ØeMISSION BAY

energy performance documentation

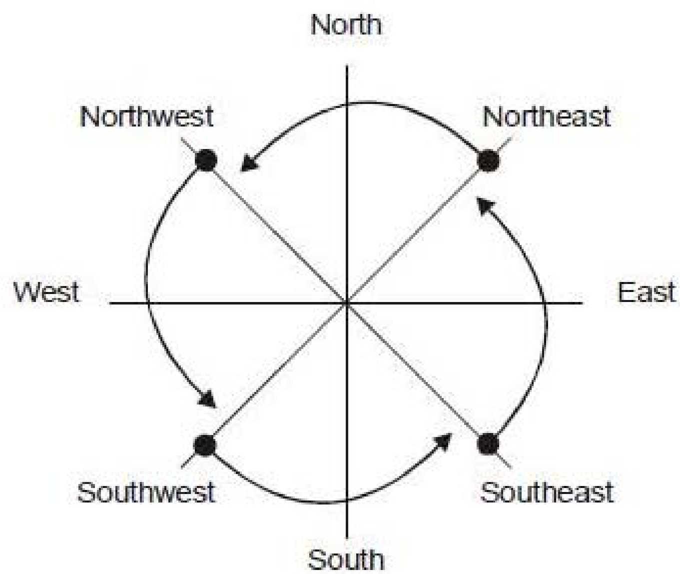
ARCHITECTURE AT ZERO 2015

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: 6,525 sf

Step 2: Total area of north façade: 13,050 sf

Window-to-wall ratio of north façade = $\frac{\text{number from step 1}}{\text{number from step 2}}$ = 50%

East

Step 1: Total area of light transmitting glazing surfaces on east facade: 35,988 sf

Step 2: Total area of east façade: 119,961 sf

Window-to-wall ratio of east façade = $\frac{\text{number from step 1}}{\text{number from step 2}}$ = 30%

South

Step 1: Total area of light transmitting glazing surfaces on south facade: 6,525 sf

Step 2: Total area of south façade: 13,050 sf

Window-to-wall ratio of south façade = $\frac{\text{number from step 1}}{\text{number from step 2}}$ = 50%

West

Step 1: Total area of light transmitting glazing surfaces on west facade: 59,980 sf

Step 2: Total area of west façade: 119,961 sf

Window-to-wall ratio of west façade = $\frac{\text{number from step 1}}{\text{number from step 2}}$ = 50%

Total Building Window-to-Wall Ratio

Step 1: Façade area$_{total}$ = step one$_{north}$ + step one$_{east}$ + step one$_{south}$ + step one$_{west}$ = 266,021 sf

Step 2: Light transmitting glazing$_{total}$ = step two$_{north}$ + step two$_{east}$ + step two$_{south}$ + step two$_{west}$ = 109,019 sf

Total window-to-wall ratio = $\frac{\text{number from step 1}}{\text{number from step 2}}$ = 41%

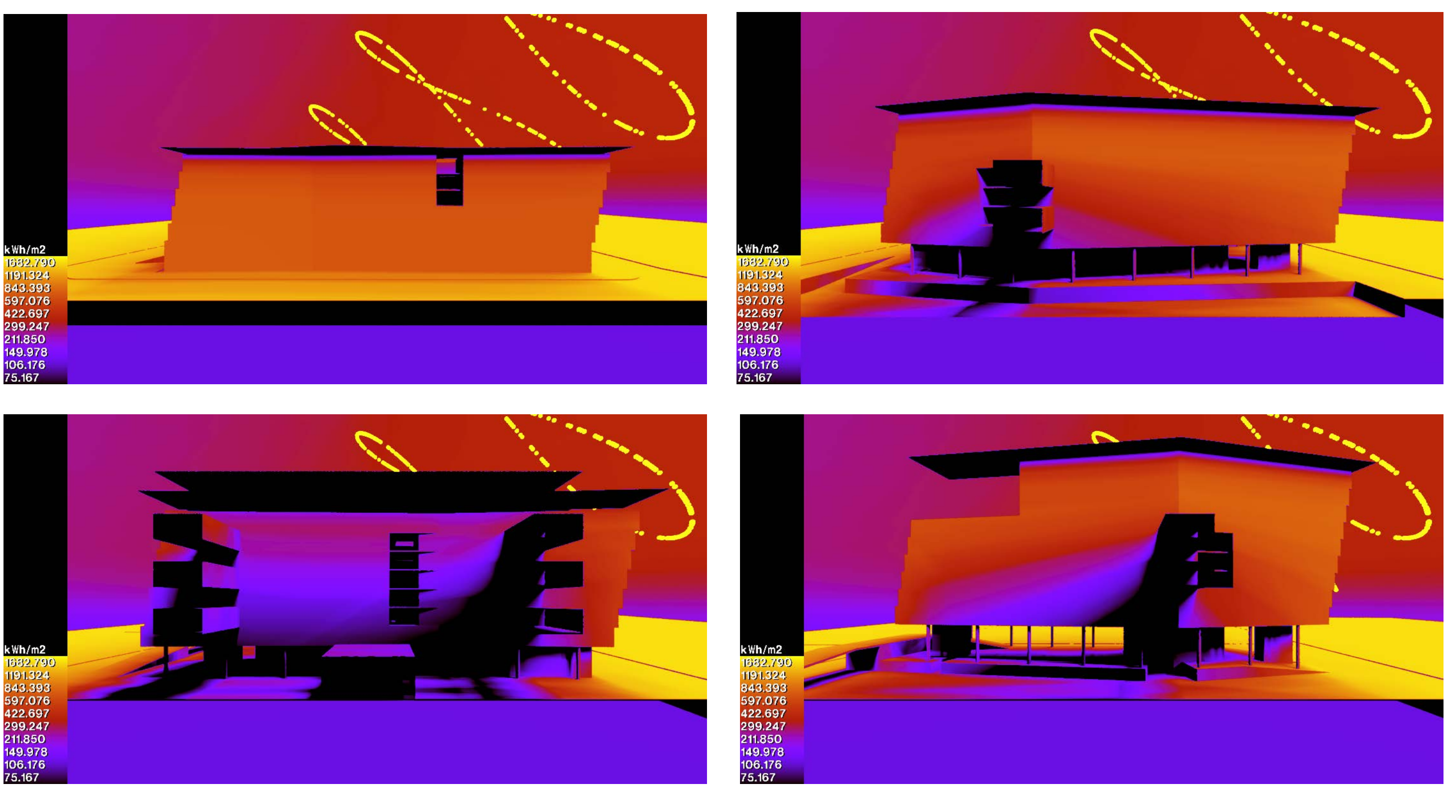
2B. Window Openings and Window Shading

The design takes an active approach to balancing visible light, solar shading, and heat loss in the window selection and façade architecture. The long facades of the buildings face primarily East and West, creating a challenging solar gain on the upper portions of the buildings. To balance the façade, an exterior screen, suspended off the glass, drapes down over the upper floors, providing shading from the Western sun when it is most intense. The screen drapes down the building as needed to control gains on floors most readily exposed to sun without inhibiting the view at the ground and lower levels.

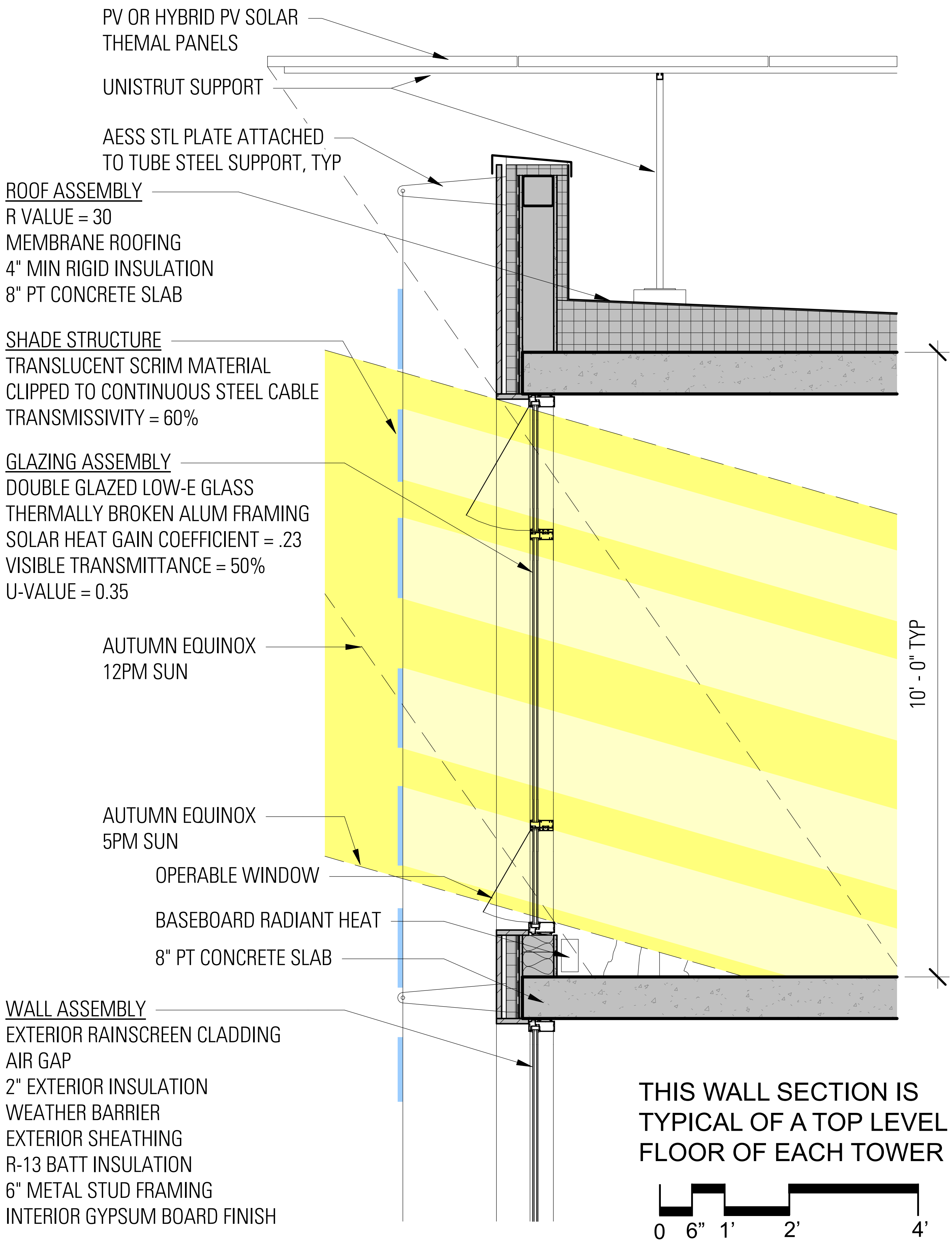
A high performance double pane glass was selected to both maximize the visible light brought in and not lose too much heat. The double-pane selection reaches an overall glass IGU performance of U-0.30 with a solar heat gain coefficient of 0.24. The double pane cavity is filled with 95% argon to provide a better insulation value and aluminum frames with thermal breaks where possible keep heating values low. This SHGC results in a visible transmittance of 51%. The selection balances high performance with a readily available product.

U-factor: 0.30 SHGC: 0.24 Visible Transmittance: 0.51

WEST FACADES - SOLAR ISOLATION ANALYSIS RESULTS



2C. Building Enclosure Details



2C. Building Enclosure Details

Wall Assemblies: These have an R-13 overall insulation value for walls only. This does not include the conductivity of the glass surfaces.

Glass Assembly: With the framing, the overall glazed assembly needs to perform at a U-value of 0.35. This is possible with a good double-pane low-e glass selection and thermally broken aluminum frames. This assembly should only require one low-e coating on the glass yet could be improved with a second low-e coating for higher performance and a lower U-value.

Glazing: Has a solar heat gain coefficient of 0.23 which will limit the visible transmittance to about 50%. This glass is similar to Solarban 90, Solarbanzn z75, VNE8-63, or Solarban 70xl on Azuria.

Shading Scrim: The exterior shade on each West façade is 60% transmissive and block 40% of the direct light. This will balance the peak cooling load to allow natural ventilation to be effective.

Roof Assembly: Each structure will have an R-30 roof. The limited area of the roof will reduce the overall heat loss of this structure in the winter. The solar canopy will provide shading in peak summer conditions. 6 to 8” of continuous insulation is provided at the roof.

Ground / Floor Assembly: At the lower level, all exposed wall sections either underground or at the base of the structure provide R-15 insulation. 3” of continuous insulation is provided to meet the recommended Code Requirements.

Exposed Under-Side Floors: Any floors or bridges that protrude based on changes in the façade line are insulated to match the wall assemblies overall performance of R-13.

2D. End Use Breakdown

Energy use was estimated using EnergyPlus 8.3 and OpenStudio. Individual models of the residential units where simulated to best align the natural ventilation cooling operations with the need for heating.

Residential Units

End Use	Design Assumptions	kWh/yr	kBtu/sf-yr
HVAC	Natural Ventilation, Radiators w/Air Source & Solar Thermal Heat Pumps		4.8
Lighting	LED Lighting with controls provided.		2.20
Refrigeration	Sunfrost super refrigerator and freezer. Lowest energy using refrigerator available.	180	0.5
Dishwasher	High efficiency ENERGY STAR units are 164 kWh/yr.	164	0.5
Clothes Washer	ENERGY STAR high efficiency shared units. 138 kWh/yr for a commercial unit. It is assumed (1) of these serves 6 units.	23	0.07
Cooking	Induction Cooktop, 60% of conventional energy assumed based against 2004 cooktop study.	362	1.0
Clothes Dryer	Heatpump dryer assumed based against typical all electric energy. Each device is shared between 6 units	40	0.1
Mis Dwelling Plugs	0.3 W/sf of mis plug loads	360	1.0
DHW			0.5

Sum	10.7

Mixed Use First Floor

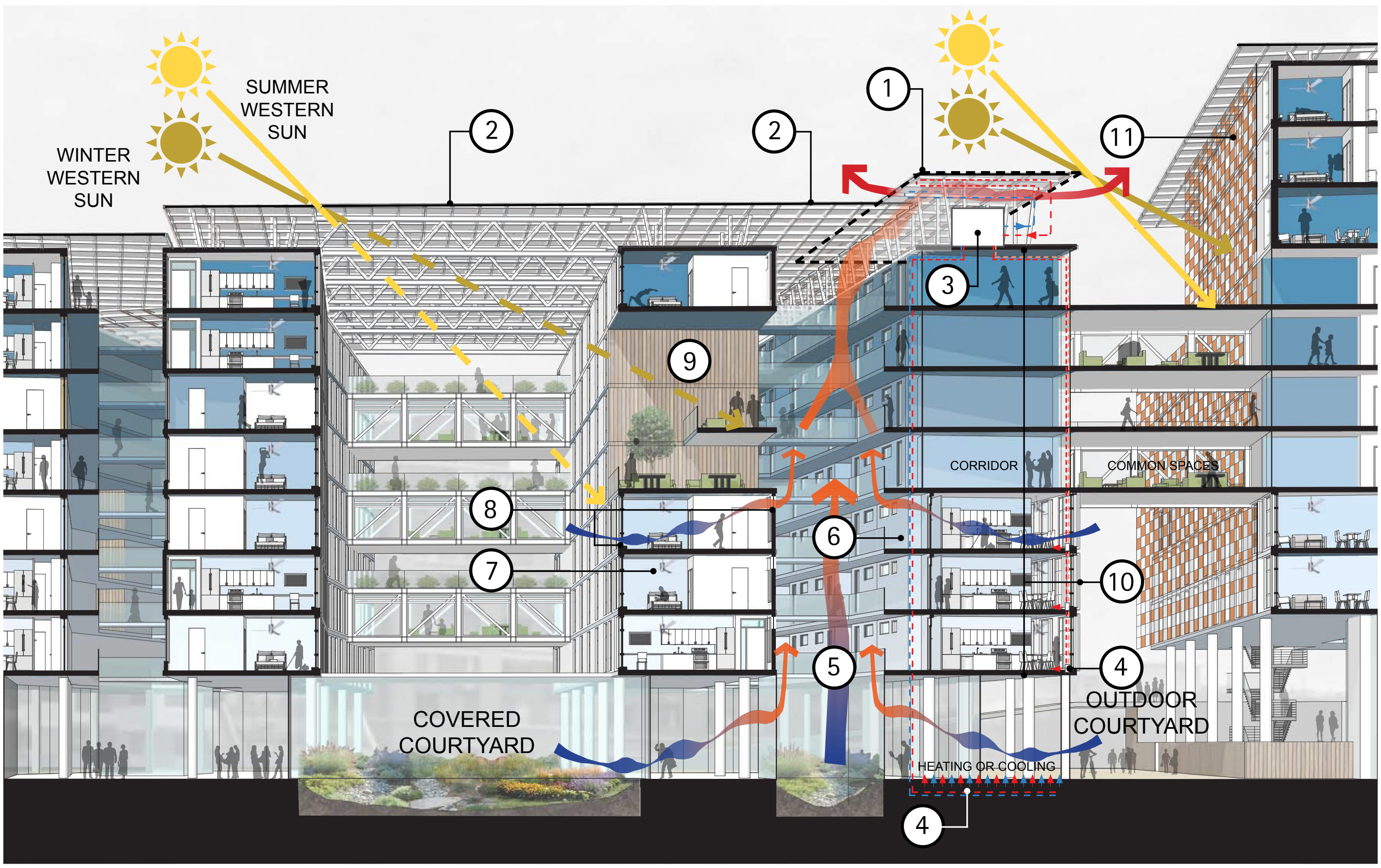
End Use	Design Assumptions	kWh/yr	kBtu/sf-yr
HVAC 1st Floor	In-Slab Radiant provides heating and cooling with dedicated outside air for ventilation. The same hot water plant.		11
Lighting	LED Lighting with active daylighting controls		3.5
Plug Loads	1 W/sf of high efficiency equipment with plug load controls on outlets.		6
DHW	High efficiency hot water use and ASHP source.		3

Sum	23.5

2E. Description and Diagram of Whole Building Heating and Cooling System

From the beginning, the design strategy is to create a multi-use building that can reach zero net energy with today's best practices and be resilient and adaptable, ready for changes in climate, how people live, and the aging of systems and structures.

The design reaches net zero energy by implementing simple yet highly effective strategies to balance energy use and equip tenants and facility leaders to be empowered to manage their energy footprint. The primary design was to provide passive cooling and comfort control coupled with a highly efficient and robust way to heat and keep people warm.



1. **HYBRID PV / T PANELS**
Area required for domestic hot water production uses a combined panel system (Hybrid PV/T) raising the efficiency of the PV and reducing the footprint of the array. The remainder of the array is made up of 100% PV panels

2. **50% PV COVERAGE & POLYCHROMATIC GLASS**
PV cells covering half of the area are laminated in polychromatic glass which effectively captures and distributes daylight into covered courts and light wells

3. **HIGH EFFICIENCY HEAT PUMP PLANT**
Each building has a very high efficiency system combining solar thermal panels with hot water produced with heat pumps and transferred to living units and podium functions via hydronic piping

4. **RADIANT HEATING AND COOLING**
Perimeter baseboard radiators provide heat to all living units. In-slab hydronic loop provides radiant heating and cooling for the podium functions. Both are connected to the rooftop heat pump plant

5. **COVERED LIGHTWELL**
PV array provides weather protection and creates a low pressure zone to promote convection and stack effect for natural ventilation through the units

6. **COLOR GRADATION FOR DAYLIGHT PENETRATION**
Light well walls are given lighter colors at lower levels, gradually darkening as they rise through the building

7. **CEILING FANS & LED LIGHTING**
Fans Creates air movement to lower perceived indoor temperature and augment air movement from convection. 100% LED lighting minimizes lighting power density

8. **NATURAL VENTILATION/OPERABLE WINDOWS**
Single loaded corridor layout provides through units. Air flow enters operable windows - moves freely through the units - passively exhausts through bathrooms into light well

9. **SKY GARDENS**
Each building has openings through the floor plan that are outdoor gardens horizontally connecting the courts to the lightwells and allowing daylight and airflow to reach the light wells

10. **HIGH PERFORMANCE ENVELOPE**
Roof, exterior walls, and elevated floors all recieve mineral wool insulation and are completely sealed against infiltration of air and moisture. Window systems use U - .35 Glass Assembly with Tvis = 50% and SGHC = .23

Roof	= R - 40
Walls	= R - 13 (*not including glass conductivity)
Floor	= R - 13 (*for elevated slabs)

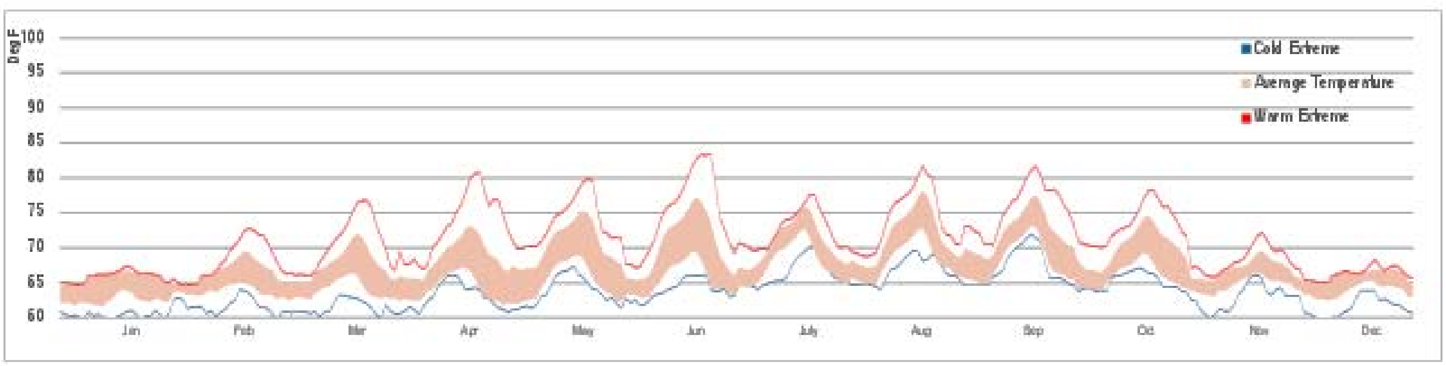
11. **SHADING SCRIM**
An external perforated scrim, the form optimized by solar insolation analysis, is suspended outboard of exterior wall. Window opening sizes on west, north, and south are consistent based upon results of shading analysis

2F. Description and Diagrammatic Sketch of Residental Unit Systems

Each residential unit will be provided with operable windows and ceiling fans to provide passive cooling and airflow. Heating will be provided by a low hot water radiator, located along the perimeter of the units. These units will be piped with medium temperature hot water, supplied at 90-105 deg F for heating. Heating will be provided from a building hot water plant, located on the roof with pipes risers connecting the units. Domestic hot water we be served from this same roof hot water plant at a higher temperature.

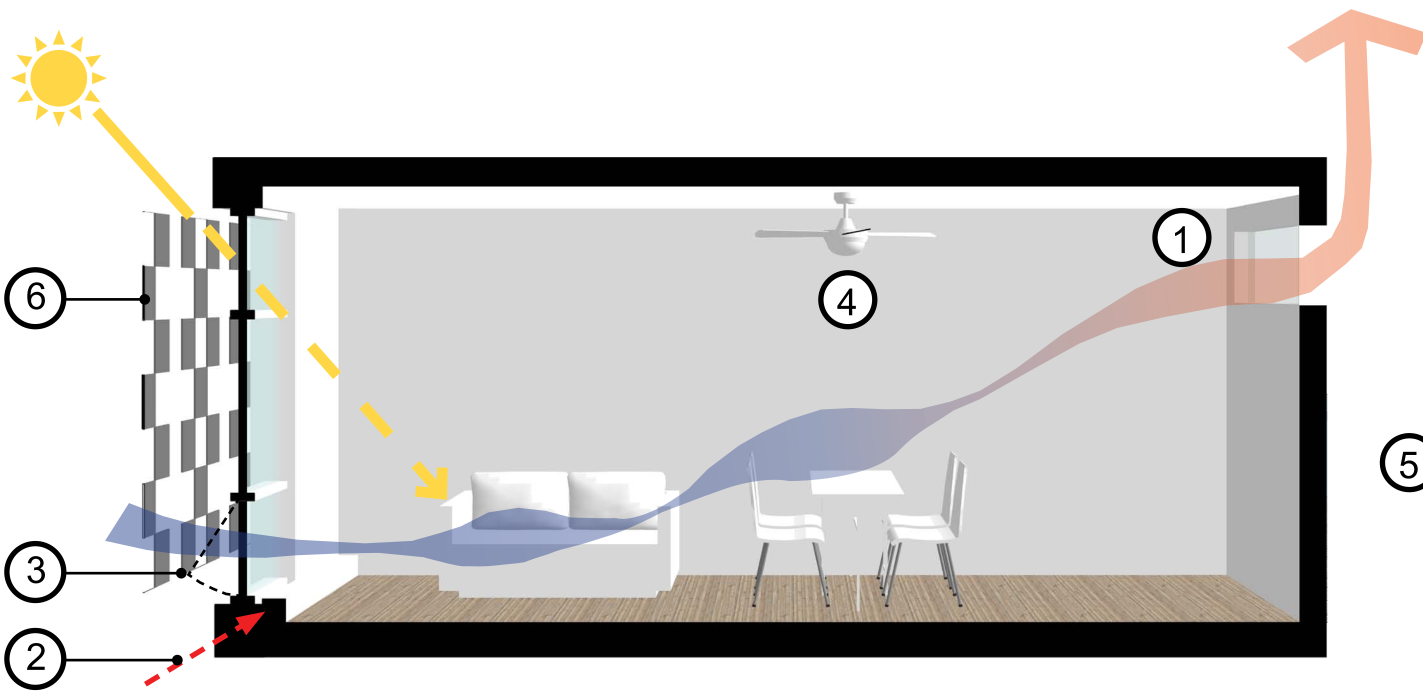
The basis of design lighting system will use high efficacy LED fixtures and provide tenants with active dimming and controls. Daylighting will be highly available in each unit and greatly reduce the amount of electric lighting needed in the daytime. Plug load equipment is specified to be high efficiency with built in stand-by and off settings.

Residencies are anticipated to float in temperature to provide an expanded thermal comfort range. The design is based on leading practices in thermal comfort criteria, set by ASHRAE 55 and CIBSE to ensure occupant satisfaction and engagement. The simulated model maintains comfort with temperatures ranging from mid 60s in winter to low 80s on the warmest days.



Annual Residential Unit Temperatures

2F. Description and Diagrammatic Sketch of Residental Unit Systems



1. **PASSIVE STACK EXHAUST:** Single loaded corridor combined with operable windows allows for natural cross ventilation throughout the unit and on those occasions with warmer or hot weather in San Francisco, the window placement aids night flushing of the unit for greater occupant comfort.
2. **HYDRONIC BASEBOARD RADIATOR:** Part of a shared solar thermal domestic hot water loop which uses water as a highly efficient means to transfer heat from the centralized solar thermal panels. Placement beneath the window helps to temper any radiation of cold which may be felt by the occupant.
3. **OPERABLE WINDOWS:** Allows for natural ventilation. Using low/high placement of operable panes, in combination with operable panes at the opposite side of the unit, permits occupants a high degree of control, expanding the comfort range and improving Indoor Air Quality (IAQ) contributing to increased occupant comfort and wellness.
4. **CEILING FANS:** Very low energy devices providing increased air movement and greater occupant control for an expanded comfort range, improved Indoor Air Quality (IAQ) and contributing to increased occupant comfort and wellness.
5. **LIGHT WELLS:** Opening up the circulation side of the traditional double-loaded corridor allows for cross ventilation of units, provides more natural light over more of the interior (greater daylight autonomy) and helps balance the daylighting for a higher quality of light.
6. **SHADING SCRIM:** Translucent, lightweight and durable panels, suspended on cables in front of the south and west facades, the density of the scrim directly responds to the annual solar insolation falling on the façade, allowing all units to maintain a maximum amount of glass while still maintaining a comfortable interior environment. On the north and east facades, the solar insolation is lower so the scrim is not required and the interior comfort can be maintained with a high performance envelope and glazing.

2G. Renewable Energy

Renewable energy is provided targeting aggressive energy performance goals for the residential and ground floor. Energy is generated through three different sources of electric and hot water solar sources at the roof:

1. **Highest efficiency flat solar PV panels** – based on a sunpower panel above 20% efficient

2. **Transparent PV panels** – half the efficiency with transmitted light to corridors below

3. **Hybrid PV / solar thermal panels** – built into one unit, these panels make hot water and produce electricity. They provide preheat to water and the air source heat pumps used to heat the building.

	Energy	kW	Area sf
High Effic Solar Panels	85%	763	41,000
Low Effic Solar Panels	9%	170	18,200
Solar PV and Hot Water*	6%	68	4,500

Panel Area sf	63,700

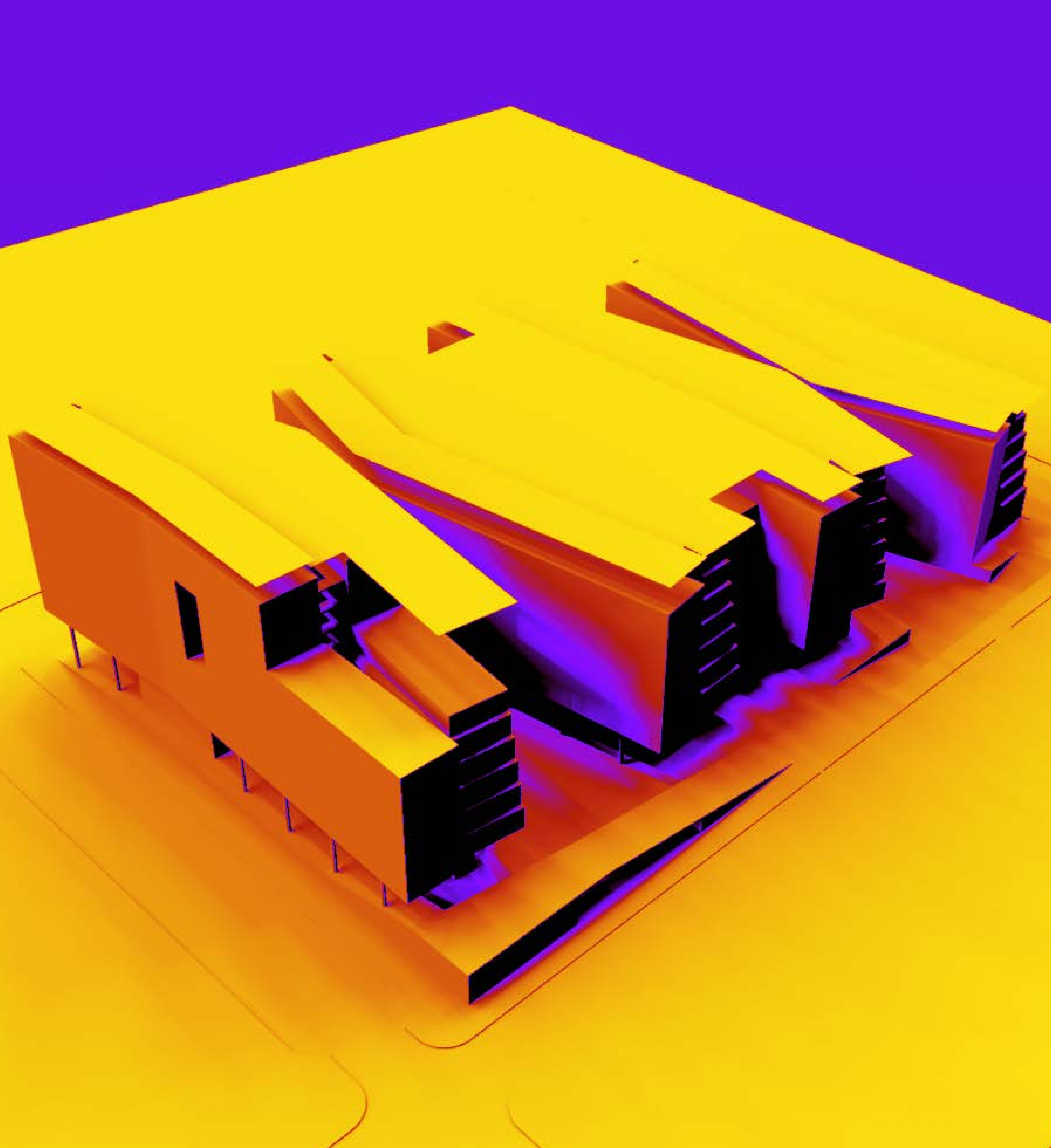
*The Solar PV Hot Water is designed for a 30% Solar Fraction

These calculations are completed based on the solar radiation specific to the San Francisco climate, accounting for local weather and cloud coverage. Panels are calculated for their energy production mounted flat at the roof level. The high efficiency panels produce 1290 kWh/kW annually and cover 18.5 Watts/sf of solar panel. The low efficiency panels are based on solar glass that allows for a lower generation capacity and transmitted light to spaces below.

This project does achieve net zero energy through solar electric and solar hot water systems, balancing the energy use annually with the energy generated. This development relies on connectivity to the electric grid to balance energy use between day and night.

2H. Occupant Behavior

The building is being designed to set a theme for low energy use of the occupants. Natural daylight and passive cooling with solar shading, operable windows, and passive stack exhaust, will create a connectivity with the environment. Smart appliances and a move to give occupants control of their home appliances will introduce another ability to reduce energy use when equipment is not in use. These systems will be best utilized when coupled with a home-introduction welcoming where each tenant can be introduced how to best run their apartment and enjoy the facility.



Insolation analysis from the northeast