Team Name: The Cooper Union

Project Proposal Presentation

Bring-Your-Own-District (BYOD) Division:

Lower East Side, Manhattan

The Cooper Union for the Advancement of Science and Art

Agenda

1. **Meet the Team**
2. **District Use Case**
   - Manhattan's Lower East Side
   - Climate Mobilization Act & LL97
   - Project Goals and Constraints
3. **System Design**
   - Project Snapshot
   - Equipment Selection
   - PV System Design and Storage
4. **Distribution System Impact**
5. **Financial Analysis**
   - Financial Assumptions
   - System Financial Summary
6. **Development Planning**
   - Zoning and Local Compliance
   - Permitting, Construction & Interconnection
   - Distributional Energy Equity

Meet The Team

Undergraduate Students:

Aaryan Mahipal
Mechanical Engineering, Class of 2025

Gautaman Asirwatham
Mechanical Engineering, Class of 2025

Logan Po
Electrical Engineering, Class of 2025

Akil Foster
Mechanical Engineering, Class of 2025

Alek Turkmen
Mechanical Engineering, Class of 2025

Advisors:

Dr. Kamau Wright
Professor of Mechanical Engineering, The Cooper Union

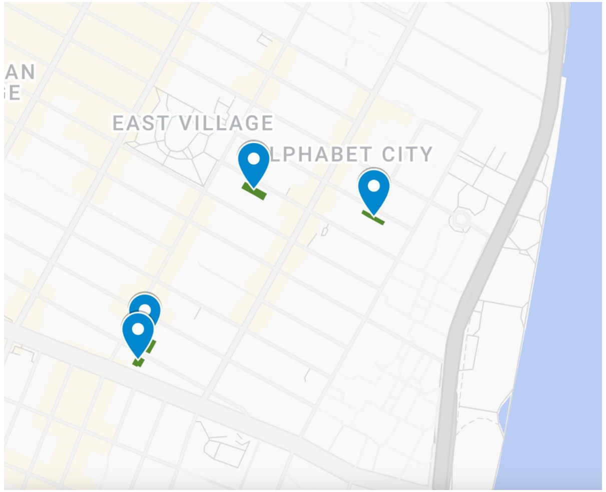
Dr. Melody Baglione
Professor of Mechanical Engineering, The Cooper Union

Paul Garrin
Ecolibrium Program Director, Loisaida Inc.

District Use Case - Lower East Side

The Lower East Side is known for its dense mix of **prewar walkups** and **postwar towers**. Although older buildings pose unique **structural** and **space** challenges, adopting **rooftop solar** can be a practical and cost-effective solution to the **fast changing regulatory landscape** and the city's ambitious decarbonization goals.

Building Address	Square Footage	Annual Electric Load (kWh)
308 E 8th Street, New York, NY	97,000	25,070.74
722-740 E 9th Street, New York, NY	64,907	128,816.75
215-219 E 2nd Street, New York, NY	22,390	26,249.55
218 E 2nd Street, New York, NY (Parking Lot)	6,570	~0



Site Map

Meet the Team | **District Use Case** | System Design | Distribution System Impact | Financial Analysis | Development Planning

Climate Mobilization Act and LL97

NYC's Regulatory Landscape and Climate Mobilization Act

New York City's Climate Mobilization Act (CMA) is a pivotal step towards achieving the city's decarbonization goals. Local Law 97 (LL97), effective from 2024, mandates that buildings over 25,000 square feet reduce their carbon emissions or face significant fines.

Local Law 97 Penalties

$$\text{Maximum annual penalty} = \left(\text{actual emissions} - \text{annual emissions limit}\right) \times \$268$$

Emission Reduction Targets

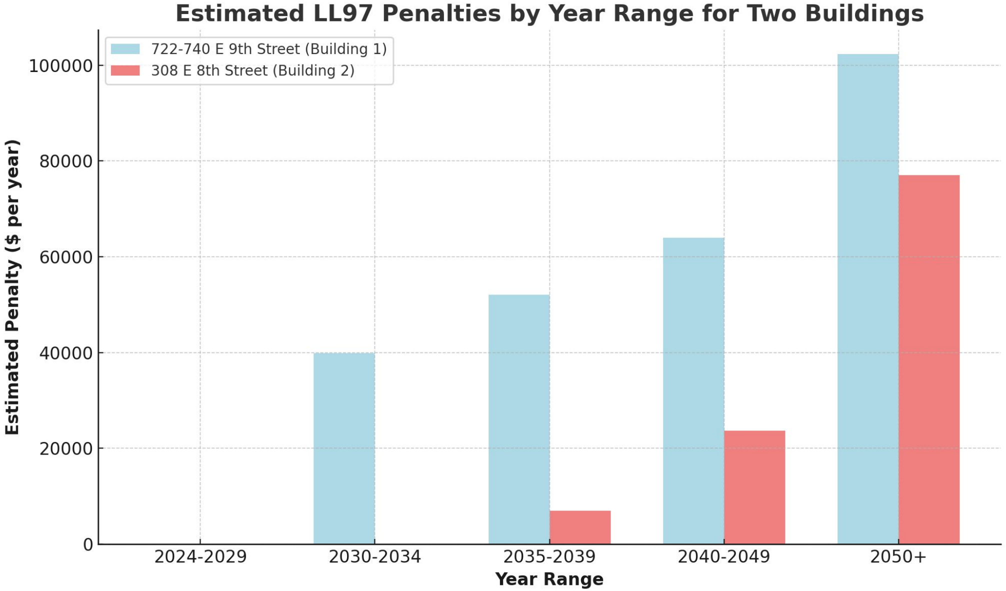
40%

By 2030

80%

By 2050

Undertaking their own micro-grid and virtual power plant feasibility studies for the Lower East Side



Project Goals and Constraints

Technical Constraints

1. **NYC's Climate**
   Although NYC experiences a four-season climate with moderate winter sun, Manhattan's average GHI is 4 kWh/m²/day, sufficient for robust solar production

2. **Compliance With Regulations Set by Various AHJ**
   Rooftop solar systems must comply with the regulations established in NYC Construction, Electrical and Conservation Codes, NYC Zoning Resolution, and NYC Fire Codes

3. **Limited Rooftop Space and Urban Canyon Effect**

4. **Grid Hosting Capacity and Interconnection Infrastructure**

Design Goals

1. **Offset Carbon Emissions**
   The primary goal is to offset the building's carbon emissions to comply with LL97 and avoid subsequent fines

2. **Peak Load Shifting**
   Incorporating a BESS where financially feasible to discharge during peak periods, allowing for a consumption shift from peak to off-peak hours

3. **Time-Of-Use Optimization**
   Ensures that energy is used at the most cost-effective times by shifting consumption and storage based on electricity prices

4. **Attractive Customer Savings and Investor's IRR**

Project Snapshot

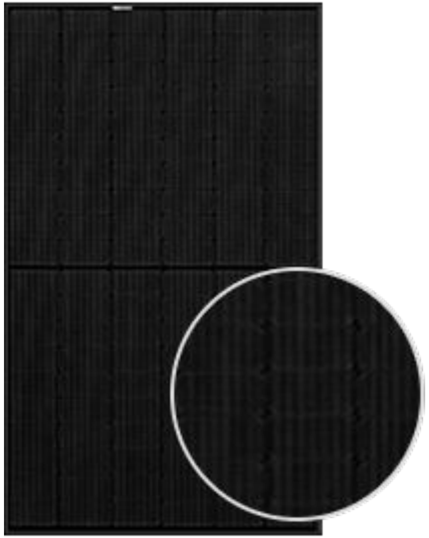
Location	Type	System Sizing (kW-DC)	Solar Panels	Annual Energy Prod. (MWh)
308 E 8th Street, New York, NY	Rooftop Canopy	30.8	75	43.80
722-740 E 9th Street, New York, NY	Rooftop Canopy	9.8	24	14.59
215-219 E 2nd Street, New York, NY	Rooftop Canopy	11.5	28	16.10
218 E 2nd Street, New York, NY	Carport	32.8	80	45.67
Total		84.9	207	120.25

66.8% of the annual electricity consumption of the campus will now be solar!

Design Decisions

- *Maximize* **solar access** and *eliminate* any **row-to-row module shading**
- *Maximize* **energy generation**, due to limite rooftop space, *maximize* **panel count**
- **South-facing** panel orientation at 24° to *maximize* **solar irradiation hours** and surface area exposed.
- **Landscape orientation** required less row spacing and allowed for more panels.

Panel Selection



Panasonic EVPV410H

Specifications

Module Efficiency	22.2%
Cell Type	Monocrystalline
Output Warranty (25 years)	90-91%
Watts per Pound	9.5 - 9.8 W/lb
Watts per sq.ft.	20.6 W/sq.ft.
Cost per Watt	$0.70-$0.85/W

Design Choice

- This module was compared with four other modules, namely, Q Cells G10, Jinko Tiger Neo, Trina Vertex S, and REC Alpha Pure
- The Panasonic EVPV410H was on the costlier side per panel, but outperformed most other choices in terms of **watts per pound, watts per square feet, and cost per watt**
- The Panasonic panel provided the best compromise for a lightweight panel that has a high module rating and efficiency
- A **lightweight panel** and high **watts per square feet** was crucial due to the limited rooftop space and raised canopy design

Inverter Selection

Amnesolar N3H-X5-US

Specifications

Max. Input DC Power	7.5 kW
Output AC Voltage	120 V RMS (Split Phase) 208 V RMS (3 Phase)
Output Frequency	60 Hz
Max. Power into Grid	5.5 kVA
THD	< 2%

Design Choice

- The standard 120 V RMS AC output aligns with U.S. household voltage, *minimizing* **integration complexity**
- This inverter is optimized for **urban installations** with protections against over and under voltage, short circuits and battery reverse polarity
- The power rating is well matched to **typical urban building loads**, enabling efficient energy output management using just a few inverters

BESS Selection

LG RESU10H Battery

Specifications

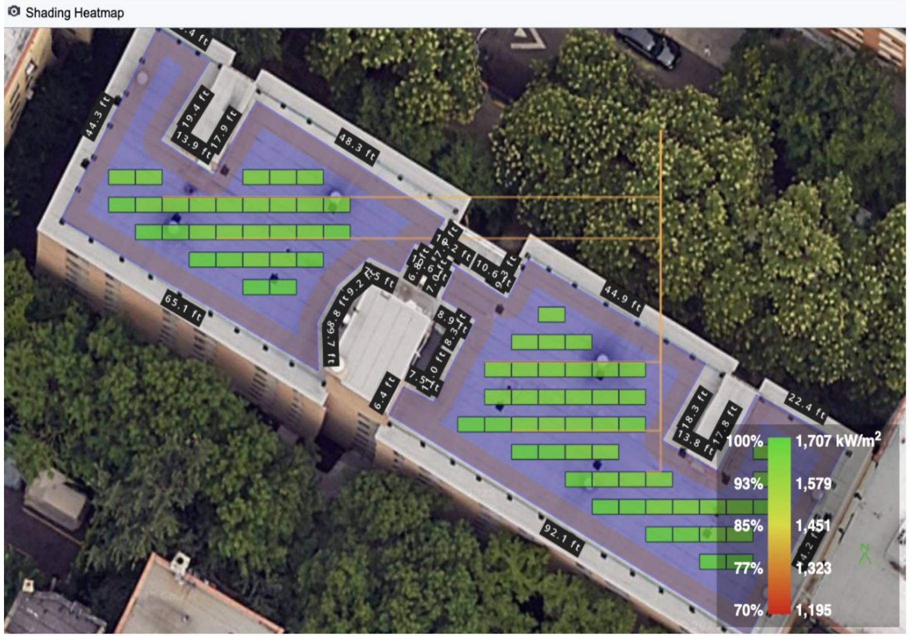
Usable Capacity	9.8 kWh
Cell Type	Lithium-Ion
Nominal Voltage	350 V
Round-Trip Efficiency	95%
Cycle Life (at 80% DOD)	6,000 cycles
Cost per kWh	$130

Design Choice

- This was chosen because it strikes an excellent balance between capacity, efficiency, and longevity.
- Its robust cycle life ensures long-term performance, while the competitive cost per-kWh makes it a cost-effective investment.
- The lithium-ion technology provides reliable performance and safety.

System Design: 308 E 8th Street

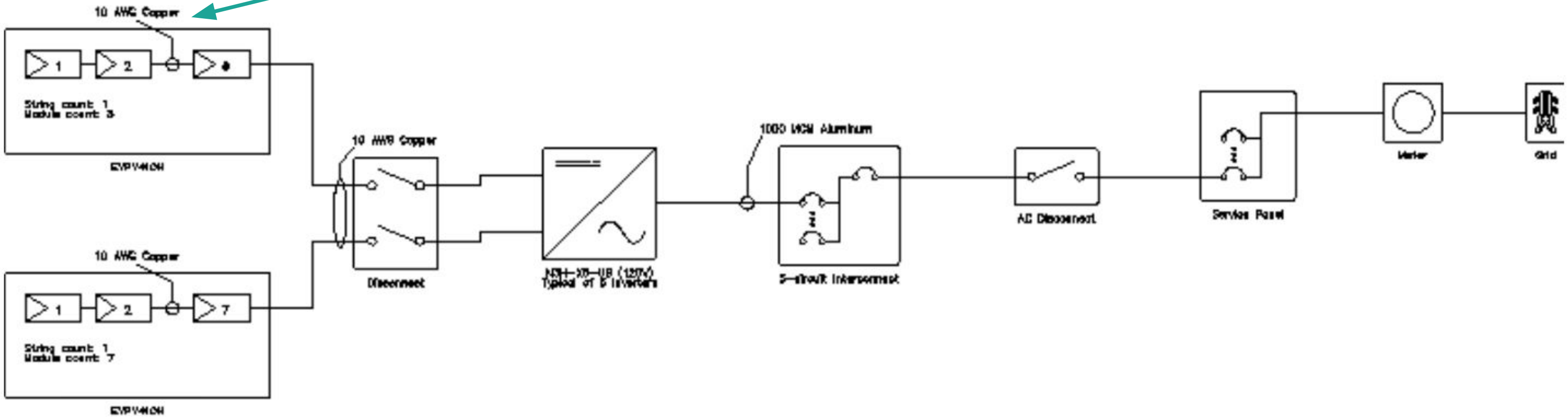
PV System Layout



Shading Irradiance Heatmap

Single-Line-Diagram for 308 E 8th Street

Standard gauge for PV wiring

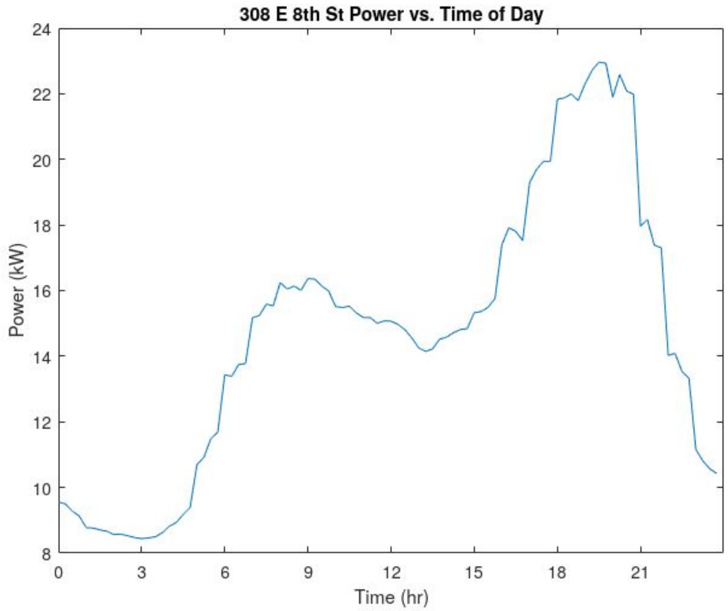


Module Specifications	
75x Panasonic EVPV410H	
STC Rating	410 W
Vmp	42.7 V
Imp	9.61 A
Voc	49 V
Isc	10.25 A

Inverter Specifications	
5x Amensolar N3H-X5-US (120V)	
Max AC Power Rating	5.5 kW
Max Input Voltage	500 V
Min AC Power Rating	0 W
Min Input Voltage	120 V

Wire Schedule		
Tier	Wire	Length
String	10x 10 AWG	30ft.

BESS Sizing for 308 E 8th Street



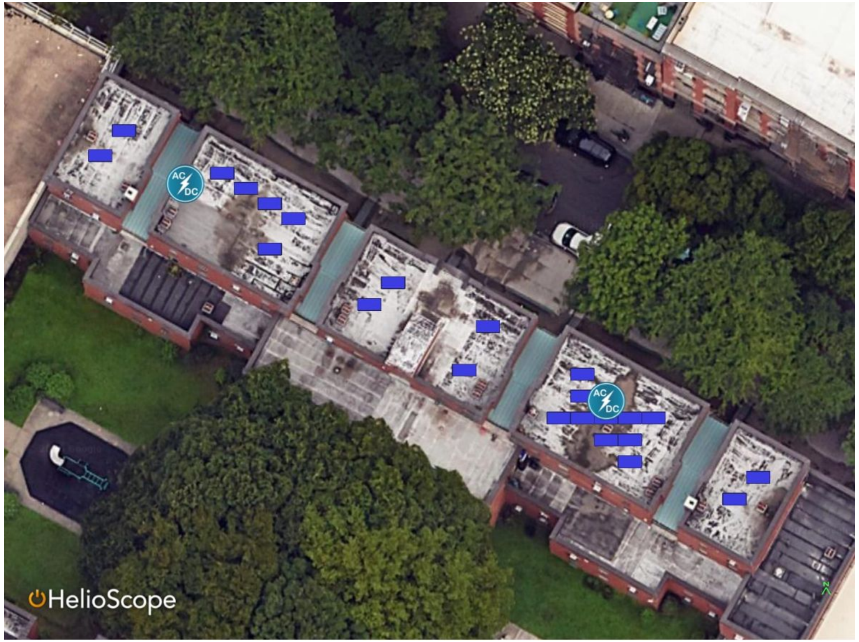
Average Daily Load Profile

Site	Battery Case	NPV ($)	LCOE (¢/kWh)	IRR (%)
308 E 8th St.	No Battery	4,674	15.02	7.02
	Small (10 kWh)	1,264	15.71	5.04
	Medium (25 kWh)	-1,518	16.27	3.63
	Large (50 kWh)	-6,467	17.21	1.51

- The SAM simulation indicates that, under current assumptions, battery integrations beyond a modest size tend to reduce project economic returns. Further optimization of battery usage (including dynamic dispatch strategies) might improve these outcomes.

- For 308 E 8th Street, the small (10 kWh) battery was selected because it had a positive NPV and improved load shifting without oversizing.

System Design: 722-740 E 9th Street

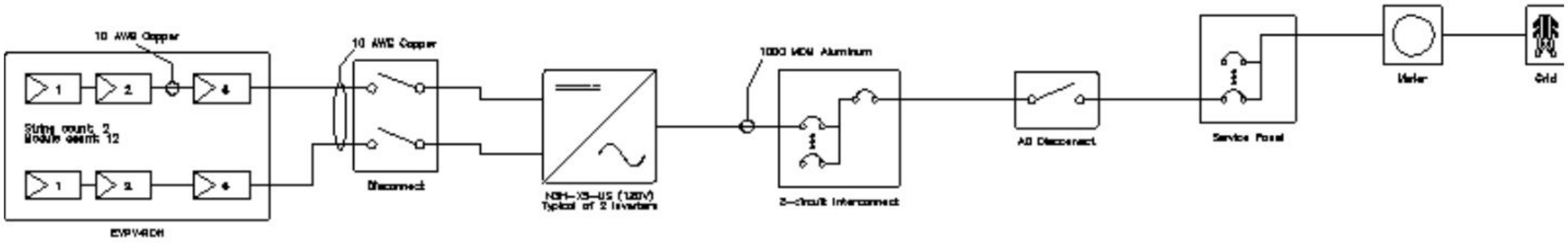


PV System Layout

Shading Irradiance Heatmap

Meet the Team | District Use Case | **System Design** | Distribution System Impact | Financial Analysis | Development Planning

Single-Line-Diagram for 722-740 E 9th Street

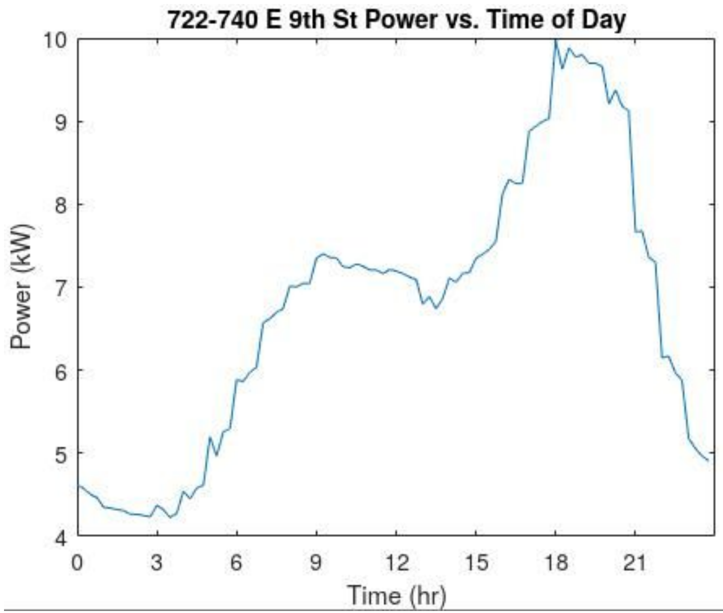


Module Specifications	
24x Panasonic EVPV410H	
STC Rating	410 W
Vmp	42.7 V
Imp	9.61 A
Voc	49 V
Isc	10.25 A

Inverter Specifications	
2x Amensolar N3H-X5-US (120V)	
Max AC Power Rating	5.5 kW
Max Input Voltage	600 V
Min AC Power Rating	0 W
Min Input Voltage	120 V

Wire Schedule		
Tier	Wire	Length
String	4x 10 AWG	556ft

BESS Sizing for 722-740 E 9th Street



Average Daily Load Profile

Site	Battery Case	NPV ($)	LCOE (¢/kWh)	IRR (%)
722–740 E 9th St.	No Battery	1,774	14.98	7.14
	Small (16 kWh)	-1,818	16.94	2.10
	Medium (40 kWh)	-6,874	19.46	-2.42
	Large (80 kWh)	-14,893	23.42	-6.92

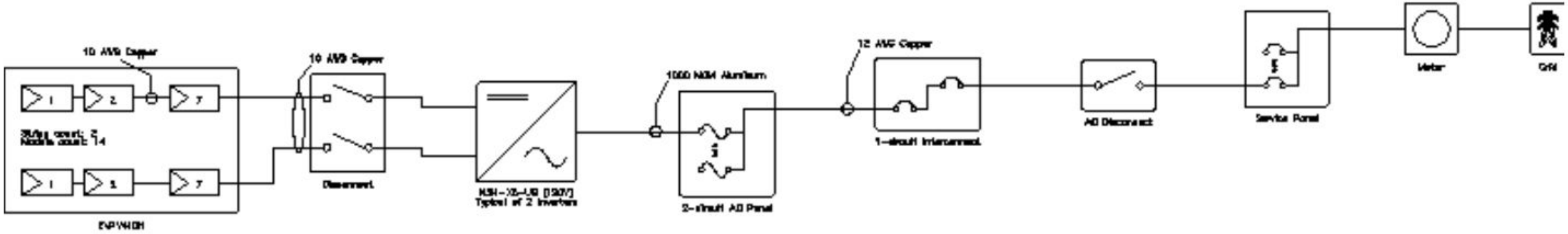
- The SAM simulation indicates that, under current assumptions, battery integrations beyond a modest size tend to reduce project economic returns. Further optimization of battery usage (including dynamic dispatch strategies) might improve these outcomes.
- For 722-740 E 9th Street, even though a small battery has a positive NPV and IRR, it diminishes savings and returns from a PV-only system and the system is not generating enough to shift peak loads.

System Design: 215-219 E 2nd Street

PV System Layout

Shading Irradiance Heatmap

Single-Line-Diagram for 215-219 E 2nd Street



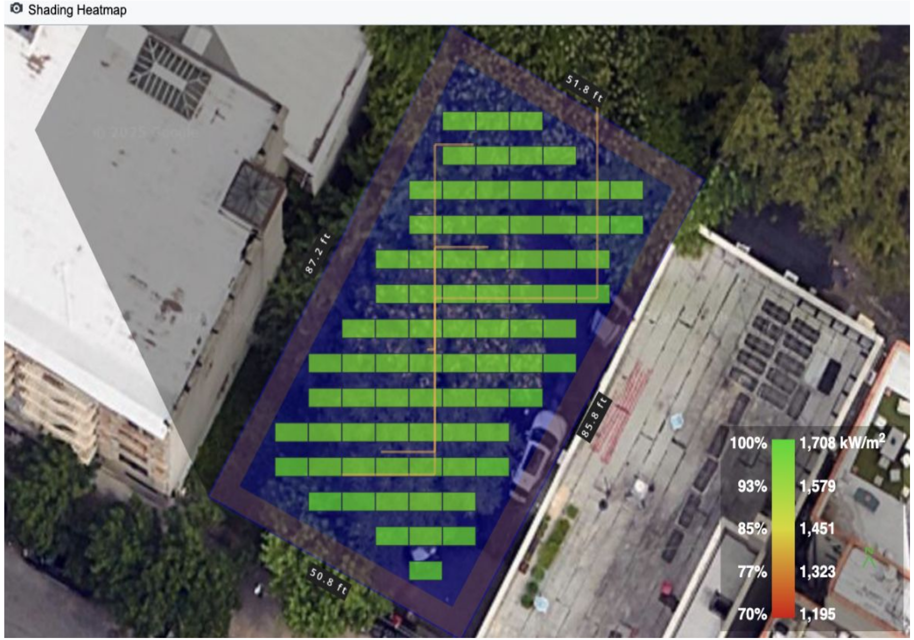
Module Specifications	
28x Panasonic EVPV410H	
STC Rating	410 W
Vmp	42.7 V
Imp	9.41 A
Voc	49 V
Isc	10.20 A

Inverter Specifications	
2x [illegible] (120V)	
Max AC Power Rating	6.6 kW
Max Input Voltage	600 V
Min AC Power Rating	0 W
Min Input Voltage	150 V

Wire Schedule		
Tier	Wire	Length
String	4x 10 AWG	140ft

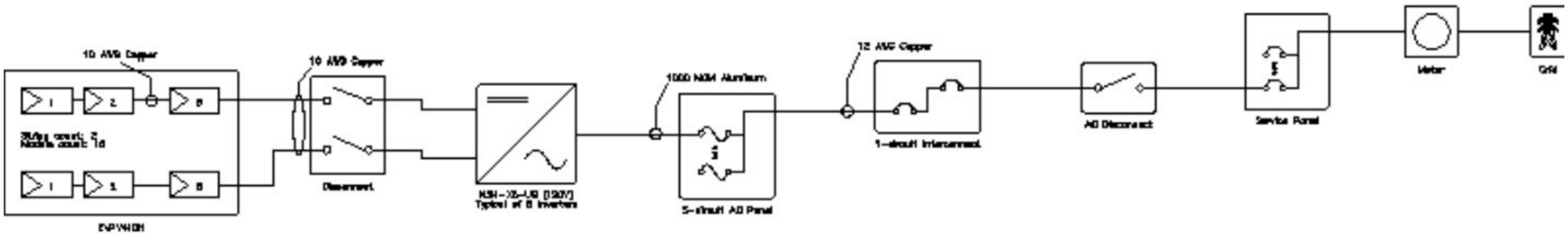
System Design: 218 E 2nd Street

PV System Layout



Shading Irradiance Heatmap

Single-Line-Diagram for 218 E 2nd Street

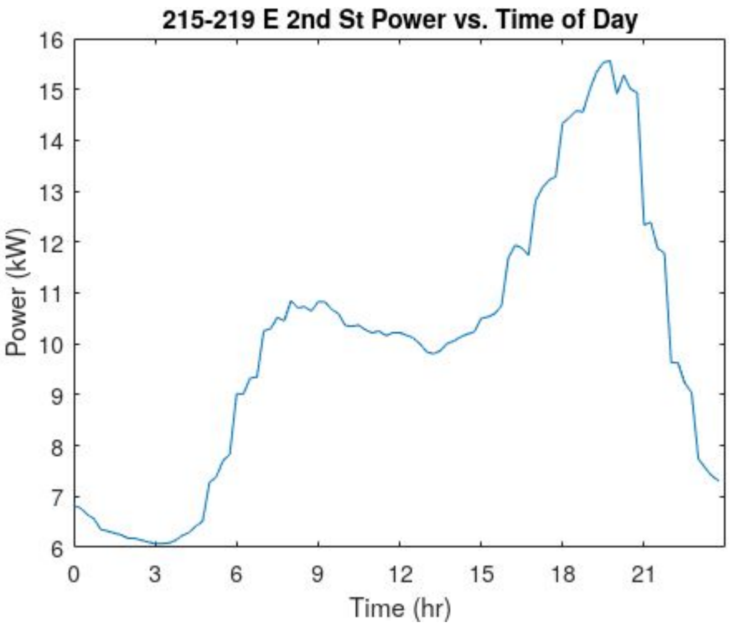


Module Specifications	
[illegible] Panasonic EVPV410H	
STC Rating	410 W
Vmp	42.7 V
Imp	9.61 A
Voc	49 V
Isc	10.26 A

Inverter Specifications	
[illegible] (120V)	
Max AC Power Rating	6.6 kW
Max Input Voltage	600 V
Min AC Power Rating	0 W
Min Input Voltage	120 V

Wire Schedule		
Tier	Wire	Length
String	10x 10 AWG	[illegible]

BESS Sizing for 215-219 E 2nd Street



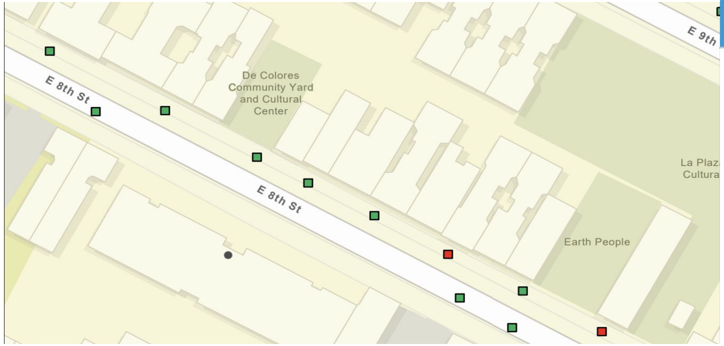
Average Daily Load Profile

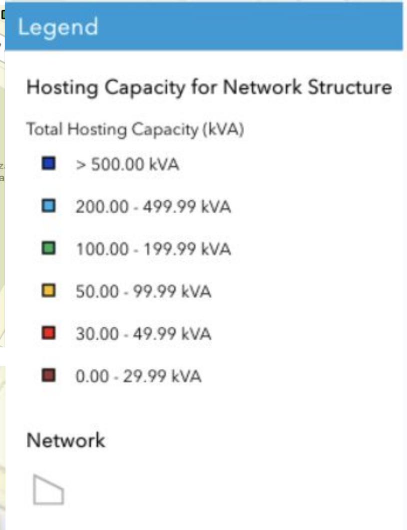
Site	Battery Case	NPV ($)	LCOE (¢/kWh)	IRR (%)
215-219 E 2nd St.	No Battery	6,538	15.02	10.52
	Small (16 kWh)	1,392	15.76	9.01
	Medium (40 kWh)	-3,357	16.44	3.21
	Large (80 kWh)	-11,289	17.50	0.90

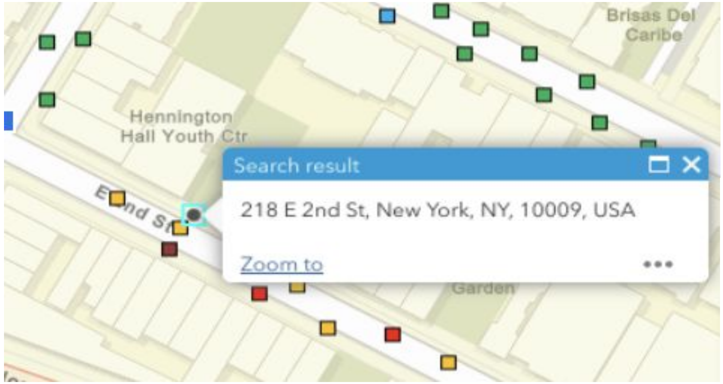
- The SAM simulation indicates that, under current assumptions, battery integrations beyond a modest size tend to reduce project economic returns. Further optimization of battery usage (including dynamic dispatch strategies) might improve these outcomes.

- For 215-219 E 2th Street, the small (16 kWh) battery was selected because it had a positive NPV and improved load shifting without oversizing.

Interconnection and Grid Hosting Capacity





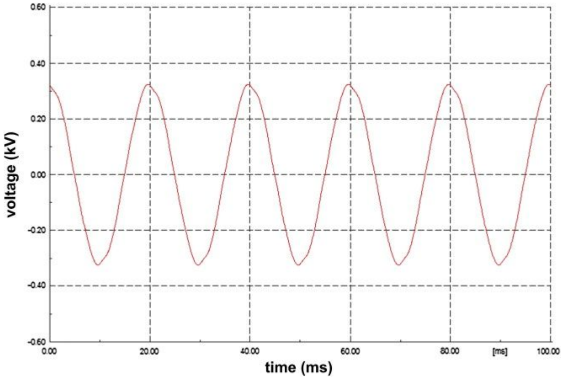


- If hosting capacity along the block is **good (>100 kVA)**, interconnect at the point closest to the building.
- If If hosting capacity along the block is **poor (<100 kVA)**, interconnect at the point closest to the building with good hosting capacity. This may mean longer interconnection distances and more infrastructure costs.

Site Location	Hosting Capacity (kVA)	Interconnection Point
308 E 8th St.	100–200	Adjacent to building (sufficient)
722–740 E 9th St.	100–200	Adjacent to building (sufficient)
215–219 E 2nd St.	Low (Insufficient)	Reconfigured to 2nd St./Ave. B

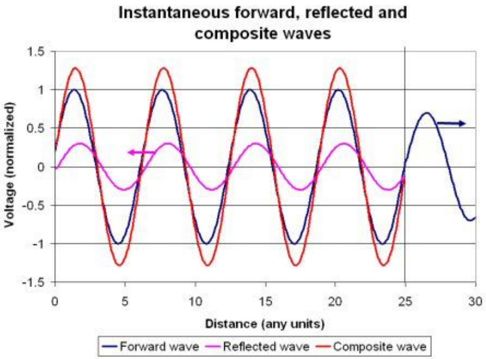
Distribution System Impact

Harmonic distortion causes a PV system to generate a higher voltage amplitude than expected.



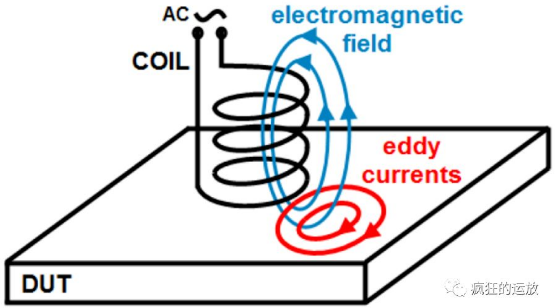
Harmonic Distribution. Image by Kresimir Fekete et al.

Grid backfeed allows excess solar generation to be reflected back into the grid, potentially overloading transformers and protective equipment.



Grid Backfeed. Image via Microwaves 101 (website)

Energy leakage is inherent to electrical components (e.g. slew rate in transistors, self-induced eddy currents in transformers) and can cause overheating.



Component Losses. Image by Tiger Transformer (website)

Financial Analysis: Inputs & Assumptions

PPA Price: $0.16/kWh **System Size: 85,400 W** **Aggregate Project Cost: $133,761**

- For the purpose of this project, it is assumed that the roofs are in sufficient condition to support the PV installation and need not be replaced.
- The property tax is set at 0% and the project life is 30 years.

  All other financial assumptions were assumed to be standard and the same as NREL's recommendations.
- System Costs were modeled considering NYC labor prices and installation costs for canopies, safety, and interconnection.

SYSTEM INPUTS	DC (W)	AC (W)
Construction Cost/Watt	$1.15	$1.29
Roof Upgrade & Warranty	$0.00	$0.00
Interconnection Costs	$0.07	$0.07
Total cost per watt	$1.22	$1.36
Size of System in W	85,400	76,250
Panel and Hard Eq. Cost per W	$1.43	$1.60
Est. P50 Annual Production (kWh per kW DC)		1,389
Annual Panel Degradation Rate		0.50%
Est. Delta, P95/P50		93.50%
Est. P50 kWh/year Production		118,621
Est. P95 kWh/year Production		110,910
AC to DC Conversion Factor		112%

Financial Analysis: Customer-Owned vs Investor-Owned

Customer-Owned Scenario

The property owner or co-op board finances and owns the system outright, capturing tax credits, incentives, and net-metering benefits

Estimated Customer Savings	$751,000
Customer After-Tax Internal Rate of Return (ATIRR)	13.04%
Investment Break-Even Year	9

Investor-Owned Scenario

A separate developer finances and owns the system, typically selling electricity back to the building via a Power Purchase Agreement (PPA)

Estimated Customer Savings	$144,000
Customer After-Tax Internal Rate of Return (ATIRR)	-5.33%
Investment Break-Even Year	26

Is our PPA Price Competitive Enough?

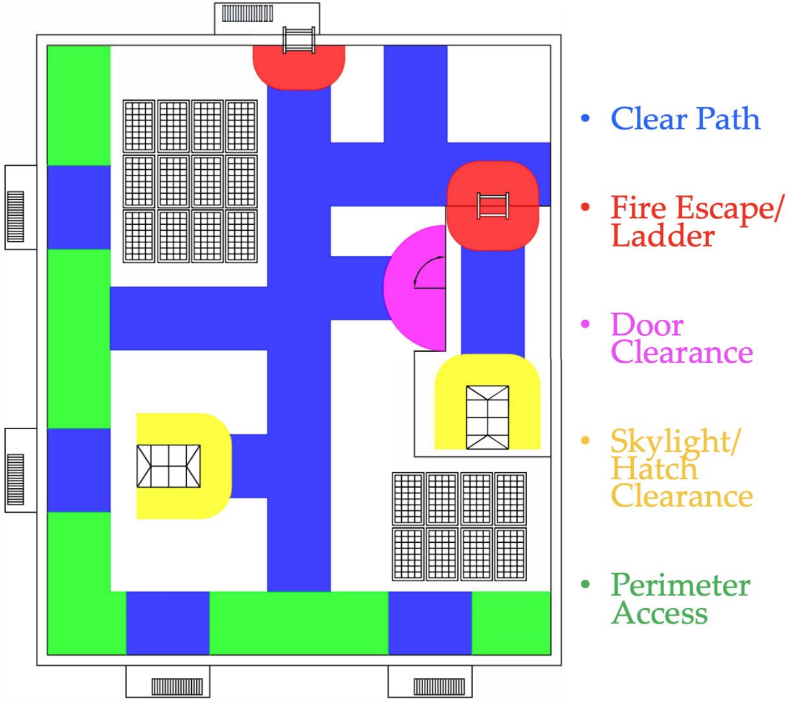
Con Edison Delivery Rate Structures

Time-of-Use Periods	PEAK RATES 8 A.M. TO MIDNIGHT	OFF-PEAK RATES ALL OTHER HOURS OF THE WEEK
JUNE 1 TO SEPT 30	35.23 cents/kWh	2.49 cents/kWh
ALL OTHER MONTHS	13.05 cents/kWh	2.49 cents/kWh

Standard Delivery Periods	RATES <250 KWH	RATES >250 KWH
JUNE 1 TO SEPT 30	16.107 cents/kWh	18.518 cents/kWh
ALL OTHER MONTHS	16.107 cents/kWh	16.107 cents/kWh

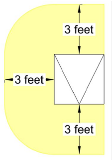
- In a customer-owned scenario, over the project lifetime, our system is able to generate **$751,000** in customer savings while breaking-even in only **9 years**.
- Depending on the building's rate structure, the savings can vary. If the building is on a **time-of-use rate structure**, our PV and storage system can potentially generate more savings through **time-of-use optimization** and **peak load shifting.**
- If the building is on a **standard delivery rate structure**, our PPA price of $0.16/kWh still remains competitive.

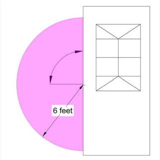
Codes and Regulations

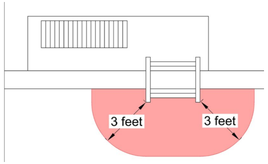


- **<u>FC504.4:</u>** This section (and its subsections) sets the minimum clearance and access requirements for building rooftops.
    - For each 12 linear feet of building perimeter accessible from the frontage space of the building, a minimum clearance of 6 feet in width and 6 feet in depth from any obstruction shall be provided.
    - Clear Path must be at least 6 feet wide and 9 feet tall
    - Distinct clear path every 100 linear feet with no more than 100 feet between distinct clear paths

- **<u>Wind Load Resistance:</u>** Rooftop-mounted PV systems and their supports must be designed and installed to resist wind loads as specified in Table R301.2(2) of the 2020 Residential Code of New York State (RCNYS). These loads should be adjusted for building height and exposure in accordance with Table R301.2(3).







Development Timeline and Energy Equity

Development Timeline

2–3 Months — Phase 1 – Feasibility & Design

3–4 Months — Phase 2 – Permitting & Procurement

3–4 Months — Phase 3 – Construction & Commissioning

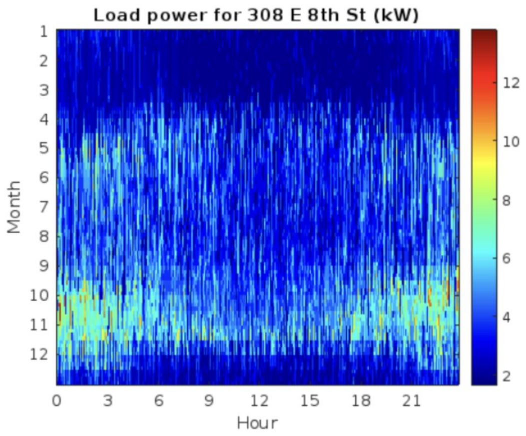
Community Outreach and Risk Mitigation

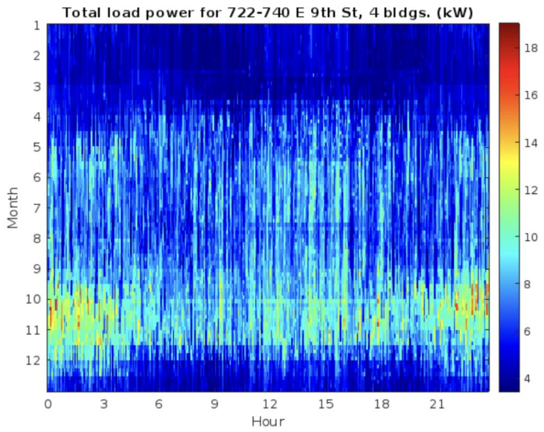
1. Early and transparent communication to rent-stabilized tenants, co-op boards and low-income housing groups on construction schedules, rooftop access, safety and to address common concerns demystifying solar

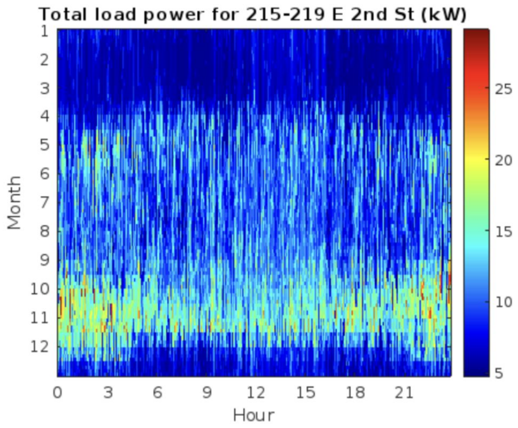
2. For BESS, compliance with UL 9540, NEC Article 706, and FDNY's TM-5 ensures adequate firefighting access and hazard mitigation

3. By emphasizing local job creation and cost savings, the initiative gains stronger community buy-in and counters skepticism about potential rent hikes or gentrification pressures.

Appendix I: Load Profiles

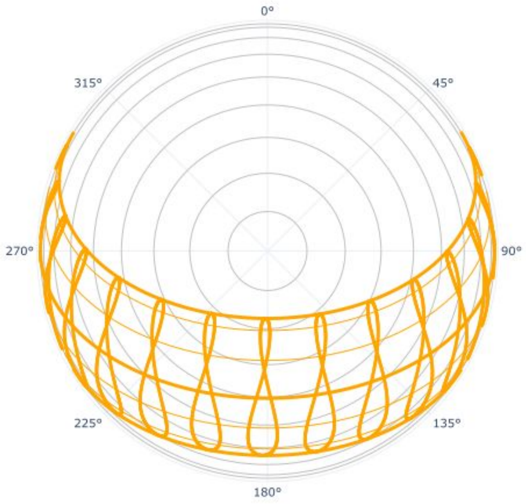






Appendix II: NYC Climate Analysis

Sun Path



Global Horizontal & Diffuse Irradiance