Scarborough Primary School Final Report

Design Integration of Active Building Systems

Scarborough Primary School
3021 Little York Rd
Houston, TX 77093

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48-655 Environment II
December 6, 2019

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01. Building Envelope with Load Calculations

Scarborough Elementary School

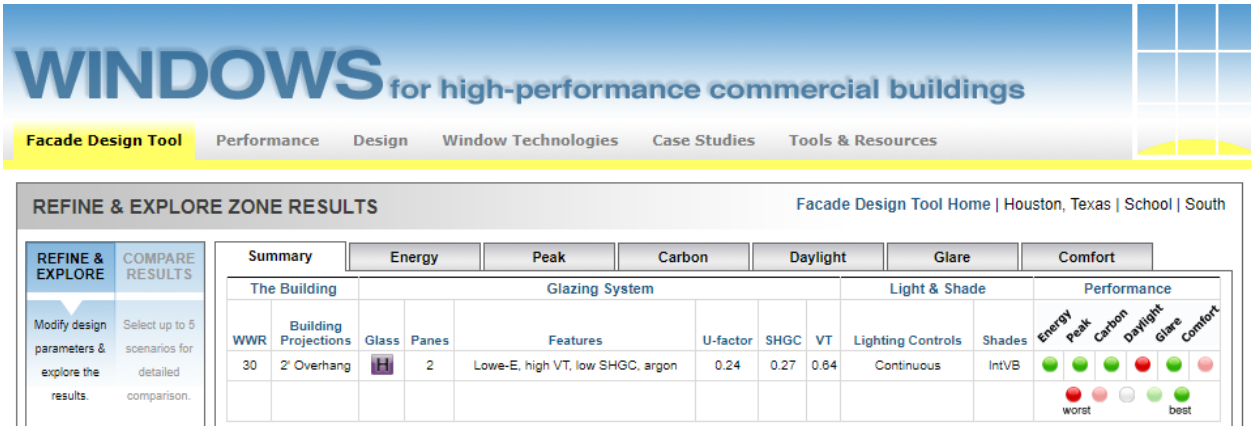
The Scarborough Elementary School, located in Houston, Texas, poses a unique design opportunity as it is a reconstruction of a school that was damaged by flood waters and wind during Hurricane Harvey in 2017. The school is situated in the Eastex/Jensen neighborhood directly north of downtown Houston. The site is fairly large, and can easily accommodate the “W” shape of the new elementary school.

Siting

To address the issue of runoff and flooding, the school will be raised above it’s previous elevation by sitework before construction. The site will be raised three feet above it’s previous elevation, with gentle grading down on all sides to meet the street and adjacent lots. A well marked and secure vestibule will serve as the primary entrance to the school, providing additional security as well as minimizing outside air infiltration, though it is not required by code in the Houston climate zone. Given the orthogonal layout of streets within the neighborhood, the site naturally accepts our building with the classroom wings running from east to west and fenestration facing north and south. Green space will separate each wing, ensuring that each classroom has natural daylight which is linked to good health and a positive learning environment. The green space dividing each wing will also be secured by way of a fence to provide a space that can be used and occupied by classes during the many temperate days of the Houston school year.

Fenestration

Due to the mild climate of Houston (2A) during the school year when the greatest occupancy will be, we feel that the greatest concern will be a manageable cooling load during the shoulder seasons. As a result, the southern facade will be equipped with 2' horizontal shading fixtures mounted above the windows. Additionally, windows have a low U value and low SHGC to help suppress the dominant cooling load in the school. It is important to note that such windows will still have a high visible light transmission and clarity to maintain a comfortable learning environment within the classrooms.



Window Selection Tool Interface & Characteristic Display

The interface pictured above run by the Efficient Window Collaborative (EWC) helps professionals identify desirable window characteristics depending on project criteria. In place of selecting a specific window product for our load calculations, we extracted data from the interface's suggested window selection pictured above. Such window characteristics were deemed acceptable as they are also drawn from case studies in similar climate zones, such as the Phoenix Central Library as outlined on CommercialWindows.org[1].

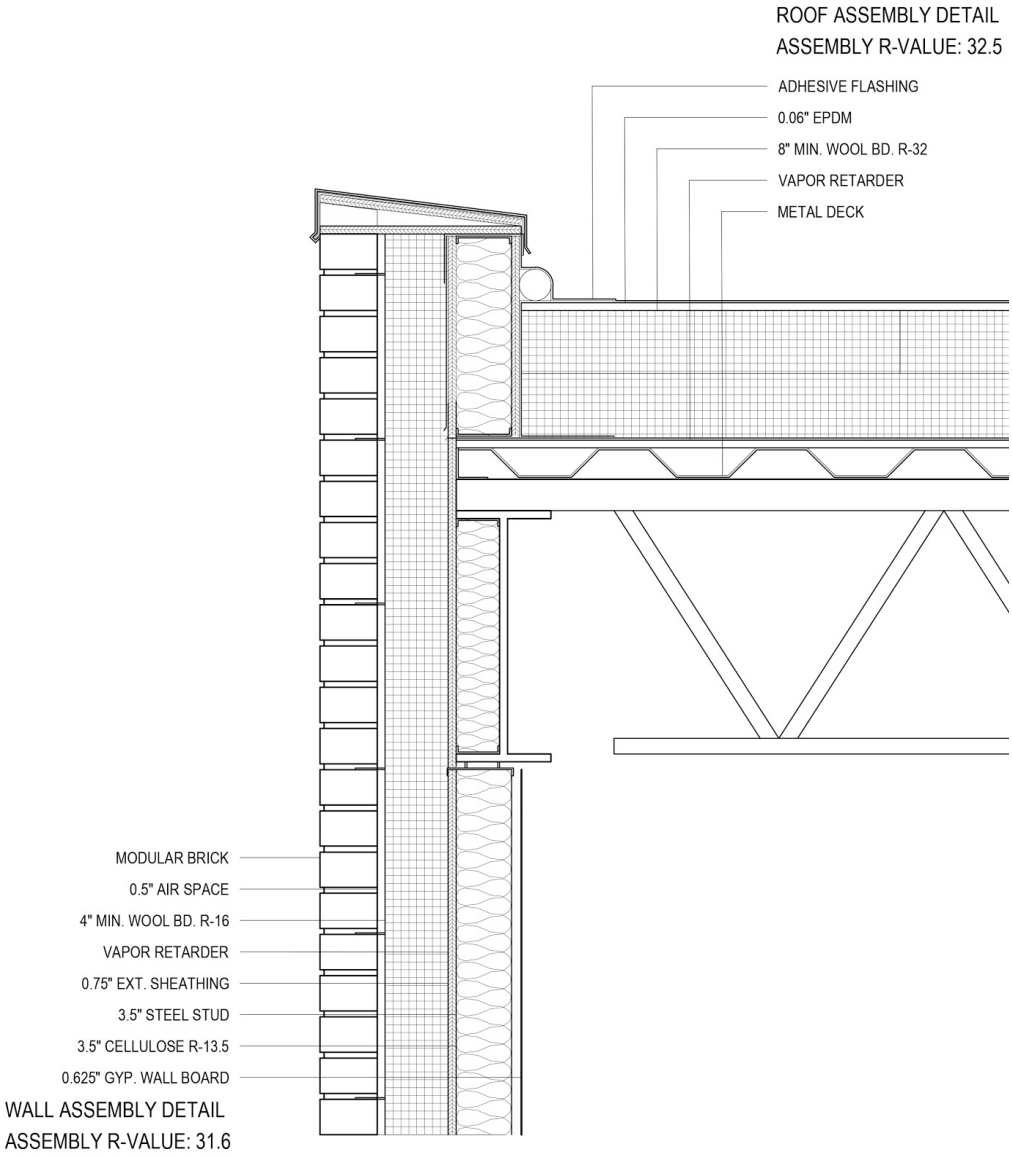
Thermal Envelope Assembly

To make educated choices considering health, environment, and efficiency for all insulation, the "BuildingGreen Guide to Insulation" was used as a significant resource[2]. The thermal envelope was constructed using steel stud construction as is standard on many commercial and institutional building types. The resulting cavity is packed with dense cellulose insulation, then covered with exterior sheathing and a vapor retarder. Then, rigid mineral wool board is applied to the exterior along with an air gap and then the brick facade. The light brick provides a first line of defense from the elements, as well as a strong barrier during heavy southern storms. Rigid mineral wool board was chosen as an exterior continuous insulation for its capable R value of R4/inch, as well as its hydrophobic characteristics and ability to drain well. This insulation choice is also sensitive to the environment as it contains on average between 75%-93% recycled content. Within the walls, environmental and health

[1] Window Education site operated by the Efficient Window Collaborative (EWC) endorsed by the U.S. Green Building Council
[2] Wilson, Alex. "What You Need to Know About Performance, Cost, Health and Environmental Considerations." *The BuildingGreen Guide to Insulation*, vol. 3, 2017.

considerations drove the decision to utilize dense packed cellulose cavity insulation. The cellulose can provide R3.8/inch, and on top of being non-carcinogenic, it also consists of up to 80% recycled content.

Aside from proper material layering and diligent installation, this envelope has been designed to reduce infiltration and thermal bridging. By placing insulation on both sides of the vapor retarder, we minimize the ability for water to migrate between the inside and outside of the wall cavity. Additionally, the mineral wood board separates the structural wall from the brick veneer, significantly minimizing thermal bridging. A taped and sealed vapor retarder/exterior sheathing combination product such as the zip wall system can be utilized to prevent infiltration as well. The roof assembly takes a similar approach to prevent thermal bridging by placing the insulation on the exterior of the assembly. Note that the roof will be a membrane roof, with a white EPDM membrane utilized to reflect as much radiation as possible.The below diagrams illustrate the wall and roof assembly.



Proposed Scarborough Elementary School Wall & Roof Section Assembly Detail.

The new Scarborough Elementary School envelope design strives to achieve higher insulative values than IECC 2018 table C402.1.3[3] prescribes for commercial buildings in climate zone 2. According to the requirements for thermal envelope insulation for a roof with insulation above the deck, the assembly would be required to have cavity insulation amounting to R-25. By utilizing 8” of mineral wool board on the roof, we surpass the IECC 2018 code. Another consideration in the roof assembly is the placement of solar panels, solar hot water heaters, and other mechanisms on the roof that end up serving as shading mechanisms simply by being located where they are. This takes some of the burden on the cooling systems off by lessening the solar radiation absorbed by the membrane roof. Similarly, the wall assembly also surpasses IECC 2018 recommendations by presenting a R-31.6 assembly where code only requires R-18. While surpassing code makes sense and is relatively attainable, the mild climate of Houston, Texas suggests that one need not go overboard by creating assemblies that go too far above what code recommends. Simply put, the money saved from a quality envelope can be spent elsewhere within the building to help support more efficient systems such as renewable energy and mechanical systems.

[3] IECC 2018 Table C402.1.3 states ONLY minimum requirements derived from the R-Value method

RTS COOLING LOAD CALCULATIONS					MASTER INPUT DATA				December 6, 2019
2013 ASHRAE FUNDAMENTALS EXAMPLE-IP UNITS					rev 2015-09-24			Page:	1
IDENTIFICATION:		Design Firm:	Smercroft Design Inc.						
		Project Engineer:	Mary P. Burdell, P.E.						
		Project Name:	Scarborough Elementary School						
		Project Location:	Houston, Texas						
		Project Number:	7						
SITE:	USA - TX - HOUSTON/INTERCONTIN - 5%				DESIGN CONDITIONS:				
					Inside Design Conditions:			Supply Air Temp:	
Latitude:	29.99	Month:	DB, F	MWB, F	Cooling:			Cooling:	
Longitude:	-95.36	1	72.3	65.2	DB, F	75		DB, F	57
Elevation	105	2	74.2	64.8	RH	50%			
		3	77.9	66.5	Heating:			Heating:	
		4	82.9	69.9	DB, F	72		DB, F	100
Htg 99.6%	30.3	5	88.7	74.7					
		6	92.6	76.5					
TZ +/- UTC:	-6	7	94.7	76.9	INTERNAL LOADS:				
Time Zone:	Central	8	95.5	77.0	Default:	People:	Default:	Lighting:	Equip.:
Std Merid:	-90	9	91.4	75.5	Sf/person:	98.6	Watts/sf:	0.6	1
		10	86.1	72.3	Btuh/person:				
Solar:		11	78.7	68.9	Sensible:	250			
Gnd Reflec	20%	12	73.2	67.6	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	0%		0%	0%
	2	17%	16%		2	0%		0%	0%
	3	9%	8%		3	0%		0%	0%
	4	5%	4%		4	0%		0%	0%
	5	3%	3%		5	0%		0%	0%
	6	2%	2%		6	0%		0%	0%
	7	2%	1%		7	100%		100%	100%
	8	1%	1%		8	100%		100%	100%
	9	1%	1%		9	100%		100%	100%
	10	1%	1%		10	100%		100%	100%
	11	1%	1%		11	100%		100%	100%
	12	1%	1%		12	100%		100%	100%
	13	1%	1%		13	100%		100%	100%
	14	1%	1%		14	100%		100%	100%
	15	1%	1%		15	100%		100%	100%
	16	1%	1%		16	100%		100%	100%
	17	1%	1%		17	100%		100%	100%
	18	1%	1%		18	100%		100%	100%
	19	1%	1%		19	0%		0%	0%
	20	1%	0%		20	0%		0%	0%
	21	0%	0%		21	0%		0%	0%
	22	0%	0%		22	0%		0%	0%
	23	0%	0%		23	0%		0%	0%
	24	0%	0%		24	0%		0%	0%

RTS COOLING LOAD DEMONSTRATION — **December 6, 2019**
MASTER INPUT DATA — **Page: 2**

IDENTIFICATION: **Scarborough Elementary School, Houston, Texas**

EXTERIOR EXPOSURES: Plan Rotation: **0** degrees

	Nominal	North	South	East	West	Roof
	Azimuth:	-180	0	-90	90	0
	Actual:	-180	0	-90	90	0
	Tilt:	90	90	90	90	0

WALL DATA:	**TYPE 1 WALL**	**TYPE 2 WALL**	**ROOF DATA:**
Descrip.	**Brick pilasters**	**Spandrel panels**	Descrip: **Metal deck**
Input Actual "U" :	**0.032**	**0.077**	Input Actual "U" : **0.031**
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%

Similar CTS ID:	Wall # **11**	Wall # **1**	Similar CTS ID:	Roof # **9**
	Brick, R-5 Insulation Board, Sheathing, Gyp Board	Spandrel Glass, R-10 Insulation Board, Gyp Board		Membrane, Sheathing, R-10 Insulation Board, Metal Deck
Hour			Hour	
1	0%	18%	1	18%
2	5%	58%	2	61%
3	14%	20%	3	18%
4	17%	4%	4	3%
5	15%	0%	5	0%
6	12%	0%	6	0%
7	9%	0%	7	0%
8	7%	0%	8	0%
9	5%	0%	9	0%
10	4%	0%	10	0%
11	3%	0%	11	0%
12	2%	0%	12	0%
13	2%	0%	13	0%
14	1%	0%	14	0%
15	1%	0%	15	0%
16	1%	0%	16	0%
17	1%	0%	17	0%
18	1%	0%	18	0%
19	0%	0%	19	0%
20	0%	0%	20	0%
21	0%	0%	21	0%
22	0%	0%	22	0%
23	0%	0%	23	0%
24	0%	0%	24	0%

RTS COOLING LOAD DEMONSTRATION						December 6, 2019
MASTER INPUT DATA						Page: 3
IDENTIFICATION:	Scarborough Elementary School					
	Houston, Texas					
WINDOW TYPE 1			WINDOW TYPE 2			
Window.Width:	1.00	ft	Window.Width:		ft	
Window Height:	1.00	ft	Window Height:		ft	
Description:	Dbl Glz, Low E, Low SHGC, Argon		Description:			
Window Area:	1.00	sf	Window Area:		sf	
Overall U-value:	0.24		Overall U-value:			
Dbl Glz, Lo e=.05 surf 2, 1/4"in, BRZ W/LE CLR, SHGC(0)= 0.26						
	58			19		
SHGC(0):	26%		SHGC(0):	49%		
SHGC(40):	25%		SHGC(40):	46%		
SHGC(50):	24%		SHGC(50):	44%		
SHGC(60):	22%		SHGC(60):	39%		
SHGC(70):	18%		SHGC(70):	31%		
SHGC(80):	10%		SHGC(80):	17%		
SHGC(90):	0%		SHGC(90):	0%		
SHGC(Hemis):	23%		SHGC(Hemis):	41%		
IAC(0):	0.74		IAC(0):	0.74		
IAC(60):	0.65		IAC(60):	0.65		
IAC(diff):	0.79		IAC(diff):	0.79		
Unshaded % C:	0%		Unshaded % C:	0%		
Unshaded % R:	100%		Unshaded % R:	100%		
Shaded % C:	54%		Shaded % C:	54%		
Shaded % R:	46%		Shaded % R:	46%		
	Overhang:			Overhang:		
Overhang Depth:	2	ft	Overhang Depth:	0	ft	
Overhang Above wind:	0	ft	Overhang Above wind:	0	ft	
	Vertical Projection:			Vertical Projection:		
Depth:	0	ft	Depth:	0	ft	
Distance from Wind:	0	ft	Distance from Wind:	0	ft	

2013 ASHRAE FUNDAMENTALS EXAMPLE-IP UNITS						rev 2015-09-24		06-Dec-19
	Smercroft Design Inc.							Mary P. Burdell, P.E.
7	Scarborough Elementary School							Houston, Texas
ROOM NO./NAME:		Building	Building Block Load - 10' Overhang - no lights/roof to RA-Table 38					
	Length:	273.925	feet				Infiltration cfm	
	Width:	270	feet	Area	73960	sq. feet	Cooling:	Heating:
	Ceiling Height:	13	feet	Volume	961477	cubic feet	2272.5	4545
INTERNAL LOADS:			Btuh/person:	Lighting,	Equipment,	Inside Design Conditions:		
		# People:	Sensible:	watts:	watts:	Cooling:	DB, F	75
	Over-ride Room Input:	0	250	0	0		RH	50%
	Default:	750	Latent:	44376	73960	Heating:	DB, F	72
	Use:	750	200	44376	73960	Outside Cooling Weather:		
EXPOSURES:		North	South	East	West	USA - TX - HOUSTON/INTERCONTIN - 5%		
	Nominal Azimuth:	-180	0	-90	90	Heating 99.6%, F:		30.3
	Actual Azimuth:	-180	0	-90	90	Supply	Cooling, F	57
	Tilt:	90	90	90	90	Air:	Heating, F	100
	Type 1 Wall Area, sf:	10010	10010	3510	3510	Brick pilasters		
	Type 2 Wall Area, sf:	0	0	0	0	Spandrel panels		
	No. Type 1 Windows:	3465	3465	1215	1215	Dbl Glz, Low E, Low SHGC, Argon		
	No. Type 2 Windows:	0	0	0	0			
	Roof Area, sf:	73960	0%	= Roof % to RA		0%	= Lights % to RA	

ROOM LOADS:		Peak Rm.Sens. Occurs:			Room	Ret. Air	Room	Room
		Month:	7	Per Unit	Sensible	Sensible	Latent	Sensible
		Hour:	14	Cooling	Cooling:	Cooling:	Cooling	Heating:
INTERNAL LOADS:			No. People:	Btuh/pers	Btuh	Btuh	Btuh	Btuh
		People:	750	232	174,000		150,000	
			watts:	Btuh/room sf				
		Lighting:	44,376	1.9	142,606			
	Lightiing % to RA:		0%	0.0		-		
		Equipment:	73,960	3.3	243,123			
ENVELOPE LOADS:								
			Roof Area,sf	Btuh/roof sf				
ROOF:	0.031	U factor	73,960	1.6	116,404			95,608
	Roof % to RA:		0%			-		
WALLS:			Wall Area,sf	Btuh/wall sf				
	Wall Type 1:	Brick pilasters						
0.032	U factor	North	10010	0.5	4,550			13,357
		South	10010	0.5	4,968			13,357
		East	3510	0.9	3,129			4,684
		West	3510	0.4	1,532			4,684
	Wall Type 2	Spandrel panels						
0.077	U factor	North	0	0.0	-			-
		South	0	0.0	-			-
		East	0	0.0	-			-
		West	0	0.0	-			-
WINDOWS:			Window Area,sf:	Btuh/win sf				
	Window Type 1:	Dbl Glz, Low E, Low SHGC, Argon						
1.00	sf/window	North	3465	12.5	43,360			34,678
26%	SHGF(0)	South	3465	13.2	45,778			34,678
0.24	U factor	East	1215	12.5	15,190			12,160
74%	IAC	West	1215	13.9	16,870			12,160
	Window Type 2:							
	sf/window	North	0	0.0	-			-
49%	SHGF(0)	South	0	0.0	-			-
	U factor	East	0	0.0	-			-
74%	IAC	West	0	0.0	-			-

INFILTRATION LOADS:			cfm	Btuh/cfm				
	Cooling, Sensible:		2272.5	21.7	49,245			
	Cooling, Latent:		2272.5	31.9			72,491	
		Heating:	4545	45.9				208,479
					=====	=====	=====	=====
				ROOM LOAD TOTALS =	**860,755**	**-**	**222,491**	**433,844**
				COOLING CFM =	**43,472**	**HEATING CFM =**		**14,086**
				CFM/SF =	**0.6**			

BLOCK LOADS:		TOTAL ROOM SENS+RA+LATENT =			1,083,245		ROOM HTG:	433,844
Peak Block Load Occurs:		OUTSIDE AIR:		OA Sensible:	-		OA Heating:	-
Month:	7	OA cfm =	0	OA Latent:	-			=====
Hour:	14	FAN HEAT:	25	HP to S. Air:	63,652	**TOT HEATING,btuh=**		**433,844**
		PUMP HEAT:	5	HP to CHW:	12,730	**Heating btuh/sf =**		**5.9**
					=====	**tons**	**sf/ton**	
				TOTAL BLOCK COOLING LOAD, btuh -	**1,159,628**	**96.6**	**765**	

02. Lighting

Electric Lighting Design

Lighting fixture choice is dependent on a number of factors, some of which include desired light intensity, direction, light use, and efficiency. Studies point out that a suspended direct/indirect fixture yields the most favorable classroom artificial lighting conditions.

- Based on the desired lighting ambiance, reputation, and luminaire type, the LN4 Suspended Ambient LED Luminaire by Cree [4] has been selected for the classrooms
- This fixture features a 60% uplight and 40% downlight light distribution
- Each 48” fixture requires 32 watts of input power

Watts Per Square Foot Method

According to IECC 2018, Table C405.3.2 (2)[5], the allowable interior power density of a classroom space is 0.96 watts/sf.

- Utilizing the watts per square foot method from IECC 2018, we are able to multiply the classroom size of 900 sf by the allowable watt/sf of 0.96 watt/sf to find that each classroom is allowed 864 watts of power.
- Since we have chosen the LN4 fixture, and know that each fixture uses 32 watts of power, we can figure the number of fixtures allowed in each classroom.
- Per code using the watts/sq. Ft. method, we are allowed up to 27 of the LN4 fixtures per classroom.

Zonal Cavity Method

The zonal cavity method of calculated required lighting accounts for the surfaces in the space being lit as well as factors such as the fixture distance to the work plane being lit. The next consideration in determining a lighting strategy for the classroom is to determine the desired illumination on the work surface (30” high desks) within the room. The age group will be almost completely below the age of 25, so using the ANSI Target Illumination Values for this age group in an educational/classroom setting, the target illumination value should be between 250-375 lux per square foot. Since we will have a few adults in the room to teach and assist the students we will choose to use the higher end of the spectrum. Additionally, knowing that we will have the capability to dim the lights, we will set our target illumination value to 375 lux, or 35 foot candles per square foot.

Using the IECC 2018 square foot method that we calculated above as a starting point, we then move on to the zonal cavity method to gain a better understanding of the number of fixtures that we need, rather than what is allowed per code.

Our first task is to identify the Room Cavity Ratio integer:

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[4] LN4 Suspended Ambient LED Luminaire - Indirect/Direct - 4’

[5] https://codes.iccsafe.org/content/iecc2018/chapter-4-ce-commercial-energy-efficiency

RCR = $\frac{5*HRC*(L+W)}{L*W}$

RCR=3…. So per LN4-34L-35K-CMA charts[6] with 80% RC and 50% RW state that CU will be 0.59

Foot Candles = $\frac{\text{Total Lumens x CU x LMF}}{\text{Area}}$

40 % Downlight Lumen Calc:

35 = $\frac{\text{Total Lumens x 0.59 x 1}}{900}$

Downlight Lumens = 53390*0.4 = 21356 from downlight

60 % Uplight Lumen Calc:

35 = $\frac{\text{Total Lumens x 0.55 x 1}}{900}$

Uplight Lumens = 57272*0.6 = 34364 from uplight

Total Lumen Summary = 21356 + 34364 = 55720 lux

# of Luminaires = $\frac{\text{Total Lumens}}{\text{Lumens/Luminaire}}$

# of Luminaires = $\frac{55720}{3400}$

# of Luminaires = 17, ten less than the prescriptive IECC 2018 option allows

If we look back at our Lighting Power Density calculated using the allowable watts/sq.ft. that IECC 2018, we see that we are allowed 0.96 watts/sq.ft or 27 light fixtures per classroom.

After using the Zonal Cavity method to more accurately determine the appropriate light level for our students and teachers, we find that we can achieve a desirable lighting effect with only 17 light fixtures per room. If we plug this quantity back into the LPD equation, we find that with 17 fixtures that achieve a desirable light level, our power density drops to 0.6 watts/sq.ft. This change would have large effects on both immediate and long term savings in power, maintenance, and unit cost of lighting in all 42 classrooms within the school. To put it into perspective, we would need to purchase and power 714 fixtures rather than 1134.

IECC 2018 Lighting Control Requirements Summary

The descriptions below outline and simplify/condense the portions of the IECC 2018 that affect the lighting controls of our school:

405.2 Lighting Controls

Lighting systems shall provide controls that comply with one of the following:

[6] LN Series with SmartCast Technology Specification Sheet

1. In Depth Specification: C405.2.1 - C405.2.6
    a. Occupant Sensor Controls C405.2.1
    b. Time Switch controls instead of Occupant Sensor C405.2.2
        i. 7 day clock, programable, manual override
    c. Daylight Responsive Controls C405.2.3

2. Luminaire level Lighting Controls - Luminaire should be independently capable of:
    a. Monitoring occupant activity to brighten or dim lighting when occupied/unocc.
    b. Monitoring Ambient Light, electric and daylight, and brighten or dim artificial light to maintain desired light level
    c. For each strategy, configuration and reconfiguration of parameters including: bright and dim setpoints, timeouts, dimming fade rates, sensor sensitivity adjustments, wireless zoning configurations

To comply with part one, we would suggest the following product selections:

Lutron Wireless Daylight Sensor - LRF2-DCRB-WH

- Features a partial open loop daylighting system that takes into account actual daylight streaming in from windows, reflectances from work surfaces, as we ll as artificial light to create a uniform lighting throughout the day

Lutron Dual Technology Occupancy Sensor (PIR & Ultrasonic)

- Detects occupancy and motion in a room to trigger lights
- Helps eliminate light usage during long periods of disuse (summer)

03. Ventilation

Local Outdoor Air Quality

The region surrounding Scarborough Elementary School in Houston, TX generally benefits from good outdoor air quality. PM2.5[7] ratings generally hover around 20-50 according to AQICN.org and AIRNow.gov, indicating that “air quality if satisfactory and air pollution poses little or no risk.” While health hazards are minimal, Ozone is the major contributor to air quality pollution[8]. Additionally, according to the EPA, this region is located in Zone 3 of radon exposure, with average indoor radon screenings measured at healthy levels of 2 pCi/L or less.

Required OA for IMC 2018

Natural Ventilation: The IMC 2018 Section 402 stipulates that the minimum openable area for natural ventilation is 4% of the ventilated floor area. Therefore, for each 900 SF classroom, this code minimum would be 36 SF of openable window area per classroom. The code minimum could be met very easily along the 30’ exterior walls of each classroom.

Mechanical Ventilation: As demonstrated in the spreadsheet below, each classroom would require a minimum of 308 CFM of fresh outdoor air to meet the stipulations of IMC 2018 Section 4. Each wing of Scarborough Elementary would require 4,366 CFM of outside air. The three wings would thus require 13,098 CFM cumulatively. We will assume that other school spaces like offices, auditorium, etc. will add an additional 25% to the ventilation load. Thus, our complete system design would need to deliver 16,375 CFM to the building as a whole.

Occupants	750						
Total Classroom SF	34200						
SF / Classroom	900						
# Classrooms	38						
Students / Classroom	19.74						
	# ppl / 1000 SF		CFM / person		CFM / SF		
	IMC 2018	By Design	IMC 2018	By Design	IMC 2018	By Design	**Total CFM**
Classroom	35	31.5	10	200	0.12	108	308
Corridor	0	0	0	0	0.06	54	54
Total per Wing				**200**		**162**	**4366**

[7] Elevated exposure to small particulate matter (PM2.5) contribute to premature death in people with lung disease, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, and increased respiratory symptoms. (EPA.gov, 2019)

[8] Excessive ozone tends to harm sensitive ecosystems during growing season and, according to the EPA, threatens human cardiovascular health. Breathing increased amounts of ozone - a primary contributor to smog - can lead to chest pain, coughing, throat irritation, and inflammation of the trachea. (EPA.gov, 2019)

Ventilation System Design

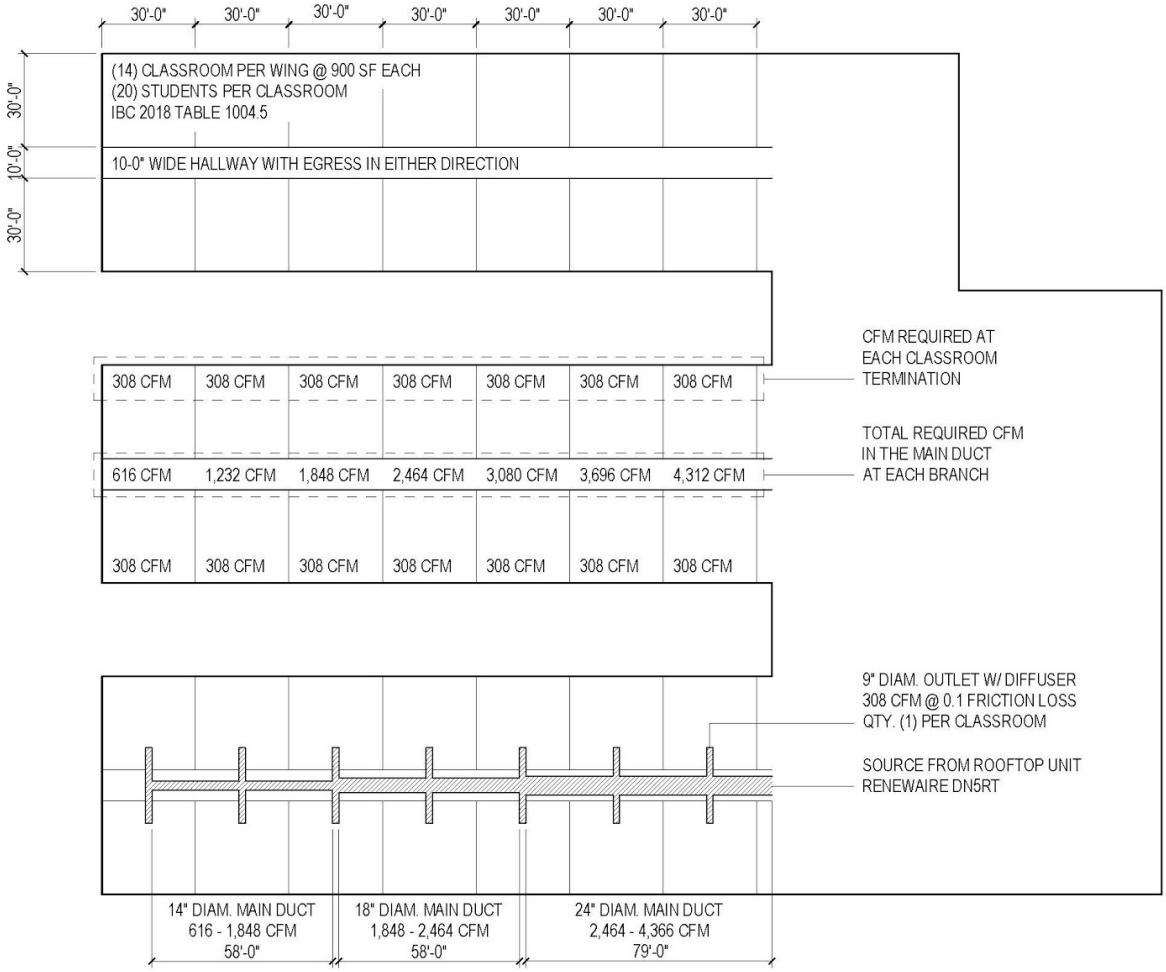
The proposed ventilation design would utilize Dedicated Outdoor Air System (DOAS) equipment that operates independently of the heating and cooling equipment to completely precondition outdoor air. The complete system would also include large operable windows, meeting the minimum 35% WWR stipulated in IBC 2018. These windows could be opened when outdoor relative humidity, temperature, and air quality are suitable for direct delivery to occupants. As mentioned earlier, this generally occurs quite frequently.

The ventilation system would utilize CO2 sensors to limit OA system usage, save energy, and limit exposure to outdoor air during poor conditions, making it a Demand Control Ventilation (DCV) system. CO2 sensors respond to actual occupancy more accurately than scheduled systems; their inclusion would reduce energy consumption related to ventilation significantly in school spaces such as the auditorium, the gymnasium, and the library, where occupancy ranges from absolute-minimum to code-maximum without a regular schedule, often randomly.

Due to the large volume of air required to ventilate classroom wings of the building, each wing would have its own rooftop DOAS. The Renewaire DN5RT, a 4,950 CFM static plate DOAS with sensible and latent heat recovery components, would be the engine of the system. The Renewaire unit comes equipped with MERV 8 filters, which are suitable for Houston's generally healthy outdoor air quality.

Renewaire DN5RT system components (source: Renewaire website)

With (14) classrooms per wing of Scarborough Primary School, the main duct of each wing would have to deliver 4,366 CFM of outdoor air, and would need to be about 24" in diameter at the beginning of the wing. As diagrammed below, the classroom wing ducting utilizes long straight runs to reduce friction and associated fan power. The only turns in the flow of air would be branches terminating in each classroom. The 308 CFM of air arriving at each classroom would require 9" round duct outlets to maintain equal friction, which would branch to (4) terminal diffusers spread across the room to reduce exit air velocity to a comfortable range of 50-100 fpm.



Building outline with ventilation calculations and diagram.

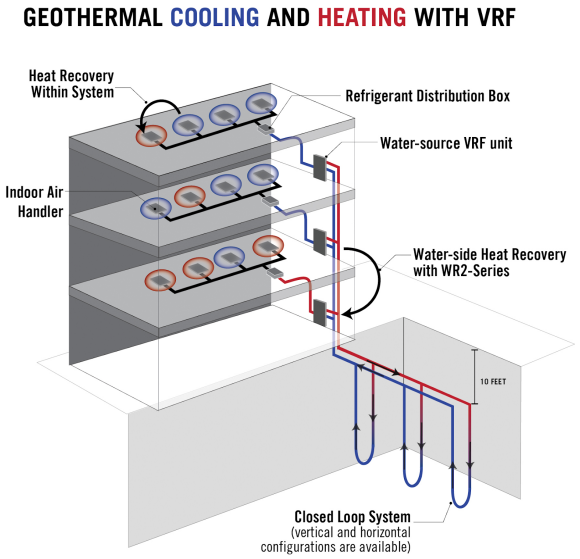
04. Heating & Cooling

Space heating and cooling for occupant comfort will be handled independently of the DOAS ventilation system described earlier. As diagrammed below, the heating and cooling system is designed as a distributed heat pump loop within the building. Each classroom will have its own designated terminal unit connected to a whole-building Variable Refrigerant Flow (VRF) loop. This system is space-efficient, allows localized temperature control and maintenance, and can increase energy efficiency.

The building's peak load, 1,159,000 million BTU/h of cooling and 434,000 BTU/h of heating, will require a total of 97 tons of cooling capacity and 36 tons of heating. Clearly, cooling Scarborough presents the more limiting factor, so efficiency should focus on cooling loads (IEER) instead of heating (COP). The equipment specified below has a 20.6 IEER and 5.25 COP, indicating exceptional energy efficiency for both heating and cooling.

According to the National Renewable Energy Laboratory (NREL)[9], geology of the Houston region provides favorable conditions for deep Enhanced Geothermal Systems (EGS), which also suggests very favorable conditions for shallow geothermal heat exchange. Taking advantage of this geology, the Scarborough Primary School will use closed-loop water-source heat pumps as both the heat source and heat sink for the indoor VRF loop. The geothermal exchanger will pump refrigerant through U-tubes located vertically in 4" bores with a contact slurry spaced at 20' apart, allowing the refrigerant to exchange heat with the ambient temperature of the ground.

Each of the three classroom wings of the school will have one 24-ton water-source VRF heat pump unit, and the secondary spaces -- offices, auditorium, etc -- will share a fourth 26-ton unit of the same make. Each classroom will have its own 2-ton[10] Mitsubishi CityMulti 4-way ceiling cassette as its terminal unit, allowing each room to be conditioned independently.



(source: ConstructionSpecifier.com)

Mitsubishi water-source VRF unit (source: mitsubishipro.com)

[9] *Geothermal Resource of the United States: Locations of Identified Hydrothermal Sites and Favorability of Deep Enhanced Geothermal Systems (EGS)*. The National Renewable Energy Laboratory at the US Department of Energy (2009). Map by Billy J. Roberts.

[10] 24 tons cooling capacity / 14 classrooms = 1.714 tons/classroom. The next lowest capacity for this model terminal unit is 1.5 ton capacity, not enough to meet the needs.

05. Water Systems

Indoor Water Systems

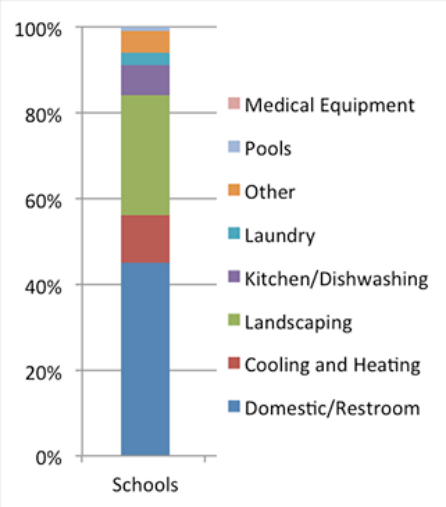
The International Plumbing Code (IPC) of 2018 stipulates indicate that the minimum code-compliant school design would only require 15 water closets, 15 lavatories, 8 drinking fountains, and one service sink. It is clearly evident that code-compliant quantities of fixtures is very insufficient. The Scarborough Primary School will instead surpass IPC minimum fixture quantities by a factor of (3), which should reduce waiting time and bathroom congestion. Interior water usage incorporates contemporary high-efficiency fixtures to reduce consumption by almost 60%; the calculations below demonstrate their impact.[11]

Occupants (students, teachers, staff)	825							
Full-Time School Days per Year	180							
[Type of Fixture]	**Female WC**	**Male WC**	**Urinal**	**Lav.**	**Shower**	**Fount.**	**Serv. Sink**	**Total**
Max. Student served per Unit (IPC 2018 Section 403)	50		0	50	0	100	1	
Min. # Per Building	17		0	17	0	9	1	
Scarborough Fixture Count	26	13	13	51	0	9	3	
LEED Fixture Use (use/day/occ)	0.5	0.1	0.4	0.5	0		0	
LEED Fixture Use (use/day/building)	206.25	41.25	165	206.25	0	0	0	
IPC 2018 Usage per Fixture (gpf)	1.6	1.6	1	2.2	2.5			
IPC 2018 Usage Estimate (gal/day)	330	66	165	453.75	0	0	0	1014.75
IPC 2018 Usage Estimate (gal/yr)	89100	17820	44550	122512	0	0	0	273982
High-Eff Alternative Usage (gpf)	1.2	1.2	0.125	0.5	2.5			
High-Eff. Usage Estimate (gal/day)	247.5	49.5	20.625	103	0	0	0	420.75
High-Eff. Usage Estimate (gal/yr)	66825	13365	5568.75	27843	0	0	0	113602.5
% Savings with Hi-Eff Fixtures	25%	25%	88%	77%				**59%**

[11] Fixture use per occupant data was pulled from the Leadership in Energy and Environmental Design (LEED) Approach to Flush and Flow Use calculations. Annual consumptions estimates calculated by multiplying (gal/day) * (full time school days) * (1.5), implying that usage rates are cut in half during non-school days.

Outdoor Water Systems

Based on the Water Use Intensity chart produced by the EPA Portfolio Manager, the average K-12 school building in America uses between 5 and 20 gal/ft^2 of conditioned floor area. With 74,000 ft^2 floorspace, the Scarborough Primary School would use between 370,000 and 1,480,000 gallons of potable water per year using this metric.



Water use data (source: EPA WaterSense)

With an average of roughly half of building potable water consumption being utilized for restrooms in American schools, we can assume that Scarborough Primary School would use around 350,000 gallons of water per year. Landscaping is another major user of potable water. At roughly 30% of annual potable water use, Scarborough Primary School is poised to consume around 105,000 gal/year on irrigation alone.

All together, estimated sanitation and irrigation water use totals around 218,000 gal/year. This water is commonly drawn from municipal potable water sources, but we propose utilizing rooftop rainwater capture and storage to drastically reduce the impact on potable water and also reduce stormwater runoff.

Average monthly precipitation in Houston on a 74,000 ft^2 ranges from 118,000 to 228,000 gallons per month. This high volume of water exceeds the roughly 18,000 gal/month needed to handle much of the potable water uses by a factor of 10. Because rainwater is so abundant in this region, it does not make sense to store a large volume of rainwater for dry seasons. Instead, strategies focus on rainwater retention onsite through permeable pavement, bioswales, and grading. Nevertheless, each of the three wings of the building would have its own 5,870-gallon storage tank, giving the building a total rainwater storage capacity of 17,616 gallons, which could supply the building with non-potable water for up to a month (depending on usage). These tanks would be located above the surface (because of the local frequency of flooding), would be 10’-0” in diameter by 10’ tall, and would include UV filtration to limit bacterial growth.

Water Heating

We may first begin by identifying which fixtures and uses will use hot water on a daily basis within the elementary school. Considering that the school is likely K-5, students will not be showering, which significantly cuts hot water usage. For the sake of calculation, we find that the only hot water usage in the school is from restroom sinks and kitchen sinks. From our above fixture sizing exercise, we know that high efficiency lavatories in the school will draw only 103 gal/day. Though actual hot water usage is likely to be less, we will say that 50% of lavatory water draws are hot water, amounting to 51.5 gal/day of hot water usage from lavatories.

To estimate kitchen hot water usage (most likely for lunch prep/cleanup) we will do a simple calculation based on EPA “End Uses of Water in Schools[12]”. The document suggests that 7% of a schools end water use is consumed in the kitchen and dish washing activities. We roughly estimate above that the Scarborough school will use 700,000 gallons of water per year, which suggests that our kitchen/dishwashing water usage comes in at 49,000 gallons per year. To remain consistent with prior assumptions, we will again assume that half of this water usage is hot water usage. We estimate that 24,500 gallons of hot water are used per year for kitchen/dishwashing.

School is only in session for 180 days of the year, which means that a kitchen would use on average 136 gallons of hot water per day. Total hot water usage per day in the school between the kitchen and lavatories amounts to 187.5 gallons per day.

IECC 2018 Table C404.5.1 places restrictions on the maximum allowable distance between a fixture and its supplying hot water source based on nominal supply pipe size. We will use ½” supply pipes for fixtures within the school which in turn dictates that our fixtures may not be more than 43’ away from the supply. Given the size of the school, we will place hot water heaters local to the restrooms and kitchen that use the hot water.

To calculate the size of each localized hot water tank, we must divide our hot water usage by location because realistically, we cannot assume that one hot water tank can supply the entire schools needs.

Location	Daily Hot Water Usage	Max. Hourly Dem.	Add'l Gal. Due to Losses	Req. Storage Vol.
Cafeteria	136	22.67	9.71	32.38
Restroom 1	25.75	4.29	1.84	6.13
Restroom 2	25.75	4.29	1.84	6.13

As we can see, our hourly required storage volumes for hot water, especially for restrooms, are extremely low. Since we are using solar energy to heat the water a majority of the time, we will specify tanks that will technically be oversized, though they are still small by traditional water heater standards. Each Rheem Professional classic electric water heater will be outfitted with the Helio-Flo element from Heliodyne’s solar water heating package. Please refer to Section 06: Renewable Energy Production for specifics on the Heliodyne system. When properly outfitted, the Rheem water heater will serve as a tank for the hot water that the Helio-Flo unit is producing. Only when there is not enough sunlight to produce hot water through the solar water system will the traditional electric element within the Rheem tank operate in a traditional sense.

For the cafeteria, a 50 gallon Rheem Professional Classic electric water heater will be used in combination with a Heliodyne solar water heater to provide hot water only for kitchen/dishwashing purposes. Note that the 50 gallon tank should be above the hourly demand of the kitchen as outlined above. This tank will be supplied by four Gobi 406 solar collectors in an open loop configuration, meaning that water from the tank is pulled directly through the solar collectors.

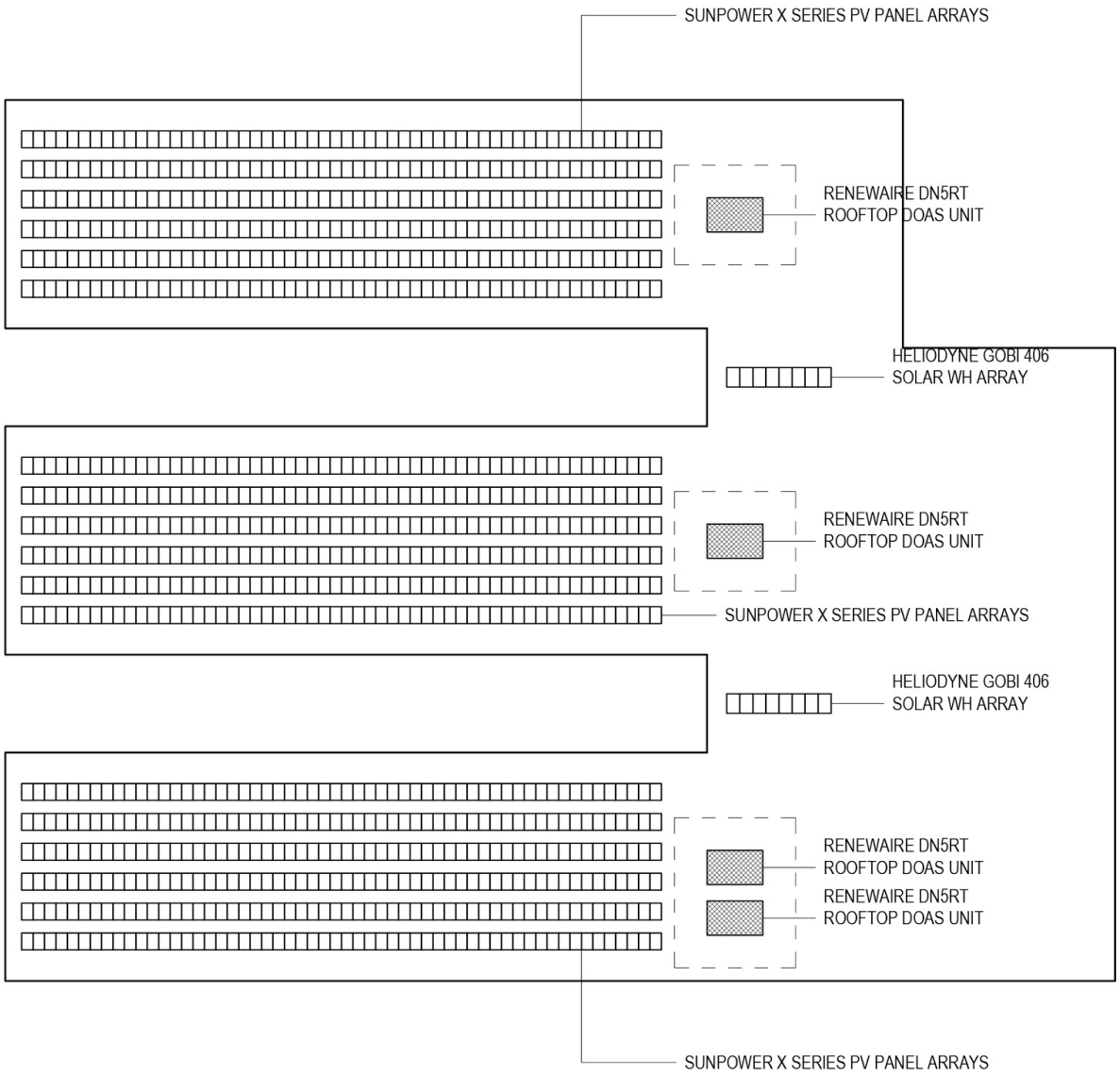
Similarly, each restroom outlined above will utilize a 20 gallon Rheem Professional Classic electric water heater in combination with Heliodyne solar collectors to provide hot water for only their local bathroom fixtures. The required storage volume for each bathroom is so low that even the smallest electric water heater available by Rheem is technically too large. Paired with each 20 gallon tank will be two Gobi 406 solar collectors which should have no problem providing ample hot water for the tank. Nonetheless, utilizing the sustainable energy of the sun to heat this water is a great option regardless of tank size. Given the restraints of having to provide localized hot water heaters at such a small scale, one could argue that the cost incurred by the solar collectors is not worth the energy savings. Rather, a point of use or small electric tankless water heater could be used, such as the Rheem RTEX-24. This demand controlled water heater could be easily installed local to each bathroom, and powered by the ample supply of solar generated electricity from the PV on the roof.

[12] Water use approximations taken from “Saving Water in Educational Facilities”, an EPA WaterSense article from 2012.

06. Renewable Energy Production

Photovoltaic Panel System

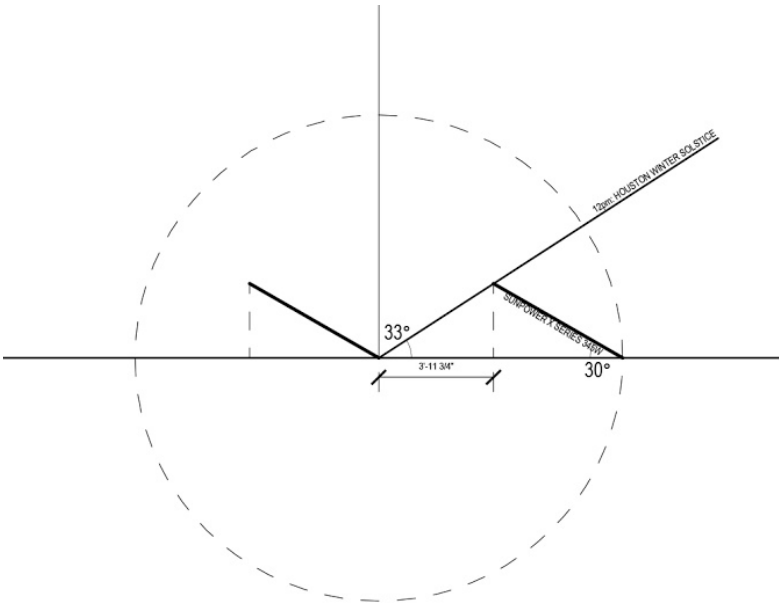
Scarborough Elementary School is located just outside of Houston, Texas with a latitude of 29.4°. The Houston climate enjoys sun a majority of the year, with a slight increase in cloud coverage during winter months, and clear skies during the summer. Considering the large roof area of the proposed school design, we will be taking advantage of a large photovoltaic array to capture sunlight.



Scarborough Elementary School Roof Mechanical and Electrical Plan

Without calculating our annual energy loads, we do not know our yearly energy usage to properly size a photovoltaic system. However, potential PV panels and support equipment have been specified to meet the peak cooling load which represents the largest possible load on the building throughout the year. It should be noted that

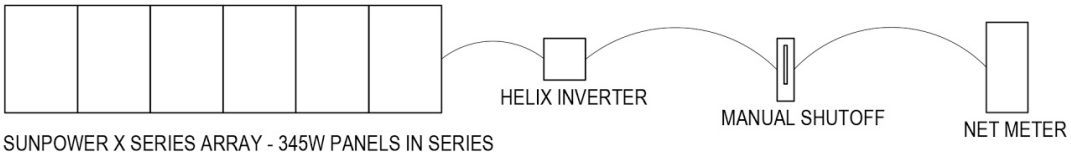
due to ample roof space, it is possible to comfortably fit over 1008 PV panels, but we have chosen this quantity as this is the number that can handle more than our peak cooling load while still being properly installed and spaced above the classroom areas. The panels shall be sourced from SunPower, a leading solar equipment manufacturer in the industry. Specifically, the SunPower X-Series[13] (SPR-X21-345) 345w panel will be utilized, boasting a 21.5% efficiency and 25 year warranty. Utilizing the SunPower X-series specifications, we have allocated space for up to a 348 kw array on the roof with proper service access and no panel/shadow overlap. The tilt angle of the panels was chosen to be 30° based on the general assumption that PV panels perform best when their angle matches the latitude of their installation location. Each row of panels faces due south, and is spaced 4’ from the previous row. This spacing distance was derived from finding the elevation of the sun at noon on the winter solstice, which represents the lowest sun elevation of the year. The winter solstice angle of 33° would create a 48” shadow when the sun casts against the mounted PV panel. This 48” spacing between rows also allows easy access to the panels for maintenance and cleaning which should be performed occasionally to ensure that the panels function at their highest possible efficiency. The above mentioned installation of 1008 panels would generate an estimated 512 kwh of electricity per year according to PV Watts[14], which should supply much more energy than the school needs.The final design will be a balance of energy production possibility, energy needs, and cost/payback.



Solar Panel Positioning Diagram

The support systems for the X-Series array will be a Helix Roof Single Tilt[15] mounting hardware, plug and play wiring with micro inverters integrated to optimize the efficiency of the array as a whole. The system comes with Energylink software that provides real time data and insight to help the school maintenance team manage the energy production and system over its lifetime. As the microinverter power stations that are included as part of the X-Series system invert produced energy from the array from DC to AC power, it will pass through a utility disconnect safety switch, and then into a central school electricity load center, featuring net electric metering.

[13] SunPower X-Series represent the top tier of leading PV panels available to consumers on the market today. Additionally, SunPower has an industry leading warranty and durable reputation.
[14] PVWatts, solar resource software developed by the National Renewable Energy Laboratory.
[15] SunPower proprietary PV array installation system optimized for quick installation & durability.



Sunpower X-Series System Layout

Net metering is available as an incentive in the state of Texas as outlined by the Database of State Incentives for Renewables & Efficiency (DSIRE)[16]. Specifically, Green Mountain Energy utility company offers net metering, however it does have its limitations. In 2019, Green Mountain Energy has limited its net metering system capacity for commercial properties to 50 kw. This suggests that in order to qualify for this net metering program, our school would need to have a smaller subsystem of 145 PV panels dedicated to the option of feeding electricity back into the grid if the scenario of excess energy generation arises.

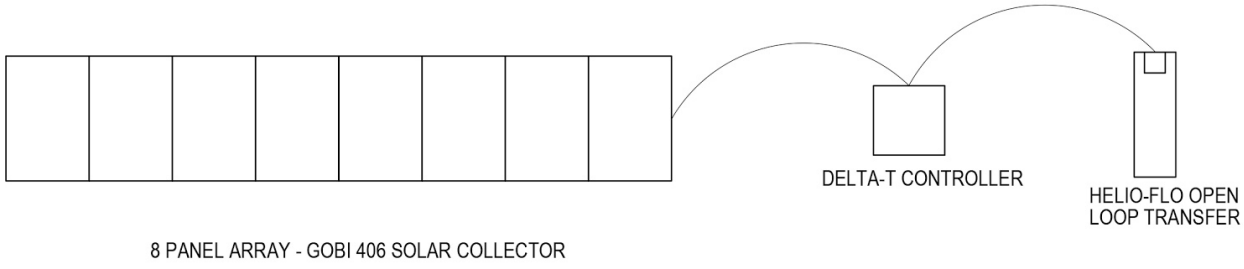
Electricity generated from the array can then at this point be distributed to lighting & plug loads, as well as to the on site Geothermal closed loop ground source heat pump system. During times of low energy demand, energy will be sold back to the grid to help the school save money.

Additional energy incentives include:

SCORE & CitySmart Programs for energy efficient products rebate
https://programs.dsireusa.org/system/program/detail/3833

Solar Hot Water Heater

The flat roof of the Scarborough Elementary School offers plenty of space on which to place solar collectors for hot water. Using solar water heaters on the roof to heat water for the school will help minimize the need for a traditional electric water heater. Heliodyne equipment will be utilized to collect solar energy and traditional water heaters will be augmented to accept the new solar system. Heliodyne's GOBI system[17] is different than a traditional water heater in that it utilizes an open loop system to heat the water. A HelioFlo unit is placed within a traditional electric element water heater. The solar collectors are connected directly to the HelioFlo unit, and pass water from the tank through the array to pick up solar heat, and then return it to the tank. A Delta-T Controller is included in the system to control the rate at which water is circulated to maintain appropriate hot water temperatures within the storage tank.



Example Heliodyne Solar Collector System Layout

[16] Operated by the N.C. Clean Energy Technology Center, Incentives database https://www.dsireusa.org/
[17] Heliodyne is an industry leading Solar Hot Water equipment manufacturer

Heliodyne's GOBI 406 solar collector utilizes a black sputter technology to collect heat. Heliodyne suggests that the 4' x 6' units should be used in a warm climate, such as Houston, and will be able to provide enough hot water for 5-7 people. Given the extremely low hot water demands of both the restrooms and the kitchen, the GOBI 406 units will suffice to provide enough hot water for the school.

Geothermal System

The geothermal closed loop ground source heat pump system has been chosen as a viable source of cooling and heating for the school due to it's ability to draw on the renewable heat sinking and sourcing capabilities of the earth. As previously described, Houston is located in a zone that is considered as an ideal location for drawing geothermal energy due to the underlying geology and ground water permeation. We have chosen a series of certified variable refrigerant flow ground loop heat pumps to be utilized with the general geothermal system that offer an EER of 20.6 and a COP of 5.25. Based on cooling peak load data, to meet our 96 ton need, we will be incorporating four vrf ground loop heat pumps as part of the mechanical equipment to heat and cool the school. Keep in mind, this system will be powered 100% by renewable solar energy that is generated on the roof of the school. The strength of this strategy is based in both the COP of the heat pumps, geology of Houston's ground, and source of the energy that is used to power the vrf heat pump system.

DSIRE website for net metering:
https://programs.dsireusa.org/system/program/detail/4176

07. Safety & Security

Safety and security in the school today begins with designing a secure building in a way that is also relaxed and appealing. The entrance of the elementary school is an essential focal point. The key is creation of a security vestibule that provides a degree of separation from the exterior world in terms of physical and visual barriers. The entrance should be clearly marked from the main street as a place that should be approached by students, faculty, police, and strangers. This obvious entrance should leave no questioning as to the location that one should access the school. Clear sightlines should be present between anyone walking up to the entrance, and the person inside who permits entrance. This suggests the presence of glass doors, and exterior and interior windows. Once inside the first set of doors, there should be a large ballistic picture window between the school receptionist and the entrant. This window should allow for a clear view of the entire vestibule and approach to it. The receptionist should be able to determine easily if the entrant is a potential threat to the safety of the school, and should be able to lock the second set of doors to prevent entry to the school if need be.

The shape of the Scarborough Elementary School has a “W” shape that creates deep wings of classrooms. On the exterior, a tall fence should be installed to prevent anyone from wandering into the courtyards between these wings. These courtyards should be havens for the students to inhabit and enjoy time outside without allowing unwanted visitors to enter the confined area with limited exit possibilities. This strategy would essentially shift the vulnerable perimeter from a W to a simple square, greatly reducing the possibly entry points to the school other than the main entrance.

All emergency exit doors shall be equipped with surveillance capabilities as well as forced entry alarms. Inside of the school zones should be defined by fire/barricade doors. These doors will remain open at all times except in the case of an emergency. The closing of the doors provides shielding and confines an assailant to one portion of the school.

The long wings of the school should be designed with wing walls, or with an offset every few classrooms to prevent a view of the entire wing of the school. This strategy provides protection in gatherings during an attack and can shield students from harm.

PROPOSED RENDERING DEPICTING A SECURE & VISIBLE SCHOOL ENTRANCE

08. Appendix

Submittals and specification sheets for all major equipment discussed in this report can be found in the following pages, in the order in which they appear in the report.

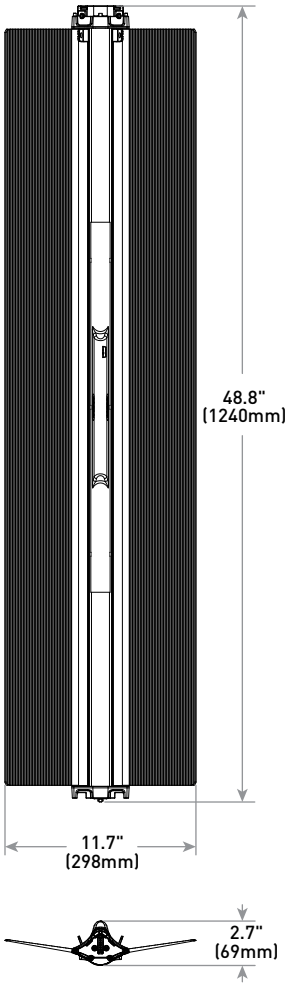
LN Series with Cree SmartCast® Technology

LN4™ Suspended Ambient LED Luminaire – Indirect/Direct – 4'

Product Description

The LN4™ suspended ambient luminaire delivers up to 115 lumens per watt utilizing Cree WaveMax® Technology. The 4' (1.2m) luminaire offers up to 3,700 lumens of Cree TrueWhite® Technology 90+ CRI in both 3500K and 4000K color temperatures. The LN Series features an architectural, sleek design with an indirect/direct lighting system that delivers superior ceiling uniformity and creates a comfortable visual environment. The LN4 luminaire with Cree SmartCast® Technology, Cree's intelligent light solution, provides extreme energy productivity and code compliance – all with installation that's so intuitive and simple, it just works.

Applications: Suspended ambient applications for new construction and upgrade



Performance Summary

Utilizes Cree TrueWhite® Technology
Utilizes Cree WaveMax® Technology
Initial Delivered Lumens: Up to 3,700 lumens (60% uplight, 40% downlight)
Input Power: 32 watts
Efficacy: Up to 115 LPW
CRI: 90+ CRI
CCT: 3500K, 4000K
Input Voltage: 120-277 VAC, 60Hz
Limited Warranty†: 10 years
Dimensions: L 48.8" (1240mm) x W 11.7" (298mm) x H 2.7" (69mm)
Controls: Cree SmartCast® Technology

† See http://lighting.cree.com/warranty for warranty terms

Accessories

Field-Installed

Mounting Hardware

LN-EC
- Power canopy and hanging hardware required to support a run. Order 1 LN-EC per run, regardless of number of fixtures in a run. For continuous rows, one LN-CK-0-AC accessory must be ordered for each additional 8' (2.4m) section added to run
- Includes 4.6" (117mm) Canopy w/32" (813mm) Aircraft Cable and Power Feed, 2.1" (53mm) Canopy w/32" (813mm) Aircraft Cable, and set of End Caps, one which accepts power feed

LN-CK-0-AC
- One required for each 8' (2.4m) section added to run beyond starter
- 2.1" (53mm) Canopy Kit w/32" (813mm) Aircraft Cable, no Power Feed

Emergency Options

Inverter

ELI-125W
- Emergency 125W inverter (ceiling installation)
- Can't be combined in continuous rows with non-emergency luminaires
- Powers continuous runs up to 12' at 100% output; maximum continuous run length (48' @ 120V; 136' @ 277V) at 5% output
- Minimum 90 minutes

Emergency Options Cont.

Emergency Relay
- For use with customer supplied generators/inverters

EL-SR-120
- 120V UL-924 Relay

EL-SR-277
- 277V UL-924 Relay

Luminaires w/Cree SmartCast® Technology

Cree SmartCast® Technology Configuration Tool

CCT-CWC-1
- One required per project when CMA control is selected

Cree SmartCast® Technology Face Plates‡

CFP-1-WH
- Matching Cree face plate, 1-gang, white

CFP-2-WH
- Matching Cree face plate, 2-gang, white

CFP-3-WH
- Matching Cree face plate, 3-gang, white

Cree SmartCast® Technology Wireless Dimmer/Switch‡

CWD-CWC-WH

Cree SmartCast® Technology Wireless Switch‡

CWS-CWC-WH

‡ Refer to the Wireless Dimmer SmartCast Control spec sheet for more details

Ordering Information

Example: LN4-34L-35K-CMA; must specify mounting hardware (see accessory table above)

LN4	34L		CMA	
Product	**Initial Delivered Lumens**	**CCT**	**Control**	**Voltage**
LN4	**34L** 3,400 lumens (35K) 3,700 lumens (40K)	**35K** 3500K **40K** 4000K	**CMA Cree SmartCast® Technology** - Integral motion and ambient sensors and wireless communication	**Blank** 120-277 Volt

Rev. Date: V4 11/27/2017

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

Product Specifications

CREE WAVEMAX® TECHNOLOGY

Featuring up to 90% optical efficiency and precise control, Cree WaveMax® Technology provides unmatched comfort and decreased LED source luminance by smoothly spreading brightness over a broader area. When integrated with luminous surfaces made of a polymer medium engineered with DiamondFacet™ optical elements, extremely high efficacy luminaires are the result – ultimately creating more visually comfortable and appealing environments while exceeding illumination performance.

CREE SMARTCAST® TECHNOLOGY

Cree SmartCast® Technology is the most intuitive and easiest to install intelligent light solution on the market. SmartCast Technology delivers up to 70% energy savings at up to half the cost of other solutions. Luminaires combine best-in-class light with onboard sensors and intelligence to deliver a better light experience. Extreme energy productivity, code compliance and a better light experience without any extra design, installation or setup work.

CREE TRUEWHITE® TECHNOLOGY

A revolutionary way to generate high-quality white light, Cree TrueWhite® Technology is a patented approach that delivers an exclusive combination of 90+ CRI, beautiful light characteristics and lifelong color consistency, all while maintaining high luminous efficacy – a true no compromise solution.

CONSTRUCTION & MATERIALS

- Constructed of durable lightweight aluminum
- Acrylic lens delivers a low-glare, diffused light distribution
- Maximum continuous run is up to 48' (14.6m) at 120V and 136' (41.5m) at 277V
- **Weight:** 9.4 lbs. (4.3kg)

OPTICAL SYSTEM

- Cree WaveMax® Technology optics enable more uniform ceiling and task illumination for a comfortable visual environment
- Inspired design targeted to deliver 60% directional uplight and 40% volumetric downlight to create a soft balanced light experience
- Optimal mounting is 18" (457mm) from ceiling

ELECTRICAL SYSTEM

- **Power Factor:** > 0.9
- **Input Power:** Stays constant over life
- **Input Voltage:** 120-277 VAC, 60Hz
- **Operating Temperature Range:** 0°C - +35°C (32°F - +95°F)
- **Total Harmonic Distortion:** < 20%

REGULATORY & VOLUNTARY QUALIFICATIONS

- cULus Listed
- Suitable for damp locations
- Designed for indoor use
- Meets FCC Part 15, Subpart B, Class A standards for conducted and radiated emissions
- DLC qualified. Please refer to https://www.designlights.org/search/ for most current information
- RoHS compliant. Consult factory for additional details

Cree SmartCast® Technology

INTEGRAL MOTION SENSOR

- Passive infrared (PIR)
- **Coverage Area:** 100 sq. ft. (30.5m^2) at 10' (3.0m) mounting height
- Not intended to be mounted higher than 12' (3.7m)
- **Operation:**
  - Grouped with a wall control: Luminaire will operate in vacancy mode (manual-on/auto-off)
  - Not grouped with a wall control: Luminaire will operate in occupancy mode (auto-on/auto-off)
- Luminaires operate at full intensity until OneButton™ Setup is initiated by the Cree Configuration Tool

INTEGRAL AMBIENT LIGHT SENSOR

- Sensor response matches response of human eye
- Not intended to be mounted higher than 12' (3.7m)
- Luminaires operate at full intensity until OneButton™ Setup is initiated by the Cree Configuration Tool
- Daylight harvesting calibration performed automatically during OneButton™ Setup

INTEGRAL WIRELESS COMMUNICATION

- 2.4GHz wireless mesh technology with AES 128-bit encryption
- Self assigns to quietest channel during OneButton™ Setup
- **Range:**
  - 30' (9.1m) in typical commercial applications
  - 300' (91.4m) open air without obstructions
- **Network:** 250 devices max.
- **Space:** 100 devices max. per group
- FCC certified
- IC certified

LUMINAIRE

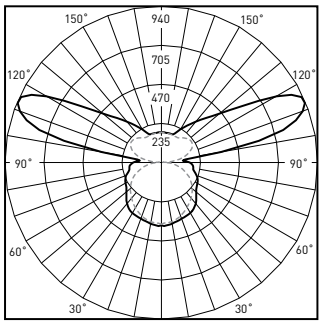
- Luminaires operate at full intensity until OneButton™ Setup is initiated by the Cree Configuration Tool
- 10 year power fail memory of settings

DEPLOYMENT

- Please refer to the SmartCast® Deployment Guide at https://www.creelink.com/exLink.asp?23613564OH88E44I39771048

Photometry

LN4-34L-35K-CMA BASED ON CESTL REPORT TEST #: PL07271-001B
Luminaire photometry has been conducted by a NVLAP accredited testing laboratory in accordance with IESNA LM-79-08. IESNA LM-79-08 specifies the entire luminaire as the source resulting in a luminaire efficiency of 100%



Coefficients Of Utilization – Zonal Cavity Method				
RC %:	**80**			
RW %:	**70**	**50**	**30**	**10**
RCR: 0	94	89	85	81
1	85	77	70	64
2	77	67	59	53
3	70	59	50	44
4	64	52	44	37
5	59	47	38	32
6	54	42	34	28
7	50	38	30	24
8	47	34	27	22
9	44	31	24	19
10	44	31	24	19

Effective Floor Cavity Reflectance: 20%

Zonal Lumen Summary			
Zone	Lumens	% Lamp	Luminaire
0-30	297	N/A	8.5%
0-40	500	N/A	14.4%
0-60	950	N/A	27.3%
0-90	1,472	N/A	42.3%
90-120	1,145	N/A	32.9%
90-150	1,849	N/A	53.2%
90-180	2,006	N/A	57.7%
0-180	3,478	N/A	100%

Average Luminance Table (cd/m²)				
	Horizontal Angle			
Vertical Angle		0°	45°	90°
	45°	1,068	1,195	1,197
	55°	1,118	1,270	1,279
	65°	1,195	1,409	1,617
	75°	1,302	1,868	2,246
	85°	1,685	4,329	6,199

Reference http://lighting.cree.com/products/indoor/suspended-ambient/ln-series for detailed photometric data

Electrical Data*				
System Watts 120-277V	Total Current (A)			
	120V	208V	240V	277V
32	0.27	0.15	0.13	0.12

* Electrical data at 25°C (77°F). Actual wattage may differ by +/- 10% when operating between 120-277V +/- 10%

LN Series Ambient Adjusted Lumen Maintenance[1]					
Ambient	Initial LMF	25K hr Projected[2] LMF	50K hr Projected[2] LMF	75K hr Calculated[3] LMF	100K hr Calculated[3] LMF
0°C (32°F)	1.07	1.06	1.05	1.05	1.04
5°C (41°F)	1.05	1.04	1.04	1.04	1.03
10°C (50°F)	1.04	1.03	1.03	1.02	1.02
15°C (59°F)	1.03	1.02	1.01	1.01	1.00
20°C (68°F)	1.01	1.00	1.00	1.00	0.99
25°C (77°F)	1.00	0.99	0.99	0.98	0.98
30°C (86°F)	0.99	0.98	0.97	0.97	0.96
35°C (95°F)	0.97	0.96	0.96	0.96	0.95

[1] Lumen maintenance values at 25°C are calculated per TM-21 based on LM-80 data and in-situ luminaire testing. Luminaire ambient temperature factors (LATF) have been applied to all lumen maintenance factors
[2] In accordance with IESNA TM-21-11, Projected Values represent interpolated value based on time durations that are within six times (6X) the IESNA LM-80-08 total test duration (in hours) for the device under testing ([DUT) i.e. the packaged LED chip)
[3] In accordance with IESNA TM-21-11, Calculated Values represent time durations that exceed six times (6X) the IESNA LM-80-08 total test duration (in hours) for the device under testing ([DUT) i.e. the packaged LED chip)

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

Occupancy/Vacancy Sensor

Design and Application Guide

LUTRON®

save energy with Lutron™ ®

Daylight Sensor

Design and Application Guide

LUTRON®

save energy with Lutron™ ®

DN 5RT

Dedicated Outdoor Air System
Standard

ROOFTOP UNIT
Dedicated Outside Air System
Unit with Energy Recovery

NEW

DN3IN, ERV + CC + HGRH + GH (BT) shown

Download specification at:
renewaire.com/specifications

ERV - Energy Recovery Ventilator
EH - Electric Heater
CC - Cooling Coil
HC - Heating Coil
GH - Gas Heat Module
HGRH - Hot Gas Reheat Coil
BT - Blow Thru
DT - Draw Thru

SPECIFICATIONS

Energy Recovery Type:
Static plate total energy transfer

Typical Airflow Range: 1,125-4,950 CFM

AHRI 1060 Certified Core:
One L-62-G5 and four L-125 G5

Standard Features:
EC Motors for both airstreams
Direct Drive backward inclined plenum
Higher ESP of up to 3" w.g. at 4,500 CFM
Integrated programmable controls
True 100% Face and bypass enthalpy based modulating economizer
Class 1 low leakage motorized isolation dampers
Stainless steel double-sloped drain pan with cooling option
1" Double wall foam injected 20 gauge galvanized panel construction with R6.5 insulation

Inlets/Outlets:
OA & RA Inlets: 60" x 16"
SA Outlet: 24" x 16"
EA Outlet: 20" x 32"

Filters:
Total qty. 10, MERV 8:
16" x 20" x 2"
Bypass Filters:
Total qty. 4, MERV 8:
16" x 20" x 2"

Unit Dimensions & Weight for 1" Cabinets:
205 1/8" L x 126 3/8" W x 92 1/8" H
2975-5500 lbs.

Max. Shipping Dimensions & Weight for 1" Cabinets (on pallet):
180" L x 101 1/2" W x 98" H
3225-5750 lbs.

Unit Dimensions & Weight for 2" Cabinets:
207 1/8" L x 128 3/8" W x 94 1/8" H
3100-5700 lbs.

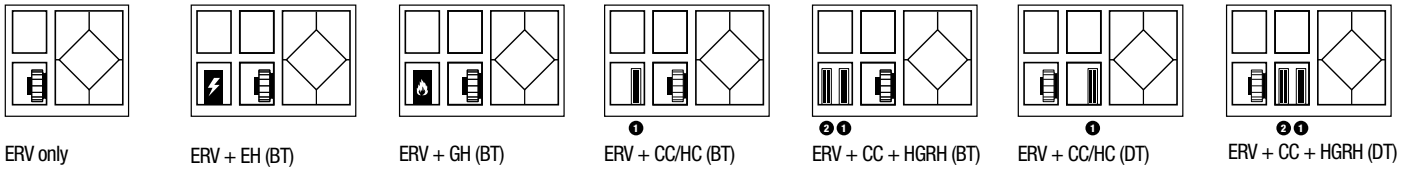
Max. Shipping Dimensions & Weight for 2" Cabinets (on pallet):
180" L x 101 1/2" W x 100" H
3350-5950 lbs.

Motor(s):
Qty. 4, Direct drive motorized impeller packages

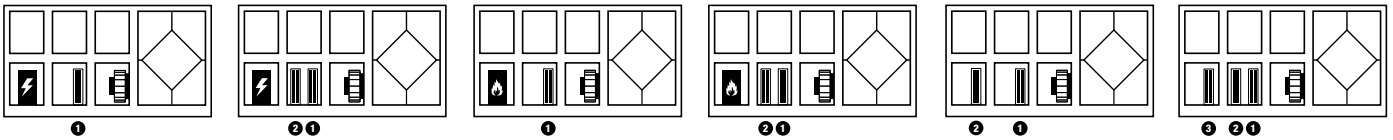
Options:
DX, heat pump, or chilled water cooling coil
Modulating hot gas reheat
Steam or hot water coil, gas heat module or electric heater
Onboard variable frequency drives (VFDs) - both airstreams
Fused disconnect
Spring isolators (VFDs only)
2" Double wall foam injected 20 gauge galvanized panel construction with R13.0 insulation
Exterior paint - grey, white, custom color
Salt spray - 2500 hour
BACNET factory activation
GFCI convenience outlet
Recirculation damper
Drain overflow switch
Mist eliminator
Electrofin coating for coils

Accessories:
Filters - MERV 13, 2" and 4" (shipped loose), MERV 14, 2" and 4" (shipped loose)
Additional filters available upon request
Roof curb - standard 14"
Hurricane or seismic rated curbs
Curb clip kit
Carbon dioxide sensor/control - wall mount (CO2-W), duct mount (CO2-D)
IAQ sensor - wall mount (IAQ-W), duct mount (IAQ-D)
Motion occupancy sensor/control - ceiling mount (MC-C), wall mount (MC-W)
Smoke detector
Room temperature and humidity sensor
Duct static pressure sensor with display to 10", without display 0-2"
Room pressure sensor with display to 1", without display 0-1"
Waterless trap negative pressure
Waterless trap positive pressure
Remote display

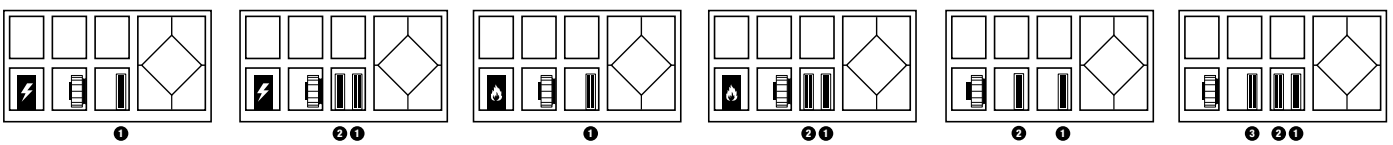
INTERNAL OPTIONS FOR HEATING AND COOLING



ERV only | ERV + EH (BT) | ERV + GH (BT) | ❶ ERV + CC/HC (BT) | ❷❶ ERV + CC + HGRH (BT) | ❶ ERV + CC/HC (DT) | ❷❶ ERV + CC + HGRH (DT)



❶ ERV + CC + EH (BT) | ❷❶ ERV + CC + HGRH + EH (BT) | ❶ ERV + CC + GH (BT) | ❷❶ ERV + CC + HGRH + GH (BT) | ❷ ❶ ERV + CC + HC (BT) | ❸ ❷❶ ERV + CC + HGRH + HC (BT)



❶ ERV + CC + EH (DT) | ❷❶ ERV + CC + HGRH + EH (DT) | ❶ ERV + CC + GH (DT) | ❷❶ ERV + CC + HGRH + GH (DT) | ❷ ❶ ERV + CC + HC (DT) | ❸ ❷❶ ERV + CC + HGRH + HC (DT)

Specifications may be subject to change without notice.

RenewAire Energy Recovery Ventilation

DN 5RT

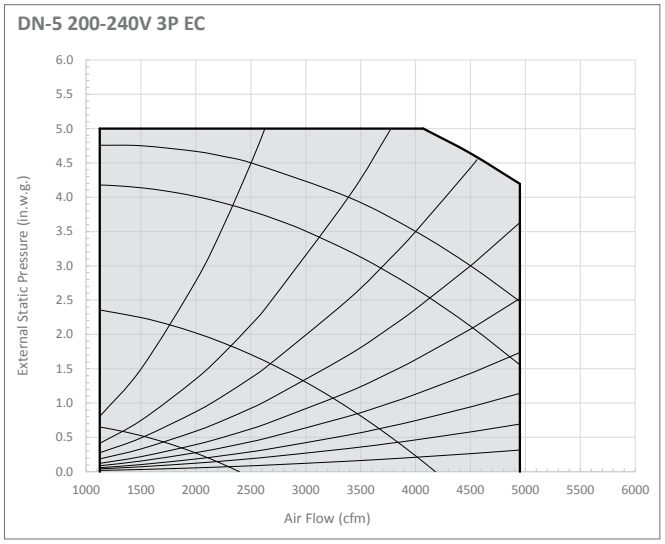
Dedicated Outdoor Air System
Standard

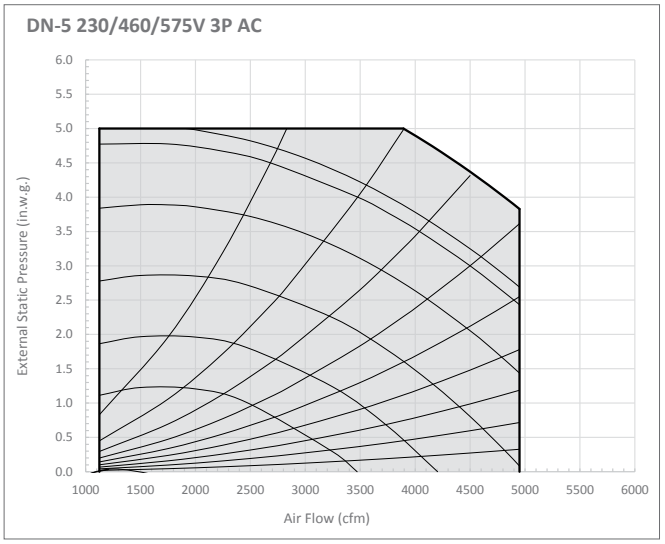
ELECTRICAL DATA

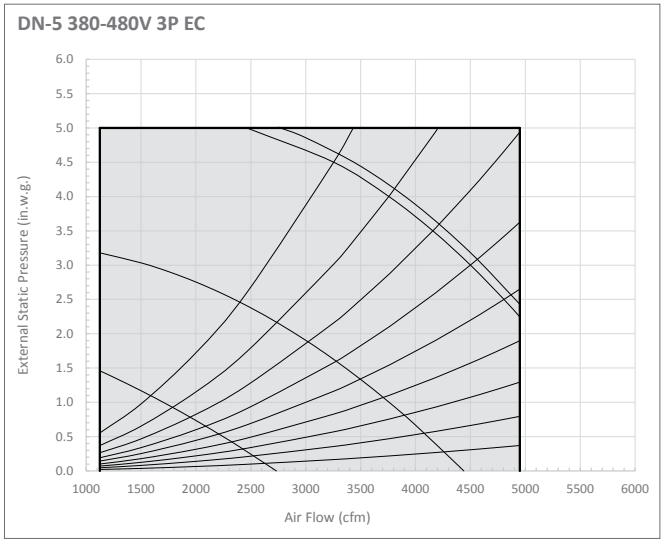
Electrical Specifications							
	Motor Qty/kW or HP	Volts	Frequency	Phase	Min. Cir. Amps.	Max. Overcurrent Protection Device	FLA per motor
EC	4 @ 2.70 kW ea.	200-240	50/60 Hz	Three	36.6	45	8.6-7.2
	4 @ 3.70 kW ea.	380-480	50/60 Hz	Three	25.5	30	6.0-4.6
VFD	4 @ 5HP ea.	208-230	50/60 Hz	Three	59.1	70	13.9-13.4/6.7
	4 @ 5HP ea.	460	50/60 Hz	Three	28.5	35	6.7
	4 @ 5HP ea.	575	50/60 Hz	Three	22.5	25	5.3

Note: Electrical data shown is for a standard unit without cooling and heating. Refer to cores.renewaire.com for project specific submittal for electrical data for the specific unit with all included options.

AIRFLOW PERFORMANCE







DN5RT Dedicated Outdoor Air System Standard 1" Cabinet

ABBREVIATIONS
EA: Exhaust Air to outside
OA: Outside Air intake
RA: Room Air to be exhausted
SA: Supply Air to inside

INSTALLATION ORIENTATION
Unit must be installed in orientation shown.

NOTE
1. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE ROUNDED TO THE NEAREST EIGHTH OF AN INCH.

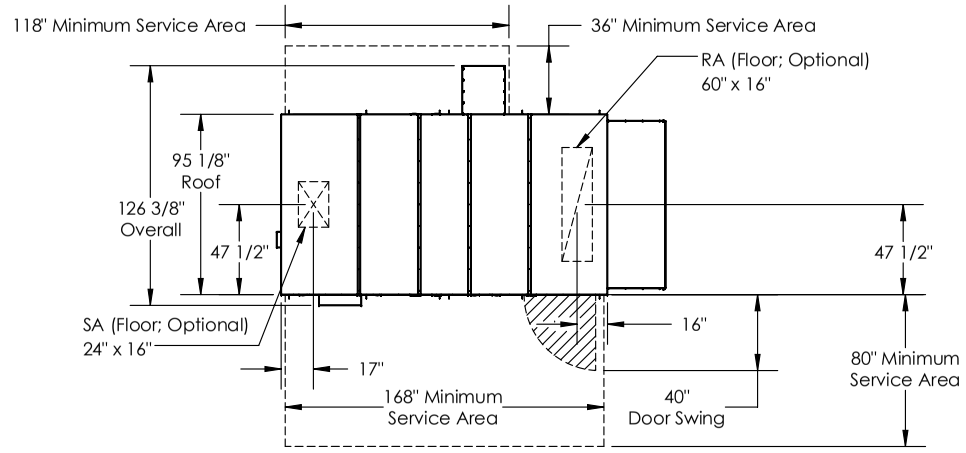
2. SPECIFICATIONS MAY BE SUBJECT TO CHANGE WITHOUT NOTICE.

3. FOR PIPE CONNECTION DETAILS REFER TO CORES OR UNIT SELECTION SUBMITTAL.

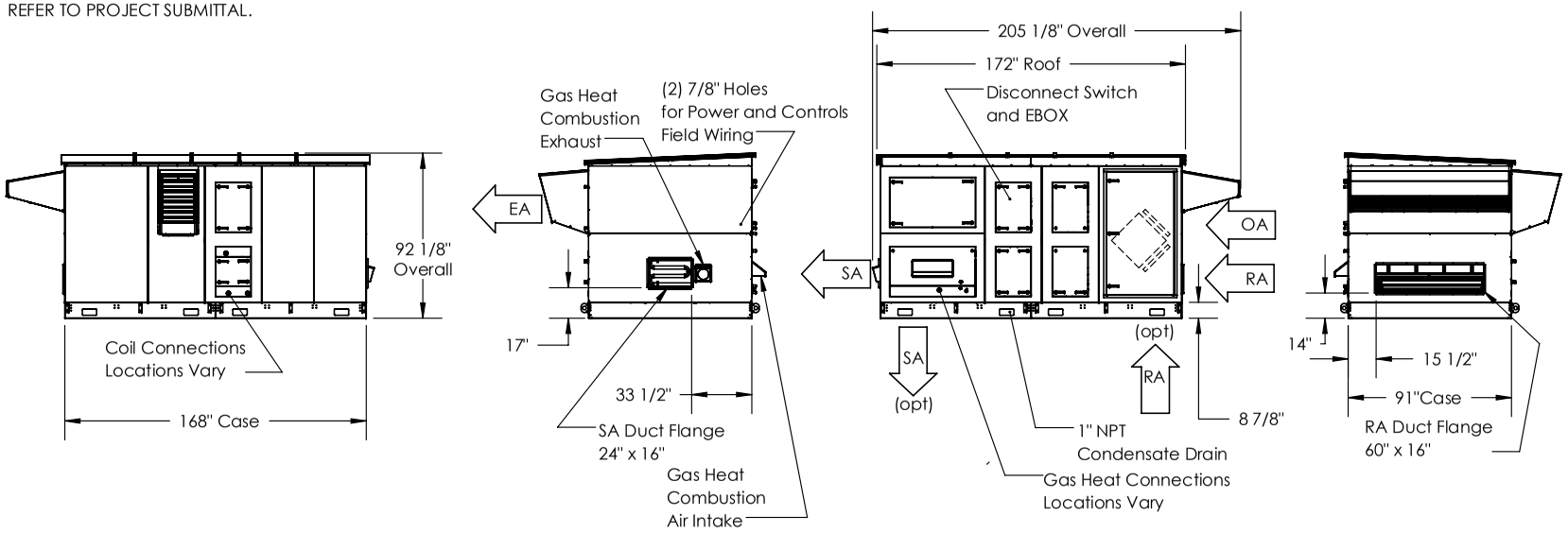
4. UNIT, UNIT DOORS, AND COILS CANNOT BE MIRRORED.

5. FOR CURB DETAILS REFER TO CURB DRAWING.

6. FOR PROJECT SPECIFIC DRAWINGS REFER TO PROJECT SUBMITTAL.



TOP VIEW

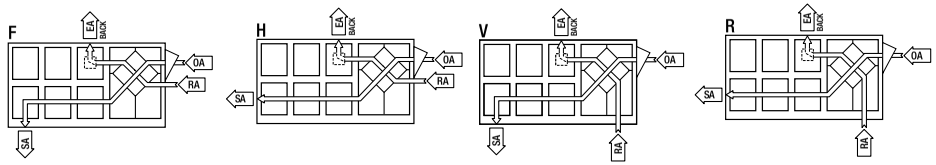


BACK VIEW LEFT VIEW FRONT VIEW RIGHT VIEW

Dimension drawings for the DN depict largest cabinet size available. Refer to CORES.RenewAire.com for project specific unit drawings.

AIRFLOW ORIENTATION

Available as shown:



UNIT MOUNTING & APPLICATION

Must be mounted as shown. Airstreams can not be switched. Duct configuration is field convertible.

ABBREVIATIONS
EA: Exhaust Air to outside
OA: Outside Air intake
RA: Room Air to be exhausted
SA: Supply Air to inside

INSTALLATION ORIENTATION
Unit must be installed in orientation shown.

NOTE
1. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE ROUNDED TO THE NEAREST EIGHTH OF AN INCH.

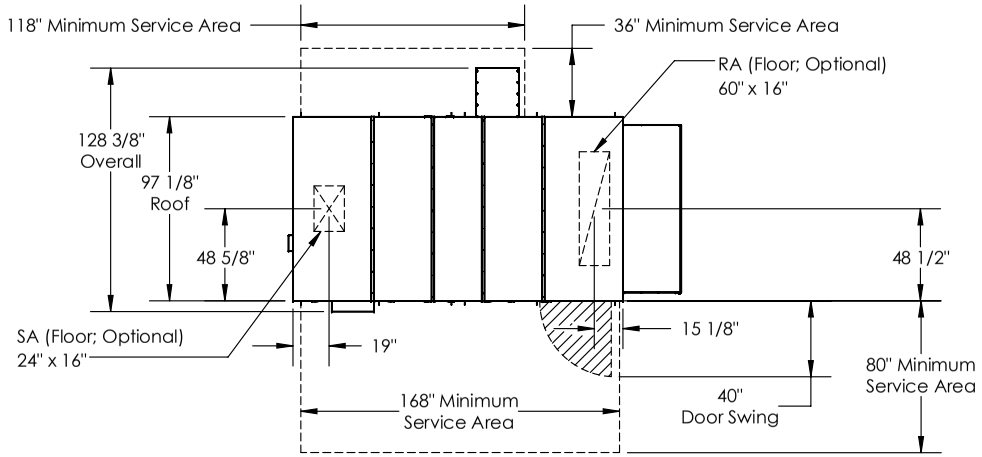
2. SPECIFICATIONS MAY BE SUBJECT TO CHANGE WITHOUT NOTICE.

3. FOR PIPE CONNECTION DETAILS REFER TO CORES OR UNIT SELECTION SUBMITTAL.

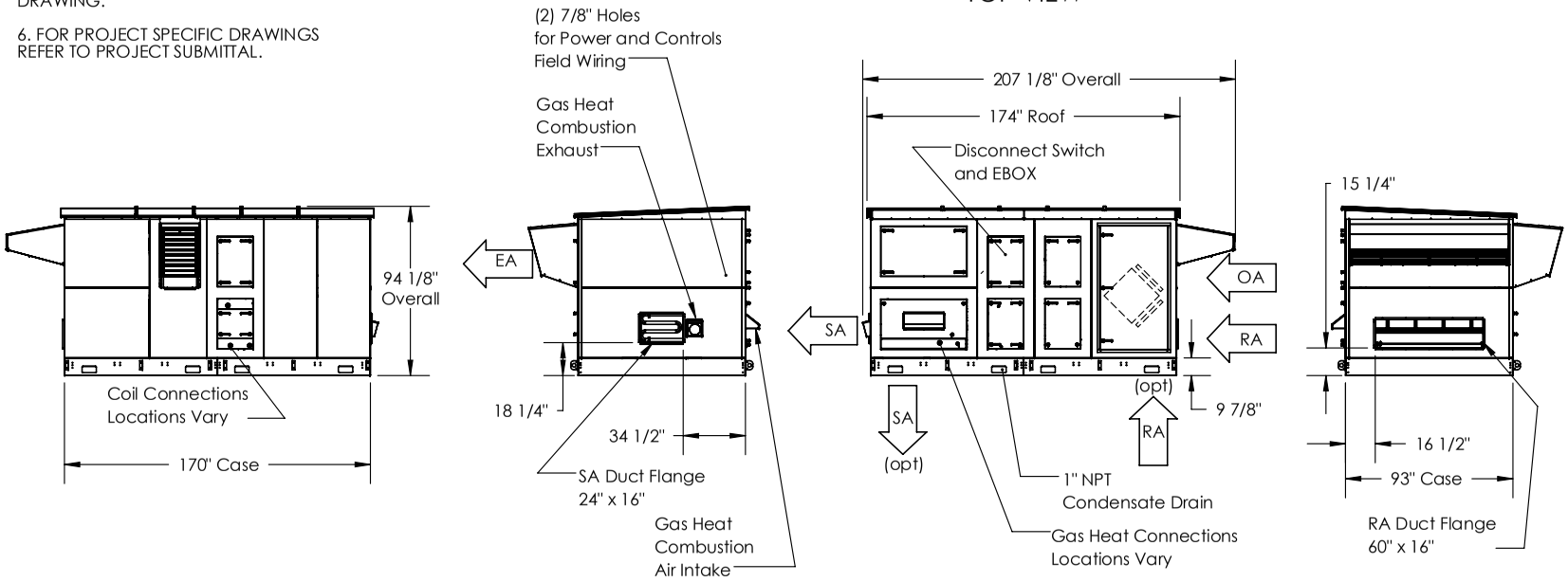
4. UNIT, UNIT DOORS, AND COILS CANNOT BE MIRRORED.

5. FOR CURB DETAILS REFER TO CURB DRAWING.

6. FOR PROJECT SPECIFIC DRAWINGS REFER TO PROJECT SUBMITTAL.



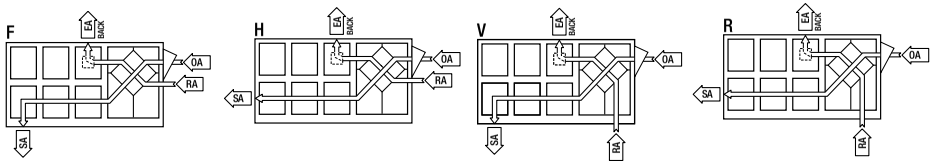
TOP VIEW



BACK VIEW LEFT VIEW FRONT VIEW RIGHT VIEW

Dimension drawings for the DN depict largest cabinet size available. Refer to CORES.RenewAire.com for project specific unit drawings.

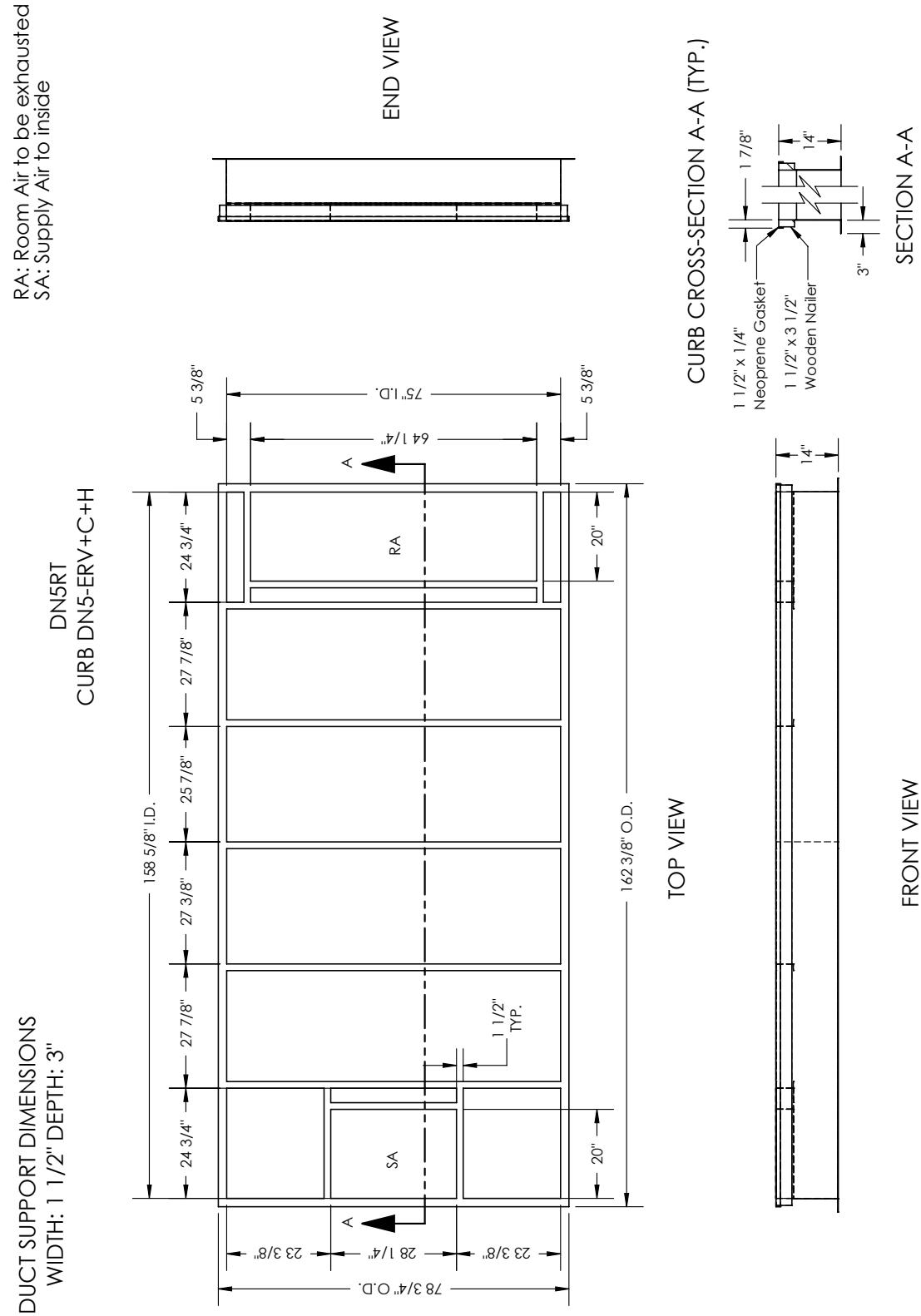
AIRFLOW ORIENTATION
Available as shown:



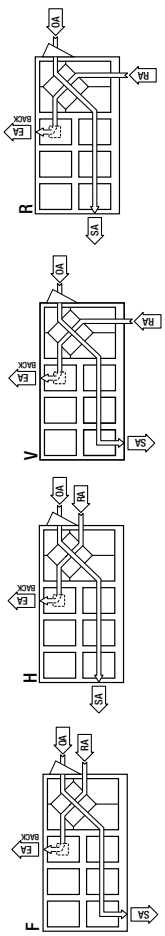
UNIT MOUNTING & APPLICATION
Must be mounted as shown. Airstreams can not be switched. Duct configuration is field convertible.

DN5RT Dedicated Outdoor Air System Curbs

Dimension drawings for the DN depict largest cabinet size available.
Refer to CORES.RenewAire.com for project specific unit drawings.



UNIT MOUNTING & APPLICATION
This universal DN Series curb can be used in conjunction with RTF, RTH, RTV and RTR models.



AIRFLOW ORIENTATION
Available as shown:

RenewAire Energy Recovery Ventilation

CITYMULTI®

MODEL: 24-TON PQRY-P288YSLMU-A1

(CONSISTS OF TWO PQRY-P144YLMU-A1 AND ONE CMY-Q200CBK TWINNING KIT)

MITSUBISHI ELECTRIC

Job Name:	
System Reference:	Date:

MODULAR WATER-SOURCE VRF HEAT PUMP SYSTEM

FEATURES

- Single modules up to 20 tons with the ability to combine single modules for systems up to 30 tons
- 208/230V, 3-Phase, 60Hz and 460V, 3-Phase, 60Hz options
- Designed for closed water loops
- Dual heat recovery - from water loop and refrigerant circuit
- 0-10V output signal to modulate water flow for compliance with energy codes
- Features Variable Evaporating Temperature (VET) technology, which enables the outdoor unit to raise the target evaporation temperature based on the difference between set point and return air temperature, saving energy.
- Water flow can be stopped while the unit is in a thermo-off state,saving on pump energy consumption. For twinned systems, both modules must be thermo-off to stop water flow.
- Enhanced water-side heat exchanger design for improved efficiency and reduced risk of clogging
- Self-cooling cabinet design
- Inlet water temperature range: 23-113° F[1]
- Max. Total Refrigerant Piping Length: up to 2,460 feet based on model
- Connects to CITY MULTI® indoor units; controlled via CITY MULTI® Controls Network (CMCN)
- External finish: Acrylic-painted steel
- Stack multiple units on a field-supplied rack to take advantage of vertical space when available
- Extended 10-year parts and compressor warranty available

ACCESSORIES

- ■ Twinning Kit (required) (CMY-Q200CBK)
- □ Joint Kit (for details see Pipe Accessories Submittal)
- □ BC Controller (for details see BC Controller Submittal)

[1]23°F EWT (Entering water temperature) is possible with glycol.

SPECIFICATIONS: PQRY-P288YSLMU-A1

Specifications			System
Unit Type			**PQRY-P288YSLMU-A1**
Nominal Cooling Capacity (460V)		Btu/h	288,000
Nominal Heating Capacity (460V)		Btu/h	323,000
Total Net weight of Modules		Lbs. (kg)	1,016 (460)
Electrical Power Requirements	Voltage, Phase, Hertz		460V, 3-phase, 60Hz
Piping Diameter (Brazed)			
From Twinning Kit to First Joint or Header (In. / mm)	Liquid pipe	In. (mm)	1-1/8 (28.58)
	Gas pipe	In. (mm)	1-3/8 (34.93)
Max. Total Refrigerant Line Length		Ft.	2,460
Max. Refrigerant Line Length (Between ODU & IDU)		Ft.	541
Max. Control Wiring Length		Ft.	1,640
Indoor Unit	Total capacity		50~150% of heat source unit capacity
	Model/Quantity		P06~P96/2~50 (Connectable branch pipe number is max. 48.)
Sound pressure level (measured in anechoic room)		dB(A)	57
Compressor Operating Range			9% - 100%
AHRI Ratings (Ducted/Non-Ducted)	EER		11.4 / 13.7
	IEER		18.5 / 20.6
	COP		4.90 / 5.25
	SCHE		20.1 / 19.0

Refer to Module Data [1]

Specifications			Module 1[1]	Module 2[1]
Unit Type			**PQRY-P144YLMU-A1**	**PQRY-P144YLMU-A1**
Nominal Cooling Capacity (460V)		Btu/h	144,000	144,000
Nominal Heating Capacity (460V)		Btu/h	160,000	160,000
Operating Temperature Range	Cooling (Indoor)	W.B.	59~75°F (15~24°C)	59~75°F (15~24°C)
	Heating (Indoor)	D.B.	59~81° F (15~27°C)	59~81° F (15~27°C)
Operating Water Temperature Range	Cooling/Heating	°F (°C)	[2] 50~113°F (10~45°C)	[2] 50~113°F (10~45°C)
External dimension H x W x D		In.	PQRY-P144YLMU-A1	57-1/8 x 34-11/16 x 21-11/16
		mm	1,450 x 880 x 550	1,450 x 880 x 550
Net weight		lbs. (kg)	508 (230)	508 (230)
External finish			Galvanized steel sheets	Galvanized steel sheets
Electrical Power Requirements	Voltage, Phase, Hertz		460V, 3-phase, 60Hz	460V, 3-phase, 60Hz
Minimum Circuit Ampacity		A	16	16
Maximum Overcurrent Protection		A	25	25
Circulating Water (quality must meet regulations)				

SPECIFICATIONS: PQRY-P288YSLMU-A1

Specifications			Module 1[1]	Module 2[1]
Unit Type			PQRY-P144YLMU-A1	PQRY-P144YLMU-A1
Flow Rate		G/min (gpm)	31.7	31.7
		L/s	2	2
Pressure Drop		Ft.	14.7	14.7
		psi	6.38	6.38
Operation Volume Range		G/min (gpm)	19.8 ~ 50.9	19.8 ~ 50.9
		L/m	70 ~ 193	70 ~ 193
Maximum Water Pressure		MPa	2	2
		psi	290	290
Water-source Connection for Inlet and Outlet		In.	1-1/2 NPT	1-1/2 NPT
Piping Diameter (Brazed)				
From Modules to Twinning Kit [In.(mm)]	Liquid (High Pressure)	In. (mm)	7/8 (22.2)	7/8 (22.2)
	Gas (Low Pressure)	In. (mm)	1-1/8 (28.58)	1-1/8 (28.58)
Sound pressure level (measured in anechoic room)		dB(A)	54	54
Compressor Type x Quantity			Inverter scroll hermetic compressor x 1	Inverter scroll hermetic compressor x 1
Motor output		kW	9.5	9.5
Lubricant			MEL32	MEL32
Refrigerant			R410A x 11 lbs. + 1 oz. (5.0 kg)	R410A x 13 lbs. + 4 oz. (6.0 kg)
Protection Devices	High pressure protection		High pressure sensor, High pressure switch at 4.15 MPa (601 psi)	High pressure sensor, High pressure switch at 4.15 MPa (601 psi)
	Inverter circuit		Over-heat protection, Over-current protection	Over-heat protection, Over-current protection
	Compressor		Over-heat protection	Over-heat protection

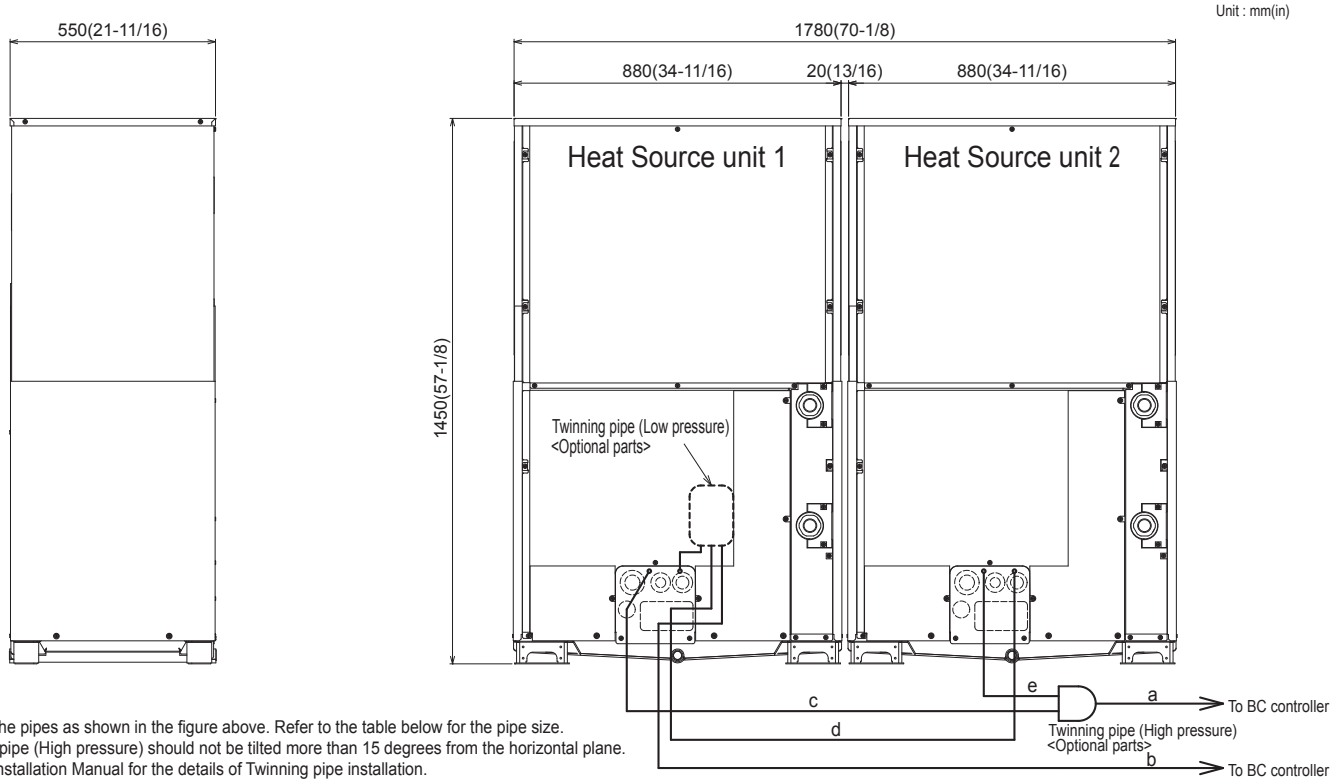
[1] Each individual module requires a separate electrical connection. Reference electrical data for each individual module.

[2] 23°F EWT (Entering water temperature) is possible with glycol.

Notes:

DIMENSIONS: PQRY-P288YSLMU-A1

Unit : mm(in)



Note 1.Connect the pipes as shown in the figure above. Refer to the table below for the pipe size.
2.Twinning pipe (High pressure) should not be tilted more than 15 degrees from the horizontal plane.
3.See the Installation Manual for the details of Twinning pipe installation.
4.Only use the Twinning pipe by Mitsubishi (optional parts).

Twinning pipe connection size

Package unit name			PQRY-P288YSLMU-A1	PQRY-P312YSLMU-A1	PQRY-P336YSLMU-A1
Component unit name	Heat Source unit 1		PQRY-P144YLMU-A1	PQRY-P168YLMU-A1	PQRY-P168YLMU-A1
	Heat Source unit 2		PQRY-P144YLMU-A1	PQRY-P144YLMU-A1	PQRY-P168YLMU-A1
Twinning pipe Kit(optional parts)			CMY-Q200CBK		
BC controller~Twinning pipe	High pressure	a	ø28.58(1-1/8)		
	Low pressure	b	ø34.93(1-3/8)		ø41.28(1-5/8)

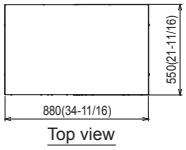
	Unit model	High pressure	Low pressure
		c or e	d
Twinning pipe~Heat source unit	P144	ø22.2(7/8)	ø28.58(1-1/8)
	P168		

DIMENSIONS: PQRY-P144YLMU-A1

Note1.Seal around the water piping, the refrigerant piping, the power supply, and the control wiring and plug unused knockout holes with putty, etc., to prevent moisture or dirt from entering cabinet.
Note2.At the time of product shipment, the front side piping serves as the local drainage connection.
When connecting on the rear side, please remove the rear side plug sealing corks, and attach on the front side. Ensure there is no leak in piping system once connected.
Note3.See Fig. A and Fig. B for service clearances.
Note4.If piping is installed in front of the unit, provide clearances as shown in Fig. A and Fig. B.
Note5.Environmental condition for installation; -20~40°C(DB) (-4~104°F) for indoor installation.
Note6.In case the temperature around the heat source unit has possibility to drop under 0°C(32°F), be careful for the following point to prevent the pipe burst by the water pipe freeze-up.
•Circulate the water all the time even if heat source unit is not in operation and provide glycol for freeze protection.
•Drain the water from inside of the heat source unit when the heat source unit will not operate for a long term.
Note7.Ensure that the drain piping is downward with a pitch of more than 1/100.
Note8.At brazing of pipes, wrap the refrigerant service valve with wet cloth and keep the temperature of refrigerant service valve under 120°C(248°F).

Unit : mm(in)

<Accessories>
- Refrigerant (high pressure) conn. pipe····· 1pc. (P144/P168/P192 ; Packaged in the accessory kit)
- Refrigerant (low pressure) conn. pipe····· 1pc. (P144/P168/P192 ; Packaged in the accessory kit)
- Water stopper····· 1pc. (P144/P168/P192 ; Packaged in the accessory kit)
- Sealing material for water stopper····· 1pc. (P144/P168/P192 ; Packaged in the accessory kit)
- Sealing material for field piping (high pressure, low pressure)····· 1pc. each (P144/P168/P192 ; Packaged in the accessory kit)
- Sealing material for drain socket····· 1pc. (P144/P168/P192 ; Packaged in the accessory kit)
- Pipe cover for low pressure····· 1pc. (P144/P168/P192 ; Packaged in the accessory kit)
- Sealing material for base leg (two types)····· 4pcs. each (P144/P168/P192 ; Packaged in the accessory kit)
- Sealing material for panel····· 1pc. (P144/P168/P192 ; Packaged in the accessory kit)



Top view

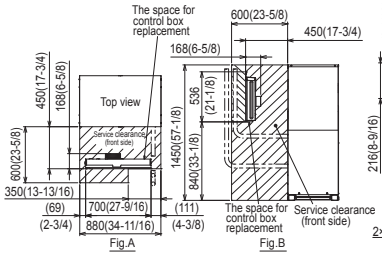
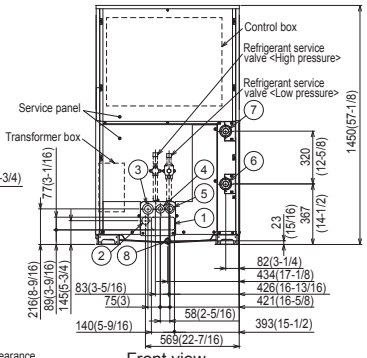
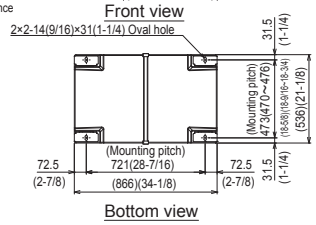


Fig.A Fig.B



Front view



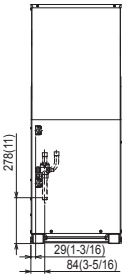
Bottom view

Connecting pipe specifications

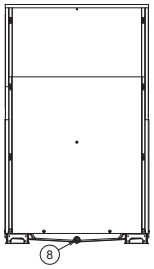
Model	Diameter			
	Refrigerant pipe		Service valve	
	High pressure	Low pressure	High pressure	Low pressure
PQRY-P144YLMU-A1	ø22.2 Brazed (7/8) *1	ø28.58 Brazed (1-1/8) *1	ø25.4 (1)	ø28.58 (1-1/8)
PQRY-P168YLMU-A1				
PQRY-P192YLMU-A1				

*1.Connect by using the connecting pipes that are supplied.

Top of unit casing not suitable for supporting system modules stacked above - field framing required for stacking modules of additional systems



Right side view



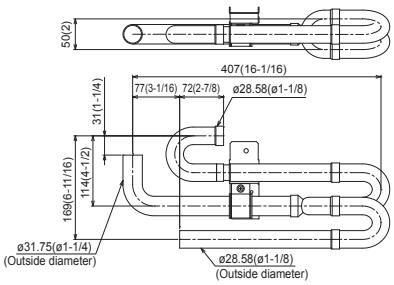
Back view

NO.	Usage		Specifications
①	For pipes	Front through hole	140 × 77 Knockout hole (5-9/16) (3-1/16)
②		Front through hole (Uses when twinning kit (optional parts) is mounted.)	ø45 Knockout hole (1-13/16)
③	For wires	Front through hole	ø62.7 or ø34.5 Knockout hole (2-1/2) (1-3/8)
④		Front through hole	ø43.7 or ø22.2 Knockout hole (1-3/4) (7/8)
⑤	For transmission cables	Front through hole	ø34 Knockout hole (1-3/8)
⑥	Water pipe	inlet	NPT1-1/2 Screw
⑦		outlet	NPT1-1/2 Screw
⑧	Drain pipe	Rc3/4 Screw	

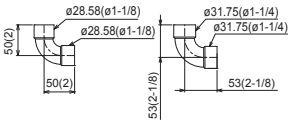
DIMENSIONS: CMY-Q200CBK (TWINNING KIT)

Unit : mm(in)

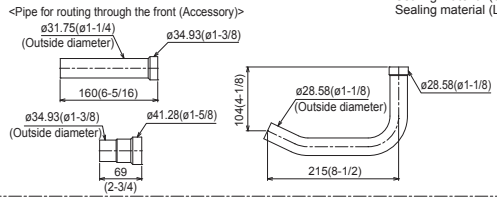
Low-pressure pipe twinning kit



<Elbow pipe(Accessory)>



<Pipe for routing through the front (Accessory)>

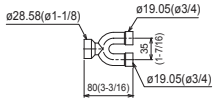


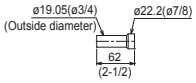
<Accessory>

Fixing screw	1
Insulation cover	1
Pipe cover (75mm(3) Length)	1
Pipe cover (360mm(14-3/16) Length)	1
Pipe cover (70mm(2-13/16) Length)	1
Pipe cover (130mm(5-1/8) Length)	1
Pipe cover (100mm(3-15/16) Length)	1
Pipe cover (160mm(6-5/16) Length)	1
Cable tie	2
Water stopper	1
Sealing material (Small)	1
Sealing material (Large)	1

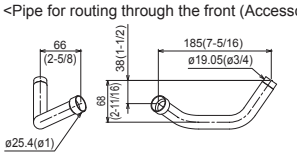
High-pressure twinning pipe

<Deformed pipe(Accessory)>

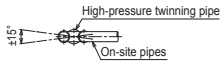




<Pipe for routing through the front (Accessory)>



Note 1. Refer to the figure below for the installation position of the high-pressure twinning pipe.



Inclination tolerance of the high-pressure twinning pipe is ±15° relative to the ground.

2. Pipe diameter is indicated by inside diameter.

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Variable Refrigerant Flow (VRF) Multi-Split AC and HP AHRI Standard 1230

c ETL LISTED US Intertek

FORM# PQRY-P288YSLMU-A1 - 201805

Model: PLFY-P24NBMU-ER2

Job Name:	
System Reference:	Date:

GENERAL FEATURES

- Dual set point functionality
- Lightweight, low-profile compact design
- Customizable wide airflow pattern with adjustable vane control through unit controller
- Auto wave airflow in heating mode—independent cycling of horizontal and vertical vane positions for even heat distribution
- Four-speed fan settings
- Auto fan
- Corner-pocket design for simplified installation
- Built-in condensate lift mechanism; lifts to 33-7/16 in.
- Ventilation air intake supported

Options

□ Air Outlet Shutter Plate (2 pieces)…….PAC-SH51SP-E
□ High-Efficiency Filter (MERV 10)…….PAC-SH59KF-E
□ Multi-function Casement……PAC-SH53TM-E
□ i-see Sensor Corner Panel……PAC-SA1ME-E
□ Wireless Signal Receiver……PAR-SA9FA-E
□ CN24 Relay Kit……CN24RELAY-KIT-CM3

SPECIFICATIONS

Capacity*

Cooling……24,000 Btu/h
Heating……27,000 Btu/h

* Cooling / Heating capacity indicated at the maximum value at operation under the following conditions:
Cooling | Indoor: 80° F (27° C) DB / 67° F (19° C) WB, Outdoor 95° F (35° C) DB
Heating | Indoor: 70° F (21° C) DB, Outdoor 47° F (8° C) DB / 43° F (6° C) WB

Power

Power Source……208 / 230V, 1-phase, 60Hz

Power Consumption

Cooling……0.06 kW
Heating……0.05 kW

Current

Cooling……0.43 A
Heating……0.36 A

Minimum Circuit Ampacity (MCA)……0.64 A
Maximum Overcurrent Protection (MOCP) Fuse……15 A

External Finish…Grille (White; Munsell No. 6.4Y 8.9 / 0.4)

External Dimensions

Inches……10-3/16 h x 33-1/8 w x 33-1/8 d
mm……258 h x 840 w x 840 d

Grille (PLP-40BAU):

Inches……1-3/8 h x 37-7/16 w x 37-7/16 d
mm……35 h x 950 w x 950 d

Net Weight

Unit……51 lbs. / 23 kg
Grille……13 lbs. / 6 kg

Coil Type……Cross Fin (Aluminum Plate Fin and Copper Tube)

Fan

Type x Quantity……Turbo Fan x 1
Airflow Rate (Low - Mid 1 - Mid 2 - High)….530-565-636-706 CFM
Motor Type……DC Motor

Standard Air Filter……Polypropylene Honeycomb

Refrigerant Piping Dimensions

Liquid (High Pressure)……3/8" / 9.52 mm Flare
Gas (Low Pressure)……5/8" / 15.88 mm Flare

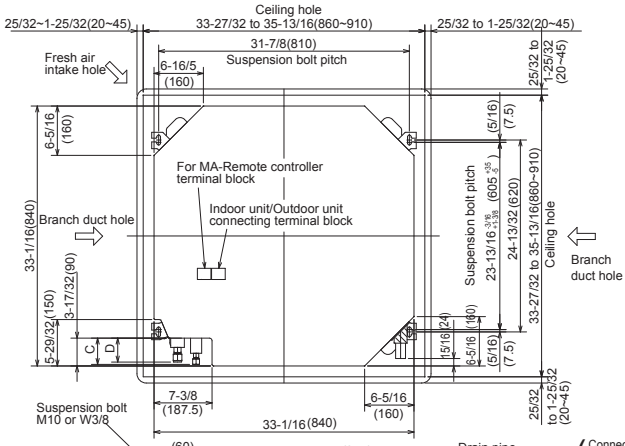
Drainpipe Dimension……O.D. 1-1/4" / 32 mm

Sound Pressure Level

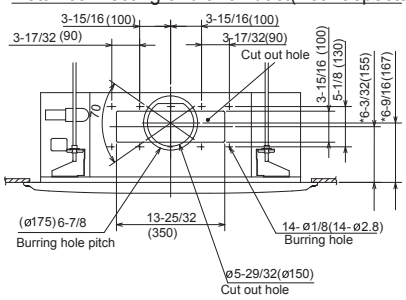
(Low - Mid 1 - Mid 2 - High)……28 - 30 - 32 - 34 dB(A)

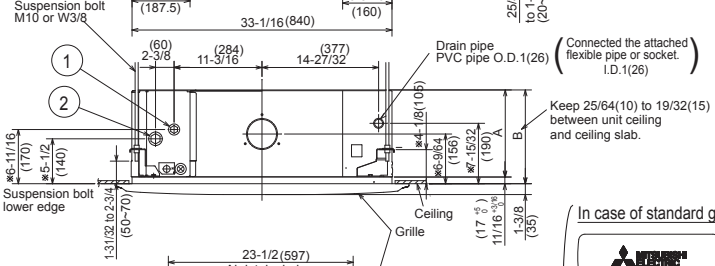
Model: PLFY-P24NBMU-ER2 – DIMENSIONS

Unit: mm (in.)

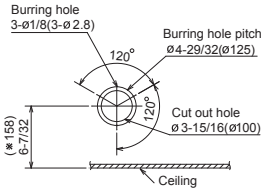


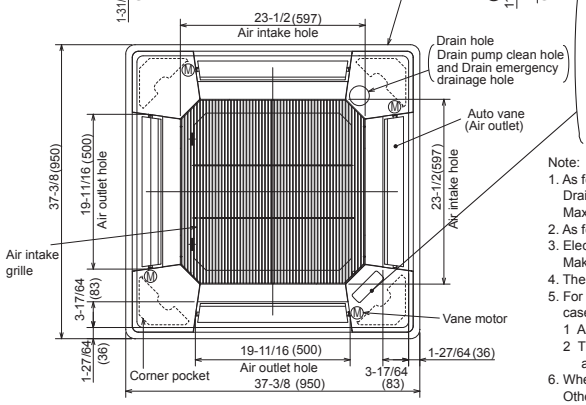
Detail connecting of branch duct(Both aspects)

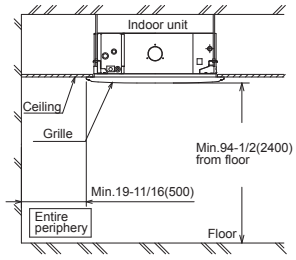




Detail drawing of fresh air intake hole

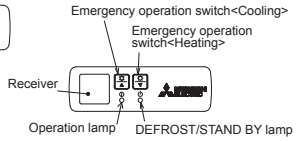






In case of standard grille

In case of wireless remote controller



Note:
1. As for drain pipe, please use VP-25 O.D. 1-1/4(32) PVC TUBE.
   Drain pump is included.
   Max. lifting height is 33-7/16 (850mm) from the ceiling.
2. As for suspension bolt, please use M10 or W3/8. (Procured at local site)
3. Electrical box may be removed for the service purpose.
   Make sure to slack the electrical wire little bit for control/power wires connection.
4. The height of the indoor unit is able to be adjusted with the grille attached.
5. For the installation of the optional high efficiency filter or optional multi-functional casement.
   1 Add 5-5/16"(135mm) to the dimensions ※ marked on the figure.
   2 The optional high efficiency filter becomes optional multi-functional casement and concomitant use.
6. When installing the branch ducts, be sure to insulate adequately.
   Otherwise condensation and dripping may occur.
   (It becomes the cause of dew drops/water dew.)
   As for necessary installation / service space, please refer to the left figure.

Accessory···Drain socket(I.D.1-1/4(32))
Flare nut 3/8 (For P18)
Flare nut 5/8 (For P18)
Flare nut 3/4 (For P36)

Models	1	2	A	B	C	D
PLFY-P12NBMU-ER2 PLFY-P15NBMU-ER2	Refrigerant pipe ··· ø 6.35 Flared connection ···1/4	Refrigerant pipe ··· Ø12.7 Flared connection ···1/2	9-1/2 (241)	10-3/16 (258)	3-5/32 (80)	2-29/32 (74)
PLFY-P18NBMU-ER2	Refrigerant pipe Ø6.35 Flared connection 1/4 (compatible)	Refrigerant pipe Ø12.7 Flared connection 1/2 (compatible)				
PLFY-P24NBMU-ER2 PLFY-P30NBMU-ER2	Refrigerant pipe ··· ø9.52	Refrigerant pipe ··· Ø15.88 Flared connection ···5/8				
PLFY-P36NBMU-ER2	Flared connection ···3/8	Refrigerant pipe ø15.88 Flared connection 5/8 (compatible)	11-1/16 (281)	11-3/4 (298)	3-11/32 (85)	3-1/32 (77)

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Intertek

FORM# PLFY-P24NBMU-ER2 - 201206

Specifications are subject to change without notice.

The new degree of comfort®

Professional *Classic*® tankless electric water heaters offer continuous hot water

Performance Features

- On demand, consistent and continuous hot water
- Compact and stylish with digital temperature control in increments of 1° ranging from 80°F to 140°F*
- Robust copper immersion heating elements with brass top increases durability and are threaded for easy replacement
- Simple Installation
- Digital temperature display
- External controls to adjust temperature in increments of 1°*

Average GPM Usage by Application

Standard Hand Sink	0.5 GPM
Washing Machine	1 to 1.5 GPM
Water-Saver Shower Head	1.5 GPM
Dishwasher	1 to 2 GPM
Kitchen Sink	1 to 2 GPM
Standard Shower Head	2.0 GPM
Bath Tub	≥ 4 GPM
Whole-Home	Up to 6 GPM

Average Gallons Per Minute (GPM) based on 2010 Plumbing Standards

Warranty

- 5-Year heating chamber and 1-year parts limited warranty

See Residential Warranty Certificate for complete information

**RTEX-04 and RTEX-06 only show output temperature and are non-thermostatically controlled*

MODEL NUMBER	TEMPERATURE RISE °F								
	0.5 GPM	1.0 GPM	1.5 GPM	2.0 GPM	2.5 GPM	3.0 GPM	4.0 GPM	5.0 GPM	6.0 GPM
SINGLE POINT-OF-USE									
RTEX-04	48°	24°	16°	12°	–	–	–	–	–
RTEX-06	75°	37°	25°	19°	–	–	–	–	–
MULTIPLE APPLICATIONS									
RTEX-08	+	55°	36°	27°	22°	18°	14°	–	–
RTEX-11	+	75°	50°	38°	30°	25°	19°	–	–
RTEX-13	+	89°	59°	44°	36°	30°	22°	–	–
RTEX-18	+	+	82°	62°	49°	41°	31°	25°	–
RTEX-24	+	+	109°	82°	66°	55°	41°	33°	27°
RTEX-27	+	+	+	92°	74°	62°	46°	37°	31°
RTEX-36	+	+	+	+	98°	82°	62°	49°	41°

+ Temperature electronically limited setting on adjustable thermostat on front cover

POINT-OF-USE

For 0.5 GPM to 2.0 GPM Applications

RTEX-04, RTEX-06

MULTIPLE APPLICATIONS

For 0.5 GPM to 6.0 GPM Applications

RTEX-08, RTEX-11, RTEX-13

RTEX-18

RTEX-24, RTEX-27

RTEX-36

Intertek

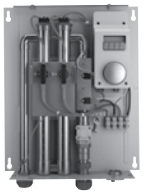
Tested and certified by the Water Quality Association against NSF/ANSI 372 for lead free compliance.

RTEX-04, RTEX-06

Unique Features:
- External Digital Display – shows outlet temperature
- Durable Copper Immersion single heating element, field serviceable
- Simple Installation – Bottom 1/2" NPT water connections

RTEX-08, RTEX-11, RTEX-13

Unique Features:
- External Adjustable Digital Thermostatic Control with LED display (+/- 1 degree accuracy)
- Durable Copper Immersion two heating elements, field serviceable
- Simple Installation – 1/2 NPT adapters included; Side 1/2" compression water connections

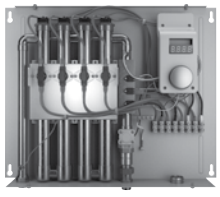


RTEX-18

Unique Features:
- External Digital Thermostatic Control with LED display (+/- 1 degree accuracy)
- Most advanced self-modulation, adjust power to meet hot water demand
- Durable Copper Immersion two heating elements, field serviceable
- Simple Installation – Bottom 3/4" NPT water connections

RTEX-24, RTEX-27

Unique Features:
- External Digital Thermostatic Control with LED display (+/- 1 degree accuracy)
- Most advanced self-modulation, adjust power to meet hot water demand
- Durable Copper Immersion three heating elements, field serviceable
- Simple Installation – Bottom 3/4" NPT water connections



RTEX-36

Unique Features:
- External Digital Thermostatic Control with LED display (+/- 1 degree accuracy)
- Most advanced self-modulation, adjust power to meet hot water demand
- Durable Copper Immersion four heating elements, field serviceable
- Simple Installation – Bottom 3/4" NPT water connections

PRINTED IN U.S.A. 05/19 WP FORM NO. TKE-101 Rev. 4

Specifications

DESCRIPTION	FEATURES							ROUGHING IN DIMENSIONS (SHOWN IN INCHES)				
MODEL NUMBER	kW	AMPS	RECOMMENDED BREAKER SIZE	VOLTAGE	RECOMMENDED WIRE SIZE (CU)	MIN. FLOW (GPM)	MAX. FLOW (GPM)	HEIGHT	WIDTH	DEPTH	WATER CONN.	SHIP WEIGHT (LBS.)
120V 1 HEATING CHAMBER												
RTEX-04	3.5	29A	(1x30)A	120	10 AWG	0.3	1.5	5-7/8	10-7/8	2-3/4	1/2 NPT	4.5
240V* 1 HEATING CHAMBER												
RTEX-06	5.5	25A	(1x25)A	220	10 AWG	0.3	2.0	5-7/8	10-7/8	2-3/4	1/2 NPT	4.5
RTEX-08*	8.0	33A	(1x40)A	240	8 AWG	0.3	4.8	12-5/8	8-1/4	3-5/8	1/2 CF	7
RTEX-11*	11.0	46A	(1x50)A	240	6 AWG	0.3	4.8	12-5/8	8-1/4	3-5/8	1/2 CF	8.5
RTEX-13*	13.0	54A	(1x60)A	240	6 AWG	0.3	4.8	12-5/8	8-1/4	3-5/8	1/2 CF	8.5
240V* 2 HEATING CHAMBERS												
RTEX-18*	18.0	75A	(2x40)A	240	8 AWG	0.3	7.0	18-1/4	14-1/2	3-1/2	3/4 NPT	14.78
240V* 3 HEATING CHAMBERS												
RTEX-24*	24.0	100A	(3x40)A	240	8 AWG	0.3	7.0	18-1/4	17-5/8	3-1/2	3/4 NPT	17.8
RTEX-27*	27.0	113A	(3x40)A	240	8 AWG	0.3	7.0	18-1/4	17-5/8	3-1/2	3/4 NPT	17.8
240V* 4 HEATING CHAMBERS												
RTEX-36*	36.0	150A	(4x40)A	240	8 AWG	0.3	8.0	18-1/4	21-5/8	3-1/2	3/4 NPT	22.7

*240V units can be used on 208V single phase with 25% reduced temperature output. Please note per UL standards the rating plate and installation instructions will all be according to a 240V applied voltage. Check with local officials prior to derating the electrical infrastructure.

Product Specifications (all models)

Rated Pressure	25 PSI min., 150 PSI max.
Certifications	ETL Listed to UL 499 and CSA
Std. Temp. Settings	120°F (Adjustable 80°F-140°F)
Temp. Accuracy	+/–1° at steady flow
Turn-On	0.3 GPM

Suggested Specifications

Unit shall have copper clad immersion heating element(s) with brass terminations for increased durability. External temperature control and display adjustable in 1° increments with a range of 80°-140°F. Display shall be capable of displaying setpoint temperature in Celsius or Fahrenheit temperature scales. Unit shall utilize a flow meter with a 0.3 gpm activation point and manage power based on actual flow rate and inlet temperature. Values should be processed 60 times per second. Unit shall be WQA certified lead free, certified to UL499 and CSA C22.2 No.64.

Optional Inline Flow Regulator

- Enhanced outlet temperature control
- Install on the outlet side of the heater
- Limit maximum volume to the specified flow rate to ensure exiting temperature is within an acceptable range
- Flow Regulators for ½" and ¾" NPT plumbing connections
- Flow range: 1 to 5 gallons per minute

RHEEM PART NUMBER	GPM RATING OF INSERTS PROVIDED	CONNECTION SIZE
RTE10001A	1.0, 1.5, 2.0	1/2" NPT
RTE10001B	2.0, 3.0, 4.0, 5.0	3/4" NPT

Suggested Sizing Guide

MODEL NUMBER	FLOW REGULATOR PART NO.	GPM INSERT TO USE BASED ON INLET WATER TEMPERATURE			
		40°F	50°F	60°F	70°F
RTEX-04	N/A	N/A	N/A	N/A	N/A
RTEX-06	N/A	N/A	N/A	N/A	N/A
RTEX-08	RTE10001A	1.0	1.0	1.0	1.5
RTEX-11	RTE10001A	1.0	1.0	1.5	2.0
RTEX-13	RTE10001A	1.0	1.0	1.5	2.0
RTEX-18	RTE10001B	2.0	2.0	2.0	3.0
RTEX-24	RTE10001B	2.0	2.0	3.0	4.0
RTEX-27	RTE10001B	2.0	3.0	4.0	5.0
RTEX-36	RTE10001B	3.0	4.0	5.0	5.0

In keeping with its policy of continuous progress and product improvement, Rheem reserves the right to make changes without notice.

Rheem.com | **800.374.8806**
Manufacturers National Service Department
400 Captain Neville Drive, Waterbury, CT 06705

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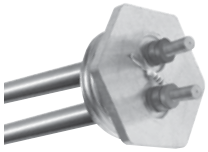
The new degree of comfort.®

Professional *Classic*® electric water heaters are engineered for longer life – resistored heating elements and premium grade anode rod

Efficiency

- .90 - .93 UEF
- Isolated tank design reduces conductive heat loss
- Resistored copper upper element and resistored Lifeguard™ stainless steel lower element to prolong anode rod and tank life



Performance

- FHR: 45 - 67 gallons, based on gallon capacity
- Recovery: 21 GPH at a 90° F rise

System Sentinel

(Available on selected models)

- Exclusive diagnostic system with glowing LEDs that verify heating element operation. LEDs pin point the exact location of functioning or non-functioning heating elements

Longer Life

- Premium grade anode rod provides long-lasting tank protection

Features

- Electric junction box located above heating elements for easy installation
- Over-temperature protector cuts off power in excess temperature situations
- Automatic thermostat keeps water at desired temperature

Plus…

- Rheemglas® tank lining resists corrosion and prolongs tank life
- EverKleen™ self cleaning device fights harmful sediment build-up with a high-velocity spiraling water stream – helps operating efficiency by saving energy, money and improving tank life

- Enhanced-flow brass drain valve
- Temperature and pressure relief valve included
- HUD certified for manufactured housing and modular construction
- Low lead compliant

Warranty

- 6-Year limited tank and parts warranty*
- With ProtectionPlus™ the 6-year limited tank warranty becomes 10-year

*See Residential Warranty Certificate for complete information

Units meet or exceed ANSI requirements and have been tested according to the AHRI Operations Manual and D.O.E. procedures. Units meet or exceed the energy efficiency requirements of NAECA, ASHRAE standard 90, ICC Code and all state energy efficiency performance criteria.

Professional *Classic*

19.9 to 55-Gallon Capacities
240 Volt AC/Single Phase
Double and Single Element Models
Electric

See specifications chart on back.

PRINTED IN U.S.A. 05/18 WP FORM NO. PROE RH N Rev. 8

Professional *Classic*® Specifications

DESCRIPTION				FEATURES		ROUGHING IN DIMENSIONS (SHOWN IN INCHES)				ENERGY INFO.
TYPE	NOMINAL GALLON CAPACITY	RATED GALLON CAPACITY	MODEL NUMBER	UEF FIRST HOUR RATING G.P.H.	RECOVERY IN G.P.H. 90° F RISE	TANK HEIGHT A	HEIGHT TO WATER CONN. B	DIAMETER C	APPROX. SHIP WT. (LBS.)	UNIFORM ENERGY FACTOR (UEF)
Tall	30	27	PROE30 T2 RH95†	46	21	47-1/2	50-3/8	19-1/4	92	0.92
Tall	40	36	PROE40 T2 RH95†	55	21	60-3/4	63-5/8	19-1/4	109	0.93
Tall	50	45	PROE50 T2 RH95†	63	21	58-5/8	61-5/8	20-1/4	121	0.93
Tall	55	55	PROE55 T2 RH94†	72	21	57	59-3/4	22-1/4	128	0.92
Med.	30	27	PROE30 M2 RH95†	45	21	37-1/2	40-1/2	20-1/4	92	0.90
Med.	40	36	PROE40 M2 RH95†	55	21	48-1/4	50-1/2	20-1/4	106	0.93
Med.	50	45	PROE50 M2 RH95†	62	21	48	50-1/2	23	132	0.93
Short	19.9	–	PROE20 S2 RH	–	21	31-1/2	31-1/2	17	62	–
Short	28	25	PROE28 S2 RH95	45	21	30	31-1/8	23	95	0.92
Short	30	27	PROE30 S2 RH95 B**	46	21	30-1/8	32	19-3/4	95	0.92
Short	36	33	PROE36 S2 RH95	46	21	31-1/2	33	24-1/4	118	0.92
Short	38	35	PROE38 S2 RH95 B**	51	21	31-1/2	32-5/8	23	108	0.92
Short	47	43	PROE47 S2 RH95	54	21	32	34	26-1/4	149	0.93

Uniform Energy Factor and rated gallon capacity based on Department of Energy (DOE) requirements.

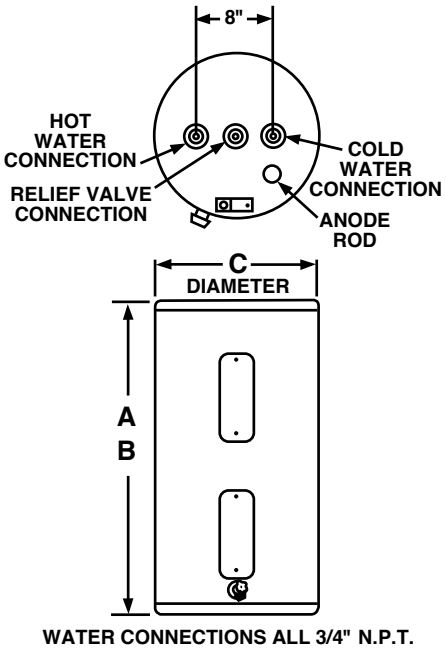
† **System Sentinel optional. Add EC1 to the end of the model number. System Sentinel not available on single element models, available on dual element models only. System Sentinel not available in excess of 5 kW on 208 V models.**

** Water heater dimensions prior to installing insulation blanket that is included with water heater.

- Heaters furnished with standard 240 volt AC, single phase non-simultaneous wiring, and 4500 watt upper and lower heating elements.
- **If heating elements of different wattages than those shown are demanded by zone requirements, they must be specifically requested.**
- Single element models available on special order (6000W max.). Substitute "1" for "2" in model number.
- Special Wiring Options – A limited number of special wiring options are available. Consult factory for price and availability.
- All models equipped with heat traps.

Recovery = wattage/2.42 x temp. rise °F.
Example: $\frac{4500W}{2.42 \times 90°}$ = 21 GPH

Recovery calculations used are based on 4500 watt elements used in non-simultaneous operation.



WATER CONNECTIONS ALL 3/4" N.P.T.

In keeping with its policy of continuous progress and product improvement, Rheem reserves the right to make changes without notice.

Rheem Water Heating • 1115 Northmeadow Parkway, Suite 100
Roswell, Georgia 30076 • www.rheem.com

PRINTED IN U.S.A. 05/18 WP FORM NO. PROE RH N Rev. 8

SOLAR COLLECTORS

The new GOBI has undergone a complete transformation for 2011 making it the industry's best flat plate collector. By redesigning the frame and incorporating state of the art components, the GOBI has a reduced profile and even better performance. With 3 sizes and 2 absorber surface types to choose from, there is a GOBI collector for every type of solar water heating application.

Thinnest Profile – The redesigned frame is easier to handle for installers and offers the end user a streamlined, sleek look on their roof compared to bulky traditional flat plate collectors.

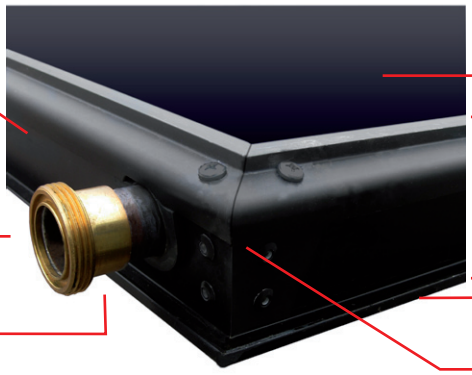
Top 10 Performer – New SRCC ratings certify that the GOBI now ranks among the 10 best OG-100 collectors. The high energy output of the GOBI offers maximum performance out of the solar hot water system.

Easiest to Install – The GOBI retains its unique Dyn-O-Seal (DOS) union interconnection method. DOS unions come factory assembled and eliminate the time consuming task of soldering each collector together in an array.

DOS unions are included to connect and cap off collectors

New Design Features

- 1" reduction in frame thickness
- Improved insulation
- Full plate absorber
- Rounded glazing profile
- OG-100 certified with higher performance and efficiency



Low profile, 6063-T6 anodized aluminum frame makes the collector extremely rigid and rust proof

Factory fitted 1" Dyn-O-Seal inter-connections eliminate the need for soldering when connecting or capping off collectors

Pipes sized for minimal pressure drop and optimal flow

Double-strength tempered low iron solar glass with anti-glare finish resists potential damage from harsh weather conditions

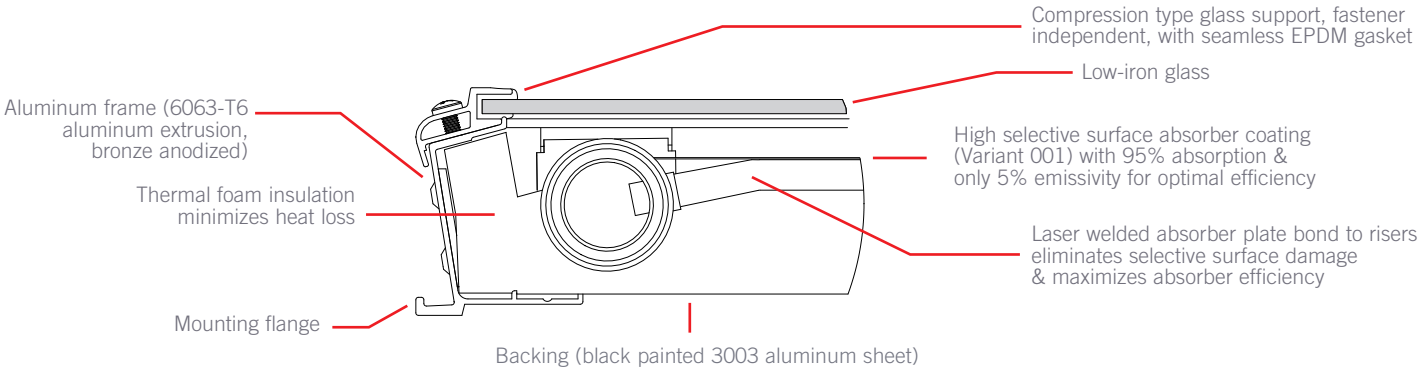
2.8" thick profile makes the GOBI the thinnest collector available in the U.S.

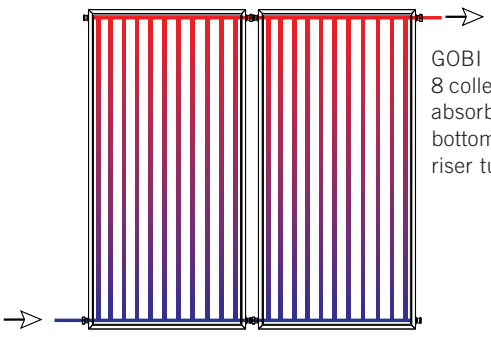
Built-in flange for mounting without collector penetration

Weep slots minimize condensation

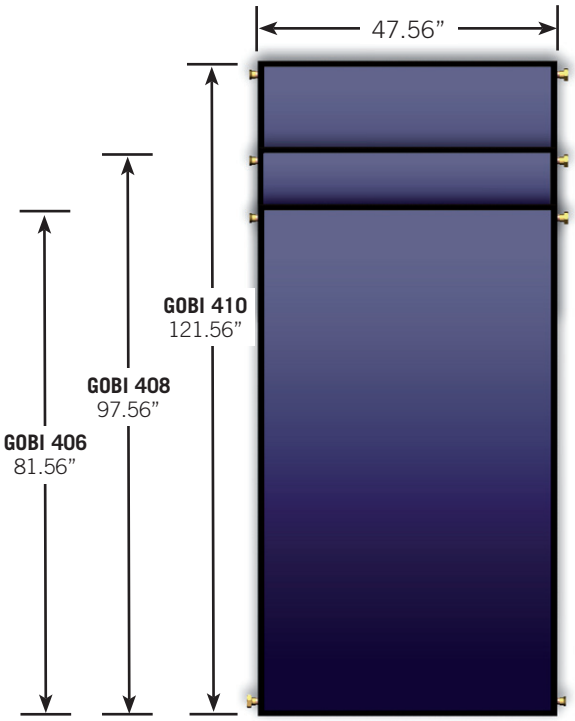
EXCELLENCE BY DESIGN™

TECHNICAL SPECIFICATIONS





GOBI headers fit together up to 8 collectors in 1 array. Solar fluid absorbs heat as it flows from the bottom to top within 11 parallel riser tubes.



NOTE: GOBIs all have a depth of 2.8”

SRCC SRCC OG-100 RATINGS (CLEAR DAY)

Category (Ti-Ta)	GOBI 406 001	GOBI 408 001	GOBI 410 001
Certification Number	2010115C	2010115D	2010115A
A (-9°F)	38.3	46.2	57.6
B (9°F)	34.9	42.0	52.4
C (36°F)	29.7	35.8	44.7
D (90°F)	20.3	24.5	30.7
E (144°F)	12.0	14.6	18.2

TECHNICAL SPECIFICATIONS	GOBI 406	GOBI 408	GOBI 410
Gross Area	26.94 ft^2	32.23 ft^2	40.15 ft^2
Net Area	24.91 ft^2	29.83 ft^2	38.3 ft^2
Dry Weight	74 lbs.	102 lbs.	127 lbs.
Fluid Capacity	0.6 gal	0.7 gal	0.8 gal
Maximum Operating Pressure	150 psi (10.34 Bar)		
Recommended Design Flow Rate (glycol/water mix)	0.8 gal/min	1.0 gal/min	1.25 gal/min
Recommended Design Flow Rate (water)	0.7 gal/min	0.8 gal/min	1.0 gal/min
Wind Load Certification	50 psf (2.39 kPa)		

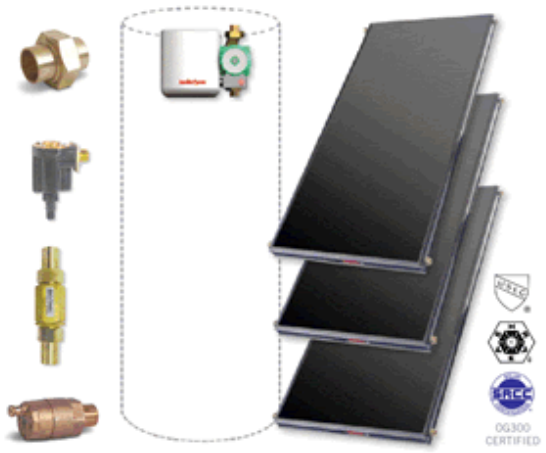
Heliodyne, Inc. • 4910 Seaport Avenue • Richmond, CA 94804
T: 510.237.9614 • F: 510.237.7018 www.heliodyne.com
Information and Support: info@heliodyne.com

heliodyne SOLAR HOT WATER

SOLAR WATER HEATING: WARM CLIMATE (OPEN LOOP)

HOW IT WORKS

When there is sufficient heat to be drawn from the collectors, the controller automatically activates a pump, which will pull cold water from the storage tank through the collectors to be heated. Once heated, the water is pumped back down into the storage tank for consumption. This process will continue as long as there is heat to be drawn from the collectors. During times when there is little or no sun, a backup heating system will be activated to provide adequate hot water.



WHAT'S INCLUDED

- Solar collectors with mounting hardware
- Helio-Flo open loop heat-transfer appliance
- SCV check valve
- Dole Dribble valve
- DOS discs

STANDARD PACKAGE	People: 1-2	2-4	4-6	6-8
Number of Collectors	**1**	**2**	**3**	**4**
Black Paint Collector Type	**GOBI 406 002**	**GOBI 406 002**	**GOBI 406 002**	**GOBI 406 002**
Helio-Flo	☑	☑	☑	☑

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

More than 21% Efficiency

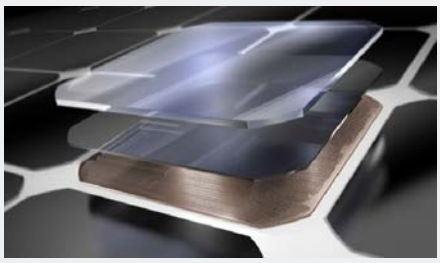
Ideal for roofs where space is at a premium or where future expansion might be needed.

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]

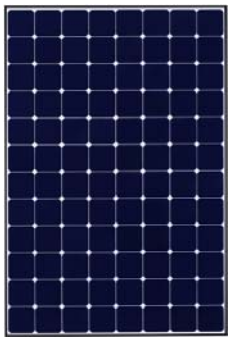
Designed for Durability

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]

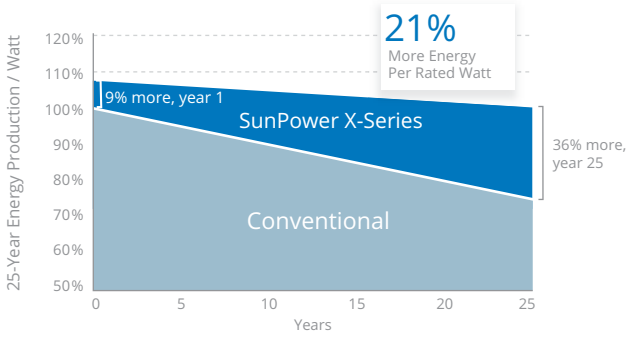
Generate more energy per square foot

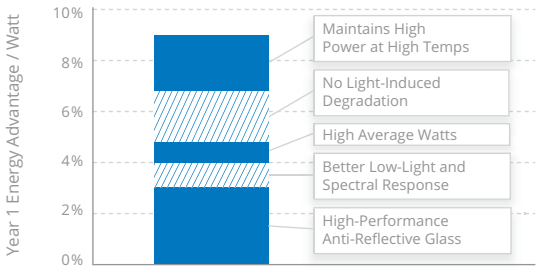
X-Series residential panels convert more sunlight to electricity by producing 38% more power per panel[1] and 70% more energy per square foot over 25 years.[1,2,3]

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]

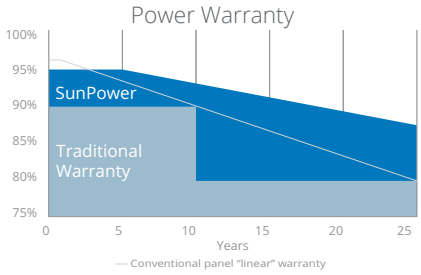




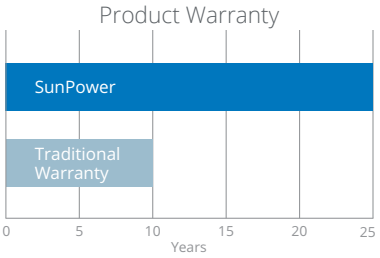
SUNPOWER®

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]

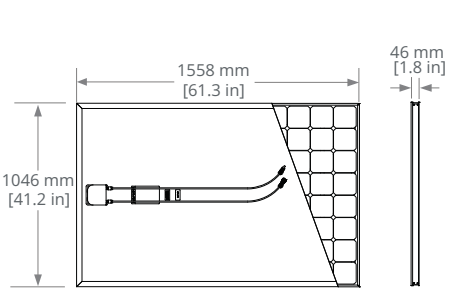


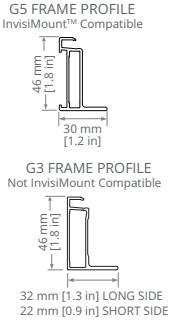
Combined Power and Product defect 25-year coverage [8]

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[9]
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 UL1703:2002.
14 See salesperson for details.

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

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

Document # 504828 Rev F /LTR_US

SUNPOWER®

SunPower® Helix™ Roof

#1 in Commercial Rooftop Solar[1]

Greater lifetime energy production

The Helix™ Roof system combines SunPower's high-efficiency, high-performance panel technology, productized mechanical mounting and electrical systems, comprehensive warranties and innovative O&M services to maximize energy output from your business's rooftop.

Healthier business operations

Implementing a solar program can help boost your bottom line, invigorate employees and improve your brand reputation. The Helix Roof system is a fully integrated solution designed for efficiency, reliability and rapid installation–so you can quickly realize the benefits of solar with minimal business disruption.

A Smart Energy future

SunPower's Helix platform provides the path to a smarter, clean energy future. From intelligent management resources that turn strategic energy insights into energy savings, to scaling your Smart Energy plan to include the adoption of new technologies like storage, potential is everywhere.

SUNPOWER®

HELIX™

sunpower.com/helix

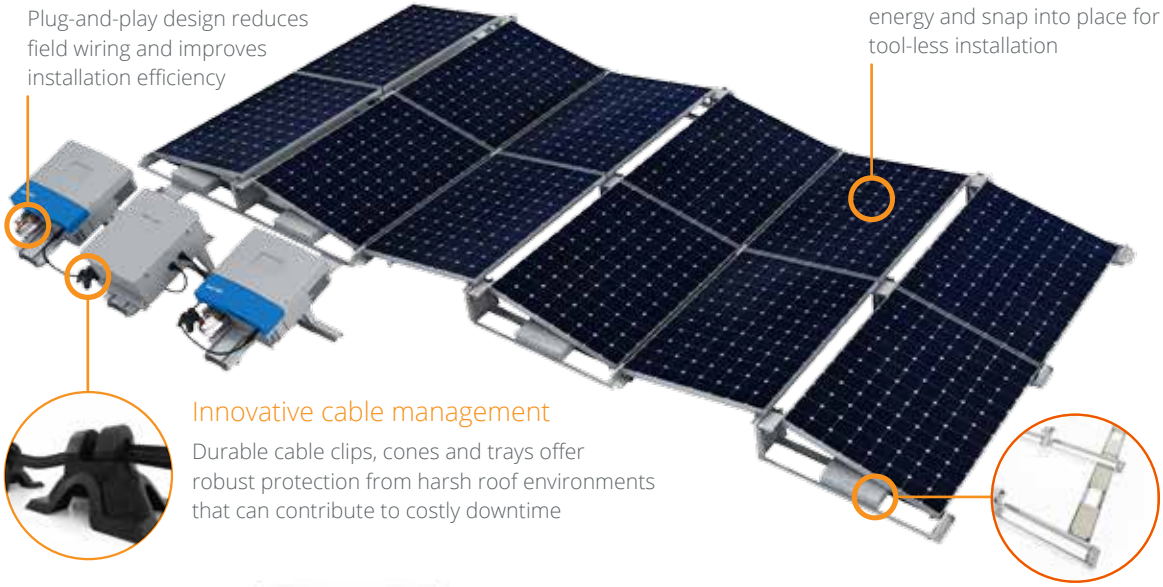
Anatomy of SunPower® Helix™ Roof

Preconfigured inverter power station

Plug-and-play design reduces field wiring and improves installation efficiency

Industry-leading solar panels

SunPower high efficiency panels maximize energy and snap into place for simple, tool-less installation



Innovative cable management

Durable cable clips, cones and trays offer robust protection from harsh roof environments that can contribute to costly downtime

Advanced mechanical mounting system

With greater coverage, Helix optimizes the yield potential of your roof, delivering higher power density

Powerful EnergyLink® Monitoring Software

Gather real-time insights for intuitive energy management

Features

- High-efficiency SunPower® panels
- Productized mechanical mounting system
- Productized electrical system
- Plug-and-play inverter power station
- EnergyLink Monitoring Hardware and Software

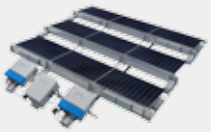
Warranties

- SunPower panels, combined power and product warranty ..... 25 years
- Helix mechanical BOS ..... 25 years
- Helix electrical BOS ..... 10 years
- Plug-and-play inverter[2] ..... 10 years
- EnergyLink Monitoring Hardware ..... 10 years

Design Options

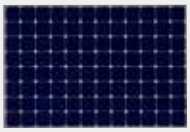
Helix Roof Dual Tilt (DT)

- Most energy per roof
- Ideal for constrained roofs
- Ideal for customers prioritizing NPV



Helix Roof Single Tilt (ST)

- Optimized output per kW
- Ideal for unconstrained roofs
- Ideal for customers prioritizing IRR

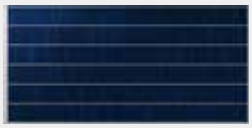


SunPower® X-Series Panel

- Highest efficiency available[3]
- High energy production
- 40 year useful life[4]
- Rated #1 in durability[5]

SunPower® E-Series Panel

- High-efficiency
- High energy production
- 40 year useful life[4]
- Rated #1 in durability[5]



SunPower® P-Series Panel

- High performance in shade
- Superior durability and reliability to conventional panels
- 35-year useful life[6]

1 Shiao, MJ, et al., Q4 2016 Solar Executive Briefing, GTM Research, Jan. 2017.
2 Manufacturer pass-through warranty. Warranties of 15 or 20 total years are available directly through manufacturer.
3 Based on search of datasheet values from websites of top 10 manufacturers per IHS, as of January 2017
4 "SunPower Module 40-Year Useful Life," SunPower white paper. 2013. Useful life is 99 out of 100 panels operating at more than 70% of rated power.
5 X-Series same as E-Series. #1 rank in "Fraunhofer PV Durability Initiative for Solar Modules: Part 3". PVTech Power Magazine, 2015. Campeau, Z. et al. "SunPower Module Degradation Rate," SunPower white paper, 2013. See www.sunpowercorp.com/facts for details.
6 "SunPower P-Series Technology Technical Review," Leidos Independent Engineer Report. 2016.