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 northeaster, 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: ______________________
Step 2: Total area of north façade: _______42,309sf_____
Window-to-wall ratio of north façade = \[rac{\text{number from step 1}}{\text{number from step 2}}\] = 0.274

**East**

Step 1: Total area of light transmitting glazing surfaces on east facade: ______________________
Step 2: Total area of east façade: _______25,354 sf_____
Window-to-wall ratio of east façade = \[rac{\text{number from step 1}}{\text{number from step 2}}\] = 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 = \[rac{\text{number from step 1}}{\text{number from step 2}}\] = 0.365

**West**

Step 1: Total area of light transmitting glazing surfaces on west facade: ________________
Step 2: Total area of west façade: _______20,408 sf_____
Window-to-wall ratio of west façade = \[rac{\text{number from step 1}}{\text{number from step 2}}\] = 0.297

**Total Building Window-to-Wall Ratio**

Step 1: Façade area\(_{\text{total}}\) = step one\(_{\text{north}}\) + step one\(_{\text{east}}\) + step one\(_{\text{south}}\) + step one\(_{\text{west}}\) = 38,629sf
Step 2: Light transmitting glazing\(_{\text{total}}\) = step two\(_{\text{north}}\) + step two\(_{\text{east}}\) + step two\(_{\text{south}}\) + step two\(_{\text{west}}\) = 122,877sf
Total window-to-wall ratio = \[rac{\text{number from step 1}}{\text{number from step 2}}\] = 0.314
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)** $E = 0.30-0.41; W = 0.30-0.41; N = \text{can} < 0.3$ due to lack of sunlight; $S = 0.30-0.41; Skylight = \text{around} 0.55$
- **Visual Light Transmittance (VLT or VT)** $E = .50; W = .50; N = .50; S(\text{up}) = .70; S(\text{view}) = .50; Skylight = .70$
- All windows operable to permit natural ventilation (no mechanical cooling required based on the climate of San Francisco see diagram in page 6)

## Type of Window & Glass

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

---

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

**East facing**

U-factor: ___________; SHGC: ___________; Visible Transmittance: ___________; **0.54**

**South facing**

U-factor: ___________; SHGC: ___________; Visible Transmittance: ___________; **0.54**

**West facing**

U-factor: ___________; SHGC: ___________; Visible Transmittance: ___________; **0.54**

**North facing**

U-factor: ___________; SHGC: ___________; 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 accommodate different unit size.

**STUDIO**

**TYPE - 1**

**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.

**I-BEDROOM**

**TYPE - 2**

**TYPE - 2A**

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

**TYPE - 2B**

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

**3-BEDROOM**

**TYPE - 3**

**TYPE - 3A**

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

**TYPE - 3B**

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

**TYPE - 3C**

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

**TYPE - 4**

**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 - 4B**

3-Bedroom north facing units don't need any shading device.
South Elevation Shading Review

angle at winter solstice 30.75°

angle at summer solstice 75.75°

optimal overhang position

D = shading depth
H = window height

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**

Legend:
- magenta: studio
- purple: 1-bedroom
- green: 2-bedroom
- yellow: 3-bedroom
- light blue: public space
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.

“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.” (BSI-001)

According to Energy Star, the site is located at zone 3. The suggested 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.

2C. BUILDING ENCLOSURE DETAILS

**WINDOW HEAD & SILL DETAIL**

**SCALE:** 2" = 1' - 0"

- R-19 Continuous Exterior Rigid Insulation
- Drained Cavity
- Water air and vapor control layer
- Exterior sheathing
- Membrane Clamped to inside provide continuous air and water control
- Flashing
- Expansion Foam/Sealant
- Double glazed Glass
- Wood Block
- Expansion Foam/Sealant
- Membrane Clamped to inside provide continuous air and water control
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.

<table>
<thead>
<tr>
<th>End Uses</th>
<th>Design Load</th>
<th>Calculated Energy Use (Btu/sf/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVAC</td>
<td>------------</td>
<td>7,637</td>
</tr>
<tr>
<td>Lighting</td>
<td>613 W/sf</td>
<td>2,092</td>
</tr>
<tr>
<td>Appliances and Plug Loads</td>
<td>2,304 W/sf</td>
<td>7,860</td>
</tr>
<tr>
<td>Domestic Hot Water</td>
<td>15,480 gal/pen/day</td>
<td>9,004</td>
</tr>
</tbody>
</table>

**TOTAL** | ------------ | 26,593 (14,063+1,592) |

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

HVAC

Heat loss rate = \( \frac{Q}{t} = \frac{(\text{Area})x(\text{T}_{\text{inside}} - \text{T}_{\text{outside}})}{\text{Thermal resistance of wall}} \)

if \( Q/t \) is in BTU/hr
Area in ft\(^2\)
\( T_{\text{in}} - T_{\text{out}} \) in °F

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

\( \text{ft}^2 \times \text{°F} \)

\( \text{BTU/hr} \)

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)

<table>
<thead>
<tr>
<th>MONTHS</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Temperature per Month (°F)</td>
<td>53.2</td>
<td>46.3</td>
<td>52.65</td>
<td>49.5</td>
<td>52.4</td>
<td>48.5</td>
<td>50.5</td>
<td>59.1</td>
<td>56.4</td>
<td>49.4</td>
<td>53.15</td>
<td>49.05</td>
</tr>
<tr>
<td>Average Temperature per Year(°F)</td>
<td>51.68</td>
<td></td>
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</tr>
<tr>
<td>Temperature Target (°F)</td>
<td>70</td>
<td></td>
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<tr>
<td>Difference (°F)</td>
<td>18.32</td>
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</tr>
</tbody>
</table>

### HEATING REQUIRED BTU/SF/YEAR

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


## LIGHTING LOAD

<table>
<thead>
<tr>
<th>Appliance, tool, light etc.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>H</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RUNNING WATTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>UNITS</strong></td>
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</tr>
<tr>
<td><strong>TOTAL WATTS</strong></td>
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<td></td>
<td></td>
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<tr>
<td><strong>Watt Hours per day</strong></td>
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<tr>
<td><strong>Watt Hours per year</strong></td>
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<tr>
<td><strong>Area</strong></td>
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<tr>
<td><strong>WH/sf/ year</strong></td>
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<tr>
<td><strong>BTU/sf/ year</strong></td>
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</tr>
</tbody>
</table>

### 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

#### Appliances and Plug Loads

<table>
<thead>
<tr>
<th>Appliance, tool, light etc.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual average</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Units</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Total KWH</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td><strong>Area</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>WH/sf/ year</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>BTU/sf/ year</strong></td>
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<td></td>
</tr>
</tbody>
</table>

#### 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 378,618 134.883 460.82
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

**Total** 72680.00 2303.54 7859.66

---

Domestic Hot Water

<table>
<thead>
<tr>
<th>Type of building</th>
<th>Consumption per occupant</th>
<th>Peak demand per occupant</th>
<th>Storage per occupant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>liter/day</td>
<td>gal/day</td>
<td>liter/hr</td>
</tr>
<tr>
<td>Factories (no process)</td>
<td>22 - 45</td>
<td>5 - 10</td>
<td>9</td>
</tr>
<tr>
<td>Hospitals, general</td>
<td>160</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>Hospitals, mental</td>
<td>110</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td>Hostels</td>
<td>90</td>
<td>20</td>
<td>45</td>
</tr>
<tr>
<td>Hotels</td>
<td>90 - 160</td>
<td>20 - 35</td>
<td>45</td>
</tr>
<tr>
<td>Houses and flats</td>
<td>90 - 160</td>
<td>20 - 35</td>
<td>45</td>
</tr>
<tr>
<td>Offices</td>
<td>22</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Schools, boarding</td>
<td>115</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Schools, day</td>
<td>15</td>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>

Appendix D

Cold Water Inlet Temperatures for Selected U.S. Locations

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

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


Regarding to Renewable Energy, we noticed that the BTU/sf/year of domestic hot water consumption is the highest. Therefore, we decided to use solar thermal collector to fulfil the domestic hot water and heating requirements (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.**
specification

SOLAR COLLECTOR CERTIFICATION AND RATING

CERTIFIED SOLAR COLLECTOR

SUPPLIER: Heliodyne, Inc.
4910 Seaport Avenue Richmond, CA 94804
USA

MODEL: 410 001
COLLECTOR TYPE: Glazed Flat-Plate
CERTIFICATION#: 2007027D

SRCC OG-100

COLLECTOR THERMAL PERFORMANCE RATING

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>CLEAR DAY</th>
<th>MILDLY CLOUDY</th>
<th>CLOUDY DAY</th>
<th>CATEGORY</th>
<th>CLEAR DAY</th>
<th>MILDLY CLOUDY</th>
<th>CLOUDY DAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (-5 °C)</td>
<td>58.0</td>
<td>43.8</td>
<td>29.7</td>
<td>A (-9 °F)</td>
<td>55.0</td>
<td>41.5</td>
<td>28.1</td>
</tr>
<tr>
<td>B (5 °C)</td>
<td>53.0</td>
<td>38.8</td>
<td>24.6</td>
<td>B (9 °F)</td>
<td>50.2</td>
<td>36.7</td>
<td>23.4</td>
</tr>
<tr>
<td>C (20 °C)</td>
<td>45.2</td>
<td>31.2</td>
<td>17.4</td>
<td>C (36 °F)</td>
<td>42.8</td>
<td>29.6</td>
<td>16.5</td>
</tr>
<tr>
<td>D (50 °C)</td>
<td>30.1</td>
<td>17.4</td>
<td>5.3</td>
<td>D (90 °F)</td>
<td>28.6</td>
<td>16.5</td>
<td>5.0</td>
</tr>
<tr>
<td>E (80 °C)</td>
<td>16.5</td>
<td>5.5</td>
<td>0.0</td>
<td>E (144 °F)</td>
<td>15.6</td>
<td>5.5</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Thousands of BTU Per Panel Per Day

COLLECTOR SPECIFICATIONS

| Gross Area: | 3.730 m² | 40.15 ft² |
| Dry Weight: | 69.4 kg  | 153 lb    |
| Test Pressure: | 1103 KPa | 160 psg |

Net Aperture Area: 3.48 m²  37.48 ft²
Fluid Capacity: 5.1 liter  1.3 gal

COLLECTOR MATERIALS

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

Pressure Drop

<table>
<thead>
<tr>
<th>Flow</th>
<th>AP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ml/s</td>
<td>gpm</td>
</tr>
</tbody>
</table>

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)ᵀ(₁)(T₁)]

S I UNITS:

θ = 0.733
(-3.40810 (P)¹ / 1 - 0.01055 (P)² / 1)
Y INTERCEPT: 0.739
SLOPE: -4.21 W/m².°C

1 P UNITS:

θ = 0.733
(-6.0034 (P)¹ / 1 - 0.00103 (P)² / 1)
Y INTERCEPT: 0.739
SLOPE: -0.70 Btu/hr.ºF²

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

K₀ = 1 0.058 (S) -0.274 (S)²
K₀ = 1 -0.23 (S) Linear Fit

REM: 0.79 gpm

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

REMARKS:

January, 2010

Energy generated by per solar thermal collector /per panel /per
RENEWABLE ENERGY - Solar Thermal

kwh/day/m² - within 365 days

Calculation

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

**As a function of the installed solar collector area:**

\[
\text{Energy generated per m}^2\text{ per day} = 0.29 \times H_0 \times A_a
\]

- **Un-glazed collectors:**
  \[0.29 \times H_0 \times A_a\]

- **Glazed collectors in DHW systems:**
  \[0.44 \times H_0 \times A_a\]

- **Glazed collectors in combi-systems:**
  \[0.33 \times H_0 \times A_a\]

**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

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy generated per m² per day</td>
<td>Area per panels</td>
<td>Total panels</td>
<td>Total Area</td>
<td>Total kWh in a day</td>
<td>Floor Area</td>
<td>Performance Ratio</td>
<td>wh/sf in a year</td>
<td>BTU/sf/year</td>
</tr>
<tr>
<td>kwh/m²/day</td>
<td>m²</td>
<td>units</td>
<td>m²</td>
<td>kwh/day</td>
<td>sf</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.605</td>
<td>3.73</td>
<td>1000</td>
<td>3730</td>
<td>9,717</td>
<td>378618</td>
<td>0.44</td>
<td>4,121.55</td>
<td>14,063</td>
</tr>
</tbody>
</table>

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

## SOLAR PANNEL MODEL NUMBER

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

## INVERTER MODEL NUMBER

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Max DC Power</td>
<td>7300 W</td>
</tr>
<tr>
<td>Max. DC voltage</td>
<td>600 V</td>
</tr>
<tr>
<td>Min. DC voltage / start voltage</td>
<td>125 V / 150 V</td>
</tr>
<tr>
<td>CEC efficiency</td>
<td>96.50%</td>
</tr>
</tbody>
</table>

After installing solar thermal collector, we will like to use the rest roof area for solar PV. In order to give a more specific electricity generated by PV. We have selected two common devices. One is solar panel made by Canadian Solar (CS6X-300P) and the other one is an 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 34ft x 15ft = 10200 sq ft which equals to 948 sq meter
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 10,938 BTU/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

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.
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.
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-like" hallways.