City of Santa Monica
High Performance Building Cost Effectiveness Study

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Prepared by

INTEGRAL
Integral Group
523 W. 6th Street, Suite 1013
Los Angeles, CA 90014
323.825.9955

SKANSKA
Skanska USA
12100 Wilshire Blvd, Suite 1420
Los Angeles, CA 90025
310.500.3758

AUTHORS

Joel Cesare
Sustainable Building Advisor
City of Santa Monica

Nico Chiarito
Project Engineer
Integral Group

Steve Clem
Vice President
Skanska USA Building

John Coster
Green Business Officer
Skanska USA Building

Nura Darabi
Engineering Analyst
Integral Group

Susan Ecker
Principal
Integral Group

Daniel Haas
Project Director
Skanska USA Building

Holly Hill
Senior Sustainability Consultant
Integral Group

Lisa Matthiessen
Principal
Integral Group

Andy Reilman
Associate Principal
Integral Group

CONTRIBUTORS

Liyang Han
Energy Analyst
Integral Group

Elizabeth Heider
Chief Sustainability Officer
Skanska USA Building

Felor Rezayat
Project Engineer
Integral Group

Pedro Ruiz
Estimating Engineer
Skanska USA Building

Joe Springgay
Mechanical Preconstruction Manager
Skanska USA Building

Table of Contents

1 INTRODUCTION

In 1994, the City of Santa Monica was among the first in the country to publish a Sustainable City Plan that established goals and performance benchmarks for an environmentally responsible, economically viable, and socially just community. The Plan set aggressive goals for energy efficiency, renewable energy and greenhouse gas emissions city wide. In 2006, an updated Sustainable City Plan established a goal for reducing community greenhouse gas emissions to 15 percent below 1990 levels by the year 2015. By 2012, the City's emissions were 14% below 1990 levels. In 2012, the City published a Climate Action Plan to create a path to achieve the 15% goal by the end of 2015, taking into account projected population and economic growth anticipated between 2012 and 2015. This Climate Action Plan recommends more aggressive energy efficiency standards than State code for new buildings, a reduction in energy use from existing buildings by implementing a benchmarking and disclosure ordinance, and the continued build out of solar capacity city wide.

The City should be commended for its leadership, transparency and data-driven approach to achieving these goals and reporting on their performance benchmarks. Though challenging, the City is on-target to meet its energy and greenhouse gas emission goals for 2015.

Looking forward, the City is again establishing bold goals'; it has committed to reducing emissions 50% below 1990 levels by 2030 and 80% by 2050. To meet these goals, Santa Monica will have to creatively assess every aspect of life in the beautiful coastal city. Maybe most critical, the City must reimagine the relationship between its built environment and the natural resources it takes to build and operate its buildings.

The sustainable building industry is fluid, and innovative elements of most projects are outdated by the time the building is occupied. The insights and observations generated from work on previous projects no longer represent the information needed to achieve the potential for current and future projects. It is the job of Santa Monica's Office of Sustainability and the Environment (OSE) to aggregate leading-edge practices and implement them in order to reach the City's ambitious sustainability goals. Designing high performance, green buildings is a foundational opportunity to literally build our sustainable city commitments into the fabric of the community. In an effort to truly understand the relationship between sustainability performance and cost, the City engaged independent, third party entities to evaluate the costs of building these high performance buildings. This was done to inform processes and better understand the City's obligation to inform the marketplace. The City enters each project with a two-fold goal: provide as much benefit to the community as possible and be mindful of real or perceived costs. OSE collaborated with the authors of this study to demonstrate quantitatively the incremental capital cost differences for a midrise, mixed use, multifamily project achieving various levels of high performance building targets. The City engages with private developers during Development Agreements to collaborate on building the most high-performance buildings possible. During this process, it would be of great value to City Staff and private developers to reference an analysis that determines the difference in capital expenditure to build the same project to various industry leading, third-party verified sustainable building targets. In addition to first costs, the study evaluates life-cycle cost analysis (LCCA) for each of these targets. Although often not included in discussions that motivate design strategies, LCCA is the most appropriate metric to determine the "cost" of decisions by capturing the operational value.

The City hired the leading consultants in the field of high performance building design and cost estimating. A prototypical building type was identified, which the City expects to see more of, pursuant to Transit Oriented Development (TOD) built into the Land Use and Circulation Element (LUCE). LEED v4 Platinum and Living Building Challenge were chosen as the most respected and utilized forward-thinking metrics at the leading edge of high performance building design. And finally, the study uses Life Cycle Cost Analysis (LCCA), which leading economists and financial experts believe is the most appropriate method to evaluate the total cost of ownership for a building project. The City is proud to produce this study; it will be a tool the Santa Monica development community can use to build the most resource-efficient projects for years to come.

2 EXECUTIVE SUMMARY

The City of Santa Monica commissioned this study to identify the cost implications of building to performance standards beyond those required by code. The City's purpose is to provide useful information for project teams that are considering high performance designs, but are concerned about cost implications.

This report analyzes costs and performance of a prototypical, midrise multifamily mixed use building in Santa Monica, at three performance levels. Performance is measured in terms of energy and water use, and against the multiple attributes of the LEED and LBC rating systems. The three performance levels are: prototypical design, LEED v4 Platinum Certified, and Living Building Challenge (LBC) v2.1 Certified. The subsequent Life Cycle Cost Analysis (LCCA) includes project costs, ongoing utility costs, and repair and maintenance (R&M) costs over a 30-year period.

The City of Santa Monica provided the team with project drawings which served as the baseline for the energy analysis, the water balance calculations, the costing exercise and the LCCA. The team found that while both LEED v4 Platinum and LBC certifications are achievable, that there are costs associated with achieving specific criteria.

The study identified a 2% - 7% increase in total project costs for LEED v4 Platinum, as compared to the prototypical Santa Monica building. The added costs are primarily for renewable energy systems, an efficient building envelope and healthy building materials. Energy costs are cut in half, and water costs are reduced by one third, while R&M costs increase only by about $1,500 per year. The simple payback (not including cost of money, etc.) is 17 years.

Given variation between specific projects, and following the trends witnessed over the past 15 years, the authors of this report believe that the estimated cost increases to achieve LEED v4 Platinum are surmountable. If LEED Platinum requirements are incorporated into the design from the beginning, projects should be able to achieve LEED Platinum without adding to construction costs.

Full LBC requires a 15% – 20% increase in total project costs over the prototype building, with higher annual Operations and Maintenance (O&M) costs as well. The cost increase can be attributed primarily due to rainwater catchment and membrane bioreactor (MBR) treatment systems, with some additional costs for enlarging the PV system. There are no water and electricity utility costs, and an annual savings on sewer discharge due to black water and grey water recycling. However, ongoing operational savings are not enough to offset the annual maintenance costs for these systems; payback for the LBC building is 29 years.

Design Profile	Primary Design Driver	Total Additional Project Costs	Payback
Prototype	2013 Title 24 Part 6 Compliance	N/A	N/A
LEED v4 Platinum Mulifamily Midrise	Tight envelope High efficiency mechanical equipment 2,500 sf of PV	2% - 7%	17 years
LBC v2.1	Tight envelope On site rainwater catchment On site grey water | black water treatment 12,500 sf of PV	15% - 20%	29 years

The authors believe that costs for systems used to achieve LBC will decrease over time, but that, in the current market, builders can expect to pay more for performance at this level. Project cost premiums may be temporary as water regulations begin to require more aggressive water reuse strategies. Additionally, as material manufacturers respond to market demand for transparency and toxic-free products, LEED and LBC materials will become more commonplace.

Note that health, wellness, productivity and societal benefits realized from the LBC building in particular (and to some extent the LEED v4 Platinum building), are not captured in this study. Project teams may wish to consider a target of LBC Petal Certification, with Energy as the Petal. This approach will yield positive financial results. Water capture and treatment systems will be economically viable at a district scale

2.1 STUDY METHODOLOGY

The study is based upon an actual, developer led, project that has been submitted to the City for permitting; the following analysis is therefore based on a plausible scenario. The project site is located in downtown Santa Monica, California. The building is four stories and 46,000 square feet total, comprising 6,500 sf of commercial space, and 53 residential units with the following breakdown: 28 studio units, 19 one-bedroom unit, and 6 two-bedroom units. For purposes of this analysis it is assumed that the retail space is light commercial, with no kitchen.

The City of Santa Monica provided the team with prototypical project drawings which served as the baseline for the energy analysis, the water balance calculations, the costing exercise and lastly the LCCA. Integral Group and Skanska developed design profiles using both passive and active strategies to meet the following performance targets:

- 2013 Title 24 Part 6 Compliance in Santa Monica's jurisdiction
- LEED version 4 (LEED v4) Platinum Certification
- Living Building Challenge (LBC) v2.1 Certification (all petals)

The team identified design strategies and technologies from the perspective of a cost, constructability, and operations conscious owner. The goal was to develop a design that is realistic and replicable for the typical developer.

The costs associated with a Net Zero Energy design profile were found to be 4% - 9% higher than the prototype building.

The first profile developed was based upon the project drawings. This as-designed developer building served as the prototype building and exceeds California's Building Energy Efficiency Standards, 2013 Title 24 Part 6. The second profile developed was the LEED v4 Platinum design; the design targets just enough points (85 points) to achieve LEED v4 Platinum, with a buffer, while using the most cost effective strategies. The final design profile was LBC. Energy Plus was used to identify and analyze various energy efficiency measures needed to meet the Net Zero Energy criteria. A water balance spreadsheet was used to calculate the potable and non-potable sources and demands to achieve Net Zero Water.

Skanska used the design profiles to develop a cost analysis and to quantify the difference in costs between the prototype building, the LEED v4 Platinum building, and the LBC building. It is noted that the costing exercise includes the construction costs, as well as owner and development costs. A LCCA spreadsheet was developed, incorporating First Costs, annual Utility Costs, annual Repair & Maintenance (R&M) costs, as well as several variables, such as escalation rates and Capital Discount Rate.

The following study outlines the green building certification criteria, the design profiles, the costing exercise and the LCCA. The report narratives are framed in the context of the prototype and LBC buildings, with specific caveats, exclusions or comments for the LEED criteria.

3 LEED V4 AND LBC ANALYSES

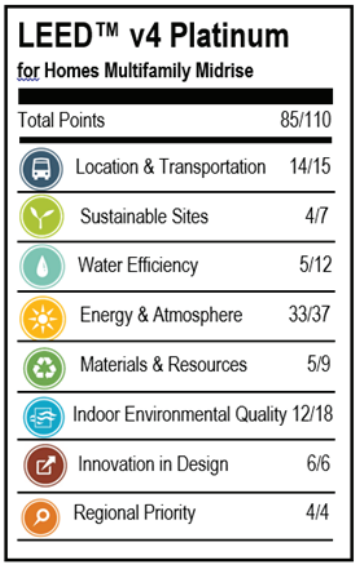
3.1 LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED)

The LEED rating system has catalyzed market transformation over the last 15 years, and LEED v4 is following suit by setting forth dramatic changes in prerequisites and criteria for buildings targeting certification. LEED v4 was introduced to the market in 2013 and has the following more robust attributes than its predecessor, LEED v2009:

- Incorporates a materials focus to promote product transparency to better understand the effect material components have on human health and the environment;
- Takes a performance-based approach to indoor environmental quality;
- Provides a clearer picture of water efficiency by evaluating total building water use;
- Includes an emphasis on building performance management;
- Significantly raises performance thresholds across the 5 credit categories; and,
- Recognizes broader issues such as climate change, human health, biodiversity, green economy, community and natural resources.

The project is a four story mixed use building, therefore, it falls under the LEED for Homes: Multifamily Midrise rating system. LEED v4 Platinum Certification is achievable for this building type and the project achieves 85 points, exceeding the Platinum minimum threshold of 80 points. However, to execute a LEED v4 Platinum project requires diligence, integrated design, thoughtful planning, and technical astuteness. Below are the credit categories and narrative. The LEED v4 Multifamily Midrise Checklist for the prototype building design and the Platinum building design are located in Exhibit A of the Appendix.

CREDIT CATEGORY DISCUSSION



Location and Transportation – The project location is not currently in a LEED for Neighborhood Development, therefore the Prescriptive Path is pursued. Fortunately, the project site is located on a previously developed infill site and is well situated in Santa Monica with access to public amenities and public transportation.

Sustainable Sites – By meeting the National Pollutant Discharge Elimination System (NPDES) and landscaping with noninvasive vegetation (if applicable), the project can meet the prerequisites in this credit category. Additional credits are achieved due to the minimal amount of hardscape on the project and good operational practices for pest mitigation.

Water Efficiency – The Performance Path was pursued in this credit category in order to maximize the number of points. Indoor water use is reduced by 33.5% by using water-conserving fixtures.

Energy & Atmosphere – By designing a tight envelope and incorporating 2,500 sf of PV, the project maximizes the points in this category and exceeds a 60% energy use reduction over a LEED baseline (as defined by ASHRAE 90.1–2010). Commissioning must be performed via ENERGY STAR protocols or a Prescriptive Path. Efficient hot water distribution is provided through insulated piping. Each residential unit requires submetering and utility usage reporting by the tenant or building owner to USGBC (or an approved third party) is expected as well.

Materials and Resources – Proper wood sourcing and good construction practices achieve the prerequisites in this category. A conservative approach was taken for the remainder of the credits, as there are various nuances for the local sourcing and environmentally preferable products which may not be feasible from a sourcing or cost perspective. Construction waste management is achieved, and requires a percent reduction above an established baseline, unlike v2009.

Indoor Environmental Quality – This credit category is robust in the Multifamily Midrise rating system and has seven prerequisites. Most prerequisites are achieved via good construction practices but diligence is required to ensure the project includes a whole-unit ventilation system for each individual dwelling unit that complies with the requirements of ASHRAE Standard 62.2–2010. Effective compartmentalization between residential units, in order to minimize leakage is expected as well. Care must be taken in the garage construction, all applicable products should be low-emitting based upon California code, and it is assumed that the building will be completely non-smoking, as required in tenant and/or sales lease language.

Innovation in Design – The LEED assessment assumed that the project team would maximize the number of ID points and that six points would be achieved in this credit category.

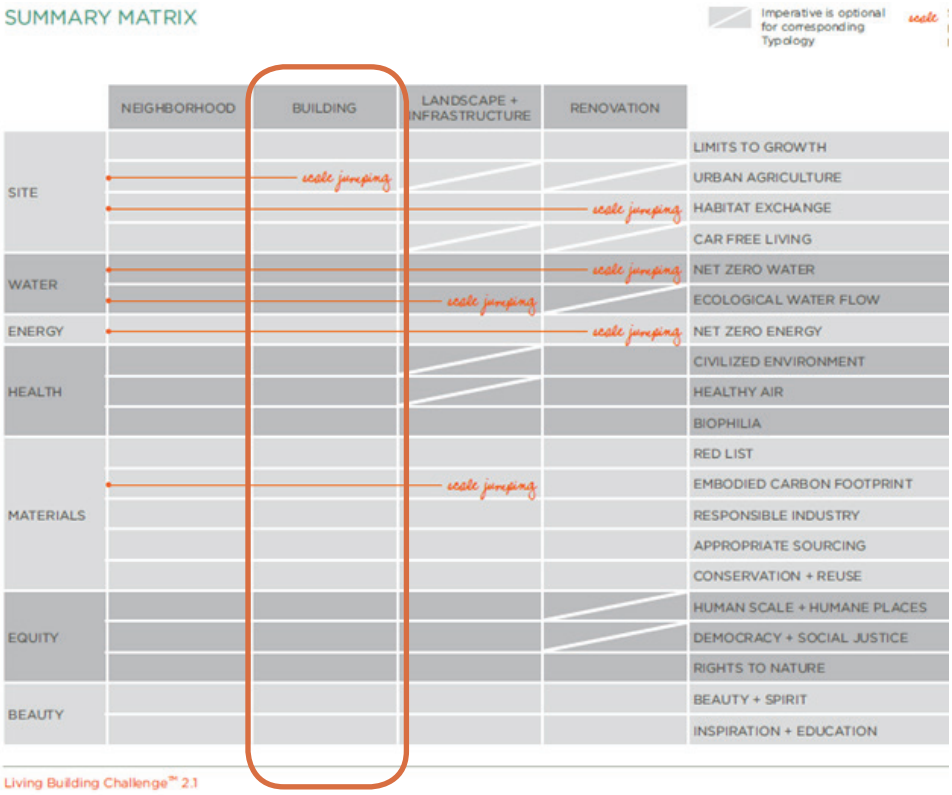
Regional Priority – The project site is located in zip code 90401 and there are seven applicable Regional Priority Credits. Once the required point threshold is achieved in the base credit, the Regional Priority Credit is earned. Projects may earn up to four Regional Priority Credits, and the credits assumed for this project with their respective point thresholds, are as follows:

- Annual Energy Use – Required point threshold is 20
- Compact Development – Required point threshold is 2
- Community Resources – Required point threshold is 1
- Access to Transit – Required point threshold is 2

3.2 LIVING BUILDING CHALLENGE (LBC)

The Living Building Challenge, set forth by the International Living Future Institute (IFLI), comprises seven performance categories, or 'Petals'; Site, Water, Energy, Health, Materials, Equity, and Beauty. Petals are subdivided into a total of twenty Imperatives. All Imperatives assigned to a specific Typology, or building type, are required. In order to achieve full LBC certification, or 'Living Status', the project must achieve all the required Imperatives across the seven Petals.

IFLI allows for Petal Recognition by satisfying the requirements of three or more Petals (at least one of the following must be included: Water, Energy or Materials), or another option, solely Net Zero Energy Building Certification. For the purposes of this study, the project is targeting full LBC Certification.



As a new construction building, the project Typology is Building. The Living Transect describes the built density of the environment where the project is located. This project lies in L4. General Urban Zone, with a FAR of 0.5 – 1.49. This project FAR is 0.98.

As is evidence in the Summary Matrix in Figure 3.1, all Imperatives are required for the Building Typology and scale jumping is allowed for specific criteria. Scale jumping is defined as the ability for a project of any typology to reach beyond the project footprint to other typologies in order to meet the Imperative. This project may potentially partner with nearby projects and identify scale jumping opportunities and solutions to achieve LBC.

Below are the Petals and narrative highlights to accompany Exhibit B – LBC Checklist found in the Appendix. LBC Petal Discussion

Site – As a previously developed infill site in a mixed use neighborhood, the project site promotes car free living and limits to growth. The project has a FAR of 0.98, therefore 20% of the project area (3,000 sf) must be set aside for urban agriculture and a minimum 0.4 hectare will be set aside in perpetuity as part of habitat exchange.

Water – The Water Petal is comprised of two imperatives; 05 - Net Zero Water and 06 - Ecological Water Flow. As expected with residential developments, there is a high potable water demand. Additionally, the project is located in a climate with little rainfall and therefore has an annual net deficit of water onsite. Care must be given to achieve Net Zero Water. As discussed in more detail below, scale jumping must be considered in order to achieve the imperatives of LBC. Thorough consideration should be given to building fixtures and the energy implications of treating and pumping recycled water.

Energy – Being a four story building, this design is right at the cusp of achieving Net Zero Energy. With minimal site and roof area, and a residential use program, the building achieves Net Zero Energy by incorporating a tight building envelope, using high efficiency equipment and maximizing the roof area with PV.

Health – The building design incorporates operable windows, providing access to fresh air and daylight, as well as ensuring a healthy indoor air quality through separate ventilation systems and prohibiting smoking. Air quality testing must also be conducted nine months post-occupancy. Six Biophilic Design Elements will be included to encourage the human connection with natural systems and processes.

Materials – The Materials Petal is an extremely challenging petal in LBC. Specific Red List chemicals or materials may not be included in the building, and careful consideration must be given to sourcing materials locally and through third-party standards for sustainable resource extraction and fair labor practices. This requires extensive research, proper specification, and diligent execution to ensure all the criteria for building materials are met. Additionally, the project must track its total embodied carbon and account for it via a one-time carbon offset. A Material Conservation Plan must also be implemented to minimize material consumption and increase diversion from landfill.

Equity – Specific design guidelines must be followed to ensure the building and site promote human and cultural interaction, as well as accessibility for all. The project must ensure that it does not inhibit fresh air, sunlight or access to waterways for “any member of society or adjacent developments”.

Beauty – The project must contain design elements which celebrate culture, spirit and place, and educate the public about the operation and performance of the project.

4.1 WATER BACKGROUND

According to the U.S. Drought Monitor, 95% of California is currently categorized as D2, Severe Drought or worse, and over 71% as D3, Extreme Drought or worse. 2013 was the driest year in California on record, which has sustained through 2014 and 2015 with no signs of relief. The importance of easing the reliance on municipally sourced potable water has never been more significant. Many water municipalities are at serious risk for complete reservoir depletion if significant conservation measures are not implemented. State water allocations set by the Department of Water Resources have been set to 0% for many municipal water districts.
With the current state of the California drought, it is all of our responsibility to conserve and reuse our available fresh water. By implementing water reuse strategies on site, efficient fixtures, we will see significant and vital water savings.

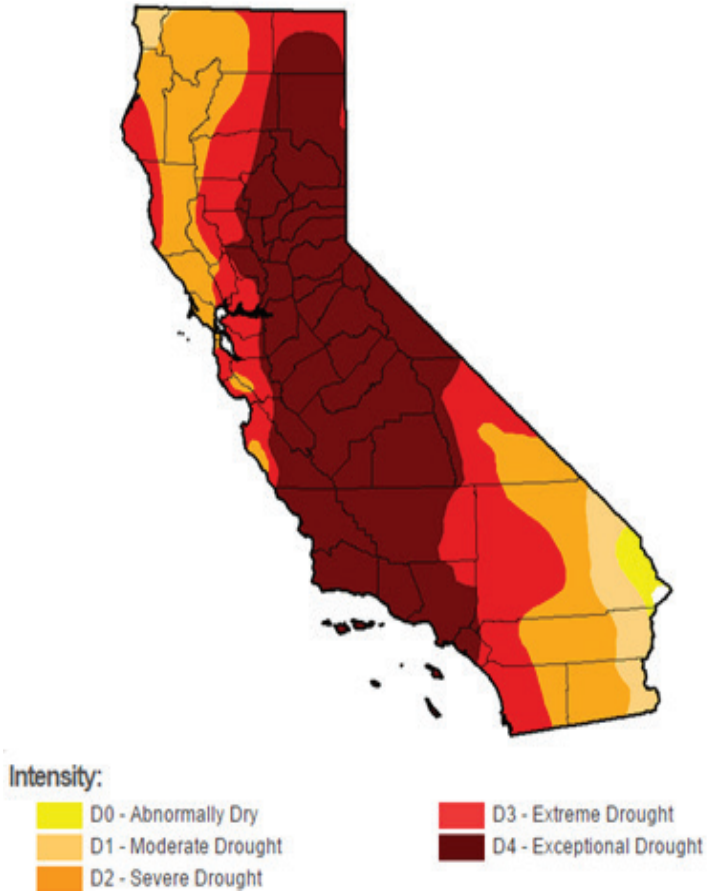


Figure 4.1. U.S. Drought Monitor – California – June 16, 2015

4.2 WATER DESIGN PROFILE

A water balance was completed to identify all the potable and non-potable water demands and available water sources. As indicated in Figure 4.2 below, the result aligns with a typical residential program; the highest potable water demands are the showers, followed by kitchen sinks and water closets. Irrigation is typically a substantial portion of residential water use, however, it is minimal for this building, and comprises 3,000 sf of landscaping for agriculture to satisfy the LBC 02 Urban Agriculture requirement.

The water balance calculation identifies a total building water demand of 1,490,000 gallons per year. If full LBC is pursued, there is a total of 1,422,000 gallons per year of available blackwater, greywater, rainwater and condensate for collection and reuse. However, in order to process water in the reverse osmosis (RO) and membrane bioreactor (MBR) systems, some of the water must be rejected as a concentrated waste stream. The total water rejected is 494,000 gallons per year which must be addressed on site or with a scale jumping solution for LBC compliance (discussed further below). Therefore, this produces a net demand of water on site of 562,000 gallons annually; this is the water that would need to be provided from offsite sources, assuming all onsite rainwater could be captured for reuse. To accommodate the need for an additional water source, the project design utilizes sewer mining. For a breakdown of water uses on site, refer to Figure 4.2. For a complete breakdown of the LBC water design, refer to the process flow diagram in Figure 4.3.

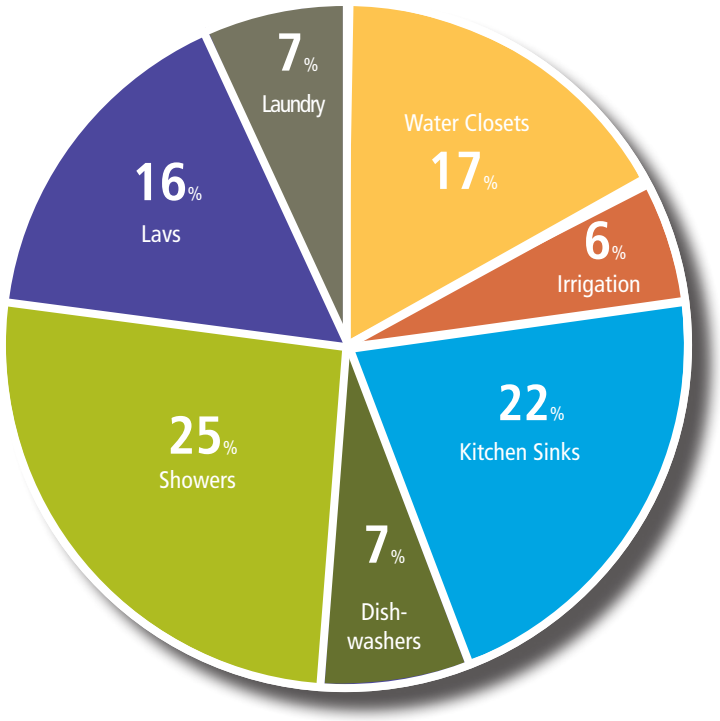
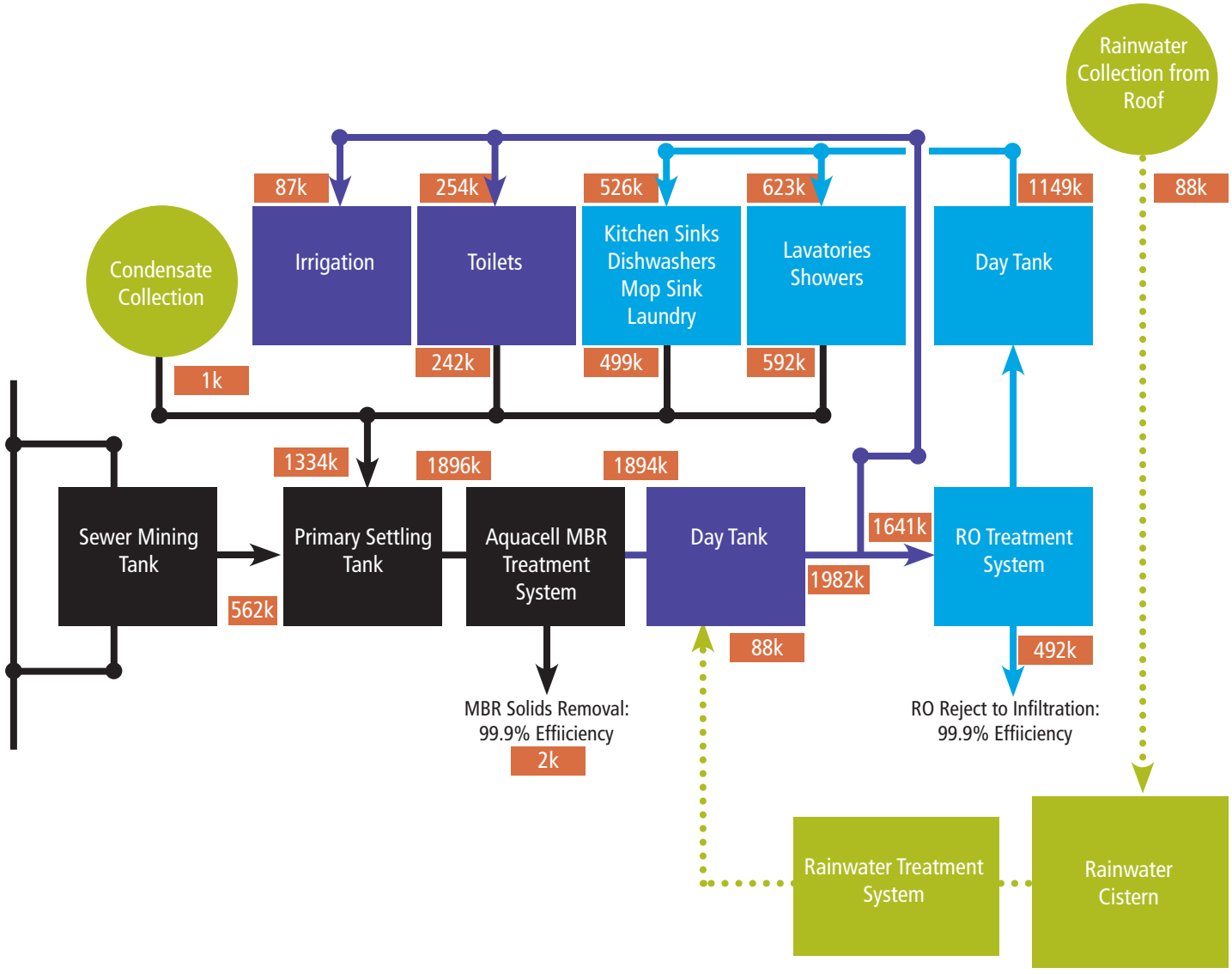


Figure 4.2 – Building Water Demands by End Use; 1.1 gpf water closets

The Water Petal includes two Imperatives; Imperative 05, Net Zero Water requires all of the project water needs to be supplied by captured precipitation or other natural closed loop water systems, and Imperative 06, Ecological Water Flow requires that all storm water must be managed onsite to feed the projects internal water demands or released onto adjacent sites.

In the water design profile, source water will be supplied by capturing precipitation, condensate and “sewer mining” (described in detail below). There will be zero municipally supplied potable water serving the building. All of the source water will be used, recycled and ultimately, used for irrigation and/or groundwater recharge. In Figure 4.3 below, the design profile is outlined with system flows and noted in thousands of gallons annually. Potable water uses are identified in blue, non-potable uses are identified in dark blue, and treatment or collection infrastructure is noted in lime green.



Rainwater/Condensate Catchment System

Water will be harvested from 13,235 sq. ft. of rooftop collection area as well as condensate from mechanical cooling equipment for a total available water supply of 89,000 gallons per year. Condensate collection is limited in volume (1,000 gallons). To mitigate large first costs for relatively little source water, condensate will be piped to the closest sanitary sewer connection (fixtures, laterals, risers, etc.). Rainwater will be collected and conveyed with typical Storm Drain pipe drops to a modular, below grade, 30,000 gallon underground cistern. An overflow drain to the municipal storm system is required, however not anticipated to be used.

Sewer Mining System
Sewer mining will provide a supplemental water supply of 562,000 gallons per year. A lateral will run parallel to the City sewer main and a 500-1,000 gallon tank will be installed to provide a pump basin, buffer, and pH monitoring point for the raw sewage. The sewage will be pumped through duplex sump pumps and a new force main to the buildings Primary Settling Tank.

Blackwater Treatment System
Blackwater will be collected from all potable (kitchen sinks, showers, lavatories, etc.) and non-potable fixtures (toilets, urinals, etc). This is a typical, code-compliant sanitary sewer system and will convey all wastewater by gravity. Supplemental wastewater, when needed will be sewer mined (see above).

A primary settling tank will screen out solids and the blackwater will be treated via a membrane bioreactor (MBR) treatment system. MBR treatment is 95% efficient. The remaining 5% of sludge will be centrifuged to increase efficiency to 99.9% creating solid waste to be exported for fertilizer or compost. The day tank will provide a buffer for treated water prior to being pumped to irrigation, toilets, laundry or to the RO treatment system for potable treatment.

RO Treatment System
A Reverse Osmosis purification system will receive water from the rainwater catchment system and MBR blackwater treatment system. All feed water will be of tertiary treatment standards. Final product water will be void of contaminants and pathogens and will be suitable for potable consumption. The RO system utilizes high pressure pumps to convey water membranes to remove the impurities. As a part of this process, a RO reject stream of around 30% is necessary. This wastewater stream will be sent to a groundwater infiltration system.

Water Distribution
Dual plumbing will be required for supply water in the building. Non-potable water will be supplied to all toilets, urinals, mop sinks and trap primers. A separate potable water distribution system will supply all potable fixtures; showers, lavatories, kitchen sinks, etc. Because all waste water will be treated, there is no need for dual piping on the collection side.

Water Quality Testing
Water quality testing for recycled water treated to potable standards is anticipated per local health department requirements, and an estimated $40,000 per year has been included in the LCCA to account for this ongoing cost.

LEED Building
To achieve LEED v4 Platinum, the rainwater catchment and onsite wastewater treatment required for LBC is not necessary. The building potable water source can be supplied solely from the municipality and wastewater can discharge directly to the sanity and stormwater systems. Using water efficiently will decrease water use by approximately 33.5% as compared to a LEED baseline and achieve five LEED points.

It is noted that the LEED v4 Platinum design mirrors the developer project in paying an “in lieu of fee” for the Low-Impact Development City requirement. The requirement is to treat the first ¾” of rainfall that falls on the site. Should the project be designed to meet the City’s requirement, rather than pay the “in-lieu of fee”, the project would achieve three additional points under the Rainwater Management credit and change the costs from soft costs to hard costs.

4.3 ENERGY BACKGROUND

Climate change due to the use of power generated from burning fossil fuels is changing our economy, our health and our communities. The economic effects are globally important and locally visible.

California has been leading energy code policy since the introduction of the California Energy Code in 1977. Since that time, California energy consumption per capita has been generally flat, in contrast to consumption in the rest of the United States, which has steadily increased.

National electricity consumption grew at an annual rate of approximately 1.4 percent from 1990 to 2000 and 1.0 percent from 2000 to its peak in 2008. Consumption fell approximately 4.3 percent from 2008 to 2010, following the financial crisis, but has begun to grow again in recent years.

The future of energy efficiency policy was described in the first Energy Action Plan (EAP) that emerged in 2003 from a crisis atmosphere in California's energy markets. The state's three major energy policy agencies (the California Public Utilities Commission, the California Energy Commission, and the Consumer Power and Conservation Financing Authority [established under deregulation and now defunct]) came together to develop one high-level, coherent, approach to meeting California's electricity and natural gas needs.
In keeping with California's history of leading efficiency through legislation, AB 32, the California Global Warming Solutions Act, was passed by the state legislature and signed into law by Governor Schwarzenegger in 2006. AB 32 sets in place the nation's most comprehensive, economy-wide global warming pollution reduction program. AB 32 requires the state's global warming pollution to be reduced to 1990 levels by 2020. This reduction will be accomplished through an enforceable and declining statewide cap on global warming emissions that were phased in starting in 2012.

Policy development and agency technical assistance, such as the results of this study, can continue to support initiatives like AB 32 and the California Public Utilities Commission Long Term Energy Efficiency Strategic Plan.

4.4 ENERGY DESIGN PROFILE

As part of this study, the team modeled the energy associated with the prototype, LEED v4 Platinum and LBC design profiles. As described previously, to achieve full LBC, the project building must achieve all seven Petals, totaling 20 Imperatives. For LBC, the primary focus for energy is the requirement to be Net Zero Energy, with no onsite combustion. 100% of the building's energy needs, on a net annual basis, must be supplied by on-site renewable energy. The system may be grid-tied or off the grid. Note that no combustion is allowed for LBC, and 'green tags' or 'green power' purchases are not recognized compliance paths.

The energy design profile for LEED v4 Platinum, in this case, is accomplished via targeting the maximum achievable energy use reduction (and therefore points) in the Annual Energy Use credit.

Model Approach and Inputs

For both the LEED v4 Platinum and Net Zero Energy/LBC energy design profiles, the most cost-effective approach is to first reduce the loads, utilize passive systems and optimize the active systems. The table below details the architectural, electrical and mechanical systems that are modeled in the prototype and proposed design profiles. The proposed mechanical systems for the LEED v4 Platinum and LBC design profiles are identical as they are both optimized, as stated above, to reduce the loads, utilize passive systems and use optimized active systems. The details for these design elements are further described in the Costing Exercise section of this document below.

MODEL INPUTS COMPARISON	Prototype Building Design Natural Gas for Heating & DHW	LEED/LBCPrototype Building Design Heat Pump for Heating & DHW
Walls	High mass, U-0.125 for first floor Low mass, U-065 for upper floors	High mass, **U-0.06** for first floor Low mass, **U-0.047** for upper floors
Roof	U 0.031	**U 0.026**
Floor	Concete Slab U-0.27	Concete Slab U-0.27
Infiltration Rate	2 ACH	2 ACH for Retail | **0.5 for residential**
Glazing U-value	0.32	**0.28**
Glazing SHGC	0.25	0.25
Window-Wall Ratio (WWR	25%	25%
Electrical		
Interior Lighting Power Density (W/sf)	1.2 for retail | 0.5 for residential	**0.9 for retail** | 0.5 for residential
Receptacle Equipment	1.0 for retail | 0.5 for residential	1.0 for retail | 0.5 for residential
Mechanical		
Cooling System Type	DX	DX
Heating System Type	Boiler/Heating Hot Water	**Heat Pump (HP)**
Domestic Hot Water System Type	Boiler	**Heat Pump (HP)**
Ventilation / Exhaust	20 cfm / person	20 cfm / person
Cooling Equipment Efficiency	COP 3.39	**COP 4**
Heating Equipment Efficiency	Boiler Efficiency 0.85	**COP 3.5**
DHW Equipment Efficiency	Boiler Efficiency 0.85	**COP 2.5**

TABLE 4.1 - Energy Efficiency Measures

Energy Model Results

The prototype and proposed design profiles, with the specific input parameters above, were modeled utilizing an hourly energy simulation based on Energy Plus. The simulation used typical schedules and typical meteorological weather data.

The Energy Use Intensity (EUI) of each of the energy design profiles is:

- Prototype: 40 kBtu/SF-yr
- Proposed: 23 kBtu/SF-yr

The EUI represents the total energy consumption, per square foot, over an entire year. This is the energy consumption that must be offset by the renewable energy produced on the project site.

The graphs below (Figure 4.4)show the breakdown of this energy use by use and fuel type.

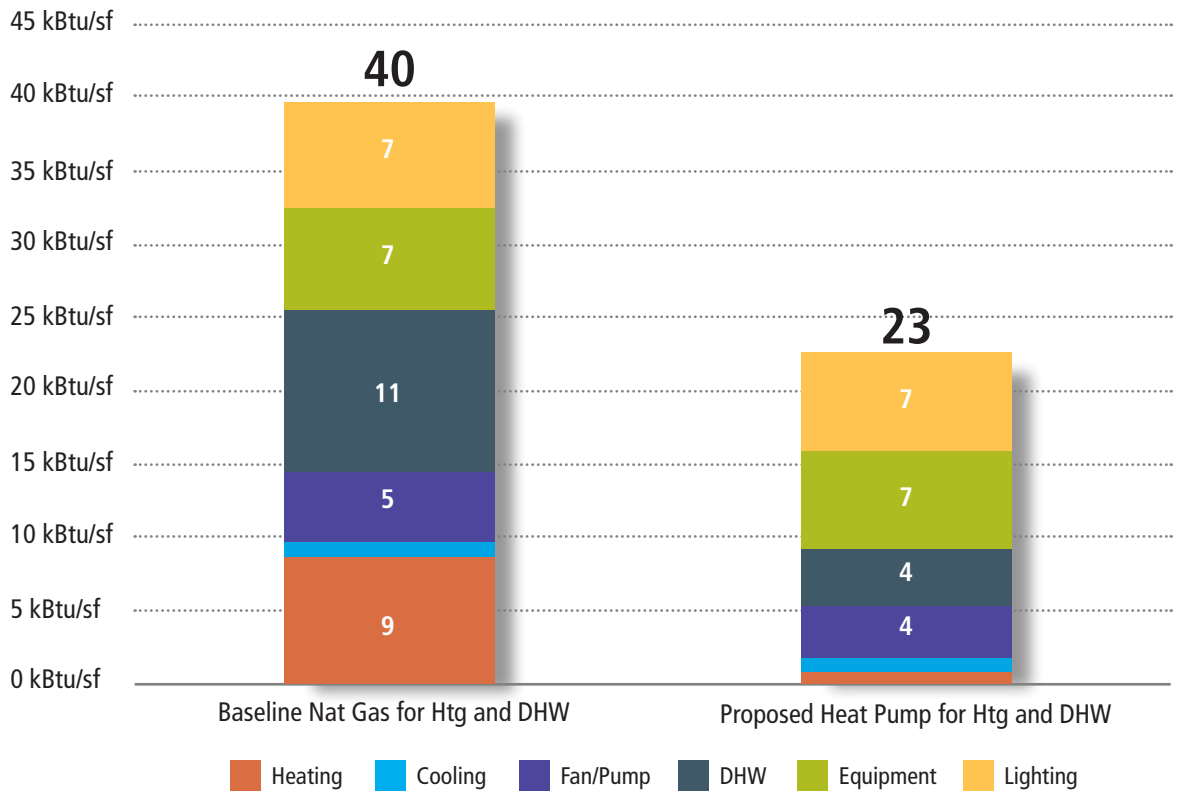


Figure 4.4 - EUI by End Use and Fuel Type

SANTA MONICA PROTOTYPE EUI - BOILER FOR HEATING

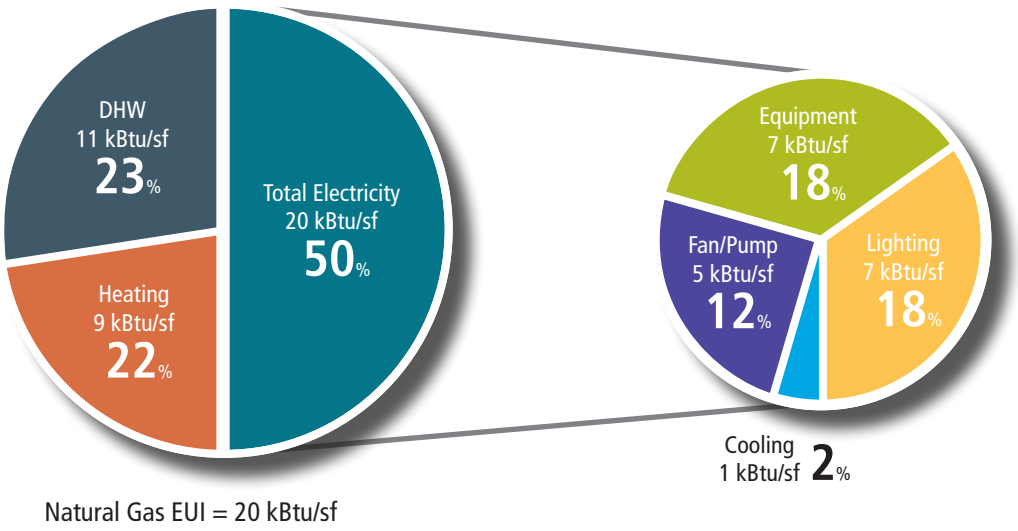


Figure 4.5 - Prototype Design Profile EUI

SANTA MONICA PROTOTYPE EUI - HEAT PUMP (HP) FOR HEATING

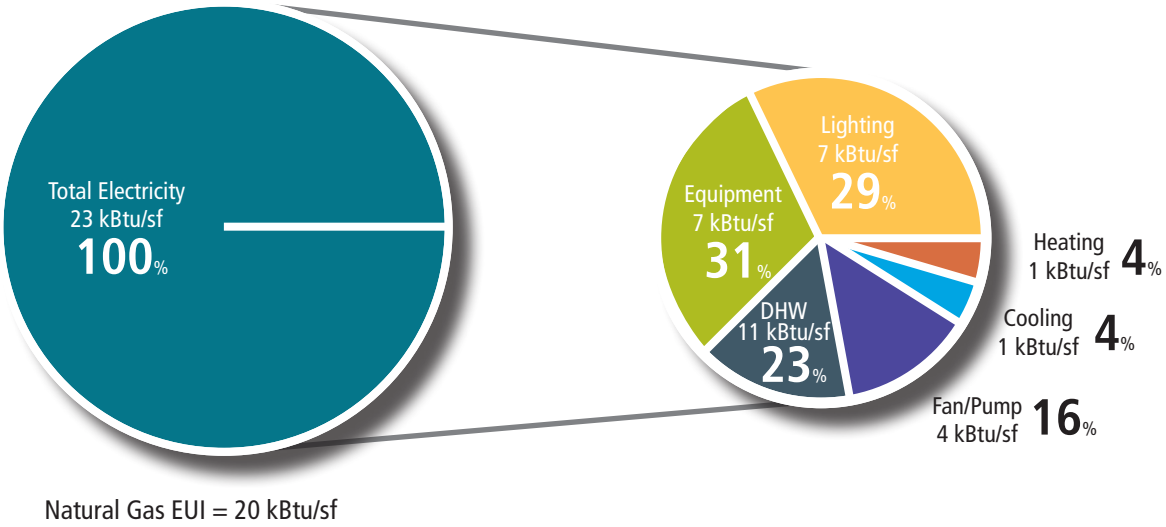


Figure 4.6 - Design Case Profile EUI

Renewable Energy

As described above, the balance of the energy consumption will be offset in whole or in part by renewable energy produced on the project site. In this case the renewable energy source is a roof-top, photovoltaic (PV), built up canopy.

The maximum size of the PV array is limited by the available roof or site footprint area. The 15,000 SF site footprint will provide area for an array of approximately 12,750 SF with an 85% area factor. The area factor provides for attachments, equipment, etc. The array will be built upon a canopy structure with a 10 degree south-facing tilt. With the above tilt at this location, the design realizes approximately 1400 kWh/kW of power generation for the installed array wattage.

The renewable energy production needed for the LBC, Zero Net Energy case is 326,692 kWh. This is based on the EUI of 23 kBtu/SF-yr with an addition 23,600 kWh for the energy associated with water treatment and pumping. The PV array to meet this annual production is 12,500 SF.

In the case of the design profile for LEED v4 Platinum, the PV array can be reduced from the size needed for the LBC, Zero Net Energy requirement. To achieve LEED v4 Platinum, there is a need to achieve the maximum amount of points under credit Annual Energy Use; this is a 60% annual energy use reduction and consequently the PV array is sized at 2,500 sf.

These factors are summarized in the table below:

PV Energy Needs		LEED	ZNE Offset	PV Area Available
Building Area	sf	44,963	44,963	44,963
Building Energy Density	kBtu/sf	3	23	
Building Energy Needs	kWh	63,134	326,692	
Panel Tilt	deg	10	10	10
PV Panel Efficiency	kWh/kW	1400	1400	1400
PV Area Needs	W/sf	18.63	18.63	18.63
Coverage Area	sf			15,000
Fraction of Total Area Available	%			85%
PV Panel Size (area)	sf	2,421	12,526	12,750
PV Panel Size (power)	kW	45.1	233.4	238

Table 4.2- PV Analysis

5 COST ANALYSIS

5.1 COST NARRATIVE

The price for the prototype project includes the direct construction costs for the fully built out development, as well as owner and development costs. In the case of the speculative ground floor retail, an allowance for tenant improvement is also included in the designs. The team estimated the cost and associated energy performance improvements from the following measures:

Energy Strategies

With the exception of the revised residential equipment, the energy strategies discussed below are utilized in both the LEED v4 Platinum and the LBC cost models.

Improved u-Value of Glazing Assemblies – The team increased the performance of the exterior doors and windows in both the residences and the retail spaces. The glazing u-value is reduced from 0.32 to 0.28. In most cases, this is achieved by switching to pultruded fiberglass systems such as Cascadia Windows.

Improved Insulation – The second main component of the improved envelope is to add rigid insulation at the spandrel panels and at the roof. The goal is to increase wall insulation to R-19 and roof insulation to R-38, assuming that the R-value of the insulation is R5.5/inch and that the wall and roof geometries are unchanged by this addition. This material is coordinated with Red List limitations.

Improved Lighting Performance – As part of the retail build-out allowance, it is assumed that there is one fixture per 80 sf installed in the prototype building. The team reduced lighting power density by upgrading the fixture types and implementing an IP-addressable ballast control system similar to enLighted luminaire-level lighting control system. The team assumes that all lighting is Commissioned, operated efficiently, turning off when occupants are not present or when sufficient daylight is available.

Improved Mechanical System – The system in the prototype design is split system heat pumps in each residential unit. This was revised to a central variable refrigerant flow system (VRF) with dedicated outside air. (DOAS). It is assumed that multiple units are paired to a condenser and that the basis of design is the Mitsubishi City/Multi or Daikin.

Revised Residential Equipment – Recognizing that the combustion of natural gas is prohibited under the LBC standard, the team replaced the gas range units with induction-based cook tops. The laundry systems are also replaced with condensing dryers. The natural gas system is completely eliminated, necessitating the removal of the exterior fire pits as well.

Renewable Energy Strategies

Photovoltaic Renewable Energy – The PV priced is a high-density panel generating at least 18.5wDC/sf. The array is assumed to be on the roof on a steel structure that would support the panels and racking. It is assumed that minimal structural upgrades to the roof would be required to account for the additional weight of the panels. The LEED v4 Platinum model includes enough PV to achieve the full points under Annual Energy Use. It is assumed that the full systems in both cases are eligible for federal incentives.

Water Strategies

A storm and rainwater retention system was added via tanks in the basement. Piping, pumps and grey water distribution (purple pipe) system have been added. The roof drains and downspouts have been re-routed into this tank. Condensate from the VRF condensers is routed into the nearest waste stack. The storm system maintains an emergency connection to the municipal system with an added flow meter to confirm zero discharge as required by LBC.

Low flow fixtures are already included in the prototype building design and cost, therefore there are no cost premiums associated for the LEED v4 Platinum and LBC v2.1 design profiles.

The grey and blackwater is treated by a membrane bio reactor that is sized for the building flows. The basis of design for this system is an Aquacell MBR. After leaving the MBR, the tertiary-level water is used for non-potable uses or treated to potable via a reverse osmosis (RO) system. The RO filter reject liquid is injected into drywells. That flow is assumed to be less than 1GPM average. The potable water system maintains a metered emergency connection to the municipal water supply. The LEED v4 Platinum model includes water conserving fixtures only and no rainwater or greywater filtration systems.

A sewer mining system is included and assumed to be a spur off of the street main flowing through a concrete vault and pumped into the MBR. Overflow is routed back into the street main. The sanitary system maintains an emergency connection to the municipal system with an added flow meter to confirm zero discharge as required by LBC.

Construction Markups

Typically, the fee and general conditions percentage drops as the project value rises. Those costs primarily based on project staffing and schedule. In this case, the percentages have been held the same to acknowledge the difficulty of managing an LBC project and one full-time project engineer position has been added to the team for a 12 month duration.

Living Building Challenge Imperatives

01 – Limits to Growth

The selected site met this imperative, therefore no costs were associated with this imperative.

02 – Urban Agriculture

The selected site met this imperative, therefore no costs were associated with this imperative, only water allocation.

03 – Habitat Exchange

Although the site is less than one acre, LBC requires a set aside of 1 acre minimum (0.4 hectares) It is priced using an industry standard $1/m2.

04 – Car Free Living

Costs for this imperative were assumed to have been meet by the prototype project.

05 – Net-Zero Water

See specific Scenarios described above.

06 – Ecological Water Flow

See specific Scenarios described above.

07 – Net-Zero Energy

See specific Scenario descriptions above.

08 – Civilized Environment

It was assumed that a cost-neutral combination of space planning, operable windows and open office tenant improvements would be used to achieve this imperative at no cost above the prototype.

09 – Healthy Air

Costs for this imperative were assumed to have been meet by the prototype project.

10 – Biophilia

No costs were added specifically for biophilia. The costs to create a building and site that meet this imperative are assumed to be captured in the premiums applied to the architecture and engineering fees.

11 – Red List

An added cost of 1.25% of direct construction cost was added to the base building to account for increased costs due to substitution of materials which did not meet the Red List or are not currently subject to exemption. A premium is added to address the environmentally preferred product requirements of LEED v4.

12 – Embodied Carbon Footprint

The project's construction carbon footprint was estimated using similar project typologies and sizes that have been run through the Tally Revit plug-in. $20 / ton was used as an offset cost based on the average pricing received from several high-quality offset providers including the Climate Trust. Carbon offsets were priced using reduction programs, not sequestration.

13 – Responsible Industry

At the time of this study, the costs to meet this imperative only include the provision of 100% FSC-certified wood on the project. Where the value of the wood products was known, a premium was applied to upgrade to certified wood. It was assumed that the LEED Platinum model would incorporate FSC in approximately half of the locations, exclusive of any temporary concrete forming materials.

14 – Appropriate Sourcing

For the purposes of this cost study, it was assumed that all products needed for the building could be obtained within the materials/service radius but that reduced competition would result in increased costs. Specific materials that pose procurement issues are aluminum windows and glazing, elevators, mechanical equipment, electrical switchgear and light fixtures. The team assumed that an 8% premium would be incurred on one third of the material purchases when selection is based on weight/distance in lieu of lowest cost. This resulted in an approximate 1.25% premium on the direct cost of work.

15 – Conservation and Reuse

Costs for this imperative were assumed to have been meet by the prototype project.

16 – Human Scale and Humane Places

Costs for this imperative were assumed to have been meet by the prototype project.

17 – Democracy and Social Justice

Costs for this imperative were assumed to have been meet by the prototype project.

18 – Rights to Nature

Costs for this imperative were assumed to have been meet by the prototype project.

19 – Beauty and Spirit

No costs were added specifically for beauty and spirit. The costs to create a building and site that meet this imperative are assumed to be captured in the premiums applied to the architecture and engineering fees.

20 – Inspiration and Education

A lump sum cost based on gross square footage was added to each building type for an instructional signage program to convey the sustainability message of the project.

Development Costs

The costs for development were adjusted to meet the unique demands of a LEED v4 Platinum or full LBC project. The percentage-based development costs were allowed to rise with the cost of work at a rate 2% greater than the traditional development costs. The effect is masked however by keeping the purchase price of the property fixed. The architecture and engineering fee percentages were increased nominally due to the extra effort required for the deep green design, including the specific items listed in the Imperative review above.
Incentives for energy, water or prescriptive ratings programs such as LEED have not been included in the cost estimate, except for the Savings by Design credit and federal PV incentives.

Conclusion

The overall cost premiums associated with the LEED v4 Platinum and LBC strategies were 4.4% and 17.9% respectively. Due to the conceptual nature of this study, the results are expressed in a +/-2.5% range, resulting in corresponding costs of 2% - 7% for LEED v4 Platinum and 15% - 20% for full LBC Certification, as compared against the typical building. It is worth noting that the seemingly high premium for LEED Platinum is for v4 for Midrise Multifamily, a project typology that has seen little cost analysis to date. It has been shown in other studies that v4 has been adding several percentage points to the same level certification, so the result of this study appear to align with that conclusion.

The relatively high demand on water for domestic uses combined with the low annual rainfall made the water strategies the most expensive component of the LBC design. Typically, that honor falls to the PV system. However, the reduction strategies coupled with the falling price of PV panels along with available incentives made getting to net zero not only technically possible but no longer the primary cost driver for LBC.

BUILDING TYPE: **MULTI-FAMILY RESIDENTIAL**
BUILDING LOCATION: **Santa Monica, CA**

SKANSKA

Multi-Family Residential Building
August 14, 2015

Base Building Gross SF = 72,478
Building Area without Garage = 45,184
Site Gross Acreage = 0.34

	Quantities		Unit Cost	Prototype Building		LEED™ v4 Platinum		Living Building v2.1	
				Total	Cost/SF	Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST									
Baseline Building (Direct Cost of Work)				**$14,763,569**	**$203.70**	**$14,763,569**	**$203.70**	**$14,763,569**	**$203.70**
Baseline Building				$14,416,709	$198.91	$14,416,709	$198.91	$14,416,709	$198.91
Retail Buildout Allowance				$346,860	$4.79	$346,860	$4.79	$346,860	$4.79
ENERGY STRATEGIES									
Improved u-value of glazing assemblies			**Unit Cost**	**$0**	**$0.00**	**$122,713**	**$1.69**	**$122,713**	**$1.69**
Upgrade from Aluminum to Fiberglass - Window Units	1,340	sf	$1.25			$1,675	$0.02	$1,675	$0.02
Upgrade High Performance Glazed System - Residence Storefron	7,507	sf	$14.00			$105,098	$1.45	$105,098	$1.45
Upgrade High Performance Glazed System - Retail Spaces	860	sf	$14.00			$12,040	$0.17	$12,040	$0.17
Upgrade High Performance Glazed System - Retail Doors	6	ea	$650			$3,900	$0.05	$3,900	$0.05
Improved insulation			**Unit Cost**	**$0**	**$0.00**	**$74,933**	**$1.03**	**$74,933**	**$1.03**
R-11 to R-19 at exterior walls	38,579	sf	$1.75			$67,513	$0.93	$67,513	$0.93
R-30 to R-38 at roof	14,840	sf	$0.50			$7,420	$0.10	$7,420	$0.10
Lighting Upgrade			**Unit Cost**	**$0**	**$0.00**	**$9,720**	**$0.13**	**$9,720**	**$0.13**
Reduce LPD from 1.2 to .9 (retail only)	72	fixtures	$135			$9,720	$0.13	$9,720	$0.13
Improved mechanical system			**Unit Cost**	**$0**	**$0.00**	**$567,613**	**$7.83**	**$567,613**	**$7.83**
Replace split system with VRF+DOAS system	1	ls	$567,613			$567,613	$7.83	$567,613	$7.83
Revised residential equipment			**Unit Cost**	**$0**	**$0.00**	**$0**	**$0.00**	**$132,999**	**$1.84**
Replace range units with induction based system	53	ea	$1,925					$102,025	$1.41
Replace dryer systems with condensing dryers	53	ea	$1,158					$61,374	$0.85
Remove NG firepits	-1	ls	$10,300					($10,300)	($0.14)
Credit: natural gas piping systems	-1	ls	$20,100					($20,100)	($0.28)
WATER STRATEGIES									
Water treatement system			**Unit Cost**	**$53,515**	**$0.74**	**$0**	**$0.00**	**$1,306,823**	**$26.20**
Rainwater capture, storage and distribution system	1	ls	$262,780					$262,780	$3.63
Stormwater LID "in-lieu-of" fee	1	ls	$53,515	$53,515	$0.74			($53,515)	($0.74)
Reverse-osmosis potable water system and drywell discharge	1	ls	$339,852					$339,852	$7.52
Membrane BioReactor for gray and blackwater treatement	1	ls	$640,911					$640,911	$14.18
Sewer mining system	1	ls	$116,795					$116,795	$1.61
RENEWABLE ENERGY STRATEGIES									
Monocrystalline Photovoltaic Panels			**Unit Cost**	**$0**	**$0.00**	**$190,000**	**$2.62**	**$950,000**	**$13.11**
Rooftop PV array- LEED	2,500	sf	$76			$190,000	$2.62	$190,000	$2.62
Rooftop PV array- Net Zero	10,000	sf	$76					$760,000	$10.49
HEALTHY MATERIALS STRATEGIES									
LBC and LEED Materials			**Unit Cost**	**$0**	**$0.00**	**$144,950**	**$2.00**	**$469,152**	**$6.47**
Red List								$152,475	$2.10
Responsible Industry						$89,826	$1.24	$179,652	$2.48
Appropriate Sourcing								$137,025	$1.89
LEED Environmentally preferred products						$55,124	$0.76		
Subtotal Direct Costs				$14,817,084	$204.44	$15,873,498	$219.01	$18,397,522	$262.01
General Conditions, General Requirements, Fee, Contingency, Insurance, Bonding				$3,600,000	$49.67	$3,716,206	$51.27	$4,322,709	$59.64
TOTAL MODIFIED CONSTRUCTION COST				**$18,417,084**	**$254.11**	**$19,589,704**	**$270.28**	**$22,720,232**	**$321.65**

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BUILDING LOCATION: **Santa Monica, CA**

SKANSKA

Multi-Family Residential Building
August 14, 2015

Base Building Gross SF = 72,478
Building Area without Garage = 45,184
Site Gross Acreage = 0.34

	Quantities		Unit Cost	Prototype Building		LEED™ v4 Platinum		Living Building v2.1	
				Total	Cost/SF	Total	Cost/SF	Total	Cost/SF
OWNER & DEVELOPMENT COSTS									
Living Building Challenge Imperatives									
Habitat Exchange	1.00	acre minimum						$4,046	$0.06
Embodied Carbon Footprint	5,000	tons						$100,000	$1.38
Inspiration and Education								$20,333	$0.28
Development Costs	LEED	LBC							
Development Costs	34.07%	31.33%		$10,183,417	$140.50	$10,417,941	$143.74	$11,044,046	$152.38
Architecture & Engineering	7.00%	7.92%		$1,289,550	$17.79	$1,412,550	$19.49	$1,798,515	$24.81
Credits / Rebates / Incentives									
Savings By Design Credit						($150,000.00)	($2.07)	($150,000)	($2.07)
Federal PV Credits	30%	of PV array costs				($57,000)	($0.79)	($285,000)	($3.93)
TOTAL OWNER & DEVELOPMENT COSTS				**$11,472,967**	**$158.30**	**$ 11,623,491**	**$160.37**	**$12,531,940**	**$172.91**
TOTAL CONCEPTUAL FIRST COST:				**$29,890,051**	**$412.40**	**$31,213,195**	**$430.66**	**$35,252,172**	**$486.38**
Multi-Family Residential Building CONCEPTUAL PREMIUM RANGE:						**2% TO 7%**		**15% TO 20%**	

6 LIFE CYCLE COST ANALYSIS

6.1 NARRATIVE

LCCA takes into consideration cost deltas between the prototype and performance designs in terms of construction costs (including materials), annual utility costs, and annual repair and maintenance (R&M) costs, over a span of 30 years.

Utility Costs include annual grid electricity and annual municipal water costs. The water cost also includes sewer discharge costs or savings. Sewer discharge is calculated based on the rates listed by the Santa Monica Public Utility Works website for multi-family residential.

Additional variables in the LCCA include a capital discount rate of 11%, an electricity escalation rate of 5%, and a water escalation rate of 10%. Theses variable are subject to market and environmental conditions and can dramatically alter LCCA results.

As compared to the prototype code-compliant design, the LEED v4 Platinum building adds first costs primarily for renewable energy systems, and for efficient building envelope and materials. Energy costs are cut in half, and water costs are reduced by one third, while R&M costs increase only by about $1,500 per year. The simple payback (not including cost of money, etc.) is 17 years.
The first costs are higher for the LBC building, with higher annual R&M costs as well, primarily due to rainwater catchment and MBR treatment systems, with some additional costs for enlarging the PV system. There are no water and electricity utility costs, and an annual savings on sewer discharge due to black water and grey water recycling. However, these savings are not enough to offset the maintenance costs for the systems. Payback for the LBC building is 29 years.

6

BACKGROUND INFORMATION

The Baseline price for the projects includes the direct construction costs for the fully built out development. In the case of the speculative ground floor retail, an allowance for tenant improvement was also included in the baseline.

LEEDv4 Platinum Building costs include additional strategies needed to meet the requirements. This includes: improved building envelope, improved mechanical systems, improved lighting systems, Photovoltaic system, and efficient water fixtures.

Living Building Challenge costs include additional strategies needed to meet the requirements. This includes: improved building envelope, improved mechanical systems, improved lighting systems, Photovoltaic system, efficient water fixtures, MBR treatment system, Rainwater treatment system, RO Treatment system, Red List materials, embodied carbon offset.

ALTERNATIVES

Baseline

LEEDv4 Platinum

Living Building Challenge

FIRST COST SUMMARY

	First Costs	Costs / SF
Baseline	$0	$0
LEED	$1,323,144	$26.46
LBC	$5,362,121	$107.24

UTILITY COSTS

Energy performance and Water use summary in the table below

	Grid Electricity (kwhr / yr)	Grid Electricity ($ / yr)	Municipal Water (gal / yr)	Municipal Water ($ / yr)
Baseline	506,415	$65,834	$2,240,927	$39,542
LEED	263,558	$34,263	$1,490,498	$26,300
LBC	0	$0	0	($8,765)

Electricity Cost: $0.13/kWh
Water Cost: $8.80/HCF($0.012/gal) + Sewer Discharge

REPAIRS AND MAINTENANCE COSTS

R & M cost summary in the table below

	Annual R& M Costs
Baseline	$0
LEED	$1,488
LBC	$133,496

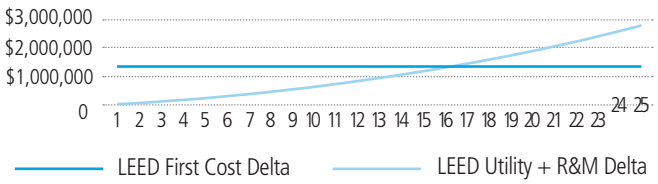
LIFE CYCLE COST REPORTING OF OPTIONS

Capital discount rate	11%
Electrical escallation rate	5%
Water escallation rate	10%
R & M escallation rate	3%
Study Life (years)	30

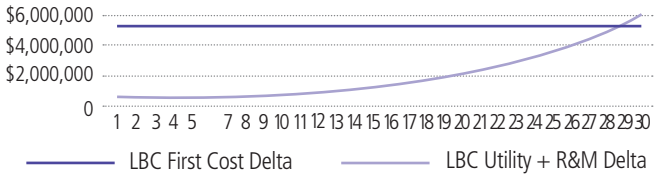
Net Present Value of Options

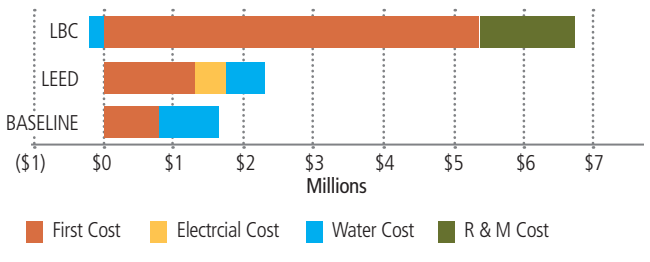
Baseline	$1.830,226
LEED	$2,428,314
LBC	$6,645,505

LEED Simple Payback



LBC Simple Payback





7 APPENDIX

Exhibit A – LEED v4 for Homes Multifamily Midrise Checklist - Prototype Design
Exhibit B – LEED v4 for Homes Multifamily Midrise Checklist - LEED v4 Platinum Design
Exhibit C – LBC Checklist

Exhibit A - LEED v4 for Homes Multifamily Midrise Checklist - Prototype Design

Project Name: Santa Monica Typical Mid-Rise Multifamily Mixed Use Building

Y	?	N			
	2		Credit	Integrative Process	2
14	1	15	**Location and Transportation**		15
Y			Prereq	Floodplain Avoidance	Required
			PERFORMANCE PATH		
		15	Credit	LEED for Neighborhood Development Location	15
			PERSCRIPTIVE PATH		
7	1		Credit	Site Selection	8
3			Credit	Compact Development	3
2			Credit	Community Resources	2
2			Credit	Access to Transit	2
4	3	0	**Sustainable Sites**		7
Y			Prereq	Construction Activity Pollution Prevention	Required
Y			Prereq	No Invasive Plants	Required
2			Credit	Heat Island Reduction	2
	3		Credit	Rainwater Management	3
2			Credit	Non-Toxic Pest Control	2
6	6	0	**Water Efficiency**		12
Y			Prereq	Water Metering	Required
			PERFORMANCE PATH		
6	6		Credit	Total Water Used	12
			PERSCRIPTIVE PATH		
		0	Credit	Indoor Water Use	6
		0	Credit	Outdoor Water Use	4
17	20	0	**Energy and Atmosphere**		37
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Energy Metering	Required
Y			Prereq	Education of Homeowner, Tenant or Bldg Manager	Required
15	15		Credit	Annual Energy Use	30
2	3		Credit	Efficient Hot Water Distribution	5
	2		Credit	Advanced Utility Tracking	2
4	3	0	**Material and Resources**		9
Y			Prereq	Certified Tropical Wood	Required
Y			Prereq	Durability Management	Required
	1		Credit	Durability Management Verification	1
	5		Credit	Environmentally Preferable Products	5
2	1		Credit	Construction Waste Management	3
5	13	0	**Indoor Environmental Quality**		18
Y			Prereq	Ventilation	Required
Y			Prereq	Combution Venting	Required
Y			Prereq	Garage Pollution Protection	Required
Y			Prereq	Radon-Resistant Construction	Required
Y			Prereq	Air Filtering	Required
Y			Prereq	Enivronmental Tobacco Smoke	Required
Y			Prereq	Compartmentalization	Required
1	2		Credit	Enhanced Ventilation	3
	2		Credit	Contamination Control	2
	3		Credit	Balancing of Heating & Cooling Systems	3
	3		Credit	Enhanced Compartmentalization	3
	2		Credit	Enhanced Combustion Venting	2
	1		Credit	Enhanced Garage Pollutant Protection	1
3			Credit	Low Emitting Products	3
1			Credit	No Environmental Tobacco Smoke	1
4	2	0	**Innovation**		6
Y			Prereq	Preliminary Rating	Required
3	2		Credit	Innovation	5
1			Credit	LEED AP Home	1
3	1	0	**Regional Priority for 90401**		4
1			Credit	Regional Priority: Access to Transit	1
1			Credit	Regional Priority: Compact Development	1
1			Credit	Regional Priority: Community Resources	1
	1		Credit	Regional Priority: Annual Energy or Total Enegy Use	1

55	55	15	**TOTALS**	Possible Points: 110

Certified: 40 to 49 points, Silver: 50 to 59 Points, Gold: 60 to79 Points, Platinum: 80 to110

Exhibit B - LEED v4 for Homes Multifamily Midrise Checklist - LEED v4 Platinum Design

Project Name: Santa MonicaHigh Performance Building Cost Effectiveness Study

Y	?	N			
2			Credit	Integrative Process	2
14	1	15	**Location and Transportation**		15
Y			Prereq	Floodplain Avoidance	Required
			PERFORMANCE PATH		
		15	Credit	LEED for Neighborhood Development Location	15
			PERSCRIPTIVE PATH		
7	1		Credit	Site Selection	8
3			Credit	Compact Development	3
2			Credit	Community Resources	2
2			Credit	Access to Transit	2
4	3	0	**Sustainable Sites**		7
Y			Prereq	Construction Activity Pollution Prevention	Required
Y			Prereq	No Invasive Plants	Required
2			Credit	Heat Island Reduction	2
	3		Credit	Rainwater Management	3
2			Credit	Non-Toxic Pest Control	2
5	5	2	**Water Efficiency**		12
Y			Prereq	Water Metering	Required
			PERFORMANCE PATH		
5	5	2	Credit	Total Water Used	12
			PERSCRIPTIVE PATH		
		0	Credit	Indoor Water Use	6
		0	Credit	Outdoor Water Use	4
33	20	0	**Energy and Atmosphere**		37
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Energy Metering	Required
Y			Prereq	Education of Homeowner, Tenant or Bldg Manager	Required
30			Credit	Annual Energy Use	30
2	3		Credit	Efficient Hot Water Distribution	5
1	1		Credit	Advanced Utility Tracking	2
5	4	0	**Material and Resources**		9
Y			Prereq	Certified Tropical Wood	Required
Y			Prereq	Durability Management	Required
1			Credit	Durability Management Verification	1
2	3		Credit	Environmentally Preferable Products	5
2	1		Credit	Construction Waste Management	3
12	6	0	**Indoor Environmental Quality**		18
Y			Prereq	Ventilation	Required
Y			Prereq	Combution Venting	Required
Y			Prereq	Garage Pollution Protection	Required
Y			Prereq	Radon-Resistant Construction	Required
Y			Prereq	Air Filtering	Required
Y			Prereq	Enivronmental Tobacco Smoke	Required
Y			Prereq	Compartmentalization	Required
1	2		Credit	Enhanced Ventilation	3
2			Credit	Contamination Control	2
2	1		Credit	Balancing of Heating & Cooling Systems	3
	3		Credit	Enhanced Compartmentalization	3
2			Credit	Enhanced Combustion Venting	2
1			Credit	Enhanced Garage Pollutant Protection	1
3			Credit	Low Emitting Products	3
1			Credit	No Environmental Tobacco Smoke	1
6	0	0	**Innovation**		6
Y			Prereq	Preliminary Rating	Required
5			Credit	Innovation	5
1			Credit	LEED AP Home	1
4	0	0	**Regional Priority for 90401**		4
1			Credit	Regional Priority: Access to Transit	1
1			Credit	Regional Priority: Compact Development	1
1			Credit	Regional Priority: Community Resources	1
1			Credit	Regional Priority: Annual Energy or Total Enegy Use	1

85	30	17	**TOTALS**	Possible Points: 110

Certified: 40 to 49 points, Silver: 50 to 59 Points, Gold: 60 to79 Points, Platinum: 80 to110

Exhibit C - Living Building Challenge v2.1 Checklist

Santa Monica High Performance Buildings Case Study | Typology: Building | Living Transect: L4. General Urban Zone

	Building	Building	
Site Petal	Scale Jumping Allowance	Required Imperatives	**Criteria**
01 | Limits to Growth	n/a	Y	Projects may only be built on greyfields or brownfields, previously developed sites that are not classified as on or adjacent to any of the specific sensitive ecological habitats.
02 | Urban Agriculture	Y	Y	The project must integrate opportunities for agriculture appropriate to the scale and density using the Floor Area Ratio (FAR) as a basis for calculation.With a FAR of 0.98, a minimum 20% of the site area must be dedicated to urban agriculture.
03 | Habitat Exchange	Y	Y	For each hectare of development, an equal amount of land away from the project must be set aside in perpetuity through the Living Future Habitat Exchange Program or an approved Land Trust organization.
04 | Car Free Living	n/a	Y	The project should contribute towards the creation of walkable, pedestrian-oriented communities. Support a car free lifestyle based on the density & the ratio of residential, commercial & light industrial within a defined catchment area. Maximum percentage of any single occupancy type within a catchment area is 60% for L4.
Water Petal	Scale Jumping Allowance	Required Imperatives	**Criteria**
05 | Net Zero Water	n/a	Y	One hundred percent of the project's water needs must be supplied by captured precipitation or other natural closed loop water systems, and/or by re-cycling used project water, and must be purified as needed without the use of chemicals.
06 | Ecological Water Flow	Y	Y	One hundred percent of storm water and used project water discharge must be managed onsite to feed the project's internal water demands or released into adjacent sites for management through acceptable natural time-scale surface flow, groundwater recharge, agricultural use or adjacent property needs.
Energy Petal	Scale Jumping Allowance	Required Imperatives	**Criteria**
07 | Net Zero Energy	Y	Y	One hundred percent of the project's energy needs must be supplied by on-site renewable energy on a net annual basis.
Health Petal	Scale Jumping Allowance	Required Imperatives	**Criteria**
08 | Civilized Environment	n/a	Y	Every occupiable interior space of the project must have operable windows that provide access to fresh air and daylight.
09 | Healthy Air	Y	Y	Entryways must have dirt track-in systems, separate ventilation and exhaust for appropriate spacess, ventilation rates must meet ASHRAE 62 and must monitor CO2, temperature, and humidity. Air quality testing required at pre-occupancy and nine months post-occupancy.
10 | Biophilia	n/a	Y	The project must be designed to include elements that nurture the innate human/ nature connection. Each of the six established Biophilic Design Elements must be represented for every 2,000 m2 of the project.

Exhibit B - Living Building Challenge v2.1 Checklist

Santa Monica High Performance Buildings Case Study | Typology: Building | Living Transect: L4. General Urban Zone

Site Petal	Scale Jumping Allowance	Required Imperatives	Criteria
11 | Red List	n/a	Y	The project cannot contain any Red List materials or chemicals.
12 | Embodied Carbon Footprint	Y	Y	The project must account for the total footprint of embodied carbon (tCO2e) from its construction through a one-time carbon offset tied to the project boundary.
13 | Responsible Industry	n/a	Y	The project must advocate for the creation and adoption of third-party certified standardsfor sustainable resource extraction and fair labor practices. Applicable raw materials include stone and rock, metal, minerals, and timber. All wood must be FSC.
14 | Appropriate Sourcing	n/a	Y	The project must incorporate place-based solutions and contribute to the expansion of a regional economy rooted in sustainable practices, products and services.
15 | Conservation + Reuse	n/a	Y	The project team must strive to reduce or eliminate the production of waste during design, construction, operation and end of life in order to conserve natural resources. Diversion during construction must be 80%-100% dependent upon the material.

Water Petal	Scale Jumping Allowance	Required Imperatives	Criteria
16 | Human Scale + Humane Places	n/a	Y	The project must be designed to create human-scaled rather than automobile-scaled places so that the experience brings out the best in humanity and promotes cultural interaction. Specific design guidelines for paved areas, street and block design, building scale and signage that contribute to livable places.
17 | Democracy + Social Justice	n/a	Y	All primary transportation, roads, non-buiding infrastructure that are considered externally focused must be equally accessible to the public.
18 | Rights to Nature	n/a	Y	The project shall provide access to, and will not diminish the quality of, fresh air, sunlight and natural waterways for any member of society. The project must also appropriately address any noise audible to the public.

Water Petal	Scale Jumping Allowance	Required Imperatives	Criteria
19 | Beauty + Spirit	n/a	Y	The project must contain design features intended solely for human delight and the celebration of culture, sipirit and place appropriate to its function.
20 | Inspiration + Education	n/a	Y	Educational materials about the operation and performance must be provided to the public to share successful solutions and to motivate others to make change.

8 GLOSSARY

Blackwater is wastewater from toilets and urinals. Wastewater from kitchen sinks (perhaps differentiated by the use of a garbage disposal), showers, or bathtubs is considered blackwater under some state or local codes.

Greywater is defined by the Uniform Plumbing Code (UPC) in its Appendix G, greywater Systems for Single Family Dwellings, as untreated household waste water which has not come into contact with toilet waste. Greywater includes used water from bathtubs, showers, bathroom wash basins, and water from clothes-washer and laundry tubs. It must not include waste water from kitchen sinks or dishwashers.

Leadership in Energy and Environmental Design (LEED) is a set of rating systems developed by the U.S. Green Building Council (USGBC) for the design, construction, operation, and maintenance of green buildings, homes, and neighborhoods. http://www.usgbc.org/leed

Life Cycle Cost Analysis (LCCA) is an accounting methodology used to evaluate the economic performance of a product or system over its useful life. It considers operating costs, maintenance expenses, and other economic factors.

Living Building Challenge (LBC) is an international sustainable building certification program created in 2006 by the non-profit International Living Future Institute. It is described by the Institute as a philosophy, advocacy tool and certification program that promotes the most advanced measurement of sustainability in the built environment. http://living-future.org/lbc

Net present value (NPV) is defined as the sum of the present values (PVs) of incoming and outgoing cash flows over a period of time. Incoming and outgoing cash flows can also be described as benefit and cost cash flows, respectively.

Net Zero Energy (NZE) is a building with zero net energy consumption, meaning the total amount of energy used by the building on an annual basis is roughly equal to the amount of renewable energy created on the site.

Net Zero Water is a standard that sets out to close the loop of a building's water consumption. In order to achieve this goal, rainwater that falls on-site is collected and stored, and all wastewater produced by the building or its occupants is treated and re-used. Rainwater is the primary source of freshwater in many regions of the world and is the easiest to treat. Filtration followed by ultra violet sterilization can make rainwater potable.

Non Potable water is water that has not been examined, properly treated, and is not approved by appropriate authorities as being safe for consumption.

Potable water meets or exceeds EPA's drinking water quality standards and is approved for human consumption by the state or local authorities having jurisdiction; it may be supplied from wells, municipal water systems, or onsite water treatment.

Red List is ILFI's list of items that have been identified to be phased out of production due to health/toxicity concerns.

Renewable energy is defined as passive solar, photovoltaics, solar thermal, wind turbines, water-powered micro-turbines, direct geothermal or fuel cells powered by hydrogen generated from renewably powered electrolysis – nuclear energy is not an acceptable option.