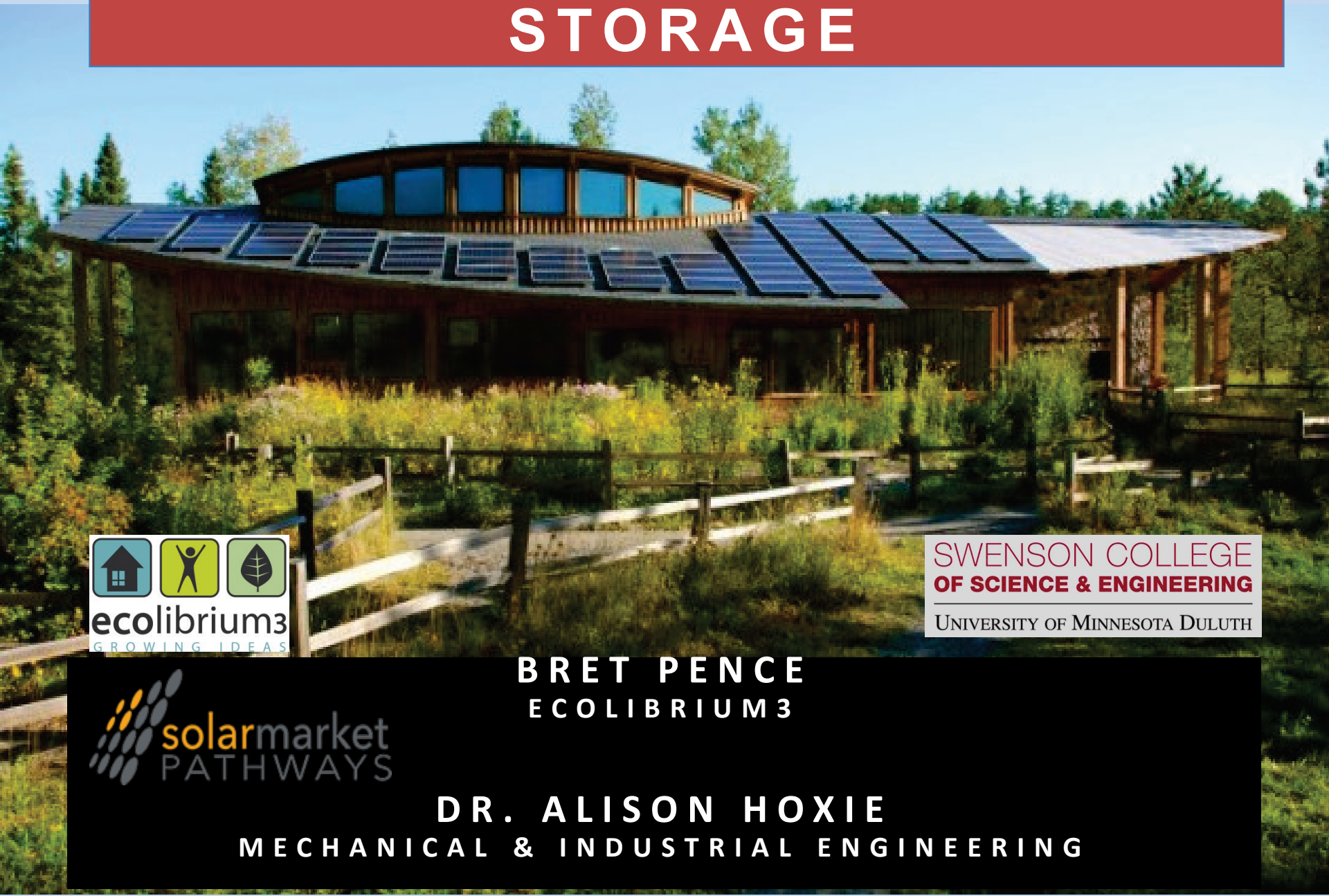
# HARTLEY SOLAR PLUS STORAGE



ecolibrium3
GROWING IDEAS

SWENSON COLLEGE
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UNIVERSITY OF MINNESOTA DULUTH


**BRET PENCE**
ECOLIBRIUM3

solarmarket PATHWAYS

**DR. ALISON HOXIE**
MECHANICAL & INDUSTRIAL ENGINEERING


- 11,000 students
- Over 500 full-time faculty
- Land-grant university

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# ECOLIBRIUM3

**Mission:** Our mission is to inspire and lead change in our community toward an equitable and sustainable future.

**Solar Market Pathways:**

1) Define barriers to solar adaptation

2) Develop pathways to reduce costs and increase adaptation of this technology in our community

3) End goal of 1MW of solar on the ground in Duluth

# PROJECT OVERVIEW

- Hartley Nature Center is a City-owned, nonprofit operated green building.
- The Center serves as a park, environmental center and outdoor-based preschool with annual visitors ~ 30,000

# PROJECT OVERVIEW

- HNC had one of the first PV systems in northern MN, installed in 2002–2003. There is 11 kW on the roof and 2 kW on a ground-mounted dual-axis tracker, with 6 inverters.

- By 2016, 4 out of 5 roof inverters were no longer operable, and replacing them all with 2 inverters and rewiring would cost ~$10,000.

- The installation is part of a larger energy retrofit of Hartley Nature center, which includes replacement of the HVAC controls and GSHP, separation of hot water from the GSHP, and lighting upgrades.

# PROJECT TEAM

- Bret Pence, Ecolibrium3
- Alison Hoxie, UMD
- Alex Jackson, City of Duluth
- Tom O’Rourke, Director Hartley Nature Center
- Brett Amundson, Operations Hartley Nature Center
- Chris LaForge, Great Northern Solar
- Paul Helstrom, Minnesota Power

# FUNDING


Minnesota Power
FOUNDATION


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LOCAL ENERGY MATTERS


CleanEnergyGroup
Innovation in Finance, Technology & Policy


UMD
UNIVERSITY OF MINNESOTA DULUTH
Driven to Discover


THE CITY OF
DULUTH
MINNESOTA


Regional Sustainable
Development Partnerships
UNIVERSITY OF MINNESOTA
Driven to Discover

# PROJECT GOALS

- Replace Inverters
- Create a public emergency shelter
- Move building to net-zero
- Explore added values with storage:
  - critical load backup and
  - behind the meter savings, including peak demand shaving
- Create an education platform for energy storage

# BATTERY SELECTION

- Sunverge, only company to meet project needs
- Small Commercial Unit (<15 kWh) & DC coupled (high voltage)
- Software ~ Energy Arbitrage, coming soon more sophisticated Peak Demand Shaving
- Other resiliency option – SPS outlet SunnyBoy grid-tied inverter connected to 5 kW of roof array

# CRITICAL LOADS


| Critical Load Backup | Description | Surge Load | Operating Load |
|---|---|---|---|
| Server, Wi-Fi, Phones | Plug load: mech. Room | 135 W | 15 W |
| Refrigerator | 115 Volts, 7.7 Amps | 250 W | 250 W |
| Lighting | Bathroom | 610 W | 232 W |
| | Mechanical Room | 128 W | 128 W |
| | Classroom 1 | 46 W | 46 W |
| | Classroom 2 | 46 W | 46 W |
| Plug Loads | **Exhibit Hall:** | 8 W/phone | 8 W/phone |
| | **Hartley:** (1: 4 plug outlet) | 32 W | 32 W |
| | **Civil:** (3: 4 plug outlet) | 96 W | 96 W |
| | **Office:** 2 desktops | 1200 W | 10 W standby |
| | **Office Library:** 2 Laptops & 6 phones | 248 W | 248 W |
| | **Classroom 2:** | | |
| | **Hartley:**(1: 2 plug outlet)- 100 W laptop | 200 W | 200 W |
| | **Civil**:(5: 2 plug outlet)- (2) 100 W laptops, (8) 8 W/ phones | 248 W | 248 W |
| **Maximum Total Loads** | | **H:2895 W / C:3007 W** | **H:1208 W / C:1319** |

# OPEN INSTALLATION PROCESS



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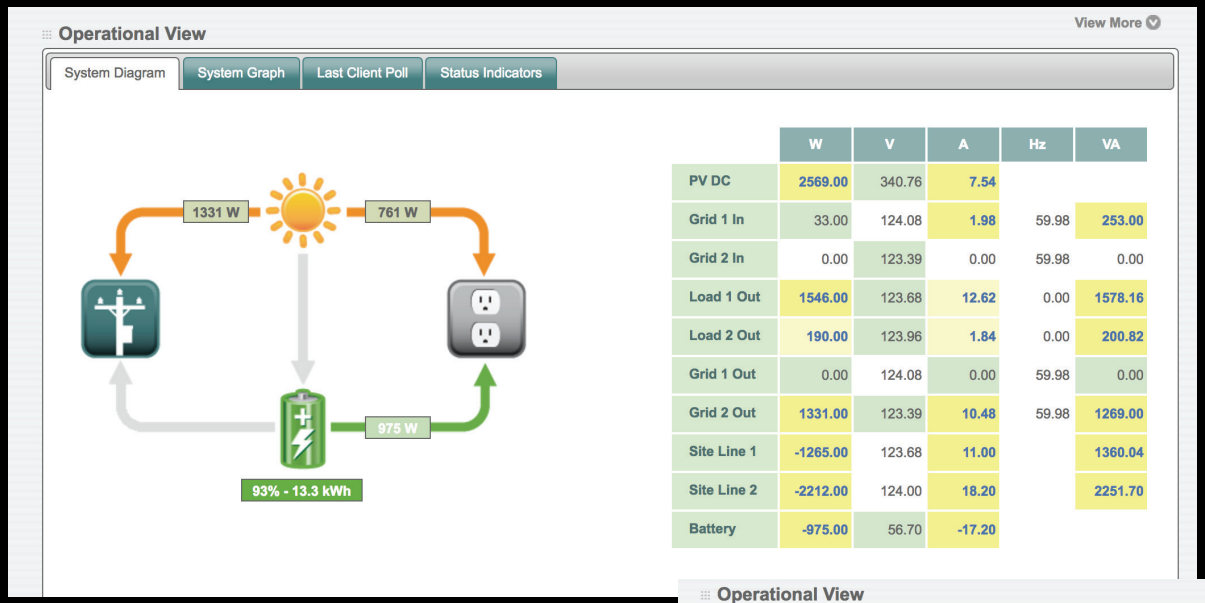
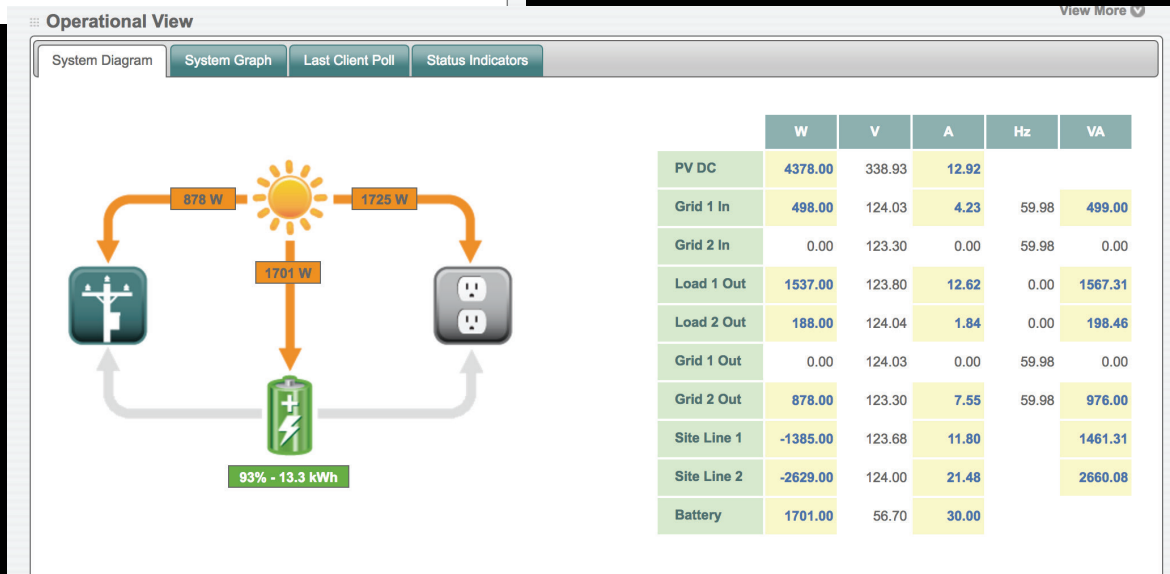
# SOLAR PLUS STORAGE AWARENESS DAY

# DATA COLLECTION AND ANALYSIS – SPRING 2016

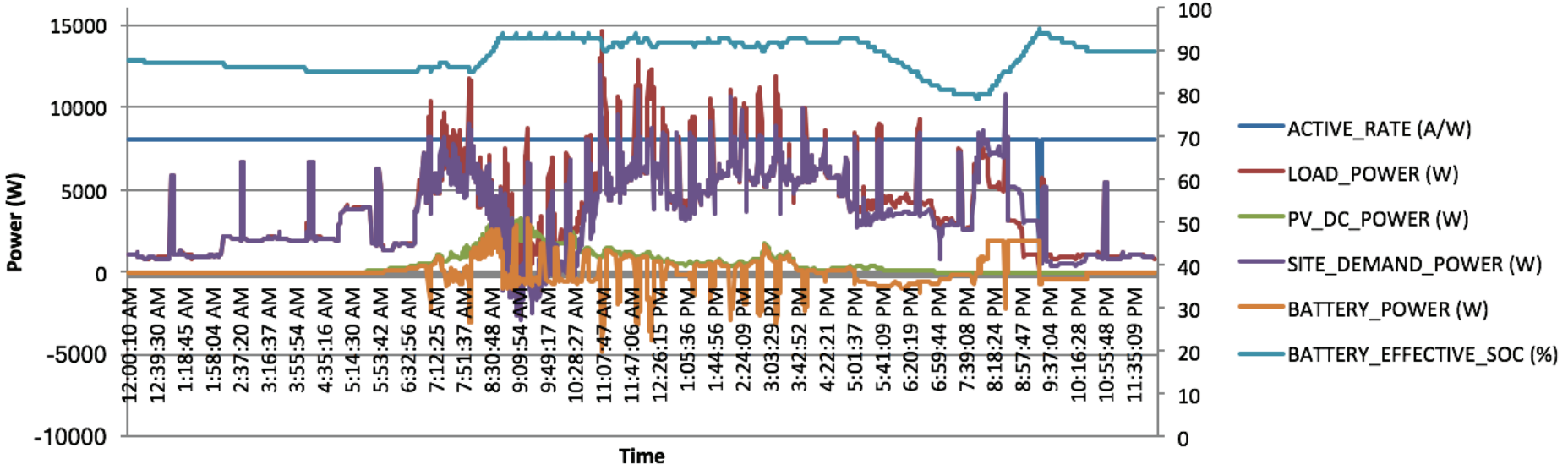



| | W | V | A | Hz | VA |
|---|---|---|---|---|---|
| PV DC | 2569.00 | 340.76 | 7.54 | | |
| Grid 1 In | 33.00 | 124.08 | 1.98 | 59.98 | 253.00 |
| Grid 2 In | 0.00 | 123.39 | 0.00 | 59.98 | 0.00 |
| Load 1 Out | 1546.00 | 123.68 | 12.62 | 0.00 | 1578.16 |
| Load 2 Out | 190.00 | 123.96 | 1.84 | 0.00 | 200.82 |
| Grid 1 Out | 0.00 | 124.08 | 0.00 | 59.98 | 0.00 |
| Grid 2 Out | 1331.00 | 123.39 | 10.48 | 59.98 | 1269.00 |
| Site Line 1 | -1265.00 | 123.68 | 11.00 | | 1360.04 |
| Site Line 2 | -2212.00 | 124.00 | 18.20 | | 2251.70 |
| Battery | -975.00 | 56.70 | -17.20 | | |

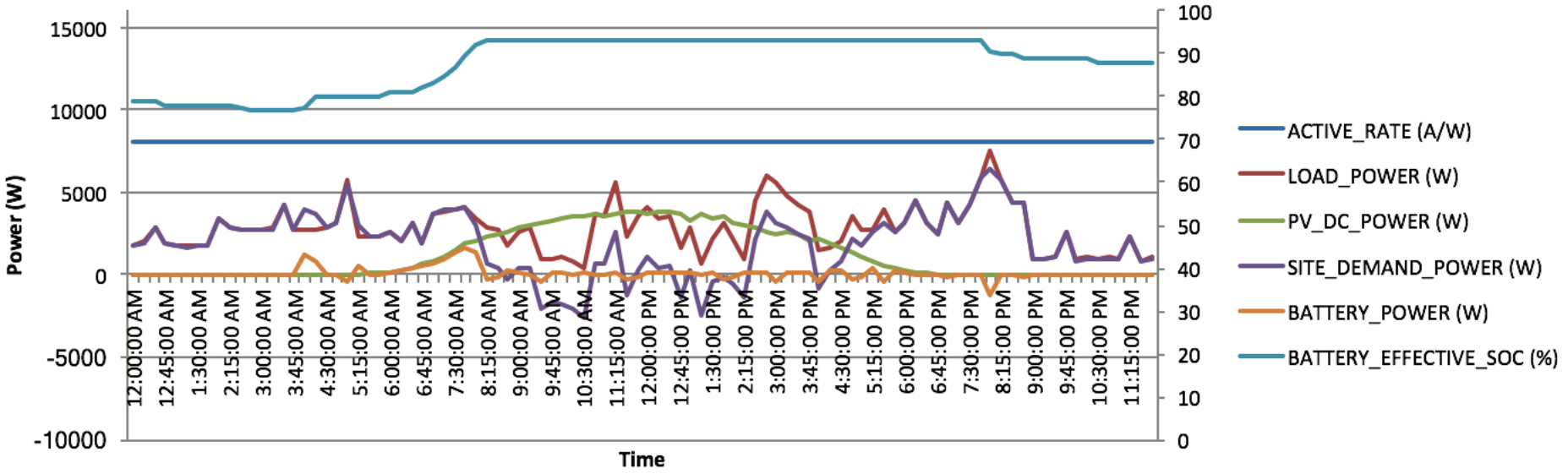



| | W | V | A | Hz | VA |
|---|---|---|---|---|---|
| PV DC | 4378.00 | 338.93 | 12.92 | | |
| Grid 1 In | 498.00 | 124.03 | 4.23 | 59.98 | 499.00 |
| Grid 2 In | 0.00 | 123.30 | 0.00 | 59.98 | 0.00 |
| Load 1 Out | 1537.00 | 123.80 | 12.62 | 0.00 | 1567.31 |
| Load 2 Out | 188.00 | 124.04 | 1.84 | 0.00 | 198.46 |
| Grid 1 Out | 0.00 | 124.03 | 0.00 | 59.98 | 0.00 |
| Grid 2 Out | 878.00 | 123.30 | 7.55 | 59.98 | 976.00 |
| Site Line 1 | -1385.00 | 123.68 | 11.80 | | 1461.31 |
| Site Line 2 | -2629.00 | 124.00 | 21.48 | | 2660.08 |
| Battery | 1701.00 | 56.70 | 30.00 | | |

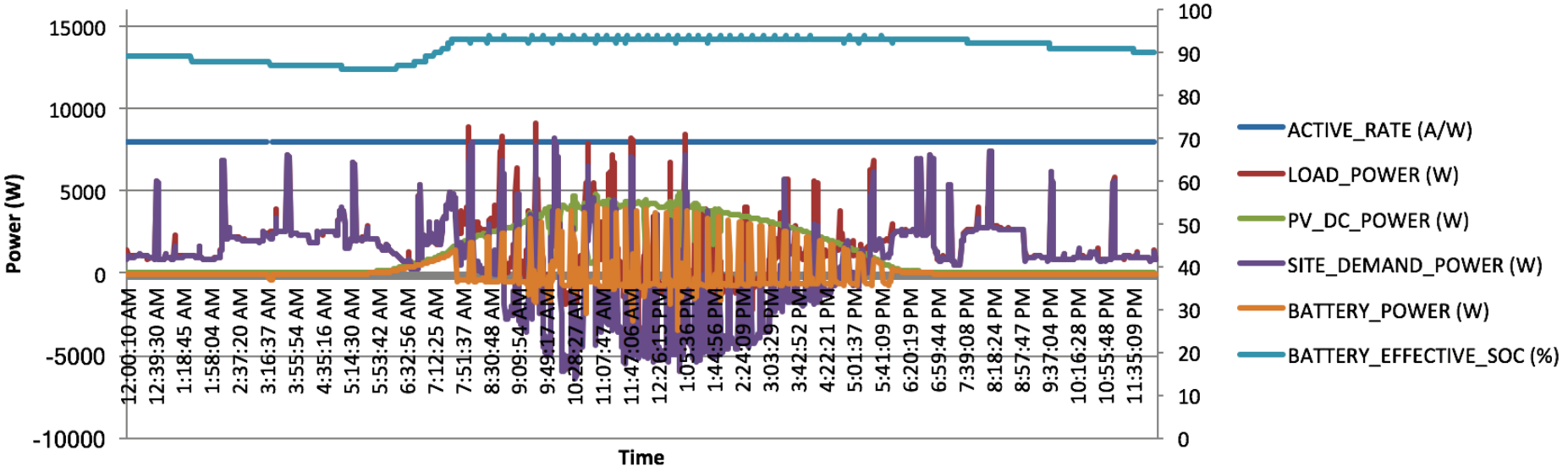
## Wednesday 8/16/2017 - Detailed Sunverge




## Wednesday 8/16/2017 - 15 Min Avg. Sunverge



## Friday 8/11/2017 - Detailed Sunverge

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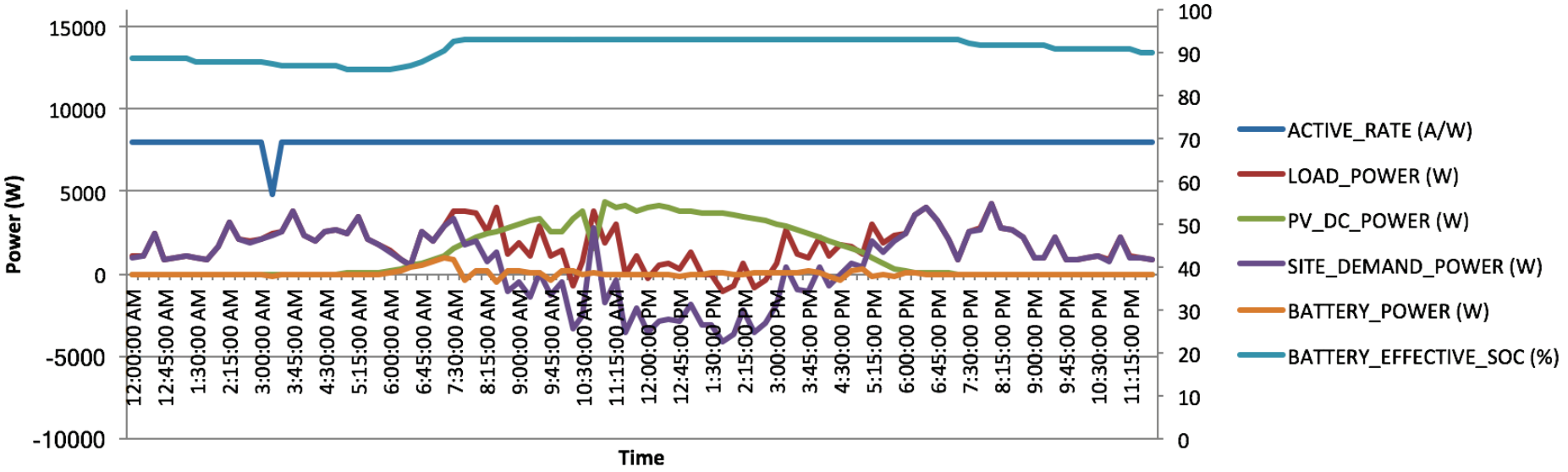

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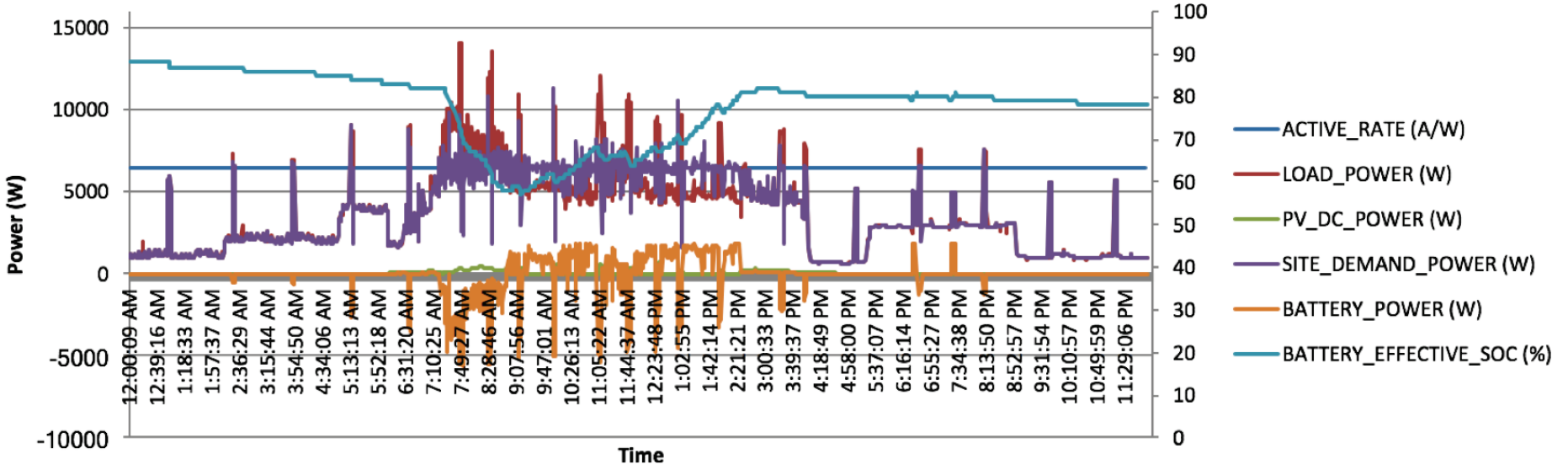


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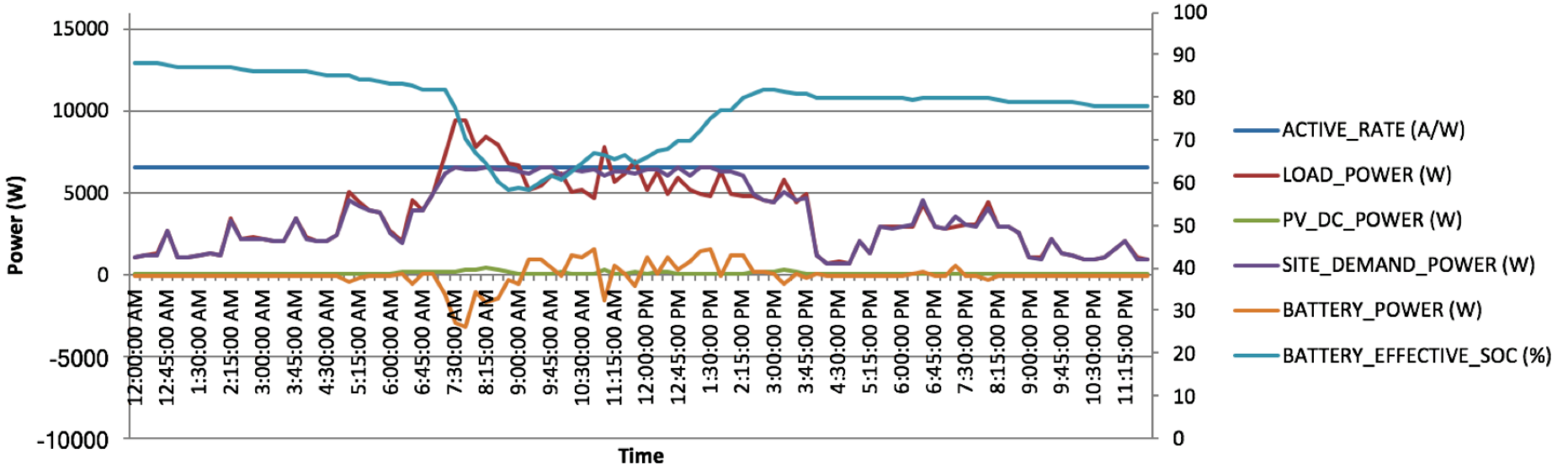
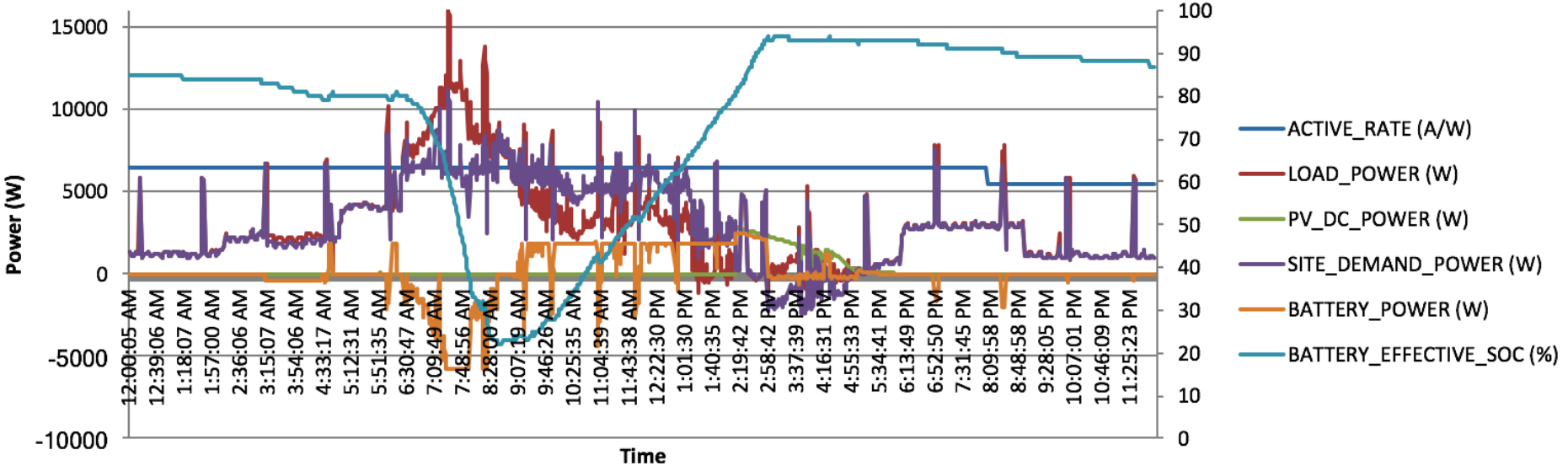
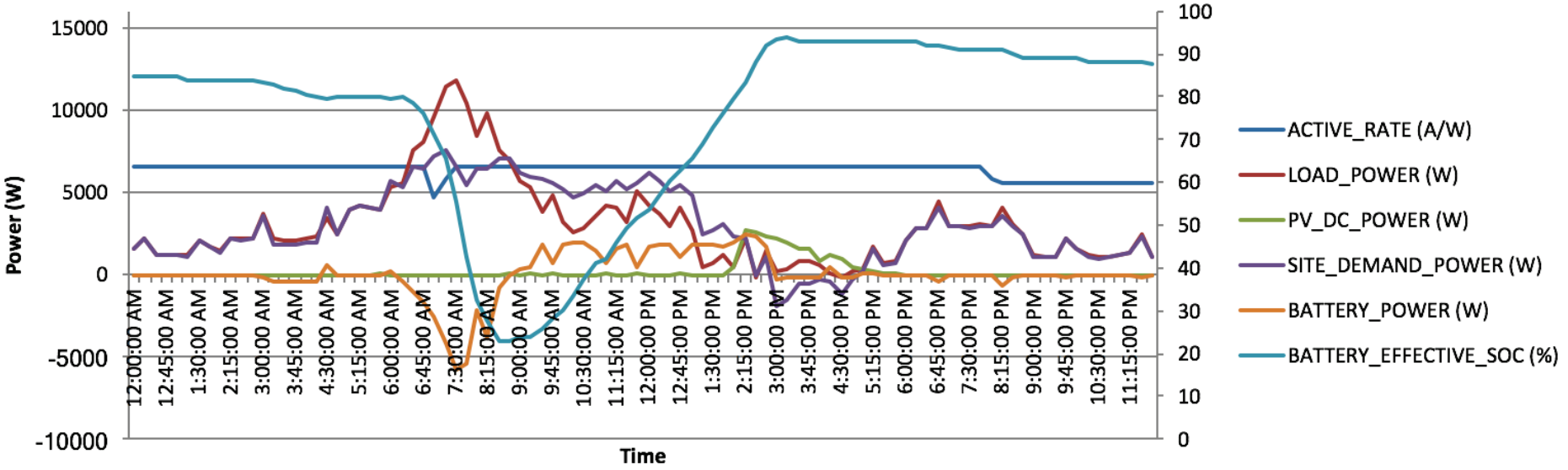


## Friday 09/22/2017 - Detailed Sunverge




## Friday 09/22/2017 - 15 Min Avg. Sunverge



# LESSONS – RETROFITS ARE HARD

- Code updates can upset the apple cart (increase cost)
  - Rapid shutdown and arc-fault protection
- Flex plans to accommodate the reality of the built environment – wiring, loads, etc.
- Initial project estimated cost ~20,000, actual ~45,000

# RETROFITS HAVE VALUE

- Project Costs – $45,000, cost to Hartley?
  - $5000
- Financial benefit- $1500/year, 30 year payback
- Value of backup – Wind storm and the value of storage
- Change to a non-demand tariff – $5000/year
  - Below 10kW peak demand, not over 2500kWh/month energy limit for 3 months in a row
  - Believe this is possible with energy efficiency upgrades, increased solar production, and strategic use of energy storage – Ask us in 3 months!

# THANK YOU.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