

8 ON MARKET: An Eco-conscious Housing Development in
Downtown San Diego

by

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A THESIS

Presented to the Department of Architecture
and the Robert D. Clark Honors College
in partial fulfillment of the requirements for the degree of
Bachelor of Architecture

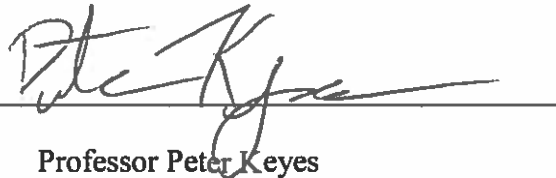
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An Abstract of the Thesis of

**Kiana Motahari for the degree of Bachelor of Architecture
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Professor Peter Keyes

The world around us is changing and this time we are the ones to blame. From melting glaciers to disappearing lakes, climate change is no longer a problem our children & children's children will have the privilege of ignoring. According to the U.S. Energy Information Administration (EIA), buildings consume nearly half of all energy and seventy-five percent of all electricity produced in the United States and were responsible for nearly half of U.S. carbon (CO₂) emissions in 2010.¹ This places architects, the puppeteers of the built environment, in a very unique position to mitigate the progression of climate change and adapt to its onset.

This creative thesis presents a viable example of environmentally sensitive architecture. The vehicle for this exploration takes the form of a mixed-use building in heart of Downtown San Diego. A fundamental goal throughout the design process was the integration of green strategies in a way that not only improved the buildings economic and environmental performance, but also enhanced the aesthetics of the building.

¹ "Why Buildings?" Architecture 2030. Accessed May 16, 2015.

Acknowledgements

I would like to thank professor Keyes for his support and guidance throughout the design process, as well as Dylan Lamar and Professor Fracchia. I am sincerely grateful for the privilege of having excellent professors who were willing to guide me through this strenuous but rewarding process.

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1. Introduction

Goal: Design an environmentally responsive housing development in an urban setting.

Audience: Eco-conscious suburbanites (young couples/individuals, families, empty nesters)

Location: 8th and Market Street, San Diego, CA

Climate: Semi-arid (cooling load dominated + water conservation)

Density: Urban

Construction Type: Concrete

Environmental Strategies: Solar shading, stack ventilation, rainwater harvesting, composting toilets, Living Machine

The Suburban Problem

The current housing default in the United States is the suburban house. According to the 2013 American Housing Survey (AHS), 64% of all households surveyed lived in single-family detached homes. However, we have come to understand that this kind of sprawling development is not without consequence. American sprawl has had many unintended repercussions since its conception in the 1940s, both locally and globally. One of the key factors contributing to the negative effects of sprawl is our increased dependence on cars necessitated by the “peripheral location” & “relatively low density” of the suburbs. To provide housing at the low densities seen in the suburbs, developers have to venture farther and farther away from city centers where land is cheap. During the conception of sprawl in the late 1940’s gas was relatively inexpensive and thus driving miles and miles each day to and from the suburban home

and the urban workplace was affordable to the majority of the population. With the substantial increase of gas prices in recent years, this is no longer true. These long commutes, necessitated by the obligatory low density of the suburbs, not only place a heavy financial burden on residents, they have also proven to have a substantial effect on the production of greenhouse gases and global warming. Also, not all residents have the ability to drive. Duany dedicates an entire chapter of his book, *Suburban Nation*, to these “victims of sprawl².” Among them are: Cul-de-sac kids, bored teenagers, stranded elderly & the immobile poor. In essence, we can breakdown suburban residents into three categories: weary drivers and non-drivers³. Both are hindered and not aided by the “peripheral location” of their homes. Furthermore, building farther and farther out into the boonies means that municipalities have to create more and more infrastructure to feed the juggernaut of sprawl. The developers that are powering this juggernaut are not the ones who pay for this infrastructure, we are: the American taxpayer. Adding to all this is the obesity epidemic that has taken over the United States. According to the Food Research and Action Center, two-third of America’s adult population is over weight⁴. Though this epidemic has many causes, inactivity due to an increase of automobile reliance is definitely one of them.

Another issue that plagues the American suburb stems from Jackson’s fifth characteristic: “economic and racial homogeneity”⁵. This segregation was and still is supported by various zoning ordinances that were put in place with the rise of the suburban model. As Jackson explains:

² Duany, “Victims of Sprawl” in *Suburban Nation*, 116-129.

³ Ibid.

⁴ "Overweight and Obesity in the U.S. « Food Research & Action Center." Food Research Action Center Overweight and Obesity in the US Comments. Accessed October 24, 2014.

⁵ Though this issue is a very important one, I will not be covering it extensively in my thesis.

The introduction of zoning ... served the general purpose of preserving residential class segregation and property values. In theory, zoning was designed to protect the interest of all citizens by limiting land speculation and congestion.... In actuality zoning was a device to keep poor people and obnoxious industries out of affluent areas. ... They sought through minimum lot and set-back requirements to insure that only members of acceptable social classes could settle in their privileged sanctuaries.⁶

This has resulted in communities full of families as similar to each as their cookie-cutter homes.

On a global level, American sprawl is unsustainable. According to Tim De Chant, the chief editor of NOVA, if all seven-billion people in the world lived like Americans, we would need five planets worth of land and resources. Some argue that the problem is not our living style, but the increase of the world's population. In answer, I point to statistics gathered by De Chant (Fig. 1). If all of the world's population lived at the density of New York, we would all fit in the state of Texas. So clearly, land is not an issue, the problem lays in the way we use the land available.

⁶ Jackson, Kenneth T. "The Baby Boom and the Age of Subdivision" In *Crabgrass Frontier: The Suburbanization of the United States* (New York: Oxford University Press, 1985), 242.

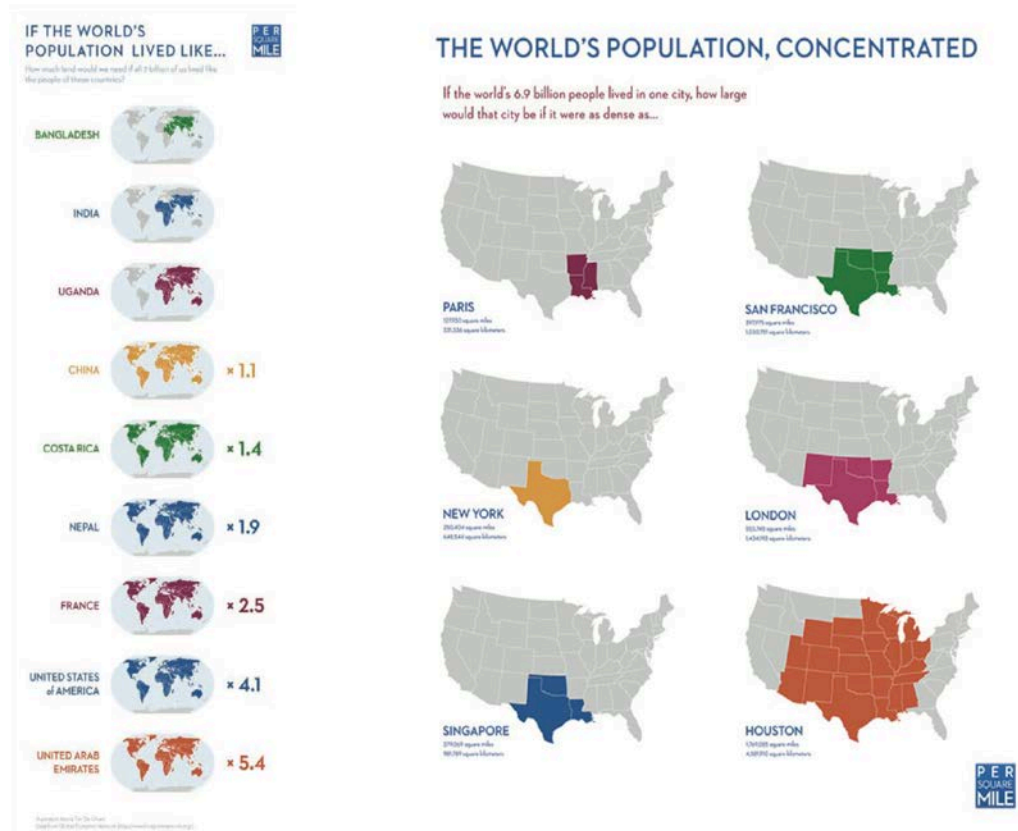


Figure 1: The world's population, concentrated

Given all the problems caused by the suburban way of life, an overwhelming majority of the American population still chooses to live in suburban single-family detached homes. What is the American homeowner looking for? According to the 2011 Community Preference Survey executed by the National Association of Realtors, the most important characteristic homeowners were looking for was “privacy from neighbors” (fig. 2). The two key housing characteristics they looked for on a unit scale, was spacious living spaces, and access to outdoor space (both private and public, as well as space). The goal was to this thesis project was to provide these positive characteristics of the suburbs in an urban housing development.

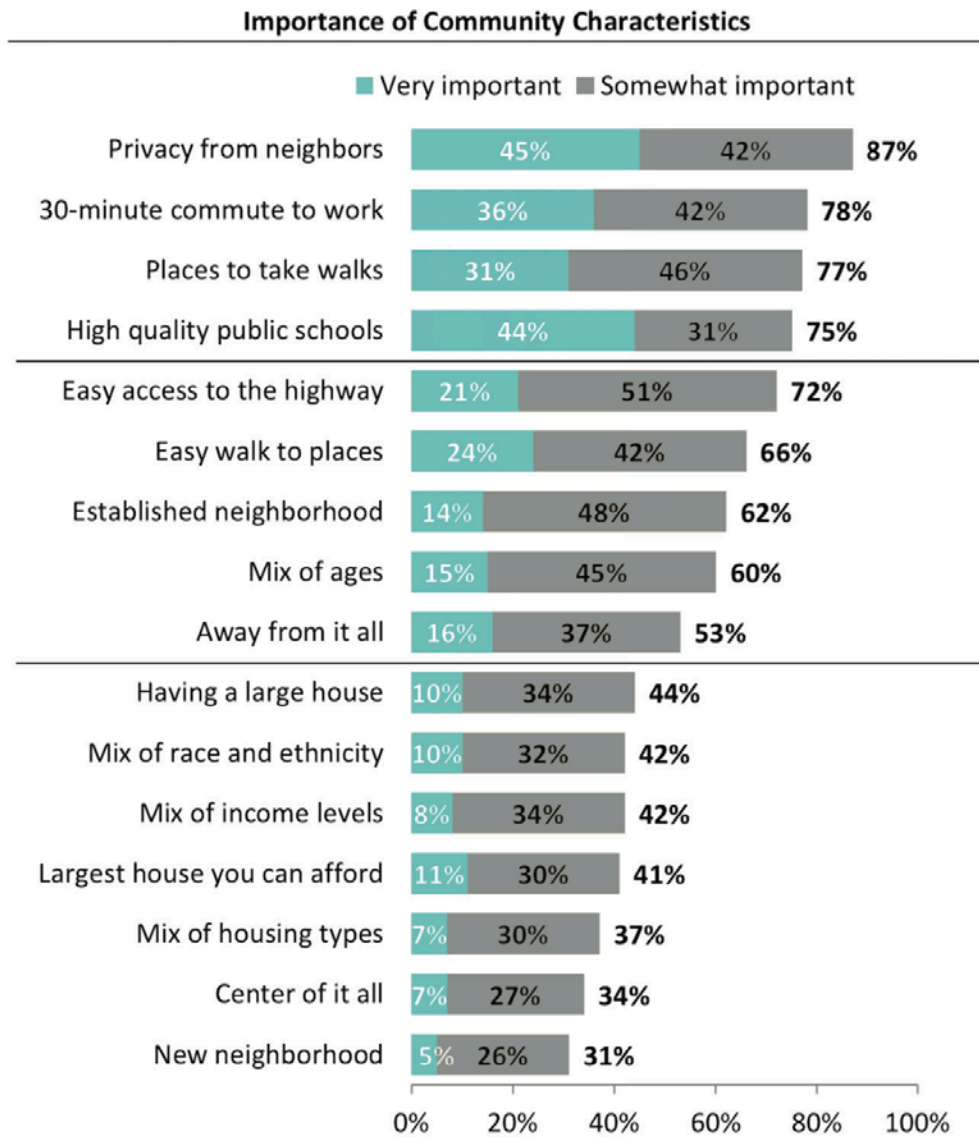


Figure 2: Importance of community characteristics

The Building

This architectural thesis presents the design of a mixed-use residential & commercial building, a few blocks from San Diego’s Petco Park. The location of the building in San Diego introduced two environmental challenges: the first was finding

passive methods for handling the cooling loads generated by the building, and the second and most pressing was addressing the severe water shortage in San Diego. Passive cooling strategies, namely extensive shading and stack ventilation⁷, addressed the building's cooling loads. The combination of these two strategies placed the buildings energy performance within Passivhaus⁸ standards without resorting to active air-conditioning systems. An extensive water conservation and reuse system significantly reduced the water demand of the building. These systems included rainwater harvesting, composting toilets and a Living Machine.

This eight-story, perimeter block building⁹ is arranged around two open-air courtyards and takes the form of an extruded orthogonal "8" (hence giving the building its name: 8 on Market). The building consists of two floors of parking below grade, one floor of commercial at street level and seven stories of residential above. The residential component was the key programmatic focus of the project. Four circulation cores connect the various floors vertically, while open-air single-loaded¹⁰ corridors connect them horizontally. The two open-air courtyards on the ground level serve to knit the occupants of the building together and create a sense of community. One of the courtyards serves as a spill-out area for various restaurants and cafes, while the other holds an on-site wastewater treatment system known as a "Living Machine."

⁷ "Stack Ventilation" is a passive cooling strategy that relies of pressure differential to draw air up and out of buildings.

⁸ Passivhaus or "Passive House" refers to a German energy standard that relies on thermal insulation & airtight construction to eliminate active heating and cooling systems in buildings.

⁹ A "Perimeter Block" building is one that is arranged around a courtyard. As opposed to a courtyard building where the building is access through a courtyard(s), in a perimeter block building one must go through the building to get to the courtyard(s).

¹⁰ Single-loaded corridor refers to hallways that have exterior exposure on one side & interior exposure on the other.

The envisioned audience for this project are eco-conscious suburbanites: individuals, couples or families who have decided to forgo the suburban way of living in favor of a more environmentally friendly lifestyle in the city. A range of one-, two-, and three-bedroom units accommodates the various household types seeking an urban life-style.

2. Site

Climate

San Diego's climate is generally very mild and sunny. Average monthly temperatures in the area fluctuate from 57 F in January to 72 F in August, though temperatures can occasionally reach 90 F or higher in late summer and early autumn.¹¹ As shown in the figure below, this climate has more cooling degree days than heating degree days.

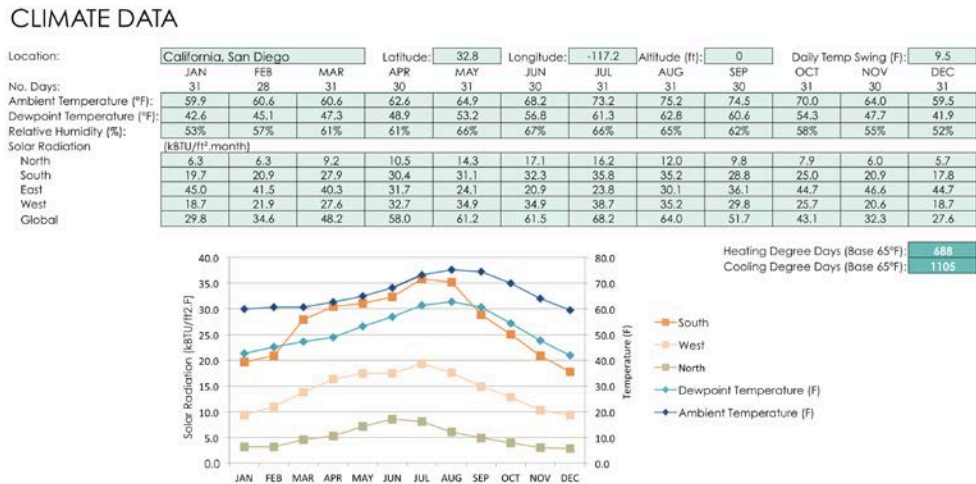


Figure 3: Climate date of San Diego

The average annual rainfall ranges from 8 to 11 inches, placing San Diego's climate in the semi-arid category. In the past few years however, the state of California has been experiencing the worst drought it has seen in 1,200 years.¹² The situation has become so dire that in April 2015, Jerry Brown, the governor of California, issued orders for the first ever water restrictions in the state. The governor "directed the State

¹¹ "Climate San Diego - California." U.S. Climate Data. Accessed May 16, 2015.

¹² O'Connor, Lydia. "Striking Photos Show Struggle Of Farmers In California Drought." The Huffington Post. January 15, 2015. Accessed May 16, 2015.

Water Resources Control Board to impose a 25% reduction on the state's 400 local water supply agencies, which serve 90% of California residents."¹³ The US Drought Monitor has estimated the population affected by this drought at a little over 37 million people.¹⁴ Furthermore, NASA has predicted that the current drought in California is actually part of a global trend toward a much drier world. According to NASA's climate models megadroughts are on the horizon, the intensities of which are dependent on human induced greenhouse gas emissions.¹⁵

Site

The site for this project is a full city block (200 by 300 feet), two blocks north of Petco Park. The site straddles the divide between the heart of downtown San Diego to the West and the East Village area. In the past few years, East Village has seen a significant amount of development, most of which consists of 4 to 7 story multi-family residential buildings with varying amounts of commercial space. As San Diego continues to grow, more and more of the city has and will spill-out to the East, making this site a prime location for urban housing development.

¹³ Nagourney, Adam. "California Imposes First Mandatory Water Restrictions to Deal With Drought." The New York Times. April 1, 2015. Accessed May 16, 2015.

¹⁴ "California." United States Drought Monitor. Accessed May 16, 2015.

¹⁵ Cole, Steve, and Leslie McCarthy. "NASA Study Finds Carbon Emissions Could Dramatically Increase Risk of U.S. Megadroughts." NASA. February 12, 2015. Accessed May 17, 2015.



Figure 4: Ariel view of San Diego



Figure 2: Ariel view of San Diego with the location of the site highlighted (Google Earth)



Figure 5: Birds-eye view of the site in context (Google Earth)

Zoning

ZONING SUMMARY	
Base Zone	CCPD-ER
Overlay District	Commercial Street
Max FAR	6
Min FAR	3.5
Max Height	85
Min Height	45
Min Step Back	None

Table 1: Zoning summary

The City of San Diego classifies this site under the “Central City Planned District-Employment/Residential Mixed Use” or CCPD-ER zoning type. The San Diego Municipal Code describes this zoning type as the following:

This district provides synergies between educational institutions and residential neighborhoods, or transition between the C[ore] District and residential neighborhoods... A variety of uses are permitted in this district, including office, residential, *hotel*, research and development, educational, and medical facilities.¹⁶

Furthermore, the north side of this site (facing Market St) falls under the “Commercial Street Overlay” or CS district. This entails that “a minimum of 60 percent of the ground-floor street frontage [must] contain active commercial usage.”¹⁷

Activities Permitted

The following activities are permitted in this zoning type^{18, 19}:

- Public Park/Plaza/open space
- Multiple dwelling units
- Live/work quarters
- Cultural Institutions
- Retail Sales
- Animal grooming & veterinary offices
- Assembly & entertainment (Live entertainment or outdoor use area not permitted)

¹⁶ San Diego Municipal Code, Chapter 15, Article 3, Division 3, Page 22. November, 2014.

¹⁷ San Diego Municipal Code, Chapter 15, Article 6, Division 3, Page 25. November, 2014.

¹⁸ San Diego Municipal Code, Chapter 15, Article 3, Division 3, Page 29-31. November, 2014.

¹⁹ Only activities relevant to this project are listed.

- Eating establishments
- Brewpubs
- Financial Institutions
- Instructional studios
- Outdoor activities (limited use)
- Offices

*Permitted Active Commercial Use*²⁰

- Minimum Required Ground-Floor Street Frontage for Active Commercial Use: None
- Maximum Required Ground-Floor Street Frontage for Active Commercial Use: 100%

*Development Standards*²¹

- Minimum Height Building Base/Street Wall (feet from ground level): 45 feet
- Minimum Height Building Base/Street Wall (feet from ground level): 85 feet
- Maximum Lot Coverage of Building Base: 100%
- Setback Requirements: None

²⁰ San Diego Municipal Code, Chapter 15, Article 3, Division 3, Page 36. November, 2014.

²¹ San Diego Municipal Code, Chapter 15, Article 3, Division 3, Page 55. November, 2014.

Floor Area Ratio (FAR) Requirements^{22,23}

- Minimum FAR: 3.5
- Maximum FAR: 6.0
- Maximum FAR (with all incentives/bonuses/TDR): 10.0

*Parking*²⁴

Table 2 summarizes the parking demand of the building. The “Parking Requirement per Bedroom” column lists the parking demand of residential units according to the number of bedrooms. The next column (“Reduction Factor”) lists the reduced parking demand of this particular building as a result of its high walkability index & access to public transit.

PARKING				
Walkability Index	Transit Index	Walkability/Transit Index	Parking Demand	
4	4	4	Low	
Bedroom	Parking Req per bd	Reduction Factor [1]	# of Units	Parking
1bd	1.25	0.1	37	3.7
2bd	1.75	0.5	52	26
3-4bd	2	0.75	12	9
5bd	2	0.75	0	0
Visitor	-	0.15	101	15.15
Staff	-	0.05	101	5.05
Commercial	Req per 1,000 gross SF			
Commercial	2.5	-	-	100.292
TOTAL PARKING				159

Table 2: Parking demand as required by the San Diego Municipal Code

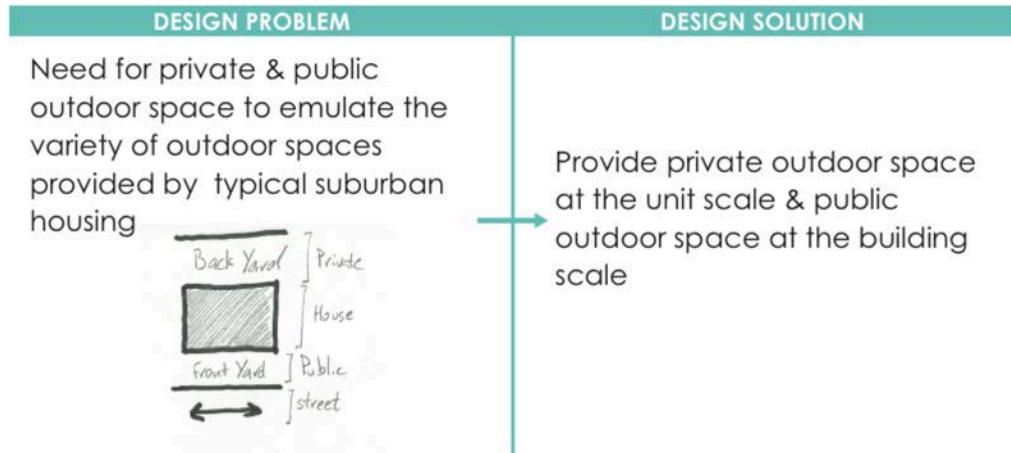
²² San Diego Municipal Code, Chapter 15, Article 3, Division 3, Page 107. November, 2014.

²³ “Floor Area Ratio” refers to the total square footage of a building divided by the total square footage of the lot the building is located on.

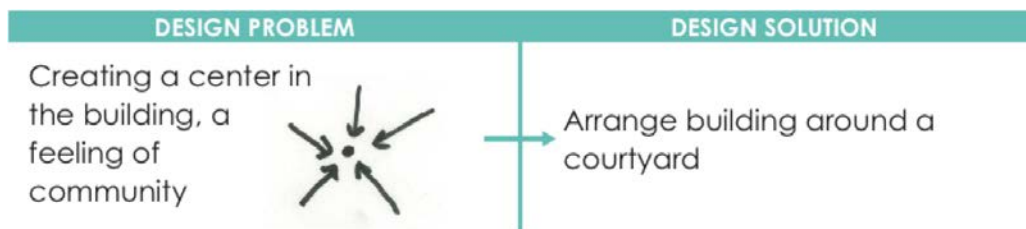
²⁴ San Diego Municipal Code, Chapter 14, Article 2, Division 5, Page 16. January, 2015.

3. Design Process

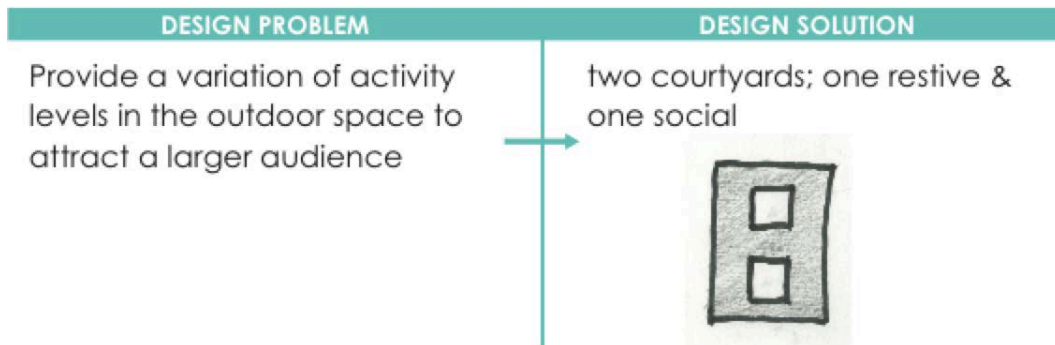
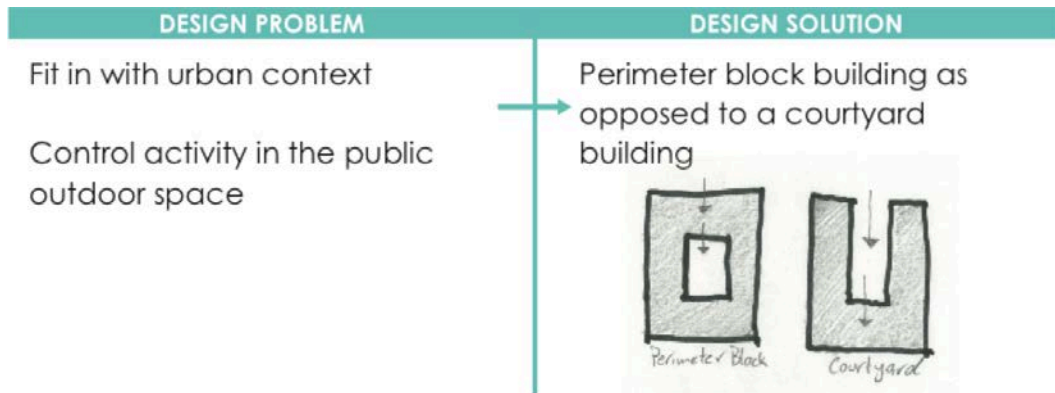
The following section describes the design problems and solutions posed along the design process:



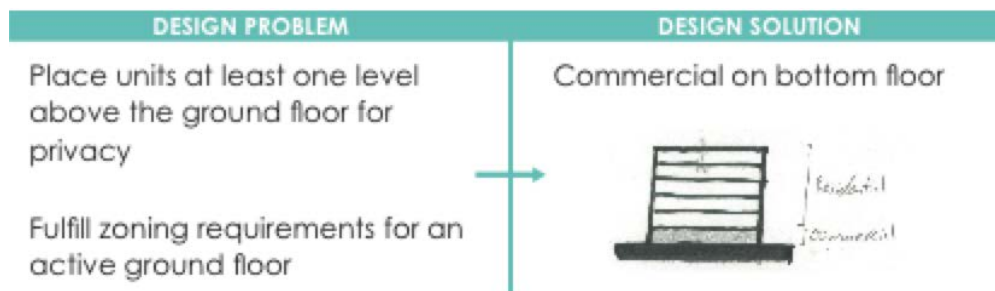
One of the key features of a suburban home is its access to outdoor space with varying degrees of privacy. A typical suburban home has a public face (the front yard), and a private outdoor space (the backyard). This model was mimicked in the design process.

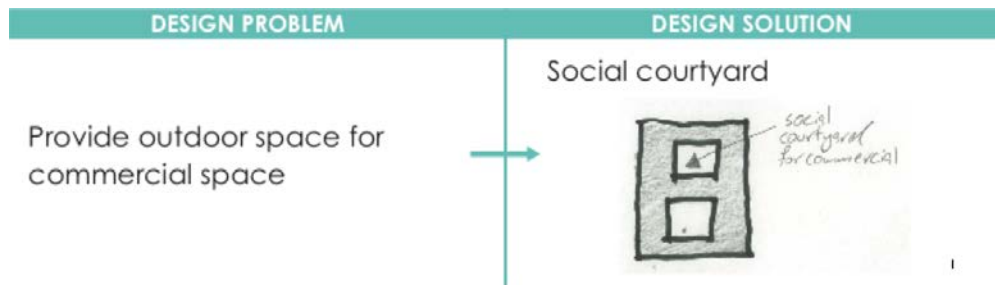


The suburbs are characterized by their dispersion. Sprawling lawns isolate homes and their residents from each other. This isolation is one of the primary reasons suburbanites choose to forgo their single-family-detached homes for an urban lifestyle. At a building scale, this desire for community is fulfilled by the inclusion of a courtyard in the building scheme.

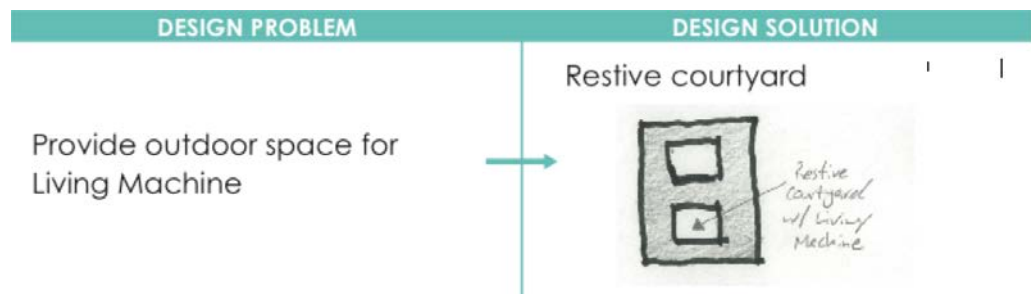


There are two building types that incorporate courtyards: a courtyard building and a perimeter block building. In a courtyard building, the building is accessed through the courtyard, whereas in a perimeter block building, one must enter the building to get to the courtyard. In this context, the latter building type presented two key benefits over the former: the first is its ability to create an urban edge and the second is the control this layout provides on the activities that happen in the courtyard.

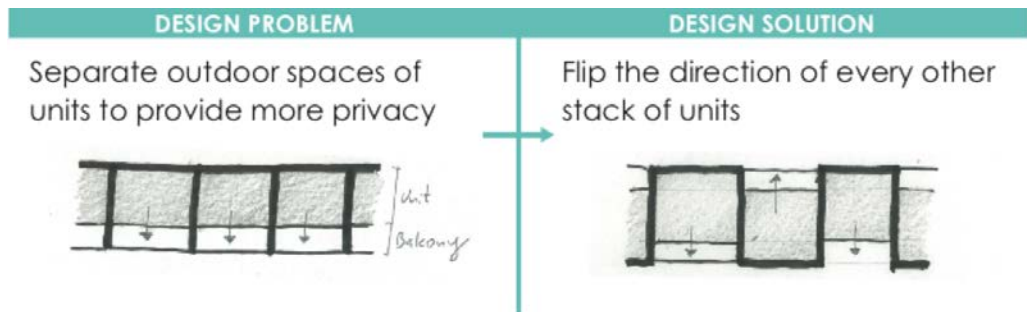




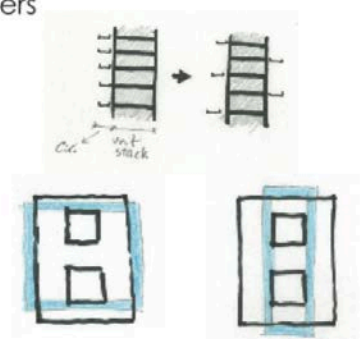
Considering San Diego's mild climate, most of the eating venues in the building would benefit from having access to outdoor space. The result of having multiple cafes and restaurants spill-out onto the courtyard is a very social and active space. The northern courtyard was chosen for this purpose, as the street to the north (Market street) is more active the street to the south (Island street).



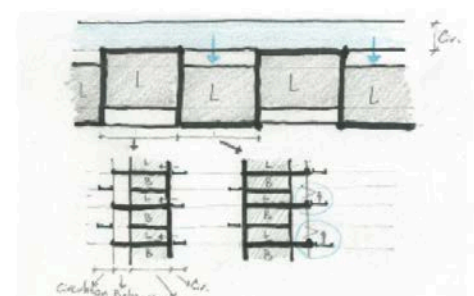
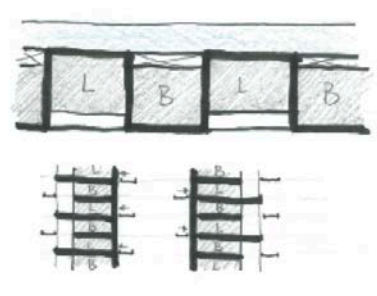
In response to the ongoing draught in the area, a Living Machine (described in chapter 6) was included in the scheme very early on in the design process. The water treatment system requires a large amount of surface area, making the southern courtyard the perfect location for the system.

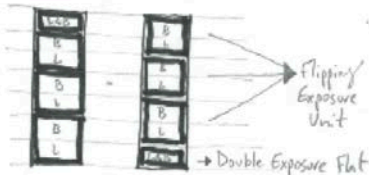


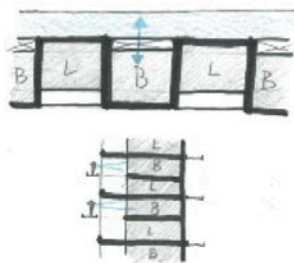
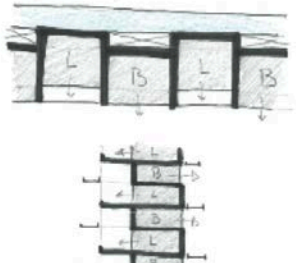
To create acoustical privacy between the outdoor spaces of adjacent units, the direction of everything stack of units was flipped. This design move not only increases privacy but also provides horizontal shading.

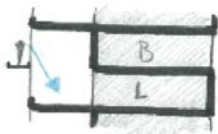
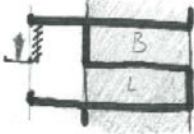
DESIGN PROBLEM	DESIGN SOLUTION
<p>Use the circulation system as a means of building a sense of community</p> <p>Visual connection between residents</p> <p>connection with courtyards</p> <p>connection with street life</p>	<p>Single-loaded corridors that pass above the courtyards on some floors and the street on others</p> 

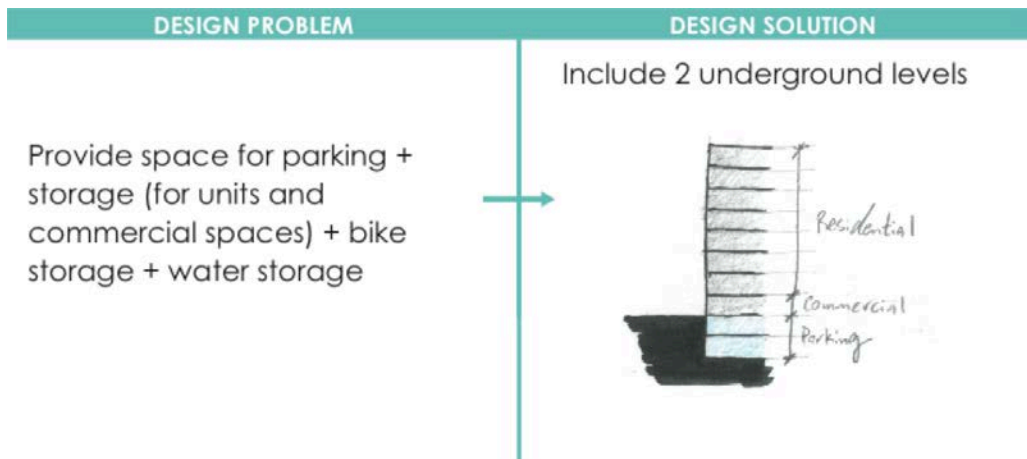
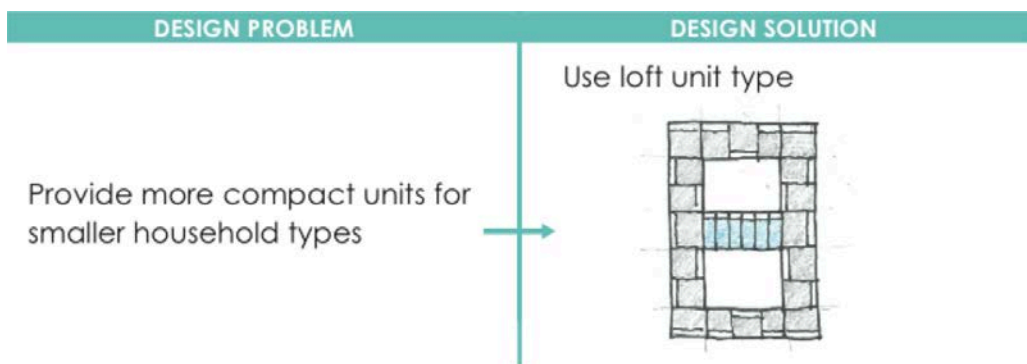
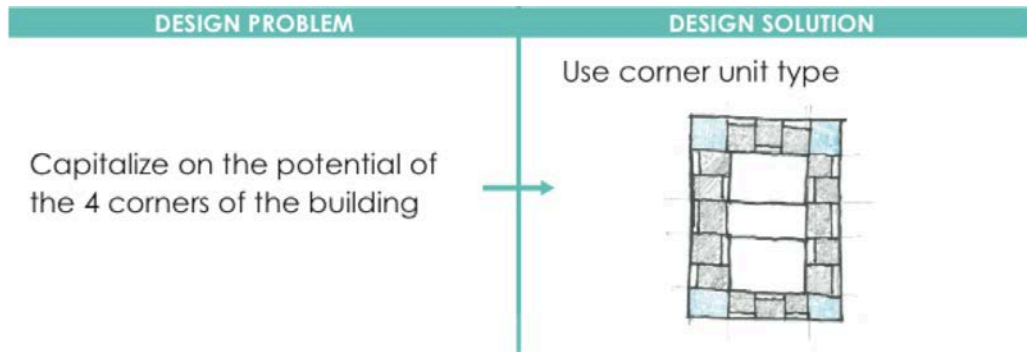
DESIGN PROBLEM	DESIGN SOLUTION
<p>Provide privacy for the outdoor space of each unit from the circulation system</p>	<p>Separate circulation paths from outdoor spaces</p> 

DESIGN PROBLEM	DESIGN SOLUTION
<p>By flipping the direction of the unit stacks, the circulation path passes by the outdoor space of some of the units, thus compromising privacy</p> 	<p>Offset the level of every other vertical stack so the circulation system can feed into every other unit, while avoiding the outdoor space of others</p> 

DESIGN PROBLEM	DESIGN SOLUTION
<p>Apply the offset floors to across 7 stories</p>	<p>Use three 2-story units (flipping exposure unit type) & one 1-story unit (double exposure unit type) in each vertical stack of units</p> 

DESIGN PROBLEM	DESIGN SOLUTION
<p>Circulation path passes by the bedroom level of every other stack of units</p> 	<p>Flip the direction of the bedroom floor so the major spaces are facing away from the circulation path (use flipping exposure unit type)</p> 

DESIGN PROBLEM	DESIGN SOLUTION
<p>The circulation path passes above the outdoor space of the units, thus compromising privacy</p> 	<p>Employ horizontal louvres to block views from the circulation path</p> 



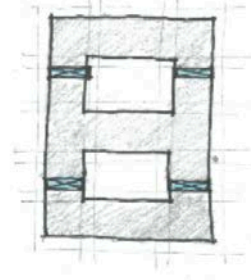
DESIGN PROBLEM

DESIGN SOLUTION

Connect all floors vertically &
meet egress requirements



4 vertical circulation cores



3. Units

The envisioned occupants of the building are previous suburbanites that have chosen to relocate to the city in favor of a more eco-friendly lifestyle. To cater to this market, all units have very spacious layouts and include sizable outdoor spaces off of their living area. All units have double-exposure, ensuring access to plenty of daylight as well as natural ventilation.

UNIT SUMMARY					
Unit Types	Corner	Corner Flat	Flipping Exposure	Double Exposure Flat	Loft
# of Bedrooms	3	1	2	1	1
# of Baths	3	1	2.5	1	1
Floors	2	1	2	1	2
Net Floor Area	1,874 SF	1,093 SF	1,910 SF	1,145 SF	950 SF
Number of Units	12	4	48	19	18

Table 3: Summary of unit characteristics

Corner Unit

- 3 Bedrooms, 3 Bath
- Net Floor Area: 1,874 SF
- 2 floors
- Asking Price: \$1.6 Million (\$850 per SF)

As its name would suggest, this two-story unit is characterized by its corner exposure. The two exposure walls are as transparent as practicality allows in order to capitalize on the daylighting potential of the unit, as well as the views allowed by its corner exposure. The main living spaces, such as the kitchen, dining room and family

room on the bottom floor & bedrooms on the upper floor are arranged along these two transparent walls. Support spaces such as storage & bathrooms are concentrated along the opposing opaque walls. The main circulation path of the unit pivots around a wet-core of restrooms. The result is a sense of compression upon entering the unit and a feeling of expansion after passing the wet-core. As with all the units designed for this building, the living space connects to a balcony that in this case looks out over street life below.

To help mediate the cooling loads of the unit, stack ventilation was employed by pulling back the upper floor thus creating a thin sliver of double-height space above the kitchen & dining room. The heat generated in the living spaces travels up this double-height space & escapes through the top of the glazed wall.



Figure 6: Floor plans of the corner unit type

Corner Unit Flat

- 1 Bedroom, 1 Bathroom
- Net Floor Area: 1,105 SF
- 1 Floor
- Asking Price: \$900,000 (\$730 per SF)

The layout of this unit is very similar to that of the 2-story corner unit described above, the key difference being that the corner unit flat comprises only one floor and one bedroom. Furthermore, this unit opens up to an L-shaped balcony, overlooking the

street below. The roof above this unit provides an extensive amount of shading, thus addressing the unit's cooling loads.

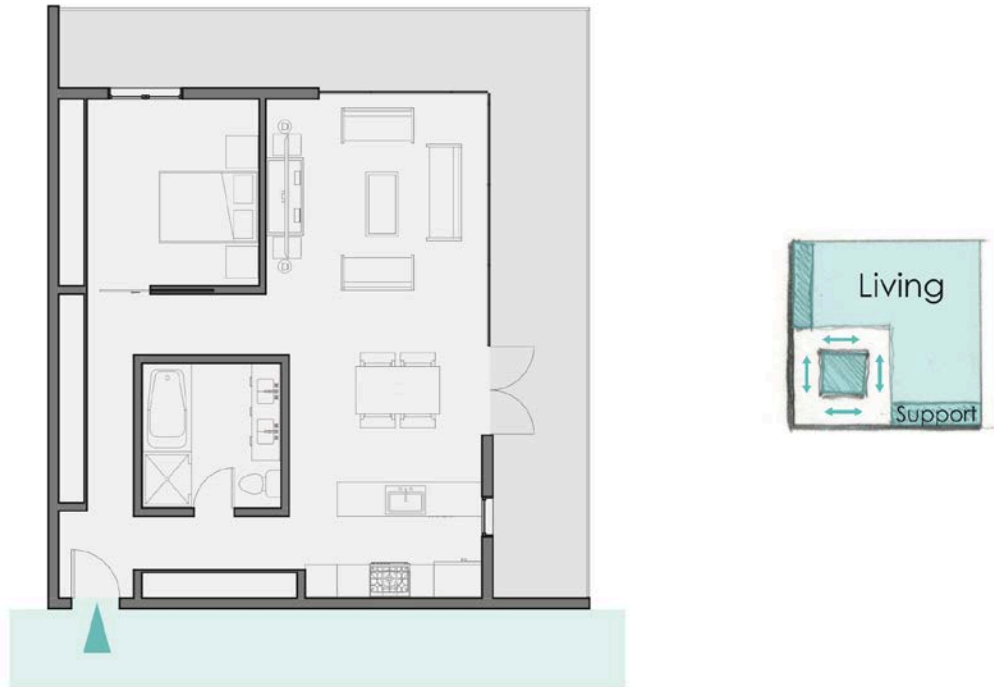


Figure 7: Floor plan of corner unit flat

Flipping Exposure Units

- 2 Bedroom, 2.5 Bathroom
- Net Floor Area: 1,910 SF
- 2 Floors
- Asking Price: \$1.3 Million (\$710 per SF)

This two-story unit has two parallel exterior walls along its longitudinal sides. The circulation system of the building greatly affected the layout of this unit type. As

will be explained in the next chapter, single-loaded corridors connect the units horizontally. These corridors occur on every floor but pass by the units on a different face on each floor. Looking specifically at the Flipping Exposure unit, the circulation path passes by the lower floor along the exterior wall not facing the balcony. If we assume that North is up on the unit plan below, then the circulation path passes by the north wall on the lower level and by the south wall on the upper level. To ensure the maximum amount of privacy for the occupants of the unit, the amount of transparency of these walls was kept to a minimum. Correspondingly, tertiary programmatic elements such as storage spaces and bathrooms are arranged along these walls. Put simply, the floor plan of each level faces away from the circulation path. This means that the direction of the unit “flips” on each floor. As with the Corner unit, stack ventilation helps mitigate the cooling demand of the unit.



Figure 8: Floor plan of flipping exposure unit type

Double Exposure Flat

- 1 Bedroom, 1 Bathroom
- Net Floor Area: 1,145 SF
- 1 Floor
- Asking Price: \$651,000 (\$560 per SF)

The layout of this unit is a derivation of the Flipping Exposure unit type, with the key difference that it includes one floor and not two. The entrance to the unit is through the balcony and opens onto the kitchen and family room. The bedroom faces the opposite direction as the balcony. This is to ensure visual privacy from the circulation path on that level.

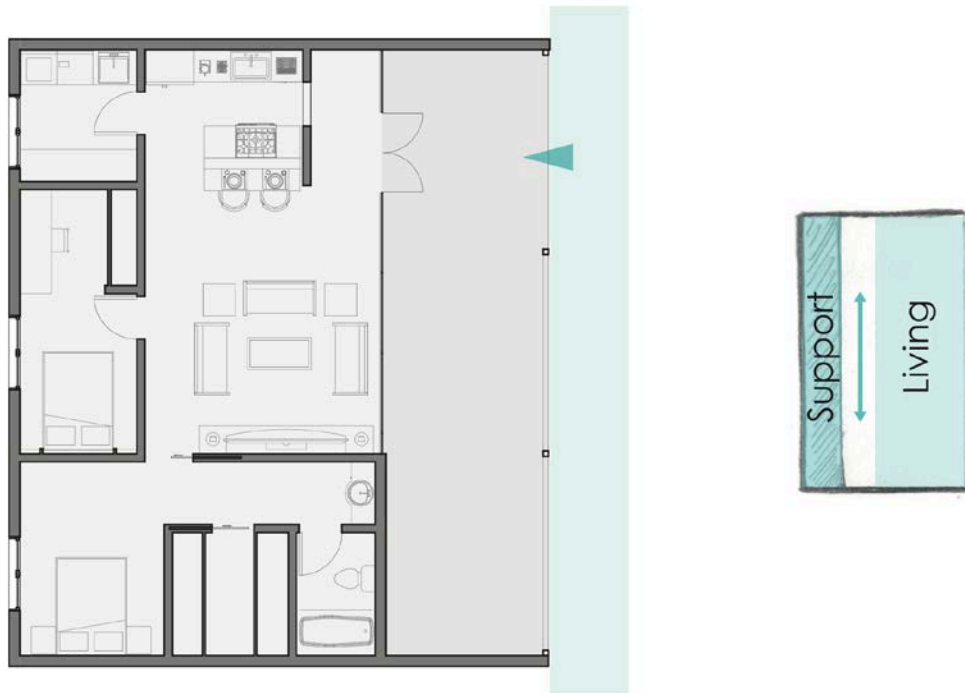


Figure 9: Floor plan of double exposure flat unit type

Loft

- 1 Bedroom, 1 Bathroom
- Net Floor Area: 950 SF
- 2 Floors
- Asking Price: \$559,000 (\$520 per SF)

The Loft unit type is the most compact of the units included in “8 on Market.” If we assume north to be up in the unit plan below, the entrance to the unit is along the southern wall. The upper floor is open to below along the north and west. This allows for stack ventilation to occur and also gives the unit a very open and spacious quality.



Figure 10: Floor plan of loft unit type

5. Building

Organization

Quick Facts	
Number of Floors (Above Grade)	8
Number of Floors (Below Grade)	2
FAR	3.5
Building Height	85 ft
Construction Type	Concrete
Number of Residential Units	101
Residential Occupancy	256
Site Dimension	200 ft x 300 ft
Square Footage of Residential	171,276.00 SF
Square Footage of Commercial	27,462.80 SF
Total Square Footage	198,738.80 SF

Table 4: Quick facts about the building

As summarized in the table above, around 100 residential units are arranged over seven stories, housing an estimated 256 people. The plans below illustrate the layout of the residential floors.

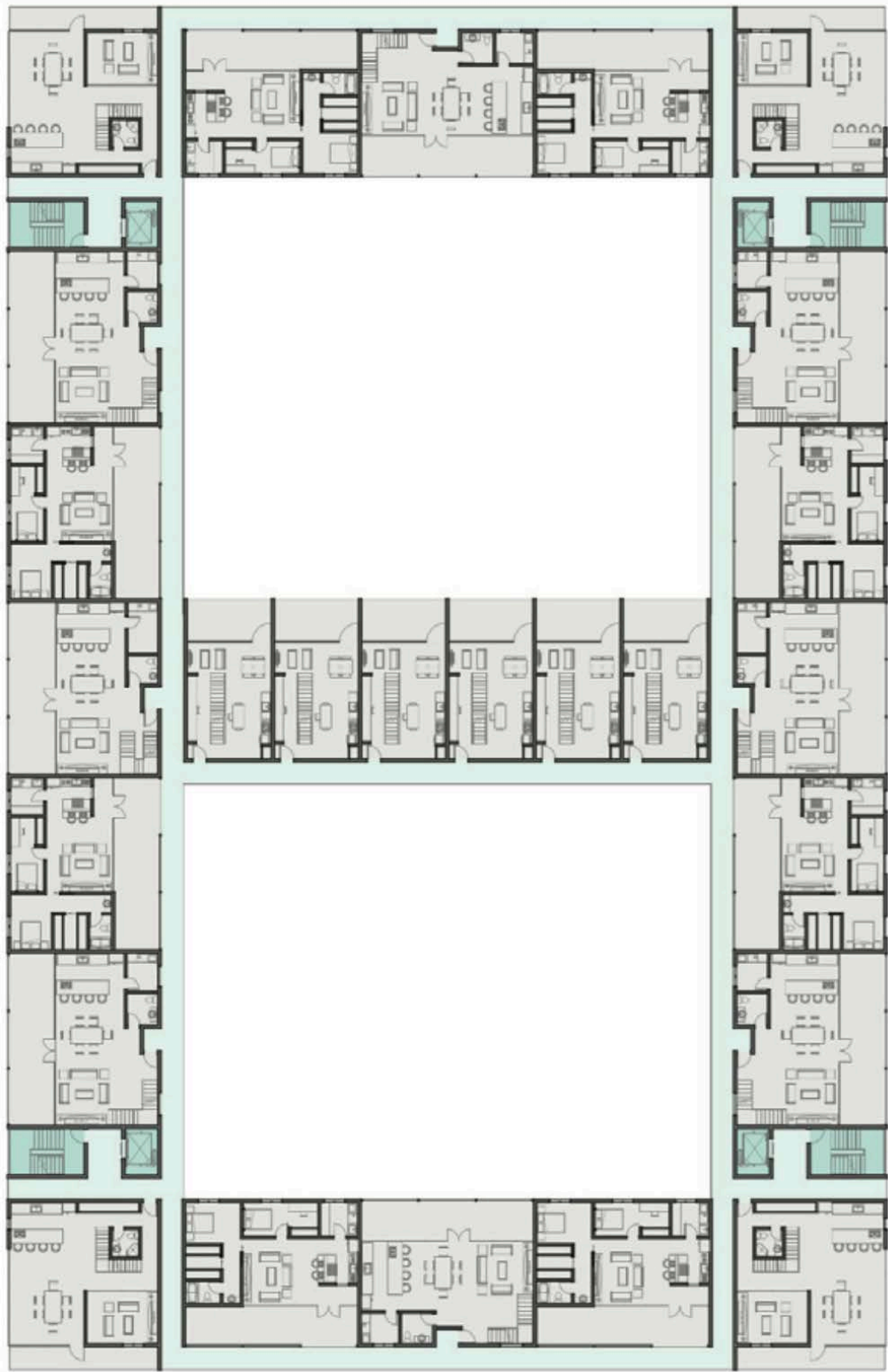


Figure 11: Floor plan of the 1st residential floor

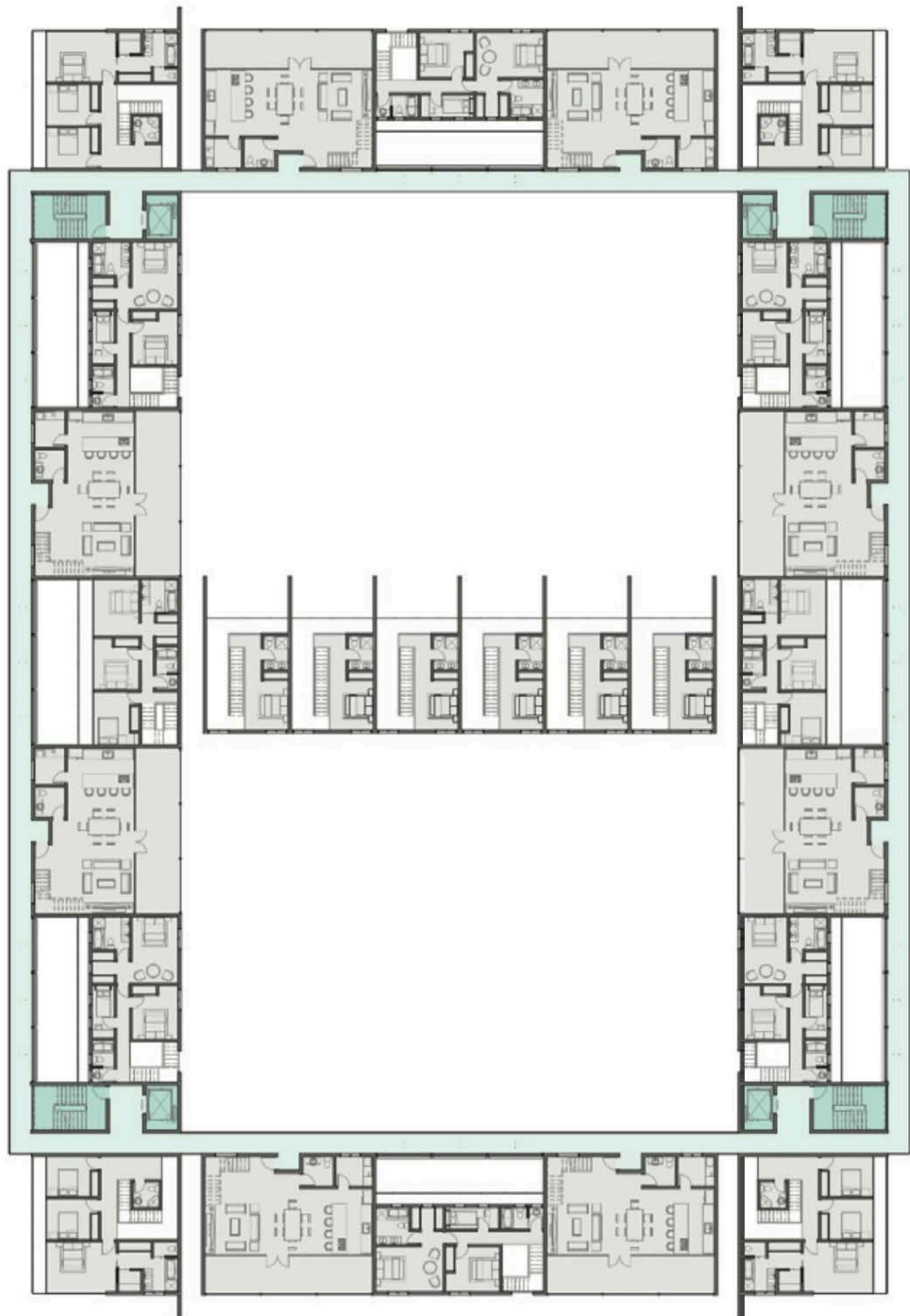


Figure 12: Floor plan of the 2nd, 4th an 6th residential levels



Figure 13: Floor plan of the 5th & 7th residential floors

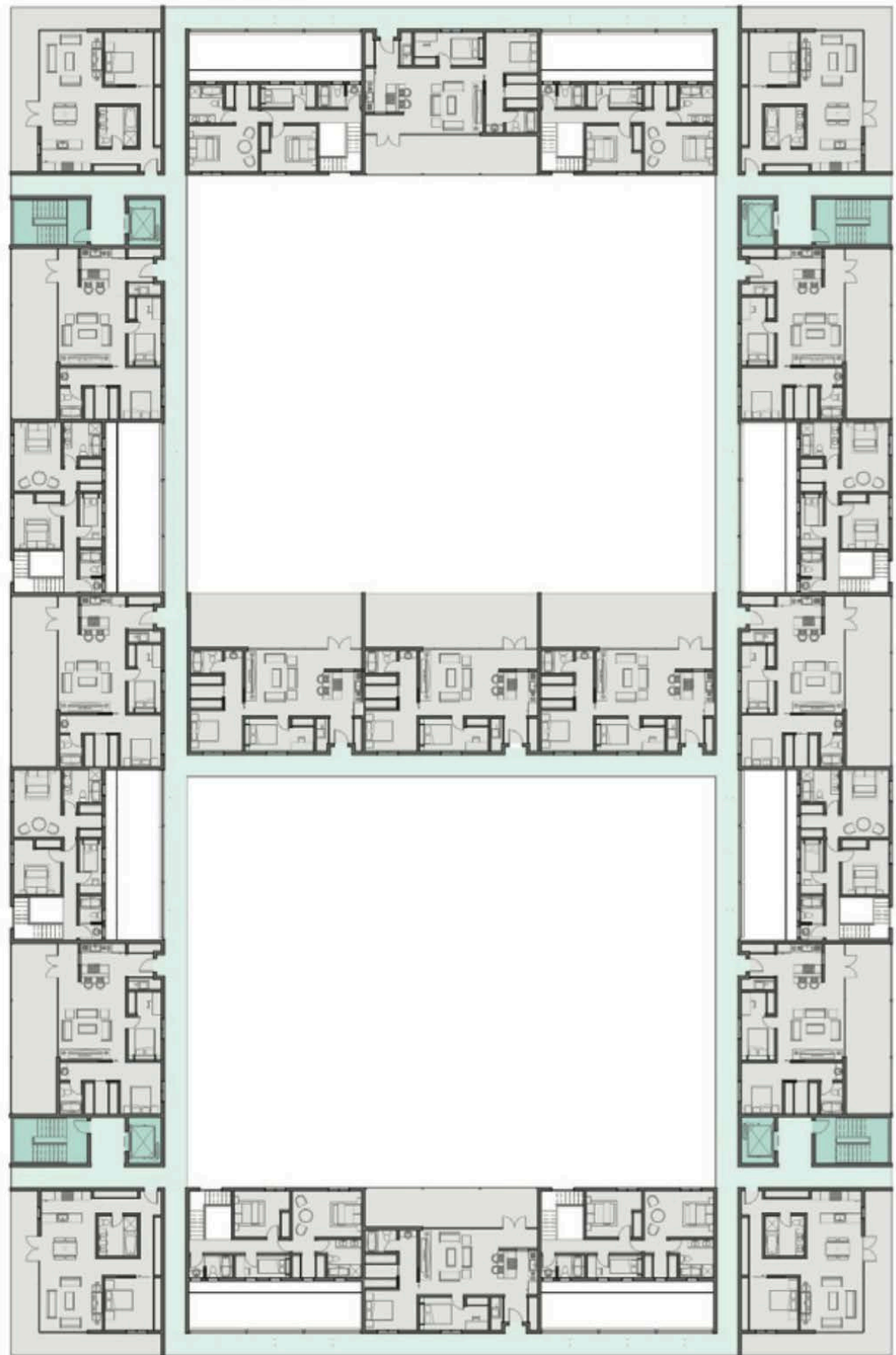


Figure 14: Floor plan of the 7th residential level

The ground floor of the building is dedicated to commercial uses such as restaurants, cafes and small shops. These spaces spill-out onto the northern courtyard, giving this space a piazza-like character.²⁵ Also housed on this level, is the main lobby for the residential units above, as well as an information center for the Living Machine located in the southern courtyard. A ramp on the southeast corner of the ground floor provides vehicular access to two underground floors. These underground levels accommodate the combined parking needs of the commercial & residential spaces. The first level of parking also includes storage rooms for the residential units & commercial spaces, bike storage, and two water storage tanks for the water going into and coming out of the on-site water treatment system.

²⁵ The hours of operation for these commercial spaces will be limited to avoid subjecting the residents of the building from excessive noise at night.



Figure 15: Ground Floor Plan

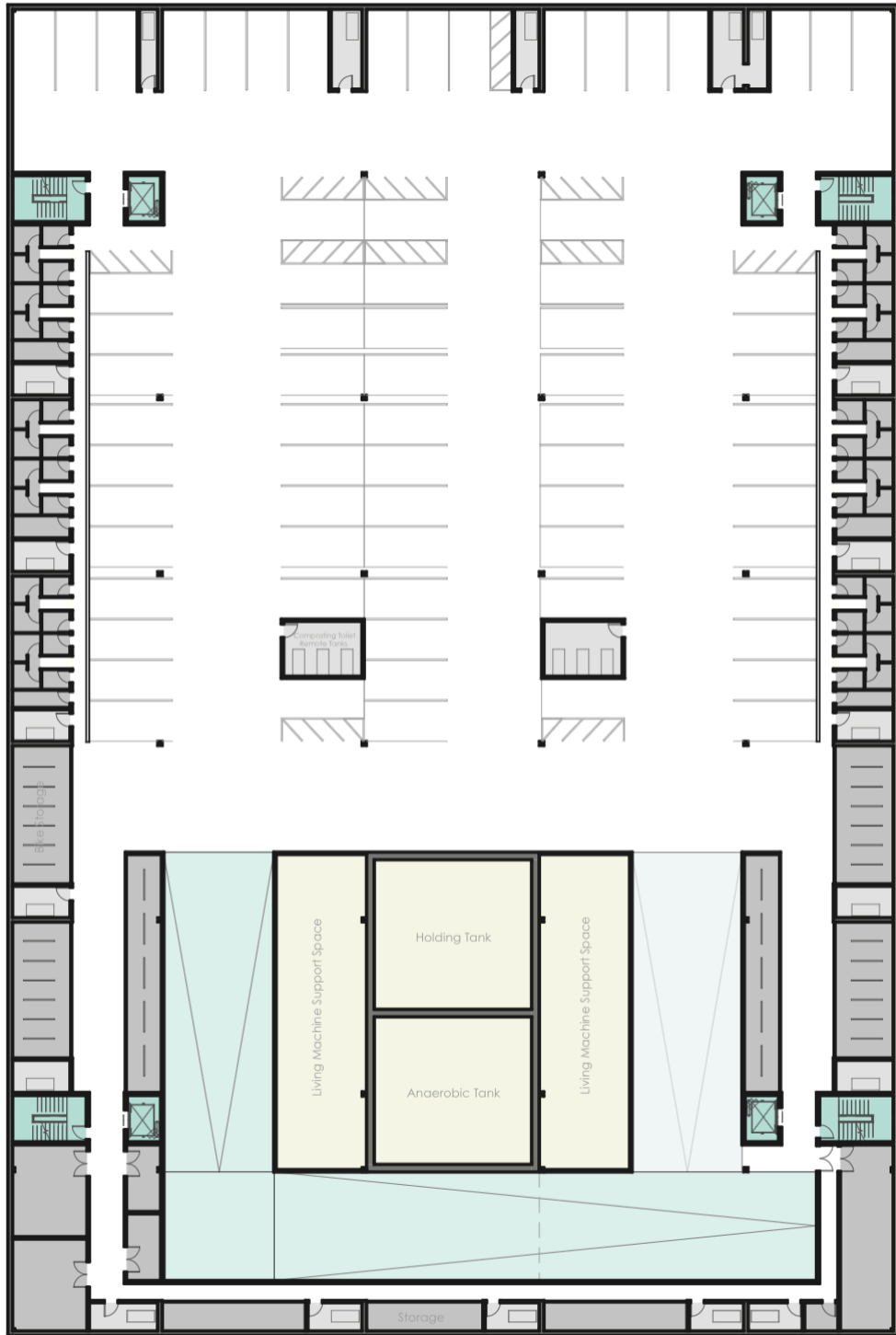


Figure 16: Parking floor plan

The following section perspectives show how the different elements and spaces in the building come together:



Figure 17: Section perspective of 8 on Market



Figure 18: Zoomed-in section perspective of a typical unit

Note the relationship between the circulation paths and the outdoor space of the unit.



Figure 19: Exterior view of 8 on Market



Figure 20: Ariel view of 8 on Market



Figure 21: Social Courtyard



Figure 21: Greenhouse of Living Machine

Structure

The structural system of 8 on Market is site-cast concrete. The diagram below describes the location and direction of the primary structural members. The location of the structural lines corresponds directly with the layout of the residential units. On the residential floors, shear walls between the units carry the load to a beam and column system in the commercial and parking levels.

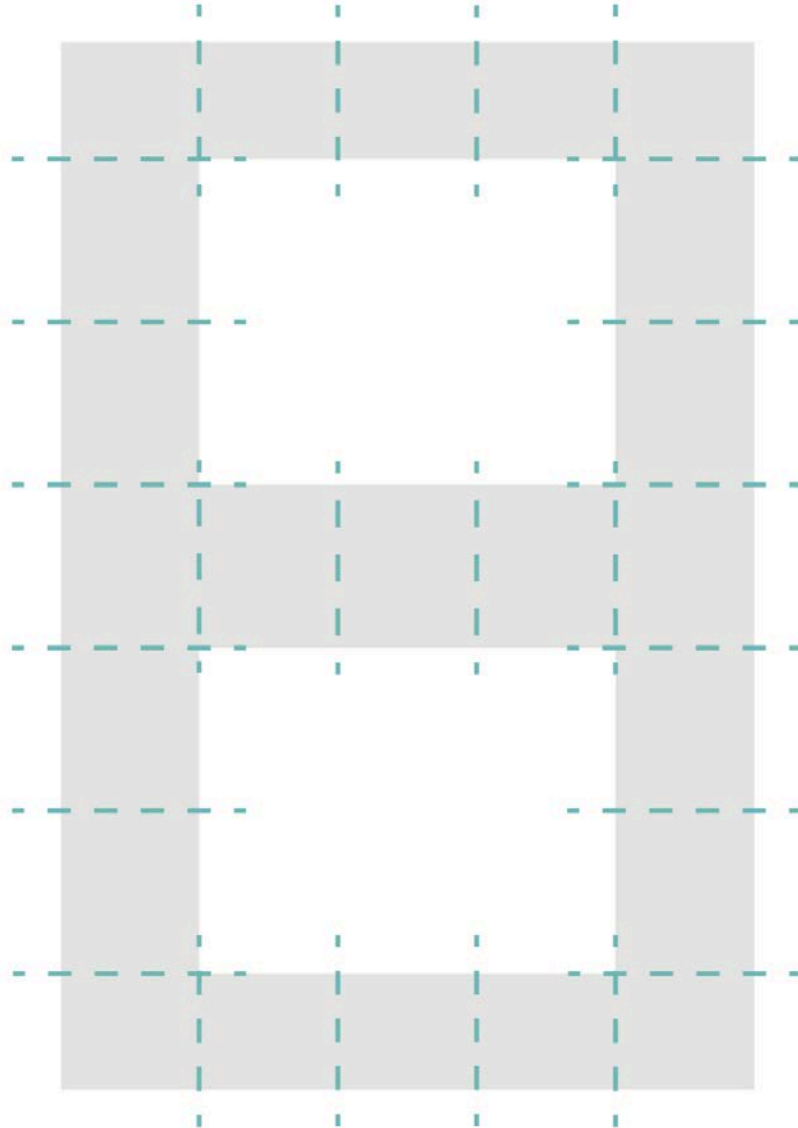


Figure 22: Diagram of primary structure

Enclosure

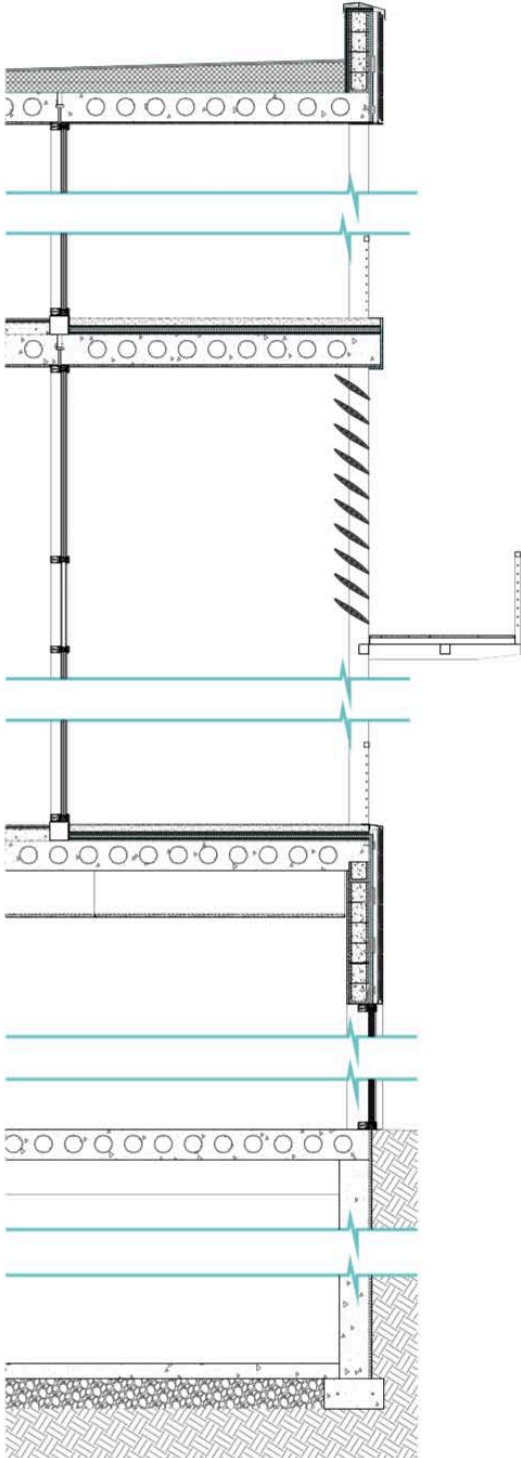


Figure 23: Enclosure diagram (CMU wall with terra cotta cladding)

A typical enclosure wall is illustrated above. The primary cladding material is terra cotta, a very durable material that is well suited for San Diego's climate. A support structure holds up these panels and connects through an inch of foam insulation to a CMU (concrete masonry unit) wall. The amount of insulation necessary to meet the energy goals set for the building (described in chapter 7) was estimated using Energy Advisor, a software program developed by Dylan Lamar.

6. Water

As discussed in chapter 2, California is currently undergoing the worst drought in its recent history and studies conducted by NASA indicate that worst is not over. In response to this acute water shortage, water conservation and reuse strategies were integrated into the design of the building. These systems, namely composting toilets, rainwater harvesting & on-site wastewater treatment, are described in the following sections:

Composting Toilets

To help reduce the water usage of the building, composting are used in all the residential units of “8 on Market.” Composting toilets rely on natural processes of evaporation and decomposition to recycle human waste. The wastewater that enters the toilets is evaporated, while the solid waste is decomposed into fertilizing soil.²⁶ These processes are either carried out in a self-contained composting toilet or in a remote tank directly under the toilets. Considering the number of toilets in the building, remote tanks were utilized in “8 on Market.” These remote tanks are located in the first underground level.

By utilizing composting toilets in the residential units, the annual water usage of the residential component of the building dropped from a little under 5 million gallons (4,905,212 gal/yr) to a roughly 3.5 million gallons (3,638,466 gal/yr). That equates to 1,266,746 gallons of water saved per year.

²⁶ "How Do Composting Toilets Work?" Lets Go Gree. Accessed May 18, 2015.

Rainwater Harvesting

The table below explores the potential of the site for rainwater harvesting in relation to the water usage of the building. The estimations below are based on the assumption that 100% of the rainwater that falls on the site can and will be collected. This assumption, though not realistic, gives a rough idea of the rainwater harvesting potential of the site. According to these calculations, the total annual rainwater that falls on this site will provide 8.22% of the building annual water usage.

With the ongoing drought in California, every drop of water is precious. As such, rainwater harvesting was integrating into the building's water management systems. The rainwater collected is fed into the Living Machine on site to be purified for reuse.

POSSIBLE WATER COLLECTION				
Annual Rainfall		Max Surface Area	TOTAL Possible Water Collection per year	
8 inch/yr	0.6 ft/yr	60,000 SF	40,000.00 ft ³ /yr	299,220.80 gal/yr

DOMESTIC WATER USAGE w/o Toilets			
Residential Water Use (gallons per capita per day) San Diego			112 gpcd
Category	US Average	Percentage	San Diego Average
Outdoor	124.0 gal/day	58.00%	73 gal/day
Indoor - Potable	35.8 gal/day	21.70%	27 gal/day
<i>Shower</i>	11.6 gal/day	32.40%	9 gal/day
<i>Dishwasher</i>	1.0 gal/day	2.79%	1 gal/day
<i>Baths</i>	1.2 gal/day	3.35%	1 gal/day
<i>Faucets</i>	10.9 gal/day	30.45%	8 gal/day
<i>Other (ie. Leak)</i>	11.1 gal/day	31.01%	8 gal/day
Indoor - Nonpotable	33.5 gal/day	20.30%	12 gal/day
<i>Clothes Washer</i>	15.0 gal/day	44.78%	12 gal/day

WATER USAGE IN BUILDING PER DAY w/o Toilets			
# of Residential Occupants	Total Residential Use per year		
	Total Indoor	Indoor Potable	Indoor Non-potable
256	9,968.40 gal/day	6,901.20 gal/day	3,067.20 gal/day

WATER USAGE IN BUILDING PER YEAR w/o Toilets			
# of Residential Occupants	Total Residential Use per year		
	Total Indoor	Indoor Potable	Indoor Non-potable
256	3,638,466.00 gal/yr	2,518,938.00 gal/yr	1,119,528.00 gal/yr

WATER HARVESTING POTENTIAL PER YEAR w/o Toilets			
Total possible water collection per year	% of Total Indoor Use Per year	% of Total Indoor Potable usage per year	% of Total Indoor Non-Potable Usage per year
299,220.80 gal/yr	8.22%	11.88%	26.73%

Table 5: Rainwater harvesting potential in comparison to water usage

Living Machine

In a typical building, “potable” or drinkable water is fed in and wastewater is pumped out and treated by a centralized water treatment system before being reintroduced into natural waterways. This linear process requires a large amount of

infrastructure, from sewage pipes to very sizable water treatment plants. Decentralized, onsite, water treatment systems offer many advantages over centralized systems, among which are: water reuse potential, modularity and flexibility for expansion, lower capital cost & running cost and the potential to create environmental awareness.²⁷ The potential for water reuse is of particular relevance in San Diego, as water supply is currently threatened by increase demand, coupled with a severe drought.

One of the most notable and eco-friendly of these decentralized systems is the Living Machine. Dr. John Todd, President of the non-profit Organization Ocean Arks International, first conceived this filtration system as a way of replicated natural water filtration systems found in lakes, rivers and wetlands. It gets its name “from the ecologically-based components that are incorporated within its treatment processes (microorganisms, protozoa, higher animals such as snails, and plants).”²⁸

The Living Machine envisioned for this project consists of 5 treatment components. These steps comprise of the following:

Step 1: Anaerobic²⁹ Tanks

This reactor operates very similarly to a septic tank and is normally placed underground. Its main purpose is to reduce the amount of solids in the wastewater through sedimentation. When a large concentration of solids are expected in the wastewater, as with this project, the anaerobic reactor is divided into two sections: the

²⁷ Brtalik, Kiernan, Marina Feraud, Dana Jennings, Howard Kahan, Geneva Travis, and Arturo Keller. "Assessing Decentralized Wastewater Treatment Options in Santa Barbara County." Bren School of Environmental Science & Management, 2012.

²⁸ "Wastewater Technology Fact Sheet: The Living Machine." United States Environmental Protection Agency. Accessed May 16, 2015.

²⁹ Anaerobic: biological processes that occur in the absence of oxygen.

first collects most of the larger solids in the wastewater while the second chamber, referred to as the clarification zone, handles finer solids. To aid this process, strips of mesh netting are often used in the clarification zone “to assist with the trapping and settling of solids, and to provide surface area for the colonization of anaerobic bacteria, which help digest the solids.”³⁰ The sludge produced in this step is periodically removed and fed to other biosolids treatment processes. Odor control is a key issue to consider in this process. Typically, this issue is solved using an activated carbon filter or biofilter to treat gasses that are produced.

Step 2: Tidal Flow Wetlands or Open Aerobic³¹ Tanks

In this step, wastewater is introduced in a horizontal direction thus giving this stage its name. Fine bubble diffusers are located at the bottom of the tank to increase the circulation of oxygen and thus promoting the growth of microorganisms that help digest impurities in the water. The surface of this tank is covered by vegetation supported on racks. As described by the EPA’s “Wastewater Technology Fact Sheet”, “These plants serve to provide surface area for microbial growth, perform nutrient uptake, and can serve as a habitat for beneficial insects and microorganism.”³²

³⁰ "Wastewater Technology Fact Sheet: The Living Machine." United States Environmental Protection Agency. Accessed May 16, 2015.

³¹ Aerobic: biological processes that rely on the presence of oxygen.

³² "Wastewater Technology Fact Sheet: The Living Machine." United States Environmental Protection Agency. Accessed May 16, 2015.

Step 3: Clarifier

The clarifier acts as a “settling tank that allows remaining solids to separate from treated wastewater.”³³ The sludge³⁴ that results from this process is reintroduced to the previous stage (the Tidal Flow Wetlands) to be digested by the microorganisms present in the tank.

Step 4: Vertical Flow Wetlands

These wetlands, also referred to as “Ecological Fluidized Beds” or EFBs, consist of both an inner and outer tank. The inner tank holds a gravel-like medium that supports the growth of microscopic plants & animals that in turn consume the waste in the water.

As described in the EPA’s fact sheet on Living Machines,

The wastewater flows into the EFB in the annular space between the inner and outer tanks and is raised by air lift pipes to the top of the inner ring that contains the media. The bottom of the inner tank is not sealed, so the wastewater percolates through the gravel media and returns to the outer annular space, from where it is again moved back to the top of the gravel bed. The airlifts also serve to aerate the water and maintain aerobic conditions.

³³ "Wastewater Technology Fact Sheet: The Living Machine." United States Environmental Protection Agency. Accessed May 16, 2015. <http://water.epa.gov/scitech/wastetech/mtbfact.cfm>.

³⁴ Sludge: accumulated solids and associated entrained water within a pretreatment component, generated during the biological, physical, or chemical treatment; coagulation; or clarification of wastewater.

Step 5: Polishing

In a typical Living Machine, the previous stage, resulting in clean yet “non-potable”³⁵ water, is considered to be the last. As the main goal of this project is to use recycled water to the fullest extent, an extra step, referred to as “polishing”, was added. In this phase, water is passed through a 20 micron filter and then through a 5 micron filter. A UV sterilizer treats any harmful impurities that remain in the water. The result of these 5 stages is potable³⁶ water fit for any kind of usage in the building.

System Sizing

The table below provides estimated sizes for the various components of the Living Machine:

LIVING MACHINE ESTIMATED SIZING								
Stage	Number	Depth	Height	Diameter	Length	Width	Area	Total Area
Anaerobic Tank	1	8 ft	-	-	30 ft	30 ft	900 SF	900 SF
Open Aerobic Tanks	6	8 ft	4 ft	8 ft	-	-	201 SF	1,206 SF
Clarifier	1	8 ft	4 ft	8 ft	-	-	201 SF	201 SF
Wetlands	1	4 ft	-	-	20 ft	20 ft	400 SF	400 SF
Polishing	1	-	8 ft	-	6 ft	10 ft	60 SF	60 SF
Holding Tank	1	8 ft	-	-	30 ft	30 ft	900 SF	900 SF
TOTAL AREA								3,667 SF
TOTAL AREA w/ Circulation								4,033 SF

Table 6: Estimated sizing of Living Machine components

³⁵ Non-potable water is deemed unfit for consumption or close contact with human bodies but can be used to irrigation and toilets.

³⁶ Potable water refers to water fit for human consumption



Figure 24: Water diagram

7. Energy Analysis - Passivhaus

The energy performance of the building was analyzed in relation to “Passivhaus” standards. Passivhaus or “Passive House” is a German energy standard that advocates passive heating and cooling systems, and active ventilation systems.³⁷ (This is the opposite of what normally happens in building; typically, the heating and cooling system is active, and the ventilation system is passive.) Passivhaus buildings achieve this goal by implementing airtight construction and high performance enclosure systems.

The ventilation system of this building consists of six heat-recovery-ventilation or HRV units. The cooling demand of the building is mitigated by copious amount of solar shading, as well as stack ventilation. As a result of these two passive systems, no additional air-condition systems were required to meet the building’s cooling demand. As San Diego has very few heating degree-days, a thin layer of insulation addressed the buildings heating demand.

The vehicle for the energy analysis of the building was “Energy Advisor”: a program developed by Dylan Lamar that compares the buildings performance in relation to Passivhaus standards. This software takes into account the enclosure system of the building, as well as solar exposure, window systems, climate and many other performance-related variables. The result on this analysis, summarized below, indicates that “8 on Market” not only falls within Passivhaus energy standards, but exceeds them. The building handles its heating demands 76%, and its cooling demand 84% better than Passivhaus requires.

³⁷ A “active” building system relies on mechanical equipment, while “passive” systems do not.

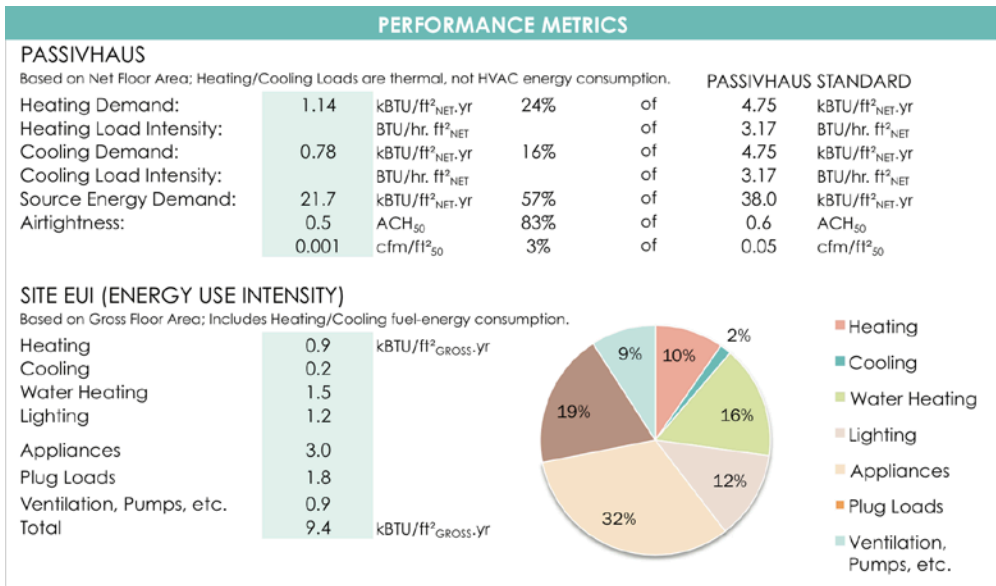


Figure 25: Results of Energy Advisor

8. Economic Analysis

RESIDENTIAL AREA + SALE PRICE										
Unit Types	Occupancy	Gross Area	Net Area	# of Units	Total Occupancy	Total Net Area	Total Gross Area	Price Per SF	Price Per Unit	Price W/ Living Machine
Double Exposure Flat	1.8	1,232 SF	1,145 SF	19	34	21,761 SF	23,408 SF	\$540	\$618,457	\$630,959
Flipping Exposure	2.8	2,024 SF	1,910 SF	48	134	91,679 SF	97,152 SF	\$690	\$1,317,886	\$1,338,426
Corner	4	2,093 SF	1,874 SF	12	48	22,484 SF	25,116 SF	\$830	\$1,555,163	\$1,576,403
Corner Flat	3	1,221 SF	1,105 SF	4	12	4,420 SF	4,884 SF	\$710	\$866,910	\$879,301
Loft	1.5	1,059 SF	953 SF	18	27	17,154 SF	19,058 SF	\$500	\$529,375	\$540,119
TOTAL	-	-	-	101	256	157,498 SF	169,618 SF	-	\$106,667,555	\$108,388,859

DEVELOPMENT COST								
Land Cost	Demo Cost	Total Land Cost	Hard Cost	Soft Cost	Living Machine	Living Machine Cost per SF	PARKING	TOTAL DEVELOPMENT COST
\$18,000,000.00	\$48,480.00	\$18,048,480.00	\$39,416,060.00	\$7,883,212.00	\$2,000,000.00	\$10.15	\$5,102,280.00	\$72,450,032.00

OPERATING COSTS			
Maintenance Cost	Insurance	Taxes	TOTAL OPERATING COST
\$96,120	\$49,270.08	\$17,206	\$162,596.28

COMMERCIAL ANNUAL RENTAL INCOME		
Total Gross Area	Rent sf/yr	Annual Rental Income
27,462.80 SF	\$35	\$961,198

PROFIT	
Net Cash Flow (ADS)	\$961,198
Capitalized Value of Project	\$16,019,967
PROFIT (Annual from Commercial)	\$798,602
PROFIT (Residential Sales)	\$35,938,827

Table 7: Pro Forma

COMP PROJECTS			
800 The Mark	Square Footage	Price	Price per SF
1bd, 1ba	878 SF	\$499,000	\$568
1bd, 1ba	739 SF	\$550,000	\$744
4bd, 4ba	2,430 SF	\$2,590,000	\$1,066
1bd, 1ba	902 SF	\$299,000	\$331
1bd, 1ba	960 SF	\$340,000	\$354
3bd, 2.5 ba	1,878 SF	\$1,260,000	\$671
3bd, 4ba	2,431 SF	\$2,000,000	\$823
820 Island Ave	Square Footage	Price	Price per SF
2bd, 2ba	1,581 SF	\$999,000	\$632
575 6th Ave	Square Footage	Price	Price per SF
1bd, 1ba	653 SF	\$385,000	\$590
2bd, 2ba	960 SF	\$619,000	\$645
2bd, 2ba	1,144 SF	\$779,000	\$681
887 Island Ave	Square Footage	Price	Price per SF
2bd, 2ba	1,431 SF	\$599,900	\$419
2bd, 2ba	1,539 SF	\$899,900	\$585
3bd, 3ba	2,330 SF	\$1,572,500	\$675
AVERAGE UNIT PRICE PER SF			
1bd			\$558
2bd			\$582
3bd			\$723
4bd			\$1,066

Table 8: Cost of comparable units in the area

The calculations above analyze the economic performance the residential component of the building. The sales price of the units was estimated by averaging the sales prices of similar units in the area (table 7). The total income from selling all the units adds up to \$108,388,859. The cost of developing the building (including the parking and commercial levels) is estimated at \$72,050,032. This brings the total profit of residential component to a little under \$36 million (Table 6). On top of this one-time profit of \$35 million, the commercial component of the building generates an annual income of around \$800,000. In summary, 8 on Market is economically viable.

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