WA Dept. of Health, Shoreline

PV Solar 2019-032A(1)

Preliminary Engineering Study

SHORELINE, WASHINGTON

JUNE 3, 2019 – REVISION 2

FOR THE LIFE OF YOUR BUILDING

Project Contacts

AREA OF RESPONSIBILITY	NAME	CONTACT NUMBER	EMAIL
Primary Client Contact	Terry Williams	206.418.5577	Terry.Williams@DOH.WA.GOV
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Sr. Program Manager & Sr. Energy Engineer	Mark Nieman	206.832.8152	markn@mckinstry.com

Contents

Executive Summary

OUTCOME SNAPSHOT

This project represents an excellent opportunity to improve this facility while saving energy and trimming utility spending. McKinstry looks forward to making this project a success.

McKinstry estimates these future possible savings, building a maximum-sized solar PV array on the Labs roof and future wing expansions:

$32,290 to 41,790
Utility cost savings range/year

Approximately 408,607
Proposed kWh production/year

Carbon dioxide emissions reductions would approximately equal:

284.3
Metric Tonnes CO_2/year

78
Acres of trees planted

292,862
Pounds of coal not burned per year

55
Average size vehicles removed from the roads

1.1 Overview

Through the Washington State Department of Enterprise Services (DES) Energy Savings Performance Contracting (ESPC) program, McKinstry conducted a study and investigation of energy upgrades for the Department of Health at its Shoreline Public Health Labs. Our Investment Grade Audit investigated the current upper limit possible of installing a solar photovoltaic (PV) system on the existing and future expansion roofs at the Shoreline Labs.

1.2 Current Situation

CHALLENGES

The Washington State Public Health Labs currently does not have any sustainable on-site power generation, such as a solar photovoltaic system. Also, Washington State Executive Order 18-01 states a goal for state facilties to pursue zero net energy.

GOALS

Providing an on-site solar PV system on the Labs' roofs will help move the Shoreline facility's overall energy use closer to the intent of Executive Order 18-01.

1.3 Solutions

This project includes:

FIM ID: 10.01-PHL FUTURE SOLAR PV

This measure looks at the future possible extent of Solar PV on the roof of the WA Public Health Labs in Shoreline, WA. The layout takes into consideration future wing expansions and looks to answer what is the maximum potential solar PV array possible at the Labs. The basis of design is a 370 kW DC system with fixed modules at a 10 degree tilt, pointed south (~180 degree azimuth). Modules are based on Jinko Solar JKM 390M-72-V (390 W modules) and inverters are based on Chint CPS SCA 36KTL-DO (36 kW inverters). Module racking is based on Panel Claw clawRF 10 Degree racks with 11" row gaps. Final pricing, performance and selection of the PV Solar system will depend on staging with the current versus future roof layouts at the Labs.

1.4 Summary of Benefits

FINANCIAL BENEFITS

Including sales tax and prior to any utility incentives, the total ROM project budget for this measure is in the range of $960,400 to $1,162,600. The ROM annual energy savings are in the range of $32,290 to $41,790. Construction tax credits are currently estimated at an incentive amount of approximately $31,800. Depending on the final actual design, layout and materials used, the project has a 22.2 to 35 year simple payback, making the solar PV measure very feasible as part of the Labs' goal to meet the intent of EO 18-01.

Executive Summary

COMPANY AT-A-GLANCE

- Established 1960
- Over 1,700 employees
- 23 offices
- 55+ Professional Engineers
- 80+ LEED Accredited Professionals

MCKINSTRY EXPERIENCE

$20 million	Customer utility savings guaranteed
$100 million	Grants & rebates secured for clients
636 million	Kilowatt hours saved
453 thousand	Metric tons of CO_2 saved
91 million	Gas Therms saved

CO_2 emission reductions resulting from McKinstry projects have environmental impacts equal to:

3,167 acres	Forest acres saved from destruction
51.5 million	Gallons of gas not used
83+ thousand	Cars taken off the road
40+ thousand	Homes taken off the power grid

ENVIRONMENTAL BENEFITS

By taking the necessary steps to produce on-site electricity through the implementation of the Solar PV facility improvement measure detailed in this report, the Department of Health will attain the savings outlined in the outcome snapshot on the previous page. This is equivalent to:

- 43,523 typical home light bulbs (13.5 Watt LED) not energized; or
- 1,062,246 miles not driven by an average size vehicle.
- Supply approximately 9.4% of the Labs' energy consumption

NEXT STEPS

McKinstry is prepared to move forward quickly with preparation of final scope information and a full Energy Services Proposal, upon approval from the Department of Health.

1.5 McKinstry Differentiators

COMPANY OVERVIEW

McKinstry has over 50 years of experience assessing and improving facilities in the Pacific Northwest. With more than 1,500 successful energy and facility improvement projects completed in the past 15 years, McKinstry has the expertise to offer comprehensive solutions to the Department of Enterprise Services. McKinstry is more than just another energy services company, we believe in serving as your trusted advisor "*For the Life of Your Building.*"

MCKINSTRY APPROACH ADVANTAGES

- Vendor- and product-neutral for truly consultative role
- Transparent pricing
- Total cost of ownership consideration
- No "shared savings" model

Scope of Work

2.1 Facility Improvement Measure (FIM) List

For full a description of the DRAFT scope of work, please refer to Section 2 - Detailed Scope of Work.

FIM # 10.01-PHL Future Solar PV

2.2 McKinstry Services

McKinstry will include the following services related to this project:

1. *Energy Audit:*
   The energy audit is complete and is submitted within this Energy Service Proposal.
2. *Design Services:*
   McKinstry will provide a detailed engineering design as needed to obtain permitting, Owner review, and approval of the proposed systems. In addition, McKinstry will also provide construction support services, start-up, testing, as-built drawings of systems installed, and provide operations and maintenance manuals.
3. *Construction:*
   Provide, or cause to be provided, all material, labor, and equipment, including paying for permits, fees, bonds, and insurance, required for the complete and working installation of McKinstry's equipment.
   a. McKinstry will provide a site superintendent who will be responsible for the onsite supervision and coordination of trades and subcontractors. This individual's responsibilities will also include regular work observations, quality control, site security, enforcement of the site-specific safety plan, as well as coordinating any impact upon building tenants with the Owner.
   b. McKinstry may perform portions of the construction work or may subcontract portions to qualified firms. In either case, McKinstry will share information regarding actual costs of the work with the Owner and DES.
   c. When McKinstry has completed the installation of the equipment, including start-up, operations verification, and training in accordance with the Proposal, McKinstry will provide to Owner and DES a "Notice of Commencement of Energy Savings."
   d. At the conclusion of the project, McKinstry will submit a "Notice of Substantial Completion" to the Owner and DES.
4. *Construction Management:*
   McKinstry will provide a dedicated construction manager who will provide contract administration services for the project. The owner is expected to coordinate day-to-day communications with tenants and any scheduling of tenant relocations in and around occupied areas.
5. *Operation Training:*
   McKinstry will provide relevant training of building staff during construction as agreed to by the Owner and DES.
6. *Performance Maintenance:*
   McKinstry will provide ongoing monitoring and support services to help ensure that guaranteed savings are achieved throughout the term of the agreement. Ongoing services shall be under separate agreement. Ongoing services shall be at the discretion of the Owner and DES to terminate. Specific tasks associated with proposed ongoing Measurement and Verification (M&V) will be provided when a final Design is proposed.

7. *Equipment Maintenance:*

   McKinstry will provide no equipment maintenance or repairs after the warranty period. Following the completion of the installation and Owner acceptance of the equipment, the Owner shall provide all necessary service, repairs, and adjustments to the equipment so that the equipment will perform in the manner and to the extent set forth in the Proposal. McKinstry shall have no obligation to service or maintain the equipment after the warranty period.

8. *Warranty:*

   McKinstry will warrant equipment for one year following Notice of Commencement of Energy Savings. Specific information regarding equipment warranty will be passed on to owner.

2.3 Extent of Subcontracting

McKinstry may subcontract the energy audit, design, construction management, start-up, and training portions of this Contract to qualified firms upon review and approval by owner. Construction subcontracts will be awarded competitively. McKinstry will endeavor to satisfy the Diverse Business Enterprise utilization goals of the Owner and DES.

2.4 Project Schedule

Project schedule will be developed when Design commences of the final Solar PV project. Design duration would be approximately two months, followed by three months for Construction.

Detailed Scope of Work

FIM ID # 41013
10.01-PHL Future Solar PV
WA Public Health Lab

GENERAL

This measure looks at the future possible extent of Solar PV on the roof of the WA Public Health Labs in Shoreline, WA. The layout takes into consideration future wing expansions and looks to answer what is the maximum potential solar PV array possible at the Labs. The basis of design is a 370 kW DC system with fixed modules at a 10-degree tilt, pointed south (~180 degree azimuth). Modules are based on Jinko Solar JKM 390M-72-V (390 W modules) and inverters are based on Chint CPS SCA 36KTL-DO (36 kW inverters). Module racking is based on Panel Claw clawRF 10 Degree racks with 11" row gaps. Final pricing, performance and selection of the PV Solar system will depend on staging with the current versus future roof layouts at the Labs.

DRAFT ROM SCOPE OF WORK INCLUDES

1. Solar
   A. Initial basis of design is a flat roof, ballasted fixed-tilt Solar PV system
   B. Layout based on a 10-degree tilt racking system (Panel Claw clawRF) with 11” row gaps, primarily ballasted. Direct mount anchors only to be used as required, based on Structural requirements.
   C. Current technology and future Lab wing build-outs suggest a system as large as 370 kW DC
   D. Initial panel selection based on Jinko Solar 390 watt modules
   E. Initial inverter selection based on Chint 36 kW inverters
   F. Final design pending actual roof area available (including final Structural analysis and Electrical design)
2. Training
   A. Provide training as required for this FIM.

Maximum Future Solar PV WSPHL Shoreline PV, 1610 NE 150th St, Shoreline WA

Report

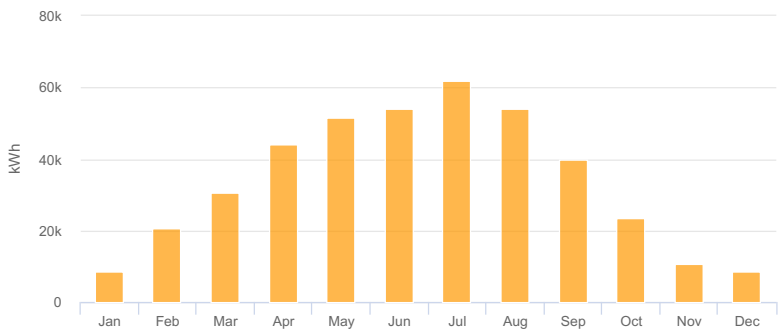
Project Name	WSPHL Shoreline PV
Project Description	Maximum Solar PV Array Study
Project Address	1610 NE 150th St, Shoreline WA
Prepared By	Mark Nieman markn@mckinstry.com

System Metrics

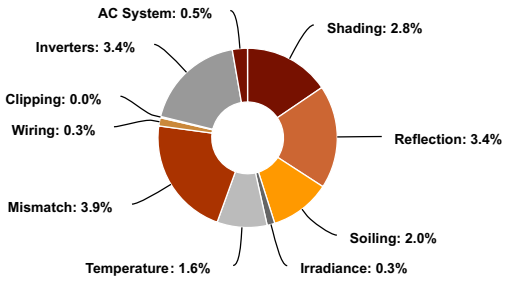
Design	Maximum Future Solar PV
Module DC Nameplate	370.9 kW
Inverter AC Nameplate	396.0 kW Load Ratio: 0.94
Annual Production	408.6 MWh
Performance Ratio	83.1%
kWh/kWp	1,101.7
Weather Dataset	TMY, 10km Grid (47.75,-122.35), NREL (prospector)
Simulator Version	8888c1159c-ca10379297-66bde7997b-97562fcf95

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,229.6	
	Adjusted Global Horizontal Irradiance	1,229.6	0.0%
	POA Irradiance	1,325.5	7.8%
	Shaded Irradiance	1,288.0	-2.8%
	Irradiance after Reflection	1,244.3	-3.4%
	Irradiance after Soiling	1,219.4	-2.0%
	Total Collector Irradiance	**1,219.4**	**0.0%**
Energy (kWh)	Nameplate	452,310.7	
	Output at Irradiance Levels	451,163.3	-0.3%
	Output at Cell Temperature Derate	443,748.2	-1.6%
	Output After Mismatch	426,252.3	-3.9%
	Optimal DC Output	425,104.8	-0.3%
	Constrained DC Output	424,913.6	0.0%
	Inverter Output	410,660.0	-3.4%
	Energy to Grid	**408,607.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		12.8 °C
	Avg. Operating Cell Temp		19.5 °C
Simulation Metrics			
	Operating Hours		4641
	Solved Hours		4641

Condition Set

Description	Condition Set 1											
Weather Dataset	TMY, 10km Grid (47.75,-122.35), 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	Characterization										
	JKM 390M-72-V (Jinkosolar)	Jinko_JKM_390M_72_V˜(G3.2_F40).PAN, PAN										
Component Characterizations	Device	Characterization										
	CPS SCA 36KTL-DO (US) (Chint)	Manufacturer										

Components

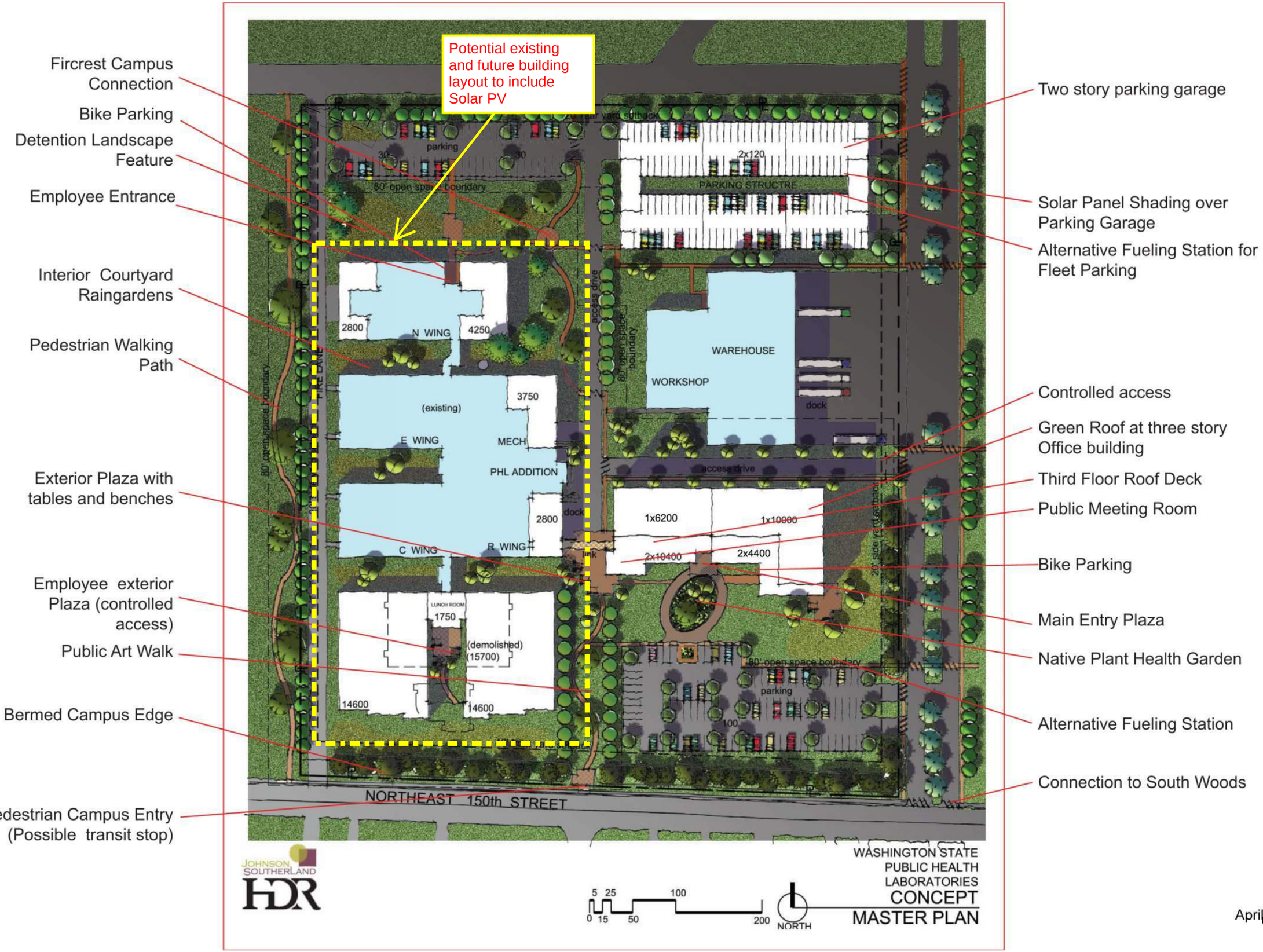
Component	Name	Count
Inverters	CPS SCA 36KTL-DO (US) (Chint)	11 (396.0 kW)
Home Runs	6 AWG (Copper)	9 (745.2 ft)
Home Runs	2 AWG (Copper)	3 (124.7 ft)
Home Runs	1 AWG (Copper)	4 (301.4 ft)
Combiners	2 input Combiner	6
Combiners	3 input Combiner	1
Combiners	4 input Combiner	4
Combiners	6 input Combiner	4
Combiners	7 input Combiner	1
Strings	10 AWG (Copper)	62 (3,840.1 ft)
Module	Jinkosolar, JKM 390M-72-V (390W)	951 (370.9 kW)

Wiring Zones

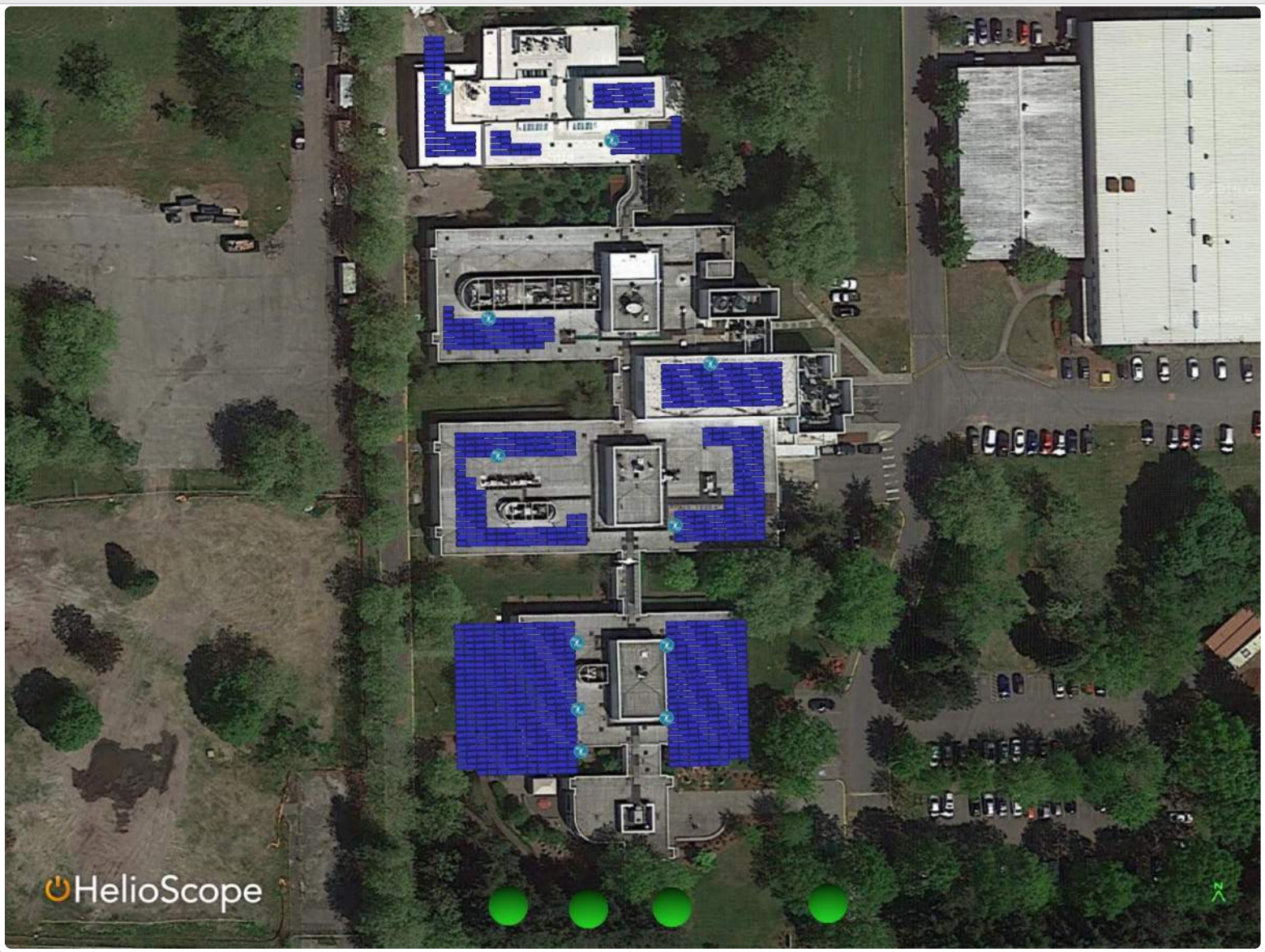
Description	Combiner Poles	String Size	Stringing Strategy
West S Wing Wiring Zone	12	14-17	Along Racking
C and R Wing Wiring Zone 2	12	14-17	Along Racking
N Wing Wiring Zone 3	12	14-17	Along Racking
East S Wing Wiring Zone	12	14-17	Along Racking
PHL Wiring Zone 5	12	14-17	Along Racking
E-Wing Wiring Zone 6	12	14-17	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
C Wing	Fixed Tilt	Landscape (Horizontal)	10°	179.227°	0.9 ft	1x1	130	116	45.2 kW
PHL Addition	Fixed Tilt	Landscape (Horizontal)	10°	178.677°	0.9 ft	1x1	84	84	32.8 kW
West South Wing Addition	Fixed Tilt	Landscape (Horizontal)	10°	178.801°	0.9 ft	1x1	291	286	111.5 kW
E-Wing	Fixed Tilt	Landscape (Horizontal)	10°	179.154°	0.9 ft	1x1	76	57	22.2 kW
N-Wing Mech	Fixed Tilt	Landscape (Horizontal)	10°	178.686°	0.9 ft	1x1	24	24	9.36 kW
N-Wing	Fixed Tilt	Landscape (Horizontal)	10°	179.288°	0.9 ft	1x1	52	44	17.2 kW
W N-Wing	Fixed Tilt	Landscape (Horizontal)	10°	179.288°	0.9 ft	1x1	50	50	19.5 kW
N-Wing Center	Fixed Tilt	Landscape (Horizontal)	10°	179.288°	0.9 ft	1x1	15	15	5.85 kW
East S Wing Addition	Fixed Tilt	Landscape (Horizontal)	10°	178.652°	0.9 ft	1x1	193	182	71.0 kW
R-Wing	Fixed Tilt	Landscape (Horizontal)	10°	178.652°	0.9 ft	1x1	98	95	37.1 kW


Potential existing and future building layout to include Solar PV
Fircrest Campus Connection
Bike Parking
Detention Landscape Feature
Employee Entrance
Interior Courtyard Raingardens
Pedestrian Walking Path
Exterior Plaza with tables and benches
Employee exterior Plaza (controlled access)
Public Art Walk
Bermed Campus Edge
Pedestrian Campus Entry (Possible transit stop)
Two story parking garage
Solar Panel Shading over Parking Garage
Alternative Fueling Station for Fleet Parking
Controlled access
Green Roof at three story Office building
Third Floor Roof Deck
Public Meeting Room
Bike Parking
Main Entry Plaza
Native Plant Health Garden
Alternative Fueling Station
Connection to South Woods
parking
2x120
PARKING STRUCTRE
80' open space boundary
access drive
N WING
2800
4250
WAREHOUSE
WORKSHOP
dock
3750
(existing)
E WING
MECH
PHL ADDITION
C WING
R WING
1x6200
1x10000
2x10400
2x4400
LUNCH ROOM
1750
(demolished)
(15700)
14600
100
NORTHEAST 150th STREET
JOHNSON, SOUTHERLAND
HDR
WASHINGTON STATE
PUBLIC HEALTH
LABORATORIES
CONCEPT
MASTER PLAN
0 15 50 200
5 25 100
NORTH

Detailed Layout



Maximum Future Solar PV WSPHL Shoreline PV, 1610 NE 150th St, Shoreline WA

Shading Heatmap

Shading by Field Segment

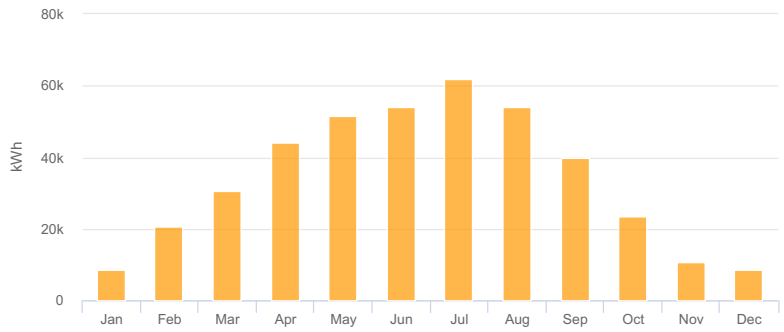
Description	Tilt	Azimuth	Modules	Nameplate	Shaded Irradiance	AC Energy	TOF[2]	Solar Access	Avg TSRF [2]
C Wing	10.0°	179.2°	116	45.2 kWp	1,281.8kWh/m^2	49.6 MWh[1]	92.3%	96.7%	89.3%
PHL Addition	10.0°	178.7°	84	32.8 kWp	1,299.4kWh/m^2	36.3 MWh[1]	92.3%	98.0%	90.5%
West South Wing Addition	10.0°	178.8°	286	111.5 kWp	1,295.4kWh/m^2	123.1 MWh[1]	92.3%	97.7%	90.2%
E-Wing	10.0°	179.2°	57	22.2 kWp	1,277.1kWh/m^2	24.3 MWh[1]	92.3%	96.3%	89.0%
N-Wing Mech	10.0°	178.7°	24	9.36 kWp	1,303.3kWh/m^2	10.4 MWh[1]	92.3%	98.3%	90.8%
N-Wing	10.0°	179.3°	44	17.2 kWp	1,270.1kWh/m^2	18.7 MWh[1]	92.3%	95.8%	88.5%
W N-Wing	10.0°	179.3°	50	19.5 kWp	1,294.9kWh/m^2	21.5 MWh[1]	92.3%	97.7%	90.2%
N-Wing Center	10.0°	179.3°	15	5.85 kWp	1,278.6kWh/m^2	6.40 MWh[1]	92.3%	96.5%	89.1%
East S Wing Addition	10.0°	178.7°	182	71.0 kWp	1,295.3kWh/m^2	78.4 MWh[1]	92.3%	97.7%	90.2%
R-Wing	10.0°	178.7°	95	37.1 kWp	1,258.4kWh/m^2	40.0 MWh[1]	92.3%	94.9%	87.7%
Totals, weighted by kWp			**953**	**371.7 kWp**	**1,288.0kWh/m^2**	**408.6 MWh**	**92.3%**	**97.2%**	**89.7%**

[1] approximate, varies based on inverter performance
[2] based on location Optimal POA Irradiance of 1,435.5kWh/m^2 at 36.2° tilt and 188.2° azimuth

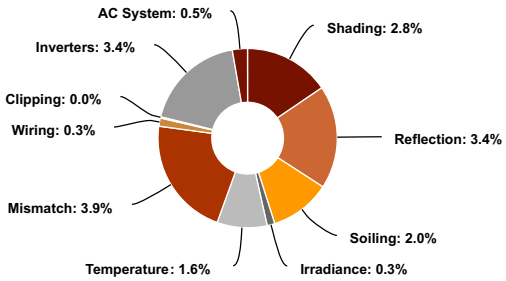
Solar Access by Month

Description	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
C Wing	89%	92%	98%	98%	98%	98%	98%	98%	98%	95%	88%	85%
PHL Addition	90%	92%	99%	99%	99%	99%	100%	100%	100%	96%	88%	86%
West South Wing Addition	89%	92%	99%	99%	99%	99%	99%	99%	99%	96%	87%	84%
E-Wing	88%	91%	97%	98%	97%	97%	98%	98%	98%	95%	88%	84%
N-Wing Mech	91%	93%	99%	100%	99%	100%	100%	100%	100%	97%	90%	88%
N-Wing	89%	92%	96%	97%	97%	97%	97%	98%	98%	94%	88%	85%
W N-Wing	89%	92%	99%	99%	99%	99%	99%	99%	99%	95%	87%	84%
N-Wing Center	91%	93%	97%	97%	97%	98%	98%	98%	96%	95%	90%	88%
East S Wing Addition	89%	91%	99%	99%	99%	99%	99%	99%	99%	96%	87%	84%
R-Wing	87%	90%	96%	96%	96%	96%	96%	96%	97%	94%	85%	83%
Solar Access, weighted by kWp	**89.0%**	**91.7%**	**98.3%**	**98.6%**	**98.5%**	**98.6%**	**98.8%**	**98.9%**	**98.8%**	**95.5%**	**87.1%**	**84.2%**
AC Power (kWh)	**8,684.5**	**20,773.7**	**30,734.3**	**44,253.8**	**51,722.8**	**54,014.6**	**61,725.9**	**54,120.3**	**39,824.3**	**23,398.3**	**10,739.5**	**8,615.4**

Monthly Production



Sources of System Loss



Southwestern Angle

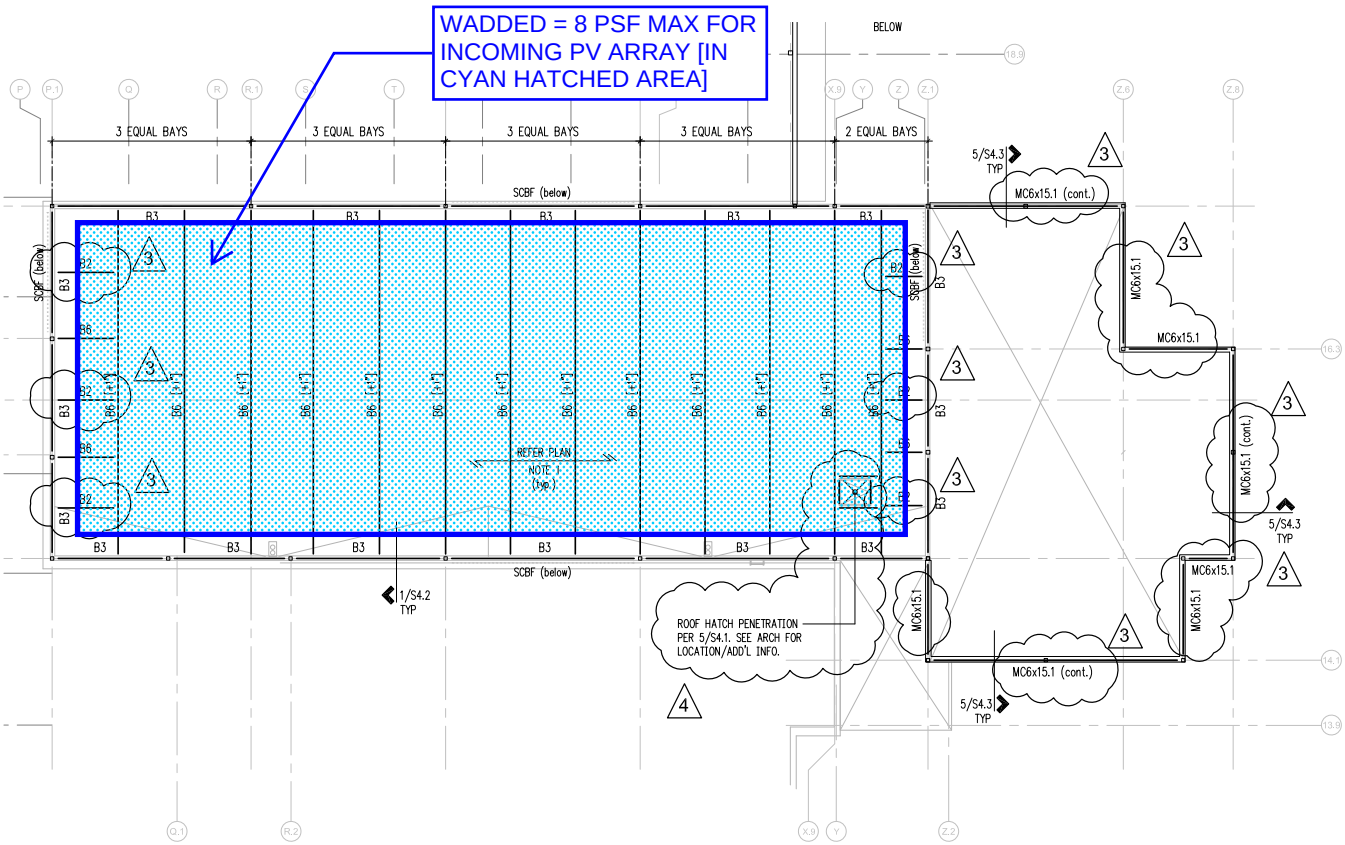
Southeastern Angle

SEE THE ATTACHED SHEETS FOR MORE INFORMATION.

McKinstry For The Life Of Your Building	PROJECT	WSPHL ROOFTOP SOLAR FEASIBILITY	
	TITLE	STRUCTURAL ANALYSIS OF ROOF FRAMING	
800.669.6223 www.mckinstry.com	BY JWG, MMR	SCALE	JOB # 203104
	DATE	REF.DWG	SHEET

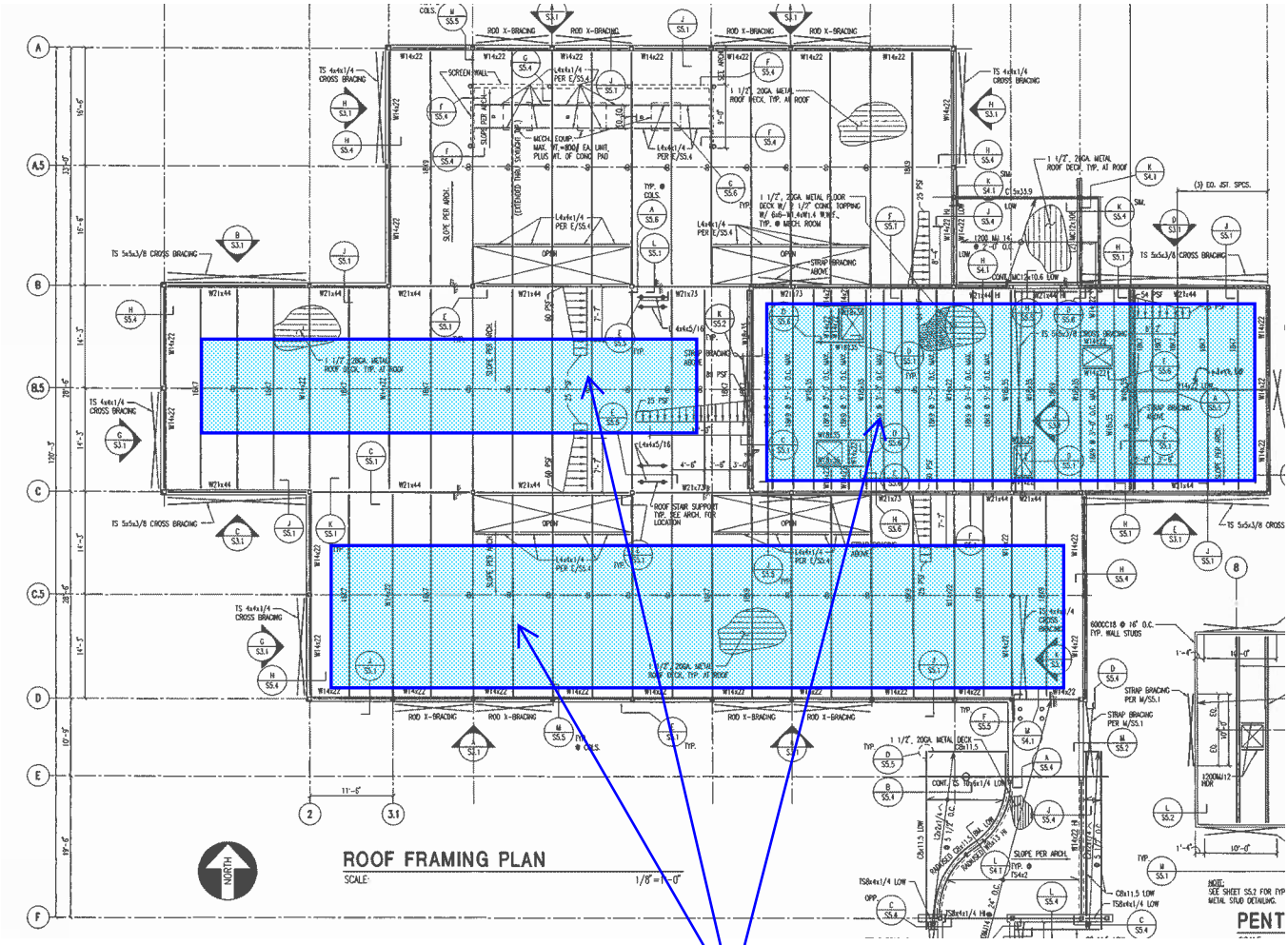
PARTIAL ROOF PLAN -- B WING BLDG

STRUCT INFO FROM MICHAEL WRIGHT S1-4



PARTIAL ROOF PLAN -- N WING BLDG

STRUCT INFO FROM NBBJ/SWMB DWG: S-2.2



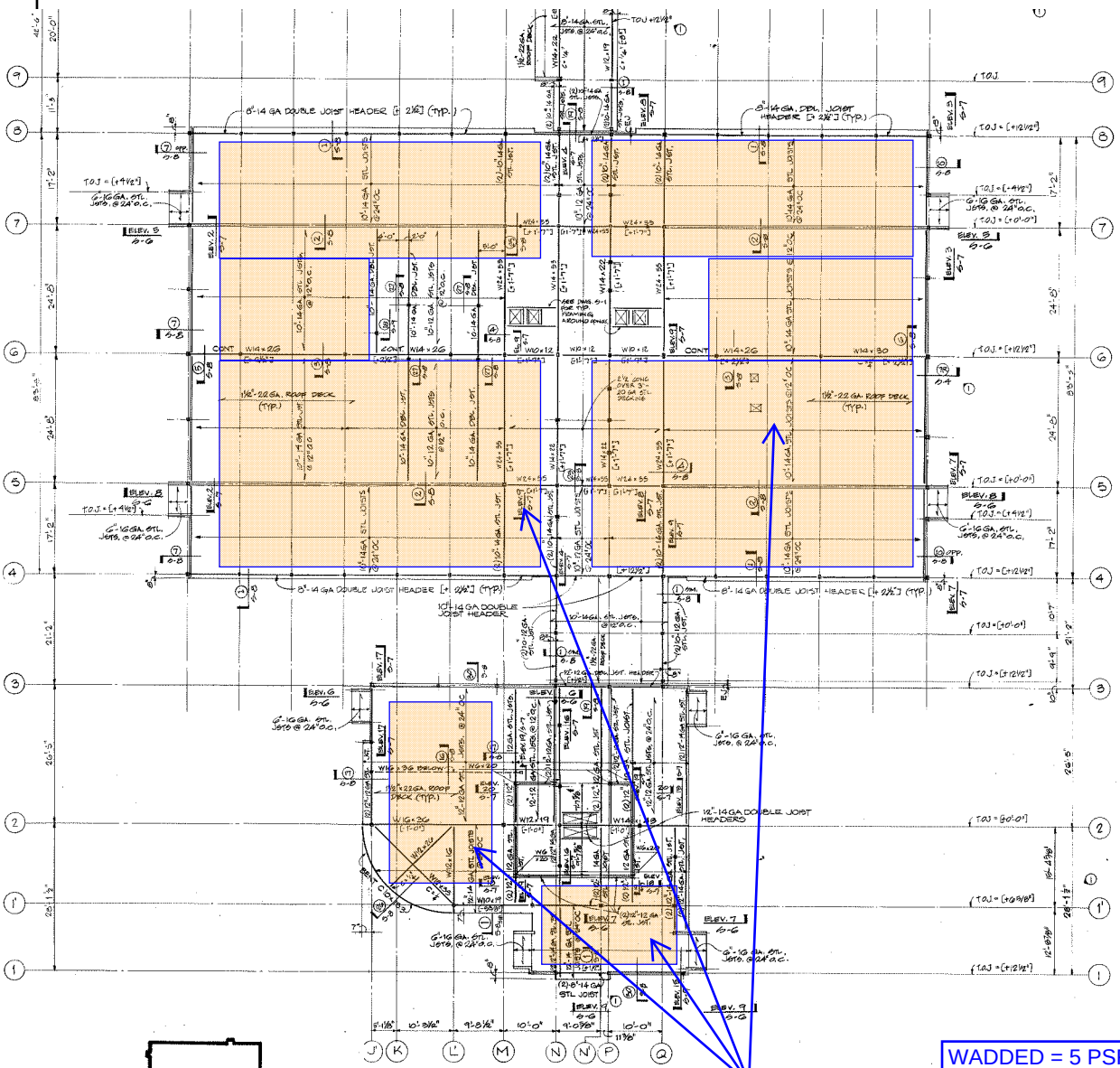
WADDED = 8 PSF MAX FOR INCOMING PV ARRAY [IN CYAN HATCHED AREA]

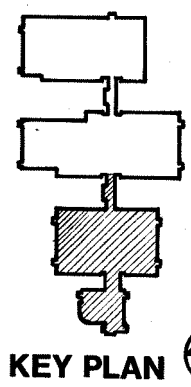
McKinstry
For The Life Of Your Building
800.669.6223
www.mckinstry.com

PROJECT WSPHL ROOFTOP SOLAR FEASIBILITY		
TITLE STRUCTURAL ANALYSIS OF ROOF FRAMING		
BY JWG, MMR	SCALE	JOB # 203104
DATE	REF.DWG	SHEET

PARTIAL ROOF PLAN -- A, Q, & S WING BLDG

STRUCT INFO FROM NBBJ/SWMB DWG: S-4.0

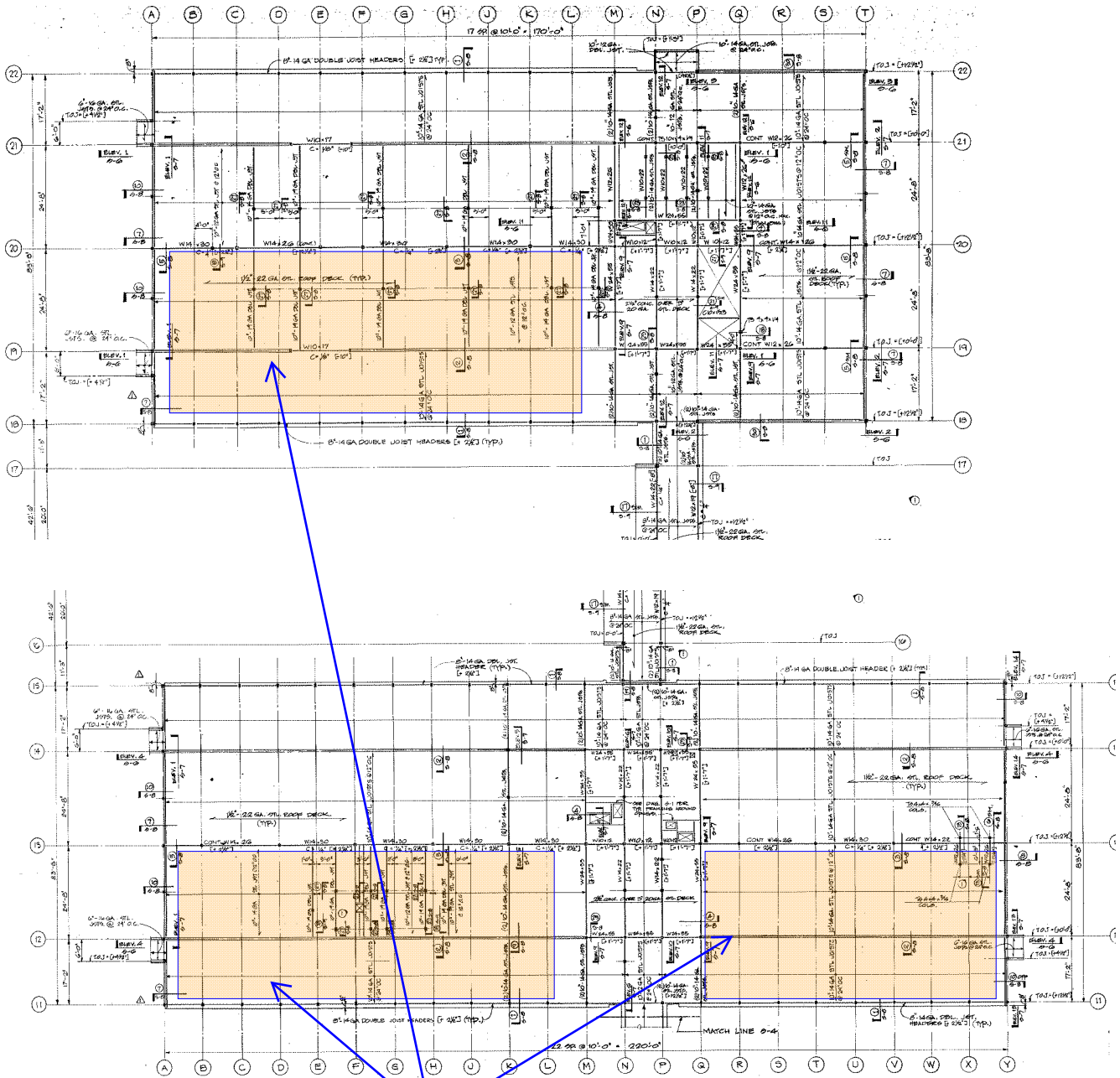




McKinstry For The Life Of Your Building 800.669.6223 www.mckinstry.com	PROJECT WSPHL ROOFTOP SOLAR FEASIBILITY		
	TITLE STRUCTURAL ANALYSIS OF ROOF FRAMING		
	BY JWG, MMR	SCALE	JOB # 203104
	DATE	REF.DWG	SHEET

PARTIAL ROOF PLAN -- C, E, R & M WING BLDG

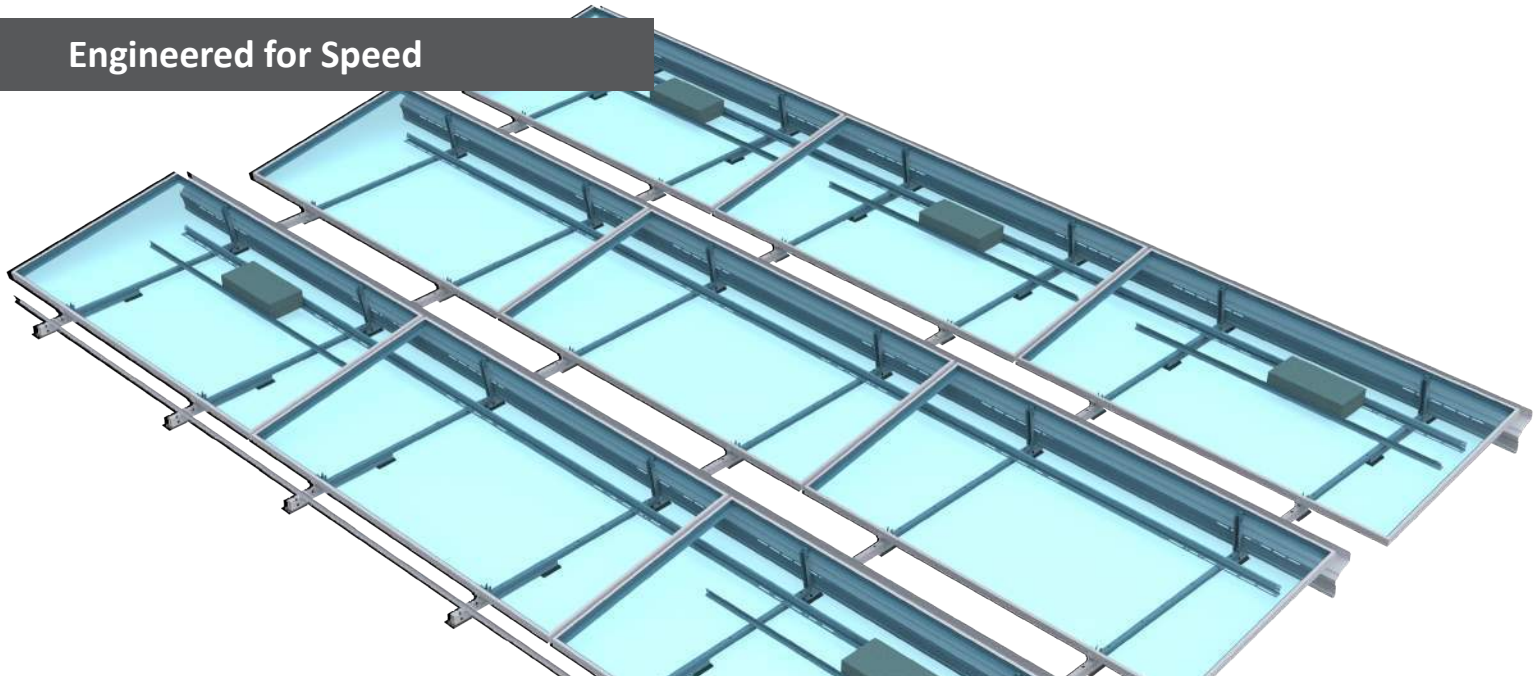
STRUCT INFO FROM NBBJ/SWMB DWG: S-5.0



clawFR®

10 Degree Flat Roof Mounting System

Engineered for Speed



Flat Roof Racking Specialists

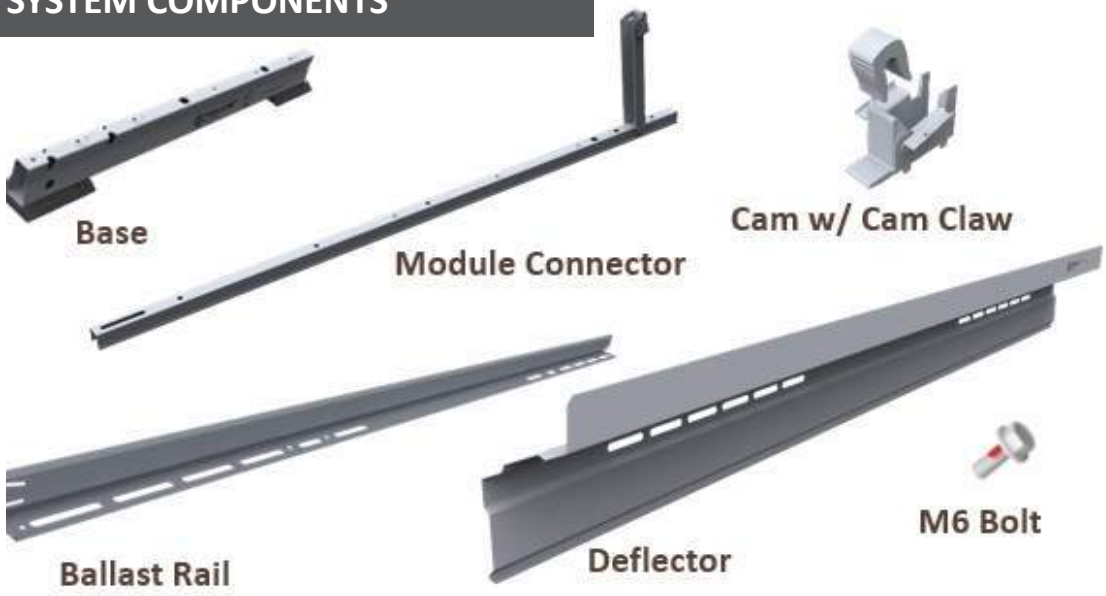
PanelClaw® is the only major racking provider in North America focused exclusively on flat roof racking. Our 11+ years of focus on flat roof result in a competitive advantage for our partners. No one knows more about flat roof racking than PanelClaw; no one delivers a more thoroughly tested and reliable platform; and no one matches our level of service. Our mission is to accelerate the deployment of flat roof PV and the best way to do this is to continue to lower its life-cycle cost while maintaining the highest levels of reliability. The clawFR platform is the result of this experience and commitment to flat roof.

More than 4.5 million modules have been installed with our products on flat roofs around the world representing more than 1.3GW of deployed racking. With 99.999% reliability, our track record in flat roof remains unmatched.

clawFR
10 Degree Flat Roof Mounting System

PANELCLAW®

SYSTEM COMPONENTS



Accelerated Construction

EPC feedback-driven features for mechanical build and wire management.

- Single M6 bolt hardware kit
- No tool module attachment method
- 90 degree single-module tilt-up feature
- Flexible order of operations installation process allows for optimized coordination of building trades on the roof
- Integrated roof protection pads
- 10” plus access ways between modules
- Only 1 ground lug required per array

Intelligent System Design

Module agnostic components allow for flexibility in module spec changes. Lead times don’t change each time you have to switch modules on a project. The modular design of clawFR also allows for designers to maximize the number of modules that will fit on a give roof. clawFR is the most flexible rail based design ever, allowing for up to 3 degrees of wavy roof undulation in two directions.

Safety and Reliability

clawFR has been subjected to a battery of reliability and performance tests that go well beyond US code requirements. Our wind tunnel test program spans more than 10 years and our in-house SolarPTL® certified satelite test laboratory along with third-party peer reviews are the most robust in the industry.

O&M Features

Many of the construction features were designed to help O&M providers, but some features were designed specifically for O&M.

- Recessed Deflector allows for easy access to module connections and optimizer equipment
- ZAM® coating with 5x better corrosion resistance than G90
- If mechanical roof attachments are needed, they are always placed in the row module gaps for easy O&M inspection

Applications
< 5° slope flat roofs (up to 7° possible w/engineering review)

Roof Type Compatibility
Membrane, tar and gravel, ballasted, BUR, concrete, asphalt (not compatible with metal roofs)

Row-to-Row Spacing Options
11”, 14” or 17”

Platform Load
~ 2.0 - 12 psf

Module Orientation
Landscape

Module Attachment
Airy point flange mounted

Basic Wind Speed
Up to 190 mph
(>190 mph by approval)

Wind Exposure Category
B and C (D requires engineering review)

USGS Seismic Categories
A, B, C, D (others require engineering review)

Building Height
No building height limitations

FM Global
Reports and methodologies meet the requirements for FM Global approval

Warranty and Certifications
25 year warranty

ANSI/UL 2703-2015 Listed System Fire Rating Class A with Type 1 and Type 2 modules

Made in USA

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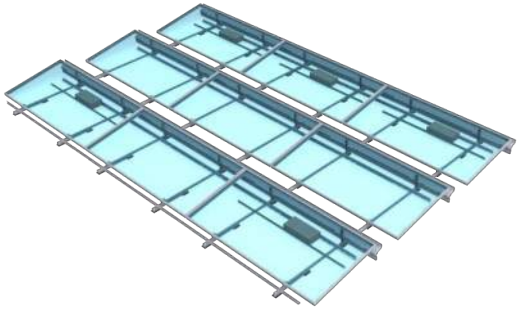
PANELCLAW®

clawFR 10 Degree Design Specifications, Rules and Guidelines



Specifications: clawFR 10 Degree

Roof Loading	2 psf to 12 psf (9.75 kg/m² to 58.6 kg/m²) including racking, modules and ballast
Roof Slope	5˚ max slope (1/12 pitch) in all directions Up to 7˚ (1.5 / 12 pitch) possible with engineering review
Wavy Roofs	clawFR can span up to to 3˚ in undulation in any two directions This system is not designed to go over roof cricketing
Wind Speed	150 mph (193 km/h) – 3 second gust per ASCE 7-05 (190 mph per ASCE 7-10) Higher wind speeds require PanelClaw engineering review
Exposures	ASCE wind exposure categories B, C and D
Seismic Design Category	USGS_seismic design category A, B, C, D Seismic zones beyond D can also be evaluated upon request
Maximum Building Height	No Limitations
Roof Material	EPDM, TPO, PVC, Mod Bitumen, Asphalt, Coal Tar, Foam, Concrete, and Gravel Loose gravel and/or river rock must be cleared out from under cFR bases
UL/ANSI 2703-2015 Grounding & Bonding	UL LISTED – Will accommodate max module fuse rating of 30 amps. Typical module fuse rating is ~15 amps
UL/ANSI 2703-2015 Mechanical Load	UL LISTED – Racking components meet electrical and mechanical requirements of standard System load rating is always module dependent (module allowable loads are typically the limiting factor)
UL/ANSI 2703-2015 Fire Listing	System Fire Rating Class A with Type 1 and Type 2 modules No additional components required for compliance for Type 1 or Type 2 modules
Ballast Block Size	Nominal 2”x 8”x 16”, 3”x 8”x 16”, or 4”x8”x16” blocks Actual dimensions: 1 5/8” or 2 5/8” or 3 5/8”x 7 5/8”x 15 5/8” with +/- 1/8” tolerance

Row Spacing and Roof Coverage Ratios: clawFR 10 Degree

Dimensions shown below vary by module except the Row-Row Gap, which is fixed.

Example clawFR 10 Degree dimensions shown below are based on a module width of 990 mm (38.98 in).

Dynamic AutoCAD building blocks are available for any framed module between 990 mm and 1070 mm wide.

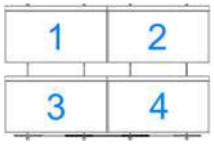
Tilt Angle [degrees]	Roof Coverage Ratio	Shading Ratio [H:V]	Row-Row Gap	N-S Repeat	Repeat E-W	Configuration Name
10	78%	1.7	11 in [288 mm]	50 in [312 mm]	Module width + 0.75 in [19 mm]	clawFR 10Deg-29 cm (11 in)
10	75%	2.0	14 in [354 mm]	52 in [378 mm]	Module width + 0.75 in [19 mm]	clawFR 10Deg-35 cm (14 in)
10	70%	2.5	17 in [443 mm]	56 in [466 mm]	Module width + 0.75 in [19 mm]	clawFR 10Deg-44 cm (17 in)

Array Layout Rules: clawFR 10 Degree

These array layout guidelines were developed to maximize the performance of clawFR over its 25+ year lifespan.

Nonconforming arrays may require layout modifications, may not be ballast-able, or may require mechanical attachments.

- **Minimum setback from roof edges - 4 ft (1.2 m)**
- **Maximum array row length[1]: 80 ft (24.4 m)**
- **Maximum array column length[1]: 80 ft (24.4 m)**
- **Minimum clearance from obstructions[2]: 6 in (153 mm)**
- **Minimum module-to-module clearance between sub arrays[2]:**
  - **Along rows: 8 in (203 mm)**
  - **Along columns: 18 in (460 mm)**
- **Avoid going over existing pipes, lighting rods/cables or vents on the roof**
- **Minimum array size 2 x 2 modules**



[1] Adjacent subarrays can be grouped with a minimum module-to-module clearances as long as those groups of subarrays do not exceed 150’ x 150’ IBC fire code requirements

[2] Unless otherwise specified in DMPV analysis for unattached designs

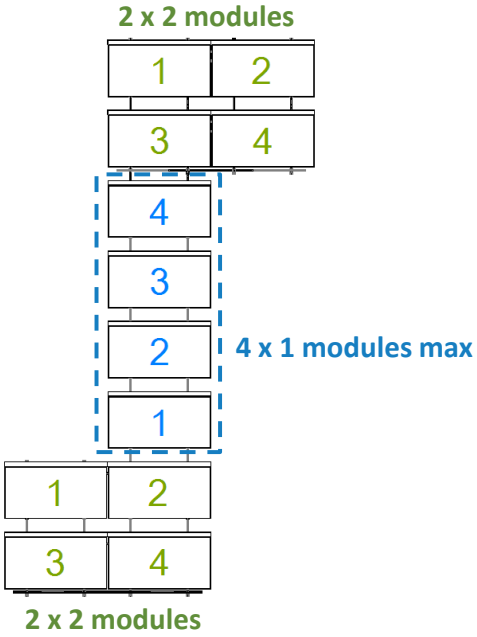
Layout Recommendations for Reducing Weight and/or Mechanical Attachment Counts

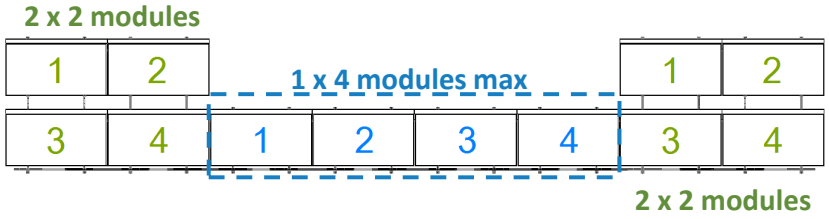
Minimize the Use of Long “Bridges”

Keep the single module wide “bridges” to no more than 1 x 4 modules or 4 x 1 modules.

“Bridges” more than 4 single modules long will require additional ballast and/or mechanical attachments.

If “bridge ends” that are at least 2 x 2 modules on both ends are not present it may result in additional ballast and/or mechanical attachments.



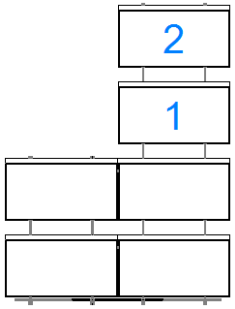


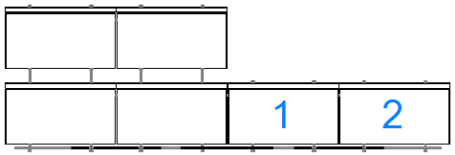
Limit “Peninsulas” to No More Than Two Modules Long

Keep “peninsulas” to no more than 1 x 2 modules or 2 x 1 modules.

“Peninsulas” that are more than 2 module long will require additional ballast and/or mechanical attachments.

1 x 2 modules





2 x 1 modules

For Questions or Feedback Contact sales@panelclaw.com or call us at (978) 688-4900

Energy Savings Estimate

3.1 Savings Overview

1. *Calculation Methodology:*

   The calculation method for the FIM 10.01-PHL Future Solar PV was based on a concept layout, using HelioScope, an on-line Solar PV calculation tool. The panel layout was based on the April 2010 Concept Master Plan, to calculate the current maximum probable performance of a full Solar PV array serving the Shoreline Labs. Depending on when the array is installed and which roofs are available, the final production output will be determined at that time.

3.2 Utility Rates

1. *Utility Rate:*

   For the purpose of calculating energy cost savings, the utility rate used was estimated based on the future Seattle City Light MDH Electric Rate Schedule that is anticipated to be implemented at the end of 2019. Electric Service is currently fed from the adjacent Fircrest Campus and will be separated in late 2019. Once the new service is implemented, the new utility rate will be confirmed at that time.

Table 3.1 - Energy Savings Summary

Project	WA State Department of Health - Public Health L
Scenario	2019 PV Solar ESP
Date	5/6/2019

		Electricity		Total		
Facility Improvement Measures	Facility	kWh	kWh ($)	($)	% kWh Savings of Bills	% Therm Savings of Bills
10.01-PHL Future Solar PV	WA Public Health Lab	408,607	$37,992	$37,992	14%	0%
	Totals	**408,607**	**$37,992**	**$37,992**		

* The savings shown in this table are estimated and not guaranteed.

Table 3.3 - Base Utility Rates

Project	WA State Department of Health - Public Health Labs
Scenario	2019 PV Solar ESP
Date	5/6/2019

Building_Name	Utility_Provider	Rate_Name	Utility_Type	Dollars_Per_Unit	Units	Published_Date_Effective
WA Public Health Lab	Seattle City Light	Future MDH kWh	Electricity	$0.092979	kWh	1/1/2019

Table 4.1 - ROM Max Budget Summary

Project	WA State Department of Health - Public Health Labs
Scenario	2019 PV Solar ESP
Date	5/28/2019

Database ID	FIM Name	Mechanical	Electrical	EMCS	Lighting	General	Equipment	Other	Total
41013	10.01-PHL Future Solar PV	$ -	$ 400,186	$ -	$ -	$ 85,715	$ 255,054	$ -	$ 740,955
	Total Base FIM Cost	$ -	$ 400,186	$ -	$ -	$ 85,715	$ 255,054	$ -	$ 740,955

A. Construction Budget					
	Construction Bonds	%	1.10%	Percent of Subtotal (FIM Cost and A)	$ 8,151
				Total Construction Cost	$ 749,106

B. Professional Services Budget					
	Design	Lump	$30,000		$ 30,000
	Const. Management & Proj. Admin	%	6.00%	Percent of Total Base FIM Cost	$ 44,457
				Total Professional Services Cost	$ 74,457

C. Other Project Budgets					
	Project Contingency	%	5.00%	Percent of Total Base FIM Cost	$ 37,048
	Performance Assurance (M&V)	Lump	$10,000		$ 10,000
				Total Other Project Cost	$ 47,048

D. Overhead Budget & Fees					
	Overhead	%	10.00%	Percent of Total Construction Cost	$ 74,911
	Profit (Fee)	%	8.00%	Percent of Total Construction Cost	$ 59,928
				Total Overhead Cost & Fee	$ 134,839

E. Total Estimated Construction & ESCO Services (A + B + C + D)	$ 1,005,450

F. Estimated Non-Guaranteed Budget					
	Sales Tax	%	10.10%	Percent of Section E	$ 101,550
	Interagency Fee	Lump	$51,600		$ 51,600
	Interagency Fee for Years 2+ M&V	Lump	$4,000	$2000 per year WA DES Fee Beyond Year 1	$ 4,000
				Total Non-Guaranteed Cost	$ 157,150

G. Total Estimated Maximum Project Budget (E + F)	$ 1,162,600

Table 4.2 - Facility Improvement Measure (FIM) Summary - Rough Order of Magnitude (ROM)

Project	WA State Department of Health - Public Health Labs
Scenario	2019 PV Solar ESP
Date	May 28, 2019

			Budget *		Annual Utility Savings		Simple Payback (SPB)			Non-Guaranteed Net Customer Cost (with Incentives)		Non-Guaranteed Simple Payback (SPB) (with Incentives)	
FIM Name	FIM Description	Facility	Min	Max	Min	Max	Min	Max	Potential Incentives ***	Min	Max	Min	Max
10.01-PHL Future Solar PV	This measure looks at the future possible extent of Solar PV on the roof of the WA Public Health Labs in Shoreline, WA. The layout takes into consideration future wing expansions and looks to answer what is the maximum potential solar PV array possible at the Labs. The basis of design is a 370 kW DC system with fixed modules at a 10 degree tilt, pointed south (~180 degree azimuth). Modules are based on Jinko Solar JKM 390M-72-V (390 W modules) and inverters are based on Chint CPS SCA 36KTL-DO (36 kW inverters). Module racking is based on Panel Claw clawRF 10 Degree racks with 11" row gaps. Final pricing, performance and selection of the PV Solar system will depend on staging with the current versus future roof layouts at the Labs.	WA Public Health Lab	$960,400	$1,162,600	$32,290	$41,790	23.0	36.0	$31,800	$928,600	$1,130,800	22.2	35.0
			$960,400	**$1,162,600**	**$32,290**	**$41,790**	**23.0**	**36.0**	**$31,800**	**$928,600**	**$1,130,800**	**22.2**	**35.0**

* Since design cost, audit cost, etc. are distributed among the FIMs, the total project cost will not go up or down by exactly the amounts shown here if a FIM or FIMs are dropped.
** For non recurring operational savings, the values are averaged over the 30 year length of this analysis.
*** Incentives are contingent on final approval and are not guaranteed. Funds are shown for reference only.

WA State Department of Health - Public Health Labs

Environmental Impact Calculator

Non-Baseload	Load Factor to Use		
NWPP	Select eGRID Subregion	1.53381	lbs CO_2e/kWh (eGRID Subregion Electricity Emissions Factor)

Amount Each Utility Type Will Be Reduced Per Year

Electricity					
408,607	kWh	=	626,725 lbs CO_2	284.3 Metric Tonnes CO_2	
Natural Gas					
0	Therms	=	0 lbs CO_2	0.0 Metric Tonnes CO_2	
Steam					
0	Mlbs	=	0 lbs CO_2	0.0 Metric Tonnes CO_2	
Fuel Oil					
0	Gallons	=	0 lbs CO_2	0.0 Metric Tonnes CO_2	
Propane					
0	Gallons	=	0 lbs CO_2	0.0 Metric Tonnes CO_2	
	Total Reduction	=	626,725 lbs CO_2	284.3 Metric Tonnes CO_2	

This Annual Emissions Reduction Is Equivalent To The Following:

55	Number of Vehicles Removed From Roads (Avg Size); or
1,062,246	Number of Miles Not Driven Per Year (Avg Size); or
7,834	Number of 75 Watt Light bulbs Not Energized; or
27	Number of Avg Sized Houses Removed From Power Grid; or
78	Acres of Trees Planted; or
292,862	Pounds of Coal Not Burned Per Year

Other Emissions Factors

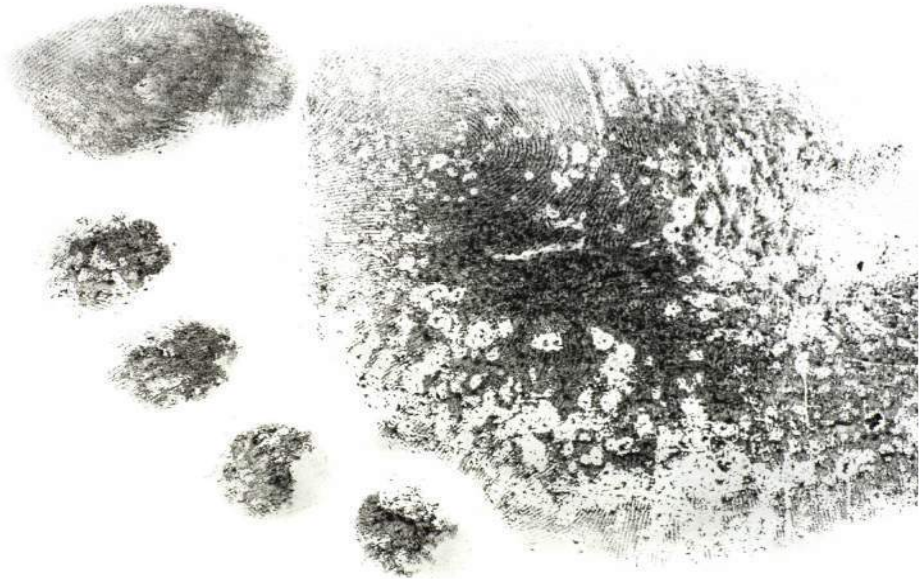
Natural Gas: 11.707 lbs CO_2 / Therm
Steam: 195.3636 lbs CO_2 / Mlbs (Seattle Steam)
Fuel Oil: 22.384 lbs CO_2 / gal
Propane: 12.5 lbs CO_2 / gal
Conversion: 2,204.623 lbs CO_2 / Metric Tonnes CO_2

Equivalents Conversions

Car Emmissions: 11,470 lbs CO_2 / car / yr
Tree Carbon Sequestation: 8,066 lbs CO_2 / acre / yr
Vehicle Mileage Emmissions: 0.59 lbs CO_2 / mile
75 W Light Bulb Emmissions: 80 lbs CO_2 / Light Bulb / yr
Tree Carbon Sequestation: 8,066 lbs CO_2 / acre / yr
Coal Emmisions: 2.14 lbs CO_2 / pound Coal
Houses Removed: 22,880 lbs CO_2 / house

Sources:

* Energy Information Agency (EIA)
* Environmental Protection Agency (EPA)
* ENERGY STAR
* eGRID 2014



Utility Rates

The table below shows the rates associated with your current utility rate schedule (MDH). Your estimated electric bills after solar are shown on the following page.

Energy Charges		Demand Charges	
Type	MDH	Type	MDH
W Flat Rate	$0.08445	W NC	$4.16
S Flat Rate	$0.08445	S NC	$4.16

Current Electric Bill

The table below shows your annual electricity costs based on the most current utility rates and your previous 12 months of electrical usage.

Rate Schedule: SCL - MDH

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges		
Bill Ranges & Seasons	Total	NC / Max	Energy	Demand	Total
1/1/2017 - 2/1/2017 W	222,566	560	$20,694	$2,566	$23,259
2/1/2017 - 3/1/2017 W	209,707	576	$19,498	$2,639	$22,137
3/1/2017 - 4/1/2017 W	243,659	592	$22,655	$2,712	$25,367
4/1/2017 - 5/1/2017 S	208,144	608	$19,353	$2,786	$22,138
5/1/2017 - 6/1/2017 S	249,473	623	$23,195	$2,854	$26,050
6/1/2017 - 7/1/2017 S	271,928	639	$25,283	$2,928	$28,211
7/1/2017 - 8/1/2017 S	260,717	655	$24,241	$3,001	$27,242
8/1/2017 - 9/1/2017 S	287,625	671	$26,743	$3,074	$29,817
9/1/2017 - 10/1/2017 S	261,752	610	$24,337	$2,795	$27,132
10/1/2017 - 11/1/2017 W	229,304	590	$21,320	$2,703	$24,023
11/1/2017 - 12/1/2017 W	220,171	570	$20,471	$2,612	$23,083
12/1/2017 - 1/1/2018 W	245,479	550	$22,824	$2,520	$25,344
Totals:	2,910,525	-	$270,613	$33,191	$303,803

New Electric Bill

Rate Schedule: SCL - MDH

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges		
Bill Ranges & Seasons	Total	NC / Max	Energy	Demand	Total
1/1/2017 - 2/1/2017 W	213,882	560	$19,886	$2,566	$22,452
2/1/2017 - 3/1/2017 W	188,933	576	$17,566	$2,639	$20,206
3/1/2017 - 4/1/2017 W	212,925	592	$19,797	$2,712	$22,510
4/1/2017 - 5/1/2017 S	163,890	608	$15,238	$2,786	$18,024
5/1/2017 - 6/1/2017 S	197,750	623	$18,386	$2,854	$21,241
6/1/2017 - 7/1/2017 S	217,913	639	$20,261	$2,928	$23,189
7/1/2017 - 8/1/2017 S	198,992	655	$18,502	$3,001	$21,503
8/1/2017 - 9/1/2017 S	233,505	671	$21,711	$3,074	$24,785
9/1/2017 - 10/1/2017 S	221,928	610	$20,634	$2,795	$23,429
10/1/2017 - 11/1/2017 W	205,905	590	$19,144	$2,703	$21,848
11/1/2017 - 12/1/2017 W	209,432	570	$19,472	$2,612	$22,084
12/1/2017 - 1/1/2018 W	236,864	550	$22,023	$2,520	$24,543
Totals:	2,501,919	-	$232,622	$33,191	$265,812

Annual Electricity Savings: $37,991

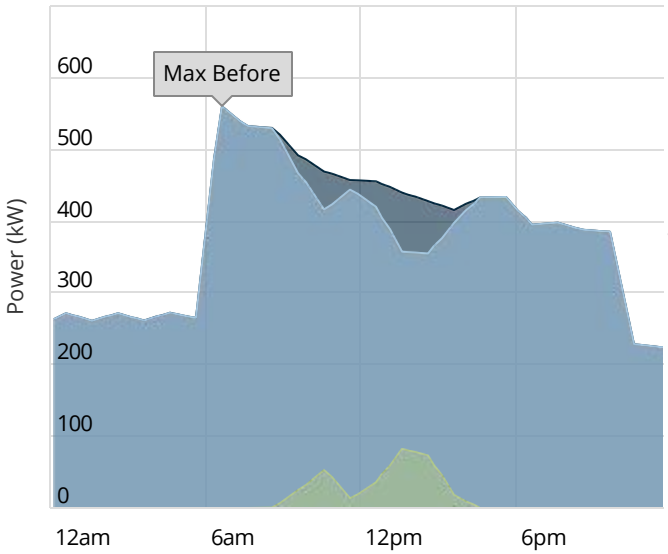
Prepared By: Mark Nieman
P: 206.832.8152, **E:** markn@McKinstry.com

Demand Profiles

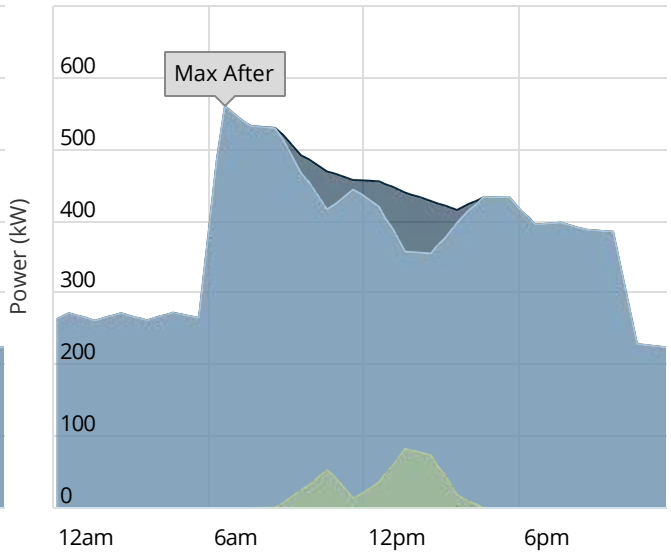
Date Range: 1/1/2017 - 2/1/2017

Max NC Demand: The charts below show when the maximum non-coincident (NC) demand for this facility occurred before and after the Solar PV system simulation.

Max Demand Before 1/2/17 06:30am



Max Demand After 1/2/17 06:30am



Legend: Demand Before | Solar PV | Energy Storage | Demand After

Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the Solar PV system simulation.

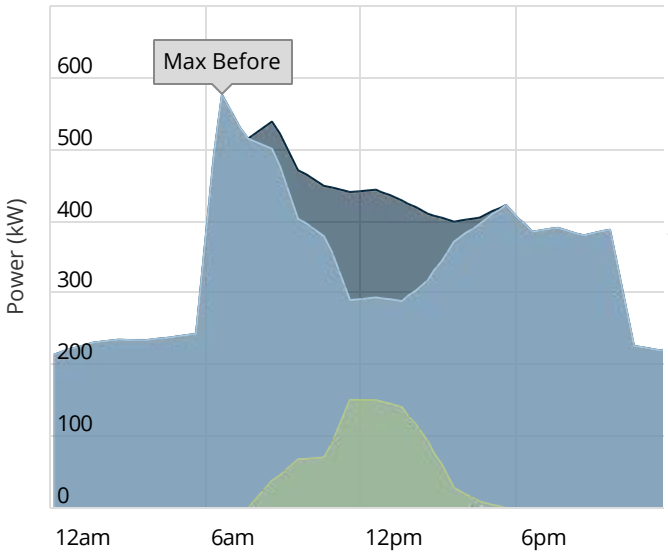
Charts Not Applicable

Demand Profiles

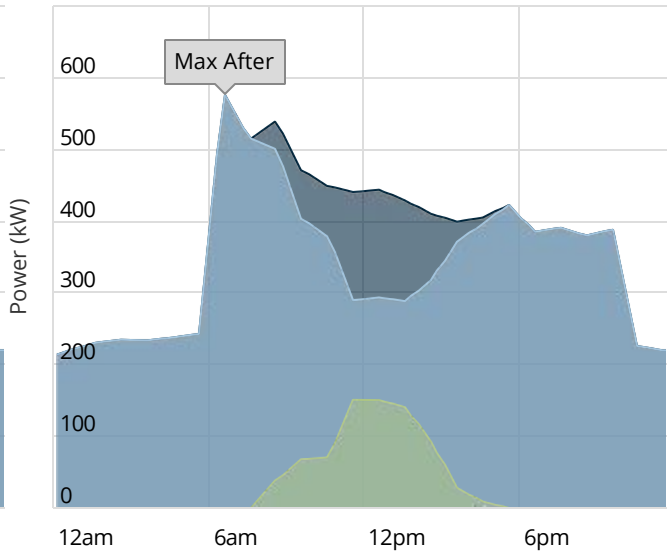
Date Range: 2/1/2017 - 3/1/2017

Max NC Demand: The charts below show when the maximum non-coincident (NC) demand for this facility occurred before and after the Solar PV system simulation.

Max Demand Before 2/13/17 06:30am



Max Demand After 2/13/17 06:30am



Legend: Demand Before | Solar PV | Energy Storage | Demand After

Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the Solar PV system simulation.

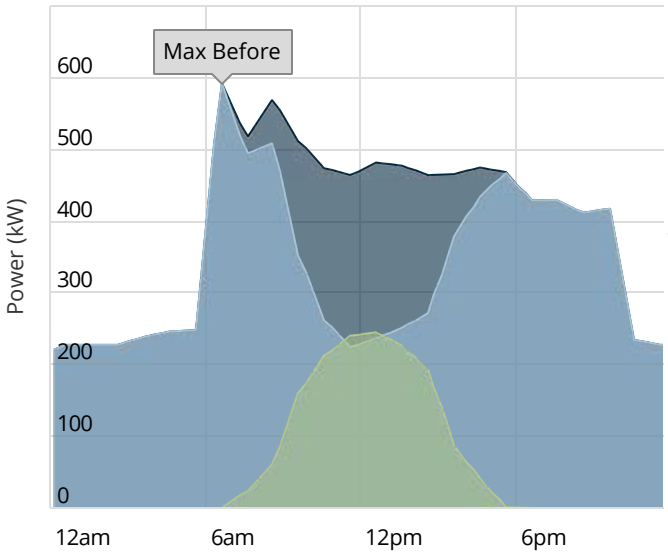
Charts Not Applicable

Demand Profiles

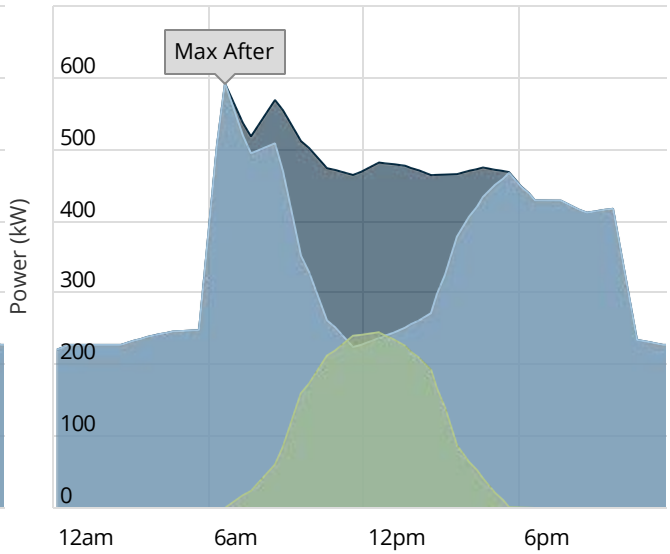
Date Range: 3/1/2017 - 4/1/2017

Max NC Demand: The charts below show when the maximum non-coincident (NC) demand for this facility occurred before and after the Solar PV system simulation.

Max Demand Before 3/6/17 06:30am



Max Demand After 3/6/17 06:30am



Legend: Demand Before | Solar PV | Energy Storage | Demand After

Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the Solar PV system simulation.

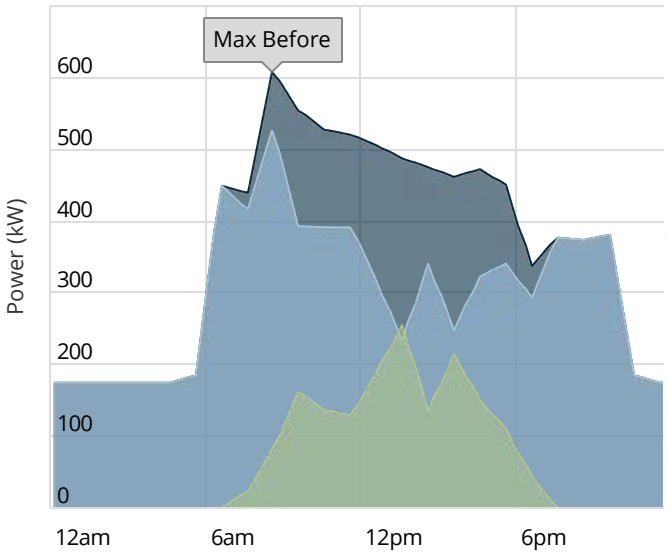
Charts Not Applicable

Demand Profiles

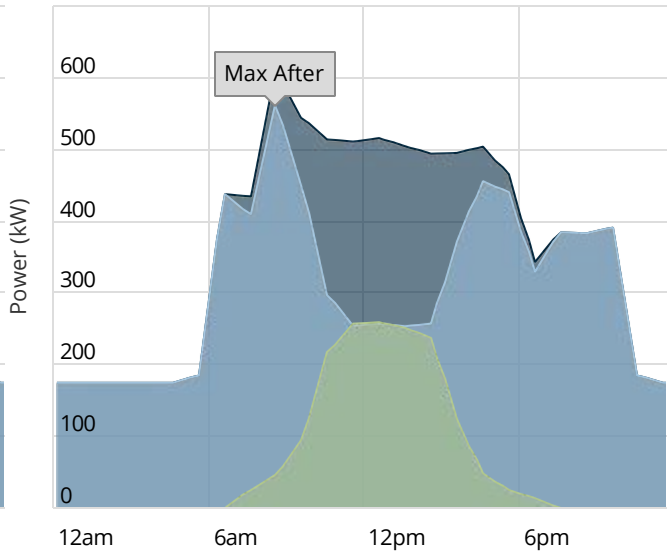
Date Range: 4/1/2017 - 5/1/2017

Max NC Demand: The charts below show when the maximum non-coincident (NC) demand for this facility occurred before and after the Solar PV system simulation.

Max Demand Before 4/6/17 08:30am



Max Demand After 4/5/17 08:30am



Legend: Demand Before | Solar PV | Energy Storage | Demand After

Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the Solar PV system simulation.

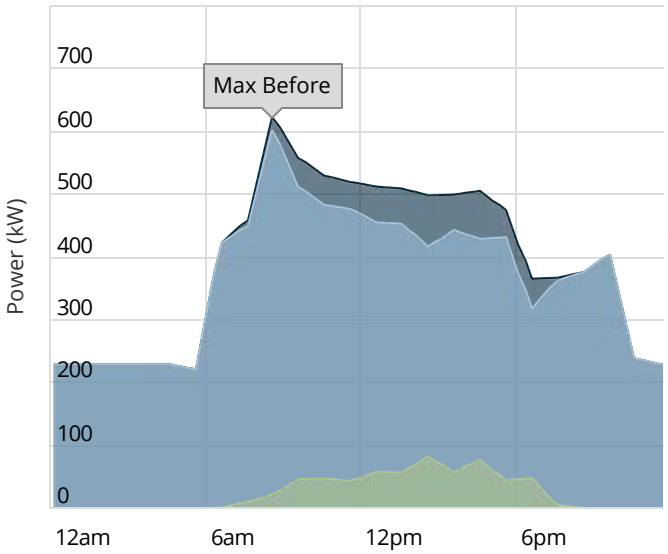
Charts Not Applicable

Demand Profiles

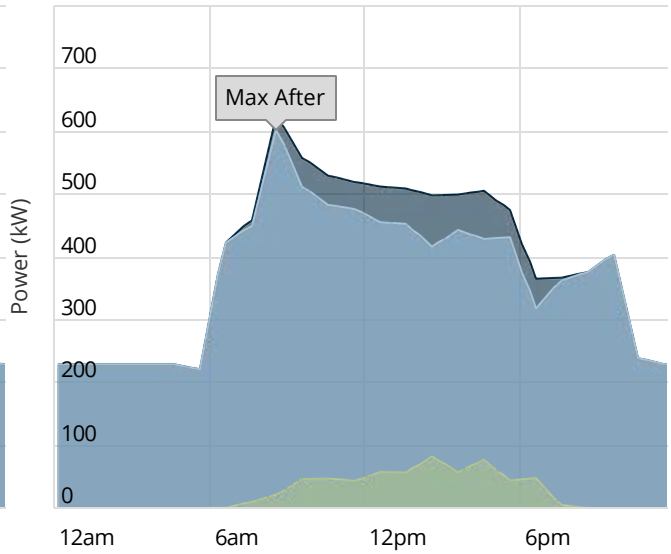
Date Range: 5/1/2017 - 6/1/2017

Max NC Demand: The charts below show when the maximum non-coincident (NC) demand for this facility occurred before and after the Solar PV system simulation.

Max Demand Before 5/10/17 08:30am



Max Demand After 5/10/17 08:30am



Legend: Demand Before | Solar PV | Energy Storage | Demand After

Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the Solar PV system simulation.

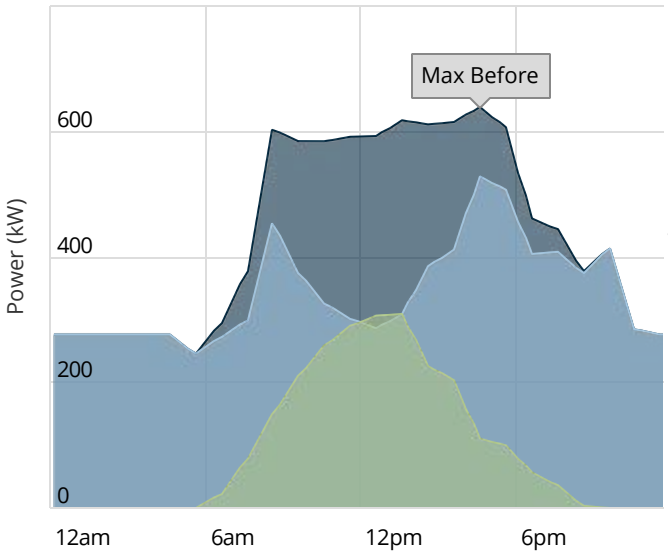
Charts Not Applicable

Demand Profiles

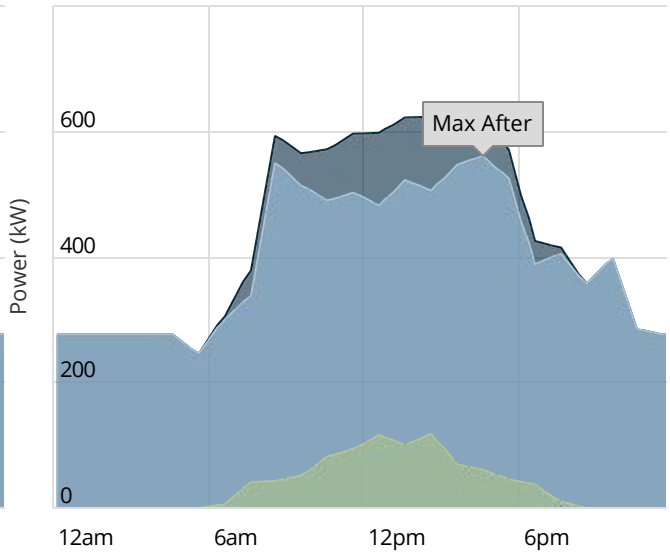
Date Range: 6/1/2017 - 7/1/2017

Max NC Demand: The charts below show when the maximum non-coincident (NC) demand for this facility occurred before and after the Solar PV system simulation.

Max Demand Before 6/20/17 04:30pm



Max Demand After 6/30/17 04:30pm



Legend: Demand Before | Solar PV | Energy Storage | Demand After

Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the Solar PV system simulation.

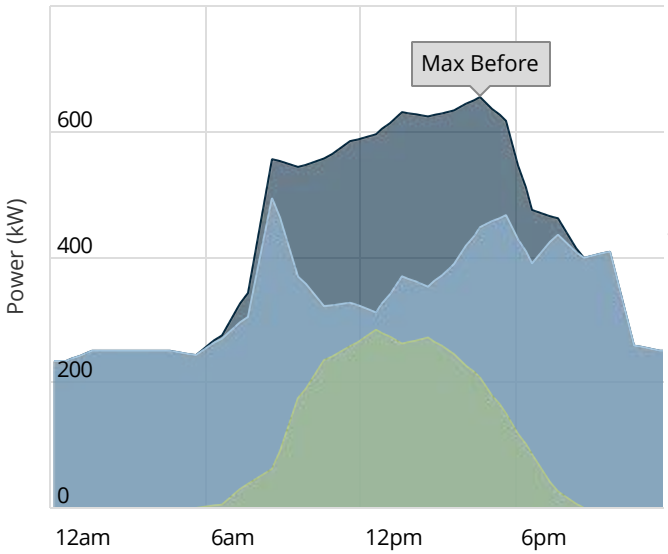
Charts Not Applicable

Demand Profiles

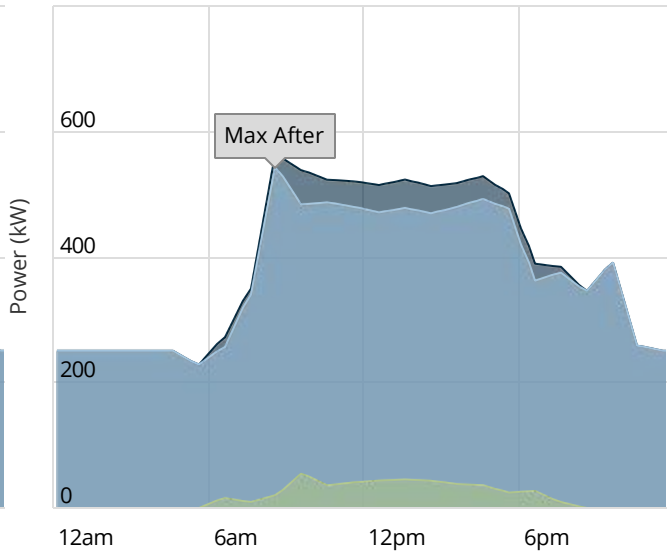
Date Range: 7/1/2017 - 8/1/2017

Max NC Demand: The charts below show when the maximum non-coincident (NC) demand for this facility occurred before and after the Solar PV system simulation.

Max Demand Before 7/24/17 04:30pm



Max Demand After 7/7/17 08:30am



Legend: Demand Before | Solar PV | Energy Storage | Demand After

Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the Solar PV system simulation.

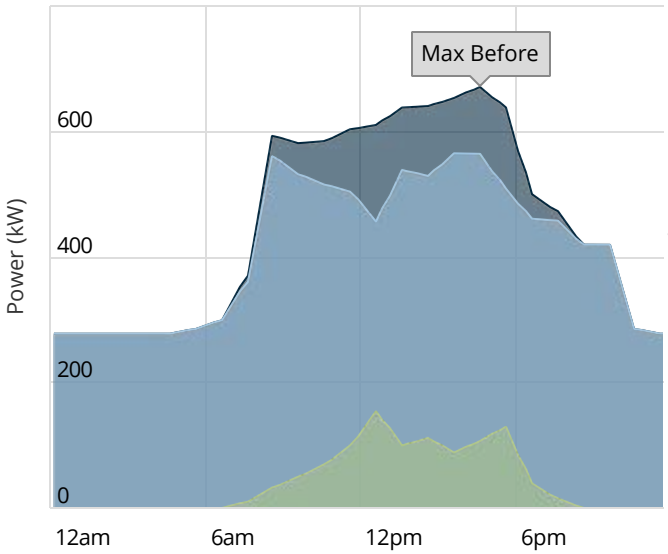
Charts Not Applicable

Demand Profiles

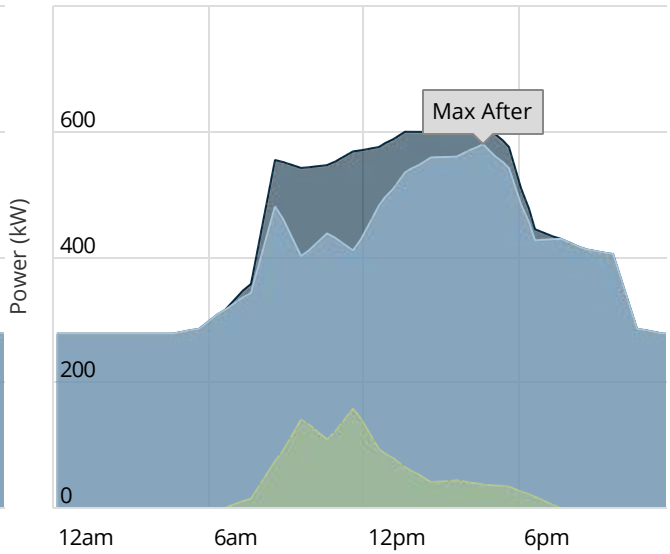
Date Range: 8/1/2017 - 9/1/2017

Max NC Demand: The charts below show when the maximum non-coincident (NC) demand for this facility occurred before and after the Solar PV system simulation.

Max Demand Before 8/10/17 04:30pm



Max Demand After 8/29/17 04:30pm



Legend: Demand Before | Solar PV | Energy Storage | Demand After

Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the Solar PV system simulation.

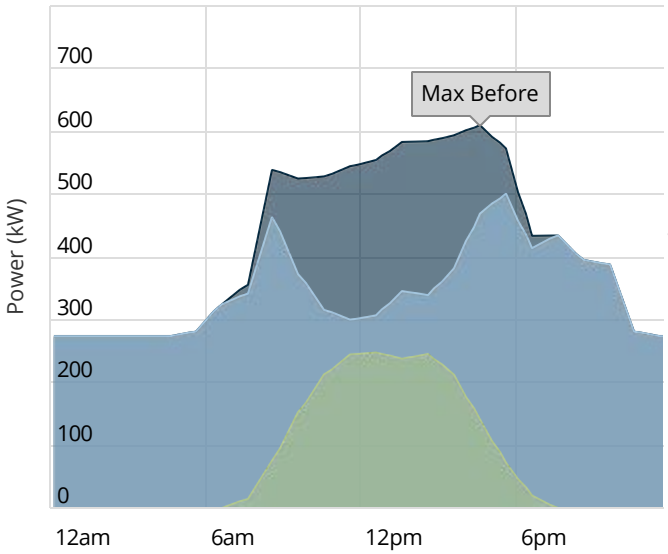
Charts Not Applicable

Demand Profiles

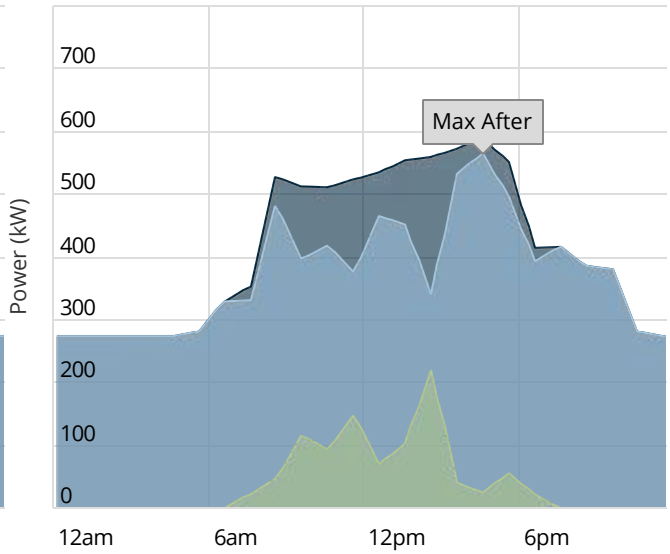
Date Range: 9/1/2017 - 10/1/2017

Max NC Demand: The charts below show when the maximum non-coincident (NC) demand for this facility occurred before and after the Solar PV system simulation.

Max Demand Before 9/13/17 04:30pm



Max Demand After 9/8/17 04:30pm



Legend: Demand Before | Solar PV | Energy Storage | Demand After

Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the Solar PV system simulation.

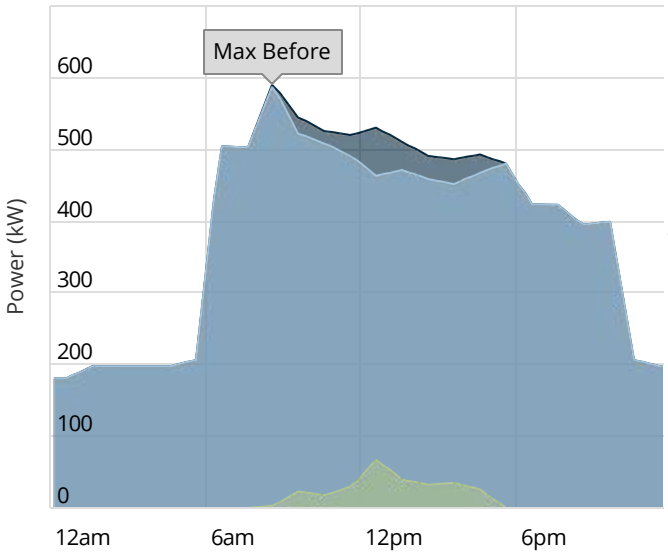
Charts Not Applicable

Demand Profiles

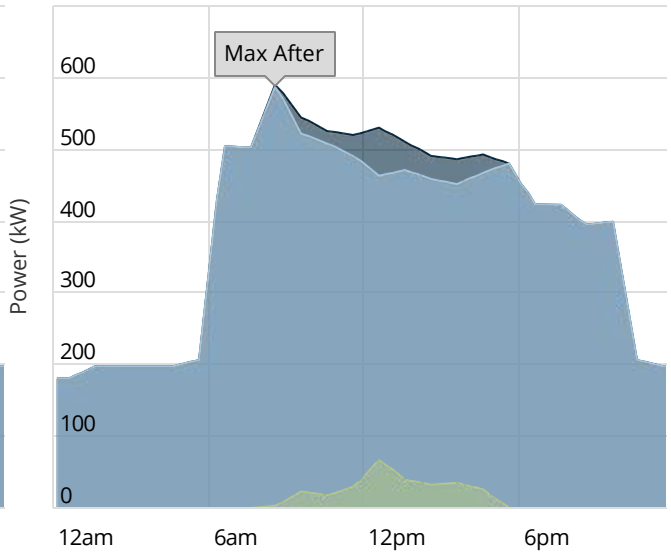
Date Range: 10/1/2017 - 11/1/2017

Max NC Demand: The charts below show when the maximum non-coincident (NC) demand for this facility occurred before and after the Solar PV system simulation.

Max Demand Before 10/30/17 08:30am



Max Demand After 10/30/17 08:30am



Legend: Demand Before | Solar PV | Energy Storage | Demand After

Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the Solar PV system simulation.

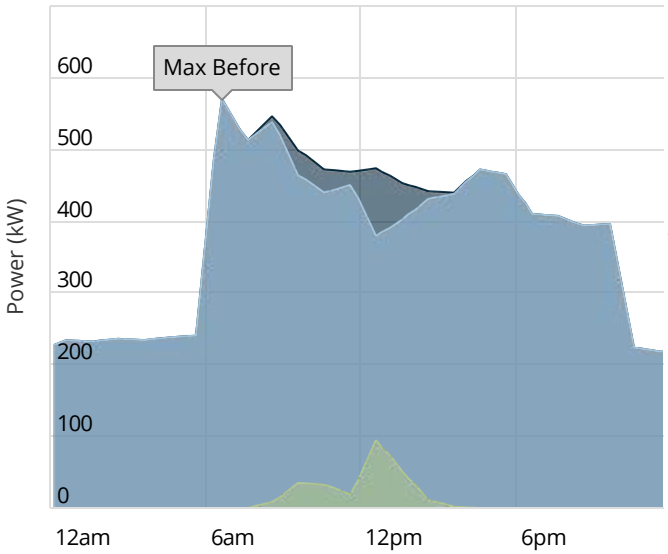
Charts Not Applicable

Demand Profiles

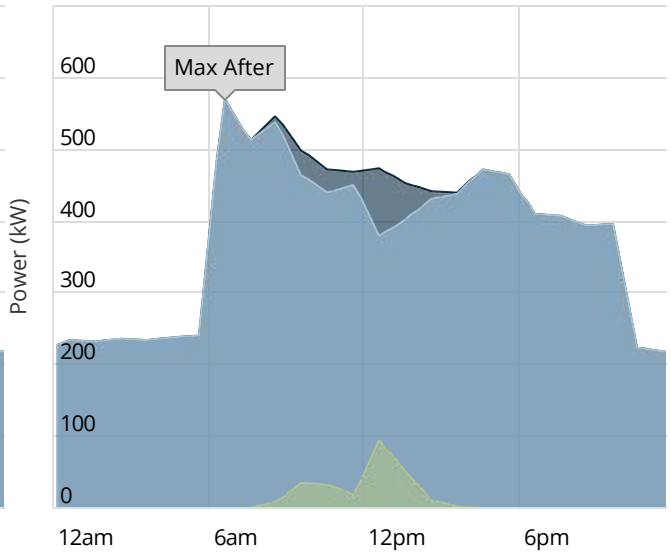
Date Range: 11/1/2017 - 12/1/2017

Max NC Demand: The charts below show when the maximum non-coincident (NC) demand for this facility occurred before and after the Solar PV system simulation.

Max Demand Before 11/27/17 06:30am



Max Demand After 11/27/17 06:30am



Legend: Demand Before | Solar PV | Energy Storage | Demand After

Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the Solar PV system simulation.

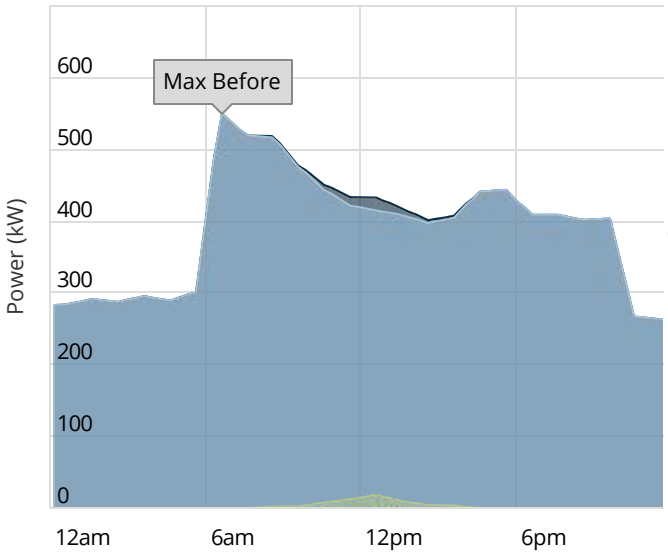
Charts Not Applicable

Demand Profiles

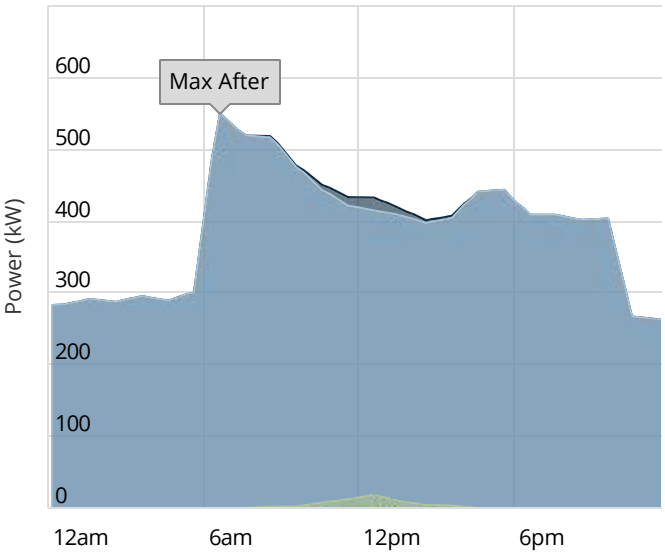
Date Range: 12/1/2017 - 1/1/2018

Max NC Demand: The charts below show when the maximum non-coincident (NC) demand for this facility occurred before and after the Solar PV system simulation.

Max Demand Before 12/26/17 06:30am



Max Demand After 12/26/17 06:30am



Legend: Demand Before | Solar PV | Energy Storage | Demand After

Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the Solar PV system simulation.

Charts Not Applicable