NEXUS

SUPPLEMENTAL PACKAGE

OCTOBER 28, 2016

"Communication is merely an exchange of information,
but connection is an exchange of our humanity."

Sean Stephenson

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PROJECT SUMMARY

NEXUS demonstrates the mutual benefits when architecture considers the complex climate and social systems of a place and its people, and follows a net positive approach to design. As our cities place excessive burdens on our climate, universities place escalating pressure on students. Academic load, peer competition, and financial security, coupled with a disconnection from familiar social support structures has been shown to cause significant negative impacts on the mental health and wellness of students across North America.

The aim of NEXUS is to not only create a net zero energy high-performance building, but also utilize design as a catalyst in the formation and maintenance of social support networks for resident and commuter students. With a design driven by renewable energy generation, system efficiency and social connectivity, the resulting program organization and building form creates an architecture which mutually benefits people and place at multiple scales of operation.

At the unit scale, a strong North/South orientation bias is established within a single-loaded corridor model. Sleeping quarters are condensed to the northern edges to relinquish more open and shared social spaces to the south. Units are nested in expanding communal spaces to balance fostering social networks with providing personal retreat.

At the site scale, the aggregation of this unit typology manifests as a serpentine structure strongly informed through analysis of optimal orientation to improve passive solar heat gain and natural lighting. The continuous structure also creates a series of diversely programmed courtyards with connections to the greater campus and city.

1 PLACE

San Francisco Bay Area, NASA Earth Observatory

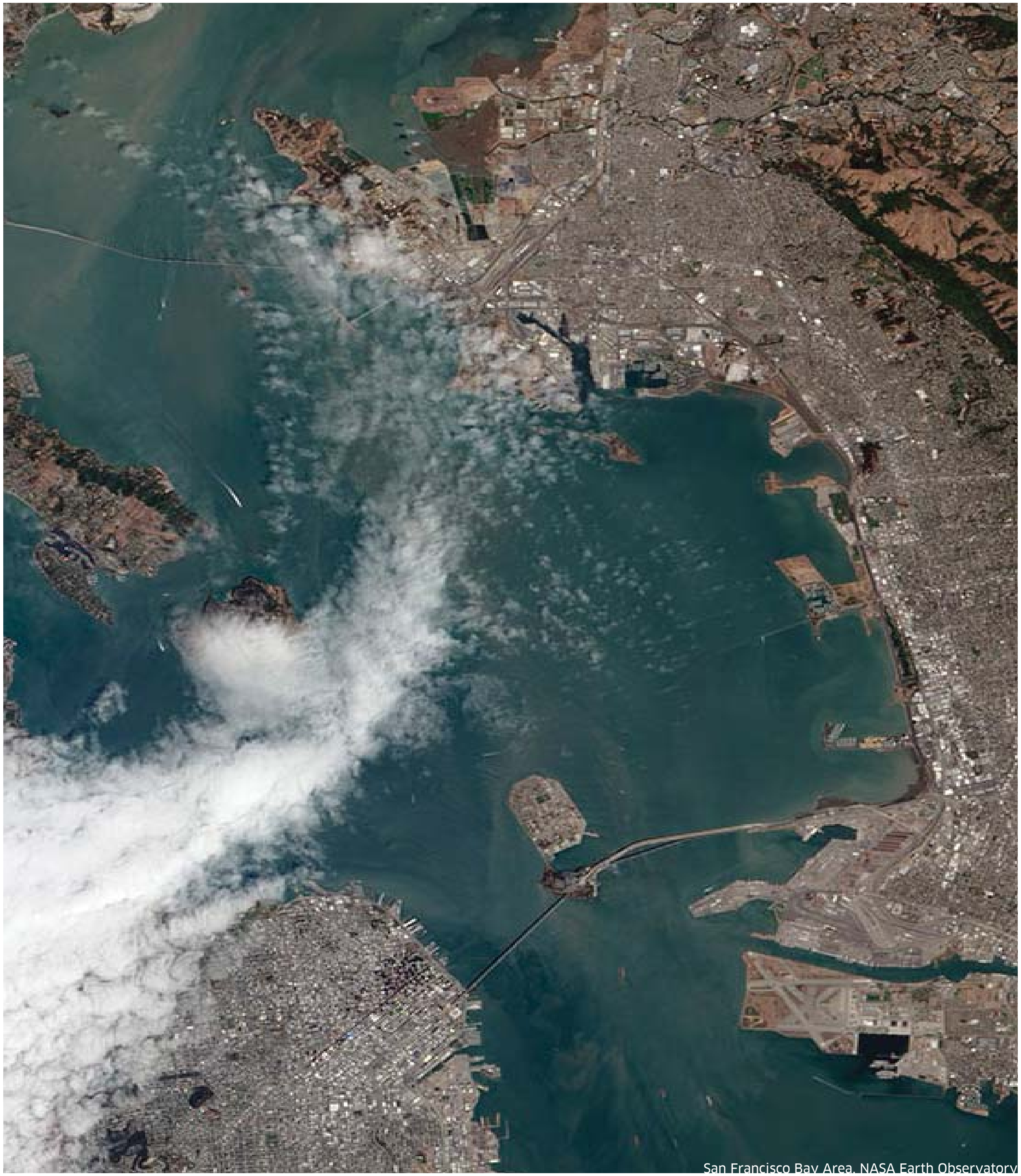
REGIONAL CONTEXT

Achieving net-zero cannot be accomplished without a deep understanding of place at both the regional and site-specific scale. At the regional scale the project exists on the pacific west coast within the San Francisco Bay Area which has evolved to become one of the most important urbanized centers within the country.

The area has an economic focus predominantly around technology, sustainable energy, agriculture and farming. Although it has one of the highest GDP values in the world a recent trend in the rise of tech companies locating to the area has contributed to an inflated and largely unaffordable housing market with median rent currently floating around $1,463 per month. Considering that the region is home to over 600,000 students today and ranks second in highest density of college graduates within the U.S. it's easy to see how financial security and affordability are major concerns voiced by this population.

Although significantly altered by human development to accommodate the needs of shipping, agriculture and urbanization, the ecological and hydrological character of the Bay Area is among California's most unique and important. The contained grasslands, wetlands, coastal scrub, dunes, woodlands, estuaries and deltas are delicate, functioning habitats for many native species of plants, animals and fungi.

The geology of the Bay Area is also very distinct with a considerable vertical relief rising upwards from the alluvial plains below. It is well known that the region is traversed by six major slip-strike fault systems and as a result is exposed to hazards associated with large earthquakes.



San Francisco Bay Area, NASA Earth Observatory

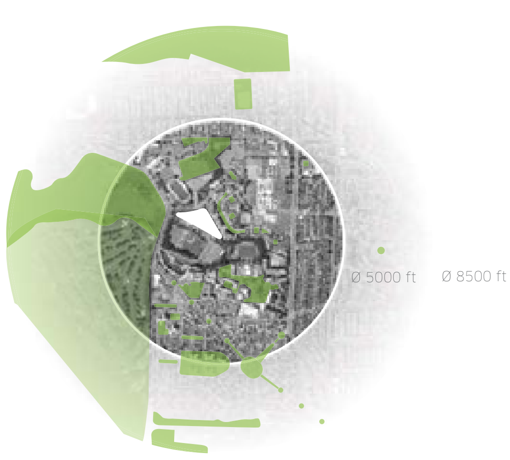
SFSU CAMPUS CONTEXT

San Francisco State University (SFSU) is a public higher education institution which was established in 1899 within the southwest area of San Francisco County. The campus covers 141 acres and is surrounding by several notable features including Lake Merced to the west, Lowell High School and Lakeshore Elementary School to the northwest, Stonestown Mall to the northeast.

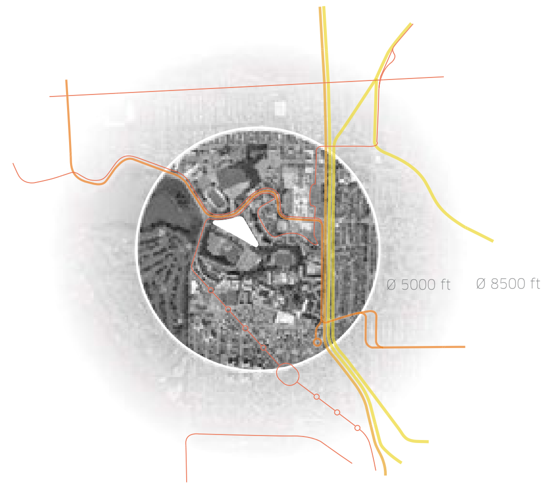
Although the campus can be considered an urban institution it is well known for its rich density of green space and vegetation which include tree groves of Monterey Cypress, Monterey Pine and Eucalyptus.

The campus is serviced by several transportation corridors. Car access is primarily via Lake Merced Boulevard to the west and 19th Ave to the east. The closest and most well used public transit line stop is Daly City which exists to the southeast and is part of the Bay Area Rapid Transit (BART) system. The campus can be reached via bus through several routes with a primary stop located in the southeast at the corner of 19th Ave and Holloway Ave. Bicycle routes to campus vary with the main access point additionally located in the southeast.

Several open spaces exist within the campus fabric including the central Quad located by the Cesar Chavez Student Centre, West Campus Green in the southwest, and recreational areas Maloney Field and Cox Stadium located further north.

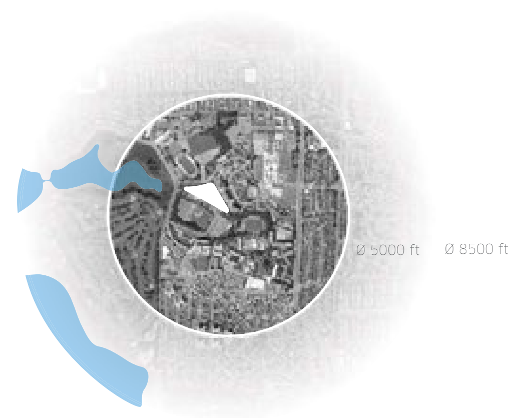


GREEN SPACE



TRANSPORTATION

RECREATION FIELDS



WATER BODIES

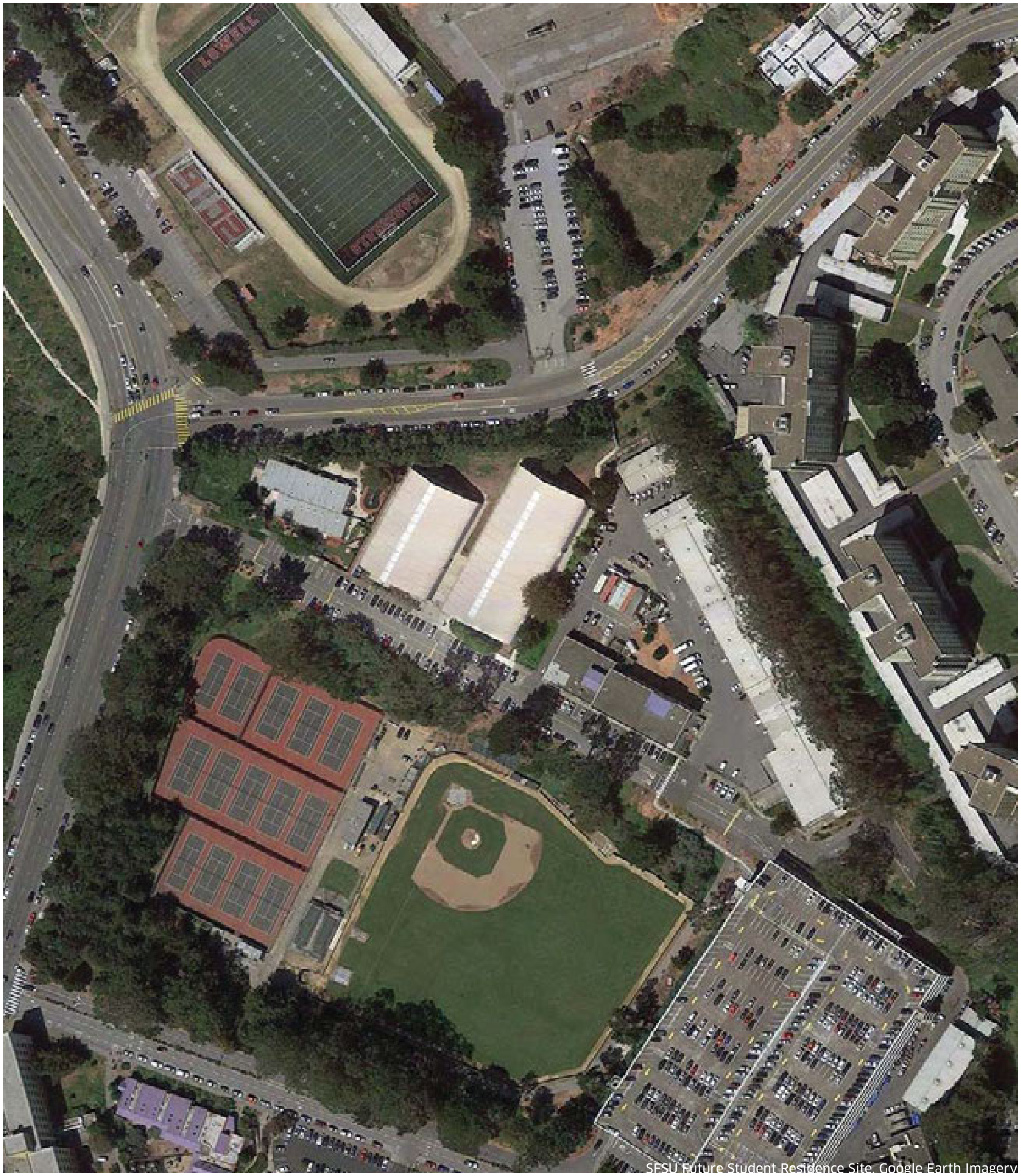
SITE CONTEXT

The site of intervention exists in the northwest corner of campus and currently contains the Corporation Yard for SFSU, the University Police, annex spaces and the Children's Campus at SF State.

The enclosed area within the triangular site is fairly flat, with steep embankments increasing in elevation to the northeast and northwest and decreasing in elevation to the south heading to Maloney Field and the SF State Tennis Courts.

IMPORTANT FEATURES:

- Pedestrian route to campus at southeast
- views to the ocean from the northwest
- Tree buffers to northeast and northwest
- High school towards the north
- Existing housing complex to northeast


SFSU Future Student Residence Site, Google Earth Imagery

CLIMATE DATA AND ANALYSIS

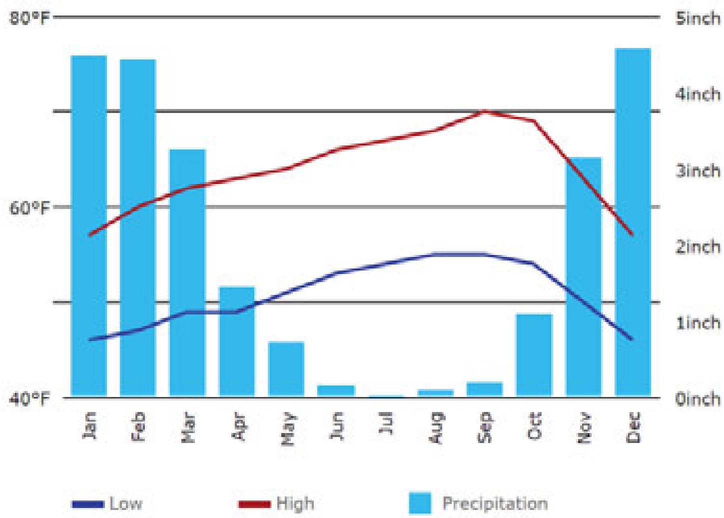
Climate and weather data were analyzed for the region using Climate Consultant and other online sources. The area has a mediterranean type climate characterized by dry summers and moist, mild winters. Modest temperature swings produce little seasonal temperature variation with a summer average high of 80°F and winter average low of 51°F.

During the summer, rising hot air in California's interior valleys creates a low pressure area that draws winds from the North Pacific High through the Golden Gate, which creates the city's characteristic cool winds and fog. This effect is most pronounced at the western coastal edge and diminishes inland.

Rainfall is at its highest between November and April with summer months offering little to no precipitation. As a result of the dry summer season the area is extremely drought-prone and sees a dramatic shift in the drying of surrounding vegetation. Between 2007-09 drought conditions were so severe that a statewide proclamation of emergency was issued and led to major water restrictions.

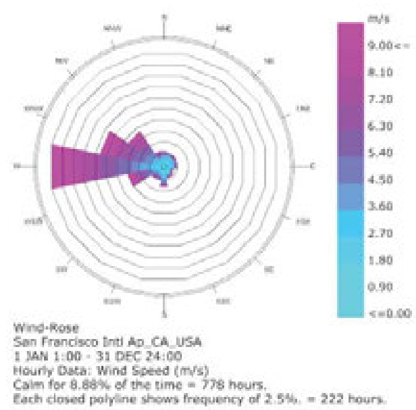

San Francisco Bay Area Skyline in Spring


San Francisco Bay Area Skyline in Summer



IMPORTANT CONSIDERATIONS:

- Mediterranean-like climate
- Drought-prone region
- Winds incoming predominantly from west
- Fog is common



2 PEOPLE

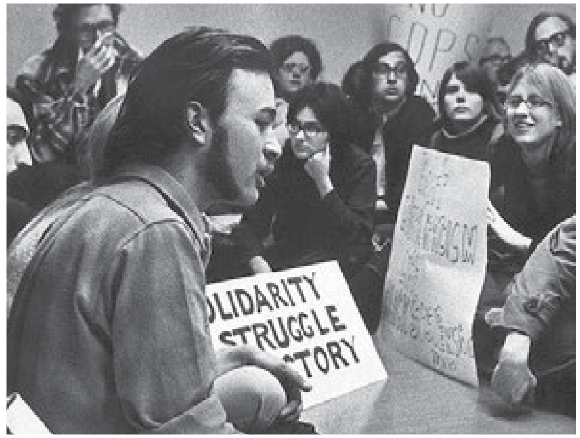
Student Activism at San Francisco State University, 1968

SFSU HISTORY OF STUDENT ACTIVISM

One of the most important defining characteristics of SFSU is its rich and somewhat controversial history of student engagement and activism. Of particular note were a series of protests between 1966-68 that focused on opposing the Vietnam War and demands for the increased support of an Ethnic Studies program at SFSU (images to right).

Today SFSU maintains a strong commitment to social justice and opposition to oppression and marginalization. As a result equity has been adopted as one of the five core University values emphasized in the current SFSU Strategic Plan:

> The principles of fairness and inclusion guide our educational mission, our institutional practices and our relations with the community around us. Our commitment to equity fosters an environment of respect, diversity, support and dignity for all of our members--faculty, staff, and students. A commitment to equity:
>
> 1) sees educational access and academic quality as reciprocal goals;
>
> 2) affirms that resources are distributed according to need;
>
> 3) empowers students who make the world a better place; and
>
> 4) eliminates barriers to success.
>
> From the 2016 SFSU Strategic Plan



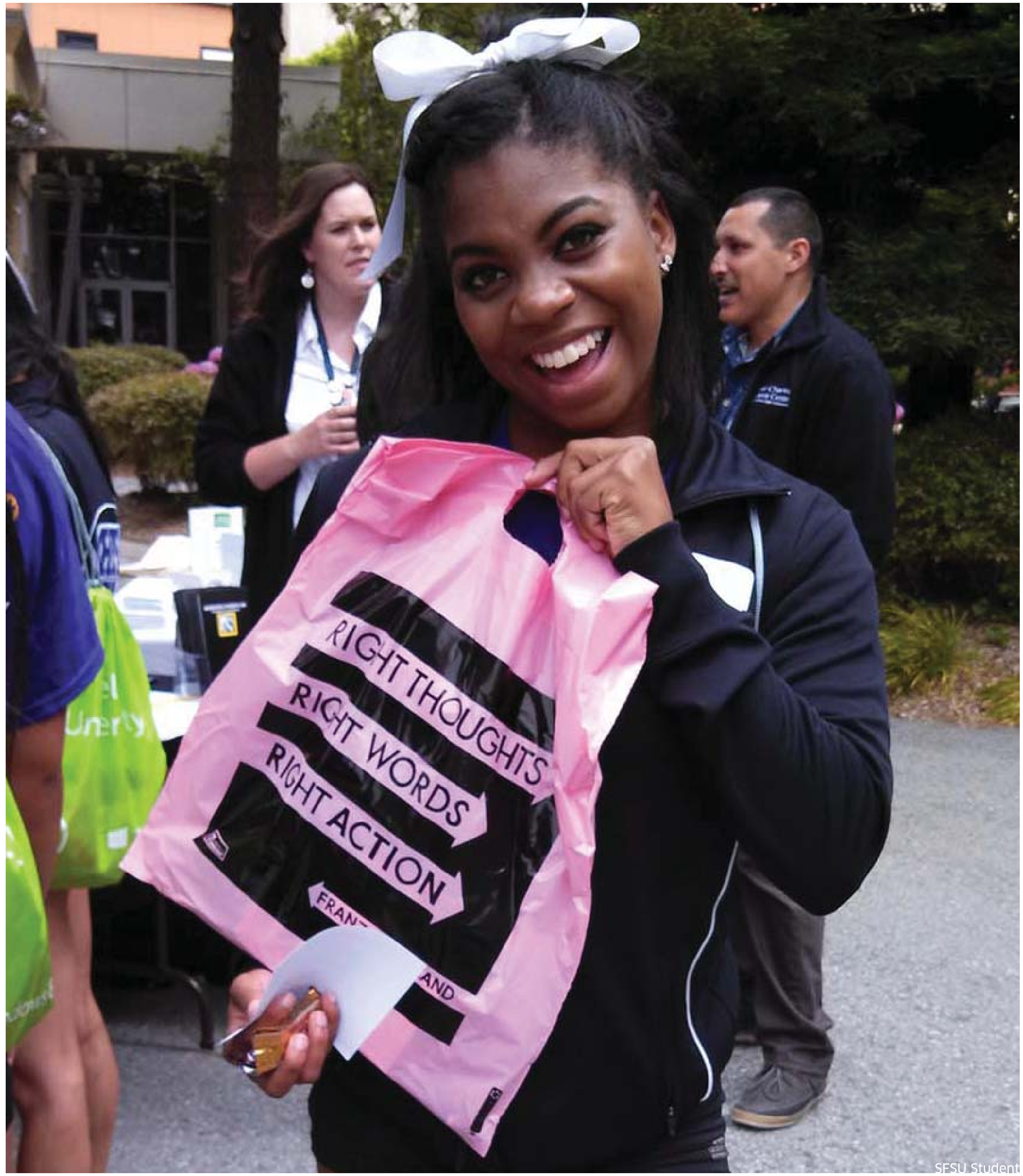
Student Activism at San Francisco State University, 1968

SFSU STUDENTS TODAY

Today SFSU accommodates over 1,600 faculty, 2,000 administrative staff, and 30,000 students. Of these students around 26,800 are enrolled as undergraduates with the remaining 3,200 enrolled in graduate or postgraduate studies. Approximately 3,500 students currently live on campus with the remaining students commuting to campus via car, bike or public transit. SFSU celebrates diversity and has a strong mix of students from different cultural and ethnic backgrounds.

11.4%	**GRADUATE**
88.6%	**UNDERGRADUATE**
88.5%	**OFF-CAMPUS COMMUTER STUDENTS**
11.5%	**ON-CAMPUS STUDENTS**
57.1%	**FEMALE**
42.9%	**MALE**

Based on 2015 data from SFSU



SFSU Student

STUDENT HEALTH AND WELLNESS

An important consideration when designing for any end user group is gaining a clearer understanding of their overall health and well being and how design may offer positive improvements. The National College Health Assessment (NCHA) is an annual wellness survey given to students across North America to assess their health and wellbeing in depth. The Assessment has been administered every year since 2000 and in 2015 was completed by more than 74,000 undergraduate students and 16,000 graduate students.

The figures included here are from the Spring 2015 NCHA undergraduate data set and provide a brief national snapshot of the state of student mental health and resulting academic impacts. Although a certain level of stress and exhaustion can be expected during college, the number of students experiencing loneliness, hopelessness and depression was more specifically alarming to our team.

While many factors lead to the manifestation of these emotions it is well known that the breadth and strength of an individuals social support network is a critical component in coping with life pressures and changes. For many students the move to collage away from existing friends and family is made more difficult as their support network becomes distant and disconnected.

HEALTH AND WELLNESS STRATEGIES:

- Improve social connections among students
- Provide areas for gathering and socializing
- Provide areas focused on de-stressing
- Undergraduates share rooms
- Graduates share social spaces

H. Mental Health

Students reported experiencing the following within the last 12 months:

Felt things were hopeless

Percent (%)	Male	Female	Total
No, never	39.0	28.1	31.5
No, not last 12 months	19.0	19.0	19.0
Yes, last 2 weeks	16.2	20.3	19.1
Yes, last 30 days	7.7	10.1	9.4
Yes, in last 12 months	18.1	22.4	21.0
Any time within the last 12 months	42.0	52.8	49.5

Felt overwhelmed by all you had to do

Percent (%)	Male	Female	Total
No, never	15.5	5.8	8.9
No, not last 12 months	7.1	3.2	4.4
Yes, last 2 weeks	41.4	57.9	52.7
Yes, last 30 days	15.6	16.8	16.4
Yes, in last 12 months	20.5	16.4	17.7
Any time within the last 12 months	77.4	91.0	86.7

Felt exhausted (not from physical activity)

Percent (%)	Male	Female	Total
No, never	18.1	8.4	11.5
No, not last 12 months	8.1	5.3	6.2
Yes, last 2 weeks	42.2	55.4	51.3
Yes, last 30 days	15.2	16.2	15.8
Yes, in last 12 months	16.5	14.7	15.3
Any time within the last 12 months	73.9	86.3	82.4

Felt very lonely

Percent (%)	Male	Female	Total
No, never	28.2	19.1	21.9
No, not last 12 months	18.1	17.4	17.6
Yes, last 2 weeks	22.9	27.8	26.4
Yes, last 30 days	10.6	13.9	12.8
Yes, in last 12 months	20.3	21.8	21.3
Any time within the last 12 months	53.7	63.5	60.5

C. Academic Impacts

Within the last 12 months, students reported the following factors affecting their individual academic performance, defined as: received a lower grade on an exam, or an important project; received a lower grade in the course; received an incomplete or dropped the course; or experienced a significant disruption in thesis, dissertation, research, or practicum work; (listed alphabetically):

Alcohol use:	4.2 %
Allergies:	2.5 %
Anxiety:	23.4 %
Assault (physical):	0.7 %
Assault (sexual):	1.3 %
Attention Deficit/Hyperactivity Disorder:	5.7 %
Cold/Flu/Sore throat:	16.2 %
Concern for a troubled friend or family member:	11.2 %
Chronic health problem or serious illness:	3.8 %
Chronic pain:	3.0 %
Death of a friend or family member:	6.0 %
Depression:	14.8 %
Discrimination:	1.2 %
Drug use:	1.9 %
Eating disorder/problem:	1.4 %
Finances:	7.1 %
Gambling:	0.3 %
Homesickness:	4.5 %
Injury:	2.3 %
Internet use/computer games:	12.5 %
Learning disability:	3.4 %
Participation in extracurricular activities:	10.5 %
Pregnancy (yours or partner's):	0.7 %
Relationship difficulties:	9.8 %
Roommate difficulties:	6.5 %
Sexually transmitted disease/ infection (STD/I):	0.4 %
Sinus infection/Ear infection/ Bronchitis/Strep throat:	5.2 %
Sleep difficulties:	22.0 %
Stress:	32.5 %
Work:	14.7 %
Other:	2.2 %

Data from Spring 2015 NCHA Undergraduate Survey


3
DESIGN

UNIT TYPES AND QUANTITIES

A breakdown of the unit types and bed quantities is shown on the right. While Nexus is able to provide program space for more than the number of students prescribed, the type of students served as well as the number of total beds provided has been challenged. There are several reasons for this decision.

First, given the density requirement along with the effort to preserve forested areas, the restrictive site area and 85' height limitation we did not see it practically feasible to fit the 2630 beds into a livable, vibrant design. The full number of units could be provided if we forgo the height limitation but the trade-off is a loss in solar access into the courtyards and living spaces.

Second, as part of the reason to provide more on-campus student housing at SFSU is to reduce the number of students disconnected by commuting to campus we felt it was very important to provide dedicated space for a subset of this population while attending SFSU.

Lastly, we could improve unit density by adopting a double-loaded corridor model, but we opted for a single-loaded corridor to foster social connectivity and utilize passive solar gains.

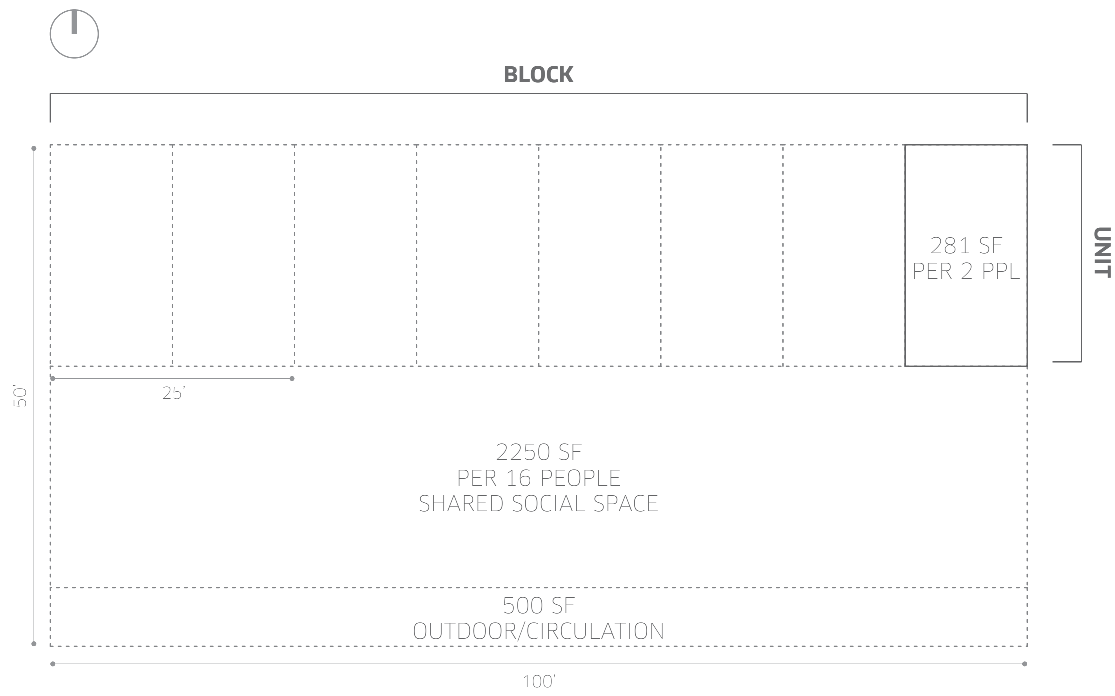
For these reasons we have catered the program towards four main user types: undergraduate students, graduate (and postgraduate) students, families and commuter students. The decision to separate family student units from graduate units was to provide a stronger community feel for family units and offer a higher degree of privacy compared to graduates and undergraduates.

UNIT TYPE	# UNITS REQUESTED	# UNITS PROVIDED	TOTAL
UNDERGRADUATE	531 UNITS 2124 BEDS	400 UNITS 1600 BEDS	2125
GRADUATE	253 UNITS 506 BEDS	125 UNITS 375 BEDS	
FAMILY		75 UNITS 150 BEDS	
COMMUTER	NONE	8 SHARED SOCIAL LOUNGES 8 BOOKABLE CLUB ROOMS 4 RENTABLE OVERNIGHT ROOMS	505
TOTAL STUDENTS SERVED:	2630	2125 LIVE-IN STUDENTS 505 COMMUTER STUDENTS	2630

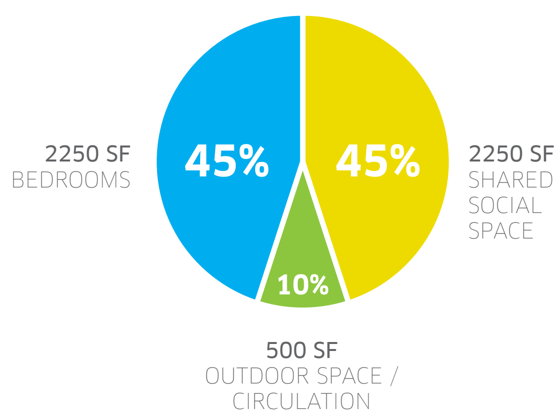
UNIT AREA AND BLOCK FORMATION

The diagram to the right shows the aggregation of a unit typology into a block typology. These blocks are the larger unit of organization that is spread along the building at the site-wide scale.

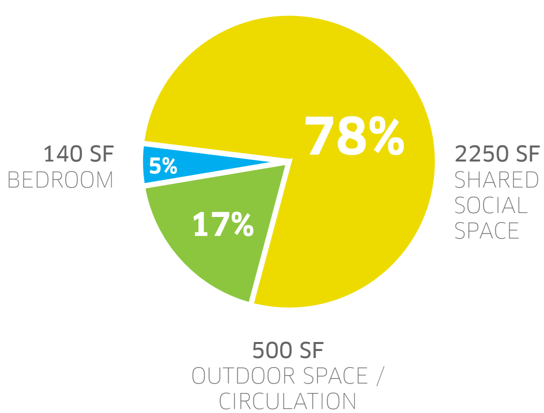
By orienting this organization with the sleeping areas to the north and the social space to the south we are able to take advantage of a duality in building form and design which tightens and insulates the north enclosure where heat is most loss, and opens the southern enclosure to allow daylight and passive solar gains into the social spaces. This will be discussed further later on.



BLOCK AREA BY TYPE
5000 SF TOTAL



BLOCK AREA PER PERSON
2890 SF TOTAL



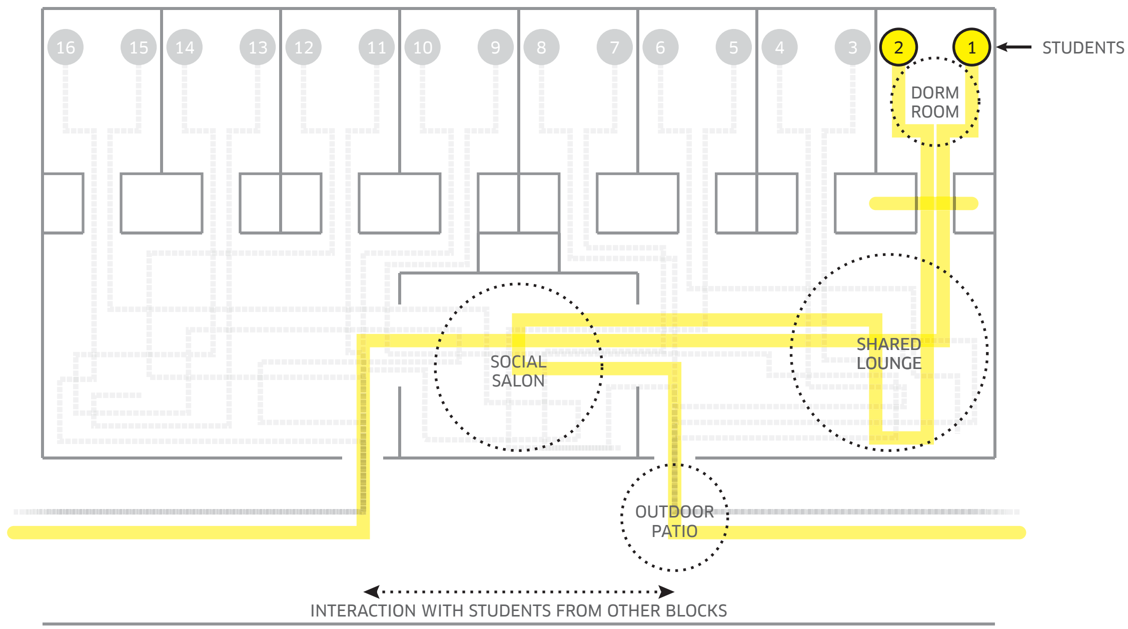
FOSTERING SOCIAL CONNECTIONS

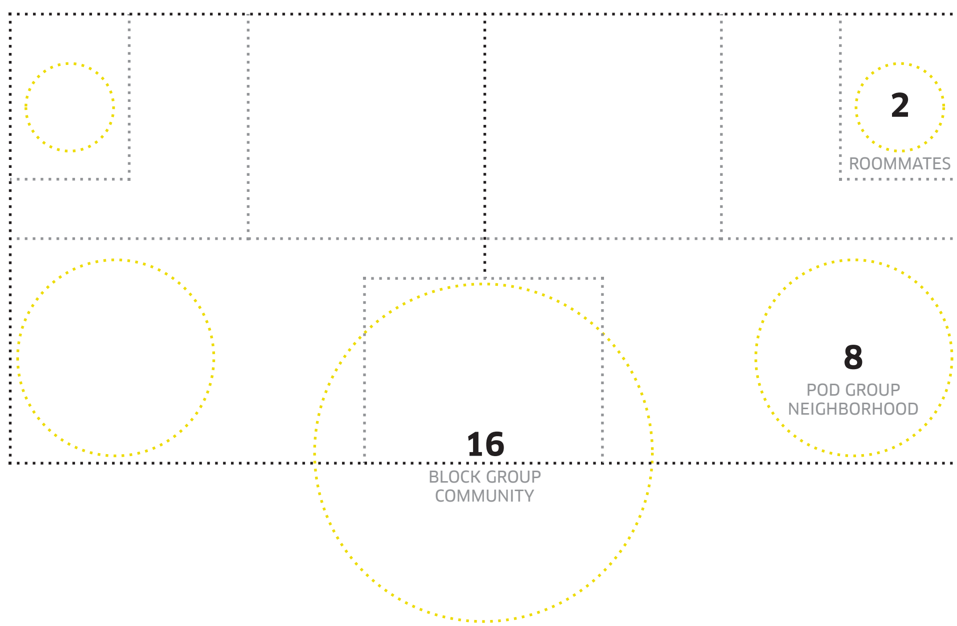
We firmly believe that design of physical space within the institutional setting plays a pivotal role in fostering new social connections and support networks for students. As such an emphasis was placed on the development of distributed and diverse social spaces over individual, isolated space.

This design decision challenges common North American conventions of shared vs. private space by allocating a higher percentage of floor area towards social spaces. By joining together the allocated social spaces of several units we generate an interconnection of communal space between a larger group of students, offering a diversity of spaces to use for socializing, studying, relaxing and more.

It is our intention that this design move helps to foster connections among students who share physical space, but offer diversity and choice to the individuals of how to occupy and arrange this larger space to meet their desires. In this way unit layouts are left as open as possible in the social area to allow for adjustment and customization by each student group to make the space feel more like their own. Movable partitions are further provided leading into the adjoining "social salon" area so that shared lounge space could be closed off for a social event or additional privacy.

Additionally as these blocks are strung together at the site scale an external walkway is provided to function as the main circulation route as well as to offer the opportunity for further social connection of students who occupy different blocks. This move creates a "social sidewalk" where students could take different pathways to their end destination and encounter old and new friends and colleagues along the way.





UNIT PLAN: UNDERGRADUATE

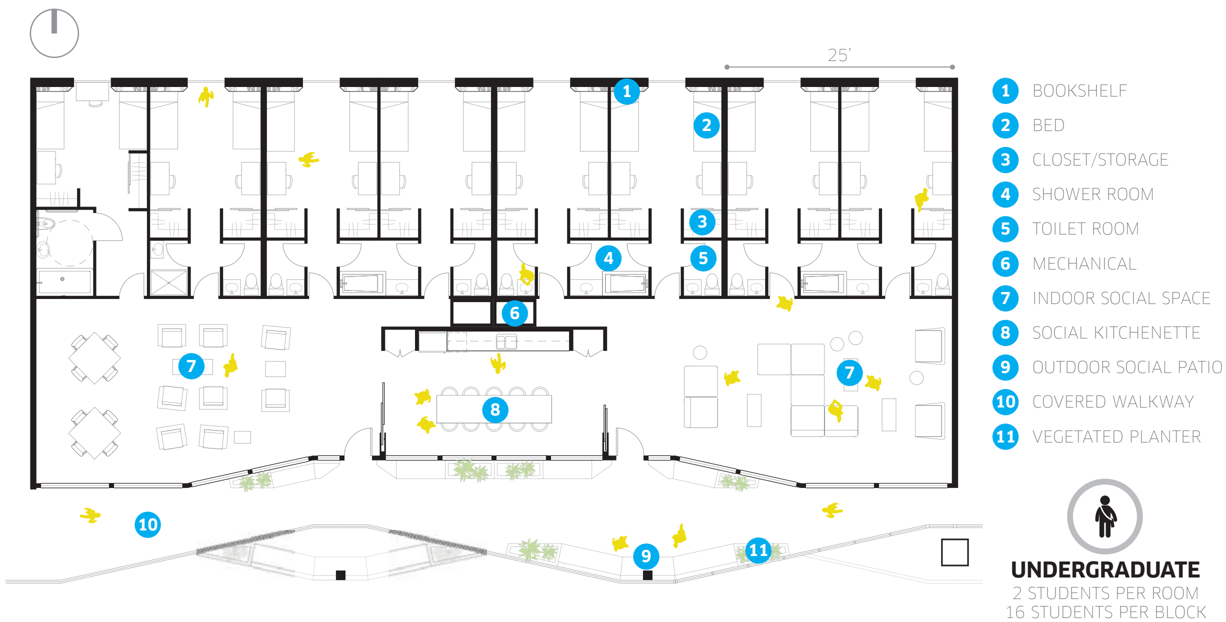
Shown here is the typical plan for an undergraduate housing block with key items labeled. For this typology students each share a room with a roommate and therefore always have at least one person in contact with them most of the day/night.

Each pair of students have both a central and clerestory window on the north side of their room to allow views and daylight into the space. Each pair also has their own private washroom and sink but share a shower room with another student pair. Each paired pod has a frontage into the social area and can flow freely between the flanking lounges or central salon space.

The larger social space is shared among 16 students with the space containing a medial break to allow a group of 8 or so to inhabit each social lounge more privately if desired. The central salon space contains a single shared bar fridge, microwave and storage cabinets. The intention is for students to be able to make a drink or eat a snack while they work or socialize.

The block has a strong frontage to the external walkway and the varied width of the walkway produces an outdoor patio gathering space for student inhabitants or students who pass by. This space includes seating and vegetated planters to increase the space quality and provide a biophilic atmosphere that compliments the surrounding campus. Most units will have a view from their walkway/outdoor patio into the courtyards or out towards campus, further reinforcing a sense of community.

Wheelchair accessible rooms are included within each block and the external walkway easily facilitates wheelchair access to and from the elevator cores located at each corner.

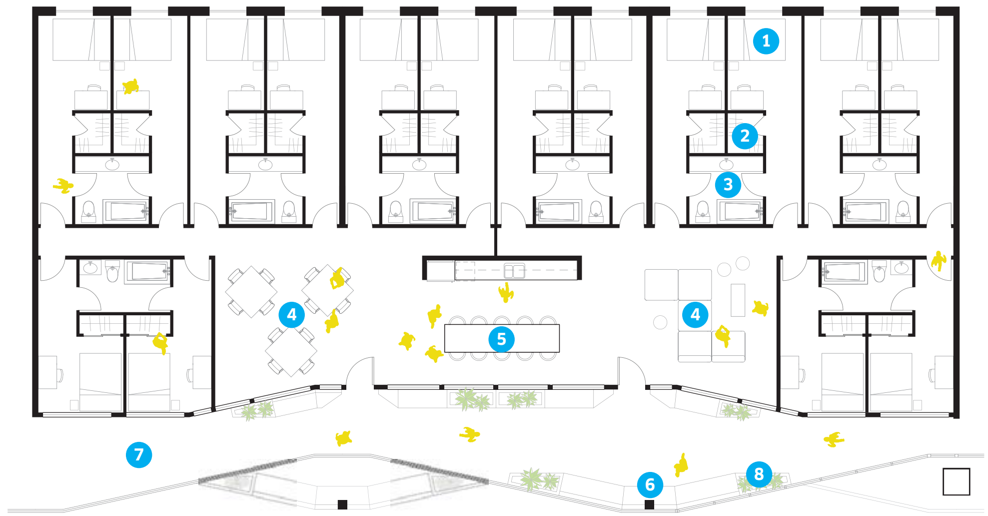


UNIT PLANS: GRADUATE AND FAMILY

The block typology for graduate students and students with families occupy the same overall dimensions as the undergraduate type but are programmed slightly differently.

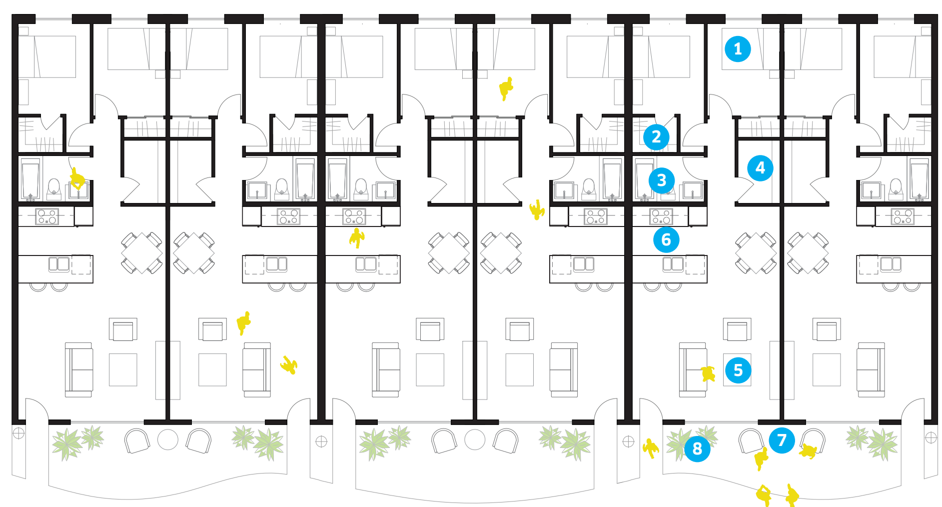
Graduate blocks are designed to also house 16 students but more space is allocated towards private rooms. Each student is given their own individual room but share a single washroom with one other student. The collective group of students share the remaining indoor and outdoor social spaces similar to the undergraduate model. Although the proportion of shared social space is diminished to accommodate larger individual units the typology still offers a much needed sense of community amongst graduate students. As many graduate students tend to work more individually and are often international students we felt it was important to create this type of clustering effect. However, as graduate schedules vary greatly it is more likely that these students are not home at the same time and furthermore will choose to work more elsewhere on campus (labs, libraries, cafes, etc.).

Family blocks are designed more like townhouses and offer much more privacy with each family occupying their own unit. In order to continue the emphasis on connectivity these units are arranged only on the lowest 2 floors of the building and spill out into the smallest courtyard provided as a children's play area. Associated to this courtyard is the daycare space which functions to provide a bit more privacy and security to the courtyard while allowing natural light into the open space. This organization allows family's to venture outside to connect with others and allow their children to play while maintaining a sense of a private home indoors.



1 BED
2 CLOSET/STORAGE
3 WASHROOM
4 INDOOR SOCIAL SPACE
5 SOCIAL KITCHENETTE
6 OUTDOOR SOCIAL PATIO
7 COVERED WALKWAY
8 PLANTER

GRADUATE
1 STUDENT PER ROOM
16 STUDENTS PER BLOCK



1 BED
2 CLOSET/STORAGE
3 WASHROOM
4 SPARE ROOM
5 LIVING ROOM
6 KITCHENETTE
7 OUTDOOR SOCIAL PATIO
8 LANDSCAPING

FAMILY
2 PEOPLE PER UNIT
12 PEOPLE PER BLOCK

SOCIAL CORNERS

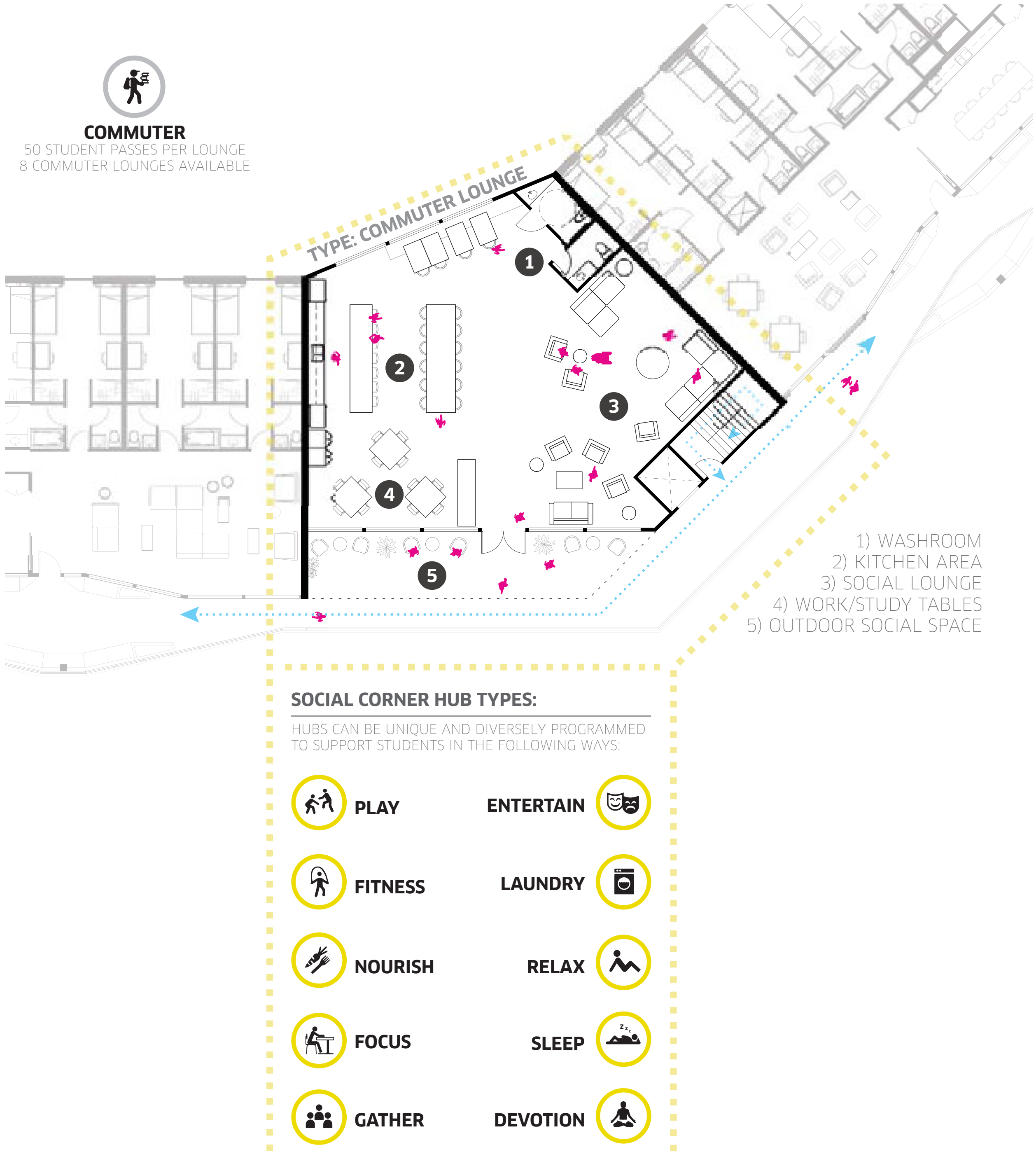
Corner conditions within Nexus are very special. As the building winds across the site the corners are allowed to shift their place slightly to accommodate a diversity of student program space aimed at improving overall health and wellness of all students. The types of spaces envisioned are included on the right with the design displaying a particular type which offers a dedicates service to commuter students at SFSU.

These Commuter Lounges provide a 'home away from home' for hundreds of undergraduate and graduate students who commute to campus daily and do not live in the complex. This model has been adopted from other universities which offer similar types of facilities with great success.

The space includes a kitchenette, communal tables, a lounge area, and study zone with charging stations. It provides commuter students an opportunity connect with and get to know other students outside of the classroom. The lounge is a safe and welcoming space where students can relax, socialize and study in-between classes.

Access to the lounge is best managed through an opt-in model where students pay a reasonable fee for a monthly subscription to the space on a term basis. This allows the space as well as the entire building to maintain the integrity of it's security system and promote responsible use.

Additionally, corner hubs and commuter lounges can dual-function as bookable event/meeting space for the over 250 clubs and student organizations which currently exist at SFSU as this type of space is always in high demand with limited quantity.



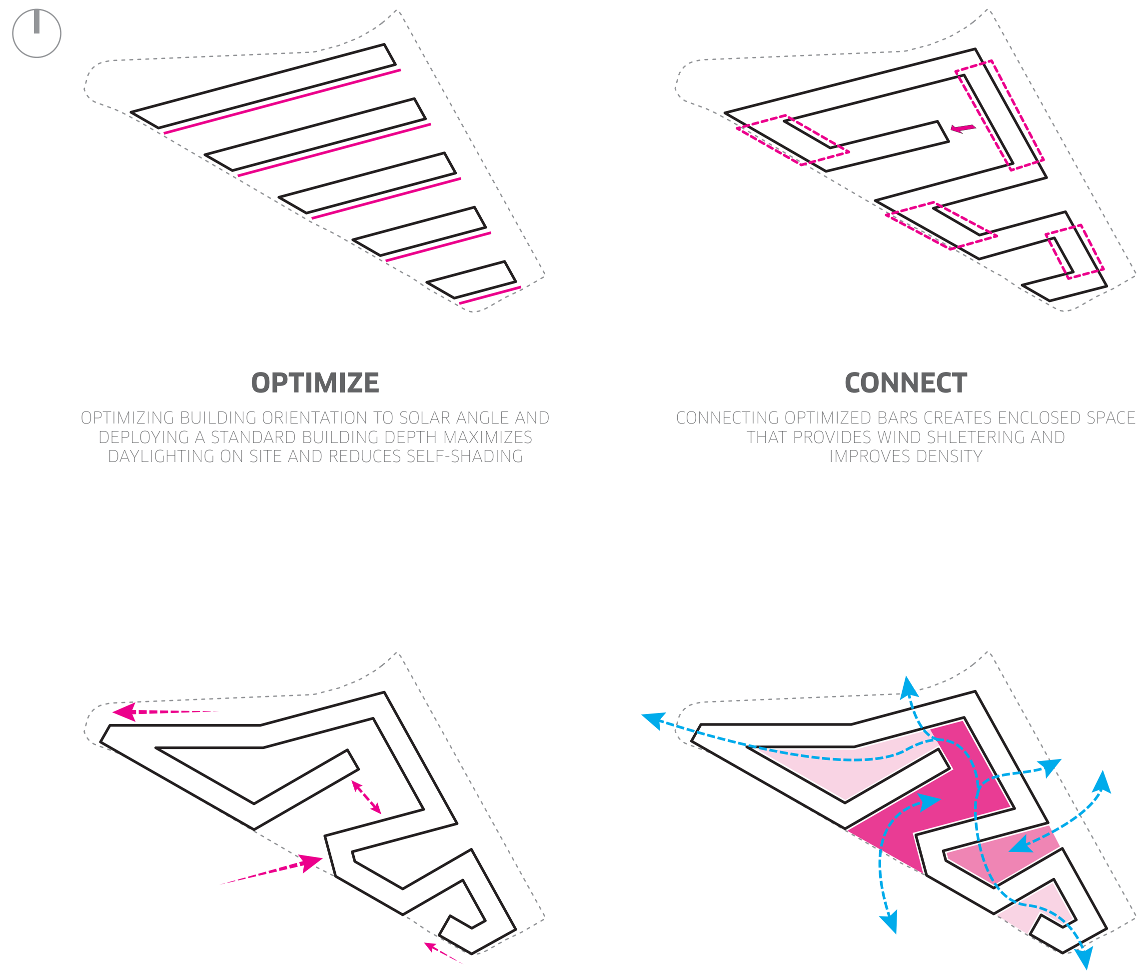
FORM FINDING AND MASSING

Our form finding and massing exploration was certainly one of the most difficult tasks. After many studies the final result was a mutualistic merging of performance goals and urban design goals.

On the performance side we operated on developing a single-loaded corridor building which would optimize solar access and heat gain into the southern spaces while allowing as much natural light as possible to enter in-between the building form. This move was complimented by the decision to enclose the space fully through a continuous building logic that allowed the creation of outdoor courtyards that function semi-privately.

The creation of these courtyards became key in supporting our social connection goals as well as providing a diversity of spaces for different users to occupy. As courtyards are a common typology on the SFSU campus the move allowed the design to be reflective of the current campus context while embracing a new building form.

The largest courtyard in the middle functions as a central hub and contains the cafeteria. The open space created can be used for larger gathering of students for events or as outdoor spaces for studying, socializing and relaxing. The middle courtyard opens towards the Eucalyptus stand and offers a more private and biophilic backdrop for relaxation and contemplation. The smallest courtyard to the southeast functions as a children's playground and is associated with the daycare.



OPTIMIZE

OPTIMIZING BUILDING ORIENTATION TO SOLAR ANGLE AND DEPLOYING A STANDARD BUILDING DEPTH MAXIMIZES DAYLIGHTING ON SITE AND REDUCES SELF-SHADING

CONNECT

CONNECTING OPTIMIZED BARS CREATES ENCLOSED SPACE THAT PROVIDES WIND SHLETERING AND IMPROVES DENSITY

SHIFT

SHIFTING BUILDING FORM AT CORNERS AND END CONDITIONS ALLOWS FOR THE CREATION OF DIVERSE SOCIAL SPACES WITH DIFFERENTIAL SOLAR ACCESS

ACCESS

CUTTING OPENINGS IN THE BUILDING FORM ALLOWS CIRCULATION AND ACCESS INTO DEVELOPED COURTYARD SPACES

FORM FINDING AND MASSING: SOLAR ANALYSIS

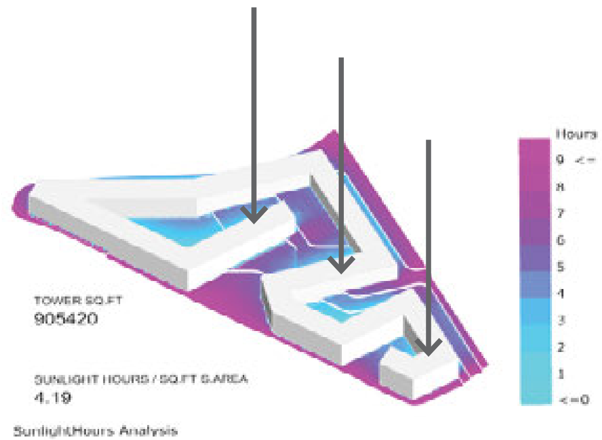
Key to the pursuit of performance driven form and massing was the use of several analytical tools.

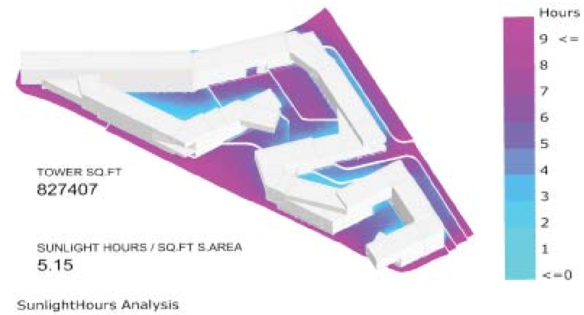
Psycrhometric chart analysis (see Passive Systems Section) identified solar gains as a key strategy for load reductions. This strategy was confirmed by early testing in Sefaira. The Sefaira energy model suggested a building orientation of 165 degree azimuth angle to capture morning sun when the heating load is greater.

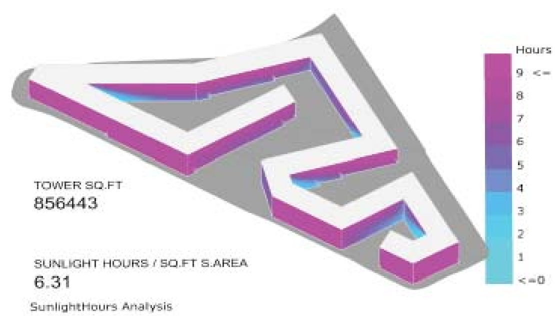
Ladybug, a grasshopper tool for Rhinoceros was used as a feedback method for testing massing iterations and building articulation. The solar analysis measured the total sunlight hours over the winter months. The average sunlight hours per surface is shown and the efficiency of the massing is measured in sunlight hours per sq. ft of facade surface area. This metric was used to quickly compare solar performance of varying options.

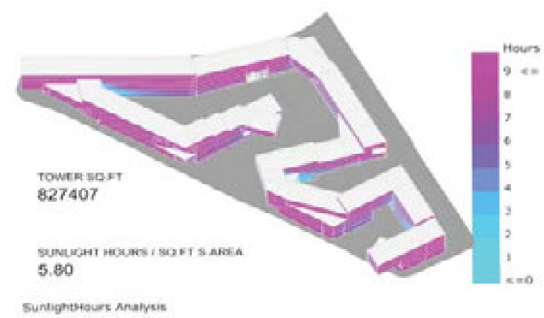
The final massing is shown to the right. The facade and courtyards were analyzed to determine the final building articulation shown to the far right. Note that the final building facade is less optimal after the articulation, but the courtyards receive significantly ~25% more direct solar.

See the appendix for a selection of iterative analyses from the “massing graveyard”.



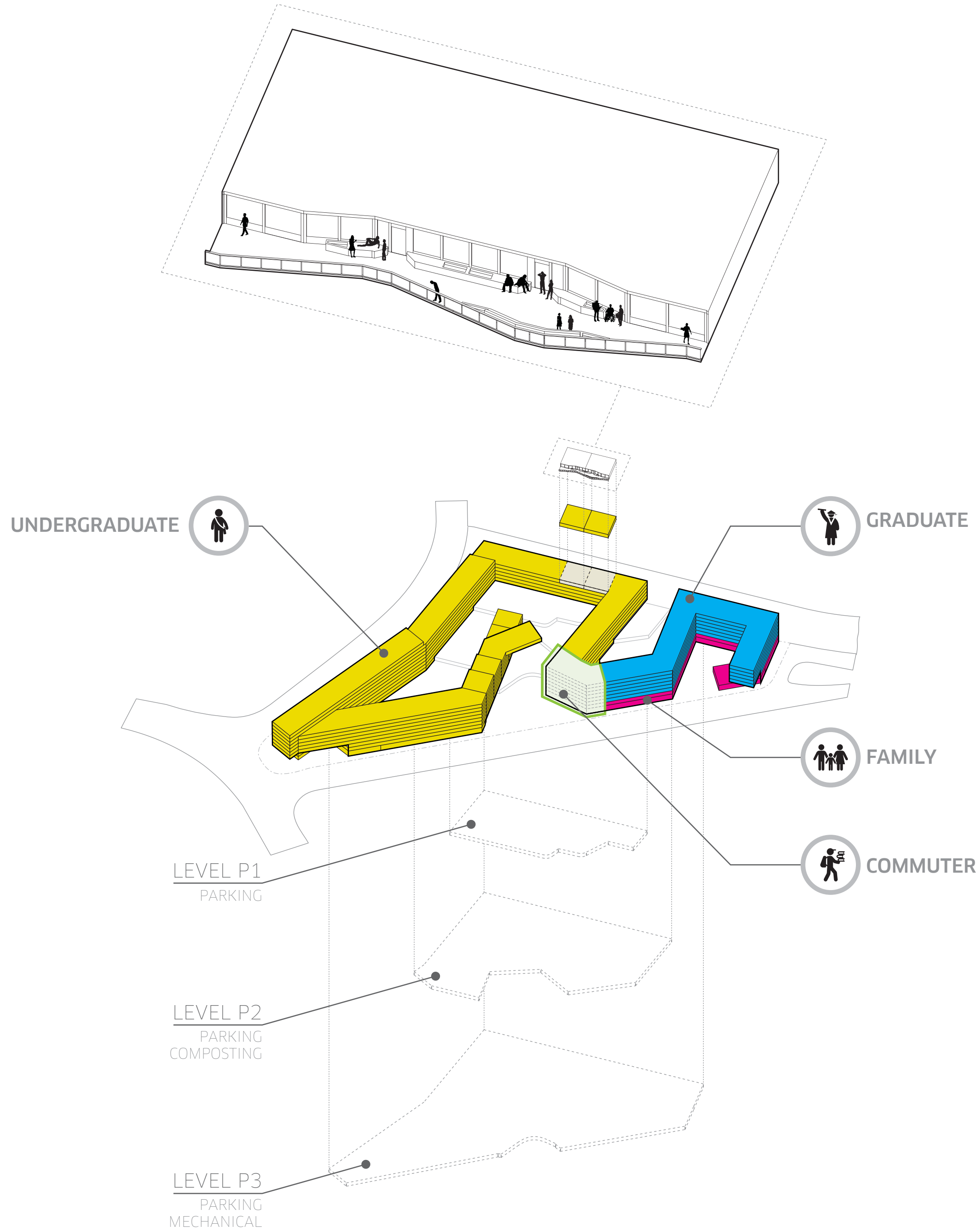






UNIT DISTRIBUTION

Unit distribution in Nexus was informed by the desire to mix students together but additionally develop neighborhood themes around user types. As such the building surrounding the largest open courtyard is predominately programmed with undergraduate units with the graduate and family units occupying the building around the smallest courtyard.



PLAN

Location of each program element is shown via the legend below.

COURTYARDS

(A) PLAZA GATHER
a1) stage / performance
a2) ramps to provide wheelchair accessibility
a3) flat stairs with sitting features
a4) outdoor seating, roofed
a5) link to courtyard C and child care facility
a6) link to mall
a7) north entrance
a8) even access to dining

(B) COURTYARD RECREATIONAL
b1) basketball court
b2) outdoor seating 3rd floor
b3) landscape surfaces with drought tolerant planting
b4) pathway to connect nw-corner & plaza level (3rd fl)

(C) COURTYARD CONTEMPLATION
c1) sloped terrain to accomodate cascading floors below
c2) extended eucalyptus canopy

(D) COURTYARD PLAY
d1) link to main plaza (3rd fl)
d2) playground

(E) LANDSCAPE FEATURES
e1) retaining trees along Winston Drive
e2) eucalyptus canopy
e3) pedestrian bridge to make connection to mall
e4) swale / planting

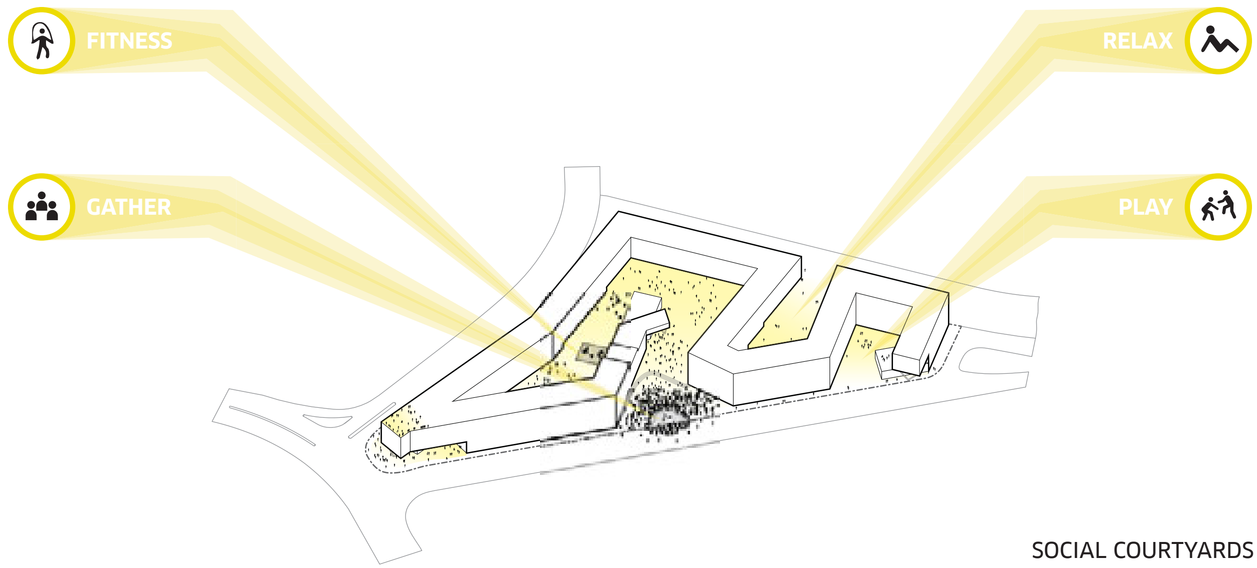
BUILDING

1) cafeteria
2) kitchen (1st fl)
3) mechanical
4) parking, 750 stalls in podium
5) living machine
6) town house living with assigned gardens
7) cafe`
8) residences
9) vertical circulation
10) commuter lounge
11) lecture theater
12) meeting rooms
13) coffee shop, with gallery space to connect 2nd/3rd fl
14) bike storage with service & change rooms
15) child care

SOCIAL CONNECTIONS

The diagrams to the right show the intention of developing heightened social spaces within the building as well as within each semi-enclosed courtyard.

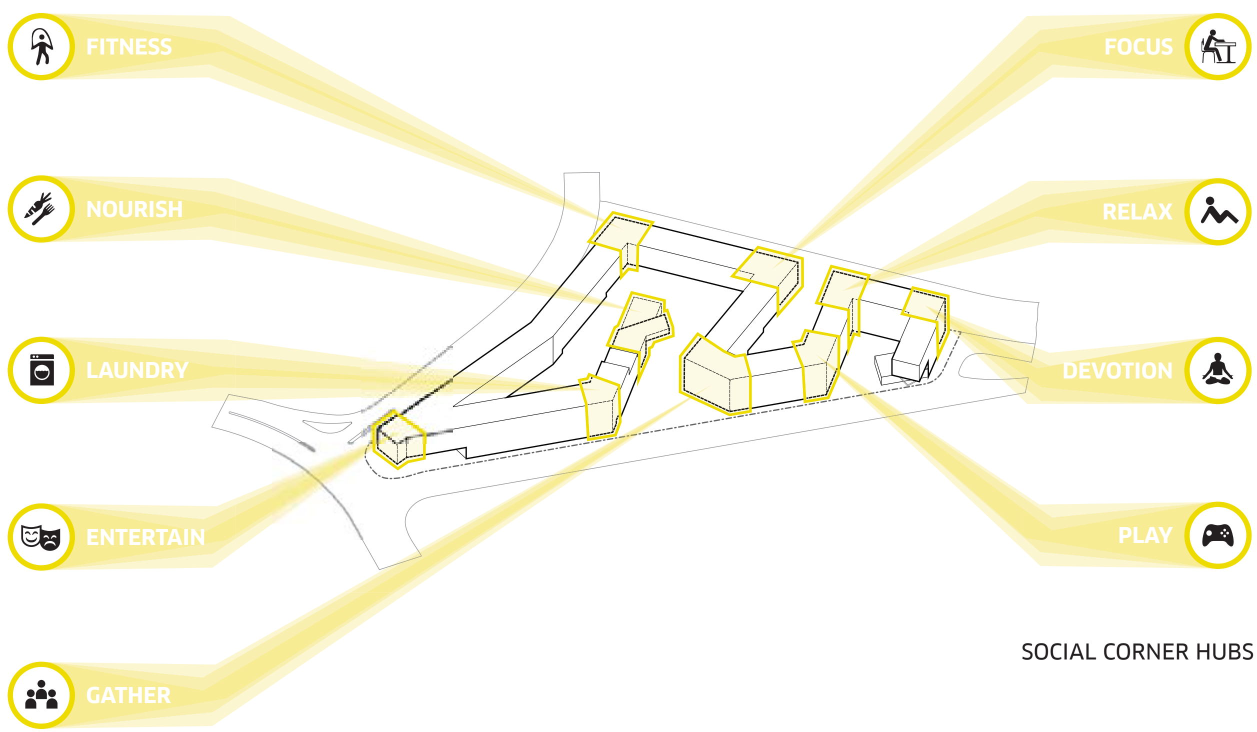
For each corner condition several floors could be used for any of the listed themes. However, as each corner is unique and has it's own degree of privacy, area of open space and framed view certain specific themes are suggested here for each corner.



SOCIAL COURTYARDS

KEY STRATEGIES:

- Improve social connections among students
- Provide areas for gathering and socializing



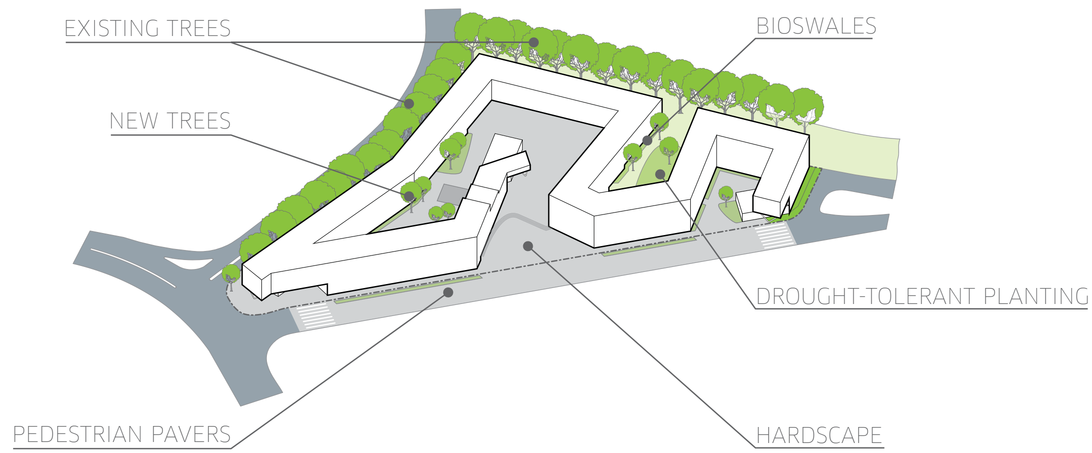
SOCIAL CORNER HUBS

VEGETATION AND LANDSCAPING

The landscaping provided focuses on complimenting the rich vegetation already existing on campus along with respecting the seasonal restrictions on rainwater supply.

Courtyards contain mostly hardscape which facilitates circulation paths as well as gathering of large numbers of students.

Bioswales are included along the building edge to treat rainwater runoff, provide a small amount of functional habitat as well as a sense of biophilia for students and visitors.



KEY STRATEGIES:

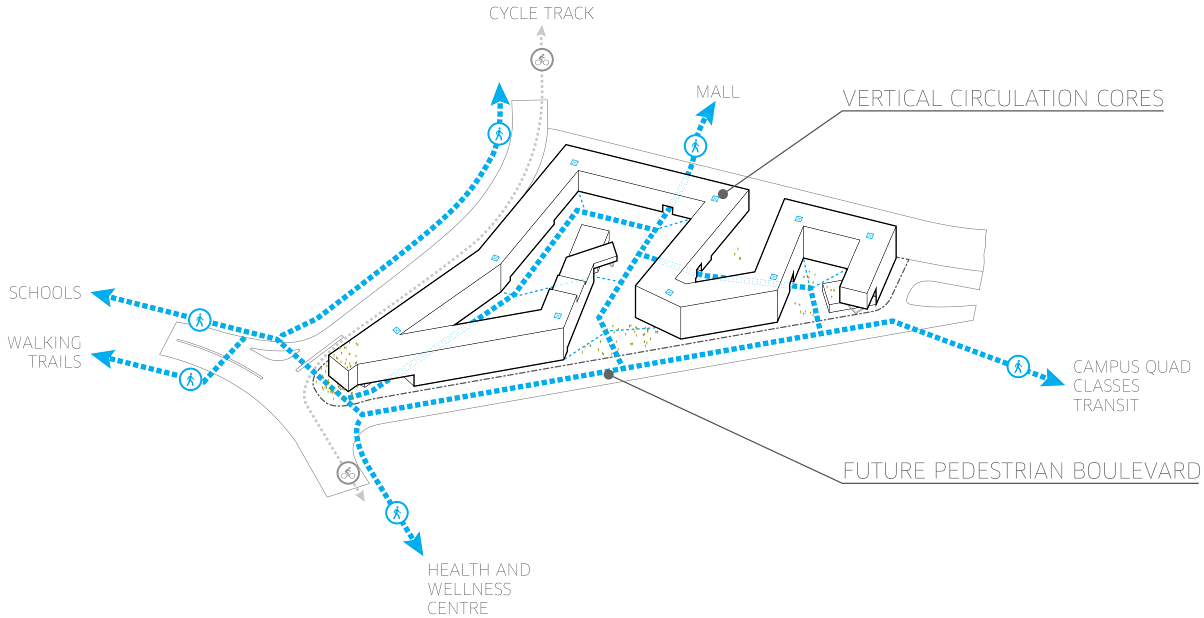
- Preserve existing tree stands
- Provide new but limited courtyard planting
- Planting needs to be drought-tolerant
- Plaza spaces contain mostly hardscape
- Pedestrian pavers for future boulevard

CIRCULATION

External circulation paths are created along N State Dr. which as indicated by the SFSU Master Plan will become a future pedestrian boulevard. As such we open access to the courtyards along this central access spine and further cut internal connections through the building at ground level to allow a more free flowing circulation path.

Vertical circulation into the building is provided by several cores with stairwell and elevator access. These conditions happen at the corner conditions and reinforce the ease of access into the social programs contained within.

Circulation along the building is provided by a dedicated external walkway which functions as a “social sidewalk” for students to encounter each other along their routine journey to the cafeteria, class and the corner social spaces.



KEY STRATEGIES:

- Southeast access is a high priority to campus
- All courtyards should be connected
- Dedicated access to the mall is needed
- Plaza spaces contain mostly hardscape
- Vertical circulation at corner conditions
- External walkway to function socially

VIEWS

SFSU campus is very fortunate to be exposed to coastal condition with spectacular views west towards Lake Merced and the Pacific Ocean. The building was designed specifically to take advantage of this opportunity and provides generous, dedicated private and public gathering spaces at the corner of N State Dr. and Lake Merced Blvd.

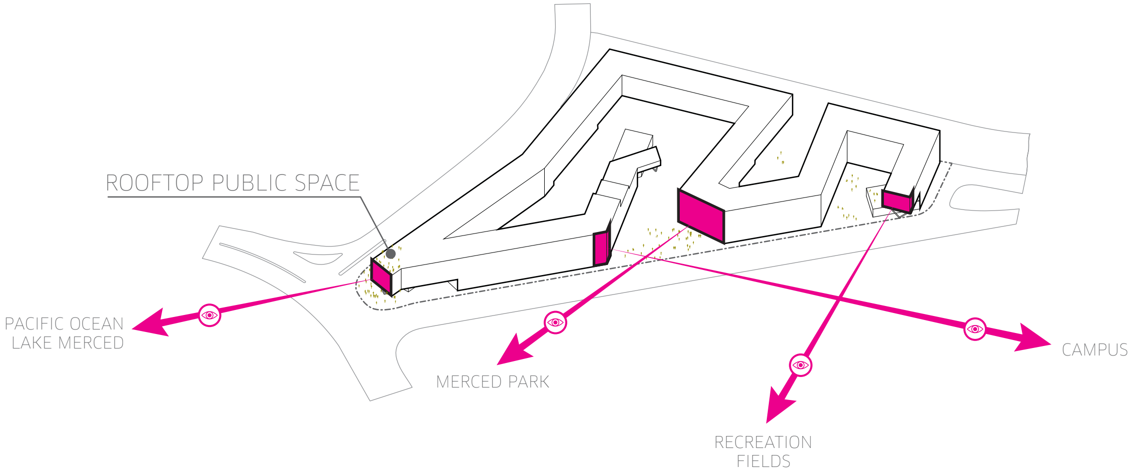
At this corner on the ground plane the building lifts up to provide a small covered plaza in which the coffee shop is situated. As a result the corner invites the public in and doubles as a visual gateway condition to the rest of campus.

Each floor on this corner is programmed with a variety of social space with a focus on event facilitation and booking for students and campus events. Additionally, the PV roof canopy lifts up towards the building edge providing a semi-covered roof patio for public and private events to take advantage of the view from above.


Photo of Lake Merced looking west to the Pacific Ocean on a foggy day

KEY STRATEGIES:

- Acknowledge the campus gateway condition
- Create a buffer between public and private
- Celebrate views towards the Lake and Ocean
- Program elevated space for outdoor events



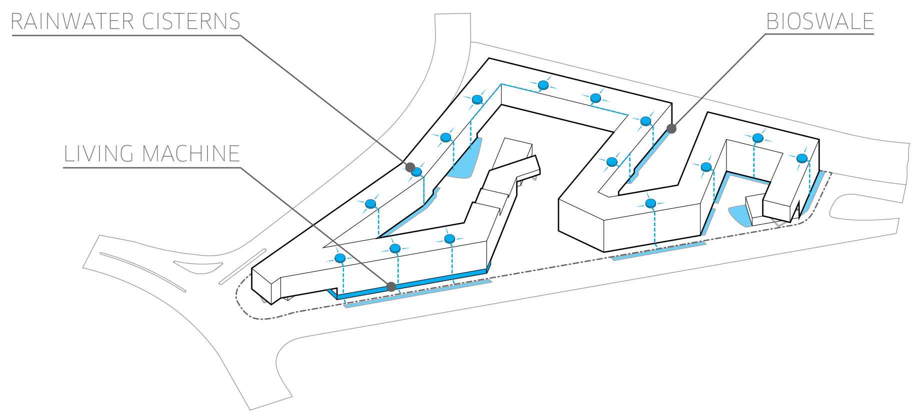
WATER: COLLECTION, STORAGE, USE

In a climate with increasingly dry summers, water conservation is incredibly important. Our system utilizes 100% of rainwater captured from the roof, and treats all sewage and greywater on-site, re-using 46% of it for toilet flushes and irrigation with the remainder available for local neighbourhood use.

The main aim of the design was to achieve net positive water consumption by reducing the amount of potable water consumed and to re-capture and treat more water than is consumed. The design reduces water demand through ultra-low-flow fixtures for sinks, showers and toilet flushes. The captured rainwater is filtered and used for laundry washes.

Excess rainwater is stored in tanks on the roof near the base of the ventilation stacks, connecting the up flow of air and the downfall of water as it is released in the summer months. Rainwater is sufficient for laundry supply for most of the year and will need to be supplemented by potable water. On-site treated water could ideally be used for laundry in the future once the acceptability of this use is approved.

See systems section for detailed quantity calculations.



KEY STRATEGIES:

- Capture as much rainwater as possible
- Drought tolerant plants reduce irrigation
- Install low-flush fixtures

WATER: TREATMENT

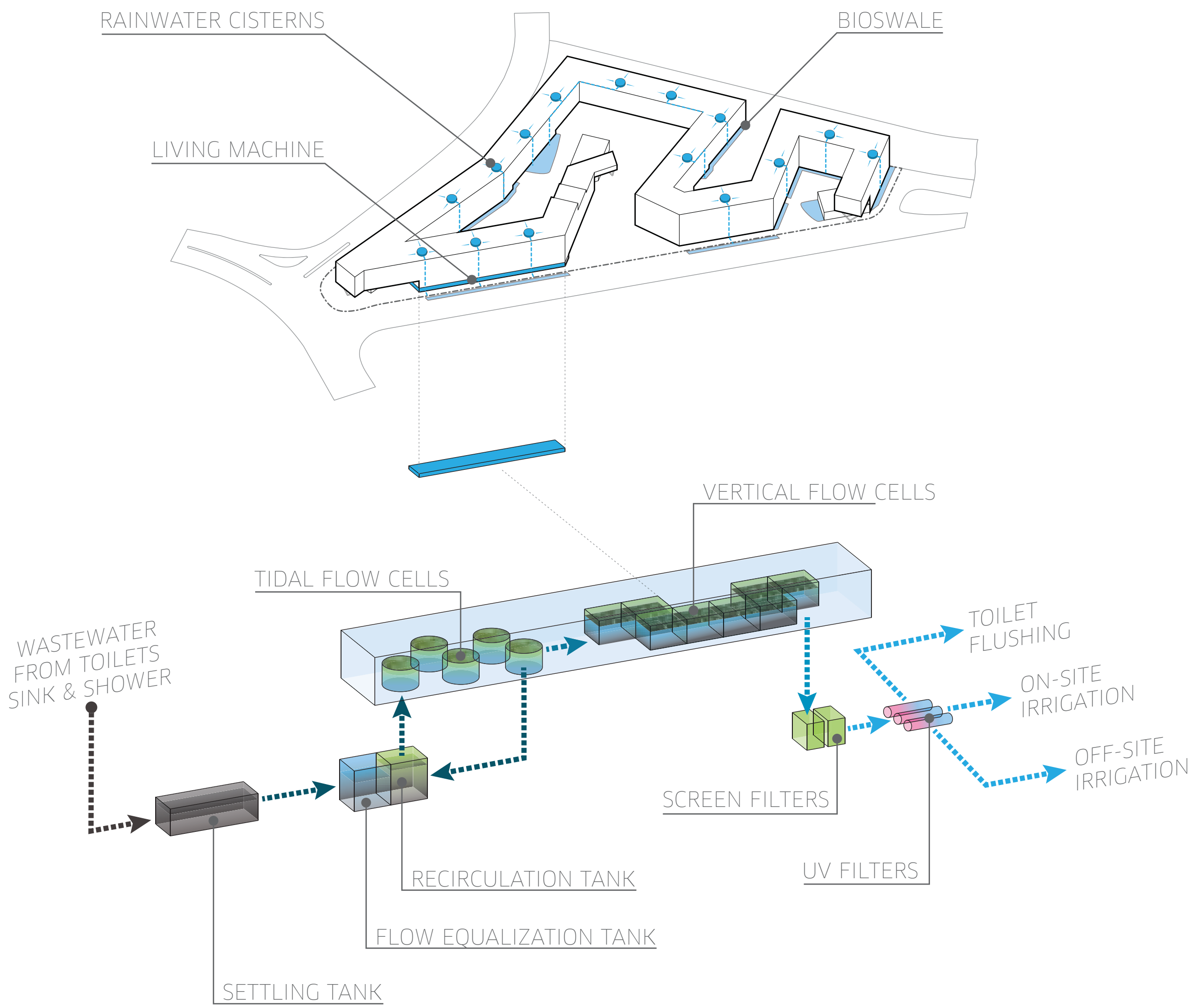
As part of creating an interconnected and closed-loop system that utilizes resources in the most efficient and holistic way possible, the design incorporates a blackwater and greywater treatment process that incorporated constructed wetlands paired with technology to filter large volumes of water for reuse on-site.

The process begins with primary treatment, where a settling tank allows the solids to be separated and decomposed through an anaerobic degradation stage. The next phase is the flow equalization tank which ensures a constant flow of water into the rest of the system. The recirculation tank then takes the water and pumps it into the tidal flow cells back and forth through many cycles during the day. The tidal flow cells are the first stage of the constructed wetlands, which includes plants such as rushes above a lightweight shale aggregate base that supports a diverse microbial community that creates a biofilm.

The second stage of the constructed wetlands are a series of vertical flow cells that hold a different ecosystem that includes lilies, ferns and a finer shale-based media that holds a different group of microorganisms. This second stage removes most remaining BODs and Total Suspended Solids. The water then goes through a filtering system that removes coarse and fine particles that need to be removed before entering the final UV and chlorine polishing treatment.

KEY STRATEGIES:

- Treat water on-site via living machine
- Output can be used for on-site irrigation
- Excess water output diverted for campus use

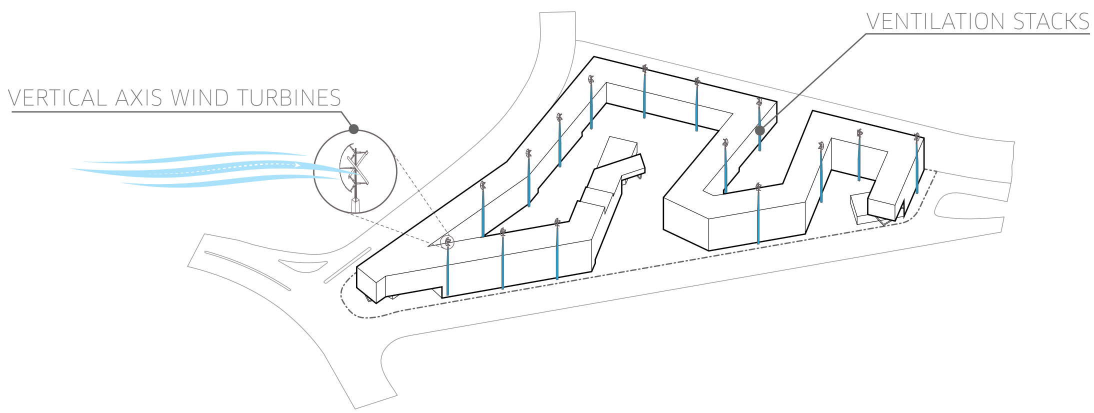


AIR AND VENTILATION

In summer, external air temperatures reach close to the limits of comfortable indoor air temperatures. With the addition of heat gain from solar, electrical equipment, people, and lower floor levels, indoor temperatures are likely to go beyond comfort levels.

The design has incorporated passive ventilation strategies to remove excess heat in the bedrooms and living spaces. Low level operable outdoor air intake vents are situated in each room with an external wall (Eight per unit cluster). High-level internal duct vents allow warm air to pass into ventilation stacks. The stacks rise 40ft above the building and exhaust into the lee-wind.

The stack system will alleviate a fair amount of overheating. Additional cooling and ventilation will be provided through operable windows. The stacks will also play important roles as structural columns, rain water distribution, and wind turbines.



SOLAR PV ARRAY

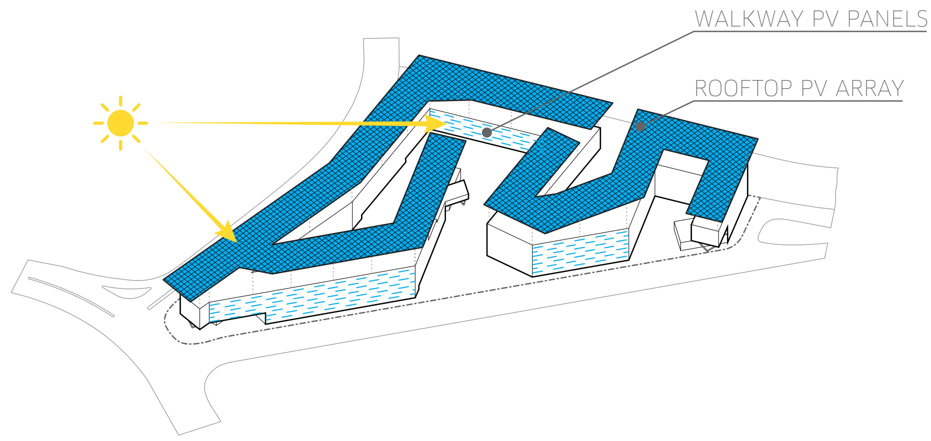
In order to achieve net-zero photovoltaic panels are relied upon heavily for renewable energy generation.

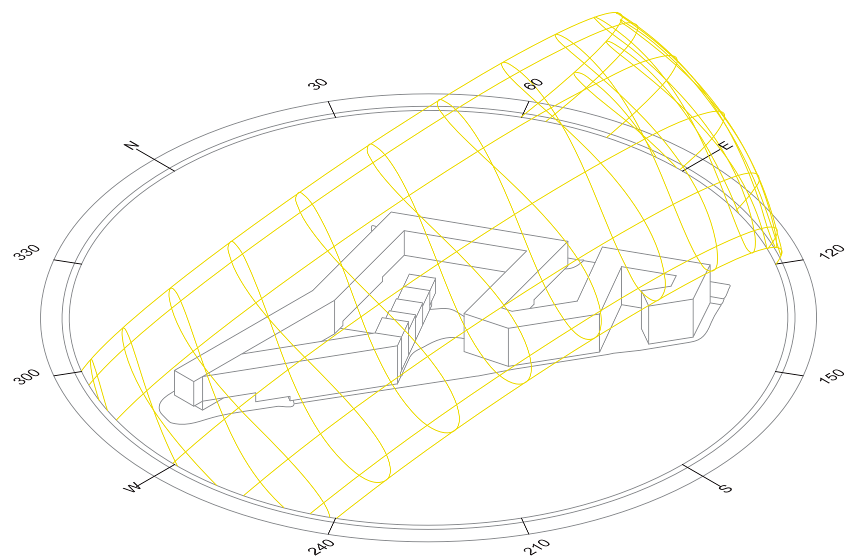
PV panels are mounted on the roof via an external structural frame and are oriented towards the south at a 180° azimuth angle and a 22° solar angle from horizontal for optimal annual capture based on the site latitude of 37.62° N.

The PV canopy covers the entire area of the roof and overhangs 4-12' around the southern edges to increase effective area and provide some solar shading during summer months. This overhung portion is supported by the ventilation stack structural system that is incorporated into the external walkways.

To gain an increased solar energy capture on site more PV panels are mounted to the external walkways in section where the railings are facing southern exposures.

Refer to systems section for further detail and calculations.





SUN-PATH DIAGRAM
LATITUDE: 37.62

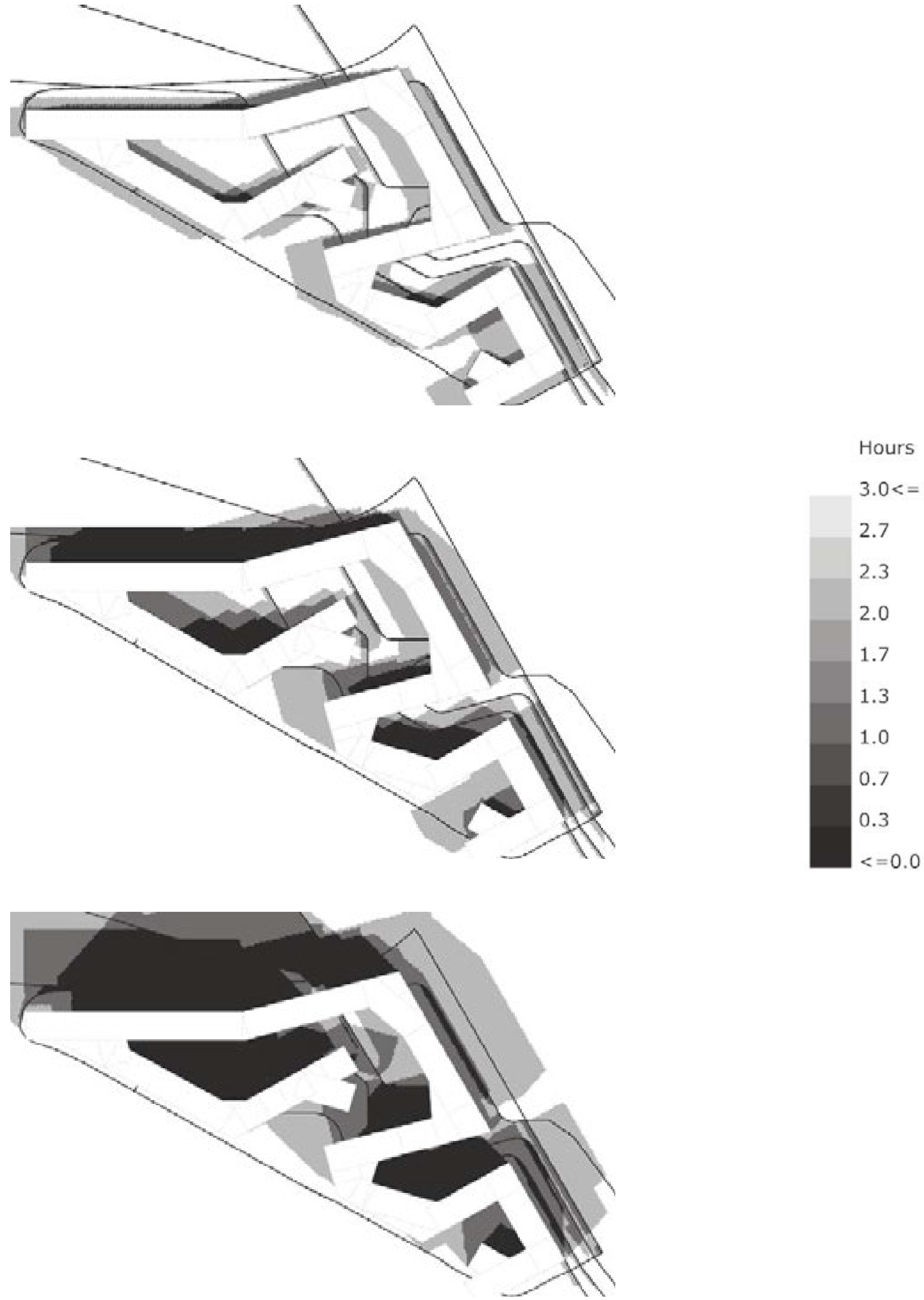
SITE SHADOW STUDY

A site massing shadow study was done using a plugin software for Rhinoceros 3D called Ladybug. Shadows were tested on three days, for three times:

- Summer Solstice: 0900, 1200, 1500
- Equinox: 0900, 1200, 1500
- Winter Solstice: 0900, 1200, 1500

The central courtyard was specifically designed to receive some direct sunlight all year round and performs quite well through analysis. The breaks in the building form on the southwest facades also function well to let further light into the courtyard and to daylight the entrance conditions.

The highest density of shading occurs to the north of the building with significant shading onto Winston Dr.



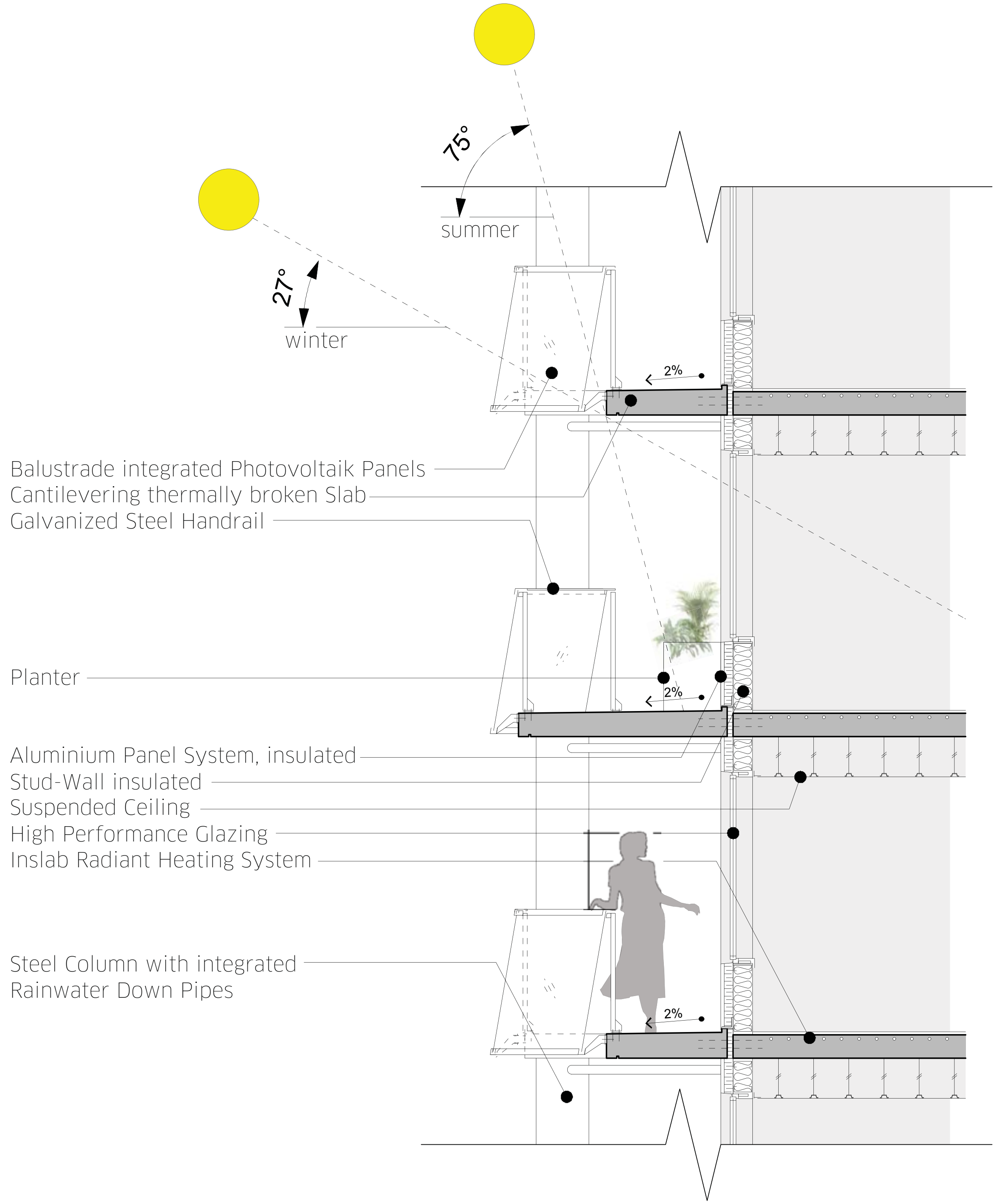
ENCLOSURE: SOUTH

In order to further maximize solar exposure into the building southern facades have increased glazing areas (70%) allowing increased solar heat gain throughout the day.

Cantilevering balconies provide shading during summer time when the sun stays high in the sky but allow light to reach deeper into these common spaces in winter when the sun angle is much lower.

The cantilevering slab is a thermally broken system that eliminates thermal bridging and heat loss (Isokorb system).

The balustrade accommodates additional photovoltaic panels on south-facing aspects to increase renewable energy generation.



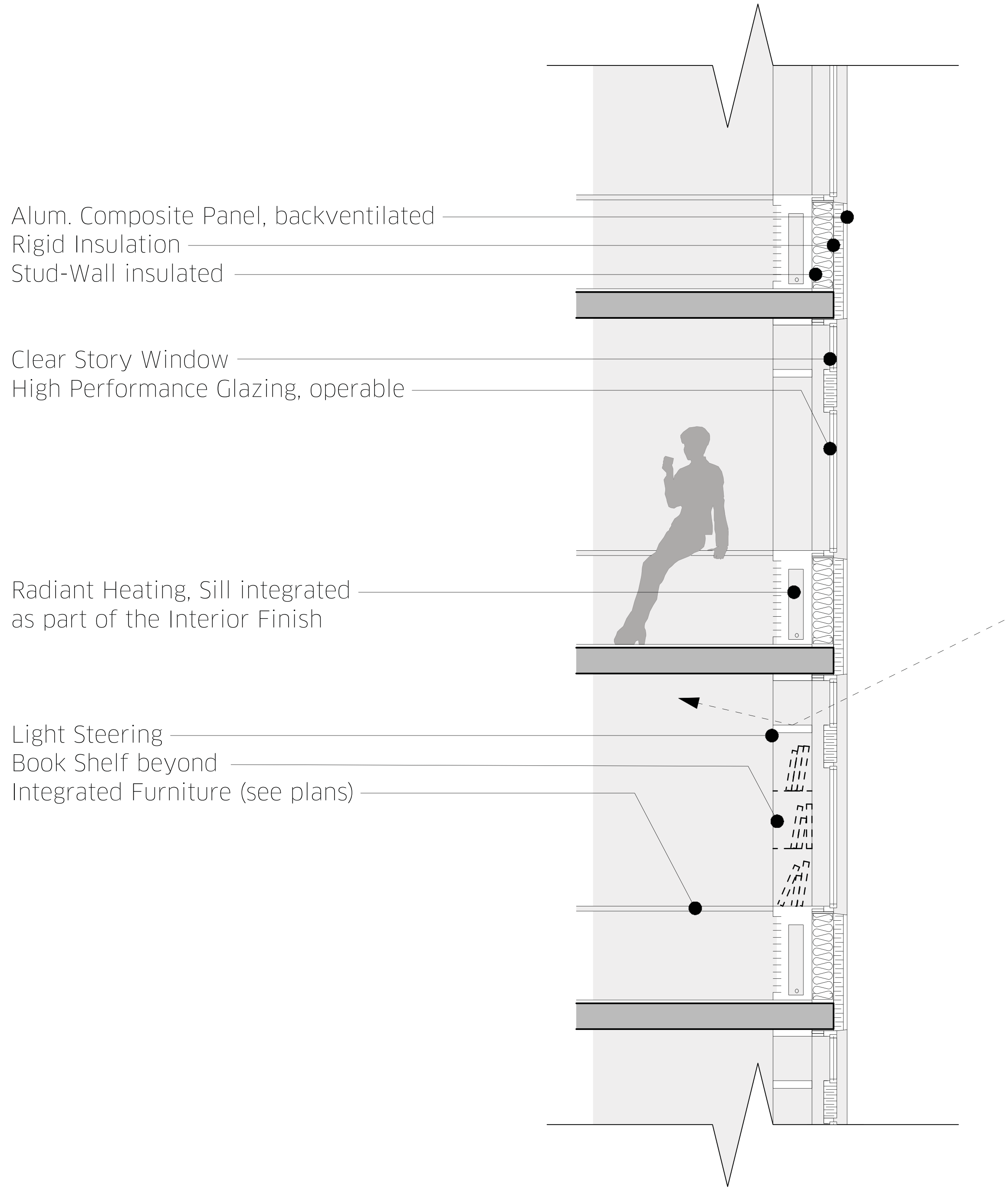
ENCLOSURE: NORTH

As the building is poised to lose a significant amount of heat from northern exposures the enclosure design is developed to be tightly insulated within a minimized glazing ratio (8%). With an emphasis on the creation of vibrant, functional and diverse social spaces within each block and throughout the building we anticipate that the bedrooms to the north are used most of the time just for sleeping. Given this dis-incentive to occupy rooms for long periods of time a reduced glazing ratio is feasible while still providing views to the outside and natural light through elevated clerestory windows.

Provided in each room is furniture which makes the best use of the limited space while providing some functional private space. One small design decision was to include a book shelf as a bed header against the interior north wall to provide additional insulation when stacked with books and other materials.

Below the window sill is an integrated radiant heater which is covered & ventilated from the front to provide a secondary flexible heat source that can be individually controlled..

The facade cladding is designed to use perforated, insulated metal panels which have a high performative and aesthetic quality.



OCCUPANT BEHAVIOR

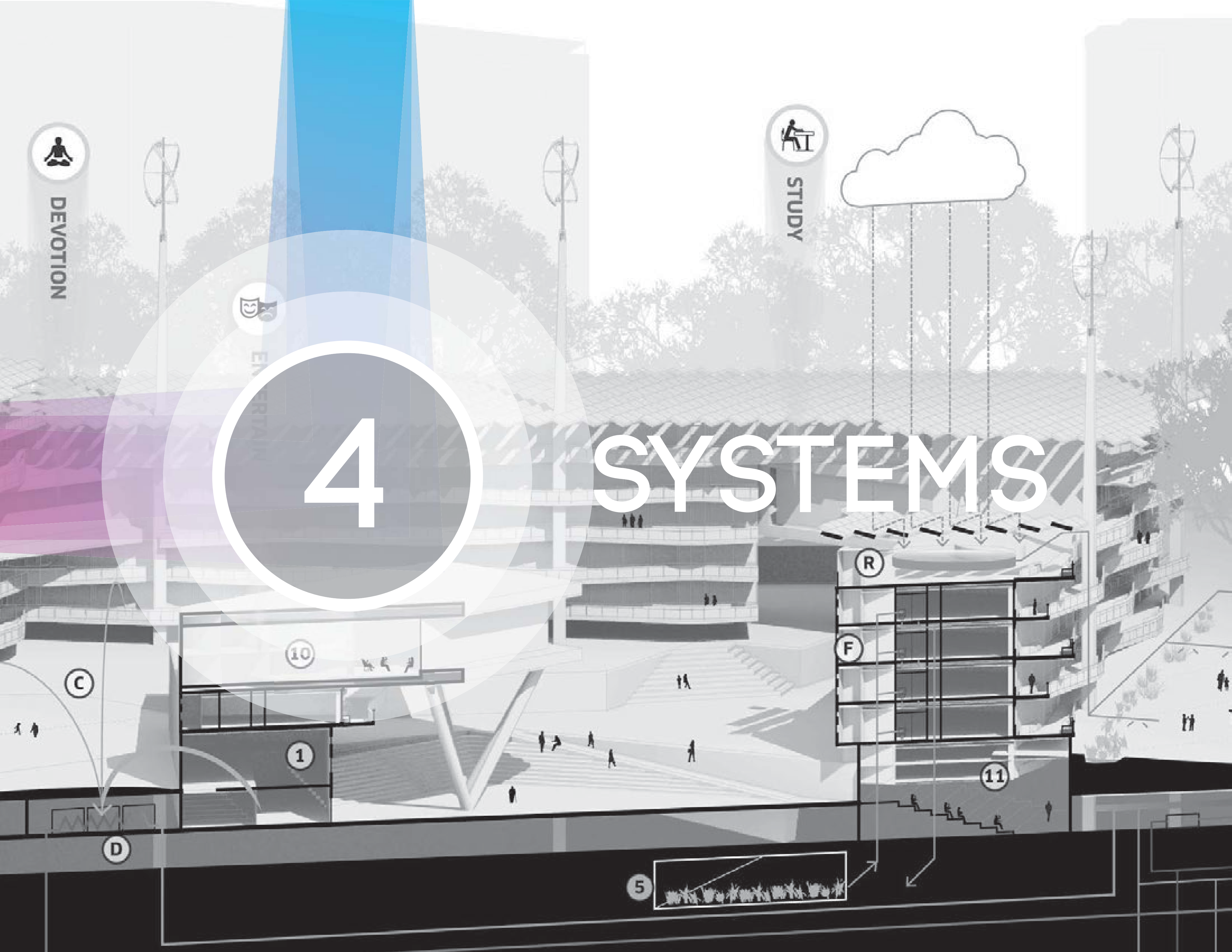
Ther term occupant implies a passive consumer. We consider people to be inhabitants--active participants in the building systems.

Systems must be expressed and inhabitants educated to be effective particpants. People are naturally good at sensing and controlling certain environmental factors, like thermal comfort and dim lighting, but not equipped for other tasks such as identifying overlit spaces. Where appropriate, we design with simple, manual controls to educate the student residents.

We propose the following strategies for educating and inviting inhabitants to be productive pieces of the systems:

- Visual thermostats with lights for energy consumption feedback;
- Competition between blocks for energy consumption targets;
- Operable windows for cooling;
- Operable external screen and internal shades for lighting control;
- Variable daylighting and solar gains due to undulated walkway, creating variable environments to allow inhabitants to find their comfortable space;
- Food scrap collection for the aerobic digester;
- Task lighting and floor lamps to create space within larger social spaces;
- Automatic dimming of LED lighting; and
- Viewable living machine to educate about the water cycle.

4 SYSTEMS

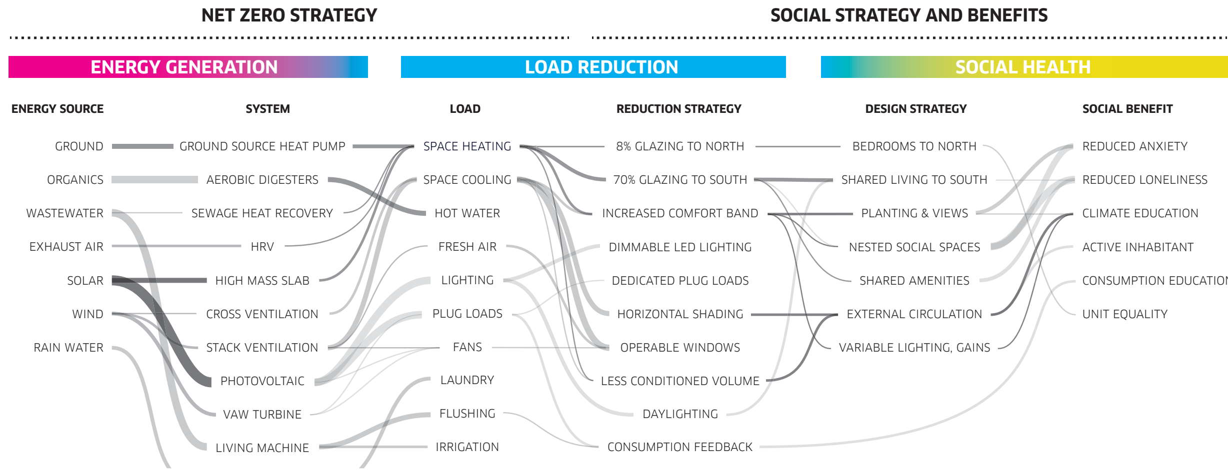


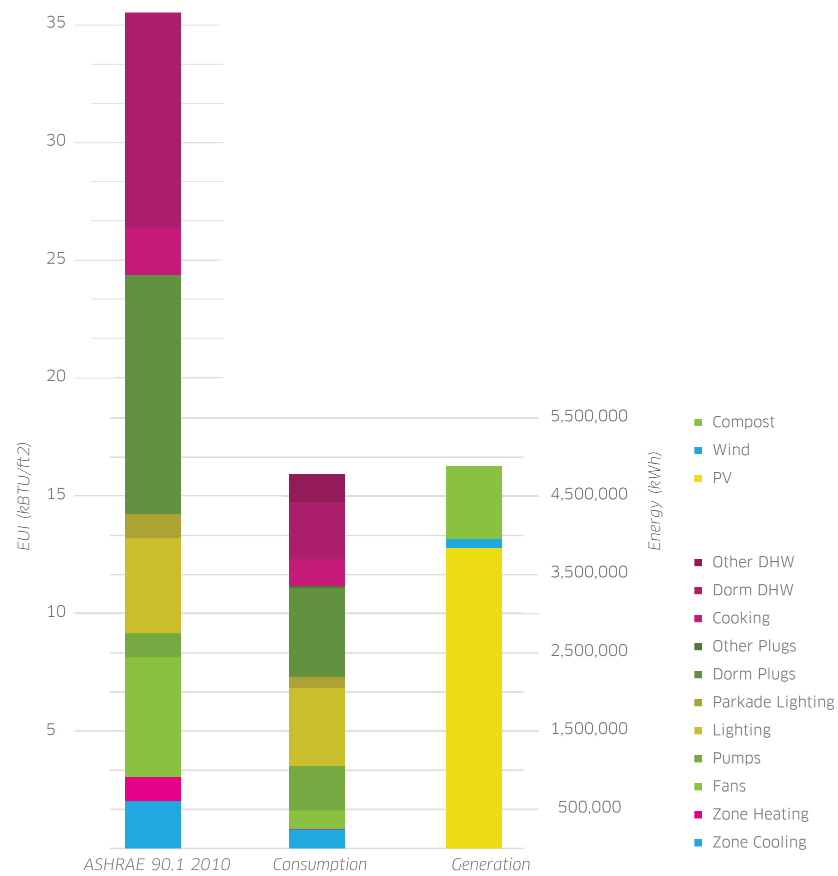
SYSTEMS ETHOS & END USE CONSUMPTION

Systems are much more than mechanical and environmental controls. They have the potential to support social needs and close resource loops, as well as offer environmental comfort and renewable energy generation.

Environmental control must consider the unique climate conditions of a place, as well as the unique comfort needs of inhabitants. Passive heating and inhabitant controlled ventilation and shading are the first stage of environmental control. Since inhabitant preferences vary, optimal solutions are impossible; thus, our strategy is to provide a range of environmental conditions across social spaces, enabling inhabitants to find their own comfort. These strategies also passively educate inhabitants about the outdoor climate, their personal needs, and the broader building systems--equipping them to understand the benefits and consequences of their decisions.

Overall weighted building EUI was determined to be 53.1 kWh/m2 (16.83 kBtu/ft2). Overall Energy Generation Intensity (EGI) was calculated to be 54.1 kWh/m2 (17.14 kBtu/ft2), yielding a slightly positive annual generation. This is only 1/2 of our focus, however, since healthy social spaces are equally important but lack metrics for measured success.



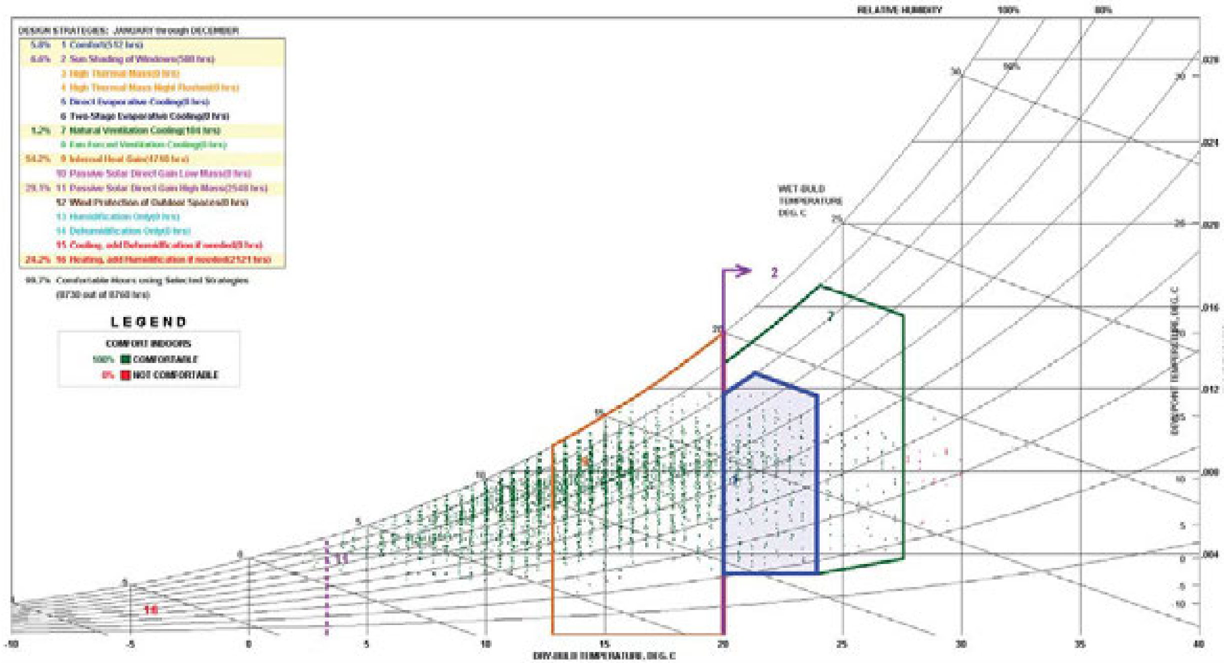


PASSIVE SYSTEMS

Heating and cooling have been designed to predominantly use passive solar gains and natural ventilation, respectively, due to analysis of the annual hourly climate data. Daylighting and views have been balanced with lighting loads and energy loss through glazing.

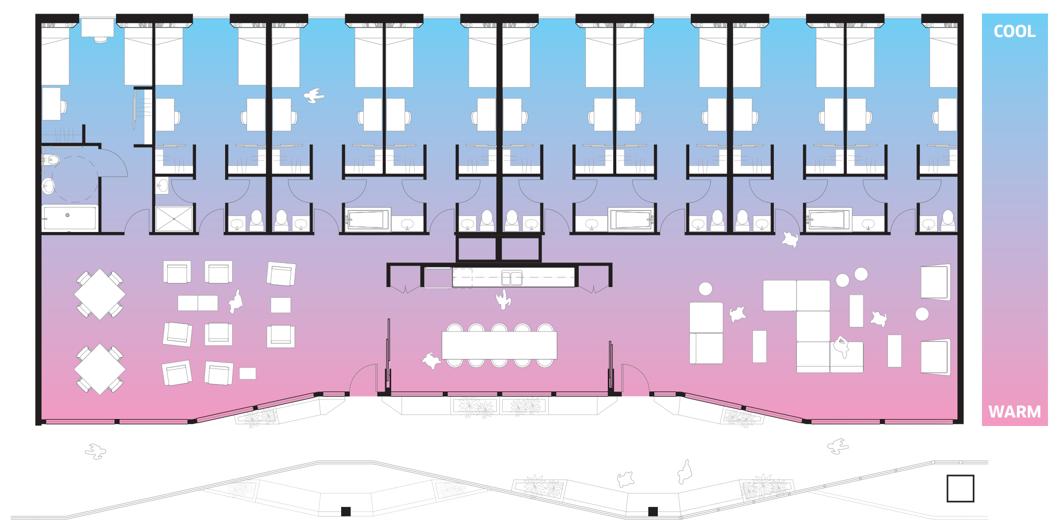
A psychometric chart and hourly climate data were used with Climate Consultant to identify passive strategies for providing comfort. This analysis showed several key strategies:

- internal heat gains
- passive solar direct gain high mass
- sun shading
- natural ventilation cooling



Passive heating has been designed across building scales. At the residential unit, sleeping quarters were moved to the northern exposed facade to provide daylighting and views with minimal glazing ratios. Shared living spaces and social lounges are located to the south--these wider, deeper rooms use high glazing ratios to celebrate views and harness passive solar gains. These shared spaces use a high mass concrete slab to temper the diurnal solar and temperature swings. The higher daytime occupancy load means that there is a larger internal load to offset the increased heat loss in the winter.

This unit configuration results in a single loaded external corridor that has added benefits including cross ventilation for cooling, equal access to light for all students, and non-conditioned circulation space. The average external walkway depth has been adjusted to optimally shade during the summer. The depth, however, undulates to and from the building to create shared social patio spaces and diversity of solar gains and daylighting across the facade.



PASSIVE SYSTEMS CONTINUED

This enables inhabitants to find their own comfortable micro-climate, whether it be basking in the sun or seeking shade.

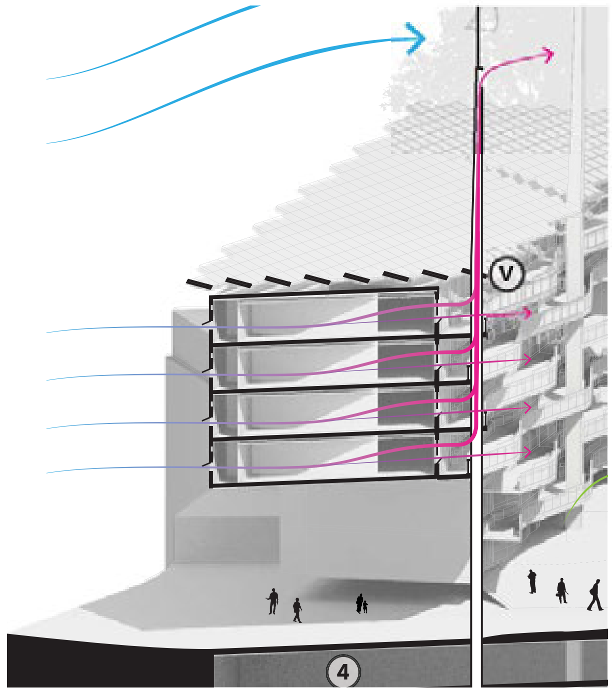
The massing has prioritized southern exposure for the shared living rooms (the optimal azimuth angle is 165 degrees to capture more morning sun and less afternoon sun, based on initial energy modeling with Sefaira). Massing models were iteratively tested with Ladybug for total sunlight hours during winter months. See the massing section for more details.

Passive cooling

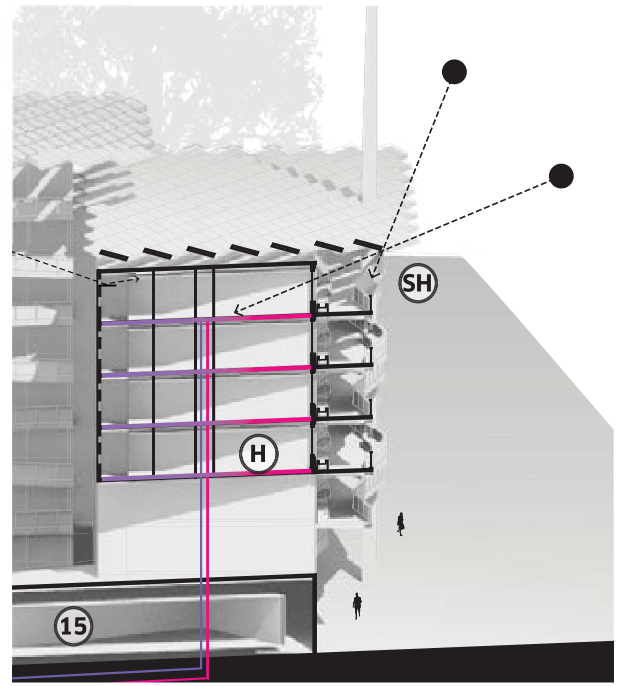
The single external corridor enables cross ventilation for cooling. Operable windows in the northern bedrooms and southern living rooms allow for inhabitant participation in finding their comfort and the high mass slab of the living space will temper rapid diurnal temperature swings. The east-west orientation for solar gains limits the cross ventilation from the westerly winds; thus ventilation stacks augment the cross ventilation. These ventilation stacks are also the structure for the external circulation, solar canopy, and wind turbines.

Daylighting

The high glazing ratio on the south face provides high levels of daylighting to the social spaces. Opaque external blinds and internal translucent screens provide daylighting control as well as additional shading and insulation. Bedrooms have two windows: a small viewing window, and a high, long clerestory for daylighting. Bookshelves under the clerestory provide additional insulation and act as a light shelf.



Natural ventilation cooling via cross ventilation and stack ventilation



Passive heating in winter months into shared living spaces with high mass

ACTIVE SYSTEMS: HVAC

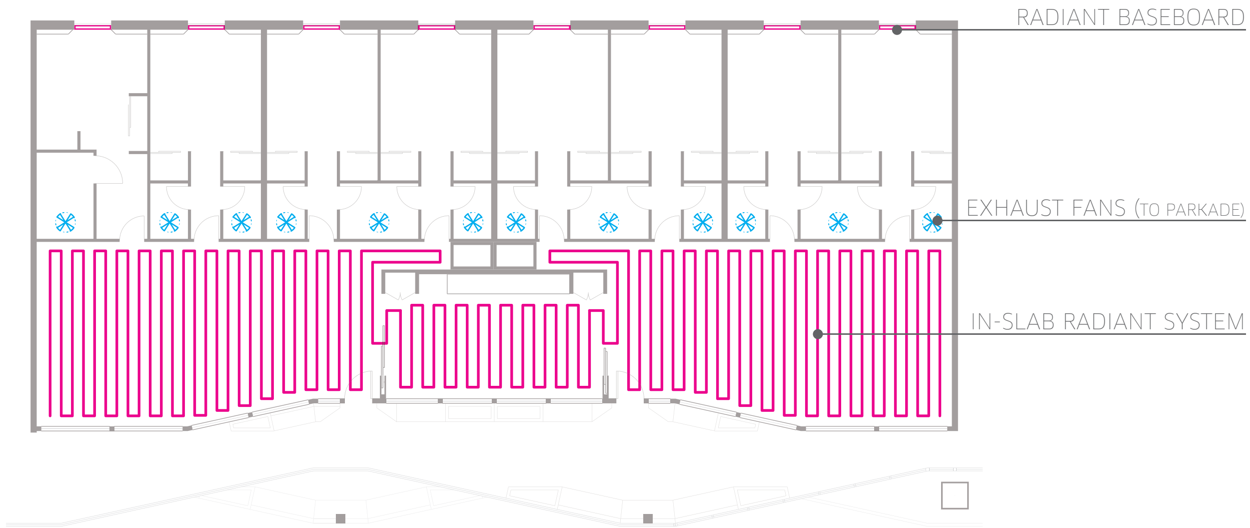
Active HVAC systems are the second stage of comfort and have been designed to be simple and efficient, focusing on transferring and balancing low grade thermal energy between units.

Radiant systems provide the balance of the heating and cooling load. Social spaces use in-floor radiant within the concrete slab to benefit from the high mass. Bedrooms, which are well insulated with fewer gains and losses, are heated via a radiant baseboard under the window. Cooling is not required in the bedrooms due to the Northern exposure and minimal solar gains present.

Radiant systems are easily zoned by room, with programmable thermostats for each social pod to respond to occupant requests. Night setbacks will be defaulted into the thermostat. Shared social spaces will be centrally controlled with a wide comfort band (68°F-78°F). This wide band is justified by research that suggests people's thermal comfort widens when they are surrounded by active radiant surfaces, people, daylight, outdoor views and plants. Temperatures are further set back by 2°F during unoccupied periods.

Ventilation is provided by a dedicated outdoor air system with enthalpy recovery wheels. Bathroom exhaust fans vent through a heat recovery wheel that tempers incoming air and ejects it through the parking structure. This eliminates the need for parking exhaust fans and provides a small amount of conditioning via unrecovered heat.

The hydronic heating and cooling system is centralized with a storage manifold to balance the inputs and outputs from the heating system. Heating and cooling is provided by a bank of ground source heat pump and a vertical geoexchange bore field with 64 x 300' deep bores. Domestic hot water heat is entirely provided by an organic waste compost digester heat recovery system operating on a 15-day digestion process to compost daily food waste from the building occupants.



Lighting

Dimmable LED lighting is used to efficiently complement daylighting. Dimming will be connected to daylight sensors. Occupancy sensors will be installed in common areas to disable lighting at night time. Social spaces and bedrooms are equipped with LED task lighting and floor lamps to creates more personal zones within the shared spaces and reduce the overall lighting load.

Plug Loads

Electrical outlets will be separated into dedicated and non-dedicated loads. Switches at room entries will turn off all non-dedicated loads, eliminating phantom loads.

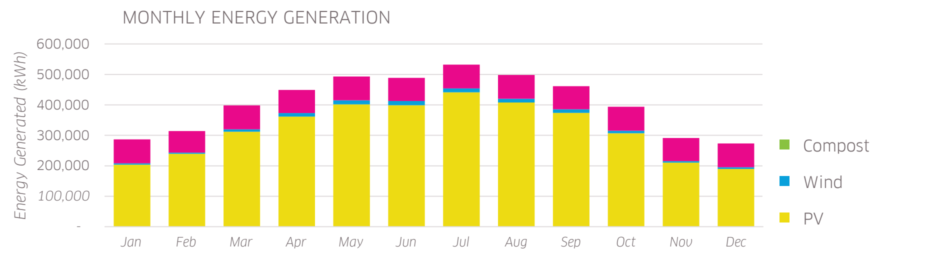
ENERGY GENERATION: PV

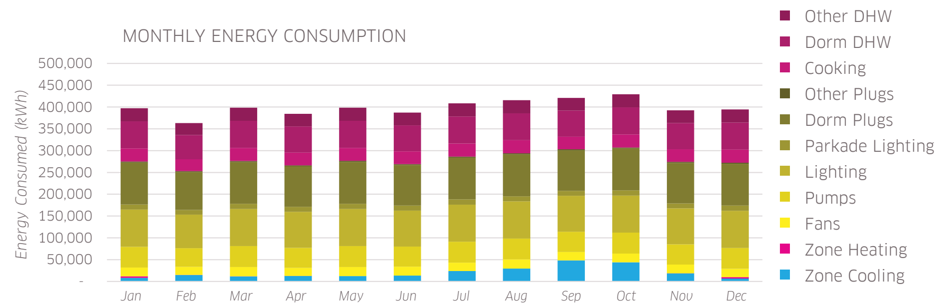
There is no single solution to energy generation. Our strategy was to diversify energy generation among the limited on-site resources: solar, wind, and food waste. Geoexchange was used for heat transfer, but has calculated as an energy sink rather than an energy generator.

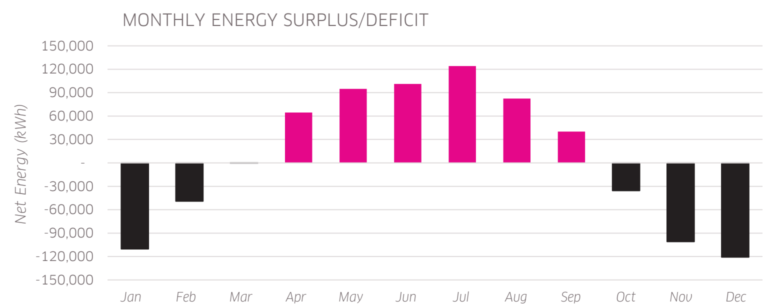
Overall Energy Generation Intensity (EGI) was calculated to be 54.1 kWh/m2 (17.14 kBtu/ft2)

PV Panels

Itek HE solar modules formed the basis of design, with calculated installed power density of 16W/ft2. An installed panel area of 131,120 ft2 covers most of the building roof with panels facing due South at a tilt angle of 22 degrees. An additional 20,330 ft2 of installed panel area is located on balcony railing areas facing roughly South. The total installed array capacity is roughly 2,440 kW. Monthly solar production at the relevant angles and azimuths was generated from the online PVWatts tool (http://pvwatts.nrel.gov/). The calculated annual generation is 3,846 MWh.







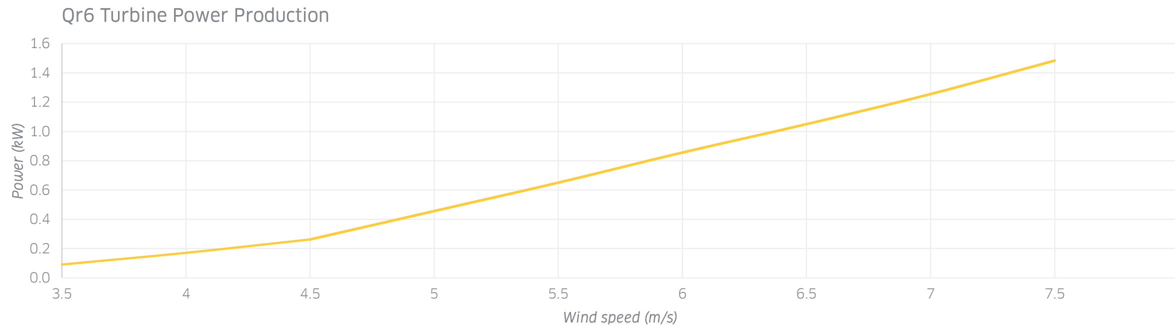
Base Assumptions	
Basis of Design	Veissman Vitovolt 303
Module Length (in)	66
Module Width (in)	42
Module Area (ft2)	19.25
Module Power (W)	313
Panel Power Density (kW/ft2)	0.0163

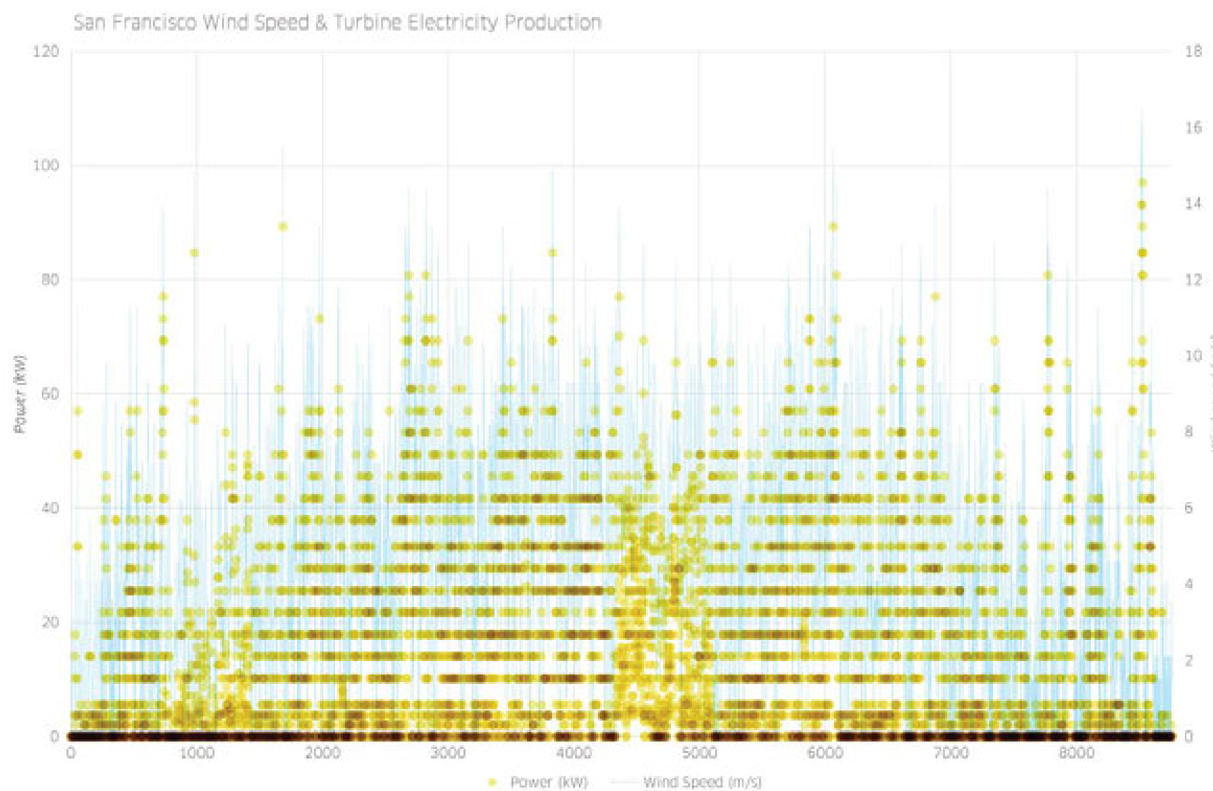
PV Production					kWh/kW												
PV	Azimuth	Angle	Installed Area (sqft)	Installed Capacity (kW)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rooftop	180	22	131120	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Façade	165	75	8232	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Façade	180	75	4200	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Façade	195	75	5124	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Façade	225	75	2772	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL					0	0	0	0	0	0	0	0	0	0	0	0	0

ENERGY GENERATION: WIND

Quiet Revolution Qr6 vertical axis wind turbines were selected for additional electrical generation. Mounted on the 19 stack cooling towers (approximately 120' to 150' high) for improved wind speeds, the Qr6 vertical axis turbine distribute loads evenly which limits noise, vibration and resulting structural requirements. The turbines are 18' tall, 10' high, with a 172 sq. ft swept area. The turbines can provide power with wind speeds as low as 3.5 m/s. The turbine efficiency improves linearly above 4.5 m/s (http://www.quietrevolution.com/products/).

The annual power output is 111,092 kWh, calculated from hourly wind speeds and the published turbine efficiency.



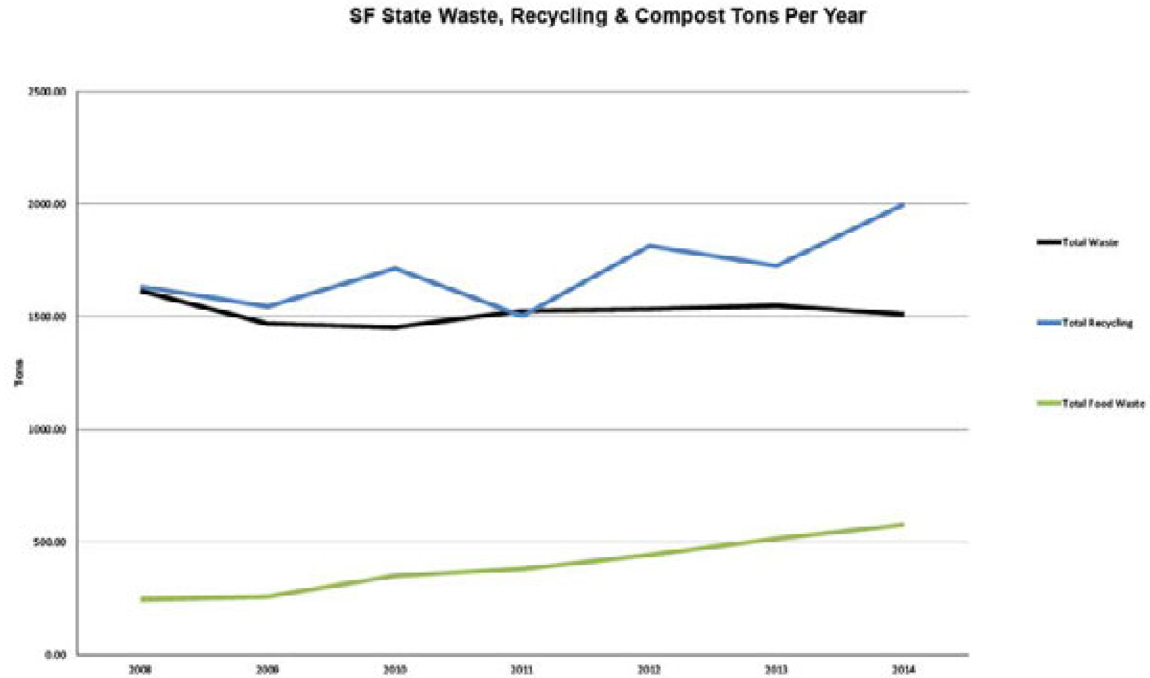


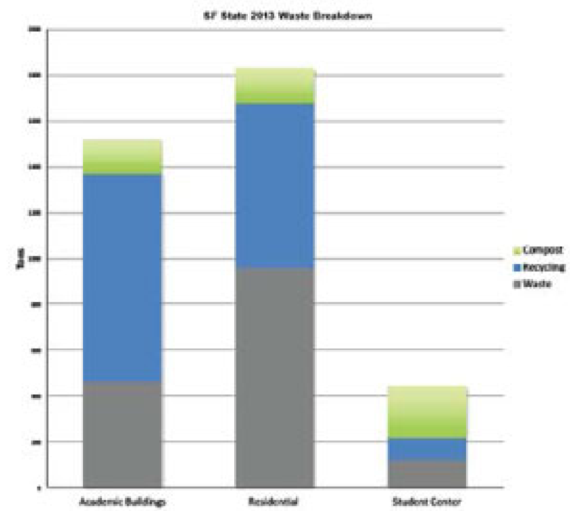
ORGANICS DIVERSION TO AEROBIC DIGESTER

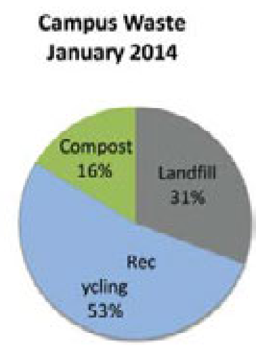
SFSU campus has a long tradition of recycling and currently diverts 76 percent of its waste away from landfills, a rate which exceeds standards set by the City of San Francisco. "Composting has helped us decrease a huge amount of waste and is definitely reflected in our Cool Schools ranking," said Caitlin Steele, sustainability programs manager. In addition to the compost bins in the Student Center and the dorms, the campus is developing a three-bin system with compartments for trash, compost and recycling. These will soon be introduced on the quad and other open spaces on campus, and in academic buildings.

This presents a great opportunity for Nexus to utilize food scraps from the dorm facilities and cafeteria/café facilities to not only produce energy but valuable nutrient-rich compost as well. In this system organics are collected and aerobically digested in a sub-grade composting facility using a 15-day continuous process. Irvine and Lamont indicates a thermal energy extraction content of up to 10,000 kJ/kg of waste over the 15 day process (Energy from Waste: Reuse of Compost Heat as a Source of Renewable Energy, https://www.hindawi.com/journals/ijce/2010/627930/).

Aerobic digestion temperatures are high enough to allow for direct generation of domestic hot water. With an assumed input of 0.35 kg compost waste per occupant, this yields an average thermal output of 105 kW (7.7 W/kg). Annually, this supplies roughly 923 MWh of heat, and almost enough for all of the domestic hot water use in the facility.







Compost data and tables provided by the Sustainable SF State Group

ENERGY MODEL

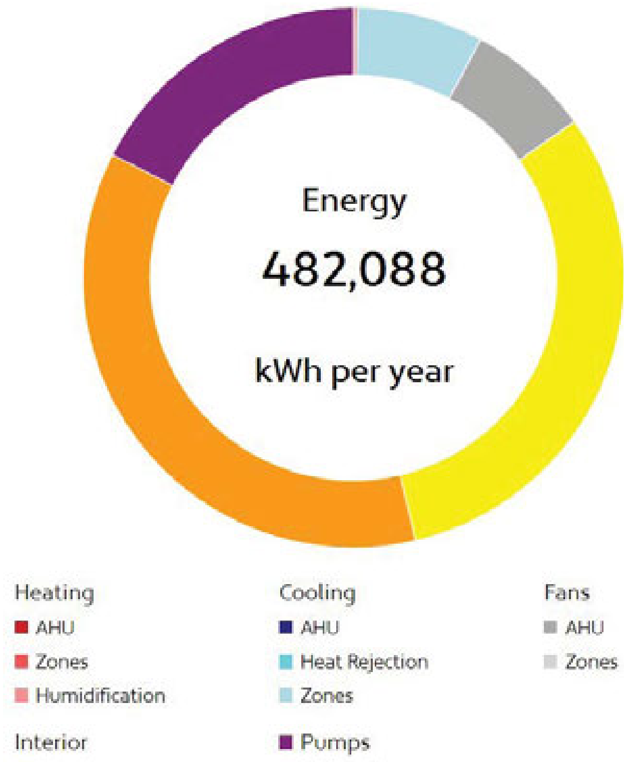
A representative block of the building dorm structure was analyzed using Sefaira Systems with geometry imported from Sketchup. All envelope performance was set to assumed values representing high quality construction that falls within standard high performance buildings:

- Glazing: U-0.33, SHGC-0.25 (low solar double pain thermally broken glazing units)
- Walls: R-25 effective
- Exposed Floors: R-30 effective
- Roof: R-30 effective
- Balconies: vertically supported, thermally broken at tie-back

Geometric shading was modeled explicitly. Rooms were modeled as separate thermal zones with loads defined with appropriate diversity factors according to programming (see table to right).

The HVAC systems were modeled as water loop heat pumps with a ground source field comprised of 64 300ft deep vertical boreholes and backup condensing boilers with a 95% seasonal efficiency. Cooling COP was set to 3.93 and heating COP was set to 3.1, corresponding to ASHRAE 90.1-2007 Chapter 6 minimum equipment efficiencies for ground source heat pumps. Zone unit fan power densities were set to 0 W/cfm, since the systems are radiant, and dedicated outdoor air power densities were set to 0.94 W/cfm, which was calculated using Greenheck ERCH energy recovery ventilators as a basis of design. The ventilation energy recovery ratio was set to 77%, which is consistent with premium ERV products.

The Sefaira model was exported to EnergyPlus for generation of final monthly consumption by category.



Item	Community Spaces	Bedrooms
Occupant Density	400 sq ft/person	150 sq ft/person
Plug Loads	0.5 W/sq ft	0.3 W/sq ft
Lighting Power Density	0.4 W/sq ft*	0.3 W/sq ft*

**Lighting density assumed -20% of installed capacity per LEED guidelines for occupant sensors*

ENERGY MODEL CONTINUED

Domestic hot water use is not accounted for in a Sefaira model, so a LEED water efficiency credit documentation method was used based on assumed occupancy and 50% water mix ratio. The compost heat recovery process provides all of the required heat for the dorm domestic hot water. Any daily shortfall is assumed to be made up by electric tank heaters.

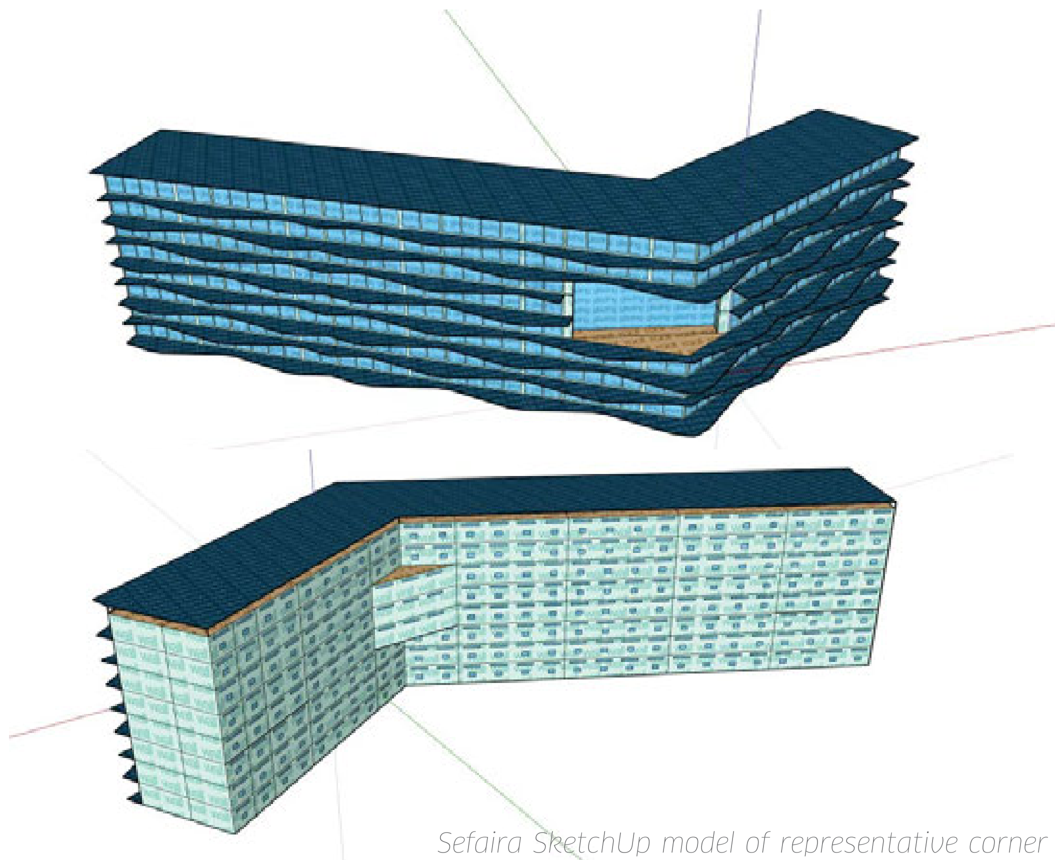
Since the balance of non-dorm space types (approx. 10% of program) were not explicitly modeled, smaller programming element energy consumptions were manually added at the end using values from The Technical Feasibility of Zero Net Energy Buildings in California (http://www.energydataweb.com/cpucfiles/pdadocs/904/california_zne_technical_feasibility_report_final.pdf). Additional loads were broken into usage types and monthly consumption in conformance with the dorm model, with the balance of energy requirements for cafeteria and café spaces assumed to be split 50/50 between domestic hot water use and process cooking loads. Simulated dormitory EUI of 40.1 kWh/m2 was noted to fall within the anticipated range of the same study.

Overall weighted building EUI was determined to be 53.1 kWh/m2 (16.83 kBtu/ft2). Overall Energy Generation Intensity (EGI) was calculated to be 54.1 kWh/m2 (17.14 kBtu/ft2), yielding a slightly positive annual generation.

Residential

Occupancy	2600					
Fixture Type	Diversity	Users	Daily Uses	Flow (gpm)	Seconds	Usage (gal)
Shower	0.5	1300	1	1.5	300	4875.0
Lavatory	0.65	1690	3	0.5	15	316.9
Kitchen Sink	0.5	1300	2	1.5	120	3900.0
TOTAL (Daily)						**9091.9**

Programming	EUI (kWh/m2)
Childcare Facilities	69.4
Cafeteria/Cafe	561.2
Lounge/Meeting Room	37.2

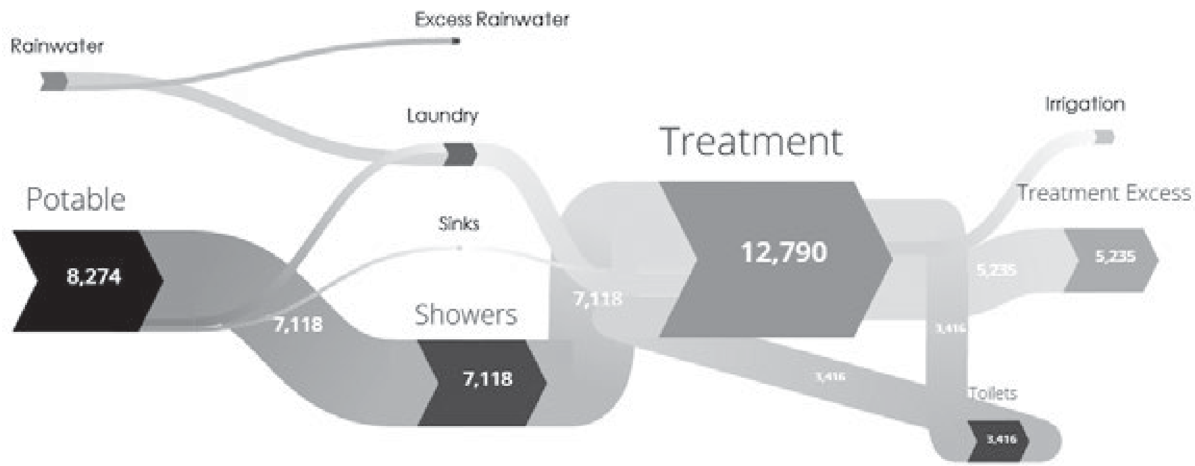


Sefaira SketchUp model of representative corner

WATER QUANTITIES AND CALCULATIONS

The output of the water capture and treatment system is more than sufficient for all on-site irrigation and toilet flushes. It produces over 5million gallons of water per year which could additionally be used for irrigation on the rest of campus.

The water use figures for the cafeteria and nursery have not been calculated. The majority of the intake will need to be potable water however the toilet flushes and wastewater will sync into the same treatment system which has been adequately sized to incorporate these facilities.



	WC	Sinks	Showers	Laundry
Uses per day per person (in Residences)	3	3	1	0.143
Duration of each use (mins)		0.25	5	
BASELINE (gallons per use (WC, Laundry) or gallons per minute)	2	2.2	2.5	27
POTENTIAL (gallons per use (WC, Laundry) or gallons per minute)	1.2	0.5	1.5	14
Users	2600	2600	2600	2600
TOTAL (gallons per day)	9360	975	19500	5205.2

US liquid gallons

Uses	Use Input	Use Output	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Sinks	Potable	Treatment	29,656	29,656	29,656	29,656	29,656	29,656	29,656	29,656	29,656	29,656	29,656	29,656	355,875
Showers	Potable	Treatment	593,125	593,125	593,125	593,125	593,125	593,125	593,125	593,125	593,125	593,125	593,125	593,125	7,117,500
Laundry	Rainwater / Portable	Treatment	158,325	158,325	158,325	158,325	158,325	158,325	158,325	158,325	158,325	158,325	158,325	158,325	1,899,898
Toilet Flushes	Treatment Output	Treatment	284,700	284,700	284,700	284,700	284,700	284,700	284,700	284,700	284,700	284,700	284,700	284,700	3,416,400
Irrigation	Treatment Output	Ground / Evaporation	0	0	0	0	118,086	177,129	354,258	354,258	177,129	0	0	0	1,180,860
Inputs															
Required Potable (Sinks and Showers)			622,781	622,781	622,781	622,781	622,781	622,781	622,781	622,781	622,781	622,781	622,781	622,781	7,473,375
Excess Potable (Laundry Use minus Rainwater Capture and Storage)			0	0	0	984	110,942	147,647	158,325	152,986	144,977	84,914	0	0	800,775
Rainwater Capture (90% of Rainwater (from weather data) falling on roof area)			299,649	296,979	218,230	97,436	47,383	10,678	0	5,339	13,347	73,411	210,221	304,988	1,577,661
Rainwater Storage (Previous month Rainwater Capture minus Laundry)			146,663	141,324	138,655	59,905	0	0	0	0	0	0	0	51,897	538,443
Treatment Output (80% re-captured from sewage, 90.4% recapture from Sinks and Showers)			819,402	819,402	819,402	819,402	819,402	819,402	819,402	819,402	819,402	819,402	819,402	819,402	9,832,826
Treatment Output Excess (Treatment Output minus Toilet Flushes and Irrigation)			534,702	534,702	534,702	534,702	416,616	357,573	180,444	180,444	357,573	534,702	534,702	534,702	5,235,566

Average Days per month 30.41666667

VENTILATION CALCULATIONS

The design has incorporated passive ventilation strategies to remove excess heat in the bedrooms and living spaces. Low level operable outdoor air intake vents are situated in each room with an external wall (Eight per unit cluster). High-level internal duct vents allow warm air to pass into ventilation stacks. The stacks rise 40ft above the building and exhaust into the lee-wind.

The stacks and vents were sized to remove all heat gains from 16 people, lighting and electrical equipment (values as per energy loads). The lighting was assumed to be off in the common spaces as over-heating is likely to occur during daylight hours. Required effective vent sizes range between 7.5 and 9.7 sq ft.

The calculations assumed all air flow to be generated through buoyancy pressure. Wind pressure could also be an effective mechanism for ventilation however around tall buildings, it is not consistent enough to be relied upon.

The stack system will alleviate a fair amount of overheating. Additional cooling and ventilation will be provided through operable windows. The stacks will also play important roles as structural columns, rain water distribution, and wind turbines.

Density of Air (Rho)	1.2	kg/m3
Gravity	9.81	m/s2
External Air Temperature (Kelvi	297.15	Kelvin
Internal Temperature	300.15	Kelvin
Discharge Coefficient	0.61	

Air Flow Required to Remove Heat Gain

Heat Gain kW	Heat Gain W	Internal Air temperature (°C)	Dry-bulb temperature (°C)	kg/s	Required flow l/s	m^3/s	Required flow per vent (8 vents) m^3/s
3.44	3440	27	24	1.142098274	951.7486	0.951749	0.119

Air flow due to Buoyancy - Required Vent Size

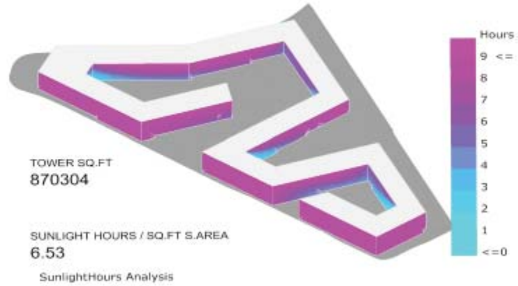
Floor	Distance from Neutral Pressure Line m	Flow rate m^3/s	Pressure Difference Ps (Pa)	Discharge Coefficient	Vent Area m^2
1	40.0	0.119	4.706446777	0.61	0.0697
2	37.5	0.119	4.412293853	0.61	0.0719
3	35.0	0.119	4.11814093	0.61	0.0745
4	32.5	0.119	3.823988006	0.61	0.0773
5	30.0	0.119	3.529835082	0.61	0.0804
6	27.5	0.119	3.235682159	0.61	0.0840
7	25.0	0.119	2.941529235	0.61	0.0881
8	22.5	0.119	2.647376312	0.61	0.0929
Exhaust	5.0	0.952	0.588305847	0.61	1.5761

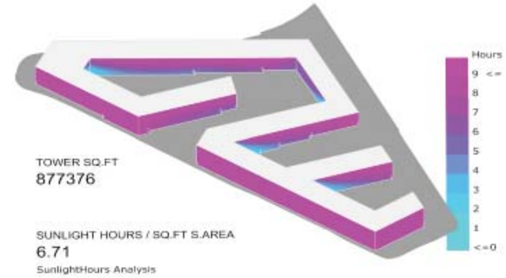
5 APPENDIX

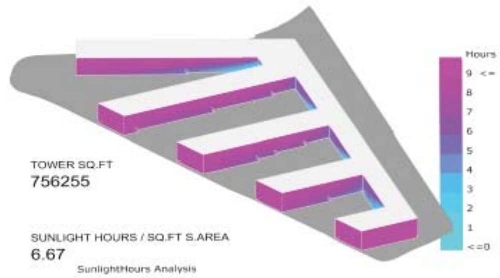
ITERATIVE MASSING WITH SOLAR FEEDBACK

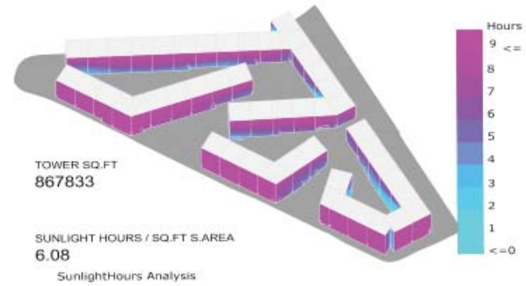
These are select massing iterations tested with the Ladybug solar hours analysis. Metrics used to test the massing included:

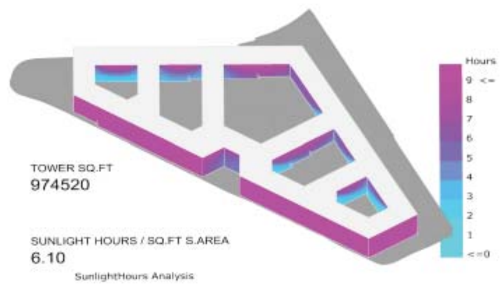
- total square footage
- sunlight hours / sq. ft of south facade surface

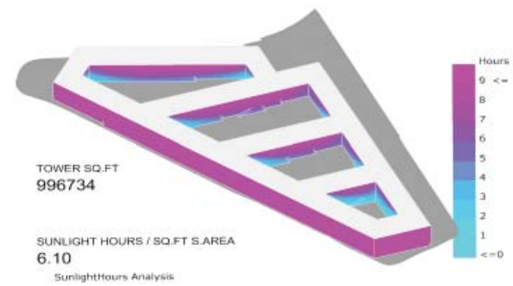


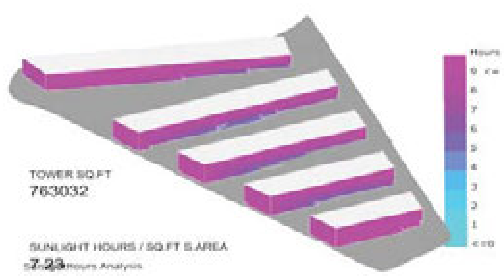


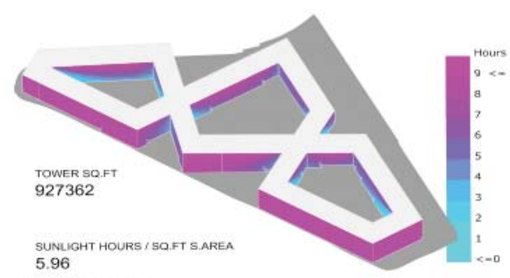




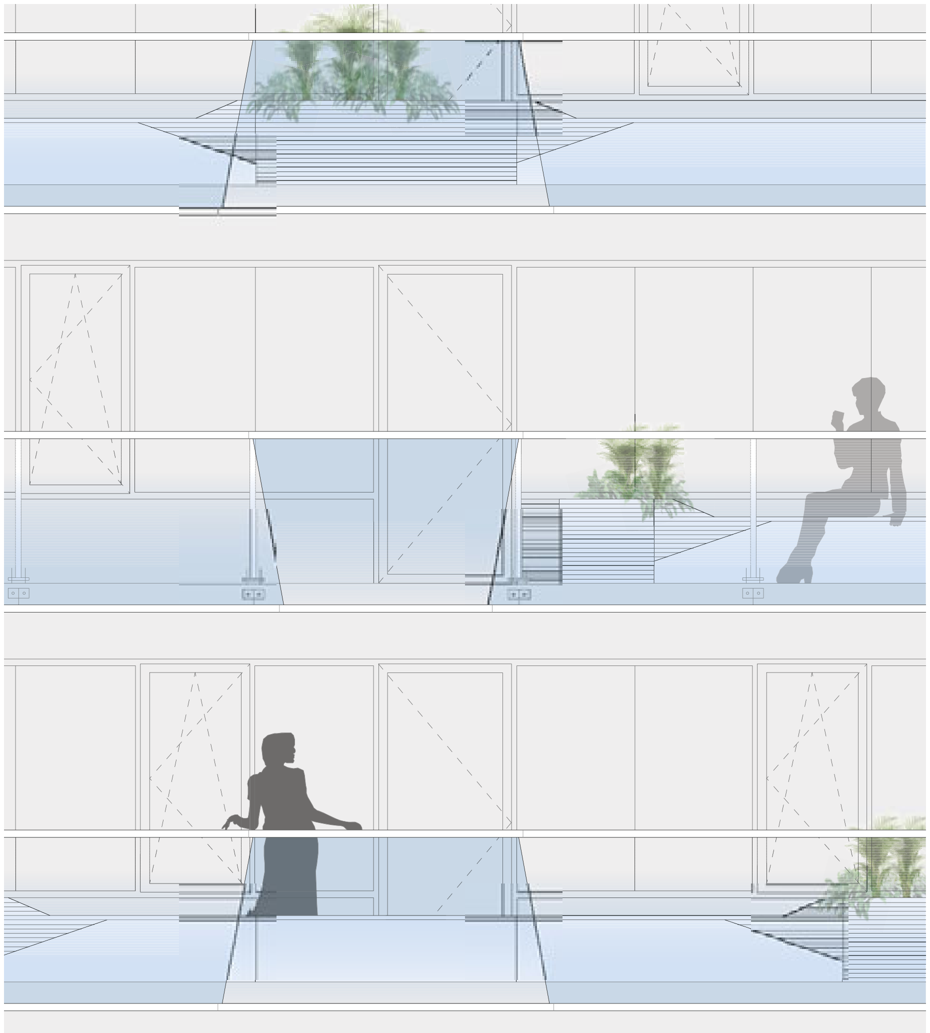




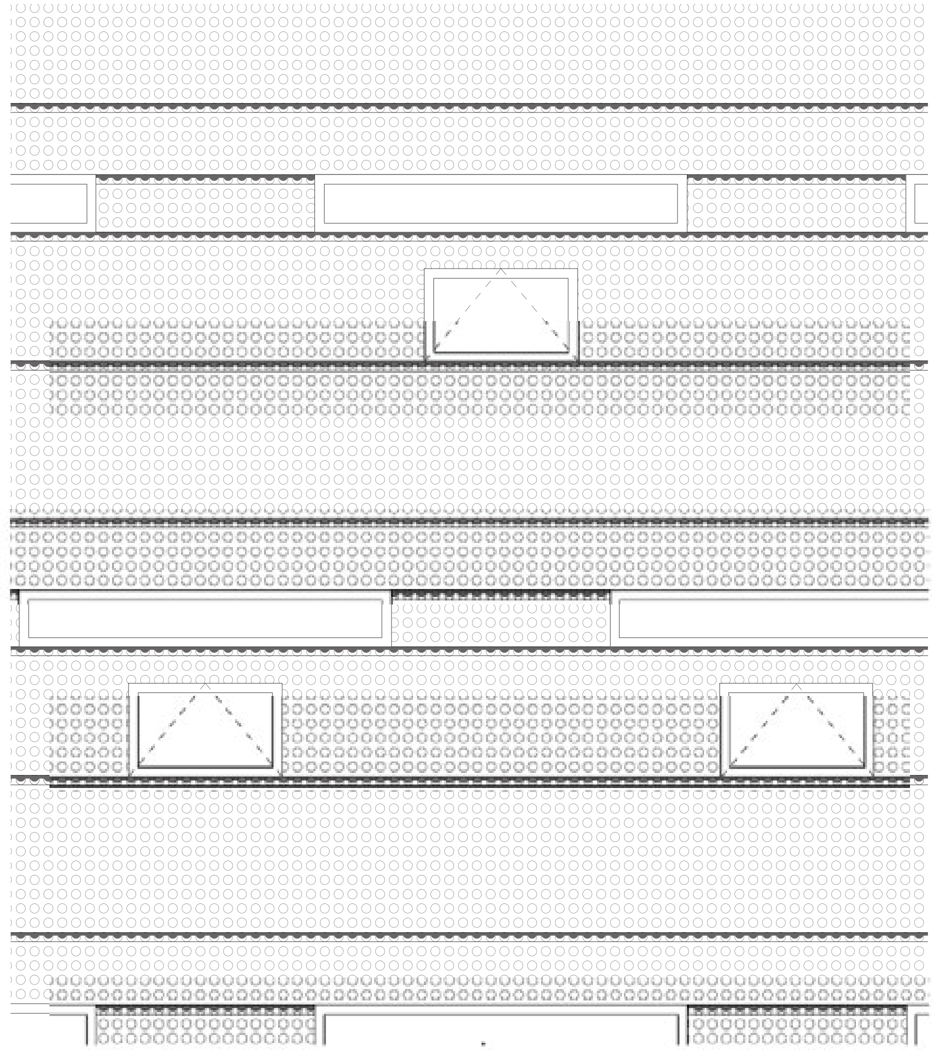




NORTH AND SOUTH FACADE COMPARISON



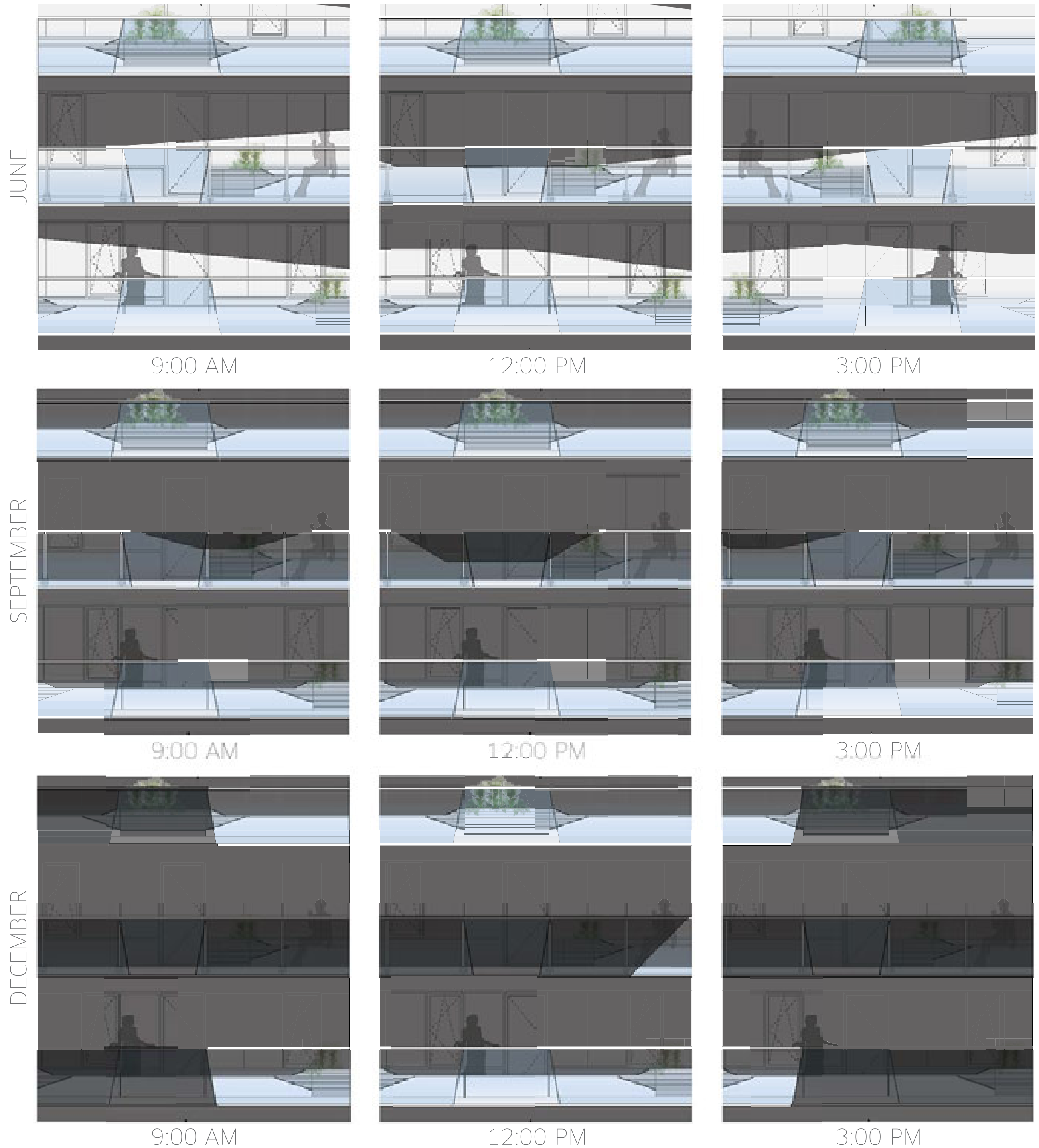
SOUTH FACADE GLAZING RATIO 70%



NORTH FACADE GLAZING RATIO 8%

SOUTH FACADE SHADOW STUDY

A shadow study was undertaken on the south facade to determine solar shading and solar access quality at different times during the year.



AERIAL RENDER

CORNER RENDER

COURTYARD RENDER

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