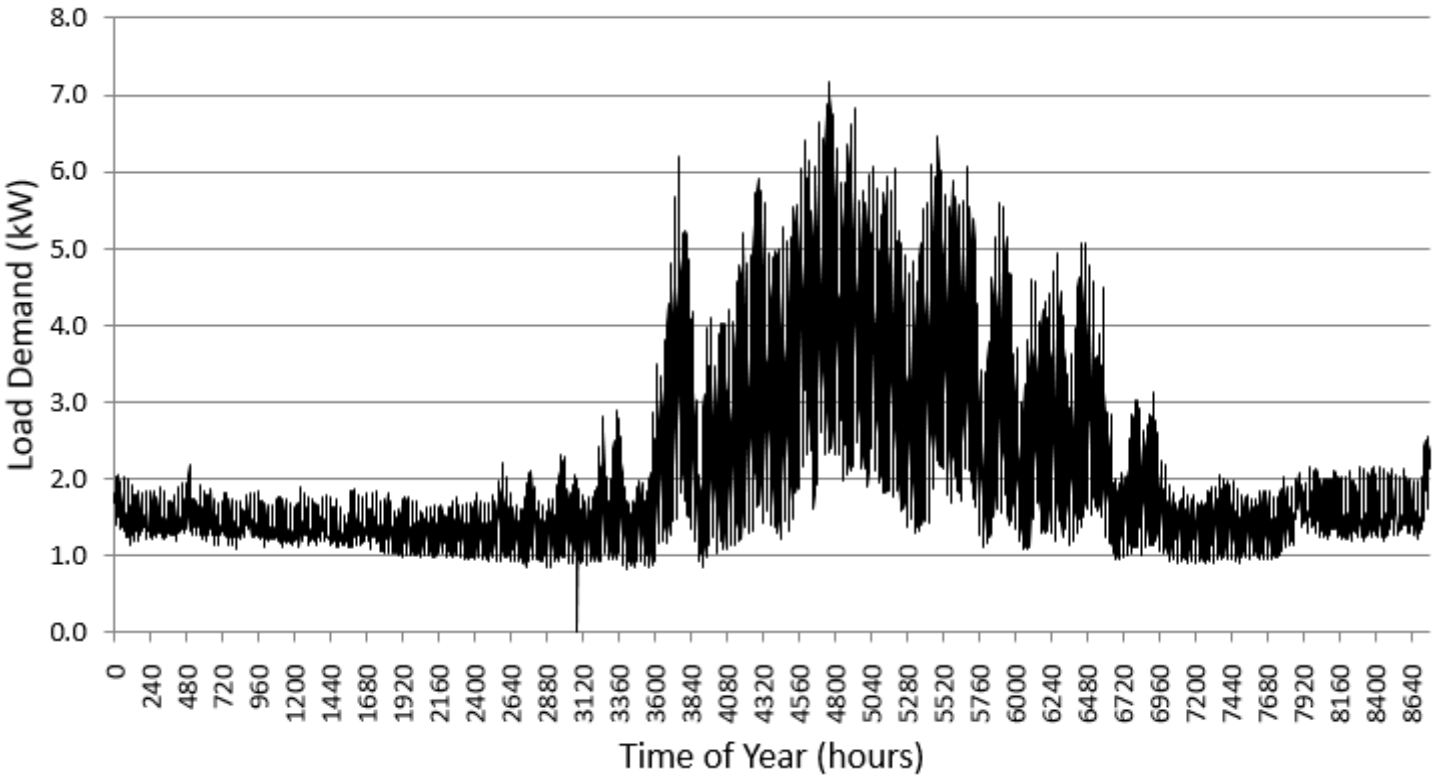


Utility Net-Metering and ToU Rates

Rate Type	Month	Time of Day	Cost ($/kWh)
Net-Metering	All year	All day	-$0.09
Summer-on-peak	June - September	13:00-19:00 on weekdays only	$0.44
Summer-off-peak	June - September	19:00-13:00 on weekdays All day on weekends	$0.06
Rest-of-the-Year	October - May	All day	$0.05

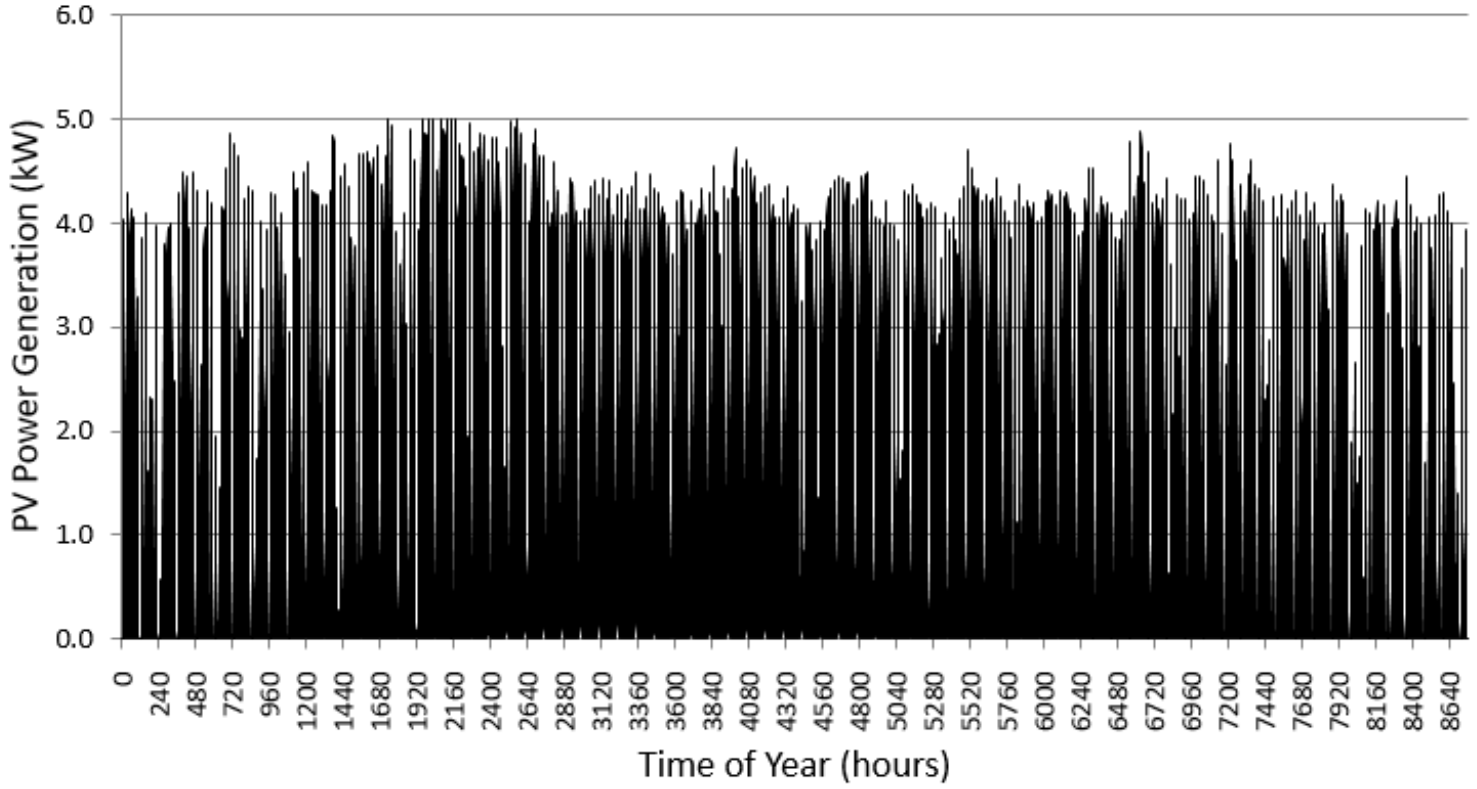
Local Customer Demand Curve

- Hourly load data of the distribution feeder that serves the neighborhood was made available.
- The data was then scaled down to closely fit the customer's annual electricity bill.
- Total house energy consumption ≈ 18,000 kWh

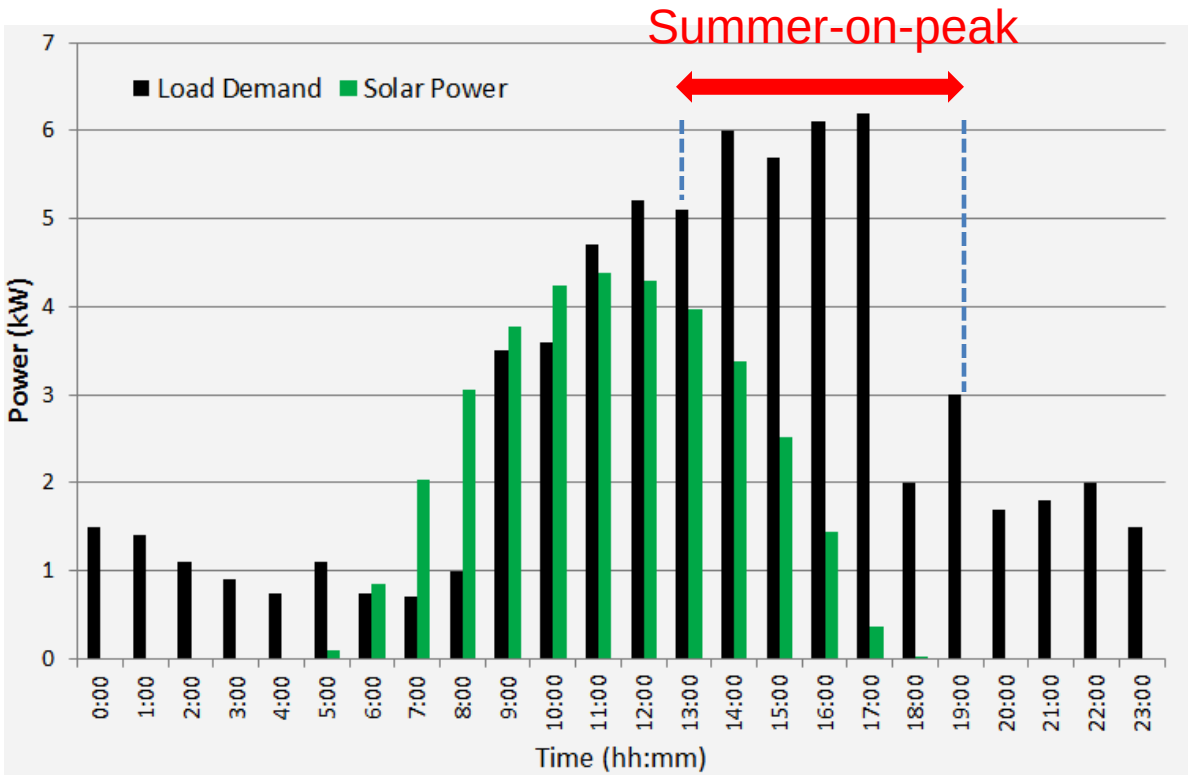


Customer Photovoltaic System (5.6 kW)

- PVWatts simulation tool was used to estimate the hourly power production of this photovoltaic system.
- PVWatts uses typical hourly weather data of the local area including solar irradiance, and ambient temperature.
- Total energy produced ≈ 10,340 kWh.



Typical Hourly Load Demand and PV Power (Summer Day)



Customer Energy Cost Breakdown w/o BESS

PV Self-Consumption: 6,655 kWh out of 10,342 kWh or 64.5%.

Utility Rate Type	Energy purchased or sold (kWh)	Cost ($/kWh)
Net-Metering rate	-3,687	-$332
ToU Summer-on-peak	1,633	$718
ToU Summer-off-peak	4,427	$266
ToU Rest-of-the-year	5,315	$266

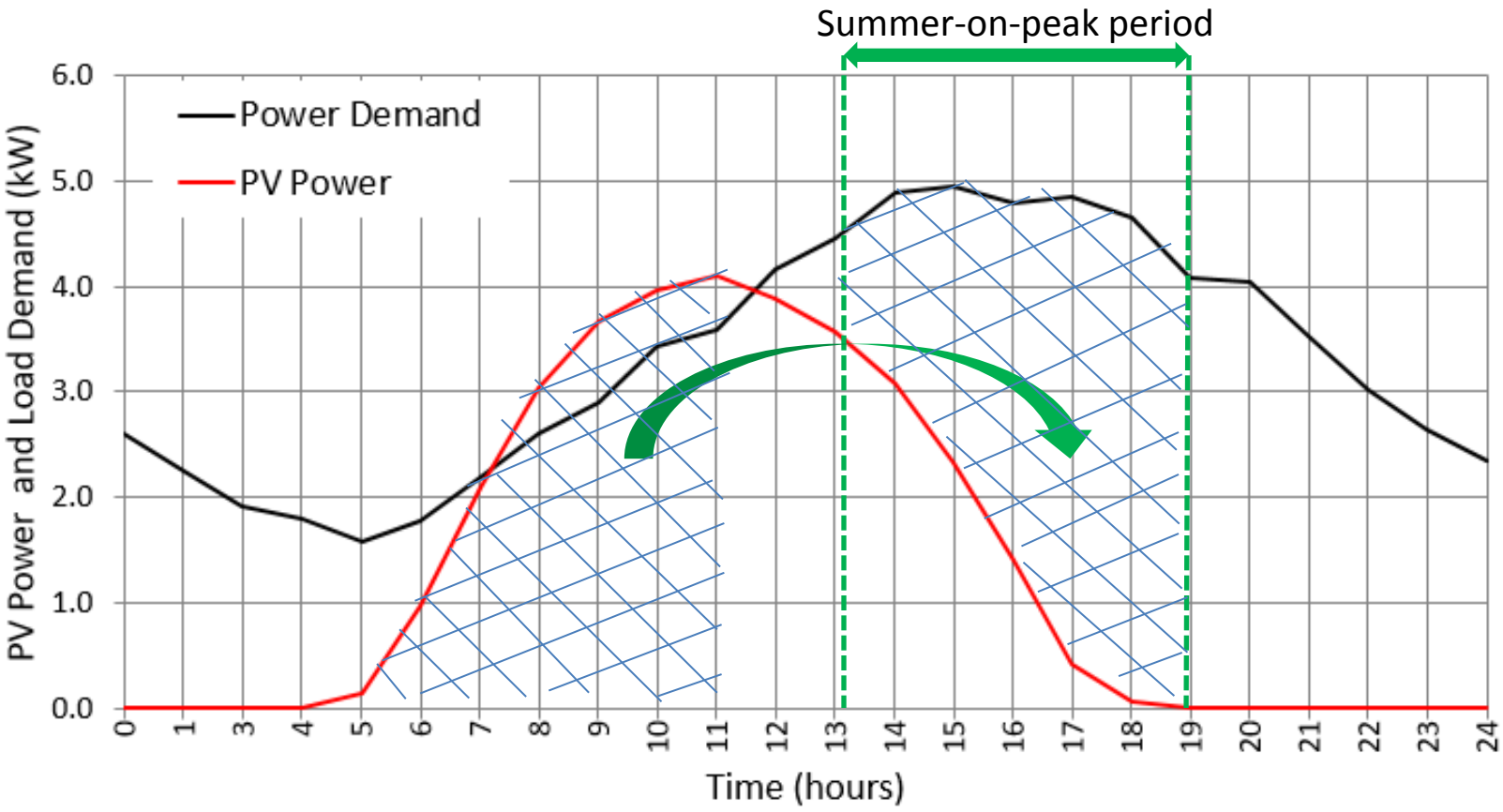
Total: $918

Battery Energy Storage System

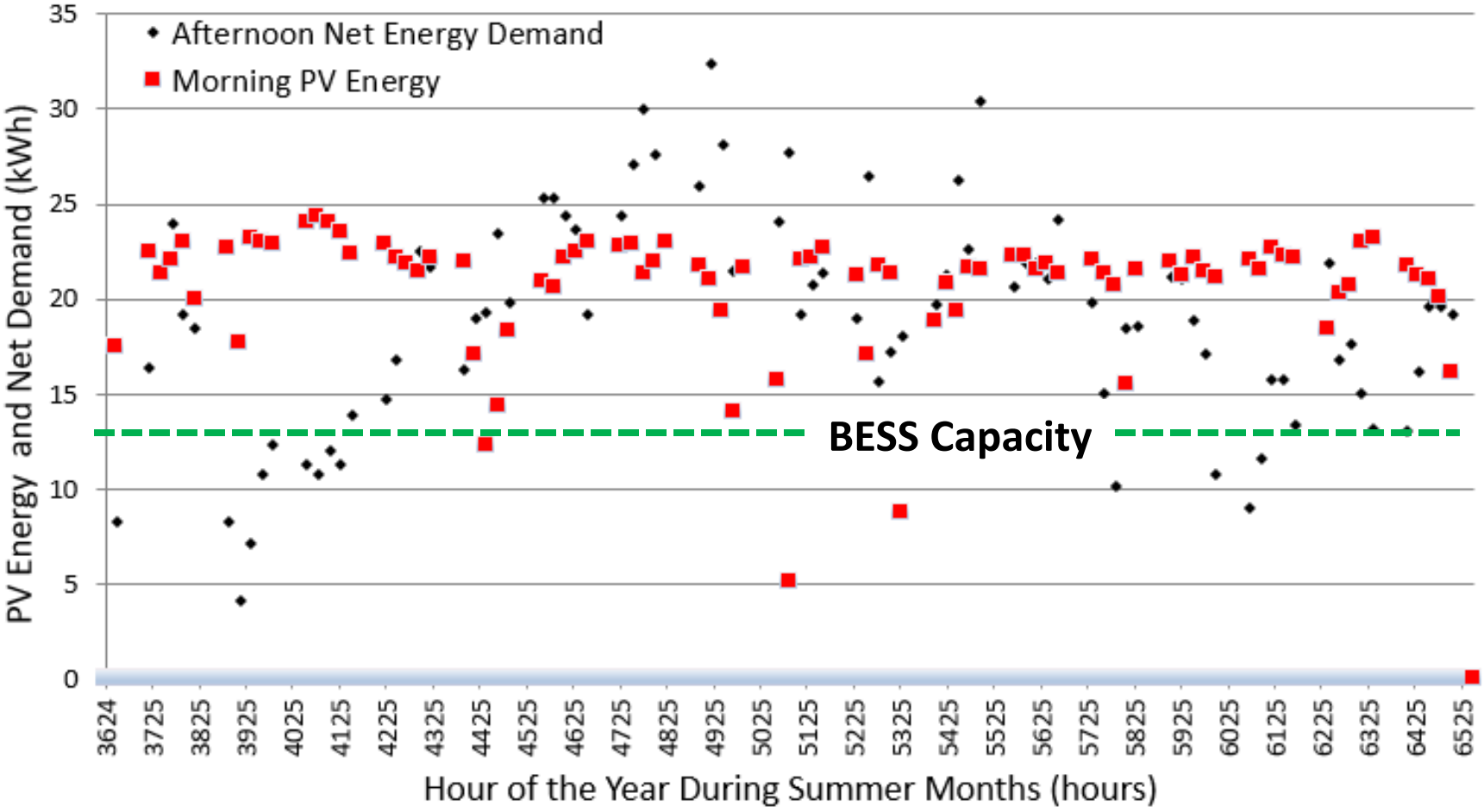
- Total/Usable Capacity = 13.5 kWh.
- Round-trip Efficiency (AC to battery to AC) = 90%.
- Maximum Continuous Discharge Power = 5 kW.
- Maximum Transient Discharge Power = 7 kW.
- Warranty = 10 years.
- Initial Cost = $7,000.
- Net Cost = $2,800.

PV Energy Shifting during Summer-On-Peak Period

- Store PV energy during the morning hours when the rate is low ($0.06/kWh)
- Release and utilize the stored energy when the rate is high ($0.44/kWh)



PV Energy Availability during Morning Hours and Demand during Summer-On-Peak Period



Customer Energy Cost Breakdown with BESS

ToU Plan	Energy purchased or sold (kWh)	Cost ($/kWh)
Net-Metering	-3,437	-$309
TOU Summer-on-peak	631	$278
TOU Summer-off-peak	5,540	$332
TOU Rest-of-the-year	5,315	$266

Total: $567

→ Savings: $351

NPV over 10 yrs. at current discount rate: $412

Conclusions

- This article conducted and economic analysis of adding a BESS to a local residential home that is equipped with PV for the purpose of reducing electric energy cost, while taking advantage of current state and federal incentives.
- Simulation results using typical load and solar irradiance data indicate that while the BESS can reduce the yearly energy bill by 38%, the *NPV* is found to be only $412 at the end of 10-year BESS warranty.
- The cost savings calculated in this study applies only to the local region and can differ significantly for other regions such as the states of Hawaii and California where electricity rates are significantly higher.
- In conclusion, despite the significant state and federal incentives, the BESS net cost is still too high for this particular application.

QUESTIONS OR COMMENTS?