Northeastern University Solar Project

ENSY 5700- Renewable Energy Development

Team 4

Ajindeep Pradeep

Daniel Lawson

Ninad Phaltankar

Sophia Wells

Sri Tejas Sinthalapad Jayakumar

Introduction

- Our team from ‘Renewable Developers’ have undergone extensive study in developing rooftop Solar and Storage systems for Northeastern University, particularly for Snell Library, Marino Centre, Shillman Hall, Snell Engineering Center, Columbus Parking and Renaissance Parking.

- Through our unique PPA proposals,we have developed intricate financial models for both Solar and Storage Solutions and have designed to create a win-win situation for all parties involved.

- By utilizing Massachusetts' various Solar and Storage incentives in our project, we not only reduce the Universities’ electricity demand, but also strive to push toward achieving the net zero emissions and combating climate change.

Project Salient features

- Project Owned and maintained by ‘Renewable Developers’
- Buyer will not have any rights to all State and Federal Incentives.
- Solar Arrays will be installed at Shillman Hall, Snell Engineering Centre, Renaissance Park and Columbus Park and the energy will be sold to the GRID to take advantage of SMART and federal incentives
- Seller use PV arrays and BESS to reduce demand charges at Marino Recreation Centre and Snell library and sell power to Northeastern University at a competitive price below market after five years.
- BESS will be integrated with Connected Solutions for a period of five years.
- After five years of operation - discounted behind the meter energy usage will function as a lease agreement.

PV Design

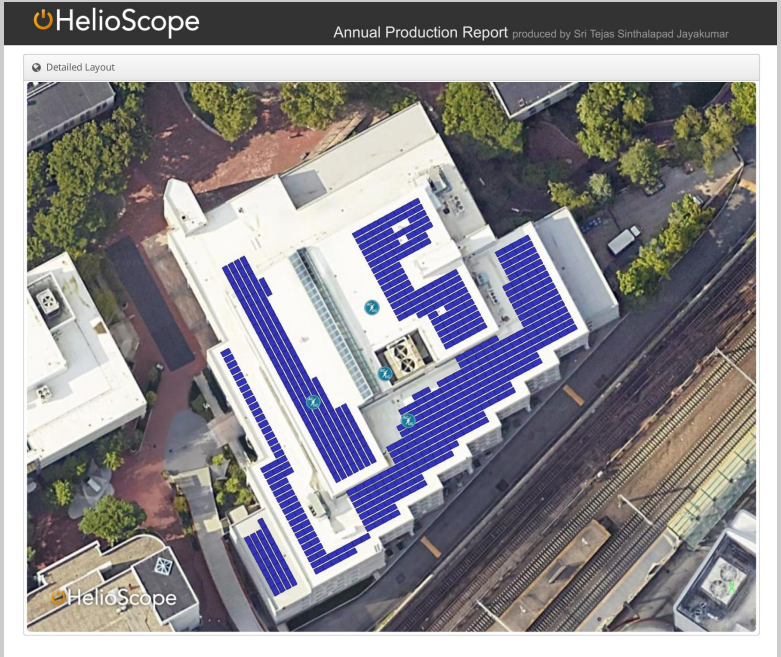
Marino Recreation Center

Key Design Specs:

- Modules: REC400AA Pure (400W)
- Inverter: Sunny Tripower Core1/US(SMA) 50W
- Number of panels: 769
- Module DC nameplate: 307.6kW
- Inverter AC nameplate: 250kW, DC/AC ratio: 1.23
- Annual Production: 385.3MWh
- Performance Ratio: 86.2%
- kWh/kWp: 1,252.6

PV Design

Snell Library

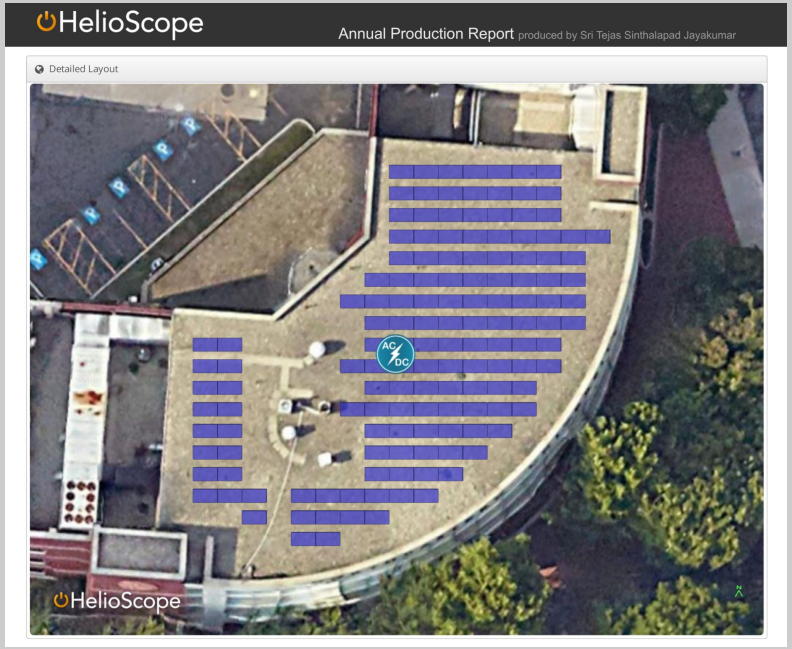


Key Design Specs:

- Modules: REC400AA Pure (400W)
- Inverter: Sunny Tripower Core1/US(SMA) 50W
- Number of panels: 624
- Module DC nameplate: 249.6kW
- Inverter AC nameplate: 200kW, DC/AC ratio: 1.25
- Annual Production: 295.1MWh
- Performance Ratio: 80.2%
- kWh/kWp: 1,182.5

PV Design

Shillman Hall

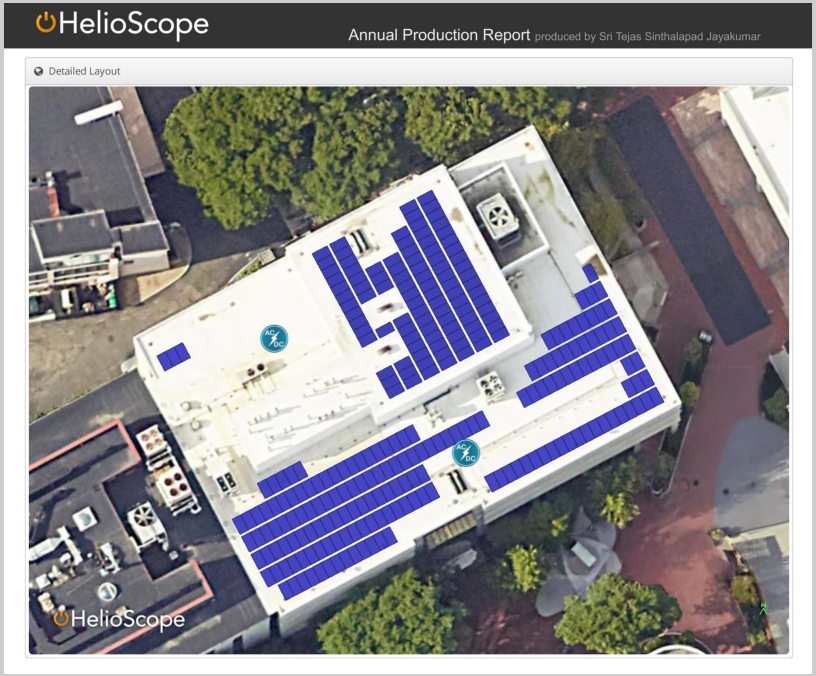


Key Design Specs:

- Modules: REC400AA Pure (400W)
- Inverter: Sunny Tripower Core1/US(SMA) 50W
- Number of panels: 143
- Module DC nameplate: 57.2kW
- Inverter AC nameplate: 50kW, DC/AC ratio: 1.14
- Annual Production: 76.50MWh
- Performance Ratio: 86.4%
- kWh/kWp: 1,337.4

PV Design

Snell Engineering Centre

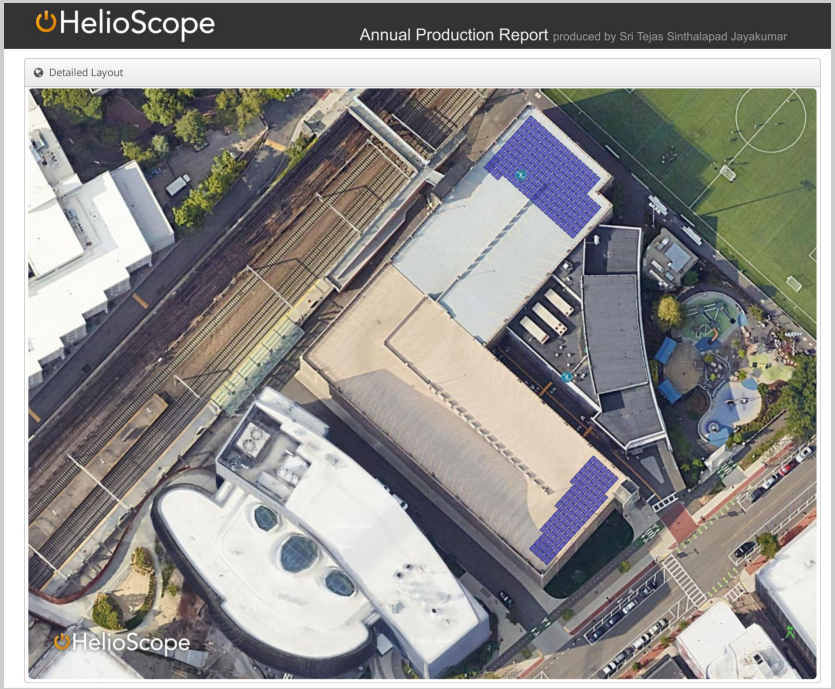


Key Design Specs:

- Modules: REC400AA Pure (400W)
- Inverter: Sunny Tripower Core1/US(SMA) 50W
- Number of panels: 268
- Module DC nameplate: 107.2.kW
- Inverter AC nameplate: 100kW, DC/AC ratio: 1.07
- Annual Production: 125.6MWh
- Performance Ratio: 81.5%
- kWh/kWp: 1,171.2

PV Design

Columbus Park

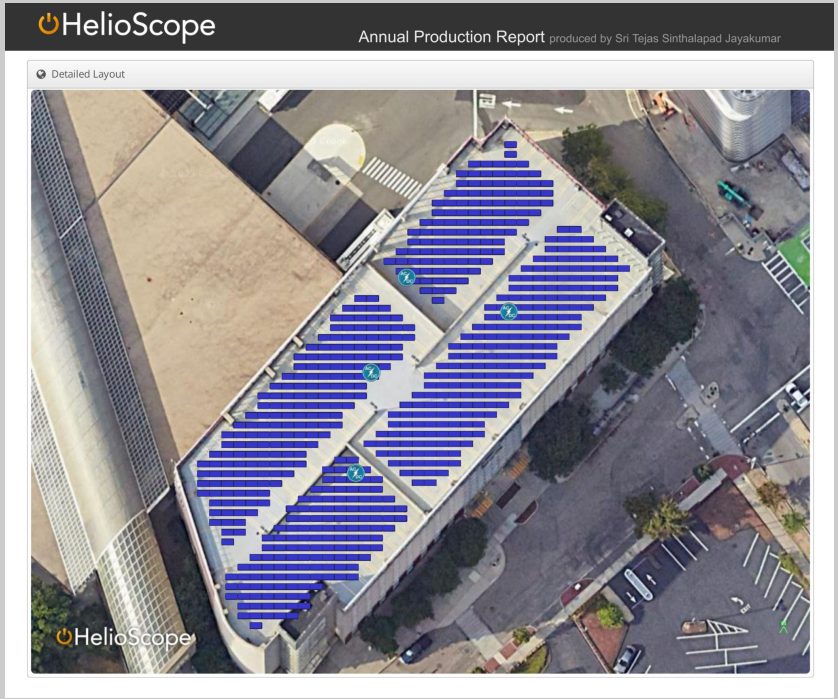


Key Design Specs:

- Modules: REC400AA Pure (400W)
- Inverter: Sunny Tripower Core1/US(SMA) 50W
- Number of panels: 303
- Module DC nameplate: 121.2kW
- Inverter AC nameplate: 100kW, DC/AC ratio: 1.21
- Annual Production: 150.4MWh
- Performance Ratio: 82.4%
- kWh/kWp: 1,241.3

PV Design

Renaissance Park



Key Design Specs:

- Modules: REC400AA Pure (400W)
- Inverter: Sunny Tripower Core1/US(SMA) 50W
- Number of panels: 665
- Module DC nameplate: 250kW
- Inverter AC nameplate: 250kW, DC/AC ratio: 1.06
- Annual Production: 263.MWh
- Performance Ratio: 84.4%
- kWh/kWp: 1,306.8

Project Structure (PPAs, Incentives)

Program Participation and Behind the Meter Applications

First five years of Commercial Operation:

From the months of October – May, Seller will utilize two Battery Energy Storage Systems, a 120 kW (4 hr) and an 80 kW (4 hr), for behind the meter applications of their host buildings (Snell Library and Marino Center, respectively). The buildings are owned and operated by Northeastern University.

A daily discharge schedule will act as a Defacto lease agreement between Buyer and Seller.

From the months of June – September, Seller will utilize both BESS to participate in ConnectedSolutions program, earning $225 per average kW output across 30-60 discharge events.

All other PV production will be utilized to participate in the SMART Program, earning $254.4 / MWh (Snell Library), $207.34 / MWh (Marino Center), $218.8 / MWh (Snell Engineering and Shillman) , and $224.8 / MWh (Renaissance Park).

Project Structure (PPAs, Incentives)

After the first five years of Commercial Operation:

Seller will utilize the two BESS for peak shaving as well as SMART participation. A daily discharge schedule will allot 2 hours of the battery towards behind the meter applications of their host buildings (Snell Library and Marino Center), which are owned and operated by Northeastern University.

Buyer will pay for this energy at an extreme discount. Starting at $50 / MWh in year 6, and increasing with 2% inflation per year.

The other two hours of battery power will go towards SMART participation. This will allow Seller to capture power that is above the inverter rating, and would otherwise be lost without a BESS.

All other PV production will be utilized to participate in the SMART Program.

Project Structure Terms

Operations and Maintenance
Seller is responsible for all operations and maintenance over the course of the contract term.

Tax Incentives
As the asset owner, Seller will be the sole beneficiary of solar tax credits.

Price/Revenue

- First five years of operation - In exchange for behind the meter applications at the two solar + storage sites, Snell Library and Marino Center, Northeastern University agrees to lease the rooftop space as well as existing interconnection hardware for all six Facilities.
- After five years of operation - discounted behind the meter energy usage will function as a lease agreement.
- Buyer retains no rights to any SMART or ConnectedSolutions revenue for this contract term.

Year	$ / MWh
6	50
7	51
8	52.02
9	53
10	54.12

…Continued through remainder of Contract Term

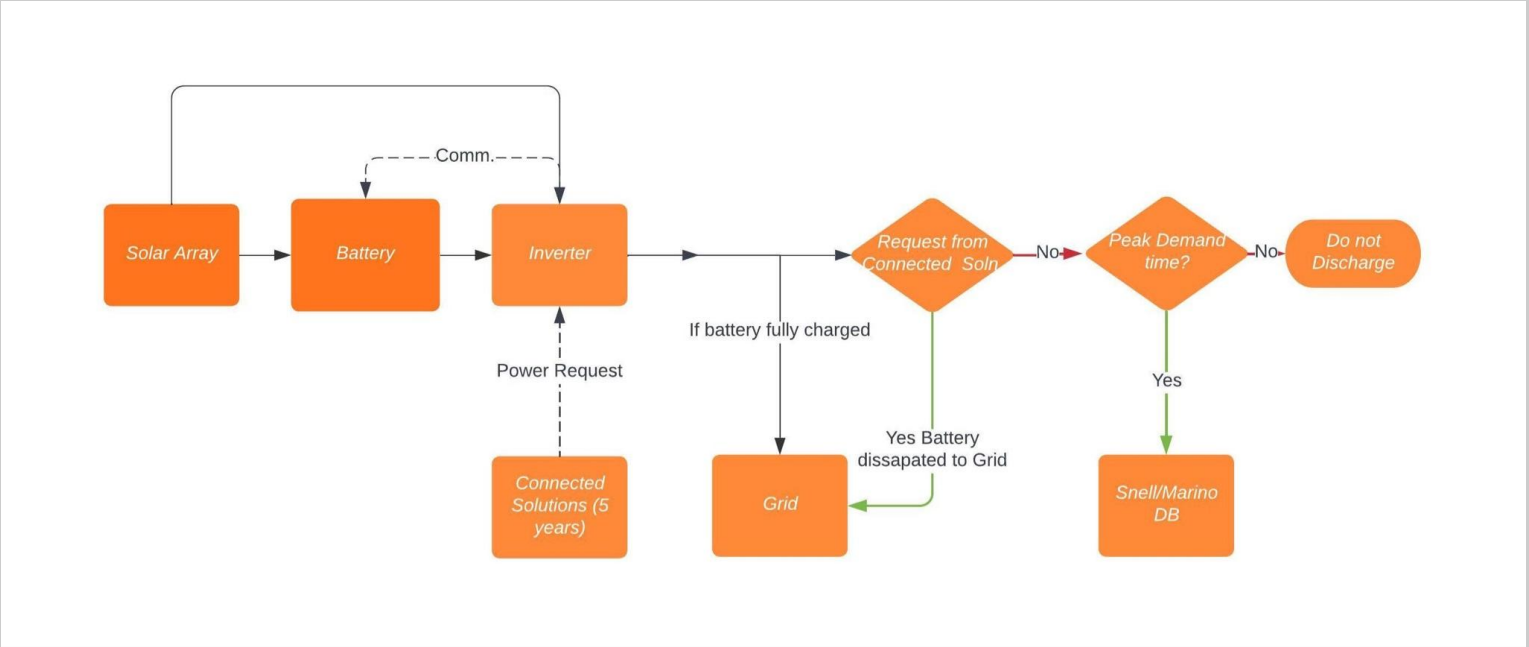
Project Structure Terms Cont.

Contracted Capacity/Output
Seller will be bound to a minimum of 90 MWh per year towards Buyer's behind the meter applications for the extent of this contract term.

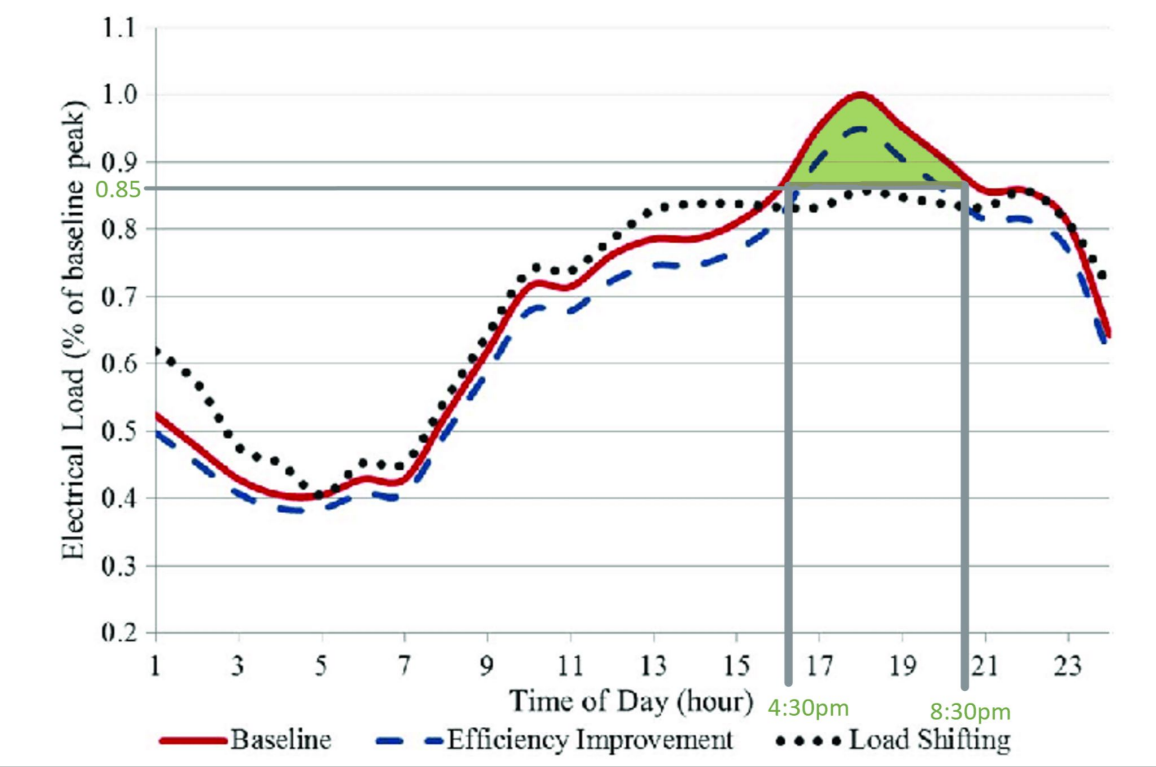
Duration
This is a 25 year contract term.

Termination
Hair trigger termination will not be permitted.

BESS Flow Chart



Storage Design

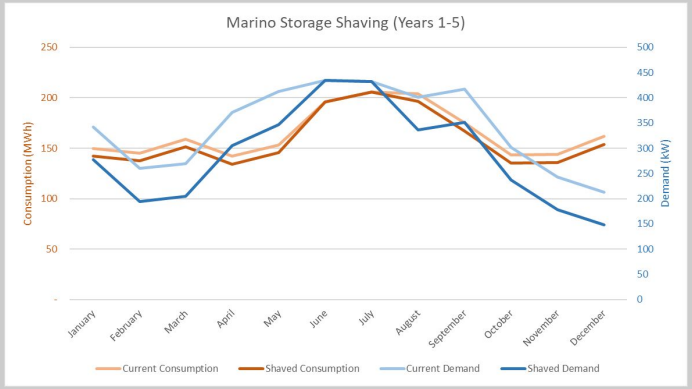


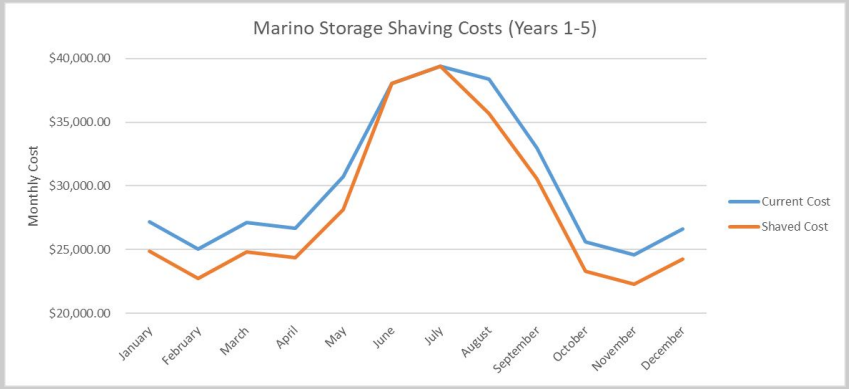
15% of max demand * 4 hours

Marino: 320kWh

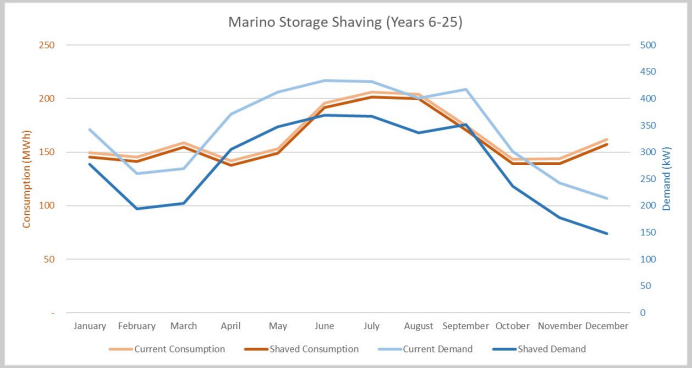
Snell: 480 kWh

Project Structure (PPAs, Incentives)



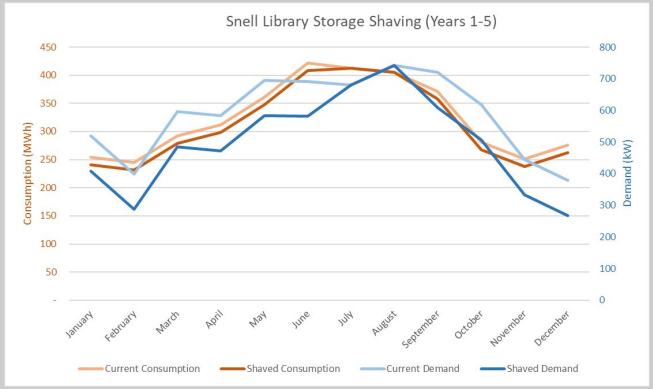


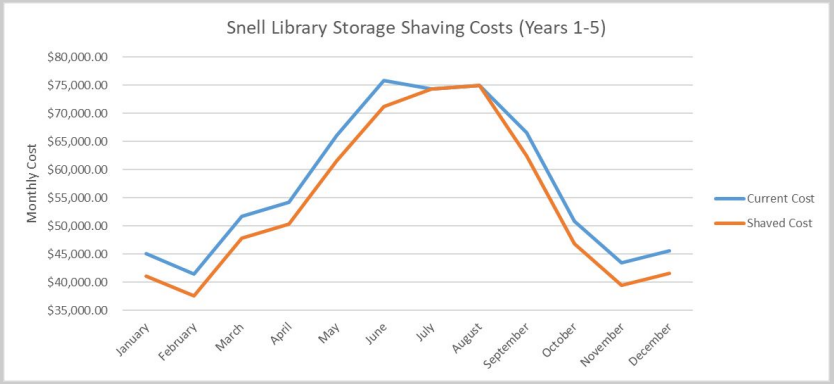
Years 1-5
Annual: $24,000
5 year: $122,120

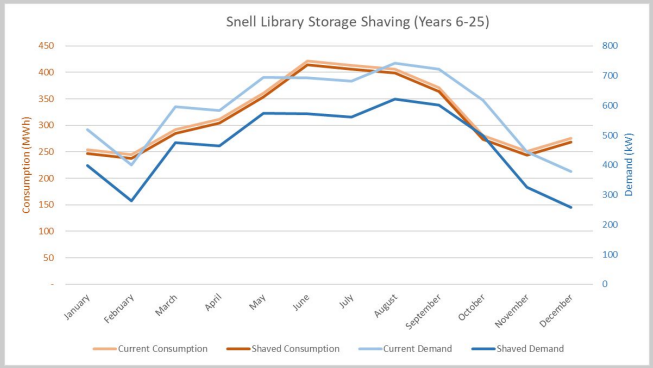


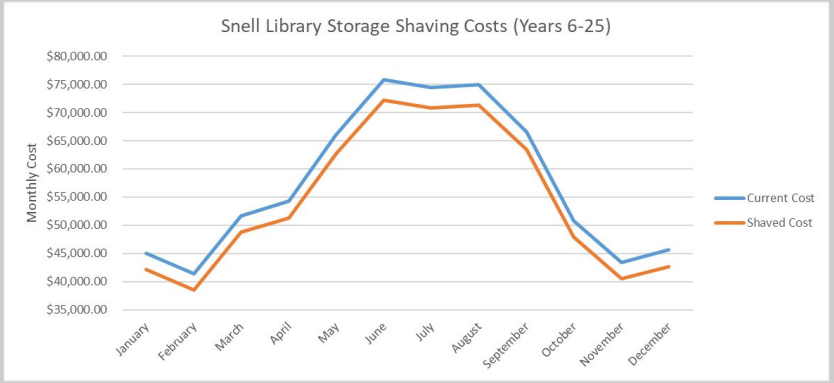
Years 6-25
Annual: $20,800
20 year: $424,400

Project Structure (PPAs, Incentives)









Years 1-5
Annual: $41,000
5 year: $209,000

Years 6-25
Annual: $37,800
20 year: $770,000

Benefits to Northeastern University

- No upfront costs
- Free peak shaving for the first five years of commercial operation - large savings upfront
- Discounted peak shaving for the remainder of contract term - not only inexpensive energy, but will also reduce peak demand charges
- Less dependent on the Grid due to BESS
- Seller is responsible for all O&M
- Reducing NEU's carbon footprint
- Partaking in the frontlines of Solar Incentive programs, will be the first of many Universities to do so
- Will solidify Northeastern's rank as a top tier University

Financial model for the Solar Systems

Building	AC Size	SMART	Storage Capacity	Loan (6% rate for 25 years)	Levered IRR
Snell Library	250kW	Base + storage + roof = $254.40	120kW	53%	17%
Marino	308kW	Base + storage + roof = $207.34	80kW	60%	29%
Shillman	57kW	Base + roof = $218.80	-	70%	68%
Snell Eng.	107kW	Base + roof = $218.80	-	75%	85%
Renaissance	250kW	Base + roof + canopy = $224.80	-	75%	80%
Columbus	120kW	Base + roof + canopy = $224.80	-	70%	57%

Room to play

Conclusion

- Project is mutually beneficial for Northeastern University and Renewable Developers
- Solar (PPA) can reduce energy costs at Marino Recreation Centre and Snell Library
- Northeastern University can purchase power at a lower rate of $50Mwh compared to local utility's retail rate
- Northeastern University can save $1,525,520 during the PPA contract lifecycle with no upfront capital or maintenance costs
- Project is mutually beneficial for Northeastern University and Renewable Developers
- Renewable Developers over 25-year contract will have an internal rate of return (IRR) starting at 17%.
- Northeastern University can reduce its carbon footprint and increase energy security during outages solidifying its ranking as a top-tier university

Thank You!

References

1. A. Beale, “Peak Sun Hours calculator (with map),” *Footprint Hero*, 06-Oct-2022. [Online]. Available: https://footprinthero.com/peak-sun-hours-calculator. [Accessed: 24-Apr-2023].
2. S. M. Derek Mitchell, *Canadian solar CS3W-440MS (440W) solar panel*. [Online]. Available: http://www.solardesigntool.com/components/module-panel-solar/Canadian-Solar/6274/CS3W-440MS/specification-data-sheet.html. [Accessed: 24-Apr-2023].
3. “Massachusetts.” [Online]. Available: https://www.mass.gov/doc/2021-smart-btm-value-of-energy-workbook-011321/download. [Accessed: 24-Apr-2023].
4. “Connectedsolutions Battery Program,” *Mass Save*. [Online]. Available: https://www.masssave.com/residential/rebates-and-incentives/connectedsolutions-batteries. [Accessed: 24-Apr-2023].
5. “National Renewable Energy Laboratory (NREL).” [Online]. Available: https://www.nrel.gov/docs/fy21osti/77324.pdf. [Accessed: 24-Apr-2023].
6. “Commercial PV,” *ATB*. [Online]. Available: https://atb.nrel.gov/electricity/2022/commercial_pv. [Accessed: 24-Apr-2023].
7. “National Renewable Energy Laboratory (NREL) home page | NREL.” [Online]. Available: https://www.nrel.gov/docs/fy22osti/80694.pdf. [Accessed: 24-Apr-2023].
8. “National Renewable Energy Laboratory (NREL) home page | NREL.” [Online]. Available: https://www.nrel.gov/docs/fy21osti/79236.pdf. [Accessed: 24-Apr-2023].
9. *Google*. [Online]. Available: https://www.google.co.in/webhp?ion=1&rct=j. [Accessed: 24-Apr-2023].
10. “Typical residential electrical load profile with base case ...” [Online]. Available: https://www.researchgate.net/figure/Typical-residential-electrical-load-profile-with-base-case-energy-efficient-case-with_fig4_260685983.