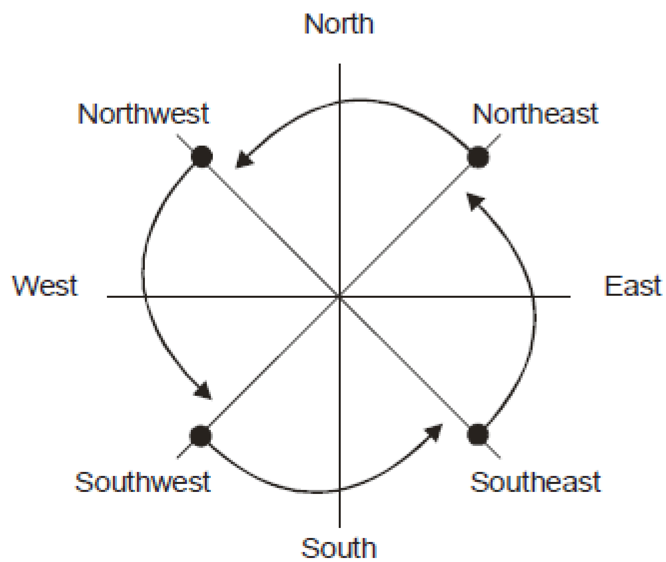
TASK II

2A. Window-to-Wall Ratio

Calculate the window-to-wall ratio for each elevation and the entire building. The window-to-wall ratio of a building is the percentage of its facade taken up by light-transmitting glazing surfaces, including windows and translucent surfaces such as glass bricks. It does not include glass surfaces used ornamentally or as opaque cladding, which do not provide transparency to the interior. Only facade surfaces are counted in the ratio, and not roof surfaces.

Here is the procedure for classifying facades that do not face a cardinal direction. In general, any orientation within 45° of true north, east, south, or west should be assigned to that orientation. If the orientation is exactly at 45° of a cardinal orientation, use the diagram at right to classify the direction of the façade. For example, an east-facing surface cannot face exactly northeast, but it can face exactly southeast. If the surface were facing exactly northeast, it would be considered north-facing.

As the window-to-wall calculation is a ratio, you may enter area in square feet or meters.



North

Step 1: Total area of light transmitting glazing surfaces on north facade: **11,604 sf**

Step 2: Total area of north façade: **42,309sf**

Window-to-wall ratio of north façade = number from step 1 / number from step 2 = **0.274**

East

Step 1: Total area of light transmitting glazing surfaces on east facade: **8,230sf**

Step 2: Total area of east façade: **25,354 sf**

Window-to-wall ratio of east façade = number from step 1 / number from step 2 = **0.324**

South

Step 1: Total area of light transmitting glazing surfaces on south facade: **12,728sf**

Step 2: Total area of south façade: **34,806sf**

Window-to-wall ratio of south façade = number from step 1 / number from step 2 = **0.365**

West

Step 1: Total area of light transmitting glazing surfaces on west facade: **6,067sf**

Step 2: Total area of west façade: **20,408 sf**

Window-to-wall ratio of west façade = number from step 1 / number from step 2 = **0.297**

Total Building Window-to-Wall Ratio

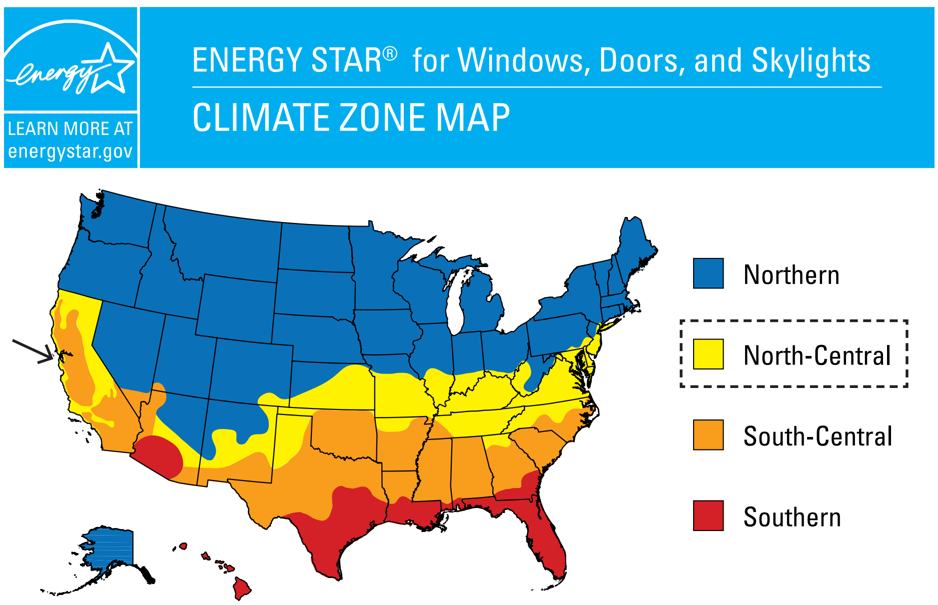
Step 1: Façade area$_{total}$ = step one$_{north}$ + step one$_{east}$ + step one$_{south}$ + step one$_{west}$ = **38,629sf**

Step 2: Light transmitting glazing$_{total}$ = step two$_{north}$ + step two$_{east}$ + step two$_{south}$ + step two$_{west}$ = **122,877sf**

Total window-to-wall ratio = number from step 1 / number from step 2 = **0.314**

2B. Window Openings and Window Shading

In the space below, describe the design approach at window openings to regulating incoming light and heat from the sun. Briefly describe the type of window and glass used on the east, south, west, and north elevations and the performance numbers targeted for U-factor, solar heat gain coefficient (SHGC), and visible transmittance.



WINDOWS		
CLIMATE ZONE	U- FACTOR[1]	SHGC[2]
Northern	≤ 0.30	Any
	= 0.31	≥ 0.35
	= 0.32	≥ 0.40
North Central	≤ 0.30	≤ 0.40
South Central	≤ 0.30	≤ 0.25
Southern	≤ 0.40	≤ 0.25

// After the research for climate of San francisco, we realized that heating is critical. Therefore, we should take advantage of windows for increasing solar heat gain and reduce heat loss. Our Sustainability Goals is (see below)

- *Windows Double-glazed or even Triple for North side elevation(better insulation)*
- *Low-e Window*
- **U-value (Thermal)** *< 0.30 (heat loss ratio - the smaller the number is, the more energy efficient and more expensive)*
- **Window -to-Wall Ratio (WWR)** *approximately 30% (An overall WWR < 0.20 does not provide enough daylight, WWR > 0.30 allows too much heat loss in winter and too much heat gain in summer.)*
- **Solar Heat Gain Coefficient (SHGC)** *E = 0.30-0.41; W = 0.30-0.41; N = can < 0.3 due to lack of sunlight ; S = 0.30-0.41; Skylight = around 0.55*
- **Visual Light Transmittance (VLT or VT)** *E = .50; W = .50; N = .50; S(up) = .70; S (view)= .50; Skylight = .70*
- *All windows operable to permit natural ventilation (no mecahnical cooling required based on the climate of San francisco see diagram in page 6)*

Diagram Citation: *"What Is An ENERGY STAR® Qualified Window". Web. 17 Sept. 2015. <http://www.thermalwindows.com/energystar.php>.*

TYPE of WINDOW & GLASS

Window Type		Energy ratings				Glass Type					Specification	
Type	Material	U Factor	SHGC	VT	CR	Panes	Glass Pane Type	Glass Coating	Gas Fill	Spacer	Company	Product number
Csmt, Crank-Out, Picture	Extr Alum Clad	0.26	0.31	0.57	41	Double Pane	Clear/No Lami	LoE-270 ThermaPlus	Air	Stainless Steel	KOLBE	KKM-K-195-00081-00001
Direct Set	Extr Alum Clad	0.19	0.4	0.5	67	Triple Pane	Clear/No Lami	LoE-180 #2/LoE-180 #5	Argon	Stainless Steel	KOLBE	KKM-K-197-00948-00001

// After finalizing the design, below is the actual number that we caculate

East facing
U-factor: *0.22*; SHGC: *0.35*; Visible Transmittance: *0.54*

South facing
U-factor: *0.22*; SHGC: *0.35*; Visible Transmittance: *0.54*

West facing
U-factor: *0.22*; SHGC: *0.35*; Visible Transmittance: *0.54*

North facing
U-factor: *0.22*; SHGC: *0.35*; Visible Transmittance: *0.54*

If you included a projecting shading device(s) or a window reveal, include a diagram of a representative residential window on the south and the west elevations showing shadows cast at the dates and times shown below. These studies should be for "solar time' rather than "clock time." (In solar time 12 noon represents the moment when the sun is due south and at the highest point in the sky it will reach that day.) Impose a 1'-0" grid on the window to make it possible for jurors to see the percent shading achieved at each time.

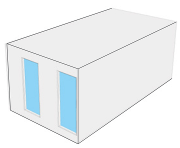
While there are a number of software tools that can be used to accurately cast shadows, it is straightforward to do this analysis in SketchUp, a free software tool.

South Elevation:
- December 21: 9 am, 12 noon, 3 pm
- March/September 21: 8 am, 10 am, 12 noon, 2 pm, 4 pm
- June 21: 9 am, 12 noon, 3 pm

West Elevation:
- December 21: 3 pm
- March/September 21: 2 pm, 4 pm
- June 21: 3 pm, 5 pm

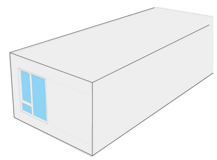
Base on unit size, we developed 4 different types of elevation systems. Each type has unique window arrangement to accomodate different unit size.

STUDIO



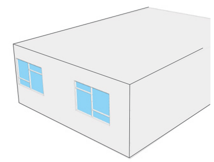
TYPE - 1

1-BEDROOM



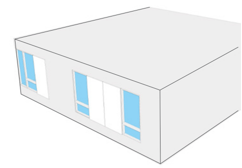
TYPE - 2

2-BEDROOM

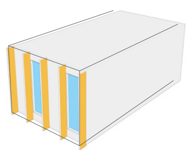


TYPE - 3

3-BEDROOM

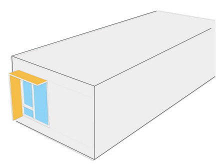


TYPE - 4



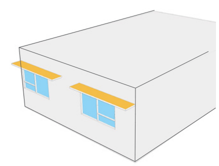
TYPE - 1A

All of the studio units are located east part of the site and facing east and west. We chose vertical fins as our shading solution for those units.



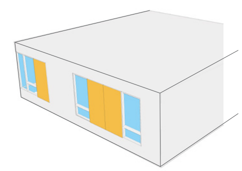
TYPE - 2A

1-Bedroom southern facing units have a system that combines horizontal and vertical fins.



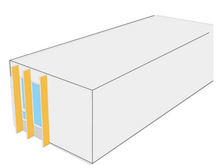
TYPE - 3A

2-Bedroom southern facing units have long horizontal shading devices that become strong elevation languege.



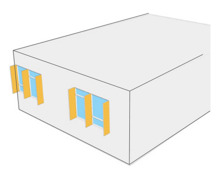
TYPE - 4A

3-Bedroom unit has very flexible shading devices. They are operable sliding perforated screens that can be closed and open as people need.



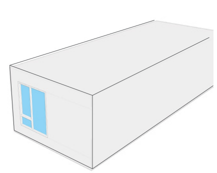
TYPE - 2B

1-Bedroom east/west facing units has vertical fins as their shading solution.



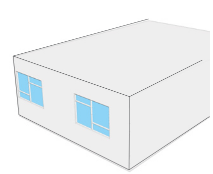
TYPE - 3B

2-Bedroom east/west facing units has vertical fins as their shading solution.



TYPE - 2C

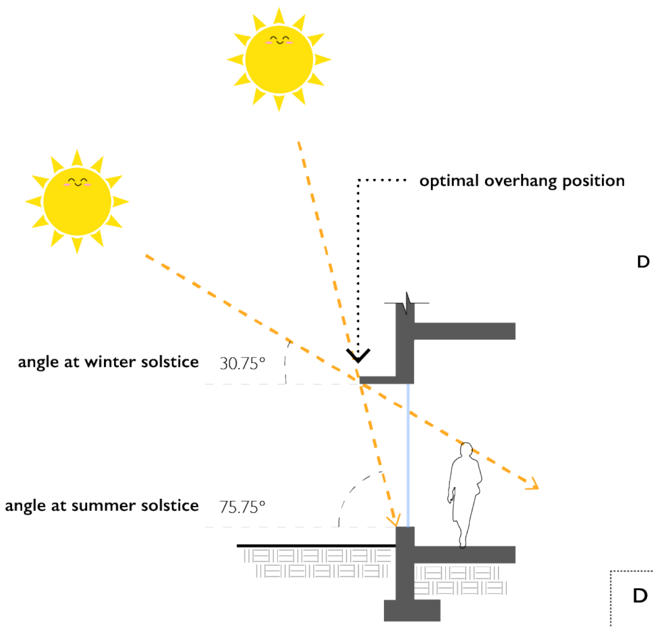
1-Bedroom north facing units don't need any shading device.

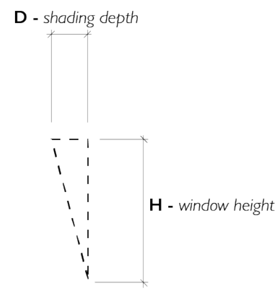


TYPE - 3C

2-Bedroom north facing units don't need any shading device.

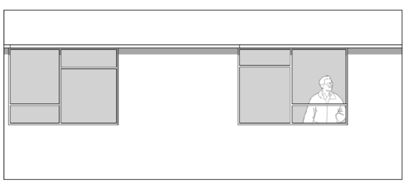
South Elevation Shading Review



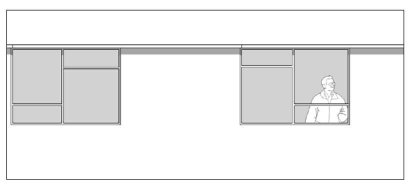


$$D = \tan(90-75.75) \times H$$
$$= \tan(90-75.75) \times 48''$$
$$= 12.19''$$

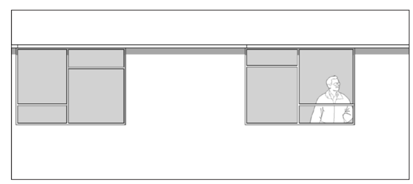
Shading Strategy for The South Elevation



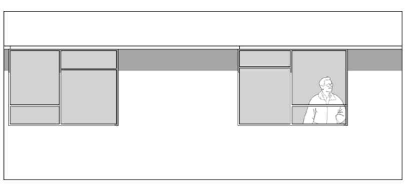
DEC 21 - 9AM



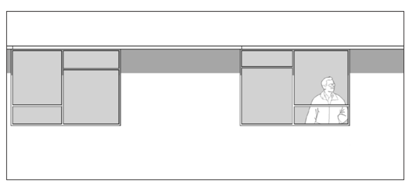
DEC 21 - 12PM



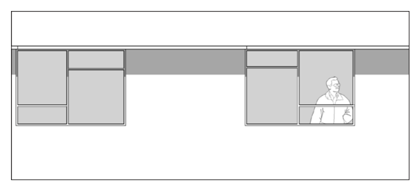
DEC 21 - 3PM



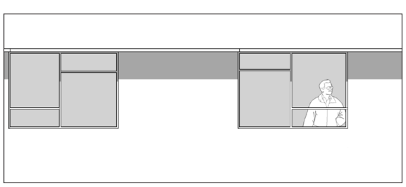
SEP 21 - 8AM



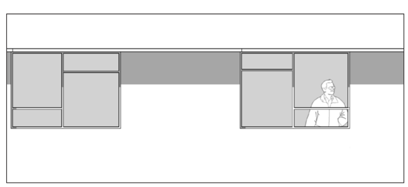
SEP 21 - 10AM



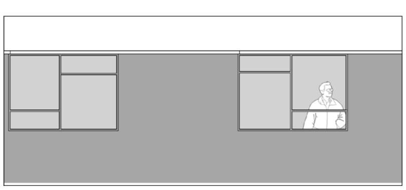
SEP 21 - 12PM



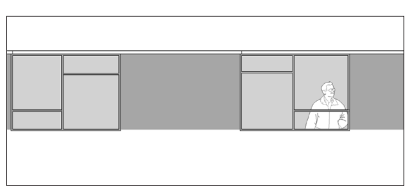
SEP 21 - 2PM



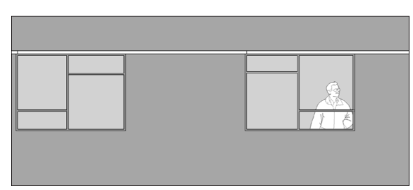
SEP 21 - 4PM



JUN 21 - 9AM

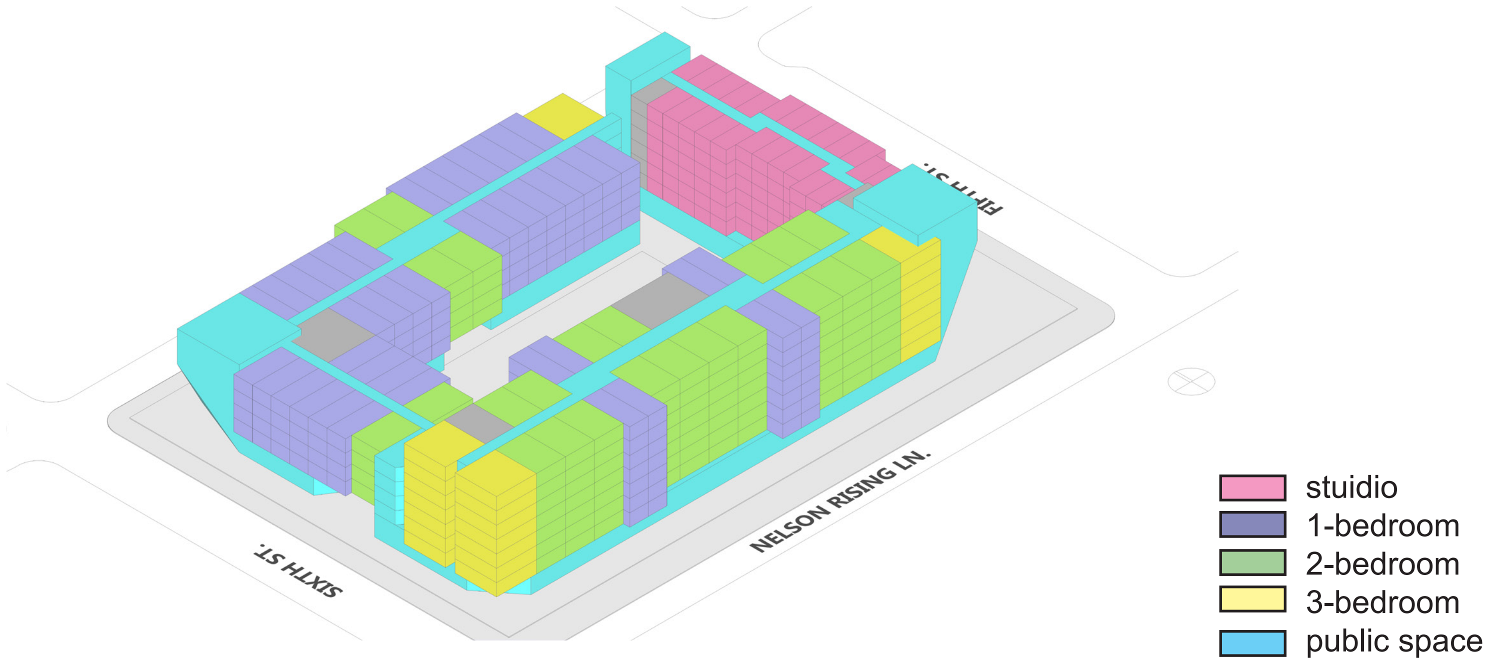


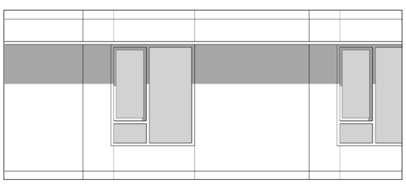
JUN 21 - 12PM



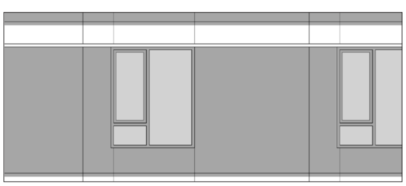
JUN 21 - 3PM

West Elevation Shading Review

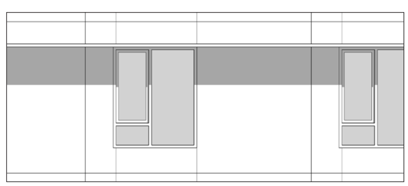




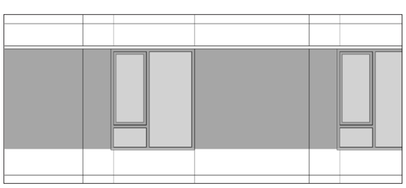
DEC 21 - 3PM



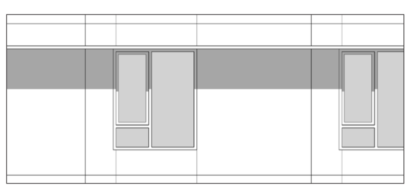
SEP 21 - 2PM



SEP 21 - 4PM



JUN 21 - 3PM

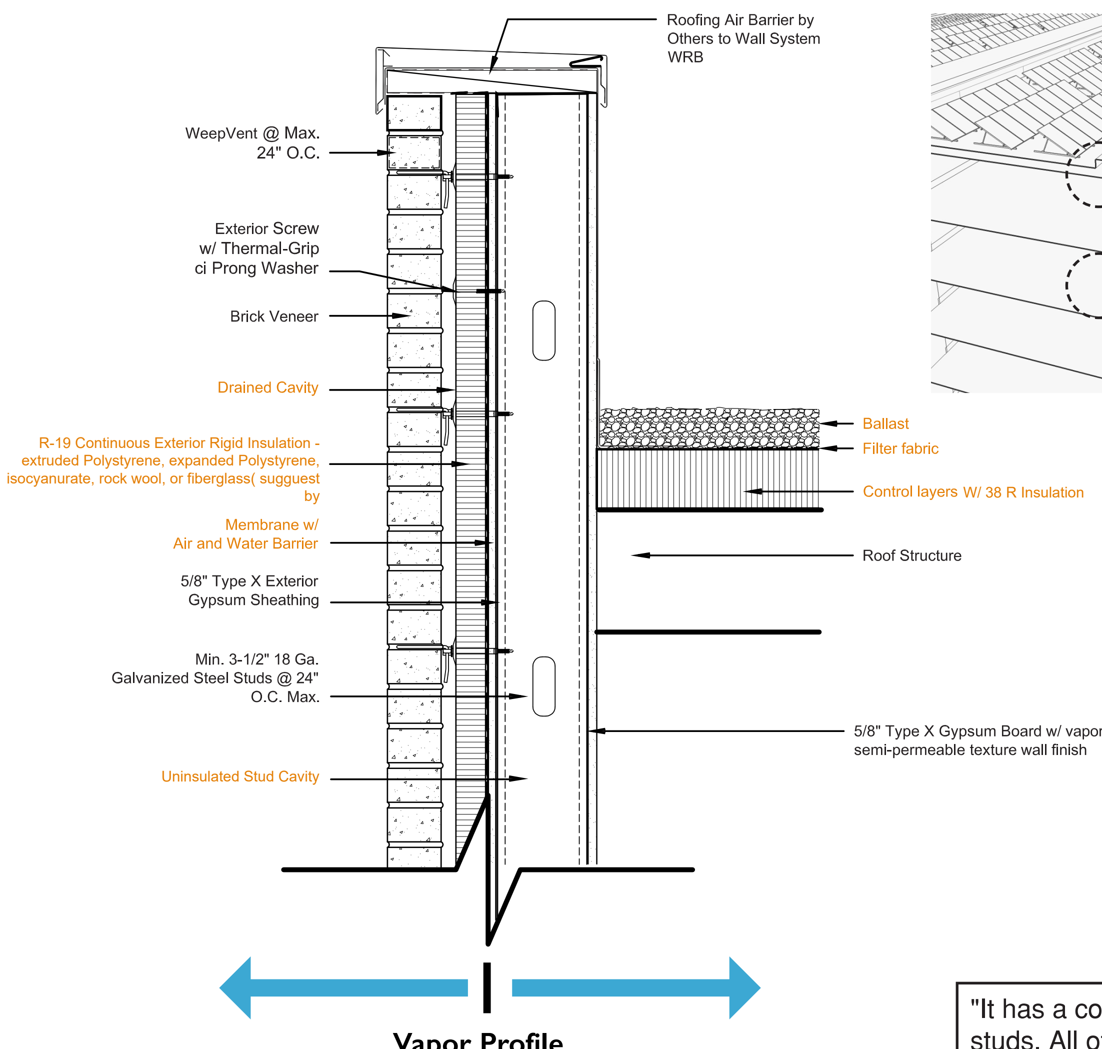


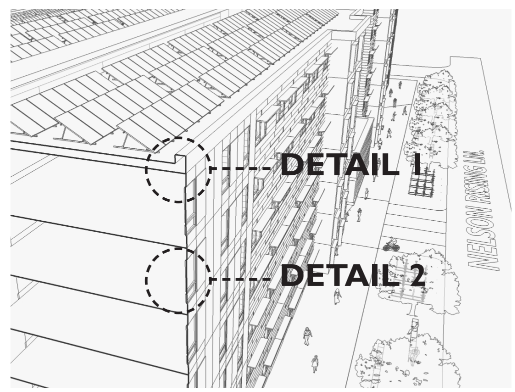
JUN 21 - 5PM

2C. BUILDING ENCLOSURE DETAILS

For one of the proposed buildings, include a section diagram through an exterior wall of a residential unit that shows the point of connection between the roof and a vertical wall, a typical window head and sill, and the condition at a typical floor level. This section should demonstrate the design strategies and details used to reduce thermal bridging and air leakage and to control bulk water flow. Include a scale on the diagram.

Provide a brief description of the insulation R-values used in the walls and roof. Include a description of other strategies used to reduce heat loss and air leakage. On the section diagram, note which building is being shown.



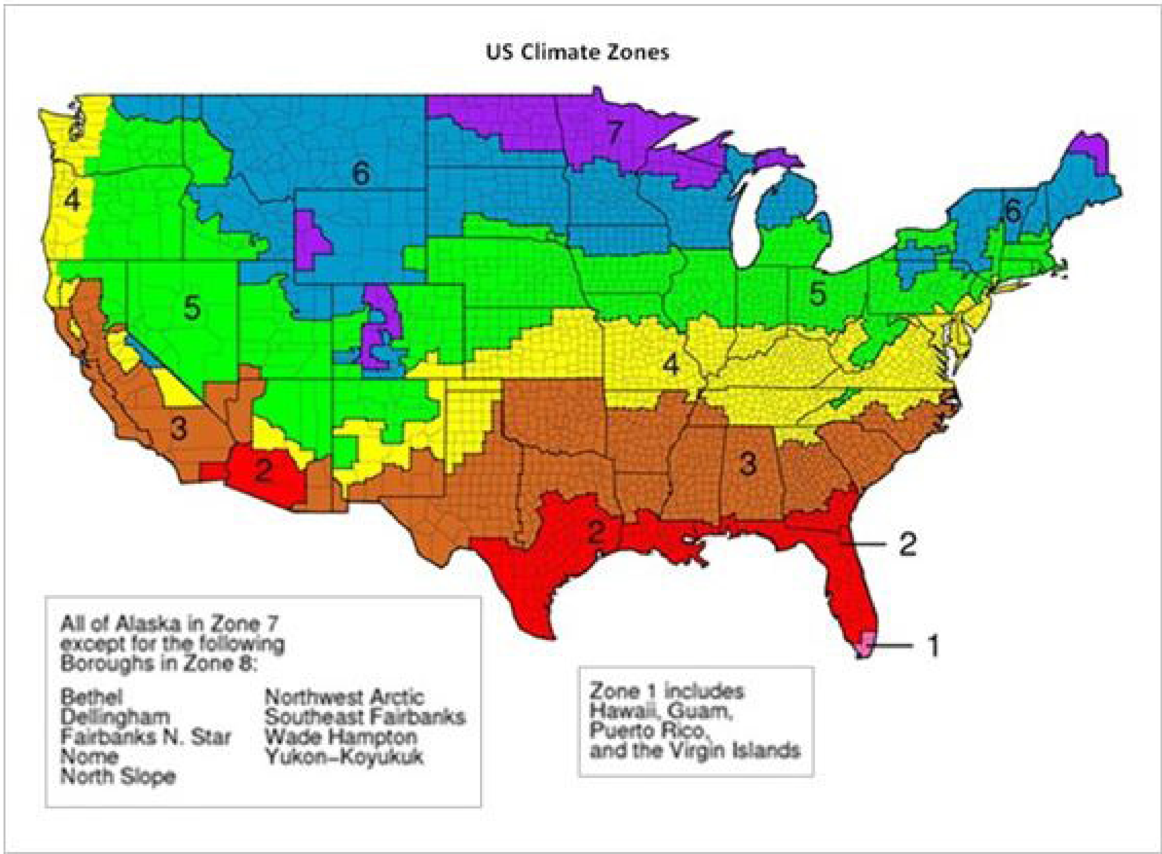


1 **DETAIL B/W WALL & ROOF** **SCALE: 1" = 1' - 0"**

"It has a conductive structure - metal studs. All of the insulation should and must be located on the outside. It is a thermodynamic obscenity to insulate within a conductive structural frame." (BS1-001)

"BSI-001: The Perfect Wall." Building Science Corporation. Web. 25 Sept. 2015. <http://buildingscience.com/documents/insights/bsi-001-the-perfect-wall#Fig02>.

2C. BUILDING ENCLOSURE DETAILS



Location	Heat Type	Attic	Wall	Floor	Crawl Space Wall**	Basement Wall
Zone 3	Natural Gas	30-38	13	13-19	13-25	11
	Oil Furnace	38	13	13-19	13	11
	Electric Furnace	38	13	13-19	13-25	11
	Electric Baseboard	38	13	13-19	13	11
	Heat Pump	30-38	13	13	13	11
	LPG Furnace	38-49	13	13-30	13-25	11

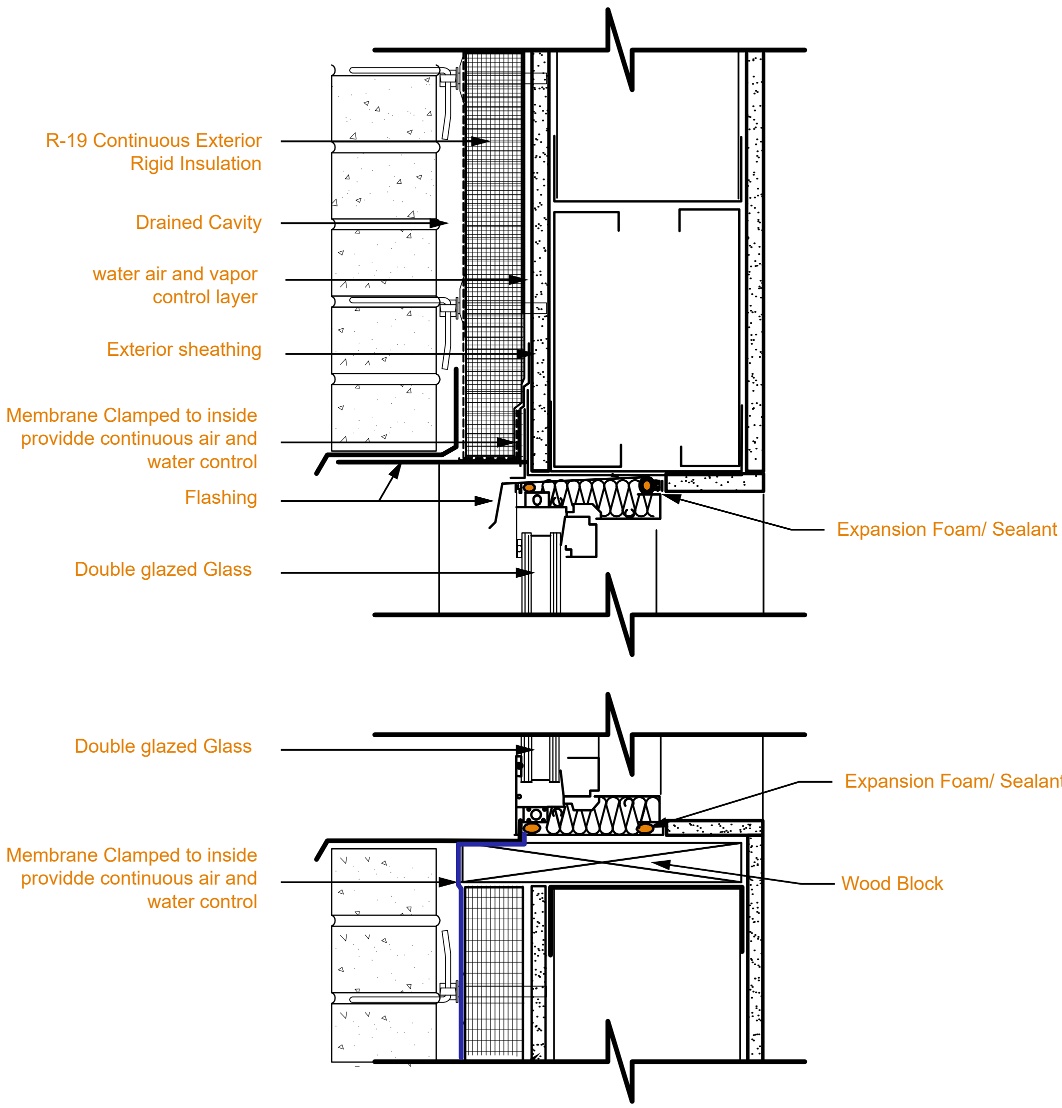
According to Energy Star, the site is located at zone 3. The sugguest wall R value is 13; roof is **38 (5 -1/4" Polyisocyanurate foil-faced)** . San francisco generally is under comfort temperature zone. Therefore, we increase Wall **R value to 19 (3 -1/2" Polyisocyanurate foil-faced)** , which will have a better performance for insulating.

The Wall & Roof detail is designed based on the article " BSI-001: The Perfect Wall " (website: http://buildingscience.com/documents/insights/bsi-001-the-perfect-wall#Fig02)

The reason why we chose metal stud structure w/ concrete floor over metal decking, is because we will like to use hydronic concrete floor heating system which is generated by solar thermal collector. It has a better efficiency than solar PV.

"Great Day Improvements - General Home Improvement Contractors & Builders In Chicago IL, Cleveland OH, Atlanta GA, New York NY, & More." Insulation R Value Chart. Web. 25 Sept. 2015. <http://www.greatdayimprovements.com/insulation-r-value-chart.aspx>.

2C. BUILDING ENCLOSURE DETAILS



2 WINDOW HEAD & SILL DETAIL SCALE: 2" = 1' - 0"

2D. END USE BREAKDOWN & 2G RENEWABLE ENENGY

As part of the Task 2 Energy Performance Documentation submittal, for each proposed building, provide annual energy use broken down by major end uses such as HVAC, lighting, domestic hot water, appliances, and miscellaneous electric loads. Please include the table below to summarize your calculations. Describe any measures taken to controls systems such as lighting and plug loads.

	Design Load*		Calculated Energy Use (Btu/sf/year)	
End Uses				
HVAC	---------------		7,637	
Lighting	613	W/sf	2,092	
Appliances and Plug Loads	2,304	W/sf	7,860	
Domestic Hot Water	15,480	gal/per/day	9,004	
TOTAL	---------------		26,593	
Renewable Production	---------------	---------------	15,655	(14,063+1,592)
Net EUI	---------------	---------------	10,938	

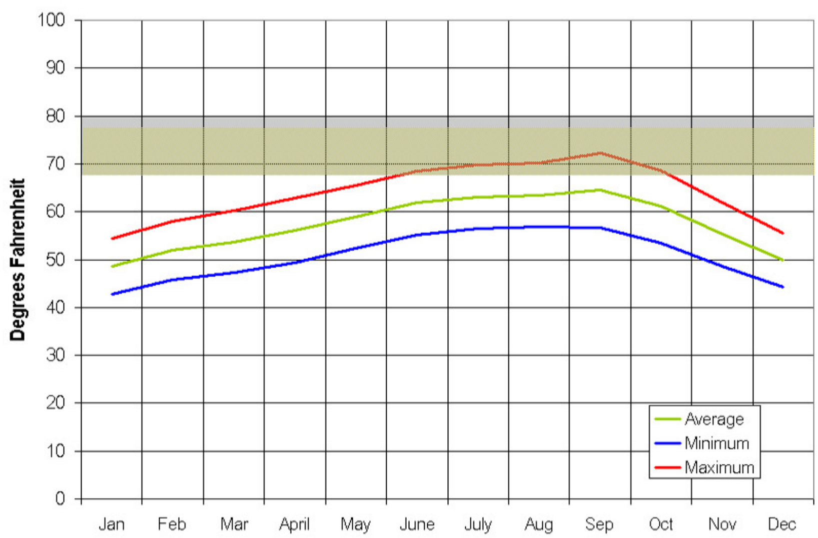
According to "The Technical Feasibility of Zero Net Energy Buildings in California". the target for Lowrise multifamily is **16.3 kBtu/sf/year** (p.75)

Our caculation shows **10.9KBtu/sf/year** because we used the most roof area for solar thermal collectr which has approximately 44% efficiency of collecting solar energy comparing to around 16% of solar PV. Please review our caculations on next page.

HVAC

Based on the temperture and huminity data conducted by PG&E(see below), we find out that the temperature of San francisco is mostly under the comfort zone. However, humidty is perfectly maintained under the comfort zone for entire year. Therefore, we belive that the primary HVAC stratgey should be heating, ventilating .

Temperature
(Typical Comfort Zone: 68-80°F)



Relative Humidity
(Typical Comfort Zone: 20-80%)

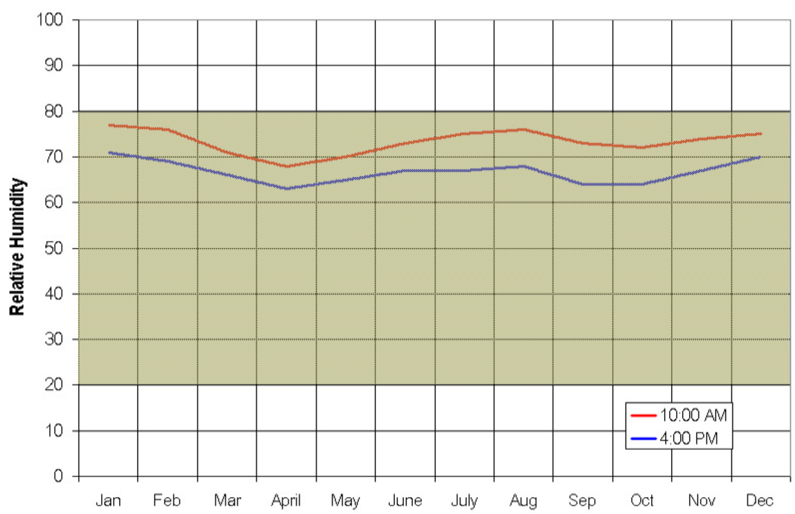
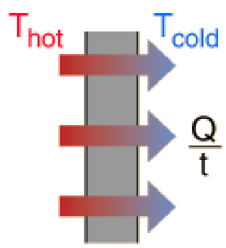


Diagram Citation: *"Pacific Gas & Electric - PG&E." Guide to California Climate Zones. Web. 17 Sept. 2015. <http://www.pge.com/myhome/edusafety/workshopstraining/pec/toolbox/arch/climate/index.shtml>.*

HVAC



$$\text{Heat loss rate} = \frac{Q}{t} = \frac{(\text{Area}) \times (T_{inside} - T_{outside})}{\text{Thermal resistance of wall}}$$

if Q/t is in BTU/hr
Area in ft^2
$T_{in} - T_{out}$ in °F

then the thermal resistance is the "R-factor" quoted by insulation manufacturers. The units of the "R-factor" are

$$\frac{ft^2 \times °F}{BTU/hr}$$

For standard R11 wall insulation, you lose 1/11 BTU/hr per square foot of wall space, per degree Fahrenheit temperature difference.

Past Temperature San Francisco - 2014 (usclimatedata.com)

MONTHS	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Temperature per Month (°F)	53.2	46.3	52.65	49.5	52.4	48.5	50.5	59.1	56.4	49.4	53.15	49.05

Average Temperature per Year(°F)	51.68
Temperature Target (°F)	70
Difference (°F)	18.32

HEATING REQUIRED BTU/SF/YEAR

A	B	C	(AxB)/C = D	D x 24 = E	F	E x F = G	G / A = H	H/3412=I
Area	Temperature difference Average in a year	Thermal resistance of wall (R19 recommended bythe U.S. Department of Energy)	Heat loss rate	Heat loss per day	days need to be heated in a year	BTU required / year	BTU / sf / year	kwh/sf/year
Total sf	°F	sq ft x °F / (BTU/hr)	BTU/hr	BTU/day	days	BTU / year	BTU / sf / year	kwh/sf/year
378,618	18.32	19	365,084	8,762,018	330	2,891,465,811	7,637	2.24

TOP - Fomula Citation: *"Calculating Home Heating Energy." Home Heating Energy. Web. 17 Sept. 2015. <http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heatloss.html>.*

Bottom - **San Francisco Temperature Citation:** *"San Francisco 2014 Temperature - Precipitation - Sunshine - Snowfall." Climate San Francisco. Web. 17 Sept. 2015. <http://www.usclimatedata.com/climate/san-francisco/california/united-states/usca0987/2014/1>.*

LIGHTING LOAD

		A	B	C	D	E	F	H	K	L
	Appliance, tool, light etc.	RUNNING WATTS	UNITS	TOTAL WATTS	Hours used per day	Watt Hours per day	Watt Hours per year	Area	WH/sf/ year	BTU/sf/ year
				= A X B		= C X D	= E X 365	sf	= G / H	= K x 3.412
	LIGHTING									
1	LED - RESIDENT (**50K HRS**)	10	9000	90000	4	360000	131400000	378,618	347.052	1184.14
2	LED - PUBLIC (50K HRS) SURFACE MOUNTED	25	1200	30000	8	240000	87600000	378,618	231.368	789.43
3	FLOOD LIGHT	150	30	4500	8	36000	13140000	378,618	34.705	118.41
4	Exit and Emergency light	5	250	1250	0.5	625	228125	378,618	0.603	2.06
								Total	613.12	2091.98

APPLIANCE LOAD

		A	B	C	D	E	F
	Appliances and Plug Loads						
	Appliance, tool, light etc.	Annual average	Units	Total KWH	Area	WH/sf/ year	BTU/sf/ year
				= A X B	sf	= (C/D) x 1000	= E x 3.412
	LAUNDRY						
1	Washing machine	400	29	11600	378,618	30.638	104.54
2	Clothes dryer - gas	400	29	11600	378,618	30.638	104.54
3	Hair dryer	25	450	11250	378,618	29.713	101.38
4	Iron	60	100	6000	378,618	15.847	54.07
5	Vacuum	48	523	25104	378,618	66.304	226.23
	KITCHEN						
1	Refrigerator	672	523	351456	378,618	928.260	3167.22
2	Blender	20	350	7000	378,618	18.488	63.08
3	Coffee maker	60	350	21000	378,618	55.465	189.25
4	Dishwasher - hot dry	156	350	54600	378,618	144.209	492.04
5	Disposal	9	350	3150	378,618	8.320	28.39
6	range top - electric	200	350	70000	378,618	184.883	630.82
7	Microwave	132	350	46200	378,618	122.023	416.34
8	Toaster	26	350	9100	378,618	24.035	82.01
9	Convection Oven	220	350	77000	378,618	203.371	693.90
	LIVING						
1	Color TV (LCD) 44"	558	250	139500	378,618	368.445	1257.14
2	Printer	20	120	2400	378,618	6.339	21.63
3	X-Box, Game Cube, Playstation, Wi	70	120	8400	378,618	22.186	75.70
4	Computer and monitor	80	120	9600	378,618	25.355	86.51
5	Laptop/notebook	12	500	6000	378,618	15.847	54.07
6	iPad - tablet - smart phone charging	2	600	1200	378,618	3.169	10.81
				72680.00	**Total**	2303.54	7859.66

Lighting&Appliance KWH/ year Citation: *"Electric Usage Chart." Web. 17 Sept. 2015. <https://www.efficiencyvermont.com/for-my-home/ways-to-save-and-rebates/appliances/refrigerators/General-Info/Electric-Usage-Chart>.*

Domestic Hot Water

Type of building	Consumption per occupant		Peak demand per occupant		Storage per occupant	
	liter/day	gal/day	liter/hr	gal/hr	liter	gal
Factories (no process)	22 - 45	5 - 10	9	2	5	1
Hospitals, general	160	35	30	7	27	6
Hospitals, mental	110	25	22	5	27	6
Hostels	90	20	45	10	30	7
Hotels	90 - 160	20 - 35	45	10	30	7
Houses and flats	90 - 160	20 - 35	45	10	30	7
Offices	22	5	9	2	5	1
Schools, boarding	115	25	20	4	25	5
Schools, day	15	3	9	2	5	1

Appendix D
Cold Water Inlet Temperatures for Selected U.S. Locations

Location	Avg. Cold Water Inlet Temperature (° F)	Location	Avg. Cold Water Inlet Temperature (° F)	Location	Avg. Cold Water Inlet Temperature (° F)
Anchorage, AK	38.6	Boston, MA	59.3	Rochester, NY	57.0
Birmingham, AL	71.7	Baltimore, MD	56.8	Rome, NY	51.3
Montgomery, AL	66.4	Portland, ME	63.5	Syracuse, NY	54.7
Little Rock, AR	63.9	Detroit, MI	49.9	Watertown, NY	51.7
Phoenix, AZ	82.3	Minneapolis, MN	45.8	Columbus, HO	54.8
Los Angeles, CA	72.8	Kansas, City, MO	51.1	Oklahoma City, OK	58.8
San Diego, CA	76.2	St. Louis, MO	61.3	Portland, OR	51.6
San Francisco, CA	67.7	Biloxi, MS	64.9	Philadelphia, PA	56.0

1 gal water 1 degree	8.345	BTU

A	B	C	D	E	F	G	H	I	J
		= A x B			= E-D	= C x F x 8.345		= G/H	= I x 365
Total Tenants	gal/person in a day	Total gallons/day	Intake T (°F)	Target T (°F)	T difference	BTU/day	Area (sf)	BTU/sf/day	BTU/sf/year
774	20	15480	67.7	140	72.3	9339757	378618	25	9004

Top Citation: *"Hot Water Consumption per Occupant." Hot Water Consumption per Occupant. Web. 24 Sept. 2015. <http://www.engineeringtoolbox.com/hot-water-consumption-person-d_91.html>.*

Bottom Citation: *"Cold Water Inlet Temperatures for Selected U.S. Locations." Web. 24 Sept. 2015. <http://www.gfxtechnology.com/WaterTemp.pdf>.*

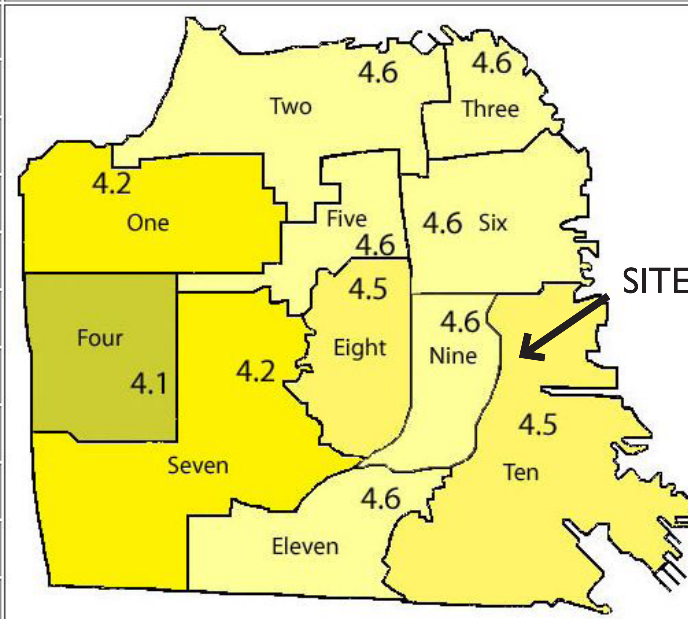
San Francisco Solar Power Map

"Make electricity while the sun shines" (anon.)

Location		Insolation		Expected AC output	
		kWh/m²/yr	kWh/m²/day	kWh/yr per kW system	kWh/day per kW system
District	zip code	(a)*	(a)/365 --- (b)	(a)x0.67 --- (c)	(c)/365 --- (d)
1	94121	1,531	4.19	1,026	2.8
2	94123	1,664	4.56	1,115	3.1
3	94133	1,679	4.60	1,125	3.1
4	94116	1,492	4.09	1,000	2.7
5	94117	1,694	4.64	1,135	3.1
6	94102	1,669	4.57	1,118	3.1
7	94116	1,524	4.18	1,021	2.8
8	94114	1,631	4.47	1,093	3.0
9	94110	1,689	4.63	1,132	3.1
10	94124	1,657	4.54	1,110	3.0
11	94134	1,671	4.58	1,120	3.1
average		**1,627**	**4.46**	**1,090**	**3.0**

Insolation

kWh/day (4.1 to 4.6) per square meter in each district (One to Eleven)



* Online data 1/1/08, this is a running average for six years.

See San Francisco solar monitoring stations. Stations 6 and 11 no longer have continuous data since 2001.
See Southwest San Francisco solar.

Regarding to Renewable Energy, we noticed that the BTU/sf/year of domestic hot water comsumption is the hgihest. Therefore, we decided to use solar thermal collector to fulfilled the demostic hotwater and heating reuirements(in floor hydronic radiant pex tubing).

The total area of the roof is **61,947 sf or 5,755 sq meter**.
About 85% of the roof area can be fully used for solar panels.
which is **52,655 sf or 4892 sq meter.**

TOP - Citation: *"San Francisco Solar Map." San Francisco Solar Map. Web. 21 Sept. 2015. <http://www.sfog.us/solar/sfsolar.htm>.*

specification

SOLAR COLLECTOR CERTIFICATION AND RATING	**CERTIFIED SOLAR COLLECTOR**	
	SUPPLIER:	**Heliodyne, Inc.** 4910 Seaport Avenue Richmond,CA94804 USA
	MODEL:	410 001
	COLLECTOR TYPE:	Glazed Flat-Plate
SRCC OG-100	CERTIFICATION#:	2007027D

COLLECTOR THERMAL PERFORMANCE RATING

Megajoules Per Panel Per Day				Thousands of BTU Per Panel Per Day			
CATEGORY	CLEAR DAY	MILDLY CLOUDY	CLOUDY DAY	CATEGORY	CLEAR DAY	MILDLY CLOUDY	CLOUDY DAY
A (-5 °C)	58.0	43.8	29.7	A (-9 °F)	55.0	41.5	28.1
B (5 °C)	53.0	38.8	24.6	B (9 °F)	50.2	36.7	23.4
C (20 °C)	45.2	31.2	17.4	C (36 °F)	42.8	29.6	16.5
D (50 °C)	30.1	17.4	5.3	D (90 °F)	28.6	16.5	5.0
E (80 °C)	16.5	5.5	0.0	E (144 °F)	15.6	5.5	0.0

Original Certification Date: 17-OCT-07

COLLECTOR SPECIFICATIONS

Gross Area:	3.730 m^2	40.15 ft^2
Dry Weight:	69.4 kg	153. lb
Test Pressure:	1103. KPa	160. psg

Net Aperature Area:	3.48 m^2 37.48 ft^2
Fluid Capacity:	5.1 liter 1.3 gal

COLLECTOR MATERIALS

Frame:	Aluminum Extrusion
Cover (Outer):	Low Iron Tempered Glass
Cover (Inner):	None

Pressure Drop

Flow		ΔP	
ml/s	**gpm**	**PA**	**in H_2O**

Absorber Material:	Tube - Copper / Plate - Aluminum
Absorber Coating:	Sputtered Selective

Insulation Side:	Isocyanurate Foam
Insulation Back:	Isocyanurate Foam & Fiberglass

TECHNICAL INFORMATION

Efficiency Equation [NOTE: Based on gross area and (P)=Ti-Taj]

				Y INTERCEPT	SLOPE
S I UNITS:	**η= 0.733**	**-3.40810 (P)/I**	**-0.01055 $(P)^2/I$**	**0.739**	**-4.21 $W/m^2 \cdot °C$**
I P UNITS:	**η= 0.733**	**-0.60034 (P)/I**	**-0.00103 $(P)^2/I$**	**0.739**	**-0.70 $Btu/hr.ft^2 \cdot °F$**

Incident Angle Modifier [(S)=1/cosθ - 1, 0°<θ<=60°]

Kα = 1	0.058 (S)	-0.274 $(S)^2$
Kα = 1	-0.23 (S)	Linear Fit

Model Tested:	Gobi 336 001
Test Fluid:	Water
Test Flow Rate:	49.8 ml/s 0.79 gpm

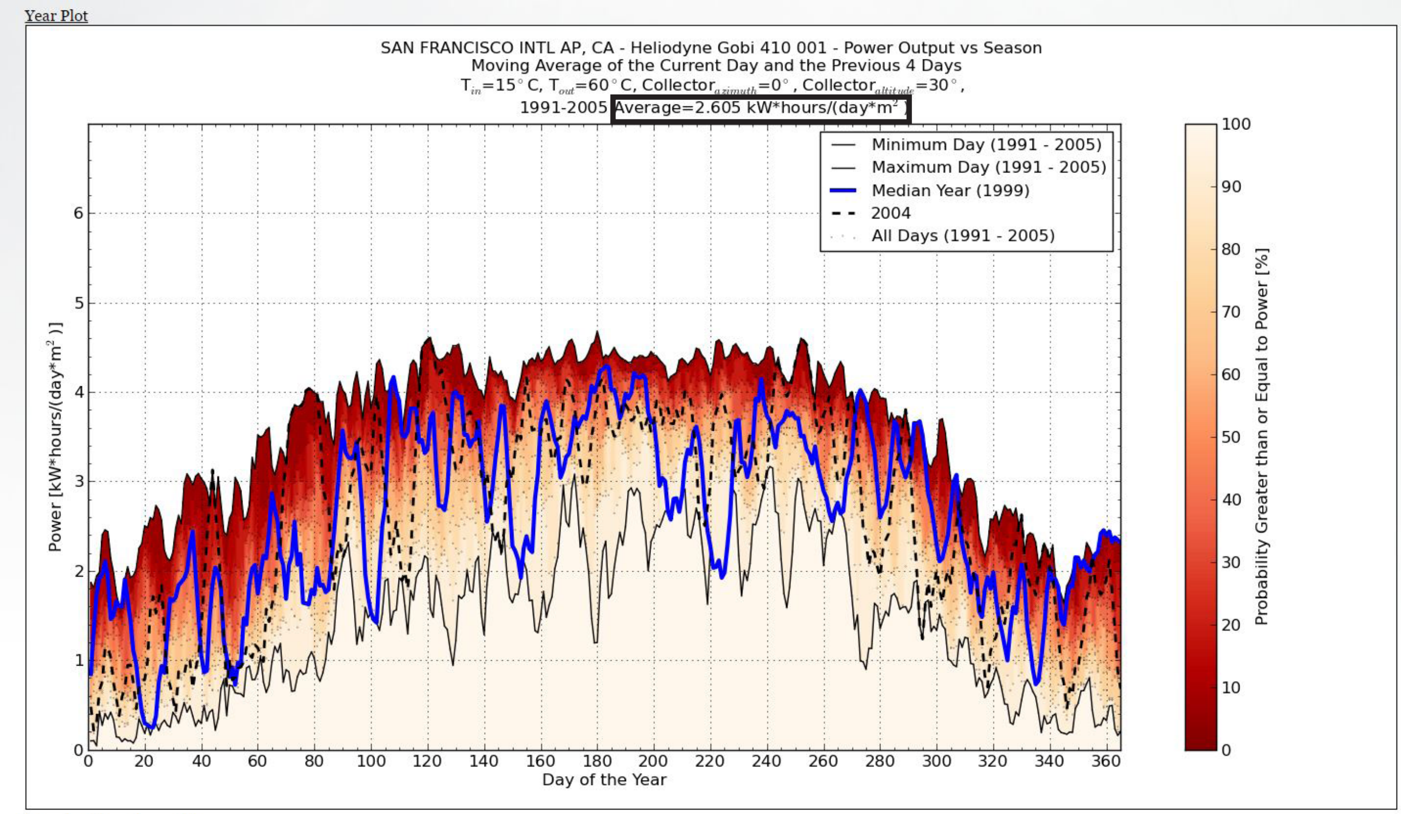
REMARKS:

January, 2010

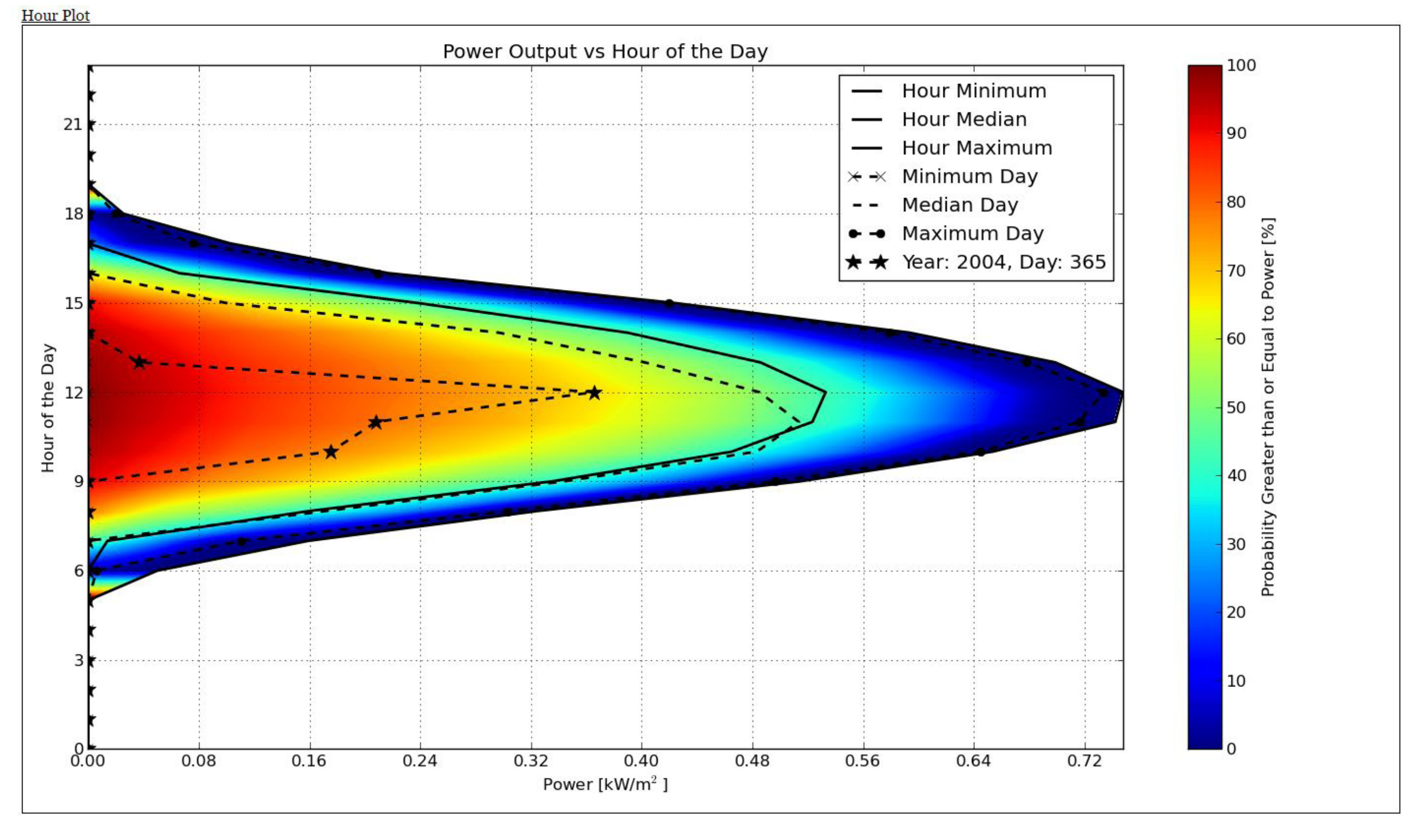
Citation: *""Andy Schroder - Solar Collector Power Output." Andy Schroder - Solar Collector Power Output. Web. 24 Sept. 2015. <http://andyschroder.com/*

Energy generated by per solar thermal collector /per panel /per

Year Plot

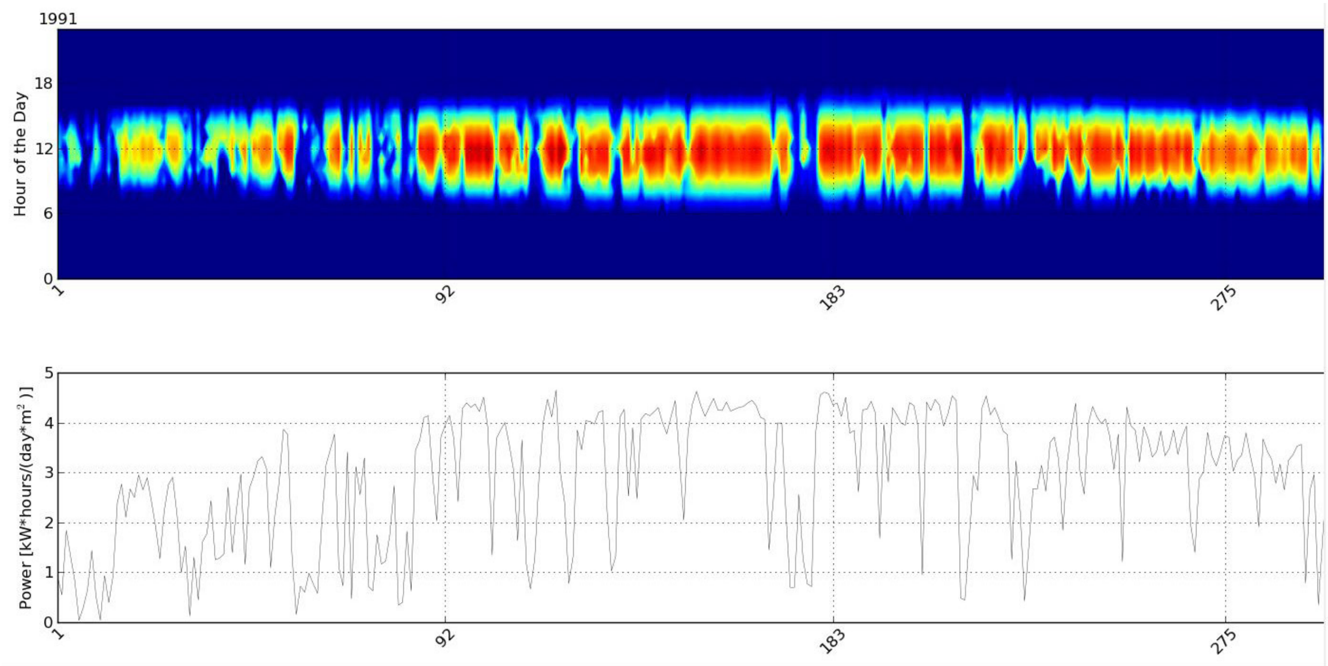


Hour Plot



Citation: *""Andy Schroder - Solar Collector Power Output." Andy Schroder - Solar Collector Power Output. Web. 24 Sept. 2015. <http://andyschroder.com/SolarEnergyResearch/SolarCollectorPowerOutput>*

kwh/day/m2 - within 365 days



Caculation

Proposed method to calculate the annual production of solar thermal energy in kWh:

As a function of the installed solar collector area:

Un-glazed collectors:	***0,29 * H0 * Aa***
Glazed collectors in DHW systems:	***0,44 * H0 * Aa***
Glazed collectors in combi-systems:	***0,33 * H0 * Aa***

Being:

H0: Annual global solar irradiation on horizontal the given location in kWh/m²

Aa : Collector aperture area in m²

Pnom : Nominal thermal power output of collector in kW

A	B	C	D	E	F	G	H	I
			= B x C				=365 x 1000 x((ExG)/F)	= Hx3.412
Energy gernated per m2 per day	Area per panels	Total panels	Total Area	Total kwh in a day	Floor Area	Perfermance Ratio	wh/sf in a year	BTU/sf/year
kwh/m2/day	m2	units	m2	kwh/day	sf		wh/sf/year	BTU/sf/year
2.605	3.73	1000	3730	9,717	378618	0.44	4,121.55	14,063

14,063 BTU/sf/year is almost sufficiant for domestic hot water and heating the space

Citation: *““Andy Schroder - Solar Collector Power Output.”Andy Schroder - Solar Collector Power Output. Web. 24 Sept. 2015. <http://andyschroder.com/SolarEnergyResearch/SolarCollectorPowerOutput>*

RENEWABLE ENERGY - Solar PV

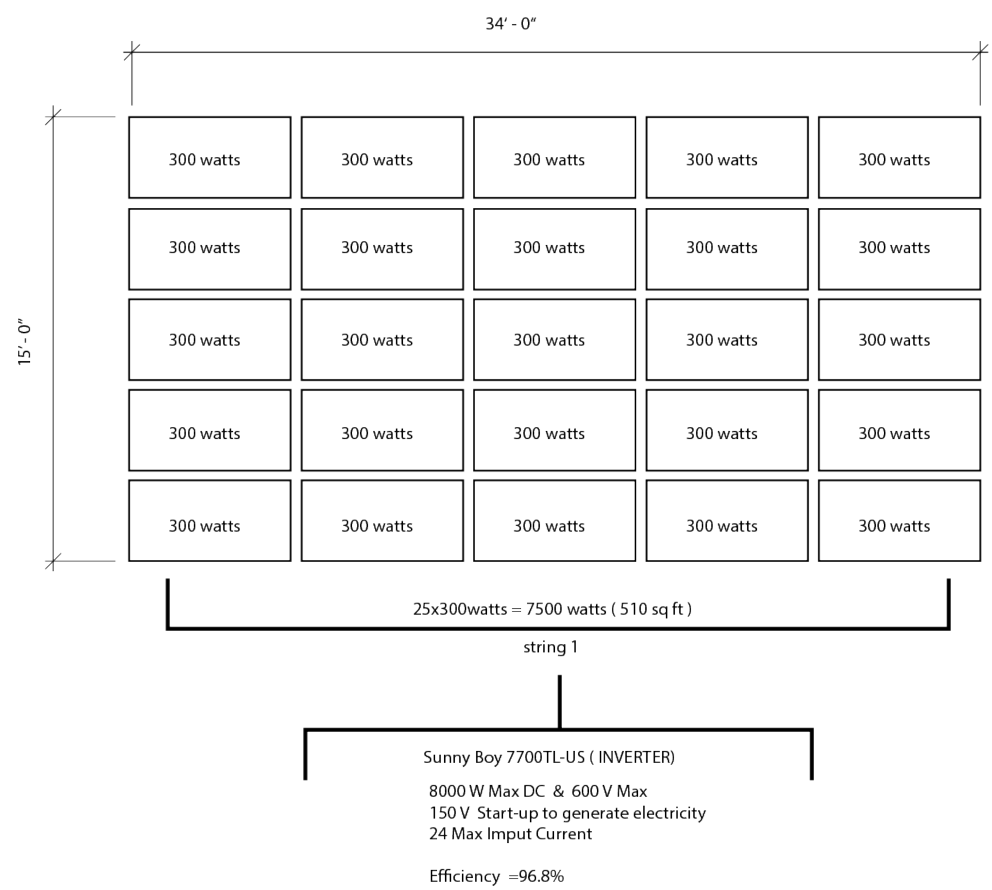
SOLAR PANNEL MODEL NUMBER	CS6X-300P
Nominal Max Power (Pmax)	300 watts
ptimum Operating Voltage (Vmp)	36.1V
Optimum Operating Current (Imp)	8.30A
Open Circuit Voltage (Voc)	44.6V
Short Circuit Current (Isc)	8.87A
Module Efficiency	15.63%
Maximum System Voltage	1000V (IEC) /600V (UL)
Maximum Series Fuse Rating	5A
Cell Type	Poly-crystalline 156 x 156mm,3 or 4 Busbars
Cell Arrangement	72 (6 x 12)
Dimensions	1954 x 982 x 40mm or (76.93 x 38.7 x 1.57in)
Area	1.918 sq meter or 20.67 sq ft
Weight	50.7 lbs (23kg)
Connectors	MC4 or MC4 Comparable

INVERTER MODEL NUMBER	Sunny Boy 7700TL-US
Nominal Max DC Power	7300 W
Max. DC voltage	600 V
Min. DC voltage / start voltage	125 V / 150 V
CEC efficiency	96.50%

// After installinng solar thermal collector. we will like to use the rest roof area for solar PV. In order to give a more specific eletricity generated by PV. We have selected two more common device. One is soalr panel made by Cannadian Solar (CS6X-300P) and the other one is a inverter unit made by Sunny Boy. Below , it is a string of solar panels, which is 34' x 15'. we can install 20 strings of them.

The total area : 20 x 34ftx15ft = <u>10200 sq ft</u>

which equals to <u>948 sq meter</u>



Calculation of the solar PV energy ouput of a photovoltaic system

(yellow)	Yelow cell = enter your own data
(green)	Green cell = result (do not change the value)
(white)	White cell = calculated value (do not change the value)

Global formula : **E = A * r * H * PR**

E = Energy (kWh)	176612	kWh/an
A = Total solar panel Area (m²)	948	m²
r = solar panel yield (%)	15%	
H = Annual average irradiation on tilted panels (shadings not included)*	1657	kWh/m².an
PR = Performance ratio, coefficient for losses (range between 0.9 and 0.5, default value = 0.75)	0.75	

Total power of the system 142.2 kWp

Losses details (depend of site, technology, and sizing of the system)

- Inverter losses (6% to 15 %)	8%
- Température losses (5% to 15%)	8%
- DC cables losses (1 to 3 %)	2%
- AC cables losses (1 to 3 %)	2%
- Shadings 0 % to 40% (depends of site)	3%
- Losses weak irradiation 3% yo 7%	3%
- Losses due to dust, snow... (2%)	2%
- Other Losses	0%

As a result, the renewable energy can be archived at 1,592+14,062 =15,654 BTU/sf/year.

After the break down of calculation, we are able to archive the goal of 10,938BTU/sf/year, which is slightly smaller than what Lowrise multifamily is 16.3 kBtu/sf/year.

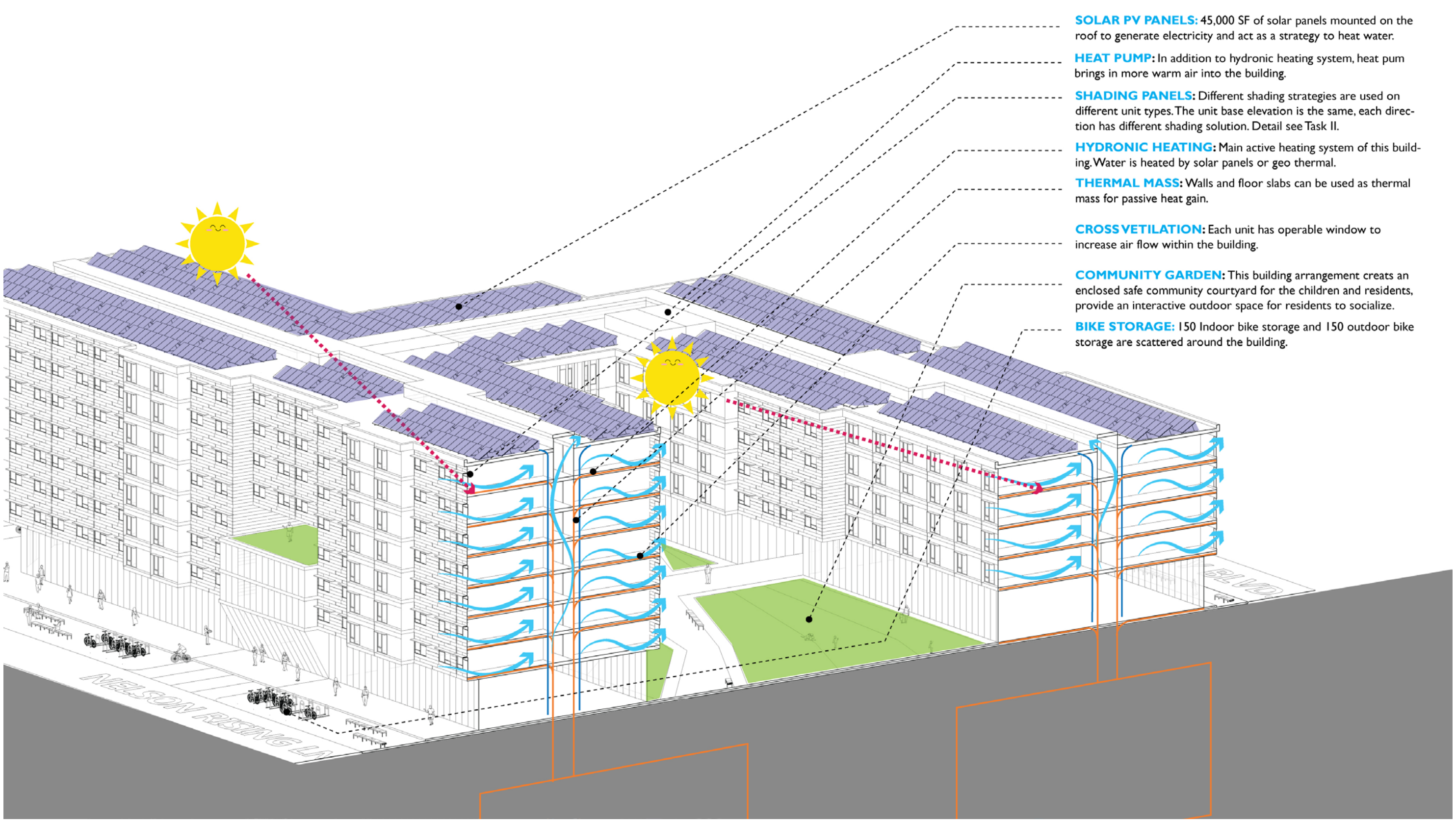
REASON:
1. sufficient roof area
2. focus on higher efficiency of solar thermal collector instead of solar PV
3. smaller WWR
4. good insulation for wall, window, and roof

A	B	C	D
		= 1000 x(A/B)	= Cx3.412
Total kwh in a year	Floor Area	wh/sf in a year	BTU/sf/year
kwh/year	sf	wh/sf/year	BTU/sf/year
176,612	378,618	466	1,592

Excel Caculator Citation: *"How to calculate the annual solar energy output of a photovoltaic system." Photovoltaic software, Web. 21 Sept. 2015. <http://photovoltaic-software.com/PV-solar-energy-calculation.php>.*

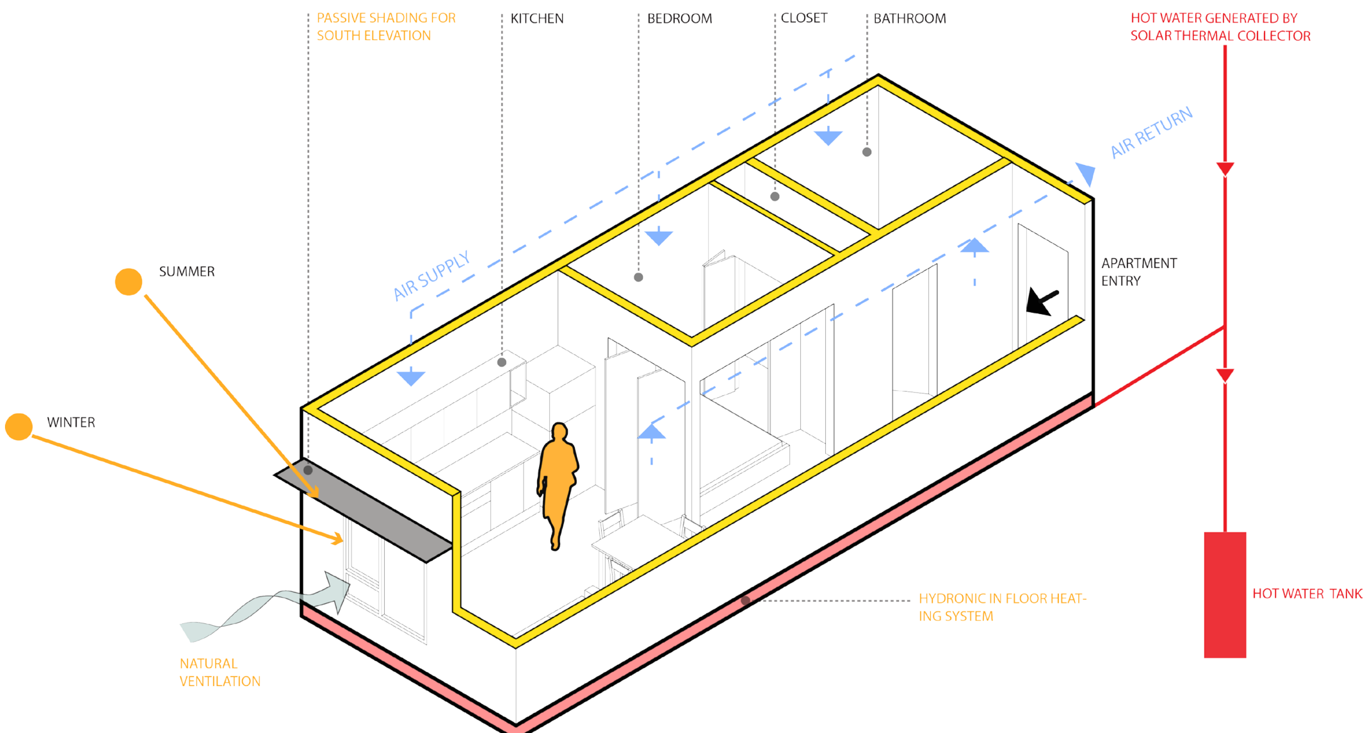
2E. BUILDING ENCLOSURE DETAILS

As part of the Task 2 Energy Performance Documentation submittal, for each proposed building, include a high-level whole building diagram depicting the major components of the HVAC system or systems serving the ground floor commercial space, the residential units, and common space (any space in the residential facility that serves a function in support of the residential part of the building that is not part of a dwelling unit, such as corridors, community rooms, mechanical rooms, and staff offices). All the spaces are heated, but only the ground floor is cooled. The HVAC system may include traditional mechanical system, emerging technologies, passive systems, or a hybrid of passive and active system



2F. DESCRIPTION AND DIAGRAMMATIC SKETCH OF RESIDENTIAL

1) how the space is heated, ventilated, and cooled (without AC); 2) how water is heated and delivered to the unit; and 3) the design of the electric lighting in the unit (not provided later by the tenants). The sketch should show the location of equipment and how hot air and water will be distributed. Provide a brief (1 page or less) written description of the approach to space heating, ventilation, and water heating of the residential units. Describe your approach to cooling the residential units and common spaces without AC.



1 BEDROOM UNITS

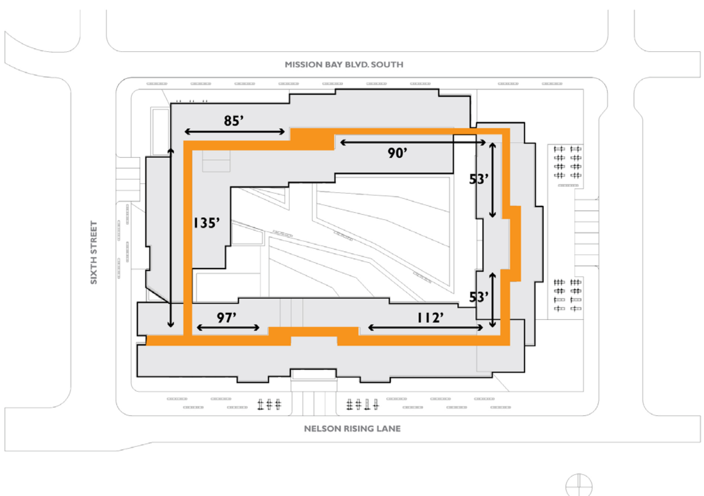
2H. OCCUPANT BEHAVIOR

Provide a brief description of aspects of each building design, if any, that are intended to influence the behavior of residents to reduce energy demand.

Sense of Community - We don't want to have this building as another residential complex like others around, we want this building could act as a connector between campus and residential community - a community nook. We maximized central courtyard space by pushing building profile to the edge of the site, leave central area as a community garden for the residents and visitors, also playground for children.

Public space - where the 3 buildings join, we created well lighted shared space for residents to hang out and social on each floor instead of staying at apartment. . Intriguing open public space with cafe and study tables, contrasts with enclosed apartment rooms. This will allow people to come out studying or hanging out, and eventually reduce lighting and video gaming electricity consumption. Moreover, the open stair is located next to the public space of each floor. It will promote using stair behavior and reduce elevator energy.

Human scale - We broke down and zig-zag the hallway in order to avoid having extremely long "Jail-look" hallways.



Long buildings will have long hallways, we intentionally broke down the hallway to multiple pieces to avoid "jail-like hallway". Non of the single run hall way is over 150', and there is always a public space at the end of hallway.