Techno-economic Analysis of an Energy Storage System Utilizing the STEP Facility

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Paper - 076

2026 International sCO_2 Energy Technologies Symposium

March 4, 2026

Pittsburgh, PA

Outline

Background & Motivation

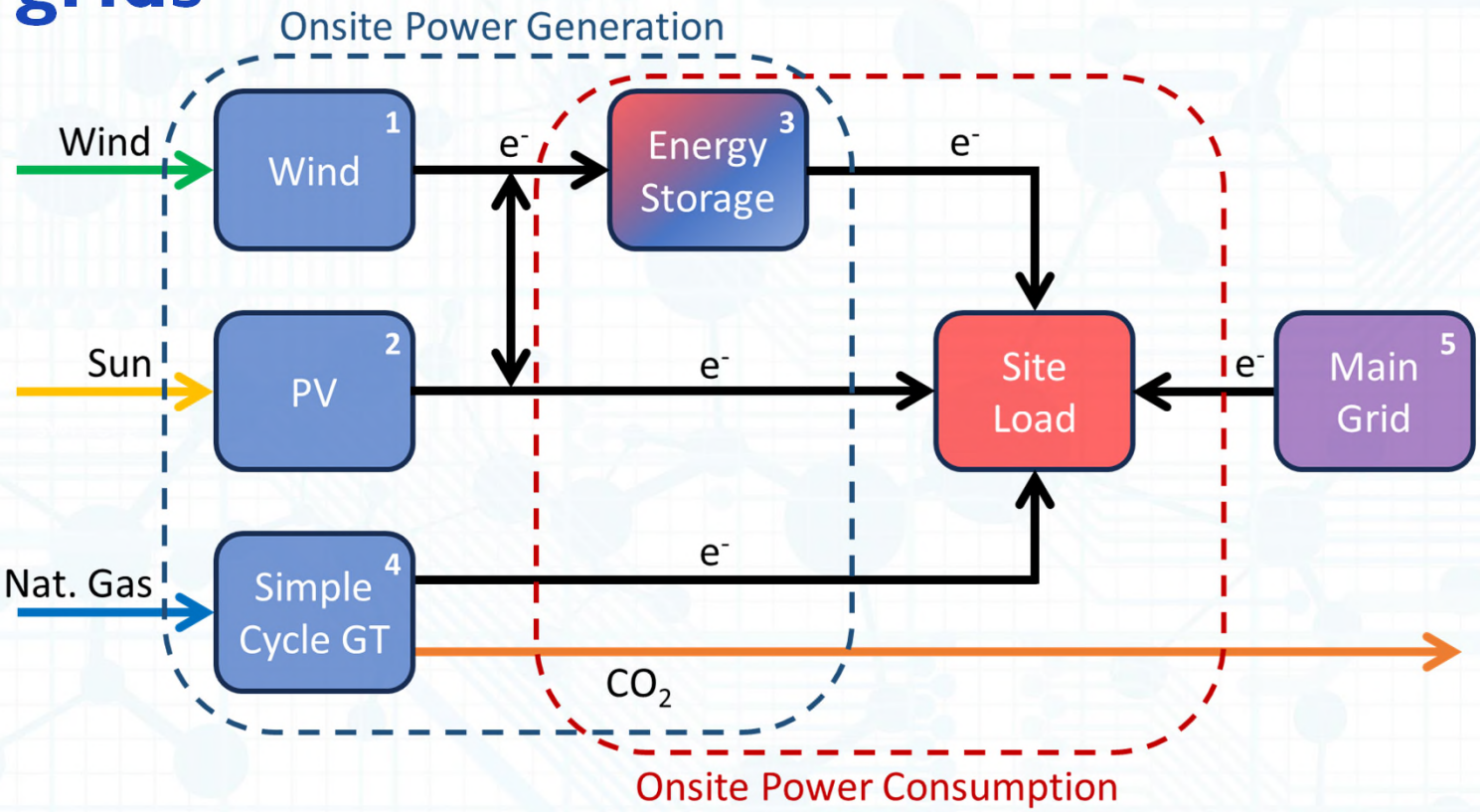
- The SwRI Microgrid
- PyZ Modeling Tool
- STEP Facility?

- PyZ Modeling Tool

Background & Motivation

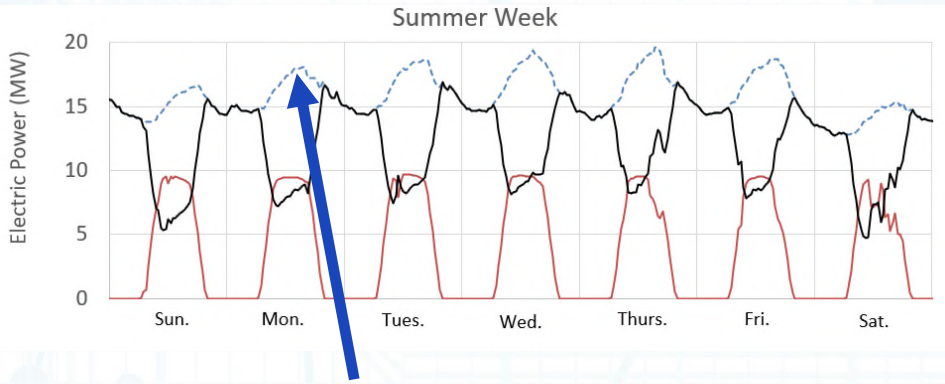
Micro-grids are small independent or semi-independent grids

- Only around 4.4 GW (0.3%) of installed capacity in US
- Often located in remote or rural areas
- Historically, dominated by fossil-fired systems



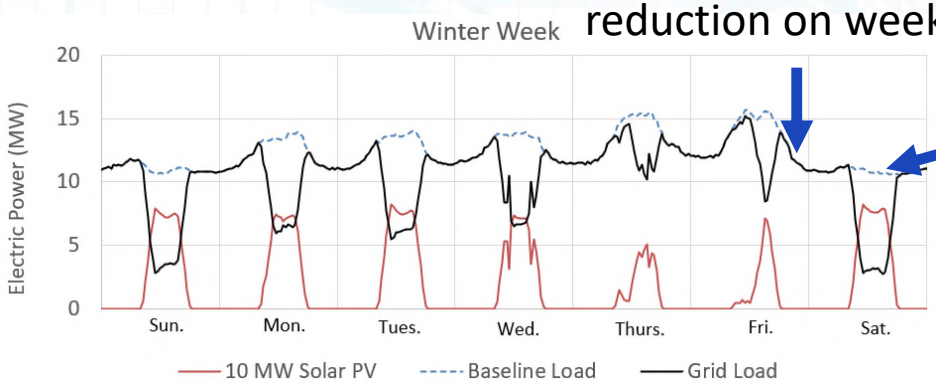
SwRI is a unique corporation to explore the energy transition

- Significant load required
- Large seasonal, diurnal and weekly load variations
- Privately owned with a significant amount of land available



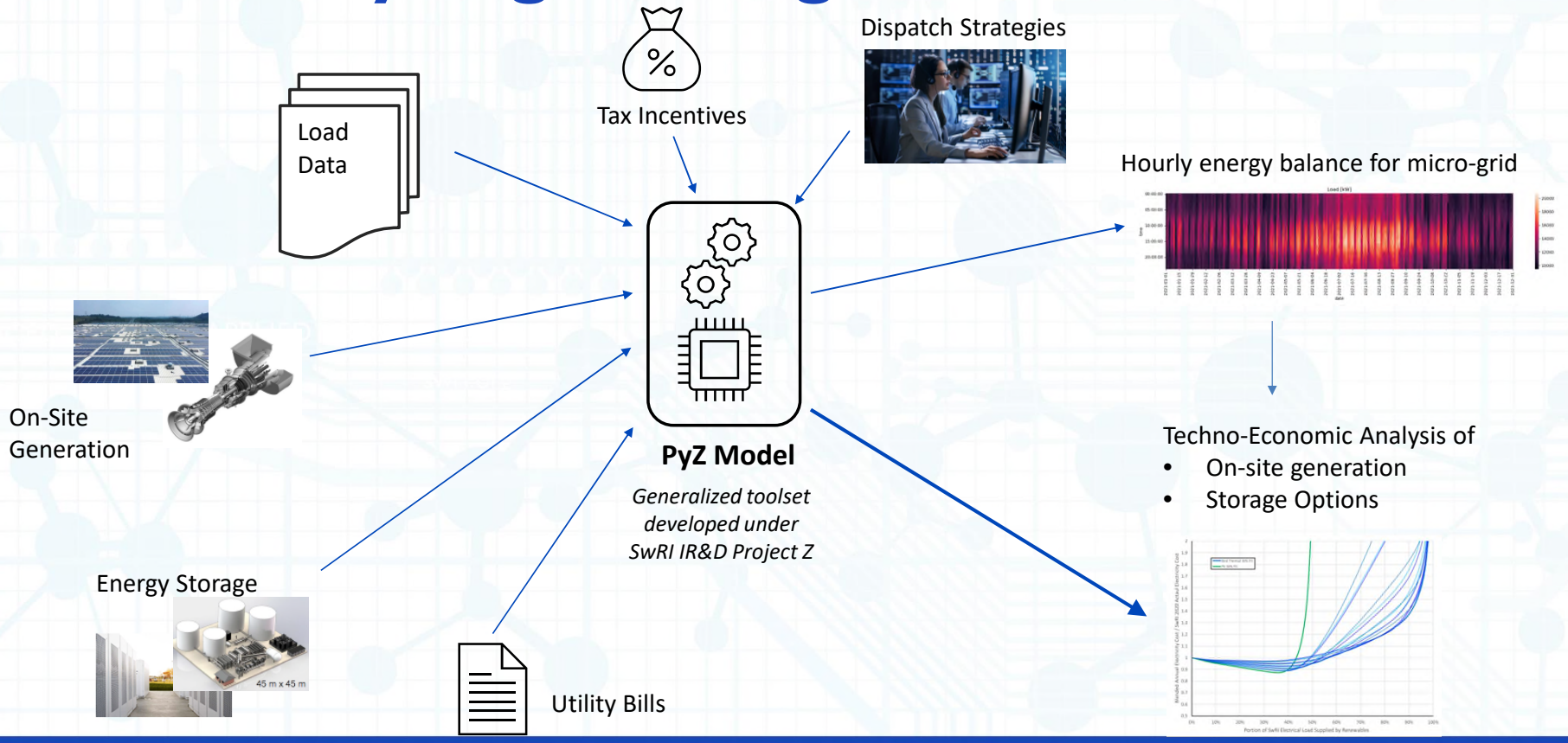
20-22 MW peak load in Summer

Up to 33% load reduction on weekends



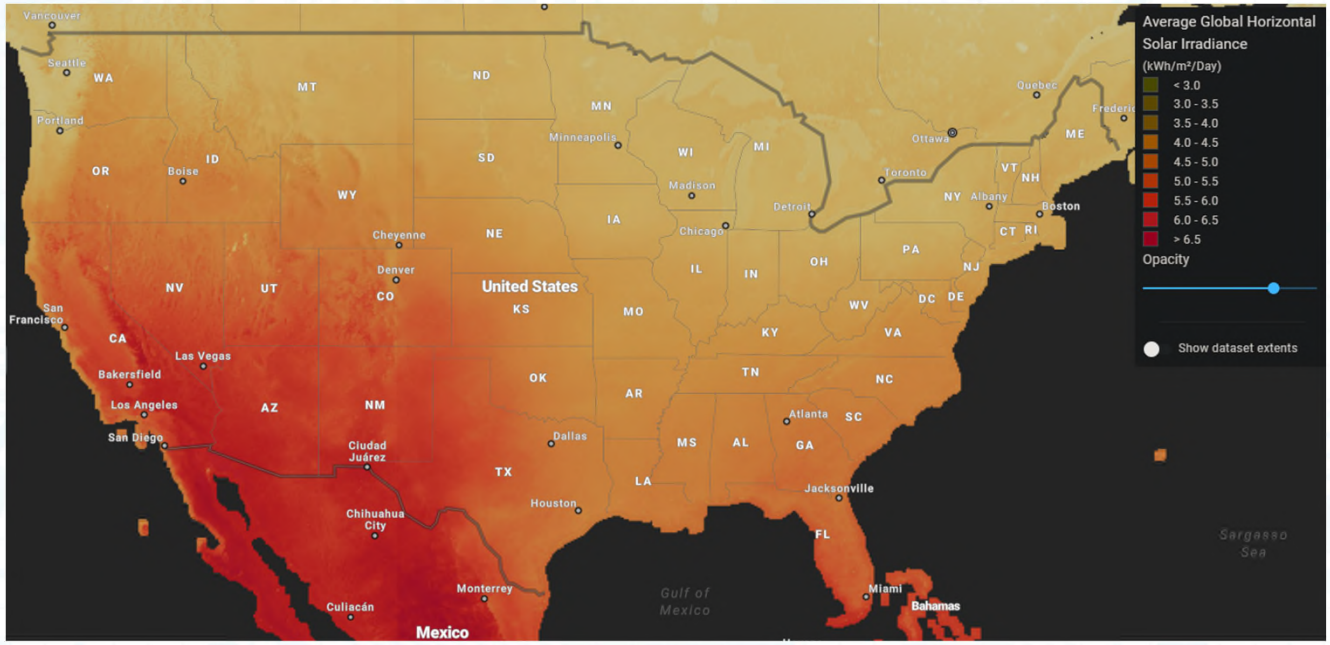
10 MW min load in Winter

PyZ was created in Python to serve as a modular tool for analyzing micro-grids



PyZ utilizes established models for renewable energy

- PVWatts 8 (SAM)
- WindPower (SAM)
- National Solar Radiation Database (NSRDB)
- Wind Resource Database (WRDB)



Average Solar Irradiance in Continental U.S.

PyZ modules have been validated against NREL baselines

Location: Fredonia, KS

Key Assumptions

Parameter	Commercial PV (Rooftop, 200 kWDC)	Utility-Scale PV (One-Axis Tracking, 100 MWDC)
Installed cost ($/WDC)	1.63	0.87
Annual degradation (%)	0.7	0.7
Levelized O&M expenses over life of asset ($/WDC-yr)	18	16
Preinverter derate (%)	85.9	85.9
Inverter efficiency (%)	96	96
tilt/azimuth	10/190	tracking/180
Array Type	Fixed Roof Mount	1-axis backtracking

Model Outputs

Parameter	Commercial PV (Rooftop, 200 kWdc)		Utility-Scale PV (One-Axis Tracking, 100 MWdc)	
	NREL Baseline	Model Result	NREL Baseline	Model Result
MSP Installation Cost [$/W]	1.63	1.64	0.87	0.87
MMP Installation Cost [$/W]	1.84	1.85	0.99	0.99
Energy Yield [kWh/kW]	1398	1395	1694	1684
MSP LCOE Levelized cost of energy real [¢/kWh]	8.70	8.83	4.10	4.10
MMP LCOE Levelized cost of energy real [¢/kWh]	N/A	9.75	N/A	4.50

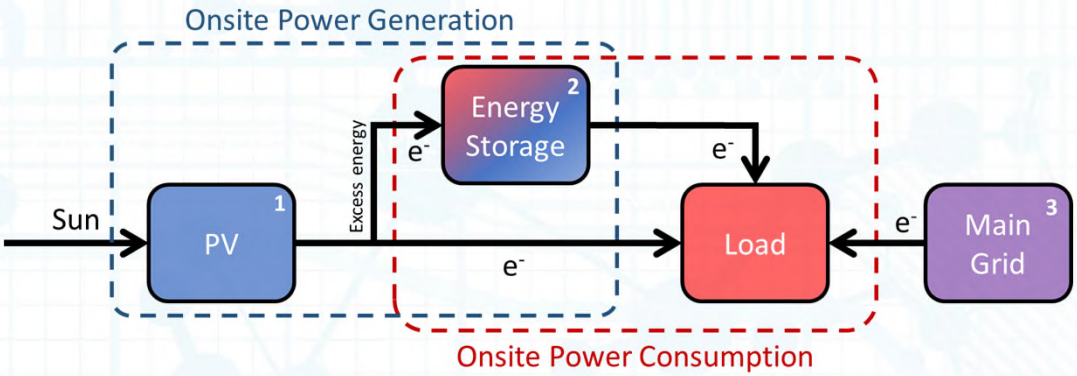
Ramasamy, V., Zuboy, J., O'Shaughnessy, E. Feldman, D., Desai, J., Woodhouse, M., Basore, P., and Margolis, M., "U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks, with Minimum Sustainable Price Analysis: Q1 2022", National Renewable Energy Laboratory, Golden, CO, September, 2022, NREL/TP-7A40-83586.

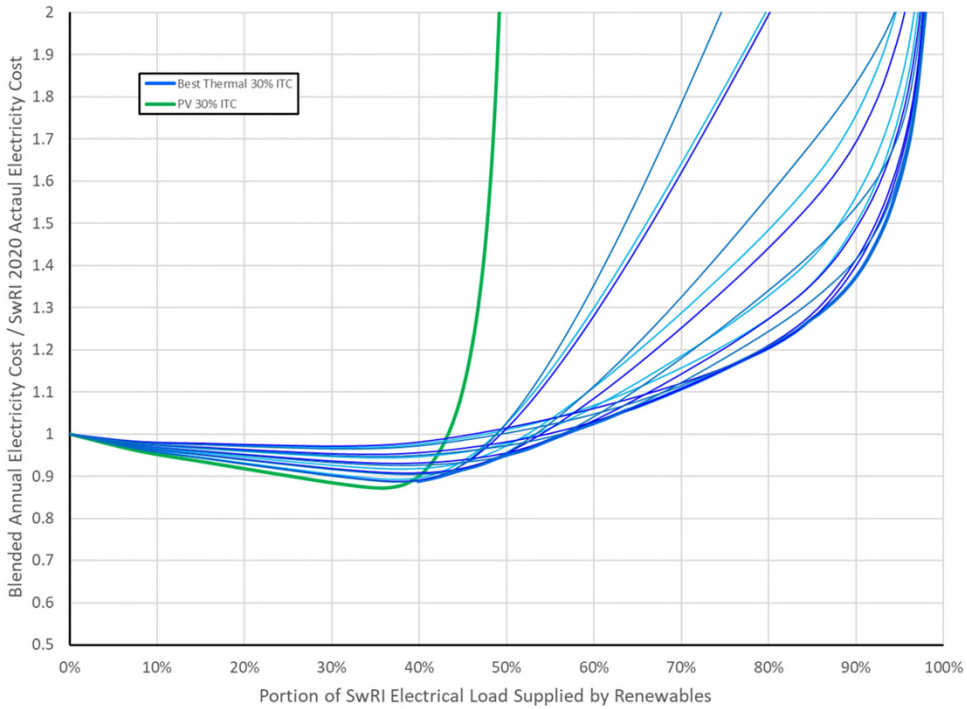
The STEP Facility is the 1st Multi-MW sCO2 Power Plant

- Designed to provide up to 10 MW to the SwRI grid
- SwRI and GTI produced 4 MW-net in the Fall of 2024

Microgrid Modeling
&
Key Assumptions

SwRI would struggle to penetrate more than 50% of their electricity with PV alone





PV System Key Assumptions

- The PV field was swept between 0-100 MW

Parameter	Value
Location for Solar Resource	San Antonio, TX
Ground Coverage Ratio	0.4
Tilt [°]	0
Azimuth Angle [°]	180
Pre-inverter DC Losses [%]	14.1
Inverter Efficiency [%]	96
Inverter Loading Ratio [-]	1.1
Array Type	1-axis-backtracking
Degradation [%/yr]	0.7
PV CAPEX [2024$/kW]	961.40
PV OPEX [2024$/kW]	16

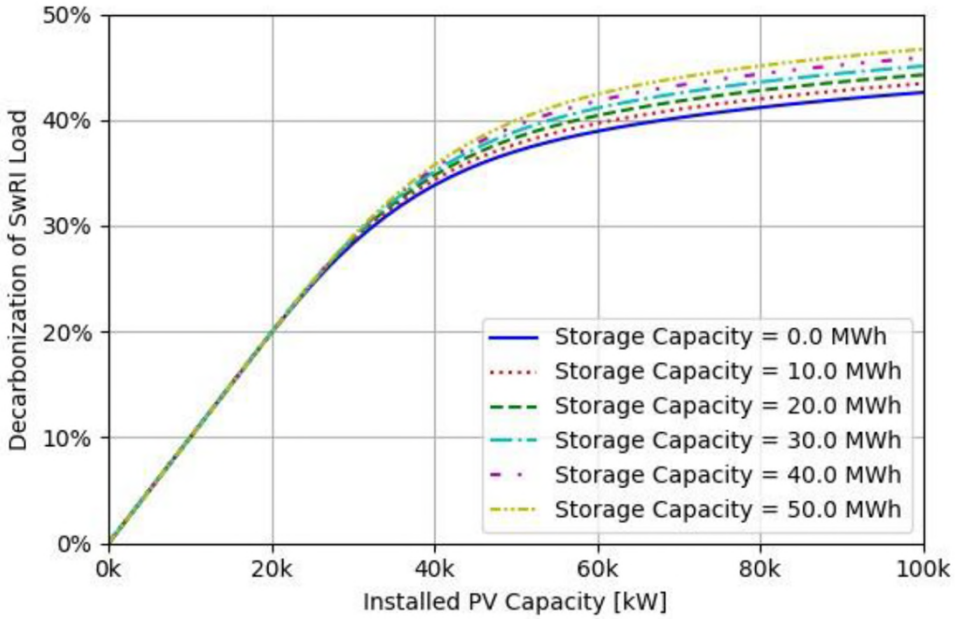
Storage and Utility Assumptions

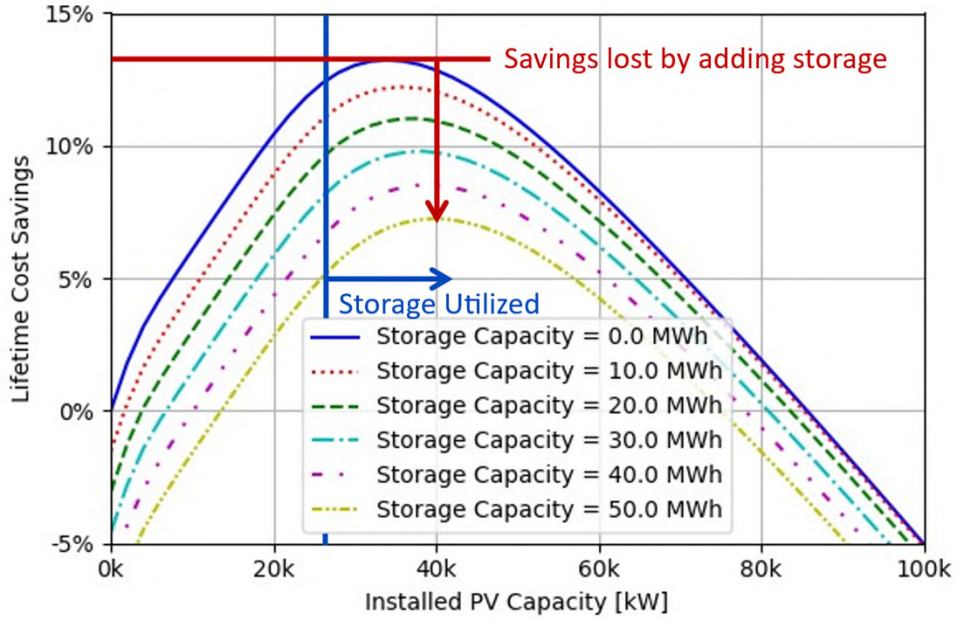
- The storage system was swept between 0-50 MWh
- The charge duration was set to 6 hours
- The discharge duration was set to 10 hours

Parameter	Value
Utility Energy Charge [$/kWh]	0.066
Utility Demand Charge (Summer Season) [$/kW]	14.37
Utility Demand Charge (non-Summer Season) [$/kW]	9.36
Investment Tax Credit [%]	30
Real Discount Rate [%]	4.74
Inflation Rate [%]	2.5
Load Escalation Rate [%]	2.0

Parameter	Value
Storage CAPEX [2024$/$kW_{th}$]	126.56
Storage CAPEX [2024$/$kW_{th}$]	126.56
Storage OPEX [2024$/kW]	0
Charge CAPEX [2024$/kW]	934.52
Charge OPEX [2024$/kW]	26.85
Discharge CAPEX [2024$/kW]	597.48
Discharge OPEX [2024$/kW]	26.85

Storage would increase grid penetration but reduce the savings

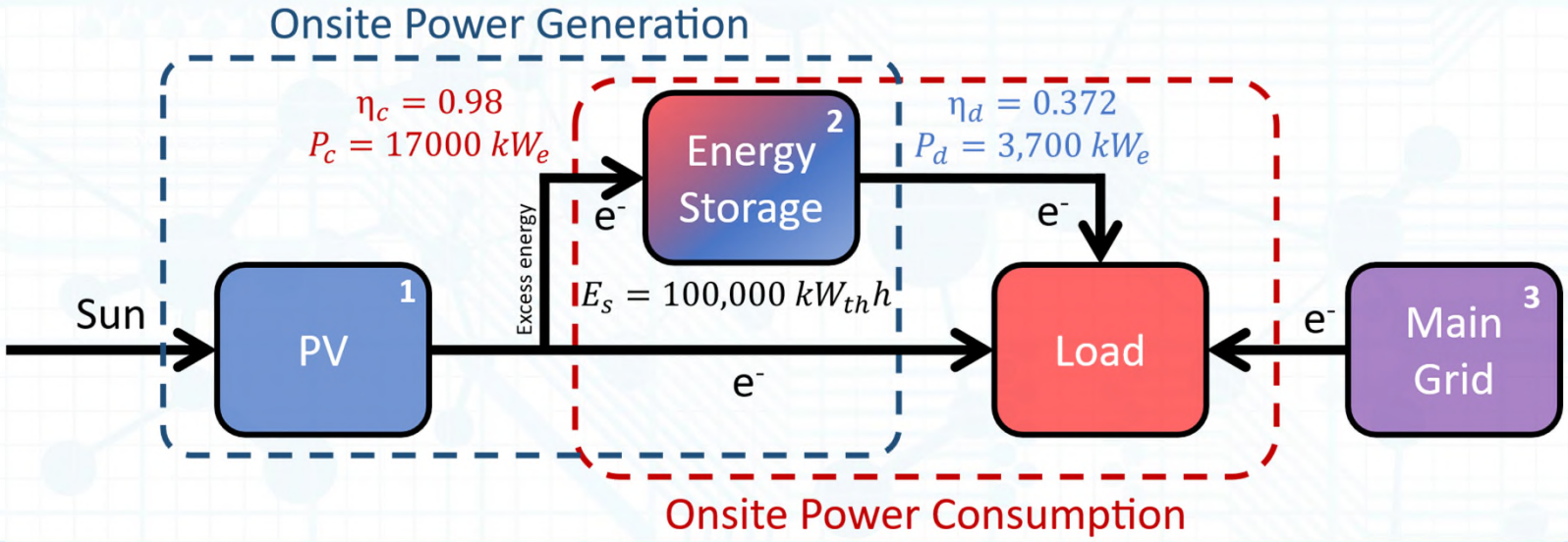




Demo System with STEP

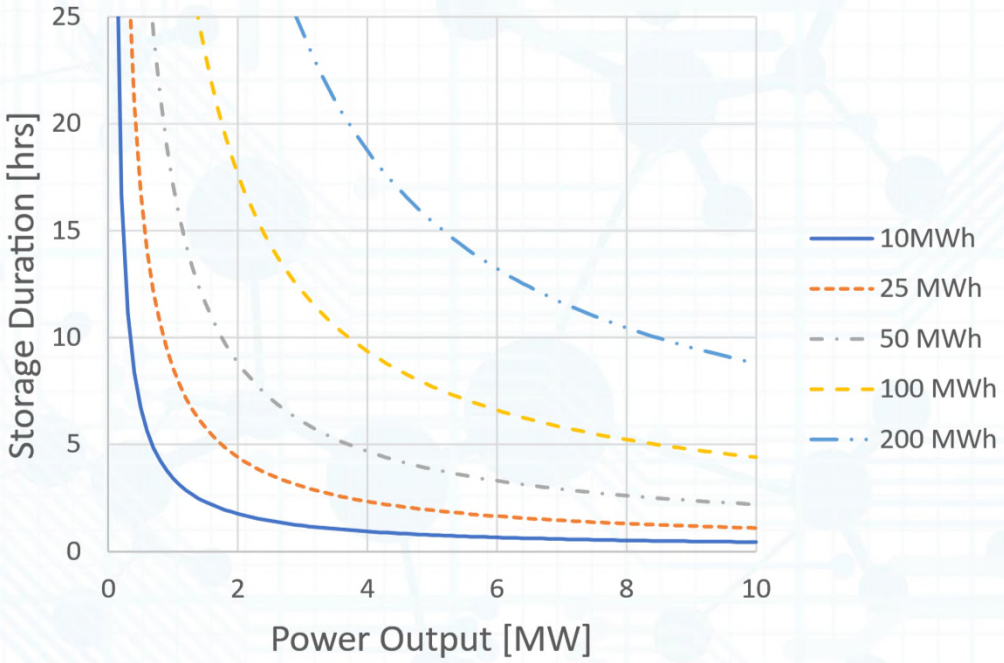
STEP Microgrid Model

- PV system was varied between 0-100 MW
- The storage system was swept between 100 MWh
- The charge duration was set to 6 hours
- The discharge duration was set to 10 hours

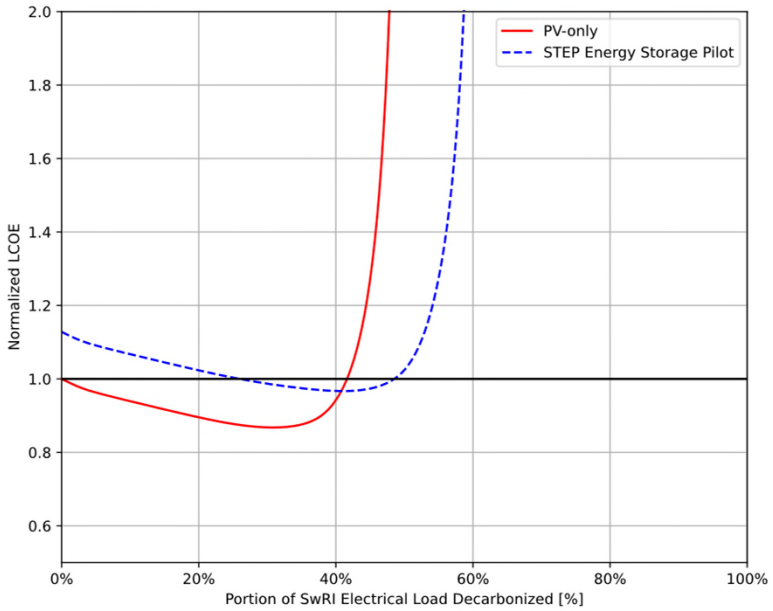


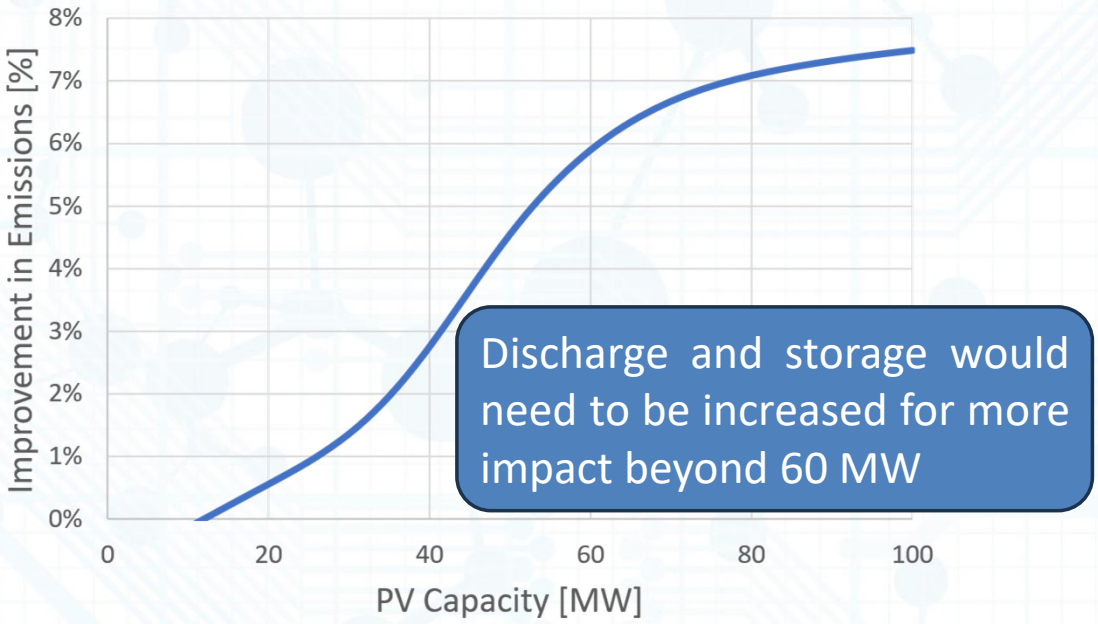
STEP system was modeled using actual test data

- Efficiency for the STEP facility was varied based on data from the Simple Cycle Configuration Test Campaign
  - 3.7 MW_{el}
  - 10 MW_{heat}



The energy storage system would reduce savings significantly but would improve emissions starting with at least 15 MW PV





Discharge and storage would need to be increased for more impact beyond 60 MW

Conclusions

- SwRI needs energy storage to produce more than 46% of its electricity
- Converting STEP to an energy Storage system would cost atleast $34MM

- SwRI could reduce carbon intensity to 0.234 kg/kWh using the STEP facility and a 40 MW PV field
- The facility would take around 14 years to payback

Questions