Appendix:
Building Electrification Report
Energy Model Report
PV Helioscope Model
Appendix Z Gap Analysis

Interface Engineering
2000 M Street NW,
Suite 270
Washington, DC 20036
TEL 202.370.9555
www.interfaceengineering.com

Electrical System Comparison

Deaf Reach

2022-0019

Prepared by:

Brandon Bandy , EIT

January 26, 2023

INTERFACE ENGINEERING

Electrical System Comparison

The purpose of this report is to provide a comparison of the electrical distribution systems across the two potential design schemes that are being proposed. This report highlights specific differences between each design choice, and how the design components change. Design option 1 includes gas for heating and hot water systems in the building, and a gas-powered emergency generator for legally required and optional standby loads. Option 1 would require a smaller electrical service size overall. Design option 2 includes electrifying all HVAC and plumbing equipment and providing a grid-scale battery backup that would provide 48 hours of standby time for the building. Option 2 would require a larger electrical service but would have the added benefit of cost savings from utilizing microgrid technology and allowing the building to operate independent of the electrical utility.

Energy Breakdown

Estimated Electrical Loads

The estimated electrical load for both buildings is as follows:

Building A lighting, receptacles, and miscellaneous:	109,981W
Building B lighting, receptacles, and miscellaneous:	28,691W
Peak HVAC (design option 1):	23,500W
Peak HVAC (design option 2):	44,000W

Electrical Components – Option 1 and 2

Voltage Utilization

The service voltage utilization for both buildings shall be as follows:

- 208/120V – Incoming Service
- 120V – General Lighting.
- 208/120V – General power and equipment.
- 120V – General power and convenience receptacles.
- Special equipment shall receive voltage and ampere rating as required.

Normal System

The buildings will be served from exterior pad mounted Transformers or underground vaults, designed to PEPCO standards, located adjacent to the buildings. The service coming from the PEPCO utility transformers will provide service conductors installed inside underground concrete ductbanks at the service entrance switchboard(s):

- Building Service Switchboard, 208/120V, 3∅, 4-wire , service switchboard located in the main electrical room that will serve all building, lighting, receptacles, low voltage, and security. A provision, rated DISCONNECT, will be provided in the switchboard, ahead of the main for PV connection. Service size will be based off what design option is chosen, with option 2 requiring the larger service.

All service duct banks and conduits from the utility transformers to the switchboards shall be owned and installed by building owner. The services' conductors will be installed and maintained following PEPCO utility requirements. Branch panelboards will be provided throughout the buildings to feed various load types.

PV System

A PV array would be installed on the green roof of each building. Option 2 would require a larger PV array, so some architectural coordination would be required to add a canopy to extend the footprint of the roof. For option 1, a maximum of 45 PV panels can be installed. For option 2, a maximum of 89 PV panels can be installed. See the PV Analysis Report for additional detail on the requirements for this system.

Proposed Distribution – Option 2 Additional Requirements

Building Electrification and de-carbonization

As part of the Building Electrification and de-carbonization Interface would promote and recommend the 'Operational Electrification' or 'Operational De-Carbonization', meaning that all normal operational energy shall be electric energy without consumption of fossil fuels. Based on this definition, heating hot water and domestic hot water shall be provided by either air-to-water heat pumps or water-to-water heat pumps. Further, we would recommend that all kitchen equipment be electric. However, emergency and standby generators could potentially be natural gas, or diesel as these devices do not run as part of the 'normal' operation of the building. The NFPA 110 is requiring testing the generator minimum 30 min per month at least 30% of the name plating kW, so the impact to the building de-carbonization will be minimum.

Two battery options are being proposed to achieve a 48-hour emergency standby time. Figures 1 and 2 below show examples of the different battery options and how they would be installed on site. Option 1 is a 2000kWH lithium-ion battery. The lithium-ion battery could be installed either indoors or outdoors. Typical construction of large-scale back-up batteries of this nature is a complete system installed in a cargo container. Battery option 2 would be a Vanadium flow battery. Flow batteries are modular systems that can be combined to achieve the desired capacity. Flow batteries can also be installed either indoors or outdoors. To meet the required KWH for this building, (6) of these flow batteries would need to be provided.
The major considerations for choosing the correct backup battery solution is price and appearance. Lithium-ion battery technology has been around for some time, and has a relatively cheap initial cost. Flow battery technology is still new in terms of large-scale backup power and has a higher initial cost.

However, it is estimated that flow batteries have a longer life span and less maintenance requirements. The appearance of these batteries can also pose a potential issue, as they have a relatively large footprint. Both battery types can be installed indoors, but architectural design considerations would need to be made to accommodate.

Figure 1: Lithium-ion battery installation

Figure 2: Flow battery installation

If the client is going to purchase and install an iron flow or a Li-ion battery energy storage system the PV System will be Provided with a Microgrid Controller from eLUM or equivalent for increased resilience. To make the site even more resilient the client could have the Emergency/Standby rated generator sized for continuous operation and can be integrated into the microgrid controller and can island the building during a power outage event and keep operating without interruption of power to the building or during peak shaving demand operation.

The microgrid controller curtails the exact amount of solar power and generator power to maximize solar penetration and/or avoiding any penalty from the utility if NET metering will not be considered.

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2000 M Street NW,
Suite 270
Washington, DC 20036
TEL 202.370.9555
www.interfaceengineering.com

Energy Analysis Report (Building A & B)

Deaf Reach

2022-0019

Prepared by:

Kyle Rives , PE, LEED AP
Alex Briel , EIT, LEED AP

January 26, 2023

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Executive Summary

This report discusses the engineering energy analysis performed to investigate different energy conservation measures (ECMs) that could be pursued by the owner to determine the most cost-effective solution for a highly sustainable building. As part of this analysis multiple improvements to the building's envelope, HVAC system, lighting system and plumbing system were modeled. Additionally, combinations of different system improvements were modeled. Below (Table 1) illustrates the improvement measures modeled.

Heating and Ventilation System ECM

	System Descriptions and Improvements
ASHRAE 90.1-2013 Baseline	Packaged Terminal Air Conditioners (PTAC) Dedicated Outside Air System (DOAS) No Energy Recovery (ER) ASHRAE 90.1-2013 Minimum equipment efficiencies
HVAC (H) ECM 1	Mini Split Heat Pump System Dedicated Outside Air System (DOAS) No Energy Recovery (ER) Increased equipment efficiency over 90.1 Baseline
HVAC (H) ECM 2	Variable Refrigerant Flow (VRF) Heat Recovery System Dedicated Outside Air System (DOAS) No Energy Recovery (ER) Increased equipment efficiency over ECM 1
HVAC (H) ECM 3	Variable Refrigerant Flow (VRF) Heat Recovery System Dedicated Outside Air System (DOAS) Energy Recovery (ER) at DOAS

Envelope ECM

	System Descriptions and Improvements
ASHRAE 90.1-2013 Baseline	Roof: R-31 (Min per ASHRAE 90.1) Wall: R-16 (Min per ASHRAE 90.1) Window: SHGC: .40, U-Value: .42 (Max per ASHRAE 90.1)
Envelope (Env) ECM 1	Roof: R-60 Wall: R-32 Window: SHGC: .20, U-Value: .23 Window Improved window performance by 20% over proposed window
Envelope (Env) ECM 2	Roof: R-60 Wall: R-32 Window: SHGC: .25, U-Value: .28 Increased wall R-Value to R-42 compared to proposed wall
Envelope (Env) ECM 3	Roof: R-60 Wall: R-32 Window: SHGC: .20, U-Value: .23 Increased wall R-Value to R-42 compared to proposed wall Improved window performance by 20% over proposed window

Electrical ECM

	System Descriptions and Improvements
ASHRAE 90.1-2013 Baseline	**Lighting** Apartment: .51 W/SF (Max per ASHRAE 90.1-2013) Office: .82 W/SF (Max per ASHRAE 90.1-2013) Patient Rooms: .57 W/SF (Max per ASHRAE 90.1-2013) **Receptacle Loads** Apartments: .3 W/SF Office: .5 W/SF **Load Schedules** Lighting is on a apartment lighting schedule, where loads are reduced during the day and normal during morning and evening hours.

Electrical (Elec) ECM 1	**Lighting** Apartment: .41 W/SF (Max per ASHRAE 90.1-2013) Office: .66 W/SF (Max per ASHRAE 90.1-2013) Patient Rooms: .46 W/SF (Max per ASHRAE 90.1-2013) **Receptacle Loads** Apartments: .3 W/SF Office: .5 W/SF **Load Schedules** Lighting is on a apartment lighting schedule, where loads are reduced during the day and normal during morning and evening hours. Lighting power density (LPD) reduced by 20%.

Plumbing ECM

	System Descriptions and Improvements
ASHRAE 90.1-2013 Baseline	Gas Water Heater - ASHRAE 90.1-2013 83% Efficiency
Plumbing (P) ECM 1	**Heat Pump Water Heater** Approx. 25% increase in efficiency compared to standard Electric Water
Plumbing (P) ECM 2	**Heat Pump Water Heater** Approx. 25% increase in efficiency compared to standard Electric Water **Drain Heat Recovery** Approx. 25% increase in efficiency compared to standard Electric Water

Approach

This report discusses the engineering simulation analyses performed in support of the buildings A and B. These buildings are located at 1203 Otis Street NE, Washington DC.

Building A

Building A is small apartment building with roughly 22 dwelling units. The ground floor includes office space and a community room. The building has a seven-car parking garage.

Building B

Building B is a small dormitory building with roughly 16 dorm rooms, each with a private bathroom. Each floor includes a common room and ground floor includes a combined kitchen, dining and living space.

A series of engineering energy simulations have been performed to assess the strategies and measures being considered for the project, to understand their impact and capability of achieving a low energy design while being cost effective. To facilitate this level of analysis, the Trane Trace 700 software was used to create the building geometry and perform the energy analysis.

This model was created to match the architectural geometry and envelope properties being considered during the conceptual phase and incorporates the lighting power, miscellaneous plug loads, occupancy densities, and HVAC systems that are being considered for energy improvement over ASHRAE 90.1-2013 baseline.

Simulation Requirements

Simulation Program

A whole building energy model was created using Trane Trace 700. This model has been used to perform a series of engineering energy measures being considered for the project to understand their impact and capability of achieving a low energy design while being cost effective.

Climatic Data

Simulation Weather

The energy simulation utilized a Typical Meteorological Year (TMY3) weather data file acquired from the nearest weather station, Ronald Reagan National Airport, WMO Station #724050. This weather file has been created by the National Renewable Energy Laboratory and contains hourly values for solar radiation, air temperature, and other climate related variables to appropriately characterize the typical climate for a location to be used in energy simulations. The TMY3 weather data represents the average monthly values from a period of 30 years, using hourly inputs from 1976-2005.

Climatic Zone – Design Criteria

The project's Design Criteria is taken from ASHRAE 90.1-2010 Table D-1 for Climate Zone 4A (Washington DC Metro Area):

- Winter Outdoor Conditions (99.6% coverage): 15°F DB

- Summer Outdoor Conditions (99% coverage): 92°F DB/76°F WB

Energy Rates

This analysis assumes state average utility rates for District of Columbia provided by the Bureau of Labor Statistics The rates used are 12.2 cents / kWh for electricity consumption, and $ 19.5 per MCF for natural gas consumption.

Other Components

Infiltration

Infiltration is modeled as a leakage rate per exterior wall area at a value of 0.3 cfm/ft^2 of exterior wall area @ 0.3" w.c (1.56 psf). The leakage rate is approximately the average air leakage rate for newly constructed commercial and institutional buildings. Typical air leakage values @ 0.3" w.c (1.56 psf) are 0.1, 0.3, and 0.6 cfm/ft2 of exterior wall area for tight, average, and leaky walls respectively per ASHRAE 2017 Fundamentals, Chapter 16, Ventilation and Infiltration.

Energy Model Criteria

Space Use Classification

Per ASHRAE 62.1-2010, Table 6-1 Minimum Ventilation Rates in Breathing Zone, the occupant density for each space was calculated and inputted into the model.

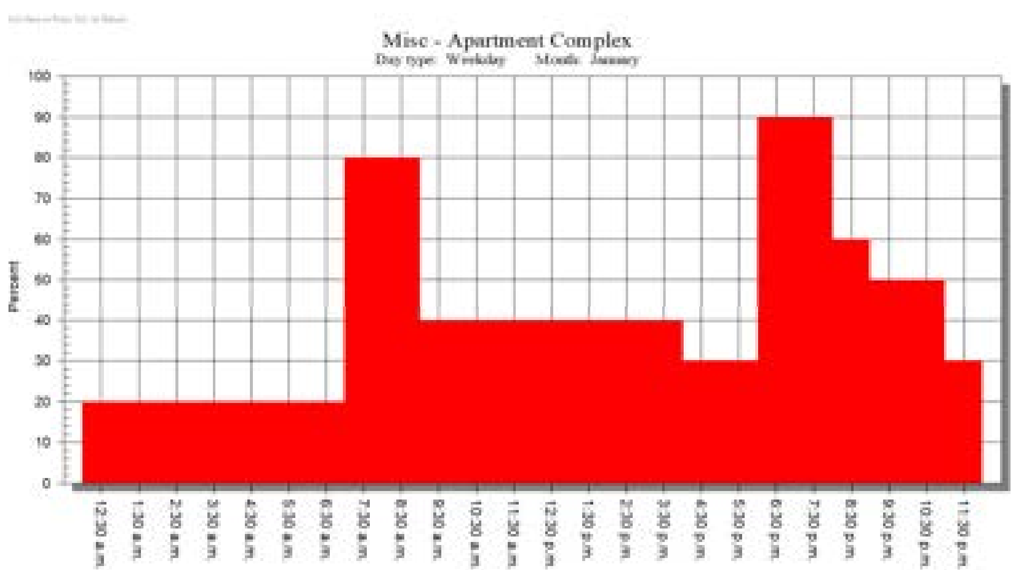
Schedules

A building's annual operational energy use is a function of the power requirements of the installed lighting and miscellaneous equipment systems, as well as the frequency of usage. This frequency and diversity of usage is accounted for in the simulation using operational and diversity schedules.

The schedules have been taken from Trane Trace 700s Lighting and miscellaneous load schedules for apartment building.

Lighting

Miscellaneuous



Results

The proposed design represents more efficient HVAC System, domestic hot water equipment, improved envelope values and lighting fixtures to minimize building energy use and cost implications. Below are the analysis results of this energy modeling.

Energy Reduction from HVAC ECMs

HVAC Improvements	Energy Consumption (10^6 Btu/h)	Annual Energy Cost ($)	Improvement Over ASHRAE Baseline (%)
ASHRAE 90.1-2013 Baseline	1,087	30,024	-
H ECM 1	530.3	18,956	51.2
H ECM 2	428.8	15,328	60.6
H ECM 3	426.3	15,237	60.8

Energy Reduction from Envelope ECMs

Envelope Improvements	Energy Consumption (10^6 Btu/h)	Annual Energy Cost ($)	Improvement Over ASHRAE Baseline (%)
ASHRAE 90.1-2013 Baseline	1,087	30,024	-
ECM 1	490.5	17,532	54.9
ECM 2	502.5	17,948	53.8
ECM 3	487.5	17,424	55.2

Energy Reduction from a Combination of HVAC and Envelope ECMs

HVAC &Envelope Improvements	Energy Consumption (10^6 Btu/h)	Annual Energy Cost ($)	Improvement Over ASHRAE Baseline (%)
ASHRAE 90.1-2013 Baseline	1,087	30,024	-
HVAC ECM 1 & ENV ECM 1	517.5	18,499	52.4
HVAC ECM 2 & ENV ECM 1	414.8	14,828	61.9
HVAC ECM 3 & ENV ECM 1	419.2	14,983	61.4

HVAC &Envelope Improvements	Energy Consumption (10^6 Btu/h)	Annual Energy Cost ($)	Improvement Over ASHRAE Baseline (%)
ASHRAE 90.1-2013 Baseline	1,087	30,024	-
HVAC ECM 1 & ENV ECM 2	523.8	18,724	51.8
HVAC ECM 2 & ENV ECM 2	427.6	15,285	60.7
HVAC ECM 3 & ENV ECM 2	423.7	15,144	61.0

HVAC &Envelope Improvements	Energy Consumption (10^6 Btu/h)	Annual Energy Cost ($)	Improvement Over ASHRAE Baseline (%)
ASHRAE 90.1-2013 Baseline	1,087	30,024	-
HVAC ECM 1 & ENV ECM 3	509.9	18,228	53.1
HVAC ECM 2 & ENV ECM 3	413.5	14,782	62.0
HVAC ECM 3 & ENV ECM 3	418.2	14,949	61.5

Energy Reduction from a Combination of HVAC and Electrical ECMs

HVAC & Elec Improvements	Energy Consumption (10^6 Btu/h)	Annual Energy Cost ($)	Improvement Over ASHRAE Baseline (%)
ASHRAE 90.1-2013 Baseline	1,087	30,024	-
HVAC ECM 1 & ELEC ECM 1	512.6	18,325	52.9
HVAC ECM 2 & ELEC ECM 1	412.9	14,758	62.0
HVAC ECM 3 & ELEC ECM 1	410.6	14,676	62.2

Energy Reduction from a Combination of Envelope and Electrical ECMs

Envelope & Elec Improvements	Energy Consumption (10^6 Btu/h)	Annual Energy Cost ($)	Improvement Over ASHRAE Baseline (%)
ASHRAE 90.1-2013 Baseline	1,087	30,024	-
ENV ECM 1 & ELEC ECM 1	489.8	17,509	55.0
ENV ECM 2 & ELEC ECM 1	484.8	17,330	55.4
ENV ECM 3 & ELEC ECM 1	476.2	17,022	56.2

Energy Reduction from a Combination of HVAC, Envelope Electrical ECMs

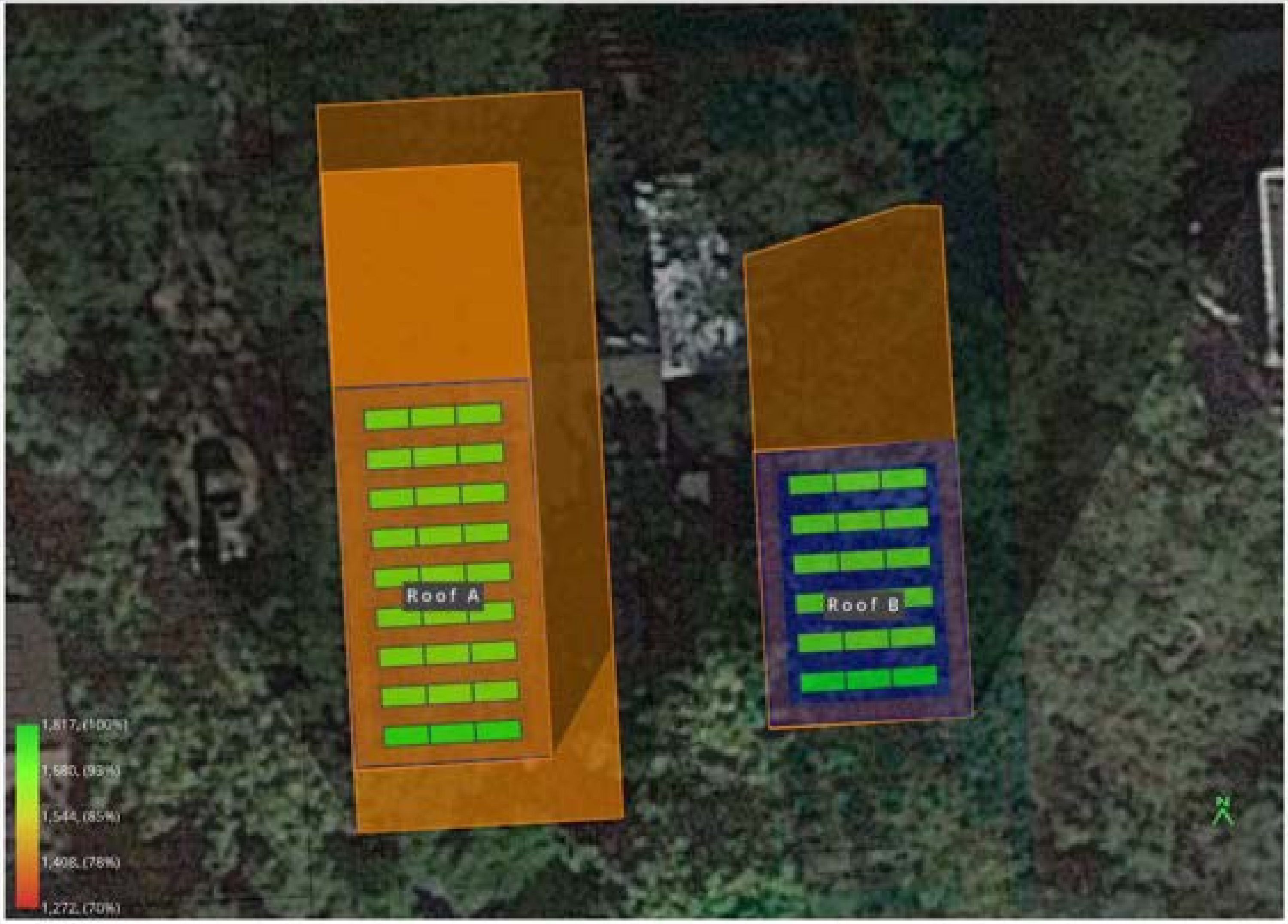
HVAC,Elec & Envelope Improvements	Energy Consumption (10^6 Btu/h)	Annaul Energy Cost ($)	Improvement Over ASHRAE Baseline (%)
ASHRAE 90.1-2013 Baseline	1,087	30,024	-
HVAC ECM 1, ELEC ECM 1, ENV ECM 3	492	17,586	54.8
HVAC ECM 2, ELEC ECM 1, ENV ECM 3	400.9	14,330	63.1
HVAC ECM 3, ELEC ECM 1, ENV ECM 3	396.7	14,181	63.5

Analysis

As illustrated in the tables above, implementing improvements to the buildings HVAC sytems and building envelope has the greatest impact on building energy consumption. Combining energy savings measures for multiple systems would also help to reduce the buildings energy use.

Deaf-Reach 1203 Deaf-Reach 1203 Otis Street, 1203 Otis Street, NE, Washington DC

Shading Heatmap



Shading by Field Segment

Description	Tilt	Azimuth	Modules	Nameplate	Shaded Irradiance	AC Energy	TOF[2]	Solar Access	Avg TSRF[2]
Roof A	32.0°	176.8°	27	12.7 kWp	1,710.6kWh/m^2	19.0 MWh[1]	99.9%	94.3%	94.2%
Roof B	32.0°	176.5°	18	8.46 kWp	1,716.8kWh/m^2	12.7 MWh[1]	99.9%	94.6%	94.5%
Totals, weighted by kWp			**45**	**21.2 kWp**	**1,713.1kWh/m^2**	**31.6 MWh**	**99.9%**	**94.4%**	**94.3%**

[1] approximate, varies based on inverter performance
[2] based on location Optimal POA Irradiance of 1,816.7kWh/m^2 at 36.0° tilt and 181.7° azimuth

Solar Access by Month

Description	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Roof A	84%	96%	97%	97%	96%	96%	96%	96%	97%	96%	90%	80%
Roof B	85%	96%	97%	97%	97%	96%	96%	97%	97%	97%	91%	81%
Solar Access, weighted by kWp	**84.3%**	**95.7%**	**97.0%**	**96.8%**	**96.4%**	**96.2%**	**96.2%**	**96.5%**	**96.9%**	**96.4%**	**90.2%**	**80.7%**
AC Power (kWh)	**1,769.9**	**2,294.5**	**2,955.6**	**3,087.1**	**3,276.7**	**3,045.7**	**3,183.2**	**3,102.9**	**2,864.5**	**2,567.7**	**1,842.3**	**1,640.1**

Deaf-Reach 1203 Deaf-Reach 1203 Otis Street, 1203 Otis Street, NE, Washington DC

Report

Project Name	Deaf-Reach 1203 Otis Street
Project Address	1203 Otis Street, NE, Washington DC
Prepared By	Joe Schmid joes@interfaceeng.com

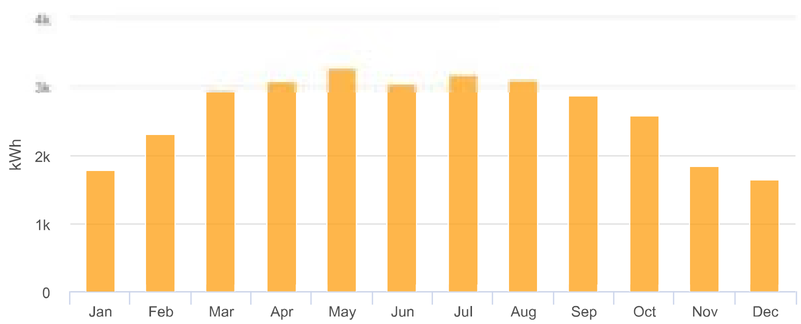
INTERFACE ENGINEERING

System Metrics

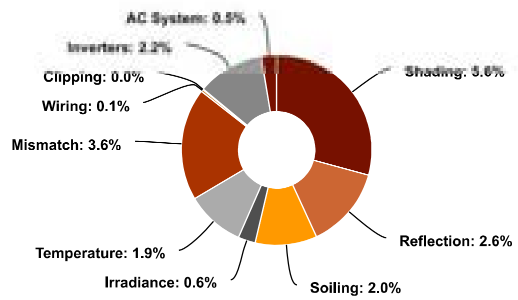
Design	Deaf-Reach 1203
Module DC Nameplate	21.2 kW
Inverter AC Nameplate	20.0 kW Load Ratio: 1.06
Annual Production	31.63 MWh
Performance Ratio	82.4%
kWh/kWp	1,495.5
Weather Dataset	TMY, 10km grid (38.95,-76.95), NREL (prospector)
Simulator Version	d6053655f3-fb238a5a73-2cbc1b667c-f178233ac7

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,553.6	
	POA Irradiance	1,814.6	16.8%
	Shaded Irradiance	1,713.1	-5.6%
	Irradiance after Reflection	1,667.7	-2.6%
	Irradiance after Soiling	1,634.4	-2.0%
	Total Collector Irradiance	**1,635.0**	**0.0%**
Energy (kWh)	Nameplate	34,598.5	
	Output at Irradiance Levels	34,402.9	-0.6%
	Output at Cell Temperature Derate	33,753.4	-1.9%
	Output After Mismatch	32,525.1	-3.6%
	Optimal DC Output	32,501.1	-0.1%
	Constrained DC Output	32,497.6	0.0%
	Inverter Output	31,789.1	-2.2%
	Energy to Grid	**31,630.2**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		15.7 °C
	Avg. Operating Cell Temp		24.3 °C
Simulation Metrics			
	Operating Hours		4672
	Solved Hours		4672

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (38.95,-76.95), 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

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
SPR-X21-470-COM (Maxeon)	HelioScope	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization

Components

Component	Name	Count
Inverters	Sunny Tripower 12000TL (SMA)	1 (12.0 kW)
Inverters	Sunny Tripower 8.0 (SMA)	1 (8.00 kW)
Strings	10 AWG (Copper)	5 (176.4 ft)
Module	Maxeon, SPR-X21-470-COM (470W)	45 (21.2 kW)

Wiring Zones

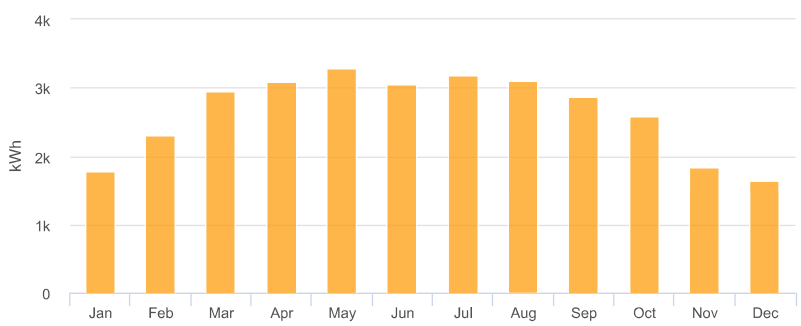
Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	-	6-10	Along Racking
Wiring Zone 2	-	4-10	Along Racking

Field Segments

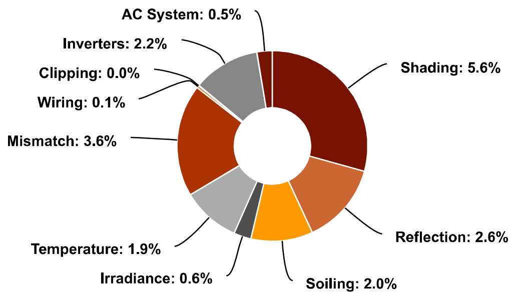
Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Roof A	Fixed Tilt	Landscape (Horizontal)	32°	176.82018°	3.0 ft	1x1	27	27	12.7 kW
Roof B	Fixed Tilt	Landscape (Horizontal)	32°	176.5142°	3.0 ft	1x1	18	18	8.46 kW

Detailed Layout

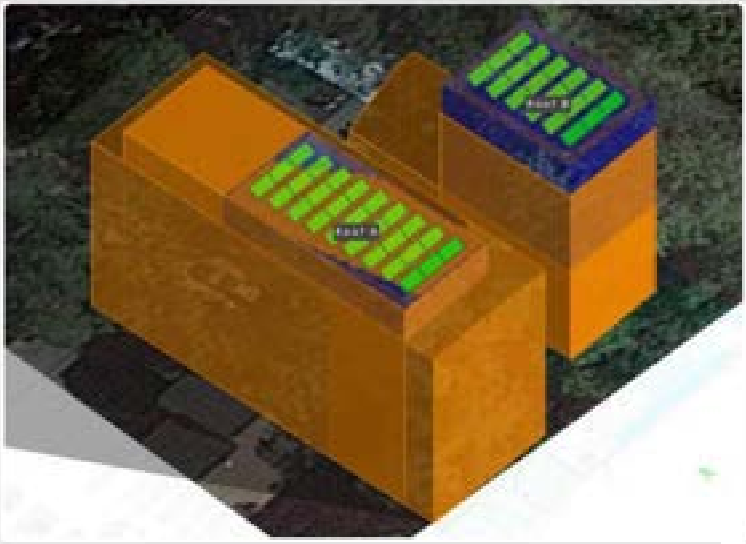
Monthly Production



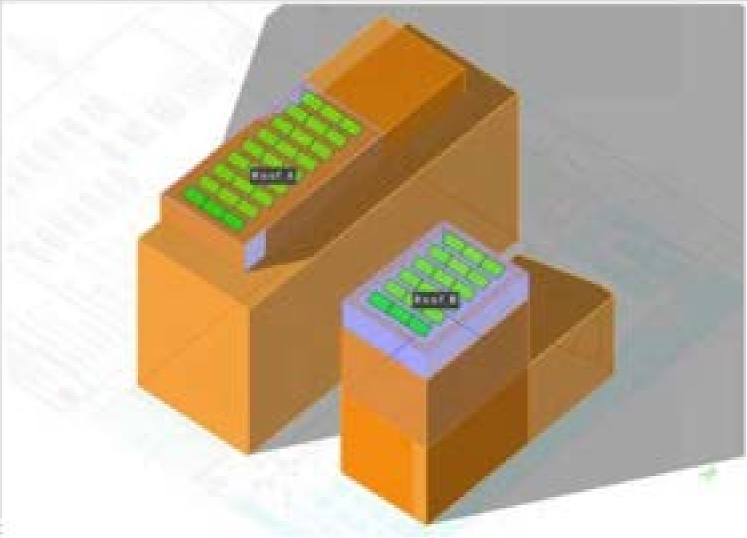
Sources of System Loss



Southwestern Angle



Southeastern Angle



Deaf-Reach 1203 Option 2 Deaf-Reach 1203 Otis Street, 1203 Otis Street, NE, Washington DC

Report

Project Name	Deaf-Reach 1203 Otis Street
Project Address	1203 Otis Street, NE, Washington DC
Prepared By	Joe Schmid joes@interfaceeng.com

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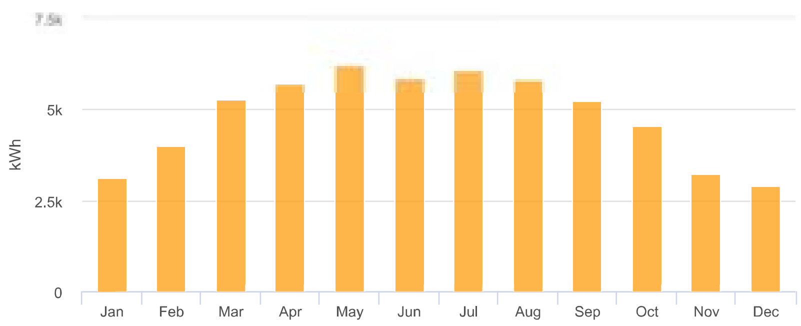
System Metrics

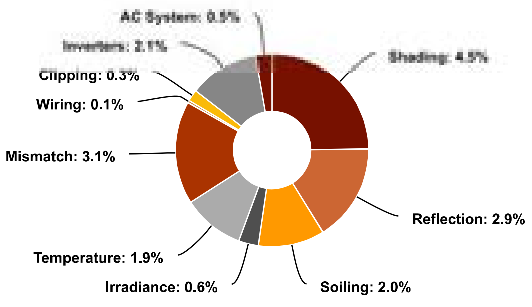
Design	Deaf-Reach 1203 Option 2
Module DC Nameplate	39.5 kW
Inverter AC Nameplate	36.0 kW Load Ratio: 1.10
Annual Production	57.91 MWh
Performance Ratio	83.4%
kWh/kWp	1,466.7
Weather Dataset	TMY, 10km grid (38.95,-76.95), NREL (prospector)
Simulator Version	78d8125b3d-4e62988b6b-5d82b38502-10d96edcb2

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,553.6	
	POA Irradiance	1,759.1	13.2%
	Shaded Irradiance	1,680.6	-4.5%
	Irradiance after Reflection	1,631.1	-2.9%
	Irradiance after Soiling	1,598.5	-2.0%
	Total Collector Irradiance	**1,598.8**	**0.0%**
Energy (kWh)	Nameplate	63,152.2	
	Output at Irradiance Levels	62,776.4	-0.6%
	Output at Cell Temperature Derate	61,612.1	-1.9%
	Output After Mismatch	59,699.1	-3.1%
	Optimal DC Output	59,654.7	-0.1%
	Constrained DC Output	59,449.2	-0.3%
	Inverter Output	58,197.5	-2.1%
	Energy to Grid	**57,906.5**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		15.7 °C
	Avg. Operating Cell Temp		24.1 °C
Simulation Metrics			
	Operating Hours		4672
	Solved Hours		4672

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (38.95,-76.95), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model
Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

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

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

Module Characterizations

Module	Uploaded By	Characterization
SPR-X21-470-COM (Maxeon)	HelioScope	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization

Components

Component	Name	Count
Inverters	Sunny Tripower 12000TL (SMA)	3 (36.0 kW)
Strings	10 AWG (Copper)	9 (334.4 ft)
Module	Maxeon, SPR-X21-470-COM (470W)	84 (39.5 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	-	6-10	Along Racking
Wiring Zone 2	-	6-10	Along Racking

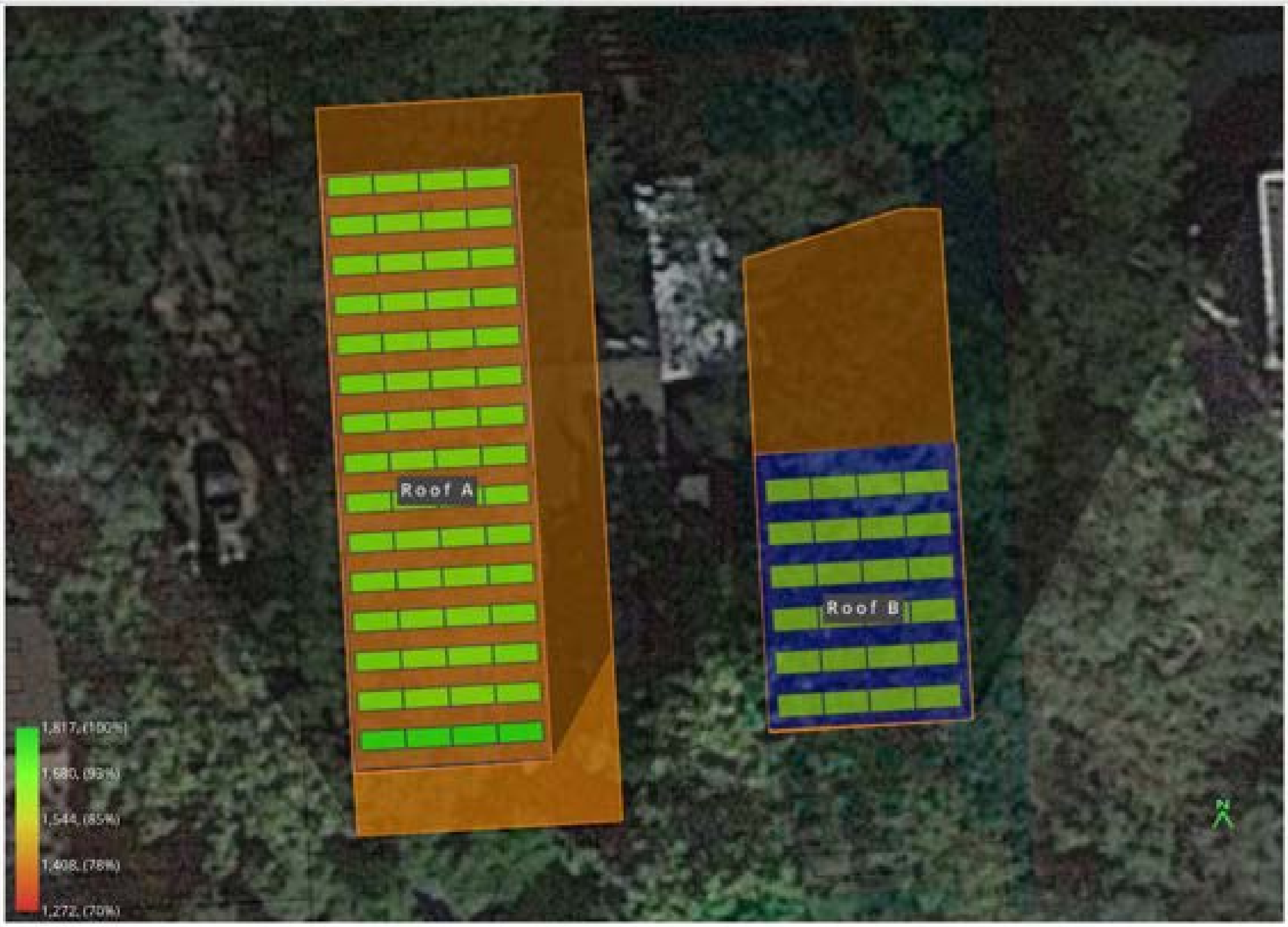
Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Roof A	Fixed Tilt	Landscape (Horizontal)	32°	176.82018°	3.0 ft	1x1	60	60	28.2 kW
Roof B	Fixed Tilt	Landscape (Horizontal)	5°	176.5142°	3.0 ft	1x1	24	24	11.3 kW

Detailed Layout

Deaf-Reach 1203 Option 2 Deaf-Reach 1203 Otis Street, 1203 Otis Street, NE, Washington DC

Shading Heatmap



Shading by Field Segment

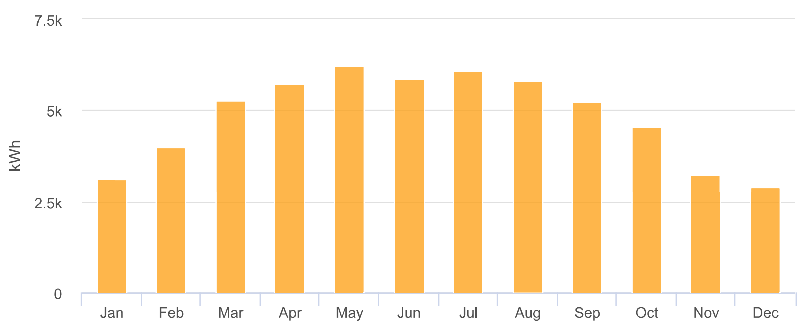
Description	Tilt	Azimuth	Modules	Nameplate	Shaded Irradiance	AC Energy	TOF[2]	Solar Access	Avg TSRF [2]
Roof A	32.0°	176.8°	60	28.2 kWp	1,704.0kWh/m²	42.1 MWh[1]	99.8%	93.9%	93.8%
Roof B	5.0°	176.5°	24	11.3 kWp	1,622.0kWh/m²	15.8 MWh[1]	89.3%	100.0%	89.3%
Totals, weighted by kWp			**84**	**39.5 kWp**	**1,680.6kWh/m²**	**57.9 MWh**	**96.8%**	**95.5%**	**92.5%**

[1] approximate, varies based on inverter performance
[2] based on location Optimal POA Irradiance of 1,816.7kWh/m² at 36.0° tilt and 181.7° azimuth

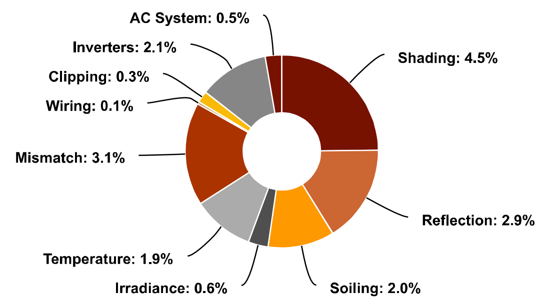
Solar Access by Month

Description	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Roof A	83%	95%	97%	97%	96%	96%	96%	96%	97%	96%	89%	79%
Roof B	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Solar Access, weighted by kWp	**86.6%**	**96.4%**	**97.6%**	**97.5%**	**97.3%**	**97.2%**	**97.1%**	**97.3%**	**97.5%**	**97.1%**	**91.8%**	**83.4%**
AC Power (kWh)	**3,098.7**	**3,993.3**	**5,253.6**	**5,691.1**	**6,224.9**	**5,858.1**	**6,082.4**	**5,823.7**	**5,224.4**	**4,540.1**	**3,235.6**	**2,880.6**

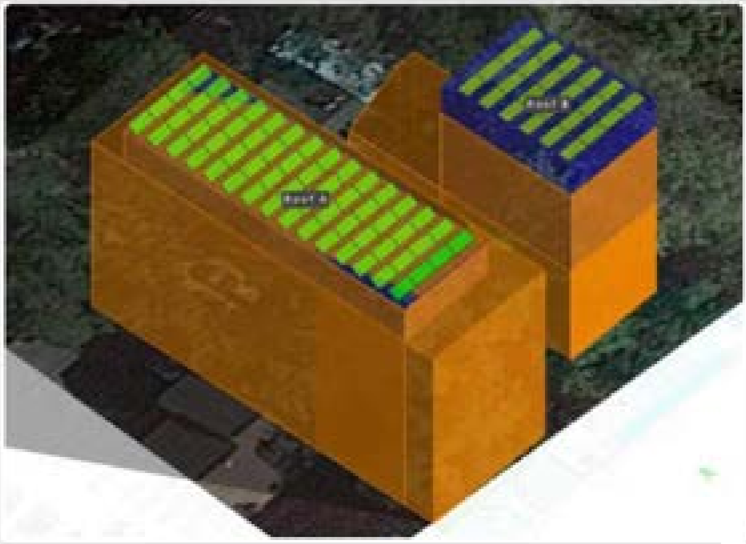
Monthly Production



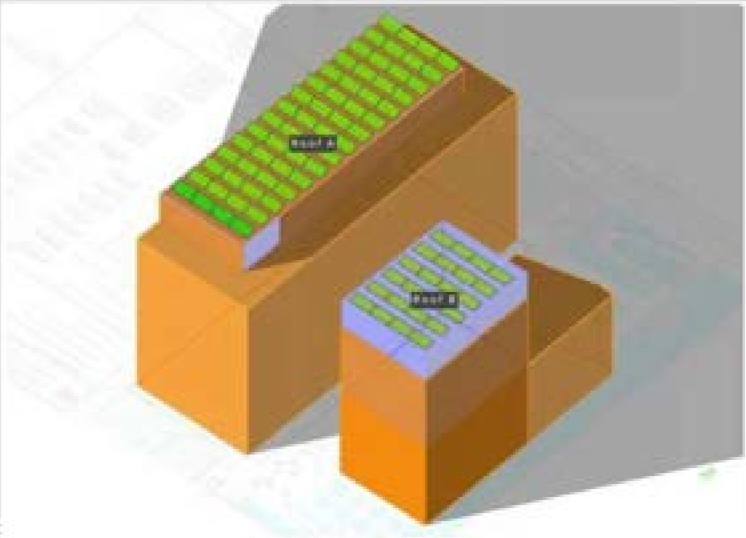
Sources of System Loss



Southwestern Angle



Southeastern Angle



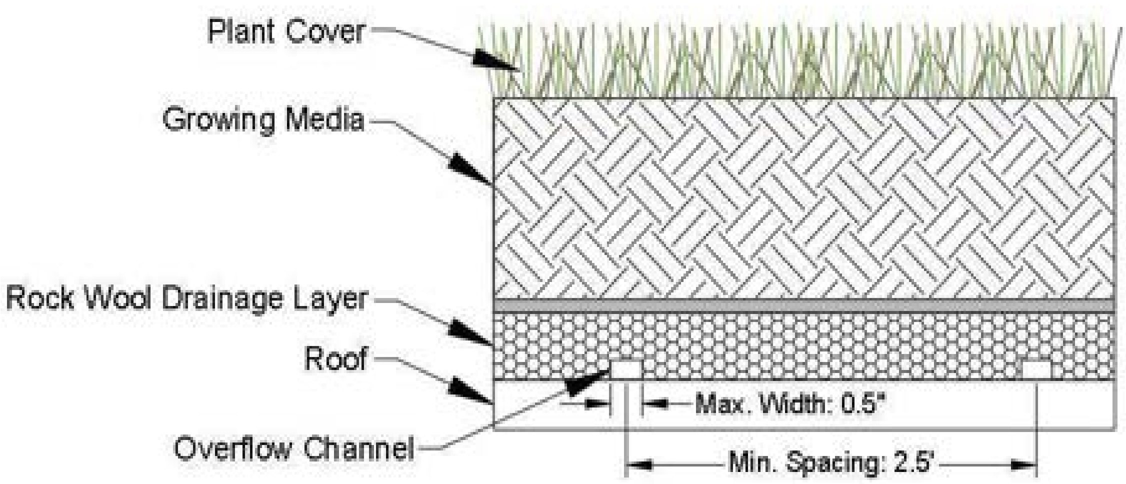


Figure 3.2 Optional overflow channels for rock wool drainage layer.

Solar Panels and Other Structures. Occasionally, structures such as solar panels or HVAC systems must be installed above a green roof. These structures can be incorporated into a green roof design with no adverse effects to the retention value assigned to the green roof if specific design requirements for runoff disbursement, maintenance access, and sun and wind exposure are incorporated, including the following:

- Structures above the green roof must be no more than 6.5 feet wide;
- Structures must have a minimum 3-foot separation between them; and
- The lower edge of the structure must be at least 1 foot above the top of the green roof, and the upper edge must be at least 2.5 feet above the top of the green roof. This allows for a tilt of at least a 15-degrees. For flatter installations, the lower edge would need to be raised to ensure that the 2.5-foot minimum elevation for the upper edge is met.

These design requirements only apply to solar panels or HVAC systems, not the conduits running to them. The conduits must be properly protected when placed on the green roof.

These design requirements are illustrated in Figure 3.3.

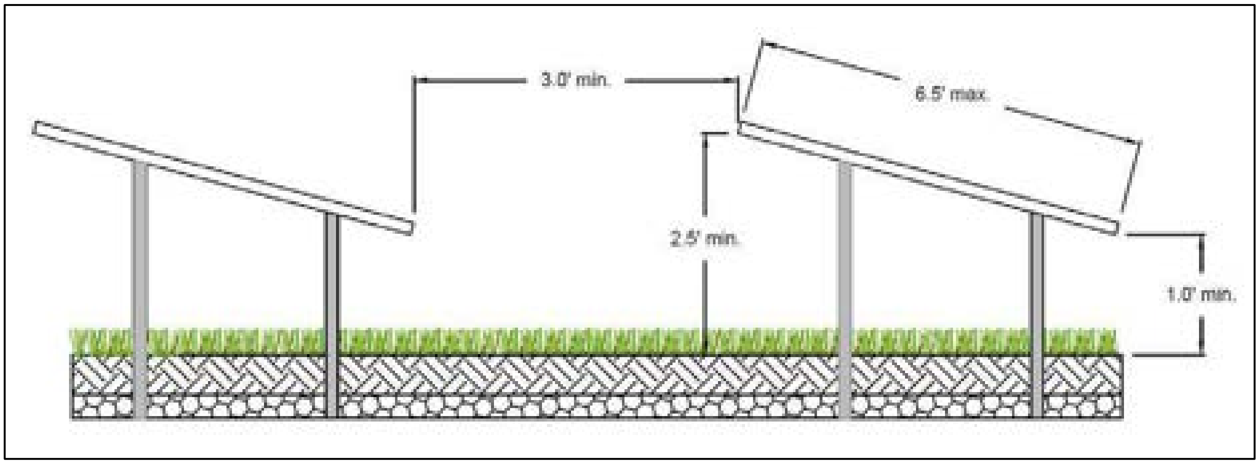


Figure 3.3 Design requirements for structures constructed above green roofs.

Green Roof Sizing. Green roof areas can be designed to capture the entire Stormwater Retention Volume (SWRv). In some cases, they could be designed to capture larger design storm volumes as well. The required size of a green roof will depend on several factors, including maximum water retention of the growing media and the underlying drainage and storage layer materials, if present (e.g., prefabricated water cups or plastic modules). As maximum water retention can vary significantly between green roof products, verification of this value must be included with the Stormwater Management Plan (SWMP). Verification shall be provided by an ASTM-certified lab using the methods described by ASTM tests E2396, E2397, E2398, or E2399, as appropriate. For green roof media, ASTM test E2399 specifies that a 4-inch thick layer be tested. For the drainage layer, the test performed must be representative of the actual thickness and depth of the drainage layer to be used (i.e., a test performed on a 2-inch thick drainage layer cannot be used to represent the maximum water retention value for a 4-inch thick drainage layer). In the absence of laboratory test results, the baseline default values must be used as provided in Equation 3.1 below, which shall be used to determine the storage volume retained by a green roof.

Irrigation and Storage Volume. Regularly irrigated green roofs receive 50% retention value for the amount of Sv provided by the practice. Only intensive systems may be irrigated.

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Product and power coverage	25 Years
Year 1 minimum warranted output	98.0%
Maximum annual degradation	0.25%

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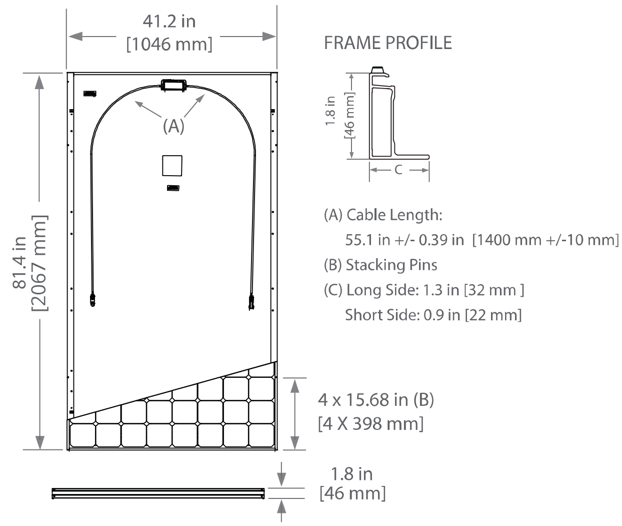
MAXEON 3 POWER: 470–485 W | EFFICIENCY: Up to 22.4%

Electrical Data		
	SPR-X22-485-COM	SPR-X21-470-COM
Nominal Power (Pnom) [2]	485 W	470 W
Power Tolerance	+5/0%	+5/0%
Panel Efficiency	22.4%	21.7%
Rated Voltage (Vmpp)	78.8 V	77.6 V
Rated Current (Impp)	6.16 A	6.06 A
Open-Circuit Voltage (Voc)	92.7 V	91.5 V
Short-Circuit Current (Isc)	6.55 A	6.45 A
Max. System Voltage	1500 V UL	
Maximum Series Fuse	15 A	
Power Temp Coef.	−0.27% / ºC	
Voltage Temp Coef.	−0.236% / ºC	
Current Temp Coef.	0.058% / ºC	

Operating Condition And Mechanical Data	
Temperature	−40°F to +185°F (−40°C to +85°C)
Impact Resistance	1 inch (25 mm) diameter hail at 52 mph (23 m/s)
Solar Cells	128 Monocrystalline Maxeon Gen 3
Tempered Glass	High-transmission tempered anti-reflective
Junction Box	IP-68, PV4S
Weight	56 lbs (25.4 kg)
Max. Load [6]	Wind: 50 psf, 2400 Pa, 244 kg/m² front & back Snow: 112 psf, 5400 Pa, 550 kg/m² front
Frame	Class 2 silver anodized; stacking pins

Warranties, Certifications (Pending) and Compliance	
Standard Tests [3]	UL1703 (Type 2 Fire Rating)
Quality Management Certs	ISO 9001:2015, ISO 14001:2015
Ammonia Test	IEC 62716
Desert Test	IEC 60068-2-68, MIL-STD-810G
Salt Spray Test	IEC 61701 (maximum severity)
PID Test	1500 V: IEC 62804
Available Listings	UL
IFLI Declare Label	First solar panel labeled for ingredient transparency and LBC-compliance. [4]
Cradle to Cradle Certified™ Silver	First solar panel line certified for material health, water stewardship, material reutilization, renewable energy & carbon management, and social fairness. [5]
Green Building Certification Contribution	Panels can contribute additional points toward LEED and BREEAM certifications.
EHS Compliance	RoHS, ISO 45001:2018, Recycle Scheme, REACH SVHC-163



Please read the safety and installation instructions. Visit www.maxeon.com/us/InstallGuideUL. Paper version can be requested through techsupport.ROW@maxeon.com.

1 Maxeon panels are less than 50 dppm, or 0.005%, on over 15 million panels shipped - Source: "A Comparative Study: SunPower DC Solar Module Warranty Claim Rates" 2019.
2 Standard Test Conditions (1000 W/m² irradiance, AM 1.5, 25° C). NREL calibration Standard: SOMS current, LACCS FF and Voltage.
3 Type 2 fire rating per UL1703:2013
4 Maxeon DC panels first received the International Living Future Institute Declare Label in 2016.
5 Maxeon DC panels are Cradle to Cradle Cradle Certified™ Silver - www.c2ccertified.org/products/scorecard/maxeon_solar_panels_-_maxeon_corporation. Cradle to Cradle Certified™ is a certification mark licensed by the Cradle to Cradle Products Innovation Institute.
6 As per IEC 61215-2016 tested and certified.

Made in Philippines (Cells)
Assembled in Mexico (Module)
Specifications included in this datasheet are subject to change without notice.

View warranty, patent and trademark information at maxeon.com/legal.

maxeon

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Interface Engineering
2000 M Street NW,
Suite 270
Washington, DC 20036
TEL 202.370.9555
www.interfaceengineering.com

Appendix Z- Gap Analysis
Otis Street

Otis Street
2022-0119

Prepared by:

Kyle Rives, PE, LEED AP BD+C
Alex Briel, EIT, LEED AP BD+C

March 22, 2023

Table of Contents

Appendix Z Gap Analysis 1

INTERFACE ENGINEERING

Appendix Z – Net Zero Energy Compliance Path Gap Analysis

This section is to investigate the feasibility of pursuing a Zero Net Energy (ZNE) certification for the new two building assited living residential facility to be constructed at 1203 Otis Street NE, Washington DC, 20017. The energy modeling and simulation reflects an early state proposed design. This model had been used for analyzing various mechanical systems during the Concept Phase and is representative of the building size and construction. The interior occupancy, lighting, power, and HVAC loads are accurately modeled per the proposed design.

With the current proposed energy model, we have a good estimate of the projected energy consumption of the building once it is operational (although future tenant loads can swing the building's energy consumption in either direction). From this annual energy consumption, we can determine the gap between the proposed design and Appendix Z compliance requirements.

Appendix Z is intended to be an optional alternative compliance path for building projects to comply with the Energy Conservation Code-Commercial Provisions. The design of a net-zero energy building shall be achieved through the use of three complementary approaches, to be employed to the maximum extent feasible, in the following order:

- Reducing building energy demand for heating, cooling, lighting, and ventilation through the use of passive design and improved envelope performance techniques.
- Reducing total building energy demand through the installation of high-efficiency mechanical systems, hot water systems, power systems, lighting, and process equipment.
- Supplying remaining building energy needs from renewable sources of energy.

Appendix Z draws on existing requirements outlined in the Energy Conservation Code—Commercial Provisions. Additional minimum performance requirements for building thermal energy performance and airtightness testing have been set to ensure new construction achieves a high degree of energy conservation.

Minimum Performance Requirements

Minimum performance requirements for building energy use intensity have been set to ensure maximum energy efficiency before adding renewable energy generation. The building and its site shall be designed and constructed to meet the mandatory prescriptive requirements in Sections *Z.2*, *Z.3*, *Z.4*, and *Z.5*. For the purposes of this study Section Z.4 and Z.5 shall not be reviewed as they are only required if the project chooses Appendix Z and the path for Energy Code Comliance.

This Appendix has many pre-requisite requirements, but of particular importance is the requirement to use predictive energy modeling to show a reduction in the Zero Energy Performance Index (zEPI). This is discussed in subsequent sections.

$$zEPI = 57 \times (EUIp/EUI_{90.1\text{-}2010}) \qquad \text{(Equation 1)}$$

Where:

- ✓ EUIp = The annual energy use of the building in source kBtu/ft^2, for the proposed design of the building and its site, calculated per Section Z2.1.2, not taking into account any on-site or off-site renewable energy.
- ✓ EUI = The annual energy use of the building in source kBtu/ ft^2 for a baseline building and its site, calculated per Section Z2.1.2, not taking into account any on-site or off-site renewable energy.

"Source: DC 2017 Green Construction Code, Section SECTION 602, MODELED PERFORMANCE PATHWAY REQUIREMENT"

Predicted Energy Performance Summary (Z2)

Z2.1 Building Energy Use Intensity

Building Energy Simulation performed for Otis Street building since the early phase. The energy model compares the proposed design model versus the baseline model (based on requirements of ASHRAE 90.1-2010 Appendix G). To correctly address Appendix Z requirements we need to compare the proposed design results with the baseline model of ASHRAE 90.1 – 2016. Since the energy simulation was performed based on the 2013 version of ASHRAE 90.1, we used the DOE estimate for source energy savings for a 90.1-2016 baseline building compared to 90.1-2013. Figure Z2.1.1 shows the simulated energy use intensity of the building.

Z2.1.1 Zero Energy Performance Index, zEPI

This Appendix has many pre-requisite requirements, but of particular importance is the requirement to use predictive energy modeling to show a reduction in the Zero Energy Performance Index (zEPI). This is discussed in subsequent sections.

$$zEPI = 50.4 \times (EUIp/EUI_{90.1\text{-}2016}) \qquad \text{(Equation 1)}$$

Where:

- ✓ EUIp = The annual energy use of the building in source kBtu/ft^2, for the proposed design of the building and its site, calculated per Section Z2.1.2, not taking into account any on-site or off-site renewable energy.
- ✓ EUI = The annual energy use of the building in source kBtu/ ft^2 for a baseline building and its site, calculated per Section Z2.1.2, not taking into account any on-site or off-site renewable energy.

"Source: DC 2013 Green Construction Code, Section SECTION 602, MODELED PERFORMANCE PATHWAY REQUIREMENT"

Building designs must demonstrate a zEPI of 30 or lower as determined in accordance with Equation 1.

	Total Energy Consumption [kBtu]	Cost [$]	Energy Use Intensity [kBtu/SF-Yr.]	Energy Saving	Cost Saving	zEPI
Baseline - ASHRAE 90.1-2013	1,087,000	30,024	38.8	NA	NA	NA
Baseline - ASHRAE 90.1-2016[1]	1,001,000	27,652	35.8	NA	NA	NA
Proposed – Design[2]	397,700	14,181	14.2	60.3	48.8	20

Table Z.2.1.1.1- zEPI calculation

1- 90.1-2016 baseline benchmarked based on simulated 90.1-2013 and DOE study comparing 90.1-2013 and 90.1 -2016 baseline performance.
2- Proposed energy saving would be the comparison of proposed vs ASHRAE 90.1-2016.

Based on results from the table above and the requirement of compliance in this section, we need to be lower than 30 to compile with the zEPI requirements. With all ECMs considered, the proposed building would meet he zEPI score requirements.

Z2.1.2 Annual Energy Use Indices

Appendix Z states to compile with this section:

> *"The EUIp of the building and building site, and the EUI, shall be calculated in accordance with Appendix G to ASHRAE 90.1-2016, as modified by Sections Z2.1.2.1 and Z2.1.2.2, and approved modeling guidelines published by the Department in administrative bulletins. The annual energy use shall include all energy used for the building systems and its anticipated occupancies."*

Energy modeling is implemented based on all Appendix G requirements, so the energy model is compiled with this section.

Z2.2 Building Thermal Energy Performance

Building thermal energy performance shall comply with Sections Z2.2.1 through Z2.2.2.

Z2.2.1 Annual Heating Demand

Building design shall demonstrate a maximum annual heating demand of 4.2 kBtu/ ft2 $_{\text{iCFA/yr}}$ (4.8 x 104 kJ/m2 $_{\text{iCFA/yr}}$).

Z2.2.2 Annual Cooling Demand

Building design shall demonstrate a maximum annual cooling demand of 6.4 kBtu/ ft2 $_{\text{iCFA/yr}}$ (7.3 x 104 kJ/m2 $_{\text{iCFA/yr}}$).

Results

Table Z.2.2 shows that the HVAC design is compiled with requirements of section Z.2.2.1 and Z.2.2.2

	Heating Demand [Kbtu/SF]	Cooling Demand [kBtu/SF]
Appendix Z Requirements	4.2	6.4
Current Design	**2.5**	**3.9**

Table Z.2.2- Annual Heating and Cooling demand

Z2.3 Multiple Buildings on a Site

"Where there is more than one building on a site, each building shall comply with Sections Z2.2.1 and Z2.2.2 or the combined demands of all the buildings on the site shall comply with Sections Z2.2.1 and Z2.2.2."

Although there are two proposed buildings on the site, the combined demands were included for calculation purposes.

Achieving Net Zero (Z3)

With the envelope and mechanical, electrical, and plumbing systems optimized the buildings EUI has been brought down to as low as reasonably possible. In order to achieve a Net Zero status, renewable energy must be generated equal to 397,700 kBTU (116,094 kWH) for the EUI_P (14.2) of the building. in accordance to the requirements of section Z3.

Z3 Renewable Energy

The building and building site shall be provided with renewable energy equal to the EUI_P on an annual basis and calculated in accordance with Section Z2.1.1. Sources of renewable energy shall comply with Sections Z3.1 through Z3.3. Section Z3.1 says that on-site combustion of fossil fuels cannot be used for the provision of thermal energy while Z3.2 states that the only acceptable sources of on-site renewable are the following:

- Photovoltaic panels.
- Solar thermal systems.
- Wind turbines; and
- Biogas.

For the purposes of this study photovoltaic panels were analyzed to achieve net zero.

Z3.3 On-Site Renewable Energy

Appendix Z states the following:

> *"Renewable energy shall be generated on-site wherever feasible. Before procuring offsite renewable energy, a building project must demonstrate one of the following:*
>
> - *A minimum of 5% of the total building energy consumption shall first be met by an acceptable source of renewable energy installed on the building roof or site.*
>
> *Exception: Where there is not adequate solar access as determined by Chapter 13 of the Energy Conservation Code—Commercial Provisions."*

Both proposed buildings currently have space allocated for a PV canopy. Per requirements, 5% of total energy consumption must be covered by PV arrays. Based on the results of the simulated energy consumption of 397,700 kBTU (116,094 kWH) we will need to generate 19,885 kBtu (5,804 kWh) of energy via PV on site at a minimum. A Solar PV study conducted using the Helios software indicated a max power generation of 57,910 kWh from PV.

Helios Scope was used to calculate the maximum possible PV array size across both buildings. The following parameters were used:

- 21.7% efficient panels
- 33 degree tilt (for fixed tracking)
- 16.6% system losses
- 1.25 DC to AC Size Ratio
- 86% efficient inverter

The building can meet this section's requirements with 5 kW solar PV arrays which provide 5,804 kWh per year and will cover 5% of the total annual energy consumption of the building. Proposed solar array would generate 57,910 kWh of power.

Deaf-Reach 1203 Option 2 Deaf-Reach 1203 Otis Street, 1203 Otis Street, NE, Washington DC

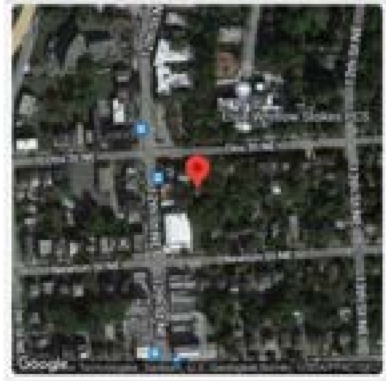
Report

Project Name	Deaf-Reach 1203 Otis Street
Project Address	1203 Otis Street, NE, Washington DC
Prepared By	Joe Schmid joes@interfaceeng.com

System Metrics

Design	Deaf-Reach 1203 Option 2
Module DC Nameplate	39.5 kW
Inverter AC Nameplate	36.0 kW Load Ratio: 1.10
Annual Production	57.91 MWh
Performance Ratio	83.4%
kWh/kWp	1,466.7
Weather Dataset	TMY, 10km grid (38.95,-76.95), NREL (prospector)
Simulator Version	[illegible]

Project Location



Monthly Production

In the two images below, the proposed roof plans for Buildings A and B are proposed.

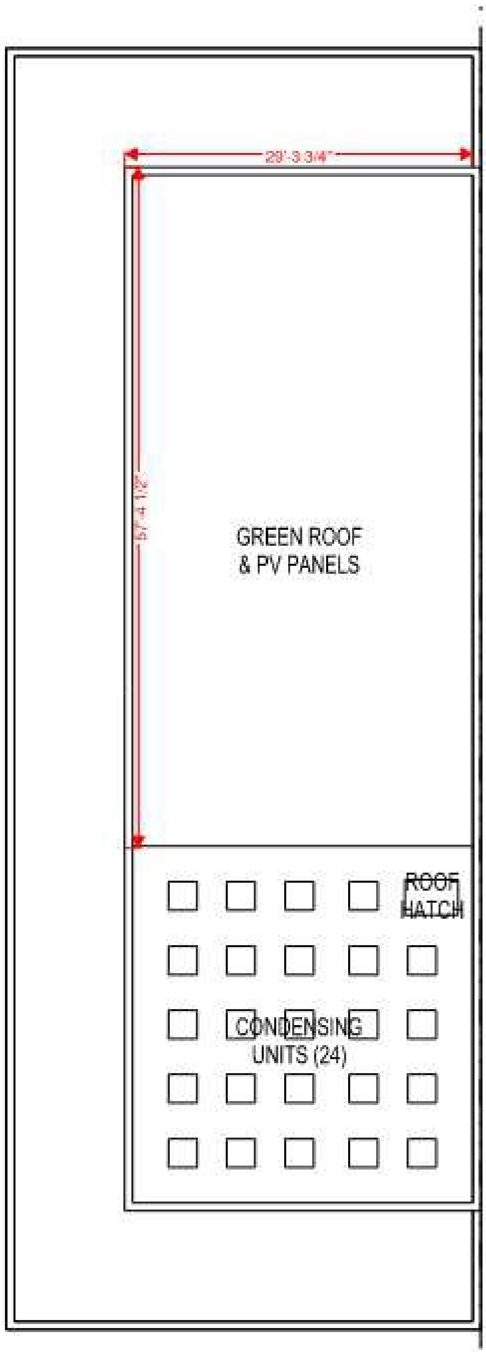


Figure 1: Building A Roof Plan

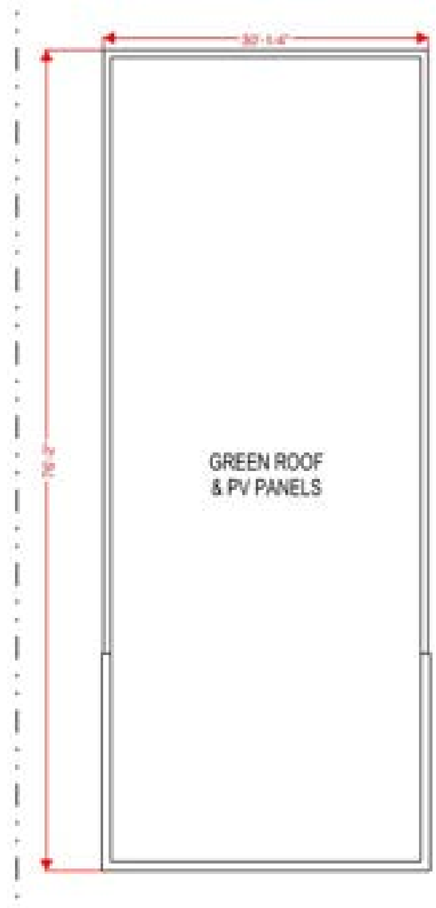


Figure 2: Building B Roof Plan

The following images illustrate the proposed PV layout options modeled using Helioscope.

Figure 3:: PV Layout on 38% of Roof Area

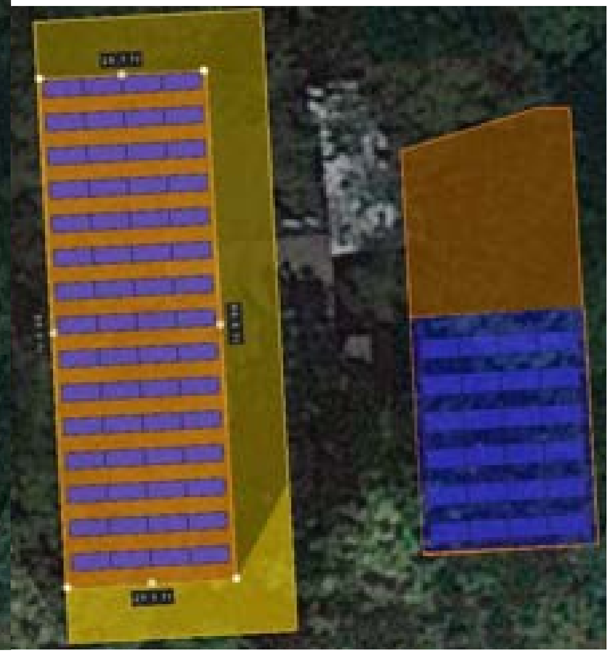


Figure 4:: PV Canopy over entire roof area.

Z3.4 Procurement of Off-Site Renewable Energy

An alternative to on-site is off-site as described below:

> *"The procurement of off-site renewable energy is acceptable only where the energy is procured from a qualified electricity supplier providing energy from Tier 1 renewable sources meeting the minimum percentages of the District of Columbia Renewable Portfolio Standard. Acceptable methods for the procurement of off-site renewable energy include any of the following or as approved by the code official:*
>
> *Owner shall provide the code official with documentation of a signed, legally-binding contract to procure offsite renewable energy through a power purchase agreement for a minimum period of 5 years for electricity generation from, solar or wind-generation facilities that are located within the District of Columbia, Maryland, or Virginia. The owner remains subject to, and must comply with, the District of Columbia's Renewable Portfolio Standard*
> *Connection to a renewable energy microgrid; or Connection to a low-carbon neighborhood thermal energy system."*

The currently proposed 37 kW PV canopy would generate 57,910 kWh of energy, enough to offset approximately 50% of the total annual energy use (116,094 kWH). Off site renewable energy would be needed to obtain the remaining 58,184 kWh of calculated consumed energy in order to truly be a Net-Zero Building.