Northeastern University

ENSY 5700- Renewable Energy Development

PROJECT REPORT

Rooftop Solar PV and Battery Storage Systems

Marino Center – Snell Library – Snell Engineering Center – Shillman Hall Columbus Parking – Renaissance Parking

Professor: Sachin Patel

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 buying, installing, and maintaining the solar PV system on the Northeastern University (NEU) buildings. Solar PVs will be installed in Shillman Hall, Snell Engineering Center, Columbus Parking and Renaissance Parking. Marino Center and Snell Library will be designed with Battery Storage along with Solar PVs mainly to reduce demand charges.

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 net zero emissions and combating climate change. Additionally all applicable state and federal tax credits will go to the Seller and as Northeastern University would not own the system.

Project Structure (PPA and Incentives)

THIS POWER PURCHASE AGREEMENT (as amended from time to time in accordance with the terms hereof) is entered into as of April 24, 2023 (the “Effective Date”), by and between Northeastern University (“Buyer”) and Renewable Developers (“Seller”).

Terms

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).

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.

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.

Table 1: BTM Lease

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

…Continued through remainder of contract term

Buyer retains no rights to any SMART or ConnectedSolutions revenue for this contract term.

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.

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

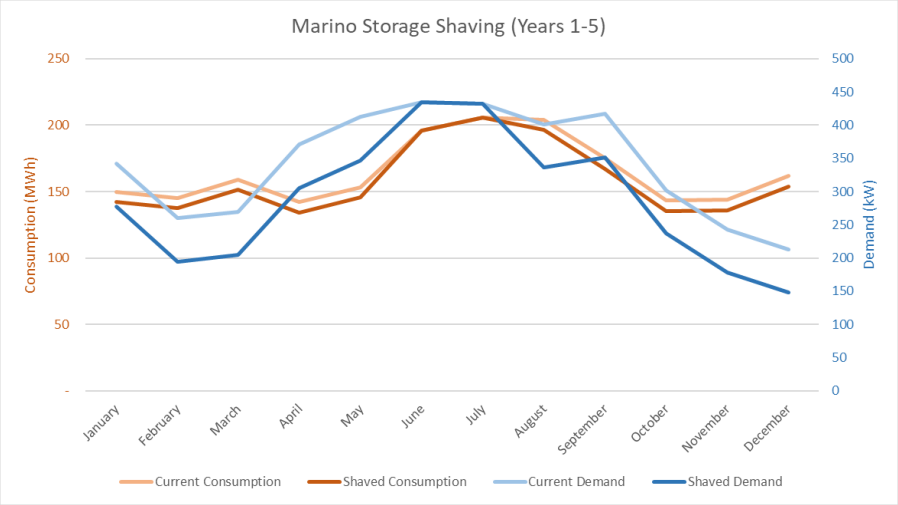


Figure 1: Marino Storage Shaving (Years 1-5)

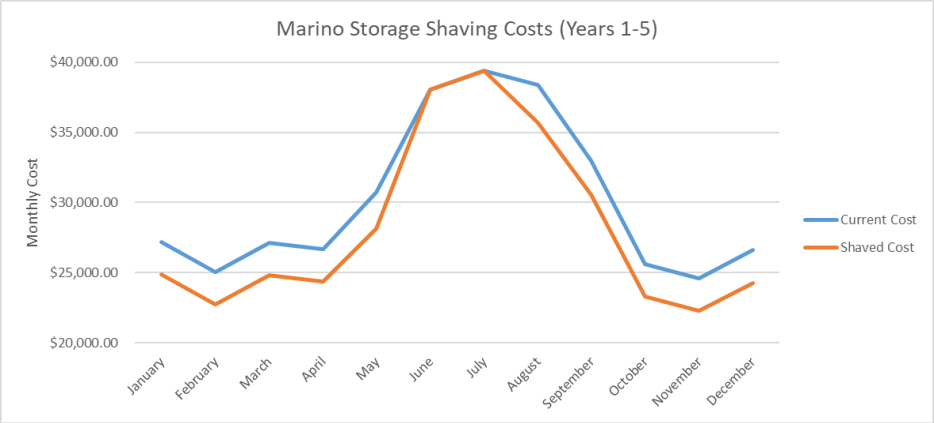


Figure 2: Marino Storage Shaving Costs (Years 1-5)

During the first five years, NEU has annual savings at Marino of $24,000 and a five year total with inflation of $122,000.

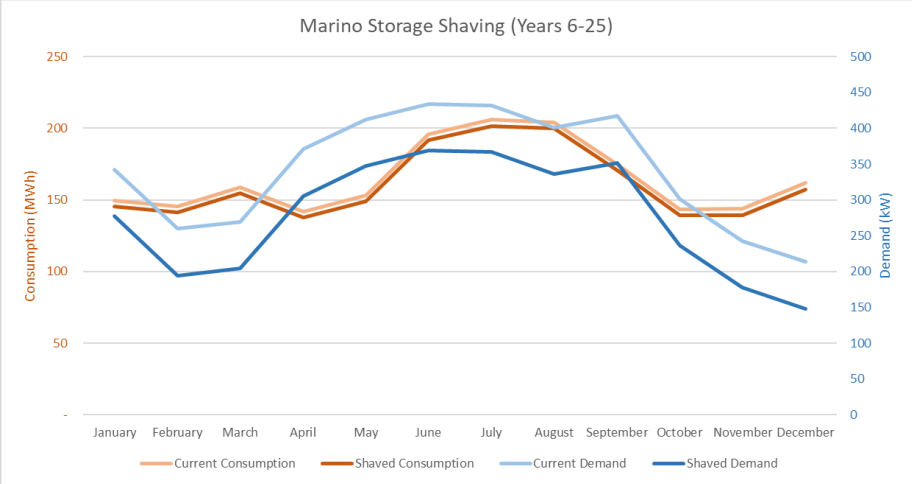


Figure 3: Marino Storage Shaving (Years 6-25)

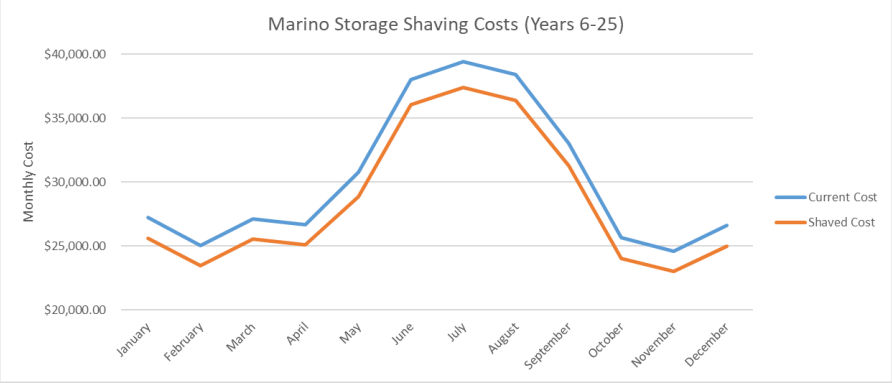


Figure 4: Marino Storage Shaving Costs (Years 6-25)

During years 6-25, NEU has annual savings at Marino of $21,000 and a 20 year total with inflation of $424,000.

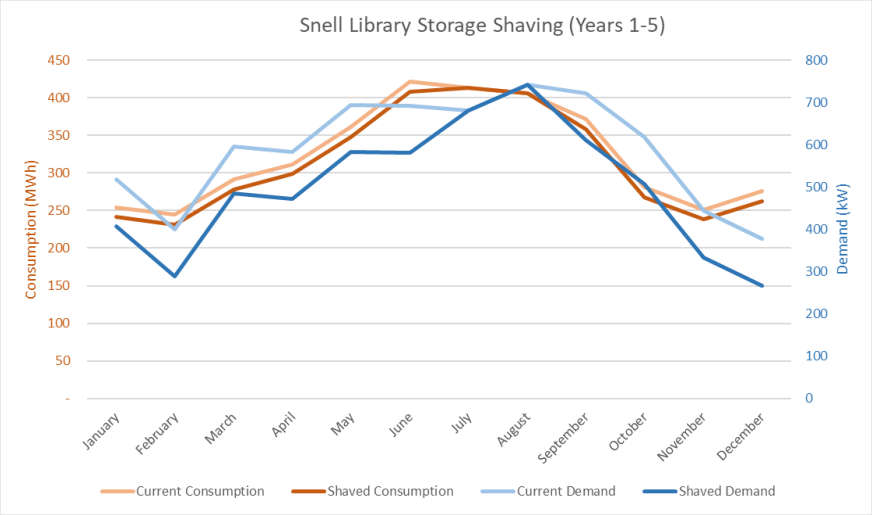


Figure 5: Snell Library Storage Shaving (Years 1-5)

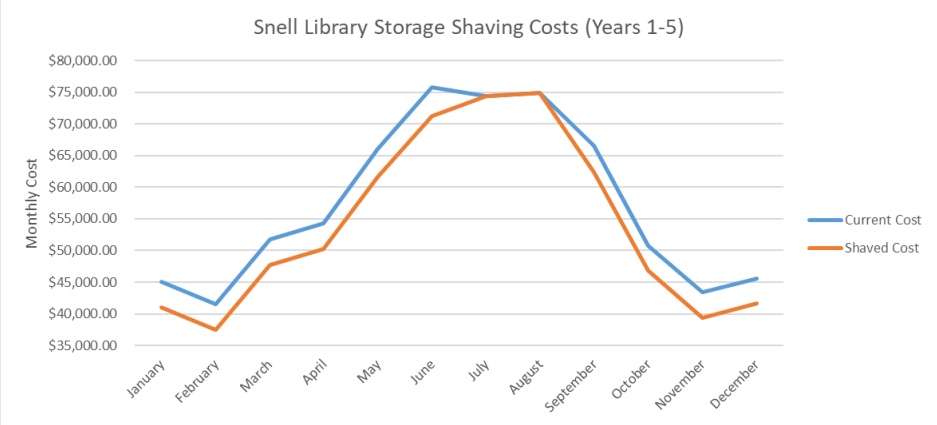


Figure 6: Snell Library Storage Shaving Costs (Years 1-5)

During the first five years, NEU has annual savings at Snell Library of $41,000 and a five year total with inflation of $209,000.

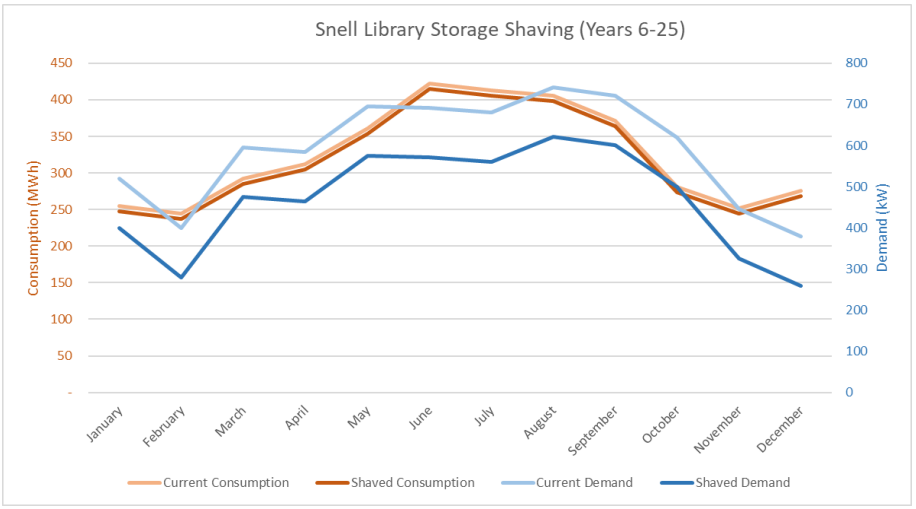


Figure 7: Snell Library Storage Shaving (Years 6-25)

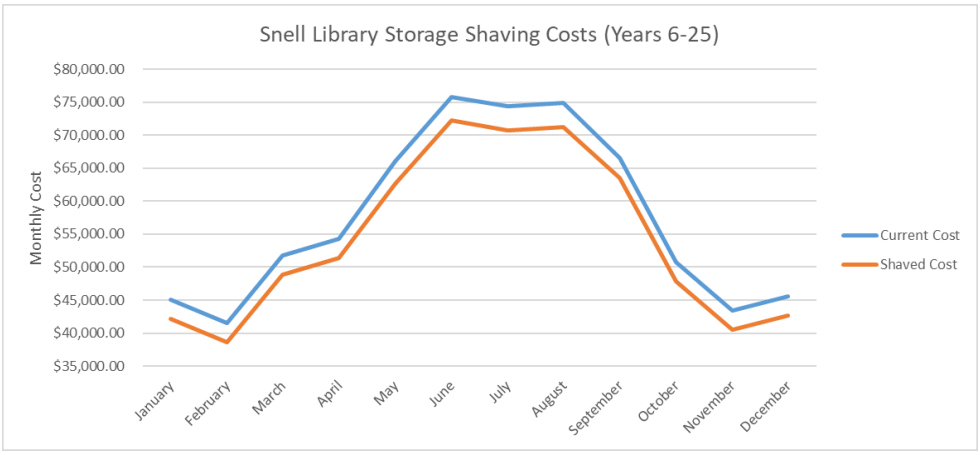


Figure 8: Snell Library Storage Shaving Costs (Years 6-25)

During years 6-25, NEU has annual savings at Snell Library of $38,000 and a 20 year total with inflation of $770,000.

Design:-

Component Selection

Solar Panels:

The REC400AA Pure (400W) panels have been chosen based on their superior performance, lower degradation rates, and competitive pricing.

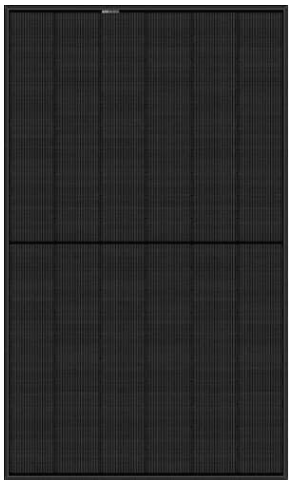


Fig 9: REC400AA Pure (400W) Panel

Inverter:

In order to maintain a DC/AC ratio within a narrow range of 1.2, it has been determined that an inverter with a capacity of 50 kW is necessary. As such, the Sunny Tripower Core 1/US (SMA) 50 kW inverter has been selected due to its exceptional efficiency, comprehensive protection functions, and impressive track record for reliability and uptime.

Fig 10: Sunny Tripower Core 1/US(SMA) 50W

Helioscope Design

1) Marino Recreation Center

Fig 11: Marino Solar Design

Key Design Specs:

- Modules: Modules: REC400AA Pure (400W)
- Inverter: Sunny Tripower Core 1/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

2) Snell Library

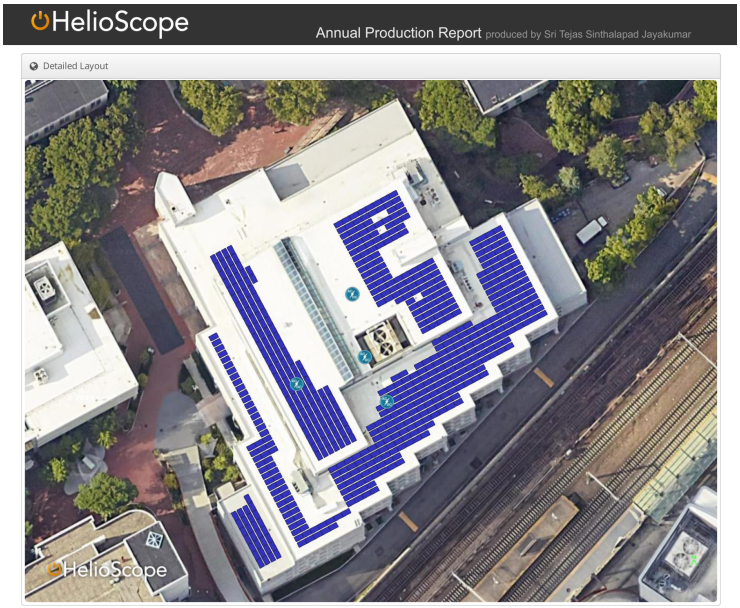


Fig 12: Snell Library Solar Design

Key Design Specs:

- Modules: REC400AA Pure (400W)
- Inverter: Sunny Tripower Core 1/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

3) Shillman Hall

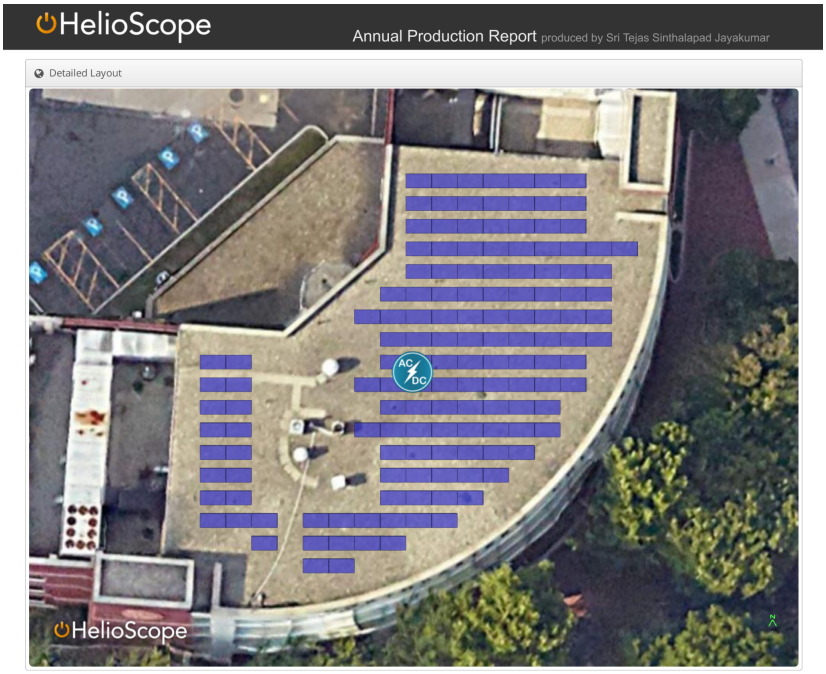


Fig 13: Shillman Solar Design

Key Design Specs:

- Modules: REC400AA Pure (400W)
- Inverter: Sunny Tripower Core 1/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

4) Snell Engineering Centre

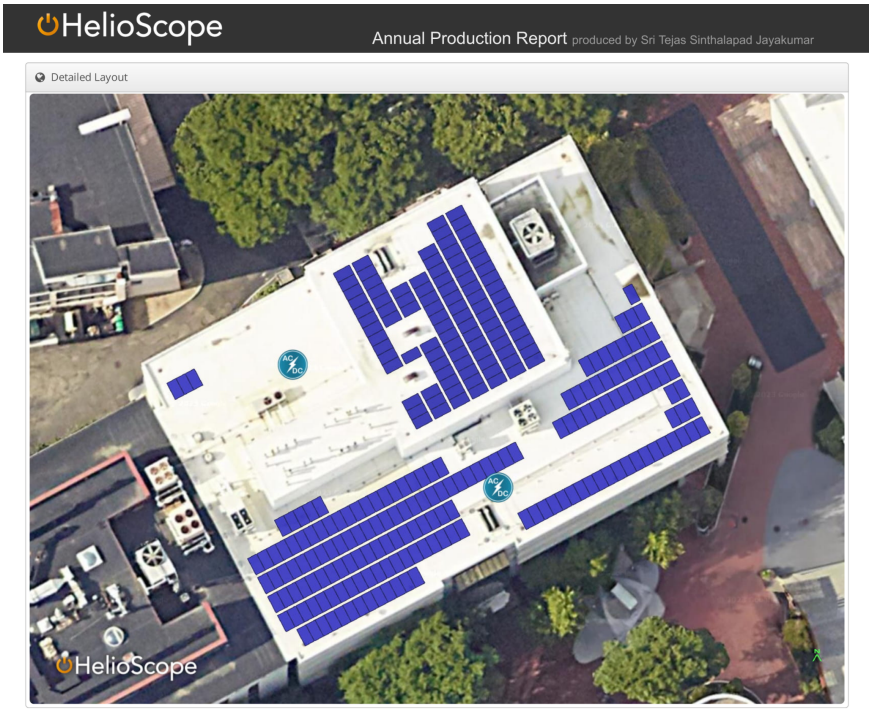


Fig 14: Snell Engineering Solar Design

Key Design Specs:

- Modules: REC400AA Pure (400W)
- Inverter: Sunny Tripower Core 1/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

5) Columbus Park

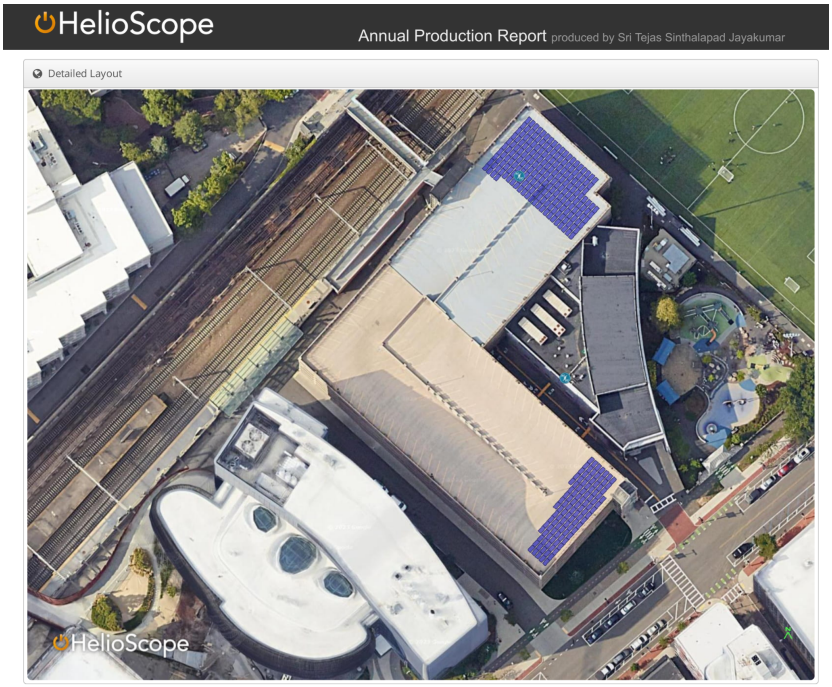


Fig 15: Columbus Solar Design

Key Design Specs:

- Modules: REC400AA Pure (400W)
- Inverter: Sunny Tripower Core 1/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

6) Renaissance Park

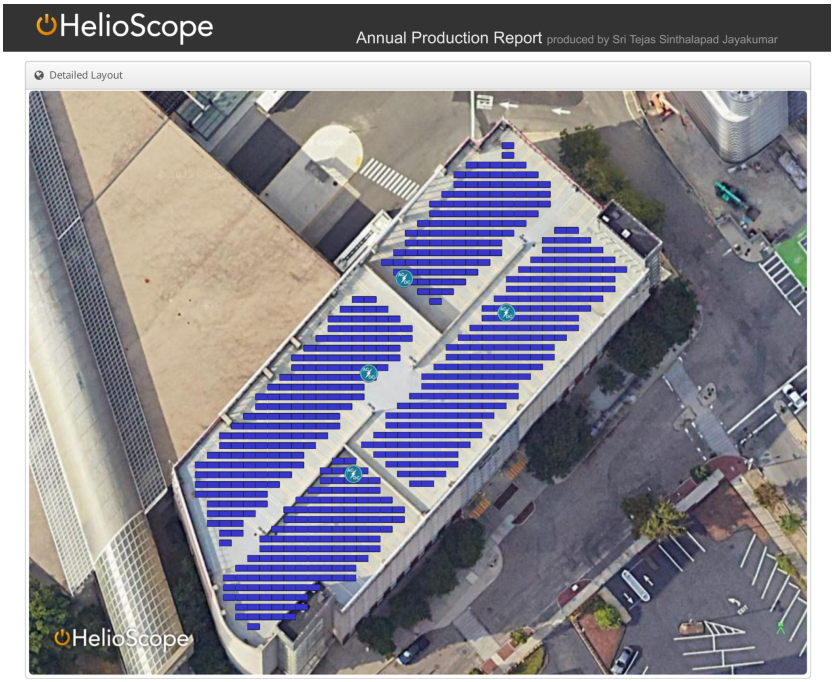


Fig 16: Renaissance Solar Design

Key Design Specs:

- Modules: REC400AA Pure (400W)
- Inverter: Sunny Tripower Core 1/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

Battery Storage System:-

The Battery Energy Storage System (BESS) for the Marino Recreation Centre and Snell Library has been custom-designed to effectively reduce peak energy demand, thereby generating cost savings on electricity bills for both locations. SMART tariffs, including Battery storage Adders, have been leveraged to optimize the BESS production.. Furthermore, Connected solutions have been integrated into the system's design for the initial five-year period. During June-September, the system will export energy to the grid as requested, while the discharged power will contribute towards fulfilling the 52 discharge events mandated for the SMART battery storage Adder.

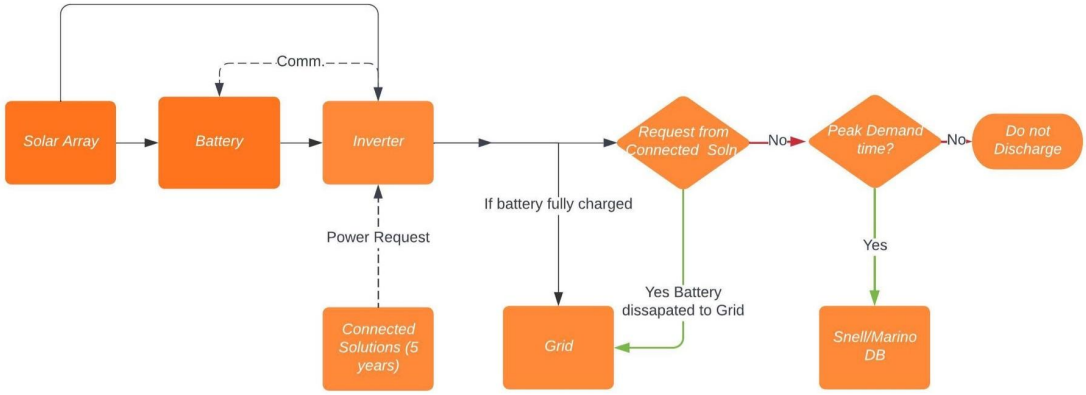


Fig 17: Storage FlowChart

We have designed a 80kW battery for Marino Recreation Centre and a 120kW battery for Snell Library as per the current Peak Demand of the two buildings.

Financial model:-

The following table is a summary of the varied inputs and key outputs of the financial model.

Table 2: Financial Model Key Takeaways

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	200kW	Base + roof + canopy = $224.80	-	75%	80%
Columbus	120kW	Base + roof + canopy = $224.80	-	70%	57%

The size of the array was taken from the Helioscope design. The production was found by inputting the location and azimuth angle into Source 1. The degradation and lifespan were found from the panel's spec sheet [2]. The SMART block tariffs were calculated using the excel sheet on mass.gov [3]. The adder for storage was calculated from Source 9. The values for connected solutions were found online from Source 4. The figures for solar cost per watt and O&M and G&A costs were found in NREL documents Sources 5 and 6, respectively. The cost for the battery and its O&M were also found in a NREL documents [7][8].

Once these researched values were applied to each project's design, the model gave values for production. From there, we applied the Connected Solutions revenue for 5 years assuming an 80% battery utilization. For the sake of the model, it was assumed that Connected Solutions would have the maximum number of draw events at 60. This was modeled conservatively as only using the batteries for Connected Solutions during the two highest power months of the year. After those 5 years, half of the battery energy is sold to NEU well below market rate at $50 per MWh and the other half is sold to the grid using the previously calculated SMART tariff.

From these revenues, the solar and storage O&M and G&A costs are subtracted. This project also used the 5 year MACRS depreciation which can be seen in the PBT. The federal tax rate is applied to get the resulting tax-adjusted cash flow.

The loan amount was decided by assuming a fixed rate of 6% and a period of 2 years, and increasing until the DSCR got close to 1.12 without going below. From this amount, the final levered IRR was taken.

Conclusion:-

The prospect of reducing energy costs without the need for capital investment and risk is highly desirable to Northeastern University. Through a solar power purchase agreement (PPA), Northeastern University will be able reduce the demand charges at Marino Recreation Centre and Snell Library, and later purchase power at a rate of $50Mwh which is significantly lower than the local utility's retail rate. As a result, Northeastern University can reduce its electricity bill, while also reducing its carbon footprint.

Renewable Developers will receive income from the sale of the produced electricity, as well as any tax credits and other incentives generated from the system. The proposal and financial model demonstrate that the project is mutually beneficial for both Northeastern University and Renewable Developers. Northeastern University will save $1,525,520 during the PPA contract's lifecycle with no upfront capital or maintenance costs, with our internal rate of return (IRR) starting at 17%.

In addition to the financial benefits, the BESS will provide system security by supplying energy during electricity outages making Northeastern University less dependent on the grid. Finally, Northeastern University will reduce its carbon footprint, which is a significant benefit in today's world solidifying its ranking as a top tier University.

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].

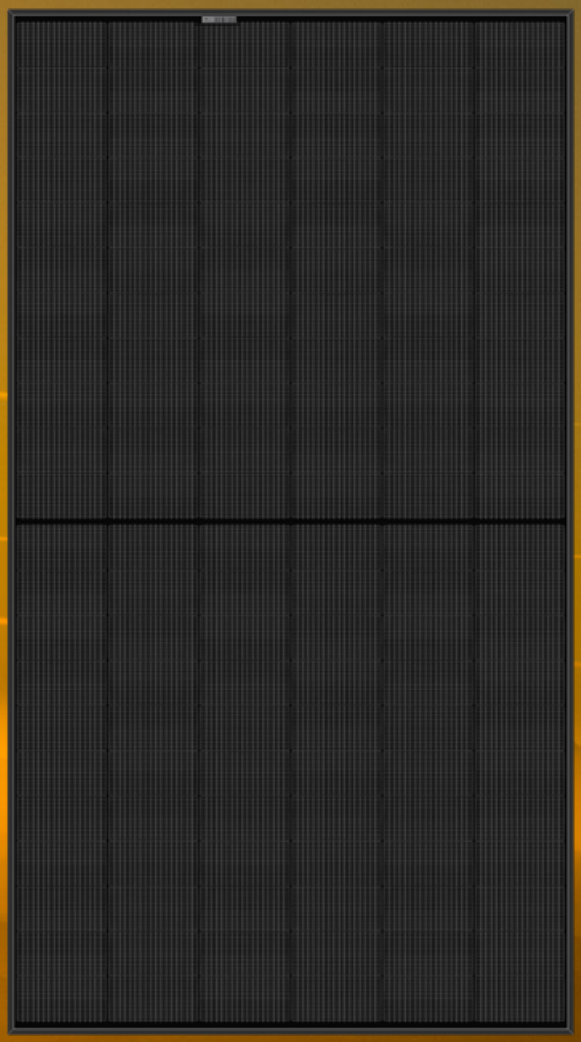
9. *Google*. [Online]. Available: https://www.google.co.in/webhp?ion=1&rct=j. [Accessed: 24-Apr-2023].

Appendix

Data Sheets

SOLAR'S MOST TRUSTED

REC



REC ALPHα® PURE BLACK SERIES

PRODUCT SPECIFICATIONS

400 WP

20.3 W/FT²

PRODUCT REC 25 YEAR ProTrust WARRANTY PERFORMANCE LABOR

ELIGIBLE

LEAD-FREE

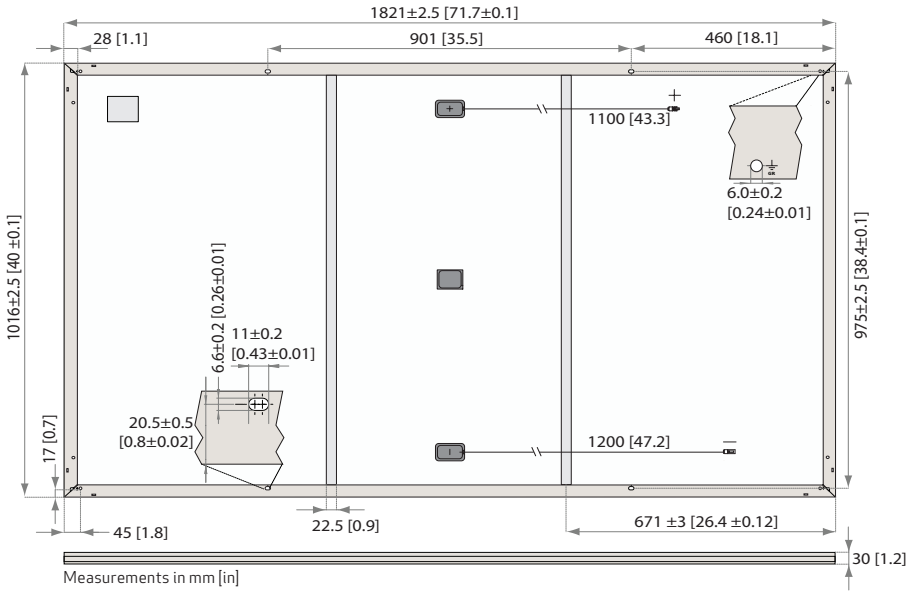
ROHS COMPLIANT

EXPERIENCE α PERFORMANCE

REC
SOLAR'S MOST TRUSTED

PRODUCT SPECIFICATIONS

REC ALPHA PURE BLACK SERIES > PRODUCT SPECIFICATIONS



Measurements in mm [in]

CERTIFICATIONS

IEC 61215:2016, IEC 61730:2016, UL 61730 (Pending)

ISO 14001:2004, ISO 9001:2015, OHSAS 18001:2007, IEC 62941

WARRANTY

	Standard	REC ProTrust	
Installed by an REC Certified Solar Professional	No	Yes	Yes
System Size	All	≤25 kW	25-500 kW
Product Warranty (yrs)	20	25	25
Power Warranty (yrs)	25	25	25
Labor Warranty (yrs)	0	25	10
Power in Year 1	98%	98%	98%
Annual Degradation	0.25%	0.25%	0.25%
Power in Year 25	92%	92%	92%

See warranty documents for details. Conditions apply

GENERAL DATA

Cell type:	132 half-cut REC heterojunction cells with lead-free, gapless technology 6 strings of 22 cells in series	Connectors:	Stäubli MC4 PV-KBT4/KST4, 12 AWG (4 mm²) in accordance with IEC 62852 IP68 only when connected
Glass:	0.13 in (3.2 mm) solar glass with anti-reflection surface treatment	Cable:	12 AWG (4 mm²) PV wire, 43+47 in (1.1+1.2 m) accordance with EN 50618
Backsheet:	Highly resistant polymer (black)	Dimensions:	71.7 x 40 x 1.2 in (1821 x 1016 x 30 mm)
Frame:	Anodized aluminum (black)	Weight:	45 lbs (20.5 kg)
Junction box:	3-part, 3 bypass diodes, IP67 rated in accordance with IEC 62790	Origin:	Made in Singapore

MAXIMUM RATINGS

Operational temperature:	-40 ... +185°F (-40 ... +85°C)
Maximum system voltage:	1000 V
Maximum test load (front):	+7000 Pa (146 lbs/sq ft)*
Maximum test load (rear):	-4000 Pa (83.5 lbs/sq ft)*
Max series fuse rating:	25 A
Max reverse current:	25 A

* See installation manual for mounting instructions.
Design load = Test load / 1.5 (safety factor)

ELECTRICAL DATA

	Product Code*: RECxxxAA Pure Black				
STC					
Power Output - P_{MAX} (Wp)	385	390	395	400	405
Watt Class Sorting - (W)	0/+5	0/+5	0/+5	0/+5	0/+5
Nominal Power Voltage - V_{MPP} (V)	41.2	41.5	41.8	42.1	42.4
Nominal Power Current - I_{MPP} (A)	9.35	9.40	9.45	9.51	9.56
Open Circuit Voltage - V_{OC} (V)	48.5	48.6	48.7	48.8	48.9
Short Circuit Current - I_{SC} (A)	9.99	10.03	10.07	10.10	10.14
Power Density (W/sq ft)	19.3	19.6	19.8	20.1	20.3
Panel Efficiency (%)	20.8	21.1	21.3	21.6	21.9
NMOT					
Power Output - P_{MAX} (Wp)	293	297	301	305	309
Nominal Power Voltage - V_{MPP} (V)	38.8	39.1	39.4	39.7	40.0
Nominal Power Current - I_{MPP} (A)	7.55	7.59	7.63	7.68	7.72
Open Circuit Voltage - V_{OC} (V)	45.7	45.8	45.9	46.0	46.1
Short Circuit Current - I_{SC} (A)	8.07	8.10	8.13	8.16	8.19

Values at standard test conditions (STC: air mass AM 1.5, irradiance 10.75 W/sq ft (1000 W/m²), temperature 77°F (25°C), based on a production spread with a tolerance of P_{MAX}, V_{OC} & I_{SC} ±3% within one watt class. Nominal module operating temperature (NMOT: air mass AM 1.5, irradiance 800 W/m², temperature 68°F (20°C), windspeed 3.3 ft/s (1 m/s). * Where xxx indicates the nominal power class (P_{MAX}) at STC above.

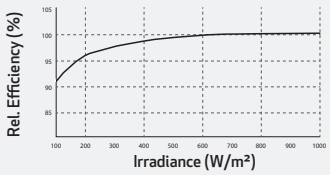
TEMPERATURE RATINGS*

Nominal Module Operating Temperature:	44°C (±2°C)
Temperature coefficient of P_{MAX}:	-0.26 %/°C
Temperature coefficient of V_{OC}:	-0.24 %/°C
Temperature coefficient of I_{SC}:	0.04 %/°C

*The temperature coefficients stated are linear values

LOW LIGHT BEHAVIOUR

Typical low irradiance performance of module at STC:



Specifications subject to change without notice.

Ref: PM-DS-12-01-Rev-A 03.21

Founded in 1996, REC Group is an international pioneering solar energy company dedicated to empowering consumers with clean, affordable solar power. As Solar's Most Trusted, REC is committed to high quality, innovation, and a low carbon footprint in the solar materials and solar panels it manufactures. Headquartered in Norway with operational headquarters in Singapore, REC also has regional hubs in North America, Europe, and Asia-Pacific.

REC
www.recgroup.com

SUNNY TRIPOWER CORE1 33-US / 50-US / 62-US

STP33-US-41 / STP50-US-41 / STP62-US-41

Fully integrated

- Innovative design requires no additional racking for rooftop installation
- Integrated DC and AC disconnects and overvoltage protection
- 12 direct string inputs for reduced labor and material costs

Increased power, flexibility

- Multiple power ratings for small to large scale commercial PV installations
- Six MPP trackers for flexible stringing and maximum power production
- OptiTrac™ Global Peak shade tolerant MPP tracking

Enhanced safety, reliability

- Integrated SunSpec PLC signal for module-level rapid shutdown compliance to 2017 NEC
- Next-gen DC AFCI arc-fault protection certified to new Standard UL 1699B

Smart monitoring, control, service

- Advanced smart inverter grid support capabilities
- Increased ROI with SMA ennexOS cross sector energy management platform
- SMA Smart Connected proactive O&M solution reduces time spent diagnosing and servicing in the field

SUNNY TRIPOWER CORE1 33-US / 50-US / 62-US

It stands on its own

The Sunny Tripower CORE1 is the world's first free-standing PV inverter for commercial rooftops, carports, ground mount and repowering legacy solar projects. Now with expanded features and new power classes, the CORE1 is the most versatile, cost-effective commercial solution available. From distribution to construction to operation, the Sunny Tripower CORE1 enables logistical, material, labor and service cost reductions. Integrated SunSpec PLC for rapid shutdown and enhanced DC AFCI arc-fault protection ensure compliance to the latest safety codes and standards. With Sunny Tripower CORE1 and SMA's ennexOS cross sector energy management platform, system integrators can deliver comprehensive commercial energy solutions for increased ROI.

Technical data*	Sunny Tripower CORE1 33-US	Sunny Tripower CORE1 50-US	Sunny Tripower CORE1 62-US
Input (DC)			
Maximum array power	50000 Wp STC	75000 Wp STC	93750 Wp STC
Maximum system voltage		1000 V	
Rated MPP voltage range	330 V … 800 V	500 V … 800 V	550 V … 800 V
MPPT operating voltage range		150 V … 1000 V	
Minimum DC voltage / start voltage		150 V / 188 V	
MPP trackers / strings per MPP input		6 / 2	
Maximum operating input current / per MPP tracker		120 A / 20 A	
Maximum short circuit current per MPPT / per string input		30 A / 30 A	
Output (AC)			
AC nominal power	33300 W	50000 W	62500 W
Maximum apparent power	33300 VA	53000 VA	66000 VA
Output phases / line connections		3 / 3-(N)-PE	
Nominal AC voltage		480 V / 277 V WYE	
AC voltage range		244 V … 305 V	
Maximum output current	40 A	64 A	79.5 A
Rated grid frequency		60 Hz	
Grid frequency / range		50 Hz, 60 Hz / -6 Hz … +6Hz	
Power factor at rated power / adjustable displacement		1 / 0.0 leading … 0.0 lagging	
Harmonics THD		<3 %	
Efficiency			
CEC efficiency (preliminary)	97.5%	98%	98%
Protection and safety features			
Load rated DC disconnect		●	
Load rated AC disconnect		●	
Ground fault monitoring: Riso / Differential current		● / ●	
DC AFCI arc-fault protection		●	
SunSpec PLC signal for rapid shutdown		●	
DC reverse polarity protection		●	
AC short circuit protection		●	
DC surge protection: Type 2 / Type 1+2		O / O	
AC surge protection: Type 2 / Type 1+2		O / O	
Protection class / overvoltage category (as per UL 840)		I / IV	
General data			
Device dimensions (W / H / D)		621 mm / 733 mm / 569 mm (24.4 in x 28.8 in x 22.4 in)	
Device weight		84 kg (185 lbs)	
Operating temperature range		-25 °C … +60 °C (-13 °F … +140 °F)	
Storage temperature range		-40 °C … +70 °C (-40 °F … +158 °F)	
Audible noise emissions (full power @ 1m and 25 °C)		65 dB(A)	
Internal consumption at night		5 W	
Topology		Transformerless	
Cooling Concept		OptiCool (forced convection, variable speed fans)	
Enclosure protection rating		Type 4X, 3SX (as per UL 50E)	
Maximum permissible relative humidity (non-condensing)		100 %	
Additional information			
Mounting		Free-standing with included mounting feet	
DC connection		Amphenol UTX PV connectors	
AC connection		Screw terminals - 4 AWG to 4/0 AWG CU/AL	
LED indicators (Status / Fault / Communication)		●	
Network interfaces: Ethernet / WLAN / RS485		● (2 ports) / ● / O	
Data protocols: SMA Modbus / SunSpec Modbus / Webconnect		● / ● / ●	
Multifunction relay		●	
OptiTrac Global Peak (shade-tolerant MPP tracking)		●	
Integrated Plant Control / Q on Demand 24/7		● / ●	
Off-Grid capable / SMA Fuel Save Controller compatible		● / ●	
SMA Smart Connected (proactive monitoring and service support)		●	
Certifications (pending as of June 2018)			
Certifications and approvals		UL 1741, UL 1699B, UL 1998, IEEE 1547, CAN/CSA-C22.2 No. 62109	
FCC compliance		FCC Part 15 Class A	
Grid interconnection standards		UL 1741 SA - CA Rule 21, HECO Rule 14H	
Advanced grid support capabilities		L/HFRT, L/HVRT, Volt-VAr, Volt-Watt, Frequency-Watt, Ramp Rate Control, Fixed Power Factor	
Warranty			
Standard		10 years	
Optional extensions		15 / 20 years	
O Optional features ● Standard features – Not available	* Preliminary data as of June 2018		
Type designation	STP33-US-41	STP50-US-41	STP62-US-41

Accessories

SMA Data Manager M
EDMM-US-10

SMA Sensor Module
MD.SEN-US-40

Universal Mounting System
UMS_KIT-10

AC Surge Protection Module Kit
AC_SPD_KIT1-10, AC_SPD_KIT2_T1T2
DC Surge Protection Module Kit
DC_SPD_KIT4-10, DC_SPD_KIT5_T1T2

Toll Free +1 888 4 SMA USA
www.SMA-America.com

SMA America, LLC

STPCORE1-DUS182821

Helioscope Design

Marino Center -1 RED Project, 360 Huntington Ave

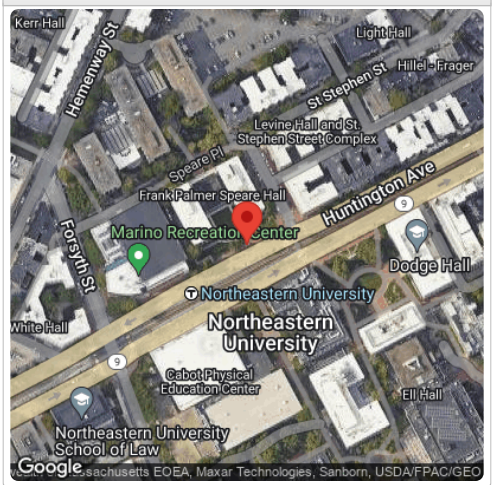
Report

Project Name	RED Project
Project Description	Project
Project Address	360 Huntington Ave
Prepared By	Sri Tejas Sinthalapad Jayakumar sinthalapadjayakum.s@northeastern.edu

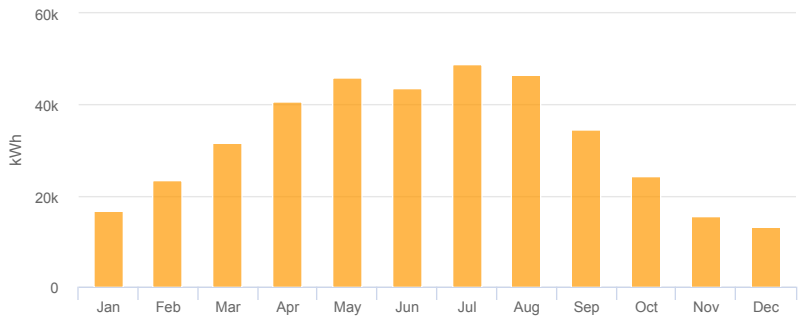
System Metrics

Design	Marino Center -1
Module DC Nameplate	307.6 kW
Inverter AC Nameplate	250.0 kW Load Ratio: 1.23
Annual Production	385.3 MWh
Performance Ratio	86.2%
kWh/kWp	1,252.6
Weather Dataset	TMY, 10km grid (42.35,-71.05), NREL (prospector)
Simulator Version	654a5617e8-f6fdcd7720-2398abb298-4bc6d73c62

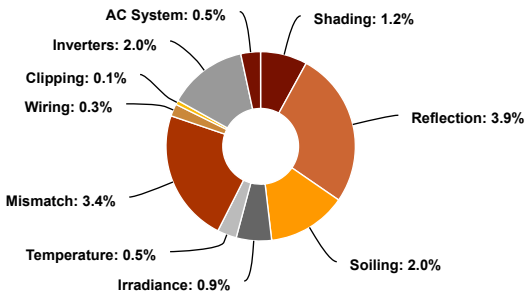
Project Location



Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,423.3	
	POA Irradiance	1,453.4	2.1%
	Shaded Irradiance	1,436.3	-1.2%
	Irradiance after Reflection	1,379.8	-3.9%
	Irradiance after Soiling	1,352.2	-2.0%
	Total Collector Irradiance	**1,352.2**	**0.0%**
Energy (kWh)	Nameplate	416,319.4	
	Output at Irradiance Levels	412,611.3	-0.9%
	Output at Cell Temperature Derate	410,606.3	-0.5%
	Output After Mismatch	396,805.9	-3.4%
	Optimal DC Output	395,582.6	-0.3%
	Constrained DC Output	395,153.6	-0.1%
	Inverter Output	387,242.1	-2.0%
	Energy to Grid	**385,305.9**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		12.0 °C
	Avg. Operating Cell Temp		18.9 °C
Simulation Metrics			
	Operating Hours		4688
	Solved Hours		4688

Condition Set

Description	Condition Set 1											
Weather Dataset	TMY, 10km grid (42.35,-71.05), NREL (prospector)											
Solar Angle Location	Meteo Lat/Lng											
Transposition Model	Perez Model											
Temperature Model	Sandia Model											
Temperature Model Parameters	Rack Type	a	b	Temperature Delta								
	Fixed Tilt	-3.56	-0.075	3°C								
	Flush Mount	-2.81	-0.0455	0°C								
	East-West	-3.56	-0.075	3°C								
	Carport	-3.56	-0.075	3°C								
Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D
	2	2	2	2	2	2	2	2	2	2	2	2
Irradiation Variance	5%											
Cell Temperature Spread	4° C											
Module Binning Range	-2.5% to 2.5%											
AC System Derate	0.50%											
Module Characterizations	Module	Uploaded By	Characterization									
	TSM-PD14 320 (May16) (Trina Solar)	HelioScope	Spec Sheet Characterization, PAN									
	REC400AA Pure (REC)	HelioScope	REC400AA_Pure.pan, PAN									
Component Characterizations	Device	Uploaded By	Characterization									
	Sunny Tripower Core1/US (SMA)	HelioScope	Spec Sheet									

Components

Component	Name	Count
Inverters	Sunny Tripower Core1/US (SMA)	5 (250.0 kW)
Home Runs	10 AWG (Copper)	9 (425.2 ft)
Combiners	4 input Combiner	4
Combiners	5 input Combiner	4
Combiners	9 input Combiner	1
Strings	10 AWG (Copper)	45 (4,146.8 ft)
Module	REC, REC400AA Pure (400W)	769 (307.6 kW)

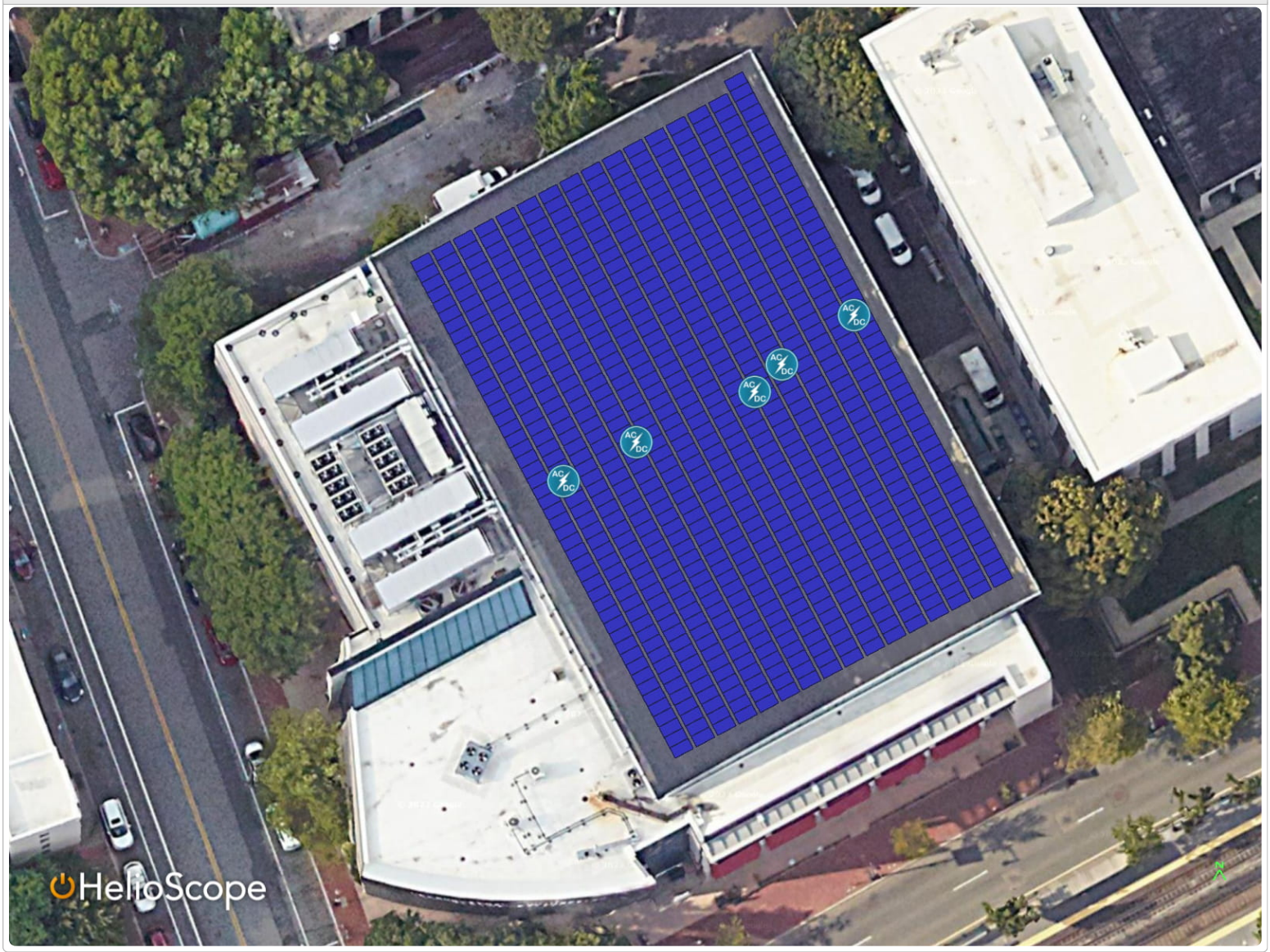
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-19	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	5°	180°	1.0 ft	1x1			0
Field Segment 2	Fixed Tilt	Landscape (Horizontal)	10°	180°	2.0 ft	1x1			0
Field Segment 3	Fixed Tilt	Portrait (Vertical)	5°	241.9011°	1.0 ft	1x1	769	769	307.6 kW

Detailed Layout



snell library-1 (copy) RED Project, 360 Huntington Ave

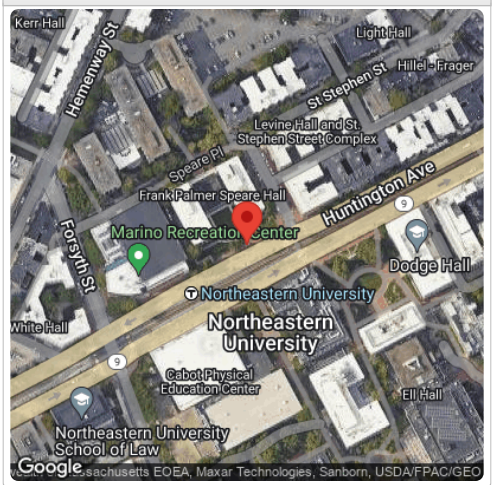
Report

Project Name	RED Project
Project Description	Project
Project Address	360 Huntington Ave
Prepared By	Sri Tejas Sinthalapad Jayakumar sinthalapadjayakum.s@northeastern.edu

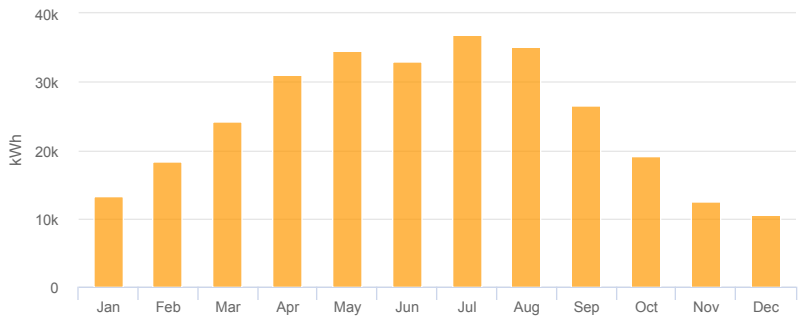
System Metrics

Design	snell library-1 (copy)
Module DC Nameplate	249.6 kW
Inverter AC Nameplate	200.0 kW Load Ratio: 1.25
Annual Production	295.1 MWh
Performance Ratio	80.2%
kWh/kWp	1,182.5
Weather Dataset	TMY, 10km grid (42.35,-71.05), NREL (prospector)
Simulator Version	654a5617e8-f6fdcd7720-2398abb298-4bc6d73c62

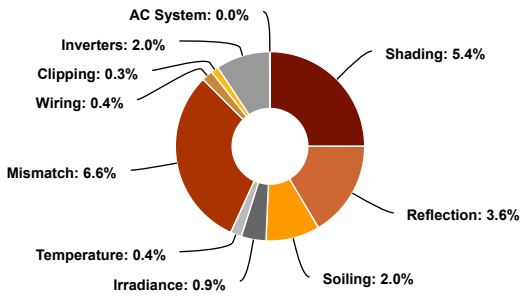
Project Location



Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,423.3	
	POA Irradiance	1,474.7	3.6%
	Shaded Irradiance	1,394.8	-5.4%
	Irradiance after Reflection	1,345.0	-3.6%
	Irradiance after Soiling	1,318.1	-2.0%
	Total Collector Irradiance	**1,318.1**	**0.0%**
Energy (kWh)	Nameplate	329,293.1	
	Output at Irradiance Levels	326,270.1	-0.9%
	Output at Cell Temperature Derate	324,909.5	-0.4%
	Output After Mismatch	303,317.7	-6.6%
	Optimal DC Output	302,048.8	-0.4%
	Constrained DC Output	301,209.0	-0.3%
	Inverter Output	295,177.2	-2.0%
	Energy to Grid	**295,140.1**	**0.0%**
Temperature Metrics			
	Avg. Operating Ambient Temp	12.0 °C	
	Avg. Operating Cell Temp	18.7 °C	
Simulation Metrics			
	Operating Hours	4688	
	Solved Hours	4688	

Condition Set

Description	Condition Set 1											
Weather Dataset	TMY, 10km grid (42.35,-71.05), NREL (prospector)											
Solar Angle Location	Meteo Lat/Lng											
Transposition Model	Perez Model											
Temperature Model	Sandia Model											
Temperature Model Parameters	Rack Type	a	b	Temperature Delta								
	Fixed Tilt	-3.56	-0.075	3°C								
	Flush Mount	-2.81	-0.0455	0°C								
	East-West	-3.56	-0.075	3°C								
	Carport	-3.56	-0.075	3°C								
Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D
	2	2	2	2	2	2	2	2	2	2	2	2
Irradiation Variance	5%											
Cell Temperature Spread	4° C											
Module Binning Range	-2.5% to 2.5%											
AC System Derate	0.50%											
Module Characterizations	Module	Uploaded By	Characterization									
	REC400AA Pure (REC)	HelioScope	REC400AA_Pure.pan, PAN									
	Q PEAK DUO BLK M-G11+ 400W (QCells)	HelioScope	Spec Sheet Characterization, PAN									
Component Characterizations	Device	Uploaded By	Characterization									
	Sunny Tripower Core1/US (SMA)	HelioScope	Spec Sheet									

Components

Component	Name	Count
Inverters	Sunny Tripower Core1/US (SMA)	4 (200.0 kW)
AC Home Runs	1000 MCM (Aluminum)	4 (887.2 ft)
Home Runs	10 AWG (Copper)	8 (367.7 ft)
Combiners	4 input Combiner	4
Combiners	5 input Combiner	4
Strings	10 AWG (Copper)	36 (5,006.9 ft)
Module	REC, REC400AA Pure (400W)	624 (249.6 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-19	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	5°	241.88138°	1.0 ft	1x1	29	29	11.6 kW
Field Segment 2	Fixed Tilt	Landscape (Horizontal)	5°	241.7068°	1.0 ft	1x1			0
Field Segment 3	Fixed Tilt	Landscape (Horizontal)	5°	152.15721°	1.0 ft	1x1	339	339	135.6 kW
Field Segment 4	Fixed Tilt	Landscape (Horizontal)	5°	331.5562°	2.0 ft	1x1			0
Field Segment 5	Fixed Tilt	Landscape (Horizontal)	10°	332.53027°	2.0 ft	1x1			0
Field Segment 6	Fixed Tilt	Landscape (Horizontal)	5°	241.8621°	1.0 ft	1x1	131	131	52.4 kW
Field Segment 7	Fixed Tilt	Landscape (Horizontal)	5°	151.65164°	1.0 ft	1x1	125	125	50.0 kW
Field Segment 8	Fixed Tilt	Landscape (Horizontal)	10°	331.38034°	2.0 ft	1x1			0
Field Segment 9	Fixed Tilt	Landscape (Horizontal)	10°	331.09457°	2.0 ft	1x1			0

Detailed Layout

shillman hall RED Project, 360 Huntington Ave

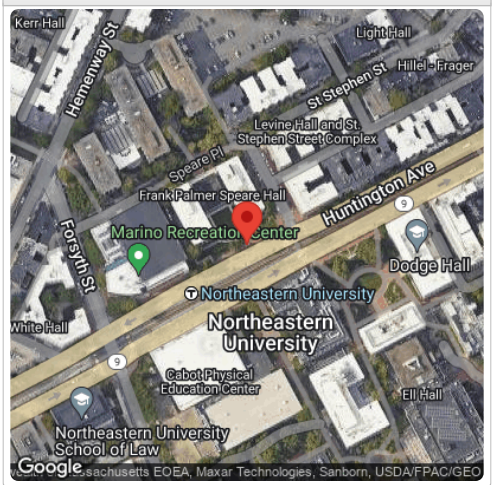
Report

Project Name	RED Project
Project Description	Project
Project Address	360 Huntington Ave
Prepared By	Sri Tejas Sinthalapad Jayakumar sinthalapadjayakum.s@northeastern.edu

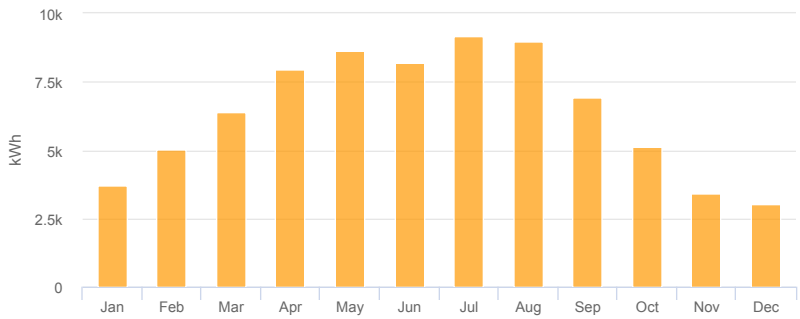
System Metrics

Design	shillman hall
Module DC Nameplate	57.2 kW
Inverter AC Nameplate	50.0 kW Load Ratio: 1.14
Annual Production	76.50 MWh
Performance Ratio	86.4%
kWh/kWp	1,337.4
Weather Dataset	TMY, 10km grid (42.35,-71.05), NREL (prospector)
Simulator Version	654a5617e8-f6fdcd7720-2398abb298-4bc6d73c62

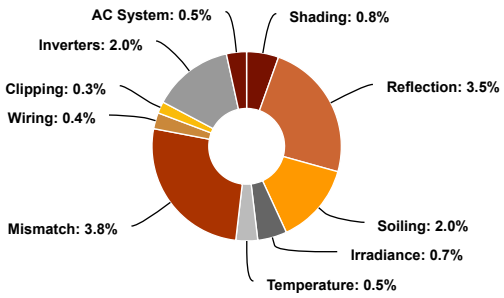
Project Location



Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,423.3	
	POA Irradiance	1,547.5	8.7%
	Shaded Irradiance	1,535.2	-0.8%
	Irradiance after Reflection	1,482.1	-3.5%
	Irradiance after Soiling	1,452.5	-2.0%
	Total Collector Irradiance	**1,452.5**	**0.0%**
Energy (kWh)	Nameplate	83,154.0	
	Output at Irradiance Levels	82,552.9	-0.7%
	Output at Cell Temperature Derate	82,107.3	-0.5%
	Output After Mismatch	78,995.6	-3.8%
	Optimal DC Output	78,680.3	-0.4%
	Constrained DC Output	78,451.9	-0.3%
	Inverter Output	76,882.5	-2.0%
	Energy to Grid	**76,498.1**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		12.0 °C
	Avg. Operating Cell Temp		19.4 °C
Simulation Metrics			
	Operating Hours		4688
	Solved Hours		4688

Condition Set

Description	Condition Set 1											
Weather Dataset	TMY, 10km grid (42.35,-71.05), NREL (prospector)											
Solar Angle Location	Meteo Lat/Lng											
Transposition Model	Perez Model											
Temperature Model	Sandia Model											
Temperature Model Parameters	Rack Type	a	b	Temperature Delta								
	Fixed Tilt	-3.56	-0.075	3°C								
	Flush Mount	-2.81	-0.0455	0°C								
	East-West	-3.56	-0.075	3°C								
	Carport	-3.56	-0.075	3°C								
Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D
	2	2	2	2	2	2	2	2	2	2	2	2
Irradiation Variance	5%											
Cell Temperature Spread	4° C											
Module Binning Range	-2.5% to 2.5%											
AC System Derate	0.50%											
Module Characterizations	Module	Uploaded By	Characterization									
	REC400AA Pure (REC)	HelioScope	REC400AA_Pure.pan, PAN									
Component Characterizations	Device	Uploaded By	Characterization									
	Sunny Tripower Core1/US (SMA)	HelioScope	Spec Sheet									

Components

Component	Name	Count
Inverters	Sunny Tripower Core1/US (SMA)	1 (50.0 kW)
Home Runs	10 AWG (Copper)	2 (152.2 ft)
Combiners	3 input Combiner	1
Combiners	5 input Combiner	1
Strings	10 AWG (Copper)	8 (494.1 ft)
Module	REC, REC400AA Pure (400W)	143 (57.2 kW)

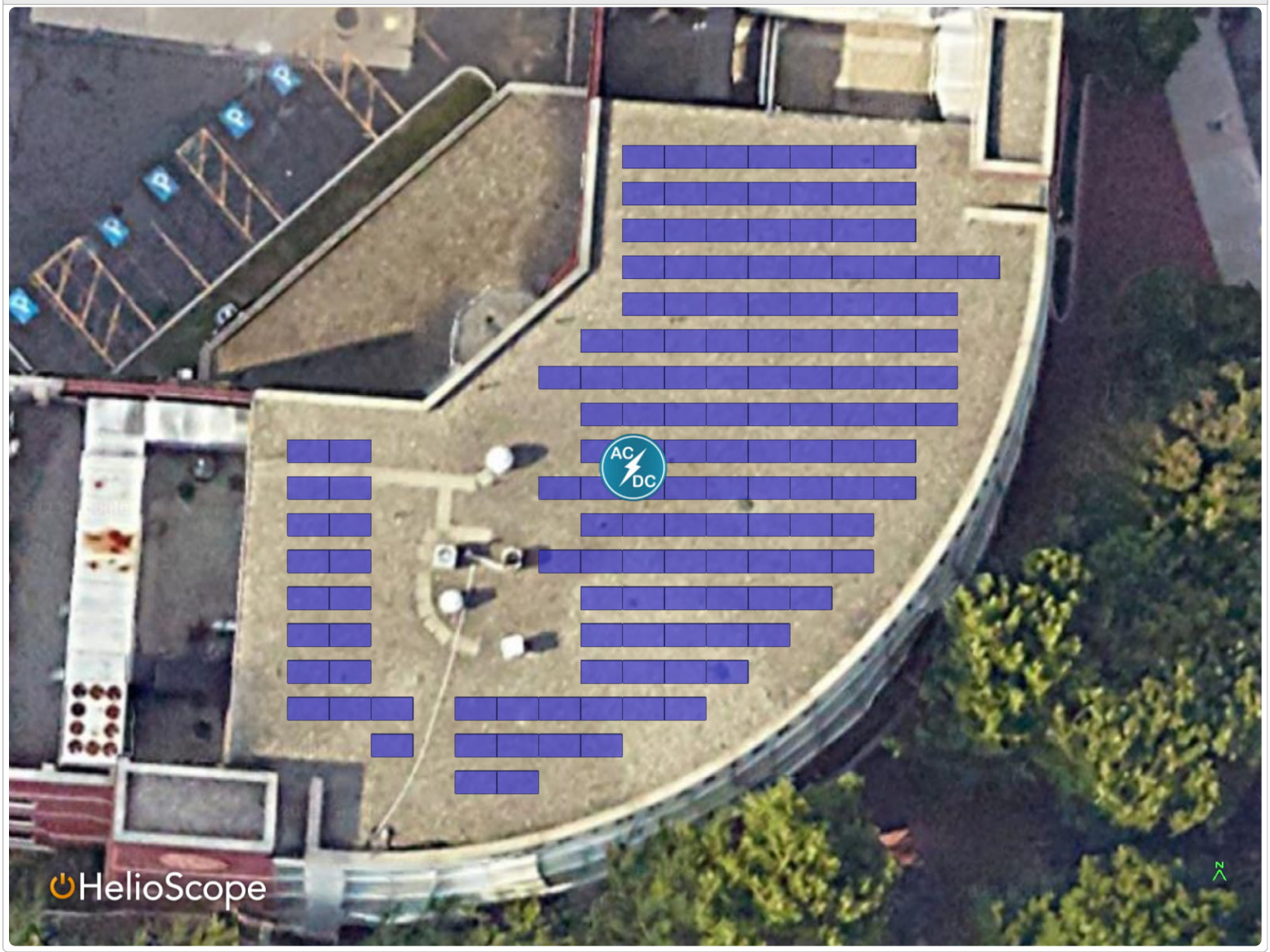
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-19	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	10°	180°	2.0 ft	1x1	143	143	57.2 kW

Detailed Layout



Snell Engineering Center RED Project, 360 Huntington Ave

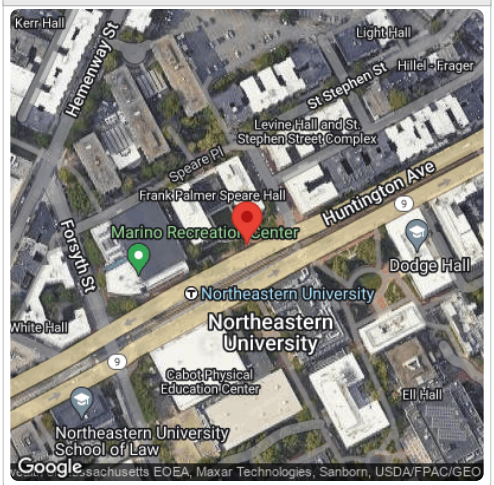
Report

Project Name	RED Project
Project Description	Project
Project Address	360 Huntington Ave
Prepared By	Sri Tejas Sinthalapad Jayakumar sinthalapadjayakum.s@northeastern.edu

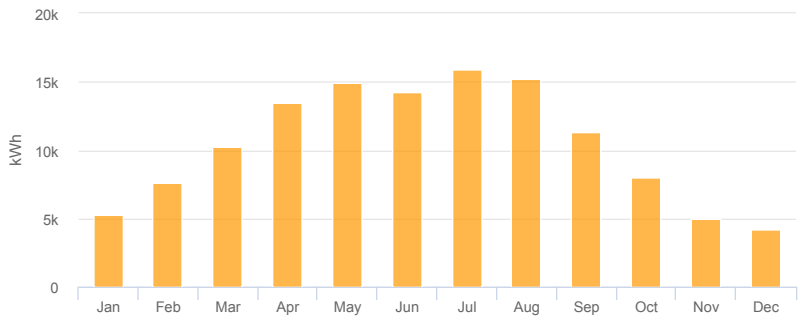
System Metrics

Design	Snell Engineering Center
Module DC Nameplate	107.2 kW
Inverter AC Nameplate	100.0 kW Load Ratio: 1.07
Annual Production	125.6 MWh
Performance Ratio	81.5%
kWh/kWp	1,171.2
Weather Dataset	TMY, 10km grid (42.35,-71.05), NREL (prospector)
Simulator Version	56f37155bc-f6dda7a4f2-e3db07d94f-c1fe5abf67

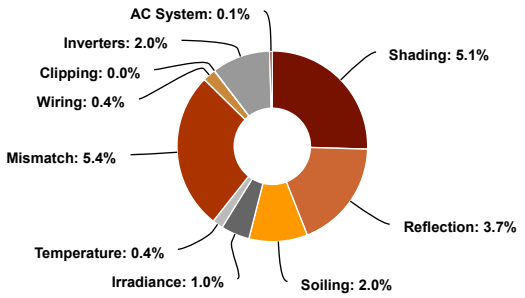
Project Location



Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,423.3	
	POA Irradiance	1,436.7	0.9%
	Shaded Irradiance	1,363.0	-5.1%
	Irradiance after Reflection	1,312.1	-3.7%
	Irradiance after Soiling	1,285.9	-2.0%
	Total Collector Irradiance	**1,286.0**	**0.0%**
Energy (kWh)	Nameplate	137,982.4	
	Output at Irradiance Levels	136,631.1	-1.0%
	Output at Cell Temperature Derate	136,134.6	-0.4%
	Output After Mismatch	128,810.4	-5.4%
	Optimal DC Output	128,236.5	-0.4%
	Constrained DC Output	128,231.9	0.0%
	Inverter Output	125,667.3	-2.0%
	Energy to Grid	**125,553.1**	**-0.1%**
Temperature Metrics			
	Avg. Operating Ambient Temp		12.0 °C
	Avg. Operating Cell Temp		18.6 °C
Simulation Metrics			
	Operating Hours		4688
	Solved Hours		4688

Condition Set

Description	Condition Set 1											
Weather Dataset	TMY, 10km grid (42.35,-71.05), NREL (prospector)											
Solar Angle Location	Meteo Lat/Lng											
Transposition Model	Perez Model											
Temperature Model	Sandia Model											
Temperature Model Parameters	Rack Type	a	b	Temperature Delta								
	Fixed Tilt	-3.56	-0.075	3°C								
	Flush Mount	-2.81	-0.0455	0°C								
	East-West	-3.56	-0.075	3°C								
	Carport	-3.56	-0.075	3°C								
Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D
	2	2	2	2	2	2	2	2	2	2	2	2
Irradiation Variance	5%											
Cell Temperature Spread	4° C											
Module Binning Range	-2.5% to 2.5%											
AC System Derate	0.50%											
Module Characterizations	Module	Uploaded By	Characterization									
	REC400AA Pure (REC)	HelioScope	REC400AA_Pure.pan, PAN									
Component Characterizations	Device	Uploaded By	Characterization									
	Sunny Tripower Core1/US (SMA)	HelioScope	Spec Sheet									

Components

Component	Name	Count
Inverters	Sunny Tripower Core1/US (SMA)	2 (100.0 kW)
AC Home Runs	1/0 AWG (Aluminum)	2 (403.9 ft)
Home Runs	10 AWG (Copper)	4 (404.6 ft)
Combiners	3 input Combiner	2
Combiners	5 input Combiner	2
Strings	10 AWG (Copper)	16 (1,177.0 ft)
Module	REC, REC400AA Pure (400W)	268 (107.2 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-19	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Portrait (Vertical)	10°	61.869053°	1.0 ft	1x1	97	97	38.8 kW
Field Segment 2	Fixed Tilt	Portrait (Vertical)	5°	152.2239°	1.0 ft	1x1	171	171	68.4 kW

Detailed Layout

Columbus Park RED Project, 360 Huntington Ave

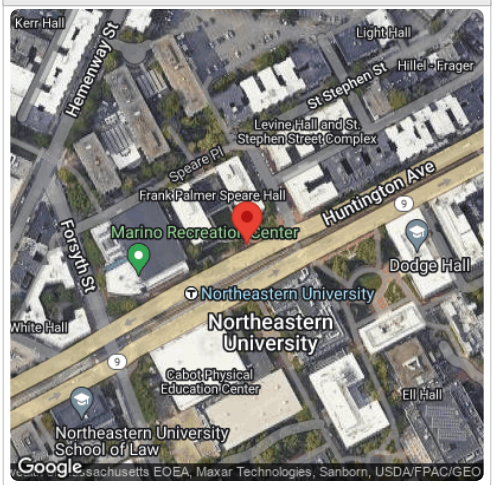
Report

Project Name	RED Project
Project Description	Project
Project Address	360 Huntington Ave
Prepared By	Sri Tejas Sinthalapad Jayakumar sinthalapadjayakum.s@northeastern.edu

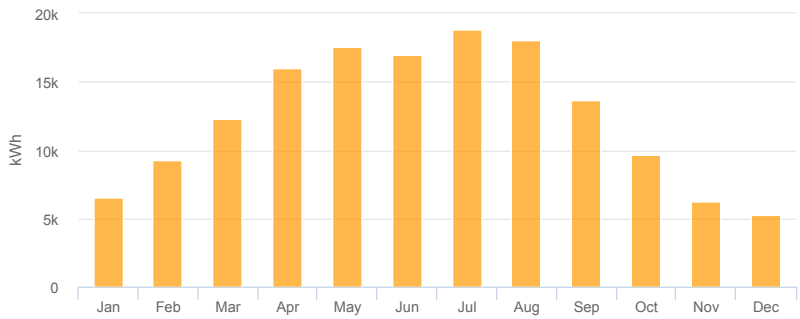
System Metrics

Design	Columbus Park
Module DC Nameplate	121.2 kW
Inverter AC Nameplate	100.0 kW Load Ratio: 1.21
Annual Production	150.4 MWh
Performance Ratio	82.4%
kWh/kWp	1,241.3
Weather Dataset	TMY, 10km grid (42.35,-71.05), NREL (prospector)
Simulator Version	8976e6651e-b01d04b752-b237458c9b-289102318d

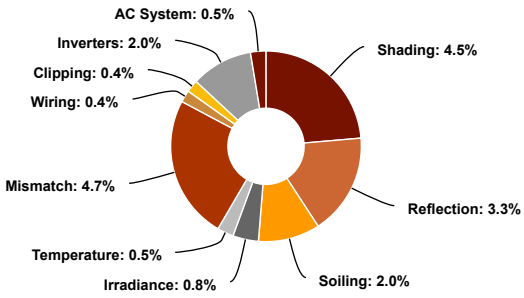
Project Location



Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,423.3	
	POA Irradiance	1,506.1	5.8%
	Shaded Irradiance	1,438.1	-4.5%
	Irradiance after Reflection	1,390.9	-3.3%
	Irradiance after Soiling	1,363.1	-2.0%
	Total Collector Irradiance	**1,363.1**	**0.0%**
Energy (kWh)	Nameplate	165,359.5	
	Output at Irradiance Levels	163,978.1	-0.8%
	Output at Cell Temperature Derate	163,113.9	-0.5%
	Output After Mismatch	155,511.5	-4.7%
	Optimal DC Output	154,906.1	-0.4%
	Constrained DC Output	154,292.4	-0.4%
	Inverter Output	151,202.6	-2.0%
	Energy to Grid	**150,446.5**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		12.0 °C
	Avg. Operating Cell Temp		19.0 °C
Simulation Metrics			
	Operating Hours		4688
	Solved Hours		4688

Condition Set

Description	Condition Set 1											
Weather Dataset	TMY, 10km grid (42.35,-71.05), NREL (prospector)											
Solar Angle Location	Meteo Lat/Lng											
Transposition Model	Perez Model											
Temperature Model	Sandia Model											
Temperature Model Parameters	Rack Type	a	b	Temperature Delta								
	Fixed Tilt	-3.56	-0.075	3°C								
	Flush Mount	-2.81	-0.0455	0°C								
	East-West	-3.56	-0.075	3°C								
	Carport	-3.56	-0.075	3°C								
Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D
	2	2	2	2	2	2	2	2	2	2	2	2
Irradiation Variance	5%											
Cell Temperature Spread	4° C											
Module Binning Range	-2.5% to 2.5%											
AC System Derate	0.50%											
Module Characterizations	Module	Uploaded By	Characterization									
	REC400AA Pure (REC)	HelioScope	REC400AA_Pure.pan, PAN									
Component Characterizations	Device	Uploaded By	Characterization									
	Sunny Tripower Core1/US (SMA)	HelioScope	Spec Sheet									

Components

Component	Name	Count
Inverters	Sunny Tripower Core1/US (SMA)	2 (100.0 kW)
Home Runs	10 AWG (Copper)	6 (122.7 ft)
Combiners	1 input Combiner	3
Combiners	4 input Combiner	1
Combiners	5 input Combiner	1
Combiners	8 input Combiner	1
Strings	10 AWG (Copper)	17 (3,215.3 ft)
Module	REC, REC400AA Pure (400W)	303 (121.2 kW)

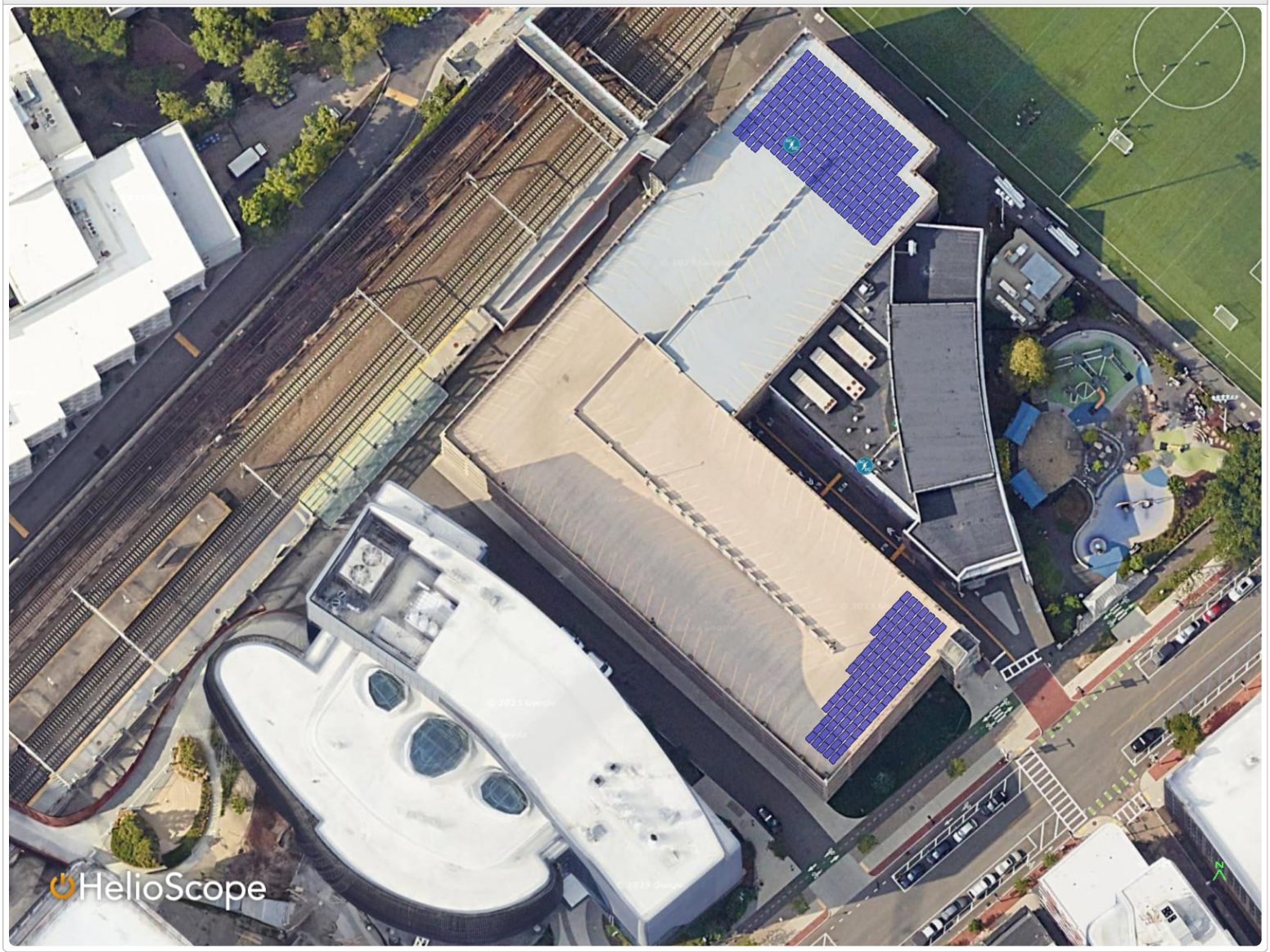
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-19	Along Racking
Wiring Zone 2	12	-	Along Racking
Wiring Zone 3	12	-	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	10°	132.12921°	1.0 ft	1x1	303	303	121.2 kW

Detailed Layout



Renaissance Park RED Project, 360 Huntington Ave

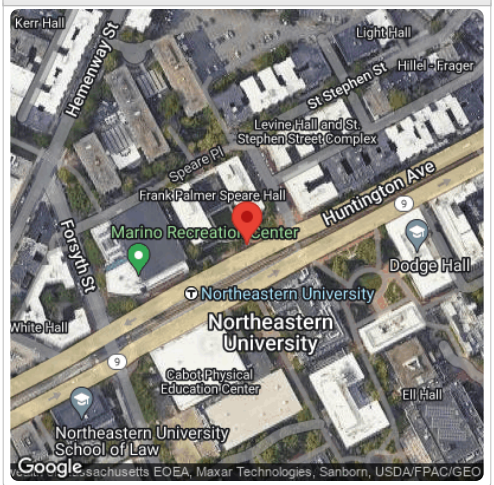
Report

Project Name	RED Project
Project Description	Project
Project Address	360 Huntington Ave
Prepared By	Sri Tejas Sinthalapad Jayakumar sinthalapadjayakum.s@northeastern.edu

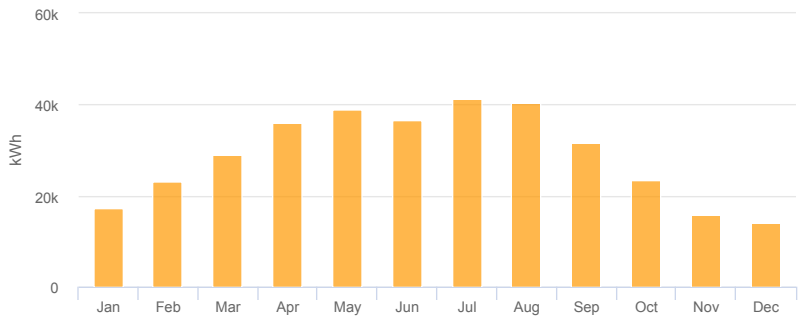
System Metrics

Design	Renaissance Park
Module DC Nameplate	266.0 kW
Inverter AC Nameplate	250.0 kW Load Ratio: 1.06
Annual Production	347.6 MWh
Performance Ratio	84.4%
kWh/kWp	1,306.8
Weather Dataset	TMY, 10km grid (42.35,-71.05), NREL (prospector)
Simulator Version	8976e6651e-b01d04b752-b237458c9b-289102318d

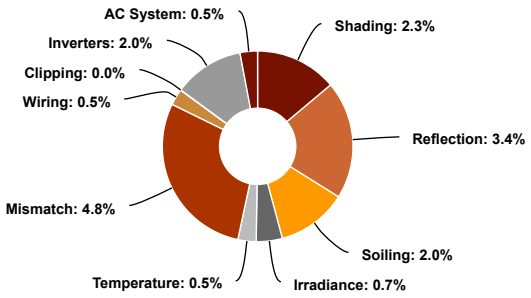
Project Location



Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,423.3	
	POA Irradiance	1,547.5	8.7%
	Shaded Irradiance	1,511.5	-2.3%
	Irradiance after Reflection	1,460.8	-3.4%
	Irradiance after Soiling	1,431.6	-2.0%
	Total Collector Irradiance	**1,431.7**	**0.0%**
Energy (kWh)	Nameplate	381,193.1	
	Output at Irradiance Levels	378,360.5	-0.7%
	Output at Cell Temperature Derate	376,405.9	-0.5%
	Output After Mismatch	358,168.5	-4.8%
	Optimal DC Output	356,509.8	-0.5%
	Constrained DC Output	356,485.7	0.0%
	Inverter Output	349,356.0	-2.0%
	Energy to Grid	**347,609.3**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		12.0 °C
	Avg. Operating Cell Temp		19.3 °C
Simulation Metrics			
	Operating Hours		4688
	Solved Hours		4688

Condition Set

Description	Condition Set 1											
Weather Dataset	TMY, 10km grid (42.35,-71.05), NREL (prospector)											
Solar Angle Location	Meteo Lat/Lng											
Transposition Model	Perez Model											
Temperature Model	Sandia Model											
Temperature Model Parameters	Rack Type	a	b	Temperature Delta								
	Fixed Tilt	-3.56	-0.075	3°C								
	Flush Mount	-2.81	-0.0455	0°C								
	East-West	-3.56	-0.075	3°C								
	Carport	-3.56	-0.075	3°C								
Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D
	2	2	2	2	2	2	2	2	2	2	2	2
Irradiation Variance	5%											
Cell Temperature Spread	4° C											
Module Binning Range	-2.5% to 2.5%											
AC System Derate	0.50%											
Module Characterizations	Module	Uploaded By	Characterization									
	TSM-PD14 320 (May16) (Trina Solar)	HelioScope	Spec Sheet Characterization, PAN									
	REC400AA Pure (REC)	HelioScope	REC400AA_Pure.pan, PAN									
Component Characterizations	Device	Uploaded By	Characterization									
	Sunny Tripower Core1/US (SMA)	HelioScope	Spec Sheet									

Components

Component	Name	Count
Inverters	Sunny Tripower Core1/US (SMA)	5 (250.0 kW)
Home Runs	10 AWG (Copper)	20 (749.3 ft)
Combiners	1 input Combiner	10
Combiners	3 input Combiner	5
Combiners	5 input Combiner	5
Strings	10 AWG (Copper)	40 (3,130.0 ft)
Module	REC, REC400AA Pure (400W)	665 (266.0 kW)

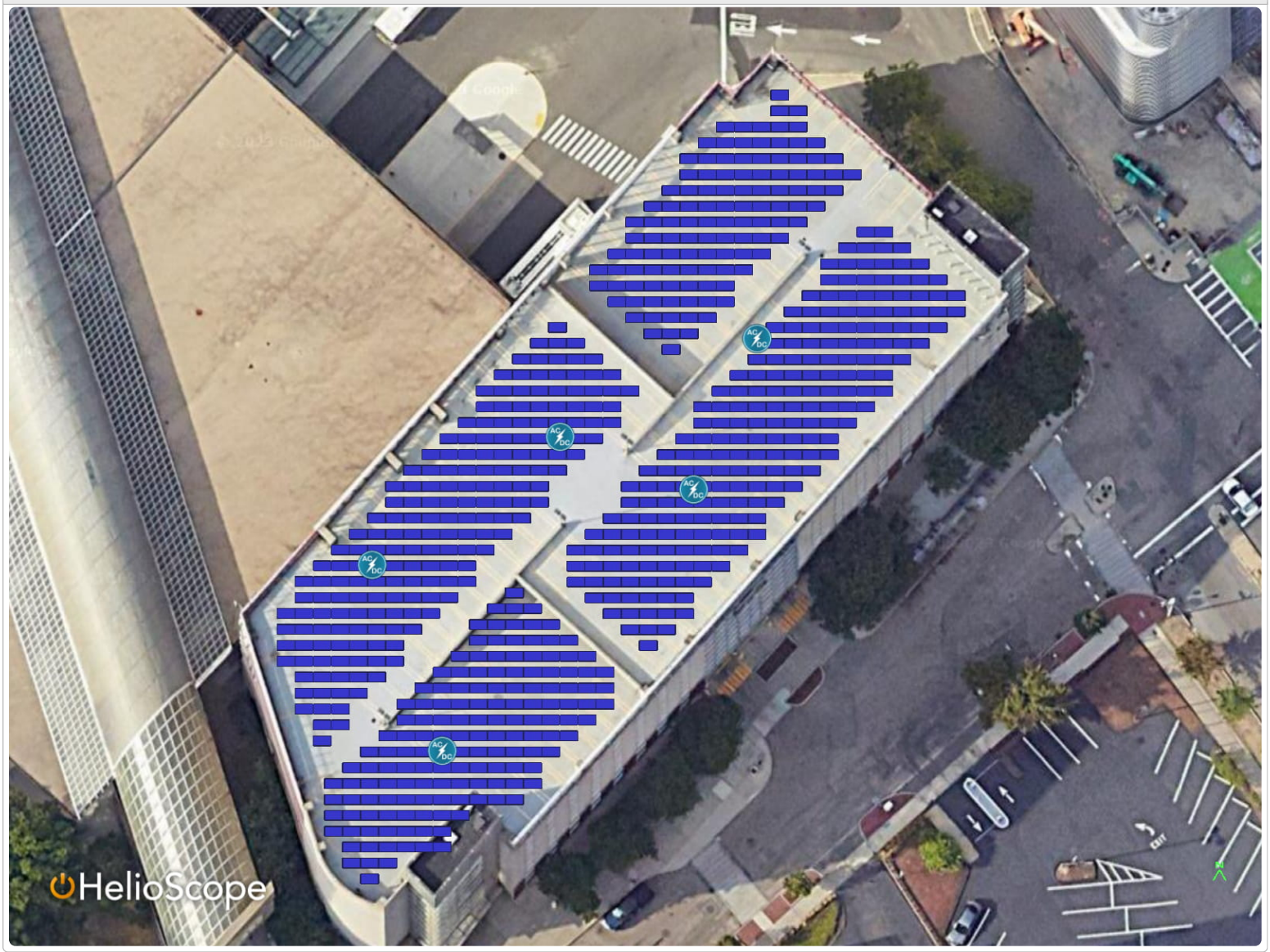
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-19	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	10°	180°	2.0 ft	1x1	214	214	85.6 kW
Field Segment 2	Fixed Tilt	Landscape (Horizontal)	10°	180°	2.0 ft	1x1	188	188	75.2 kW
Field Segment 3	Fixed Tilt	Landscape (Horizontal)	10°	180°	2.0 ft	1x1	115	115	46.0 kW
Field Segment 4	Fixed Tilt	Landscape (Horizontal)	10°	180°	2.0 ft	1x1			0
Field Segment 5	Fixed Tilt	Landscape (Horizontal)	10°	180°	2.0 ft	1x1	148	148	59.2 kW

Detailed Layout



Single Line Diagram

HelioScope | Save & Exit | Design Revisions | Sri Tejas Sinthalapad Jayakumar

shillman hall Preferences

Saved | Showing Array

Mechanical | Keepouts | Electrical | Advanced

Field Segments New

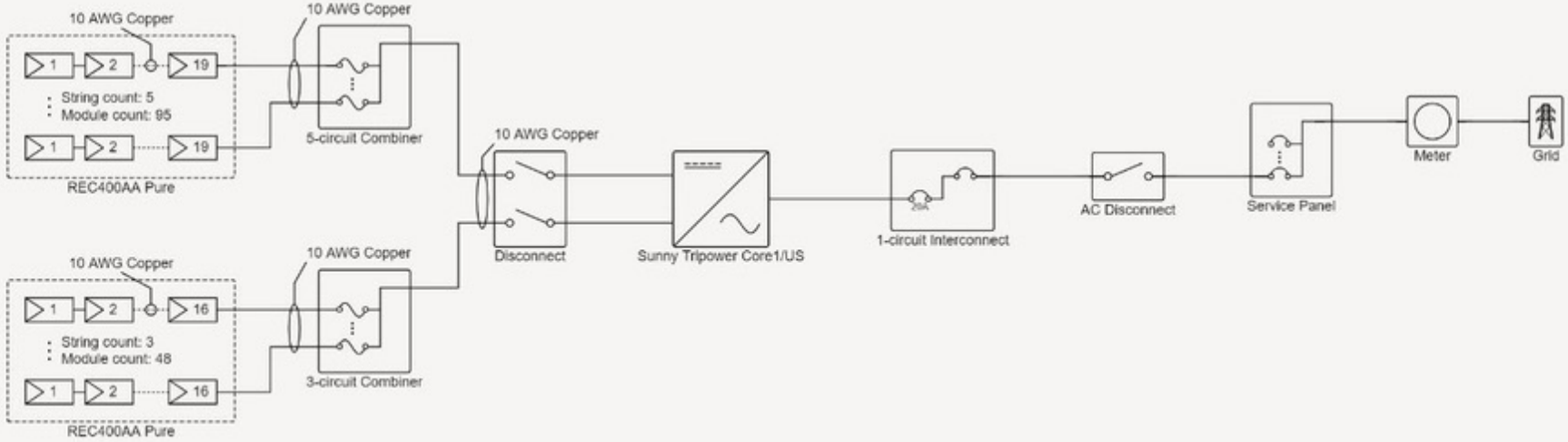
Field segments cast shadows

Description	Modules	Action
Field Segment 1	143 (57kW)	

143 Modules, 57.2kWp

Map | SLD | Export DXF

PREVIEW



Module Specifications	
143x REC REC400AA Pure	
STC Rating	400 W
Vmp	42.1 V
Imp	9.51 A
Voc	48.8 V
Isc	10.25 A

Inverter Specifications	
1x SMA Sunny Tripower Core1/US	
Max AC Power Rating	50 kW
Max Input Voltage	1,000 V
Min AC Power Rating	0 W
Min Input Voltage	150 V

Wire Schedule		
Tier	Wire	Length
Bus	2x 10 AWG	152ft
String	8x 10 AWG	494ft

Renaissance Park

Preferences

Saved | Showing Array

Mechanical | Keepouts | Electrical | Advanced

Field Segments

New

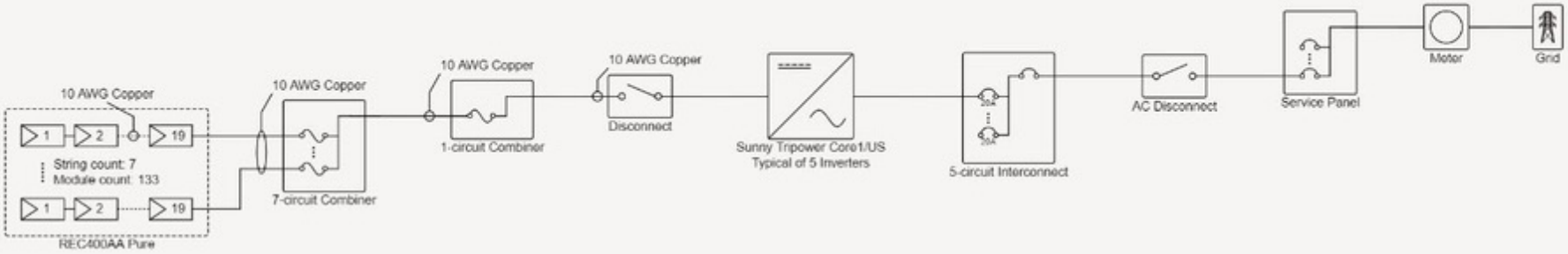
Field segments cast shadows

Description	Modules	Action
Field Segment 1	214 (86kW)	
Field Segment 2	188 (75kW)	
Field Segment 3	115 (46kW)	
Field Segment 4	0	
Field Segment 5	148 (59kW)	

665 Modules, 266.0kWp

Map | SLD | Export DXF

PREVIEW



Module Specifications	
665x REC REC400AA Pure	
STC Rating	400 W
Vmp	42.1 V
Imp	9.51 A
Voc	48.8 V
Isc	10.25 A

Inverter Specifications	
5x SMA Sunny Tripower Core1/US	
Max AC Power Rating	50 kW
Max Input Voltage	1,000 V
Min AC Power Rating	0 W
Min Input Voltage	150 V

Wire Schedule		
Tier	Wire	Length
Trunk	5x 10 AWG	185ft
Bus	5x 10 AWG	<1ft
String	35x 10 AWG	3855ft

Questions? Ask us!

Columbus Park

Preferences

Saved | Showing Array

Mechanical | Keepouts | Electrical | Advanced

Field Segments

New

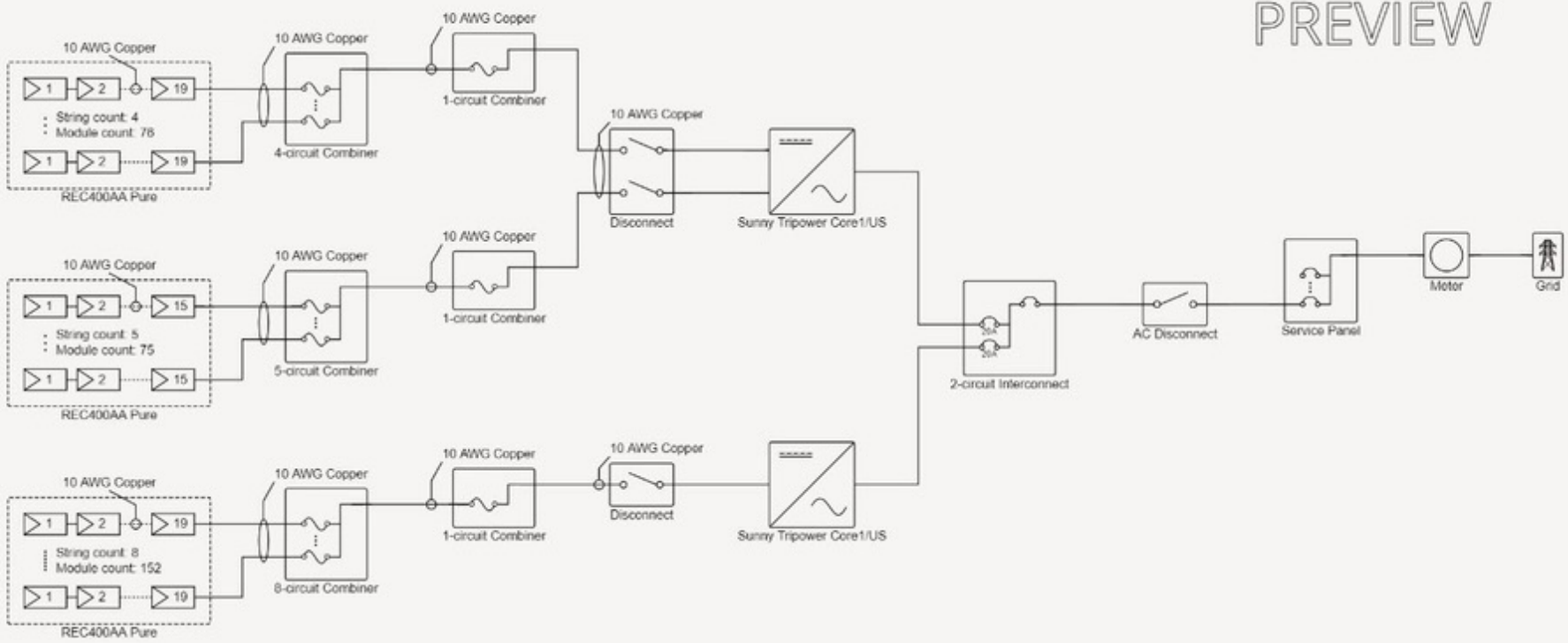
Field segments cast shadows

Description	Modules	Action
Field Segment 1	303 (121kW)	

303 Modules, 121.2kWp

Map | SLD | Export DXF

PREVIEW



Module Specifications	
303x REC REC400AA Pure	
STC Rating	400 W
Vmp	42.1 V
Imp	9.51 A
Voc	48.8 V
Isc	10.25 A

Inverter Specifications	
2x SMA Sunny Tripower Core1/US	
Max AC Power Rating	50 kW
Max Input Voltage	1,000 V
Min AC Power Rating	0 W
Min Input Voltage	150 V

Wire Schedule		
Tier	Wire	Length
Trunk	3x 10 AWG	123ft
Bus	3x 10 AWG	<1ft
String	17x 10 AWG	3215ft

Questions? Ask us!

Snell Engineering Ce... Preferences

Saved | Showing Array

Mechanical | Keepouts | Electrical | Advanced

Field Segments New

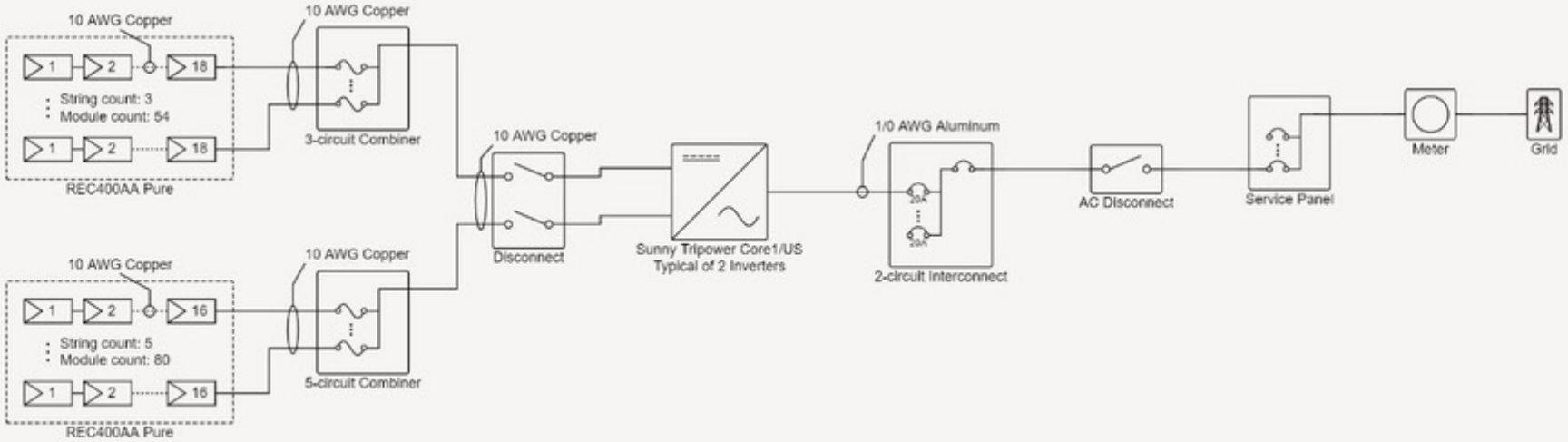
Field segments cast shadows

Description	Modules	Action
Field Segment 1	97 (39kW)	
Field Segment 2	171 (68kW)	

268 Modules, 107.2kWp

Map | SLD | Export DXF

PREVIEW



Module Specifications	
268x REC REC400AA Pure	
STC Rating	400 W
Vmp	42.1 V
Imp	9.51 A
Voc	48.8 V
Isc	10.25 A

Inverter Specifications	
2x SMA Sunny Tripower Core1/US	
Max AC Power Rating	50 kW
Max Input Voltage	1,000 V
Min AC Power Rating	0 W
Min Input Voltage	150 V

Wire Schedule		
Tier	Wire	Length
AC Branch	2x 1/0 AWG	404ft
Bus	4x 10 AWG	405ft
String	16x 10 AWG	1177ft