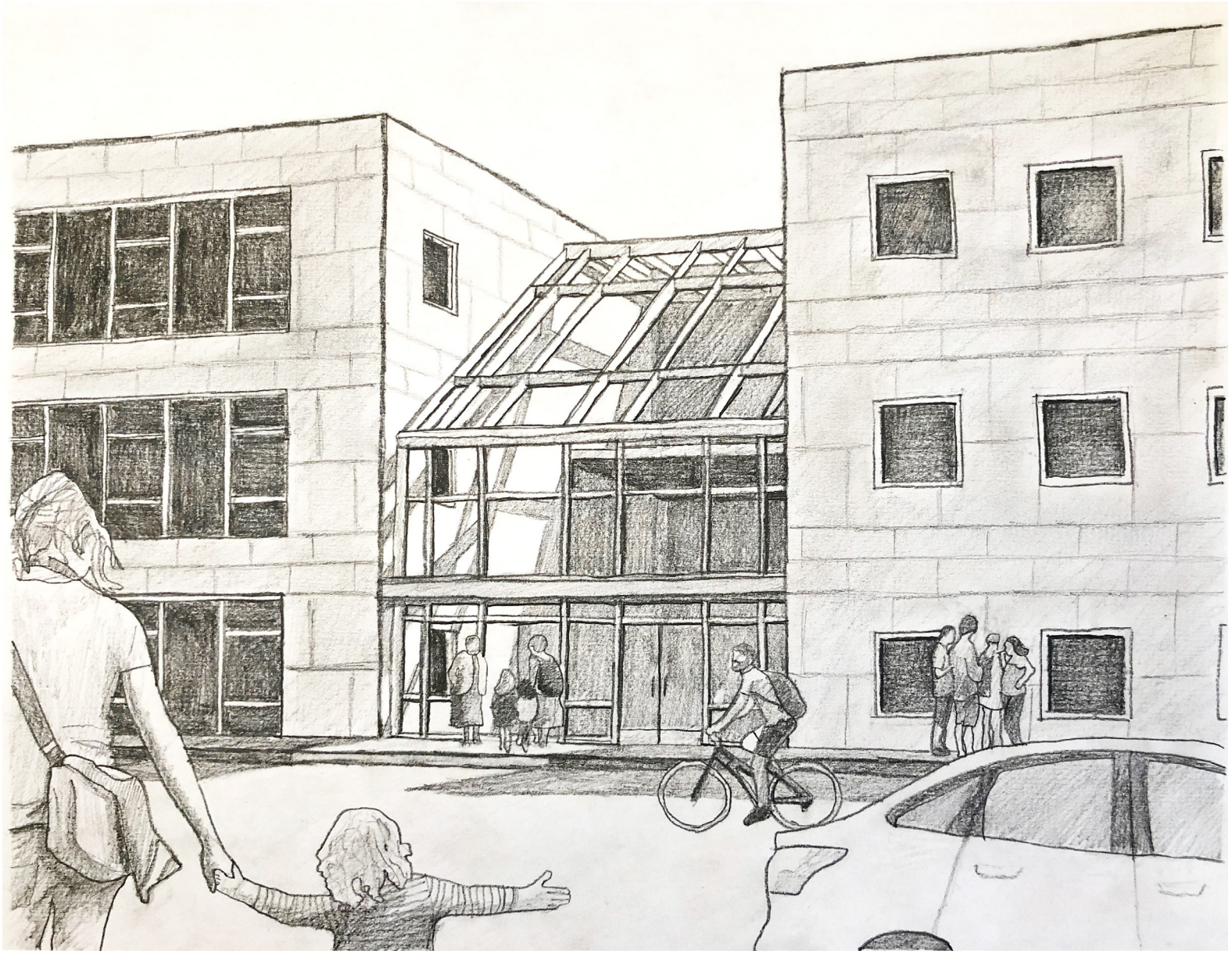


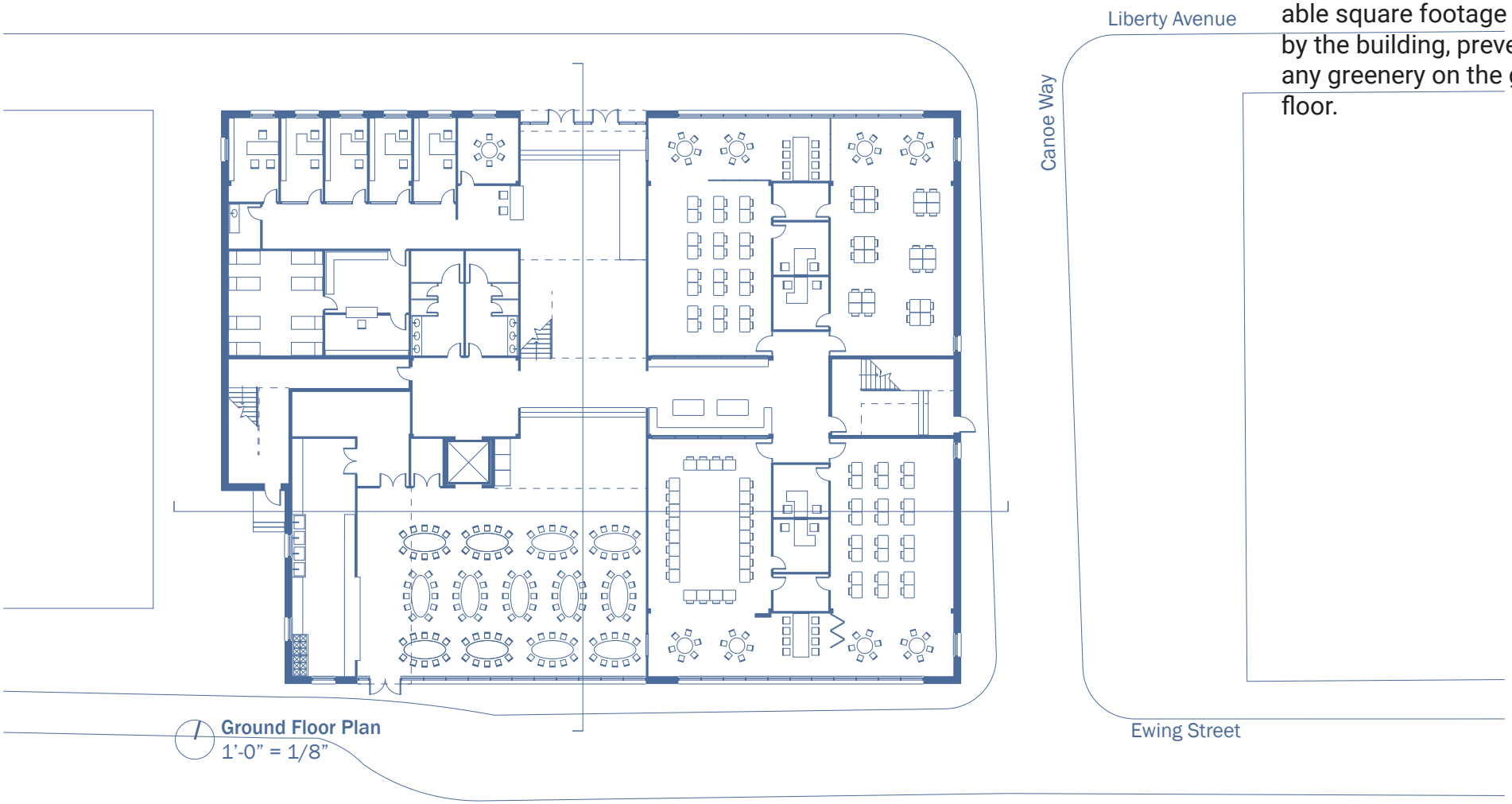
Environmental Charter School
4052 Liberty Ave
Pittsburgh, PA 15224

School Project Report

OWEN HAFT +
CASSANDRA HOWARD

ENVIRONMENT II: DESIGN INTEGRATION
OF ACTIVE BUILDING SYSTEMS

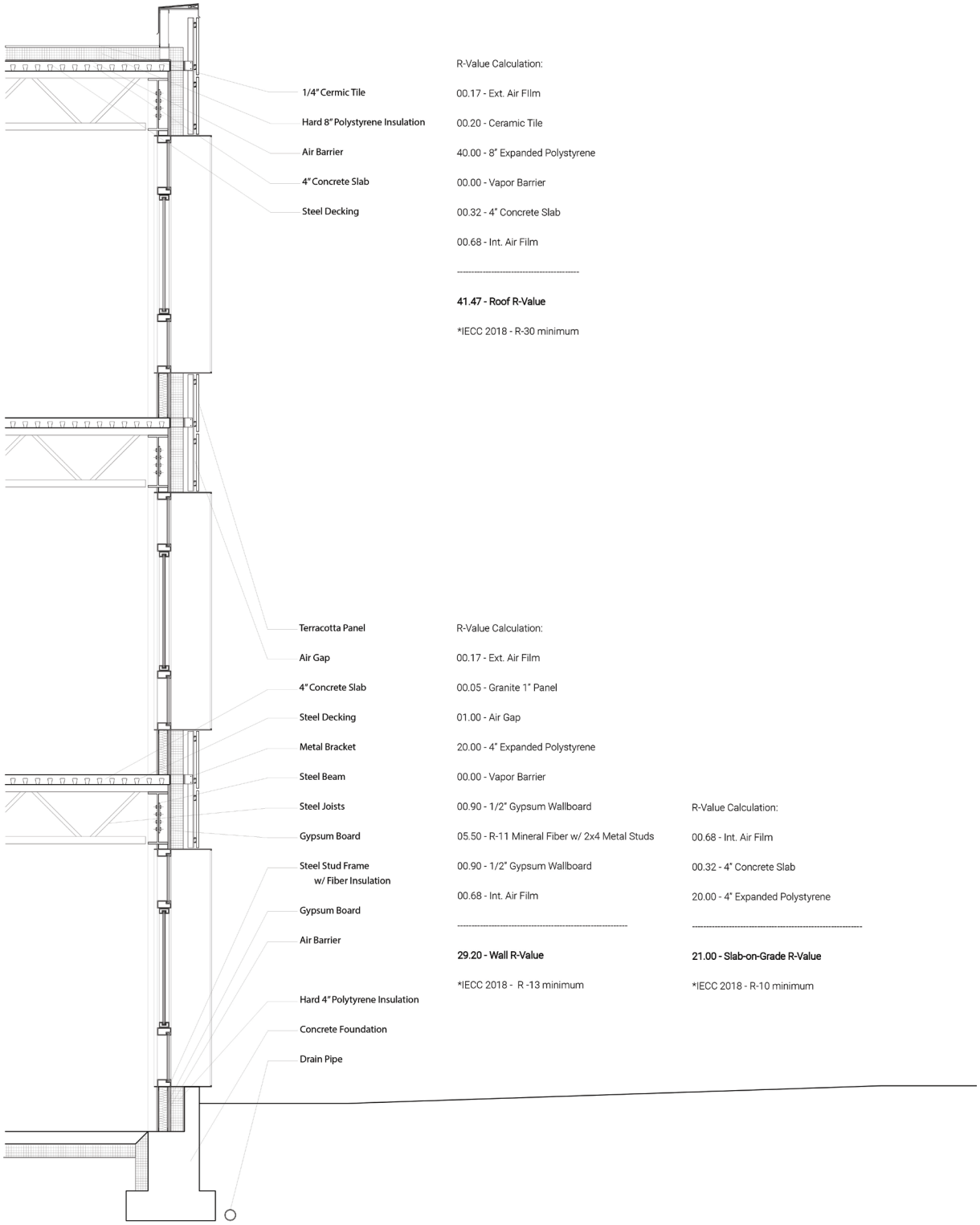
Located in Bloomfield, the site's North side faces Liberty Avenue and is surrounded on all sides by two side roads and an alley. The South side faces a baseball field and forested hillside that slopes away from the site. Because the site is only 142 ft by 110 ft, and there is a three-story zoning limit, all of the available square footage is used by the building, preventing any greenery on the ground floor.



1 Ground Floor Plan
1'-0" = 1/8"

BUILDING ENVELOPE WITH LOAD CALCULATIONS

OWEN HAFT + CASSANDRA HOWARD



The design heavily focuses on the envelope to ensure a well insulated enclosure to help minimize thermal loads for the building. This is done primarily by having two layers, rigid and fiberglass, of insulation in the walls, and a high R-value roof insulation.

Climate Zone 5 R-Value Requirments
Roof R-Value = 41.47
*IECC 2018 - R-30 Minimum

Wall R-Value = 29.20
*IECC 2018 - R-13 Minimum

Slab-on-Grade R-Value = 21.0
*IECC 2018 - R-10 Minimum

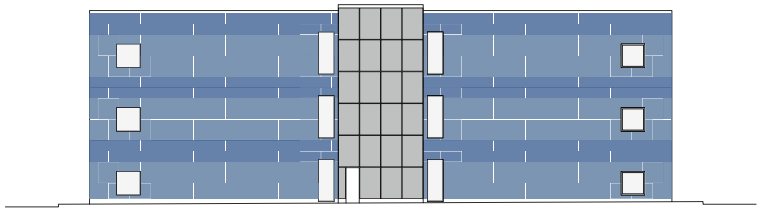
Both windows types, for fixed and openable windows, have an Overall U-Value of 0.30 meeting the respective maximums of 0.38 and 0.45. Both types also have the same SHGC of 0.34 again meeting the maximum required SHGC of 0.51 for Northern facing windows and 0.38 for South, East, and West facing windows. (IECC 2018 Table C402.4)

BUILDING ENVELOPE WITH LOAD CALCULATIONS

OWEN HAFT + CASSANDRA HOWARD

WWR = 365 / 3,964 = 9.2%

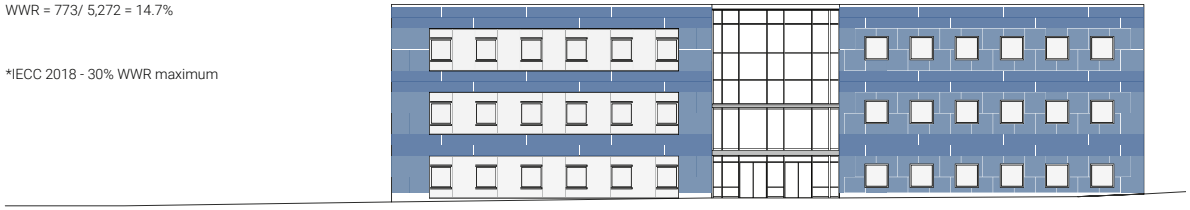
*IECC 2018 - 30% WWR maximum



East Elevation

WWR = 773/ 5,272 = 14.7%

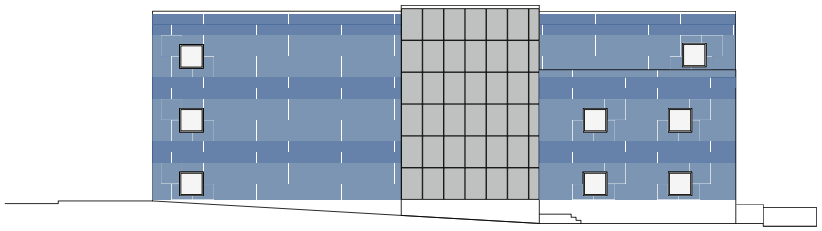
*IECC 2018 - 30% WWR maximum



North Elevation

WWR = 162/ 3,964 = 4.1%

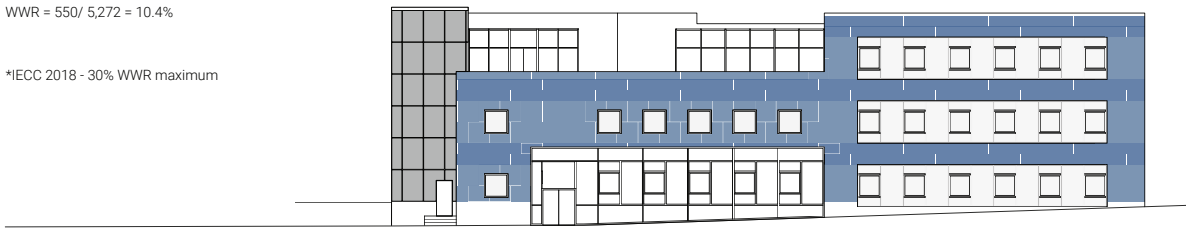
*IECC 2018 - 30% WWR maximum



West Elevation

WWR = 550/ 5,272 = 10.4%

*IECC 2018 - 30% WWR maximum



South Elevation

WWR for each orientation and the glazing characteristics compared to IECC 2018 and the glazing approach meets or exceeds the energy code

East WWR: 9.2%
North WWR: 14.7%
West WWR: 4.1%
South WWR: 10.4

BUILDING ENVELOPE WITH LOAD CALCULATIONS

OWEN HAFT + CASSANDRA HOWARD

Load Calculation Spreadsheet
Attached in .zip

SITE:	USA - PA - ALLEGHENY CO - 5%				DESIGN CONDITIONS:				
					Inside Design Conditions:			Supply Air Temp:	
Latitude:	40.36	Month:	DB, F	MWB, F	Cooling:			Cooling:	
Longitude:	-79.92	1	52.9	48.0	DB, F	75		DB, F	57
Elevation	1273	2	52.1	45.7	RH	50%			
		3	65.0	52.7	Heating:			Heating:	
		4	73.1	57.4	DB, F	75		DB, F	100
Htg 99.6%	5.6	5	80.8	64.9					
		6	84.4	69.9					
TZ +/- UTC:	-5	7	87.5	72.0	INTERNAL LOADS:				
Time Zone:	Eastern	8	86.1	70.9	Default:	People:	Default:	Lighting:	Equip.:
Std Merid:	-75	9	80.5	66.9	Sf/person:	320	Watts/sf:	0.81	1
		10	72.1	60.6	Btuh/person:				
Solar:		11	63.2	54.4	Sensible:	250			
Gnd Reflec	20%	12	53.6	48.2	Latent:	200			
	RADIANT TIME SERIES SELECTION:				Convective %:		Convective %:		
						40%		52%	70%
	MW w Carpet 50% glass				Radiant %:	60%	Radiant %:	48%	30%
	RTS Type:	8				Usage		Usage	Usage
RTS Data:	Hour	Non-Solar	Solar		Hour	Profile		Profile	Profile
	1	49%	54%		1	18%		38%	0%
	2	17%	16%		2	18%		38%	0%
	3	9%	8%		3	18%		38%	0%
	4	5%	4%		4	18%		38%	0%
	5	3%	3%		5	18%		38%	0%
	6	2%	2%		6	18%		38%	0%
	7	2%	1%		7	18%		38%	0%
	8	1%	1%		8	90%		38%	0%
	9	1%	1%		9	90%		95%	95%
	10	1%	1%		10	90%		95%	95%
	11	1%	1%		11	90%		95%	95%
	12	1%	1%		12	90%		95%	95%
	13	1%	1%		13	90%		95%	95%
	14	1%	1%		14	90%		95%	95%
	15	1%	1%		15	90%		95%	95%
	16	1%	1%		16	90%		95%	95%
	17	1%	1%		17	90%		95%	16%
	18	1%	1%		18	90%		38%	16%
	19	1%	1%		19	90%		38%	16%
	20	1%	0%		20	90%		38%	16%
	21	0%	0%		21	90%		38%	16%
	22	0%	0%		22	18%		38%	0%
	23	0%	0%		23	18%		38%	0%
	24	0%	0%		24	18%		38%	0%

RTS COOLING LOAD DEMONSTRATION								December 12, 2019
MASTER INPUT DATA								Page: 2
IDENTIFICATION:	ECS Bloomfield							
	Pittsburgh, Pennsylvania							
EXTERIOR EXPOSURES:					Plan Rotation:	-10	degrees	
		Nominal	North	South	East	West	Roof	
		Azimuth:	-180	0	-90	90	0	
		Actual:	-190	-10	-100	80	-10	
		Tilt:	90	90	90	90	0	

WALL DATA:	TYPE 1 WALL	TYPE 2 WALL	ROOF DATA:
Descrip.	Brick Veneer, Metal	Metal Panel, Metal	Descrip: Metal deck
Input Actual "U" :	0.025	0.025	Input Actual "U" : 0.016
Absorbtance:	0.45	0.9	Absorbtance: 0.45
h(outside):	3	3	h(outside): 3
Emittance:	1	1	Emittance: 1
delta R:	0	0	delta R: 20
Convective %:	54%	54%	Convective %: 40%
Radiant %:	46%	46%	Radiant %: 60%
	Brick, R-11 Batt, Gyp Bd	Metal Wall Panel, R-11 Batt, Gyp Bc	Slate or Tile, R-19 Batt, Gyp Bd

BUILDING ENVELOPE WITH
LOAD CALCULATIONS

OWEN HAFT + CASSANDRA HOWARD

LSQ Square Series

LSQ4 Square Series LED Surface Ambient Luminaire - 4'

Product Description

The LSQ surface ambient luminaire delivers up to 100 lumens per watt with 90+ CRI illumination. The 4' (1219mm) luminaire is available with up to 5,000 lumens in 3500K, 4000K and 5000K color temperatures.
The new LSQ Series features an all new square lens design in a standard Lambertian optic. The new decorative end caps provide a sleek and compact architectural design. The LSQ Series offers a variety of lumen packages and color temperatures, and standard 0-10V dimming. Flexible mounting of the LSQ Series allows for individual mount or continuous row applications for surface mount, suspended mount, pendant mount and cove installations.
Applications: Surface and suspended ambient applications for new construction and upgrade

Performance Summary

Initial Delivered Lumens: 4,000-5,000 lumens

Input Power: 44-50 watts

Efficacy: Up to 100 LPW

CRI: 90+ CRI

CCT: 3500K, 4000K, 5000K

Input Voltage: 120-277 VAC or 347 VAC

L_{70} Lifetime: > 100,000 hours at 35°C

Limited Warranty[1]: 10 years on luminaire

Limited Warranty Emergency Back Up (EB) Battery: 1 Year on Back Up. Test regularly in accordance with local codes

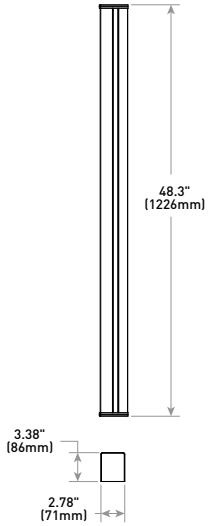
Dimensions without End Caps: L 48.0" (1219mm) x W 2.57" (65mm) x H 3.26" (83mm)

Weight: 6.2 lbs. (2.8kg)

Dimming: 0-10V dimming to 5%

[1] See http://lighting.cree.com/warranty for warranty terms

Shown With End Cap Accessory



Ordering Information

Example: LSQ4-40L-35K-10V; Note: End caps must be ordered separately. Refer to Field-Installed Accessory table on page 3 for details

LSQ4				10V			
Product	**Lumen Package**	**CCT**	**Voltage**	**Control**	**CRI**	**Options**	**Lens**
LSQ4	**40L** 4,000 Lumens **50L** 5,000 Lumens	**35K** 3500K **40K** 4000K **50K** 5000K	**Blank** 120-277 Volt **34** 347 Volt - Available with 40L only	10V 0-10V dimming to 5%	**Blank** 90+ CRI	**EB14 Emergency Backup** - Minimum 90 minutes - 1,400 lumens - Minimum operating temperature: 0°C (32°F) - Not for use with 34 voltage **TW Through Wire Option** - Factory installed - Includes quick connects for use in continuous row applications - Not for use with EB14 option	**BLANK Lambertian Optic**

Rev. Date: V1 03/14/2019

US: lighting.cree.com T (800) 236-6800 F (262) 504-5415

Canada: www.cree.com/canada T (800) 473-1234 F (800) 890-7507

All windows of the classrooms are located on the North or South facades. All windows facing the North already experience indirect light during the day. All windows facing the South have a shading device that overhangs enough to block all direct southern sun without blocking the view, thus providing indirect light to those classrooms as well, while helping to preserve thermal comfort in summer months.

Each classroom space is equipped with occupant sensors that automatically turn off after 30 minutes and manual switches with dimmers.

This product was chosen because LEDs have a much longer life than fluorescents, in addition this luminaire offers both indirect and direct light to the space.

LIGHTING

OWEN HAFT + CASSANDRA HOWARD

Zonal Cavity Method:

RCR = 5 (hrc) x (L+W) = 5 (6ft) x (45.5ft + 24.5ft) = 30ft x 70ft = 2,100ft^2 = 1.88

L x W	45.5ft x 24.5ft	1,115ft^2	1,115ft^2

CU = 103 - ((103 - 93) x 88%) = 0.94

LLF = 1

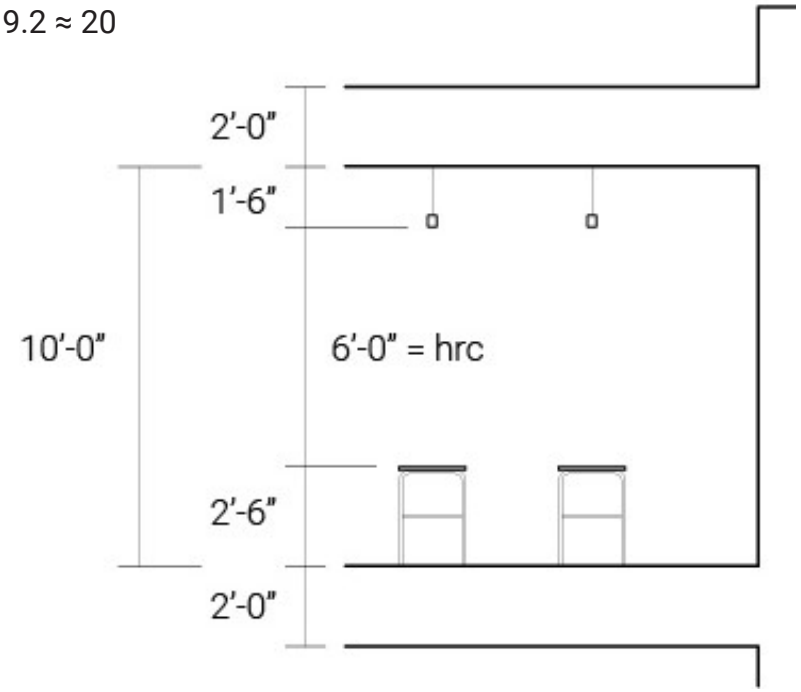
# of Luminaires = Illuminance x Area = (200/10.76) x (1,115ft^2) = 18.6 x 1,115ft^2 = 4.9 ≈ 5

Lumens x CU x LLF	4,500 x 0.94 x 1	4,230

IECC 2018 Allowance:

# of Luminaires = LPD x sq.ft. = 0.81 x 1,115ft^2 = 19.2 ≈ 20

Wattage	47W

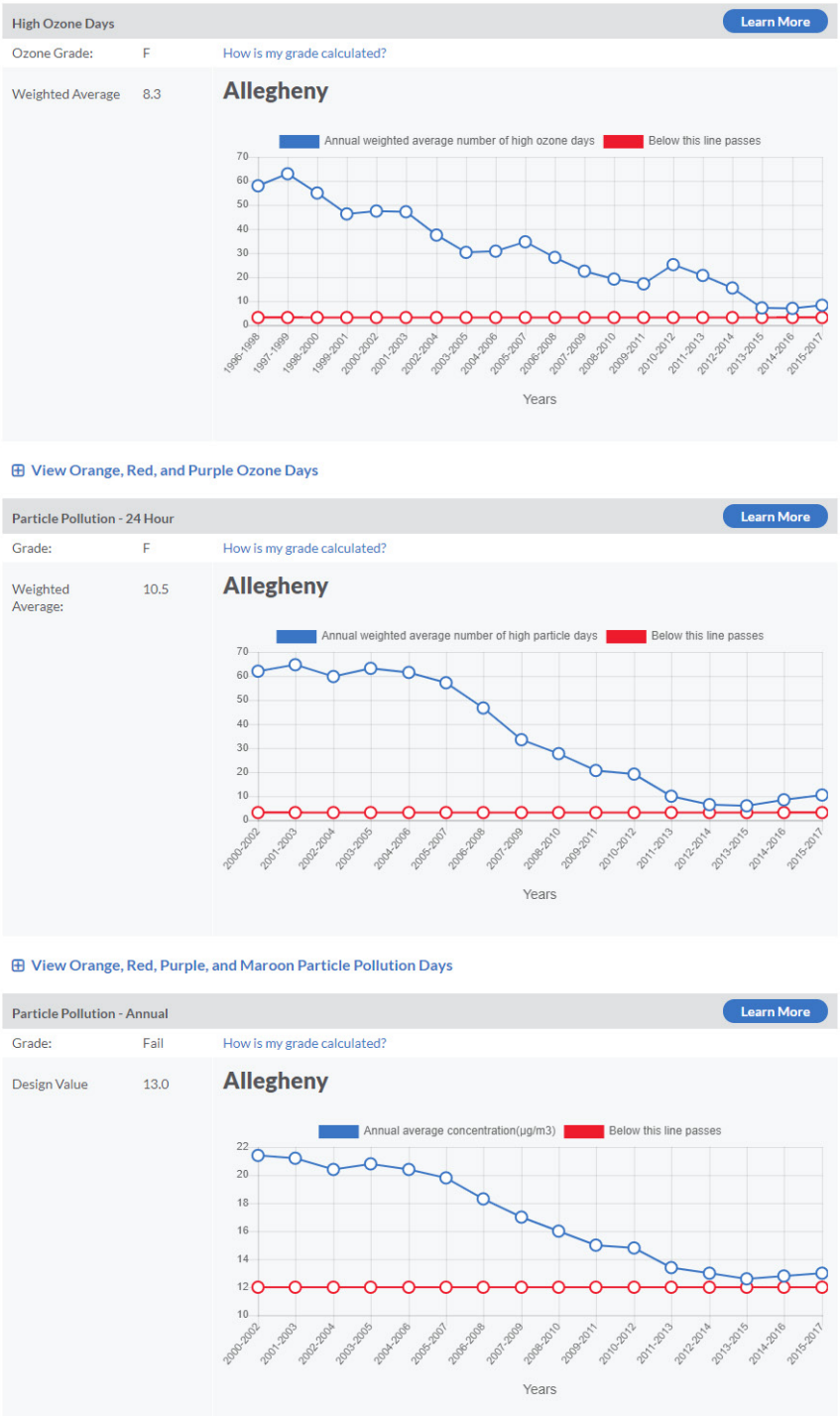


The luminaries determined by the IECC 2018 Allowance: 19.2. The luminaires according to the zonal cavity method is just 5.

Considering there are 4 classrooms per floor, the zonal cavity method would suggest installing a total of 20 luminaires for the classroom floor.

By using the Zonal Cavity Method over the IECC 2018 Allowance to calculate the number of luminaires needed for each classroom, the school only needs to purchase 5 luminaires per classroom rather than 20, a 75% savings. The school saves 75% when purchasing the luminaires for construction/installation as well as money saved on monthly electric bills.

***Middle School Desk Height = 30"
***The interpolated average of the CUs for the luminaire is used
***Assuming an illuminance of 200 lux based on RP-1
***Because the luminaire is LED, an LFF of 1 is assumed
***LPD of 0.81 based on IECC 2018 C405.3.2(1)



If you live in Allegheny County, the air you breathe may put your health at risk.

Ozone	Particle Pollution 24-hour	Particle Pollution Annual
F	F	FAIL

For roughly the past two decades, Allegheny County has never reported passing levels of air quality including high ozone days, particle pollution over 24 hours, and annual particle pollution. Ground-level ozone has been shown to cause respiratory harm, cardiovascular harm, and possible early death. Particle pollution can similarly cause cardiovascular and respiratory harm, as well as cancer and possible reproductive and developmental harm.

VENTILATION

"State of the Air: Pennsylvania." American Lung Association. Accessed December 12, 2019. https://www.lung.org/our-initiatives/healthy-air/sota/city-rankings/states/pennsylvania/allegheny.html.

OWEN HAFT + CASSANDRA HOWARD

Required Minimum Openable Area based on IMC 2018

Dimensions	IMC Table 402.2 Minimum Openable Area			Total Openable Area
1150 ft2 (45.5ft * 24.5ft)	4%			46 ft2
				*4 classrooms on second floor
				= 184 ft2

Required Outdoor Air based on IMC 2018

Dimensions	IMC Table 403.3.1.1 Occupancy based on floor area	IMC Table 403.3.1.1 CFM based on occupancy	IMC Table 403.3.1.1 CFM Based on floor area	Total CFM
1150 ft2 (45.5ft * 24.5ft)	40 people (35/1000ft2)	(10/ person) = 400 CFM	(1150 * .12) = 138 CFM	538 CFM
				*4 classrooms on second floor
				= 2,152 CFM

***The outdoor air was calculated with the total maximum occupancy allowed enabling the school to grow in size over time or to allow for community meetings of a larger occupant size in the classrooms, and still have mechanical systems designed to support the school

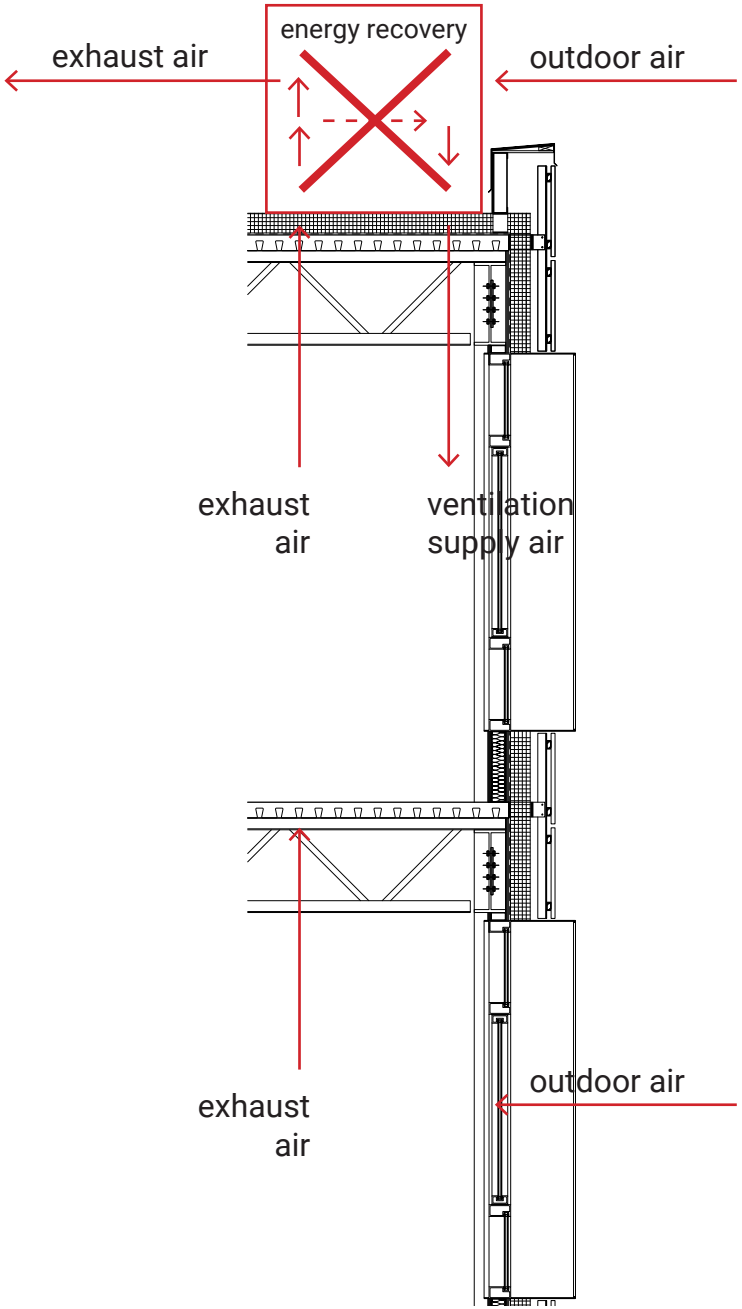
These calculations will apply to the second floor of ECS. The building is currently designed with a minimum of 48ft2 openable area per classroom, meeting the 46ft2 requirement from IMC402.2.

IMC Table 403.3.1.1 requires that the total CFM, outdoor air, must be equal to 2,152 CFM for the 4 classrooms on the second floor of the building.

VENTILATION

OWEN HAFT + CASSANDRA HOWARD

DEDICATED OUTDOOR AIR SYSTEM



For the Environmental Charter school we are recommending a Dedicated Outdoor Air System.

Primarily, the system is being recommended due to the extremely poor air quality in Pittsburgh, PA. A DOAS, by separating ventilation from the heating and cooling systems, can provide less chance for air contamination, as well as improved air filtering.

Secondarily, the system is being recommended so that both systems, the VRF and the DOAS, can have greater efficiencies without combining goals.

Supply side ducts should be sized to 19” and the exhaust side ducts should be sized to 20”.

Application Type: Rooftop

Ventilation Type: Static plate, heat and humidity transfer

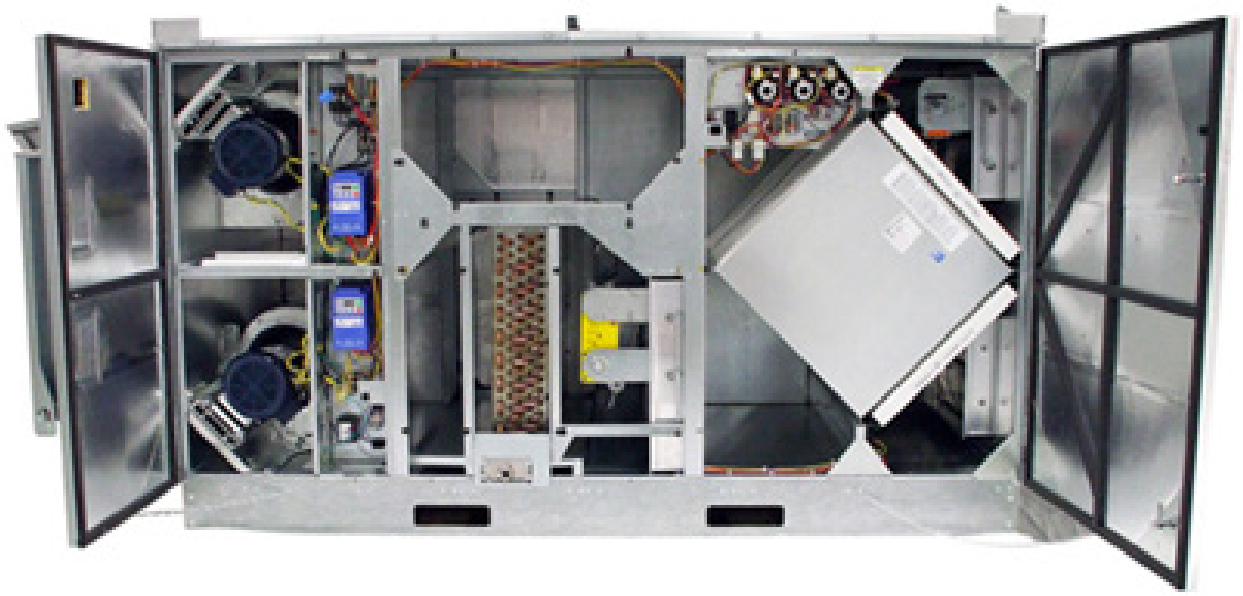
Typical Airflow Range: 500-2,200 CFM

AHRI 1060 Certified Core: Two L125-G5

OA Filter(s): Total Qty. 2, MERV 8: 20" x 20" x 2"

RA Filter(s): Total Qty. 3, (2) MERV 8: 20" x 20" x 2" and (1) 20" x 14" x 2"

Unit Dimensions & Weight: 131 3/4" L x 58 1/2" W x 55" H, 1,093-1,360 lbs. (varies by option)



We chose the RenewAire Rooftop DOAS model RD2XRT because it meets the specified CFM calculation of 2,152 CFM per classroom floor. This means we will could have 3 DOAS systems for the building, one per floor. The system comes with a MERV 8 filter, but there is a specified MERV 13 accessory available that is recommended for purchase considering the poor air quality in Pittsburgh.

VENTILATION

"RD2XRT - RenewAire." RenewAire. Accessed December 12, 2019. https://www.renewaire.com/erv/rd2xrt/.

Name: QuickCalc 12/12/2019
General Description:
Engineer:
Firm/Company:
Prepared By:
Phone Number:
Fax Number:
Email Address:
Model Number: RD2XRT (Info)
Core Designation: G5 = J

Ventilation Inputs

			Winter		Summer	
Fresh Air Flow Rate:	2000 CFM	Room Exhaust Air	DB:	72.0 F	DB:	75.0 F
Fresh Air Ext. Static Pressure:	0.50 in W.C.	Room Exhaust Air	RH:	35 %	RH:	55 %
Exhaust Air Flow Rate:	2000 CFM	Outside Air	DB:	2.0 F	DB:	89.0 F
Exhaust Air Ext. Static Pressure:	0.50 in W.C.	Outside Air	WB:	2.0 F	WB:	72.0 F

Performance Data Save and Calculate Performance Data

	Sensible		Total	
	Winter	Summer	Winter	Summer
Exchanger Effectiveness (Info)	65 %	65 %	59 %	50 %

	Room Exhaust		Outside Air		Supply Air	
	Winter	Summer	Winter	Summer	Winter	Summer
Dry Bulb (F)	72.0	75.0	2.0	89.0	47.3	79.9
Wet Bulb (F)	55.9	64.0	2.0	72.0	38.7	68.2
Relative Humidity (%)	35	55	99	45	44	56
Absolute Humidity (lbH20/dryair)	0.0058	0.0102	0.0009	0.0129	0.0030	0.0120
Enthalpy (BTU/lb)	23.6	29.1	1.4	35.6	14.6	32.4

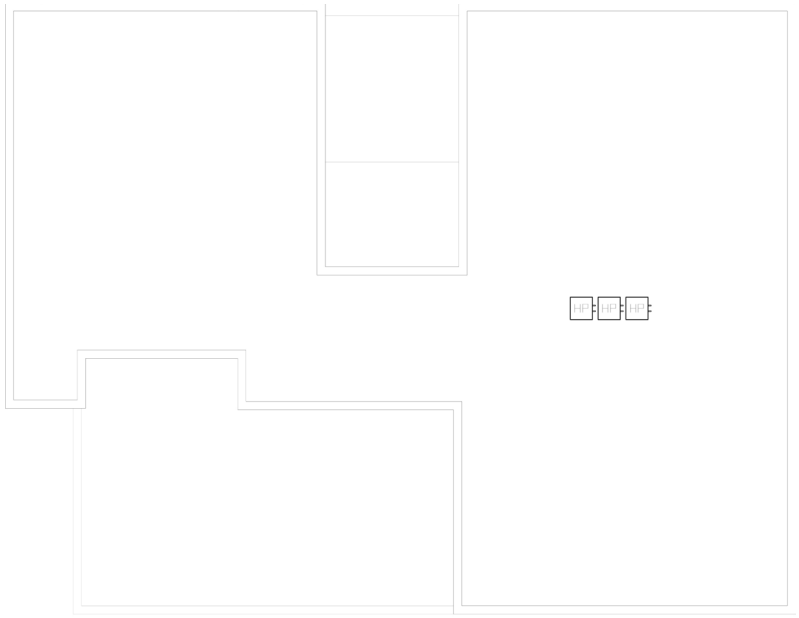
(Info on Loads)	Sensible		Latent		Total	
	Winter	Summer	Winter	Summer	Winter	Summer
Original Load (BTU/h)	151200	30240	48867	27915	200067	58155
Original Load (Tons)		2.5		2.3		4.8
Load with RenewAire (BTU/h)	53445	10689	28183	18649	81628	29338
Load with RenewAire (Tons)		0.9		1.6		2.4
Savings (BTU/h)	97755	19551	20684	9265	118439	28816
Savings (Tons)		1.6		0.8		2.4
Load Savings Ratio (Info)					59 %	50 %

Combined with the Dedicated Outdoor Air System will be an Energy Recovery Ventilation system. This allows energy to be recovered from the exhaust air that can be recirculated to heat or cool incoming outdoor supply air.

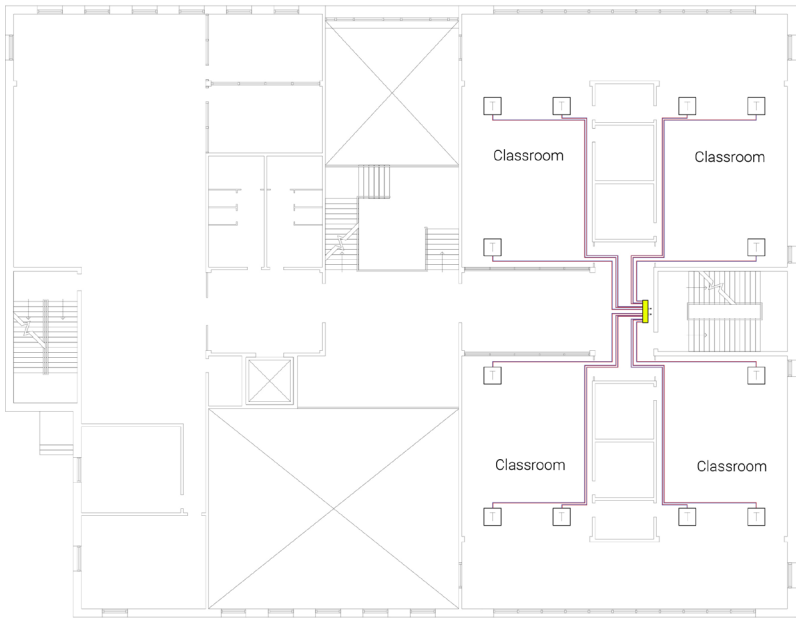
In the Winter, the total original load is 200 kBTU/hr and in the Summer, the original load 58 kBTU/hr. With the RenewAire Energy Recovery Calculator, there is a potential to bring Winter loads to 81 kBTU and Summer loads to 29 kBTU. The ERV system has a Load Savings Ratio of 59% and 50% in Winter and Summer, respectively.

***The RenewAire calculator did not allow the CFM to go above 2000 even though the DOAS has been specified for up to 2200. Instead of completing oversizing the system, we decided to use 2000 as our CFM input, instead of the calculate 2152 CFM input.

"RenewAire ERV Calculator (ERVCalc)." RenewAire ERV Calculator. Accessed December 12, 2019. https://www.ervcalc.renewaire.com/pages/QuickCalc-Edit.php?id=81919.



Roof Plan



Classroom Reflected Ceiling Plan

HP = Heat Pump (1 per floor)

T = Terminal Unit

= Refrigerant Distribution

= Refrigerant Tube (Supply/Return)

Our school will use a Variable Refrigerant Flow system with combined heating and cooling, as a standalone system separate from the DOAS. An assumed OA of 0 cfm is used in load calculations because ventilation is using a DOAS. Three heat pumps are placed on the roof, each supplying heating/cooling to one of the three floors. The refrigerant from each heat pump is sent down to a refrigerant distributor on each floor, which distributes the refrigerant equally to all twelve terminal units (3 per classroom). The entire system is non-ducted, using only refrigerant tubes.

Total Cooling Load: 805,995 BTUh
Total Heating Load: 240,591 BTUh

Classroom Floor Cooling Block Load: 221,995 BTUh

4 Classrooms per floor x 3 Terminal Units per Classroom = 12 Units per floor

221,995 BTUh / 12 = 18,500 BTUh per Unit

HEATING AND COOLING

OWEN HAFT + CASSANDRA HOWARD

VRF SYSTEM SPECIFICATIONS

HEAT PUMP

AHRI CERTIFIED® www.ahridirectory.org

Certificate of Product Ratings

AHRI Certified Reference Number : 10612350 Date : 12-12-2019 Model Status : Active

Brand Name : PANASONIC

Series Name : MF2

AHRI Type : HMSR-A-CB

Indoor Type : Non-Ducted Indoor Units

System Model Number : WU-288MF2U9

Module Model Number 1 : U-72MF2U9

Module Model Number 2 : U-72MF2U9

Module Model Number 3 : U-144MF2U9

Rated as follows in accordance with the latest edition of AHRI Standard 1230 for VRF Air-Conditioning and Heat Pump Equipment and subject to rating accuracy by AHRI-sponsored, independent, third party testing:

Cooling Capacity (95F) : 288000

EER (95F) : 10.00

IEER : 22.80

SCHE : 21.60

High Heating Capacity (47F) : 300000

High COP (47F) : 3.28

Low Heating Capacity (17F) : 192000

Low COP (17F) : 2.52

†"Active" Model Status are those that an AHRI Certification Program Participant is currently producing AND selling or offering for sale; OR new models that are being marketed but are not yet being produced."Production Stopped" Model Status are those that an AHRI Certification Program Participant is no longer producing BUT is still selling or offering for sale.
Ratings that are accompanied by WAS indicate an involuntary re-rate. The new published rating is shown along with the previous (i.e. WAS) rating.

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AHRI AIR-CONDITIONING, HEATING, & REFRIGERATION INSTITUTE
we make life better™

CERTIFICATE NO.: 132206538845177462

TERMINAL UNIT

Panasonic

ECOi™ Submittal Data

S-24MU2U6
Indoor Unit: 4 Way Cassette

Job Name: _____ Approval: _____
Location: _____ Date: _____
Engineer: _____ Construction: _____
Submitted To: _____ Unit #: _____
Submitted By: _____ Drawing #: _____
Reference: _____

Capacities	
Cooling: Btu/h	25000
Heating: Btu/h	27000
Sensible Heat Ratio	0.72
Cooling Mode Nominal Conditions	
Indoor: °F DB/°F WB	80/67
Outdoor: °F DB	95
Pipe Length: Feet	25
Level Difference: Feet	0
Heating Mode Nominal Conditions	
Indoor: °F DB	70
Outdoor: °F DB/°F WB	47/43
Pipe Length: Feet	25
Level Difference: Feet	0
Refrigerant and Piping	
Refrigerant Type	410A
Metering Device (Electronic Expansion Valve)	EEV
Liquid Piping (Inches)	3/8
Gas Piping (Inches)	5/8
Condensate	
Drain Piping (OD) Inches	1.25
Fan	
Type	Turbo
Drive	Direct
Fan Motor Output: W	60
Airflow rate (L/M/H)	494/600/777
Power Supply	
V/PH/Hz.	208/230/1/60
Minimum Circuits Amps (MCA): Amps	15
Nominal Power Input - Cooling (W)	40
Full Load Amps (FLA): (A)	0.36
Max. Overcurrent Protection (MOCP)	15
Nominal Power Input - Heat (W)	40

Weight	
Weight: (lbs)	53
Sound Data	
Sound Level (H/M/L) 5' below unit	37/32/29
Coil	
Coil Face Area: (sq. ft.)	4.20
Number of Rows:	2

Parts Warranty: One Year
Built in Drain Pump
Washable Filters
Wired, Wireless or Simple Remote
Remote Sensor Option

Heat Pump:
MF2 - HSMR-A-CB
Brand: Panasonic
# of Units: 3 (1 per floor)
Indoor Type: Non-Ducted
Cooling Capacity at 95F: 288,000 BTUh
EER (95F): 10.00
IEER: 22.80
Low Heating Capacity: 192,000 BTUh
Low COP: 2.52

Terminal Unit:
ECOi - S-24MU2U6
Brand: Panasonic
# of Units: 36 (3 per class-room)
Cooling Capacity: 25,000 BTUh
Heating Capacity: 27,000 BTUh

The VRF system is environmentally sustainable because it uses refrigerants, rather than water or air, which are more efficient due to a faster phase change response, and can lower energy consumption.

HEATING AND COOLING

OWEN HAFT + CASSANDRA HOWARD

PLUMBING FIXTURE COUNT, IPC 2018 TABLE 403.1

Total Number of Occupants = 320

Classification	Description	Water Closets Male	Water Closets Female	Lavatories Male	Lavatories Female	Drinking Fountain	Other
Educational	Educational Facilties	1 per 50	1 per 50	1 per 50	1 per 50	1 per 100	1 service sink
	ECS	**7**	**7**	**7**	**7**	**4**	**1 service sink**

PLUMBING FIXTURE SAVINGS

Fixture Type	Codes-Based Value	High-Efficiency Perfomance	% Savings
Water closet	1.6 gpf	1.12* gpf	65.7%
Urinal	1.0	.125	87.5%
Faucet (Lavatory)	2.2 gpm	.5 gpm	77.5%

PLUMBING FIXTURE USES

Fixture Type	Gender	Occupants	Uses/Day	Total Uses/Day	Days / Year	Code-Based Use	High-Efficiency Use	Savings
Water closet	Female	160	3 flushes/ day	480	215	165,120 gpf	115,584 gpf	**49,536 gpf**
	Male	160	1 flush/day	160	215	55,040 gpf	38,528 gpf	**16,845 gpf**
Urinal	Male	160	2 flushes/ day	320	215	68,800 gpf	8,600 gpf	**60,200 gpf**
Lavatory	Female + Male	320	3 uses/day	960	215	454,080 gpm	103,200 gpm	**350,880 gpm**
					Total	**743,040 g/yr**	**265,912 g/yr**	**477,461 g/yr**

***65.7% improvement for dual flush toilets at 5 flushes per day with one flush at 1.6 gpf and four flushes at 1.0 gpf. Dual Flush toilets have been selected for the high-efficiency performing equipment.

*** For this exercise, students have been considered to have the same use as the “Full Time Employee” category because they occupy the school for the same length of time.

*** Days/Year calculated based on 5 days/ week and 43 weeks of occupancy in a year, eliminating 9 weeks for a typical summer break.

Indoor Water-Saving Strategies

The building is currently designed with 3 bathrooms per gender, per floor. This equals a total number of 9 bathrooms for the entire school. There are equal number of lavatories to water closets and there is a service sink in the janitor’s closet. The only thing missing from the current design are 4 drinking fountains, which can be added to satisfy the International Plumbing Code.

To go further than the plumbing code, we would like to recommend 4 water closets per floor, adding an additional toilet per floor, to aid during times of high occupancy use such as recess or lunchtime. Section 424.2 states that urinals should not be substituted for more than 67% of the required water closets. We would also like to recommend 2 urinals per male restroom to substitute 50% of the required water closets. This will help to improve water use efficiencies.

By utilizing the calculations shown, High-Efficiency Water Fixtures can reduce total water use by 477,461 gallons per year, which is a savings of 66% gallons per year.

WATER SYSTEMS

OWEN HAFT + CASSANDRA HOWARD

ROOFTOP RAINWATER COLLECTION POTENTIAL

Total sq. ft. for potential collection = 10,000 ft2 * .95 = 9,500 ft 2

Month	Avg Monthly Rainfall in Inches	Avg Gallons of Rainfall per Ft2 of roof area (Col B x 0.623)	Avg Gal Available per Month based on Roof Area in Ft2*	Collection at 90% Efficiency** (in Gallons)
Jan	2.1	1.31	12,429	11,186
Feb	1.9	1.18	11,245	10,121
Mar	2.7	1.68	15,980	14,382
Apr	2.4	1.50	14,204	12,784
May	2.8	1.74	16,572	14,915
Jun	3	1.87	17,756	15,980
Jul	2.9	1.81	17,164	15,447
Aug	2.6	1.62	15,388	13,849
Sep	2.3	1.43	13,613	12,251
Oct	1.9	1.18	11,245	10,121
Nov	2.2	1.37	13,021	11,719
Dec	2.3	1.43	13,613	12,251
Total	**29**	**18**	**172,228**	**155,006**

Total Number of Gallons that could be harvested = 155,006 Gallons

Total amount of water used for water closet and urinal flushing = 162,712 Gallons

SIZING THE CISTERN

155,006 / 365 * 20 = 8,493 gallon capacity

Round Cistern

$8{,}493 = \pi r^2 h$

$r = 5\ ft^2$

***Assume 5% of roof area will be used for equipment.

Ltd, Freerain. “Is Legionella Problem for Rainwater Harvesting Systems?” Is Legionella problem for rainwater harvesting systems?, January 1, 1970. http://rainwater-harvesting-systems.blogspot.com/2008/12/is-legionella-problem-for-rainwater.html.

Outdoor Water-Saving Strategies

For the Environmental Charter School, we are proposing a rainwater collection system. This system could almost fully meet the needs for water closet and urinal flushing on site, with only a roughly 7,000 gallon difference.

Sizing the cistern, water should be kept only a max of 20 days due to bacterial growth. Due to the constraints of the site, there is no outdoor space on the building lot. Therefore the rainwater cistern will be placed underground. Therefore the round cistern was sized with a max height of 8 feet, and a radius of 5 feet.

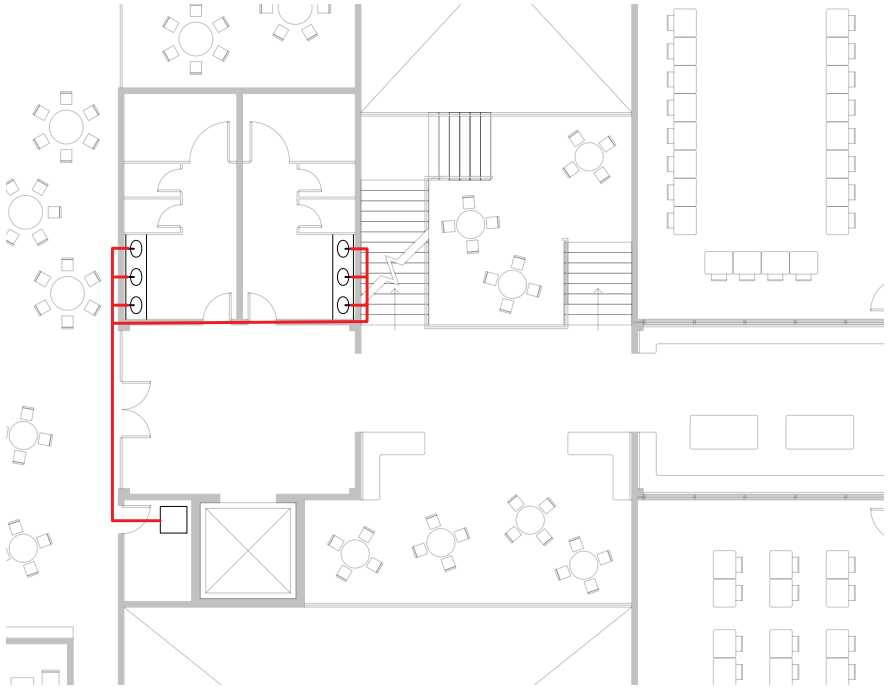
HOT WATER NEEDS FOR ECS

Total number of occupants = 288 students, 32 faculty

Upper school hot water use per student = 1.0 gal / student, .4 / faculty

Maximum hourly demand = 288 * 1.0 + 32 * .4 = 300.8 gallons

Maximum hourly demand with 70% efficiency = 428 gallons



The Environmental Charter School will need a hot water heater for 428 gallons of water. For this school, we have specified to include 2 hot water heaters, the A.O. Smith BTHL 300A 300 which each have a capacity of 220.0 gallons. These are natural gas, storage type hot water heaters which can have a relationship with the solar hot water heating system detailed later.

The 2 hot water heaters will be located in the service closets on the first and second floor. There is not a closet on the third floor.

HOT WATER STORAGE SPECIFICATION

A.O. SMITH BTHL 300A 300 x 2

AHRI CERTIFIED®
www.ahridirectory.org

Certificate of Product Ratings

AHRI Certified Reference Number : 204595314 Date : 12-12-2019 Model Status : Active

Brand Name : A. O. SMITH

Model Number : BTHL 300A 300

This certificate serves as verification that the model has been rated in accordance with applicable federal Testing methods and verified by AHRI as capable of achieving the energy efficiency and performance rating as Tested within prescribed tolerances. The certificate and these certified ratings ONLY apply to the specific model and are non-transferable to alternate models or configurations.

Thermal Efficiency (%) : 94

The following data is for reference only and is not certified by AHRI

Energy Source : Natural Gas

Heater Type : Storage

Rated Volume (gal) : 220.0

SunPower® X-Series Residential Solar Panels | X21-335-BLK | X21-345

More than 21% Efficiency
Ideal for roofs where space is at a premium or where future expansion might be needed.

Maximum Performance
Designed to deliver the most energy in demanding real-world conditions, in partial shade and hot rooftop temperatures.[1,2,4]

Premium Aesthetics
SunPower® Signature™ Black X-Series panels blend harmoniously into your roof. The most elegant choice for your home.

Maxeon® Solar Cells: Fundamentally better
Engineered for performance, designed for durability.

Engineered for Peace of Mind
Designed to deliver consistent, trouble-free energy over a very long lifetime.[3,4]

Designed for Durability
The SunPower Maxeon Solar Cell is the only cell built on a solid copper foundation. Virtually impervious to the corrosion and cracking that degrade conventional panels.[3]

Same excellent durability as E-Series panels.
#1 Rank in Fraunhofer durability test.[9]
100% power maintained in Atlas 25+ comprehensive durability test.[10]

Unmatched Performance, Reliability & Aesthetics

SIGNATURE™ BLACK
SPR-X21-335-BLK

SPR-X21-345

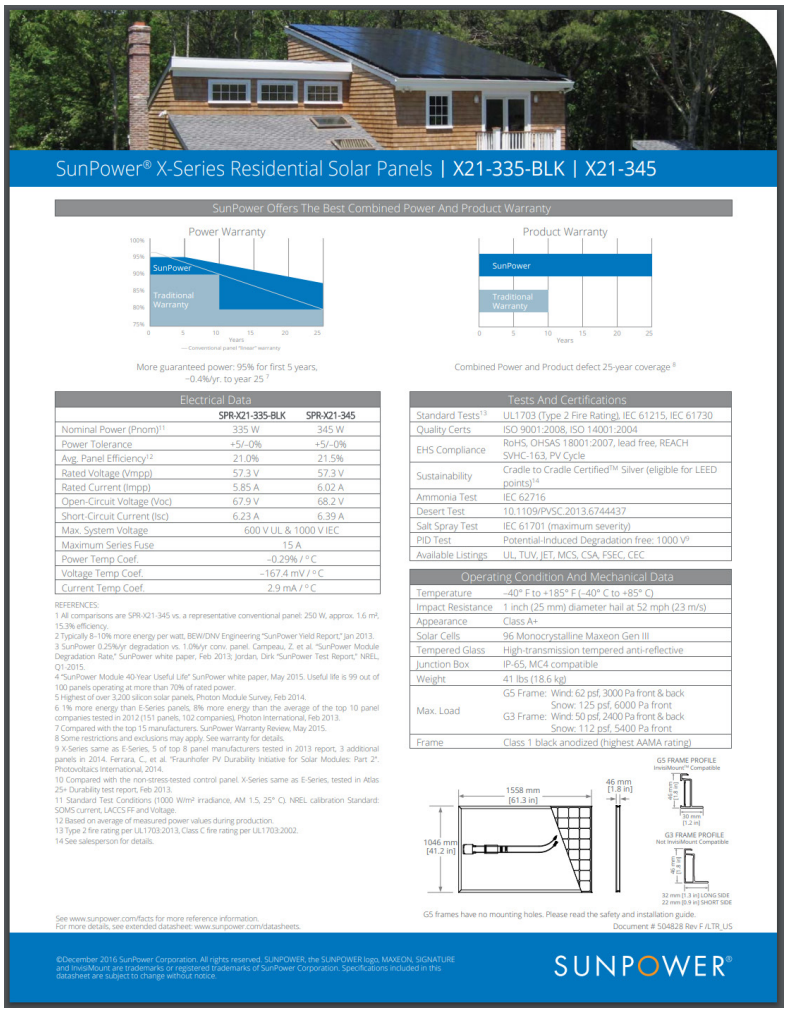
X21 SERIES

Highest Efficiency[5]
Generate more energy per square foot
X-Series residential panels convert more sunlight to electricity by producing 38% more power per panel[1] and 70% more energy per square foot over 25 years.[1,2,3]

Highest Energy Production[6]
Produce more energy per rated watt
High year-one performance delivers 8–10% more energy per rated watt.[2] This advantage increases over time, producing 21% more energy over the first 25 years to meet your needs.[3]

Datasheet

SUNPOWER®



SunPower® X-Series Residential Solar Panels | X21-335-BLK | X21-345

SunPower Offers The Best Combined Power And Product Warranty

More guaranteed power: 95% for first 5 years, –0.4%/yr. to year 25 [7]

Combined Power and Product defect 25-year coverage [8]

Electrical Data	SPR-X21-335-BLK	SPR-X21-345
Nominal Power (Pnom)[11]	335 W	345 W
Power Tolerance	+5/–0%	+5/–0%
Avg. Panel Efficiency[12]	21.0%	21.5%
Rated Voltage (Vmpp)	57.3 V	57.3 V
Rated Current (Impp)	5.85 A	6.02 A
Open-Circuit Voltage (Voc)	67.9 V	68.2 V
Short-Circuit Current (Isc)	6.23 A	6.39 A
Max. System Voltage	600 V UL & 1000 V IEC	
Maximum Series Fuse	15 A	
Power Temp Coef.	–0.29% / °C	
Voltage Temp Coef.	–167.4 mV / °C	
Current Temp Coef.	2.9 mA / °C	

Tests And Certifications	
Standard Tests[13]	UL1703 (Type 2 Fire Rating), IEC 61215, IEC 61730
Quality Certs	ISO 9001:2008, ISO 14001:2004
EHS Compliance	RoHS, OHSAS 18001:2007, lead free, REACH SVHC-163, PV Cycle
Sustainability	Cradle to Cradle Certified™ Silver (eligible for LEED points)[14]
Ammonia Test	IEC 62716
Desert Test	10.1109/PVSC.2013.6744437
Salt Spray Test	IEC 61701 (maximum severity)
PID Test	Potential-Induced Degradation free: 1000 V[3]
Available Listings	UL, TUV, JET, MCS, CSA, FSEC, CEC

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)
Appearance	Class A+
Solar Cells	96 Monocrystalline Maxeon Gen III
Tempered Glass	High-transmission tempered anti-reflective
Junction Box	IP-65, MC4 compatible
Weight	41 lbs (18.6 kg)
Max. Load	G5 Frame: Wind: 62 psf, 3000 Pa front & back Snow: 125 psf, 6000 Pa front G3 Frame: Wind: 50 psf, 2400 Pa front & back Snow: 112 psf, 5400 Pa front
Frame	Class 1 black anodized (highest AAMA rating)

REFERENCES:
1 All comparisons are SPR-X21-345 vs. a representative conventional panel: 250 W, approx. 1.6 m², 15.3% efficiency.
2 Typically 8–10% more energy per watt, BEW/DNV Engineering "SunPower Yield Report," Jan 2013.
3 SunPower 0.25%/yr degradation vs. 1.0%/yr conv. panel. Campeau, Z. et al. "SunPower Module Degradation Rate," SunPower white paper, Feb 2013; Jordan, Dirk "SunPower Test Report," NREL, Q1-2015.
4 "SunPower Module 40-Year Useful Life" SunPower white paper, May 2015. Useful life is 99 out of 100 panels operating at more than 70% of rated power.
5 Highest of over 3,200 silicon solar panels, Photon Module Survey, Feb 2014.
6 1% more energy than E-Series panels, 8% more energy than the average of the top 10 panel companies tested in 2012 (151 panels, 102 companies), Photon International, Feb 2013.
7 Compared with the top 15 manufacturers. SunPower Warranty Review, May 2015.
8 Some restrictions and exclusions may apply. See warranty for details.
9 X-Series same as E-Series, 5 of top 8 panel manufacturers tested in 2013 report, 3 additional panels in 2014. Ferrara, C., et al. "Fraunhofer PV Durability Initiative for Solar Modules: Part 2", Photovoltaics International, 2014.
10 Compared with the non-stress-tested control panel. X-Series same as E-Series, tested in Atlas 25+ Durability test report, Feb 2013.
11 Standard Test Conditions (1000 W/m² irradiance, AM 1.5, 25° C). NREL calibration Standard: SOMS current, LACCS FF and Voltage.
12 Based on average of measured power values during production.
13 Type 2 fire rating per UL1703:2013, Class C fire rating per ULT703:2002.
14 See salesperson for details.

G5 frames have no mounting holes. Please read the safety and installation guide.

See www.sunpower.com/facts for more reference information.
For more details, see extended datasheet: www.sunpower.com/datasheets.

Document # 504828 Rev F /LTR_US

SUNPOWER®

For the Environmental Charter School, we have chosen the SunPower X-Series. This product is suited for both residential and commercial projects because while it is a smaller size, it has a higher efficiency and more powerful output than other larger PV panels.

SPR-X21-345
Nominal Power: 345W
Avg. Panel Efficiency: 21.5%
PTC: 323.3W

Mitchell, Derek, and Sean Mitchell. Sunpower SPR-X21-345 (345W) Solar Panel. Accessed December 13, 2019. http://www.solardesigntool.com/components/module-panel-solar/Sunpower/2223/SPR-X21-345/specification-data-sheet.html.

OWEN HAFT + CASSANDRA HOWARD

RESULTS

71,598 kWh/Year*

System output may range from 69,006 to 74,369 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.03	4,464	511
February	3.97	5,170	591
March	4.33	6,002	687
April	5.00	6,512	745
May	5.30	7,032	805
June	5.44	6,806	779
July	5.65	7,138	817
August	5.76	7,295	835
September	5.49	6,810	779
October	4.29	5,624	643
November	3.63	4,894	560
December	2.64	3,851	441
Annual	4.54	71,598	$ 8,193

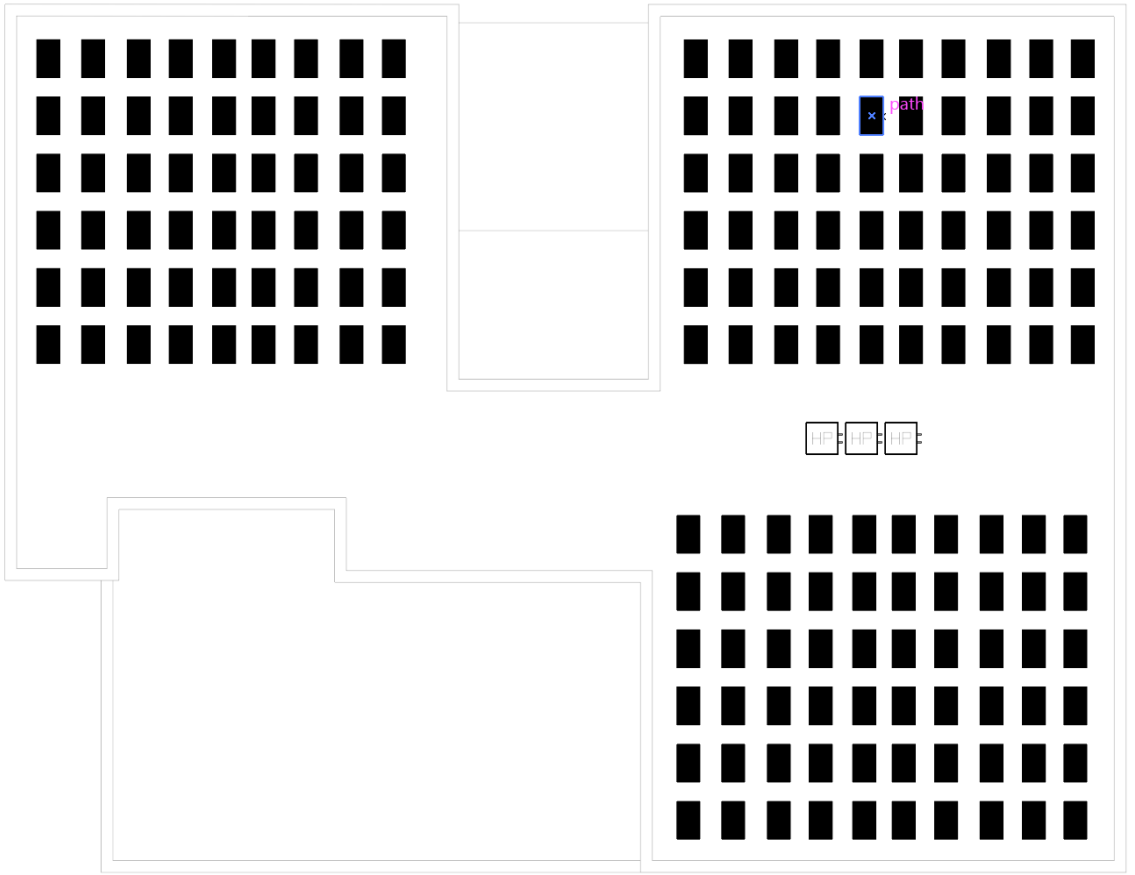
Location and Station Identification	
Requested Location	pittsburgh, pa
Weather Data Source	Lat, Lon: 40.45, -79.98 1.0 mi
Latitude	40.45° N
Longitude	79.98° W

PV System Specifications *(Residential)*	
DC System Size	56.25 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	40°
Array Azimuth	180°
System Losses	12.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics	
Average Retail Electricity Rate	0.114 $/kWh

Performance Metrics	
Capacity Factor	14.5%

Our PV array has 174 panels, which has a peak power of 56,254.2 watts, or 56.25 kW.



Roof Plan

RENEWABLE ENERGY PRODUCTION

"PVWatts." PVWatts Calculator. Accessed December 13, 2019. https://pvwatts.nrel.gov/pvwatts.php.

OWEN HAFT + CASSANDRA HOWARD

SIZING A SOLAR HOT WATER SYSTEM

Step 1. Enter project and location information.

Step 2. Calculate Hot Water Load and System Size

Select the appropriate building type from the drop-down menu. Tips on average Federal facility hot water load will be displayed to help complete the remaining fields. Then, enter the desired cold and hot water temperatures. Common temperatures are pre-entered for convenience, but can be changed to match your conditions.

Building Type

School

Amount of Water Usage (M) - gallons / person / day / person

2

Number of person(s)

320

Cold Water Temperature (°F)(T_{cold})

50

Hot Water Temperature (°F)(T_{hot})

130

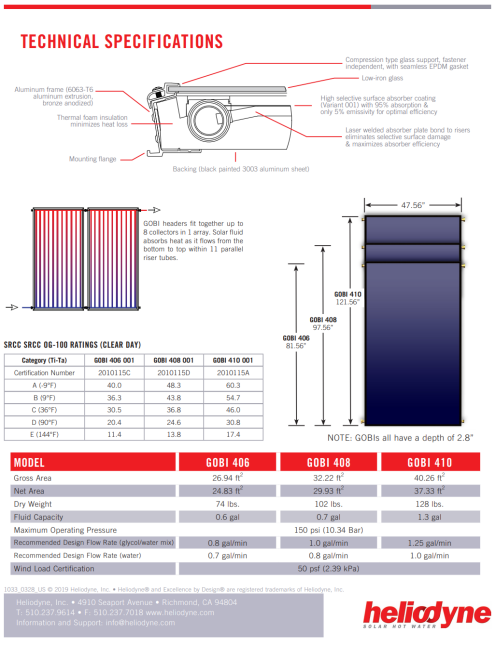
Calculate Load

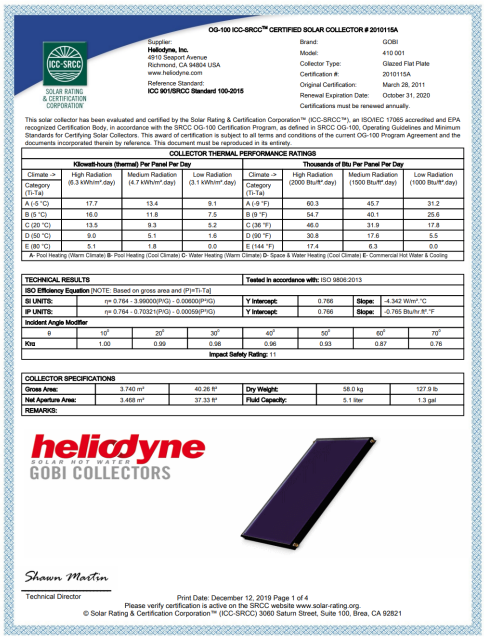
Water Usage Estimates

Office: 1 gal/day/person
School: 2 gal/day/person
Barracks: 10 gal/day/person
Dormitory: 13 gal/day/person
Residence: 30 gal/day/person
Food Service: 2 gal/meal
Motel: 15 gal/day/room
Hospital: 18 gal/day/bed

Estimated System Size: 51.09 m^2

SELECTING A SOLAR HOT WATER SYSTEM





We are also specifying a solar hot water system to be used in tandem with our conventional water heater. This will lessen our impacts on energy and water use [energy-water nexus.]

According to the Office of Energy Efficiency and Renewable Energy, the estimated solar hot water system size is 51.09m^2 or 550 ft^2.

The Heliodyne GOBI collectors are SRCC rated as one of the top OG-100 Collectors offering maximum performance out of a solar hot water system. The GOBI collectors are thin and sleek, adding a modest aesthetic to a powerful machine.

For this system, we will use 14 GOBI 410 Collector Systems, which has a capacity of 563.64 ft^2.

At the Oakland University, Nursing and Health Sciences school in Rochester, MN, solar hot water panels provided heat for the dedicated outdoor air system, entrance vestibules, lobbies, etc. The building has an EUI of 60kBTU/ft^2 which is great for a a university mixed-use building type.

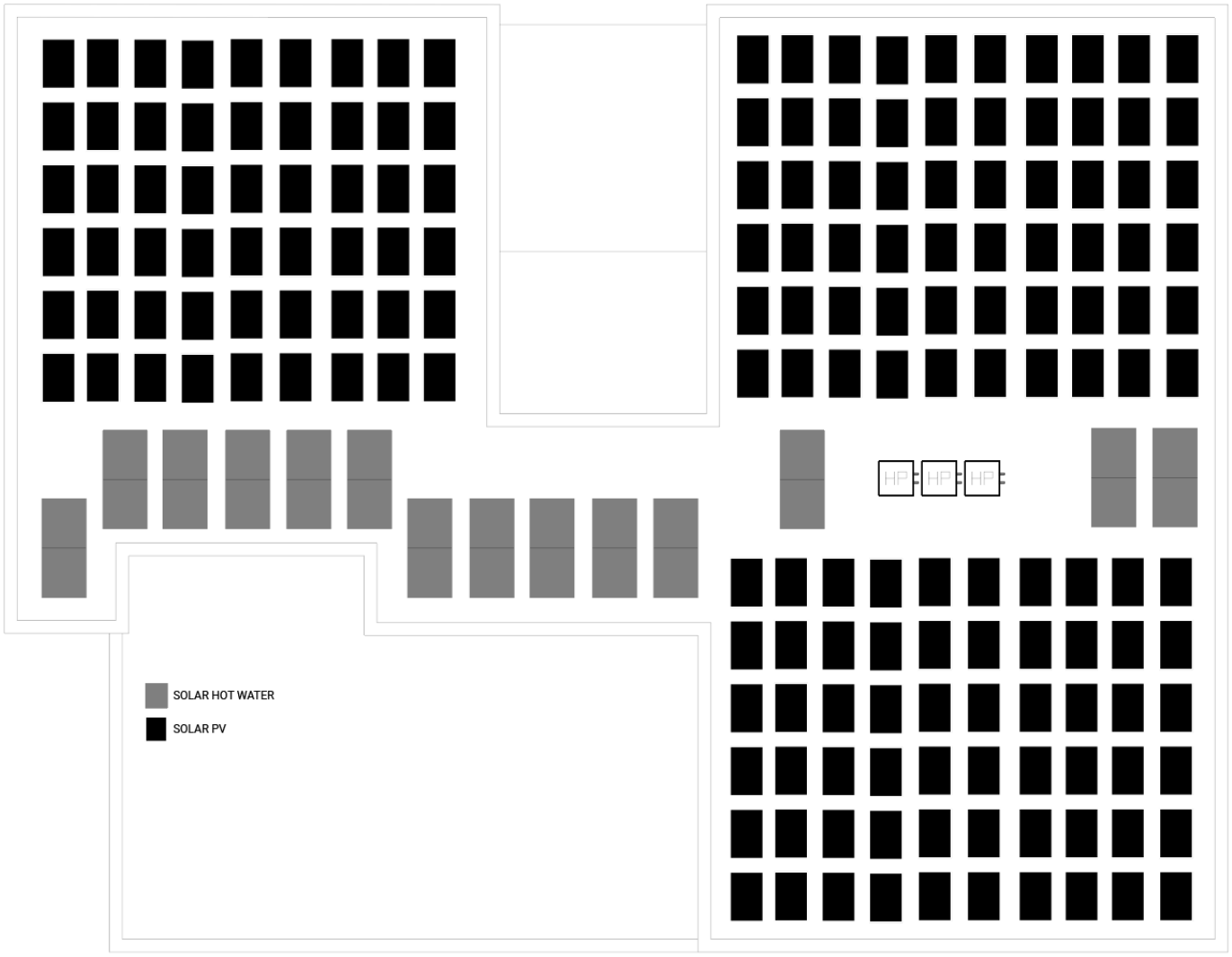
[48432 48655 F19 23 Solar Hot Water and Water Harvesting.pdf]

RENEWABLE ENERGY PRODUCTION

Solar Hot Water System Calculator. Accessed December 13, 2019. https://www.eere.energy.gov/femp/solar_hotwater_system/.

OWEN HAFT + CASSANDRA HOWARD

SOLAR HOT WATER SYSTEMS LAYOUT

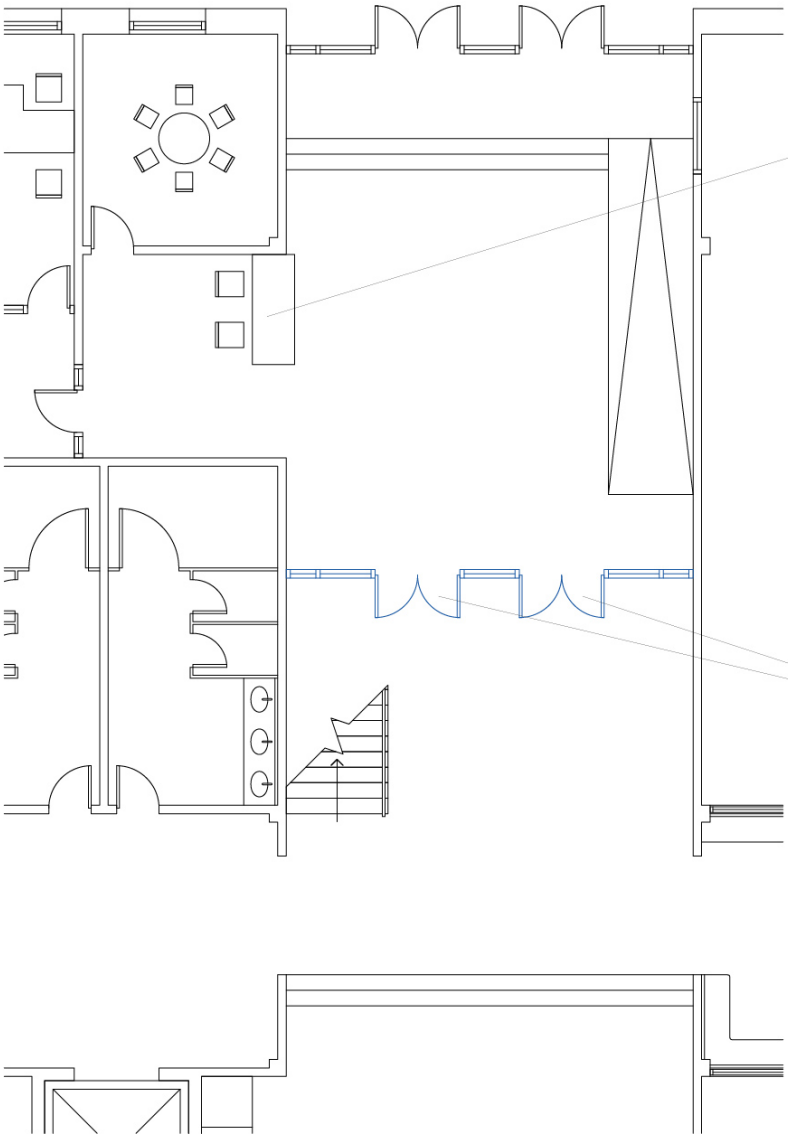


Roof Plan

This is the combined layout of the solar hot water and solar PV systems.

There is at least 3 ft between panels for maintenance.

Liberty Ave.



Proposed Reception/Front Desk to monitor all students and visitors entering.

Added Security Door, unlockable only by front desk to allow access to the school.

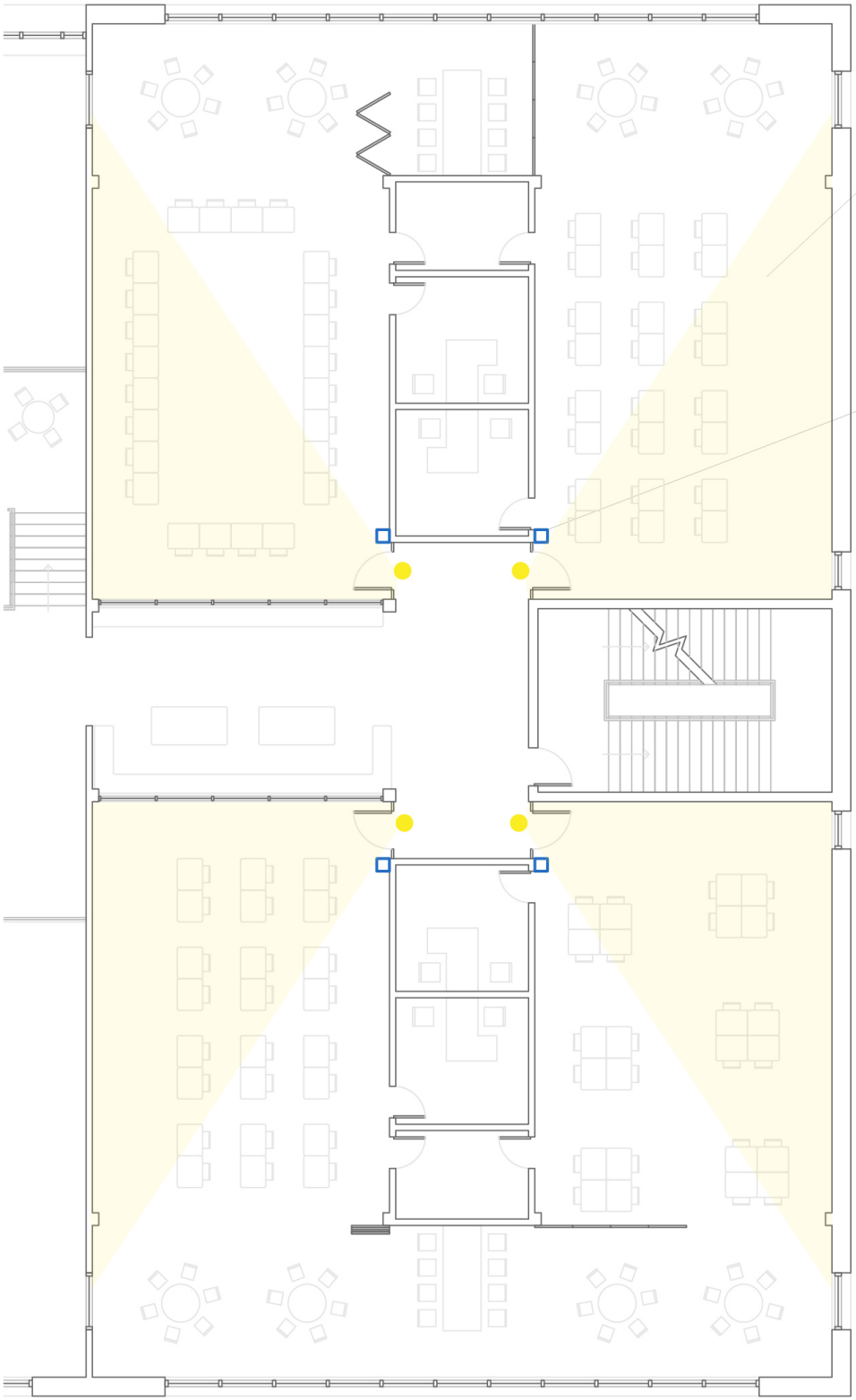
Already implemented in my design is a reception desk directly adjacent to the entry, allowing an employee to monitor all people entering the school.

In the article cited below, one of the many strategies mentioned by NAC Architecture is having a “security vestibule” in which a visitor needs clearance from the reception to be able to fully enter the school, a strategy I implemented in the diagram below showing my Entry Proposal.

“Security vs. 21st Century Learning: We Shouldn’t Have To Choose.” NAC Architecture: Architects in Seattle & Spokane, Washington, Los Angeles, California. Accessed December 13, 2019. https://www.nacarchitecture.com/naclab/school-security.aspx.

SAFETY AND SECURITY

OWEN HAFT + CASSANDRA HOWARD



New sightlines greatly limit view into room allowing student to hide.

Added Blocking near door to limit view into classroom.

In the diagrams shown, added blocking near the doors to limit view into classrooms and an added locked door after the entrance into the school are used to further secure the safety of the school and students.

SAFETY AND SECURITY

OWEN HAFT + CASSANDRA HOWARD