LIVING

BUILDING FINANCIAL STUDY

THROUGH A CLEAR LENS

nbi new buildings institute

SKANSKA

INTERFACE ENGINEERING

SERA

Gerding Edlen DEVELOPMENT

INDEX:

CONTRIBUTORS

Cascadia Region Green Building Council

Jason McLennan, Eden Brukman and Brandon Smith

SERA Architects

Clark Brockman, Lisa Petterson, Kate Turpin, John Echlin, Matthew Schuler, Logan Cravens, Ethan Timm and Gauri Rajbaidya

Skanska USA Building

Beth Heider, Steve Clem, Mark Jones, Bob McGinnis and Dave Jackman

Gerding Edlen Development

Dennis Wilde, Renee Loveland and Christina Skellenger

Interface Engineers

Omid Nabipoor, Andy Frichtl, Jon Gray and Dennis Kangas

New Buildings Institute

Mark Frankel

INTRODUCTION

The **Living Building Financial Study** documents the anticipated cost differential between a set of nine reference LEED Gold buildings and those same nine buildings conceptually designed to meet the Living Building Challenge in four separate climate cities. The study summarizes the cost premium range and expected payback for each building type in each climate city. It is comprised of four parts: the **Cost Comparison Matrix**, an **Executive Summary**, the **Study Report** and an **Appendix.** The report is organized to allow the reader to navigate through the study with links (indicated in colored text) to the various sections for easy review and comparison.

The information contained in the report is graphically summarized in the Living Building Financial Study: **Cost Comparison Matrix.** Similar to the Packard Study, the matrix format was selected to allow for easy comparison of the key variables studied. The matrix is organized with the climate cities on the X axis and building types on the Y axis. Each cell of the matrix represents the characteristics of the specific Living Building Modification. Each cell contains information about the building's layout, form, energy use, water use, photovoltaic array size, cost per square foot, percent increase over the base building (as modified for the climate city), and anticipated payback period. The reverse side of the matrix provides greater detail about each variable and summarizes the methodology of the study.

The Living Building Financial **Study Report** illustrates the assumptions and calculations made for each building type in each climate city and documents the process the study team undertook to arrive at the projected incremental cost. The Living Building Financial **Study Report** is divided into five sections:

1. Study Methodology and Process:

This section describes the process used by the study team to analyze the nine different building types in each of the four climate cities. Included in this section are subsections which describe the process of selecting each reference building and climate city and a detailed description of the methodology undertaken by each of the four study subgroups (design, energy, water, and cost estimating). This section also includes a Reference Building subsection, which consists of a one page comparison of the characteristics of the nine reference buildings used in the study.

2. Key FIndings Description:

This section elaborates on the Key FIndings presented in the executive summary with concrete results and descriptions

3. Living Building Modifications:

This section includes information about each of the 36 Living Buildings conceptually redesigned for the study. The Living Building Summary Descriptions are organized by climate city, with each description including a one page summary of the design modifications undertaken with selected illustrations, an energy worksheet which estimates the energy savings for each energy conservation strategy employed and calculates the amount of PV necessary for each building to achieve Net Zero Energy and a comparison cost model between the base building and the reference LEED building, as adjusted, for the climate study.

4. Living Building Strategy Descriptions:

This section describes all of the strategies employed in each of the 36 Living Buildings. The strategies are numbered for easy reference to the Living Building modifications.

5. Prerequiste Summary:

This section summaries the approach to each of the sixteen Living Building prerequisites.

Appendix:

This section contains a glossary defining the terms used in the study and a set of Comparison Summaries that allows for detailed comparison of the variety of characteristics studied by the team. It also includes detailed information comparing the characteristics of the reference buildings, a water usage summary comparison, an energy summary comparison, and a comparison of the reference building's LEED point total. An outline of the Living Building Challenge Prerequisites is also included for reference. Detailed information about the Living Building Challenge is available at http://www.cascadiagbc.org/resources/living-buildings.

The report is accompanied by an **Executive Summary** which provides an introduction to the rationale for the study and summarizes its key findings and a set of key finding diagrams which illustrate those concepts.

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STUDY PROCESS AND METHODOLOGY

This section of the report outlines the process and methodology used for the study – discussing the work of each subgroup and how each subgroup built on each other's work to arrive at the cost conclusions presented in the cost summary matrix and the key findings. Although the information is presented in a linear fashion; the reader should note that the work was highly collaborative and iterative, utilizing an integrated design process for the entire study effort.

Selection of Building Types and Base Buildings

(click on each building type for more detailed information on the reference building)

Cascadia identified nine distinct building types (see below) to be investigated in four climate zones:, Cool, Temperate, Hot Humid and Hot Arid:

- Single Family Residential
- Multi-Family Residential
- High Rise Mixed Use (including residential)
- Low Rise Office Building
- Mid Rise Office Builidng
- Mixed Use Renovation (including office)
- Elementary School
- University Classroom (non – lab)
- Hospital

One of the first tasks of the team was a brainstorming session where the building types and climate zones were reviewed and evaluated. The study deliberately selected different buildings types that are roughly the same scale – in the range of 140,000 to 160,000 sf to facilitate easy comparison of the effect of building type on similar sized projects. For residential and office projects – three different scales were selected to illustrate the effects of building size on cost premium.

Four cities, each of them known for demonstrating advanced green building practice, were selected to represent a range of climates. An additional criterion – the availability of good cost data – was also a factor in the choice of cities within each region.

The study required identification of actual reference projects for the group to use in evaluation of whole building systems. LEED Gold was chosen as a metric for the reference buildings in order to establish a reasonable base sustainability threshold for the projects before they were redesigned to meet the Living Building Challenge. LEED Gold was selected as the baseline reference for a typically green building, based on the Davis Langdon study "The Costs of Green Revisited" where they found there was no significant difference in the average cost of green buildings compared to non-green buildings.

Three factors were of primary importance when selecting the reference buildings to be used in the study.

1. **Availability of cost data:** The availability of cost information, in sufficient detail to be able to estimate the cost of all design modifications, including addition and subtraction of the various features of the Living Building Challenge, was critical to the outcome of the study.
2. **Project's LEED status:** To minimize the number of variables which affect the cost differential, the team endeavored to select buildings which started with similar green building goals, as represented by the buildings LEED status. LEED gold was selected as a baseline for the project as the highest level of green building performance commonly available without a significant cost increase. Two buildings studied in the project were targeted as LEED Platinum. For these projects, the most costly points were subtracted from the cost estimate to create a base building estimate that represents a LEED Gold building.
3. **Project location:** To minimize the number of factors affecting the cost estimate baseline, all but one of the buildings selected were located in the Portland metro area, assisting in the process of normalizing the baseline cost models. The single exception to this was the OSU Kelly Engineering building, which is located 80 miles away in Corvallis, Oregon and thus would have very similar construction economics. All of the selected projects were assumed to be in compliance with the first two Living Building Challenge prerequisites – prerequisite 1) Responsible Site Selection and prerequisite 2) Limits to Growth, since these pre-requisites in themselves do not carry cost implications.

Study Reference Buildings

The following reference buildings were used for the study. Documentation, in the form of Construction Documents, was received from the respective design teams and was used to analyze the base building's characteristics. Site plans, floor plans, sections, and wall sections were the primary reference drawings culled for use in the study. In addition, the base building cost estimate for each building was also reviewed. See the Appendix for more detailed information on each building type.

UNIVERSITY CLASSROOM

Oregon State University Kelley Engineering Center

Project Team:
Architect: Yost Grube Hall Architecture
Contractor: Skanska USA Building, Inc.
Developer: Oregon State University
MEP Engineer: GLUMAC International

Location: Corvallis, OR
Size: 153,000 sf
LEED Score: 41 (NC)
Date Completed: 2005

SCHOOL K-8

Sherwood Elementary & Middle School

Project Team:
Architect: Dull Olson Weekes Architects, Inc.
Contractor: Skanska USA Building, Inc.
Developer: Sherwood School District
MEP Engineer: MFIA Inc. Consulting Engineers

Location: Sherwood, OR
Size: 141,000 sf
LEED Score: 47 (NC)
Date Completed: 2009

LOW RISE OFFICE

Cascade Station Corporate Center II

Project Team
Architect: Fletcher Farr Ayotte, Inc.
Contractor: Skanska USA Building, Inc.
Developer: Trammell Crow Company
MEP Engineer: PMC Mechanical; The Stoner Electric Group

Location: Portland, OR
Size: 35,000 sf
LEED Score: 36 (CS)
Date Completed: NA

MID RISE OFFICE

Cascade Station Corporate Center I

Project Team
Architect: Fletcher Farr Ayotte, Inc.
Contractor: Skanska USA Building, Inc.
Developer: Trammell Crow Company
MEP Engineer: Charter Mechanical, McCann Engineering; The Stoner Electric Group

Location: Portland, OR
Size: 99,000 sf
LEED Score: 36 (CS)
Date Completed: NA

MIXED USE RENOVATION

NW 14th & Everett Mixed Use

Project Team
Architect/Designer: GBD Architects
Contractor: Skanska USA Building, Inc.
Developer: Gerding Edlen Development
MEP Engineer: GLUMAC International

Location: Portland, OR
Size: 183,800 sf
LEED Score: 60 (NC)
Date Completed: 2009 (Est)

SINGLE FAMILY RESIDENCE

Bacon-Brenes Residence

Project Team:	**Location:**	Portland, OR
Designer: Debar Architecture	**Size:**	1,800 sf
Contractor: Coho Construction	**LEED Score:**	N/A
Developer: NA	**Date Completed:**	2002
MEP Engineer: Christopher Diamond		

MULTI FAMILY RESIDENTIAL

Tupelo Alley Mixed Use Development

Project Team:	**Location:**	Portland, OR
Architect: SERA Architects, Inc.	**Size:**	179,470 sf
Contractor: TCR Pacific Northwest Construction	**LEED Score:**	41 (NC)
Developer: Trammell Crow Residential	**Date Completed:**	2009
MEP Engineer: MKE & Associates, Inc.		

HIGH RISE MIXED USE

12th & Washington

Project Team:	**Location:**	Portland, OR
Architect: Zimmer Gunsul Frasca Architects	**Size:**	540,300 sf
Contractor: Hoffman Construction Company	**LEED Score:**	56 (NC)
Developer: GerdingEdlen Development	**Date Completed:**	2009
MEP Engineer: GLUMAC International		

HOSPITAL

Providence Newberg Health Center

Project Team:	**Location**	Newberg, OR
Architect : Mahlum Architects	**Size:**	180,000 sf
Contractor: Skanska USA Building, Inc.	**LEED Score**:	39 (CS)
Developer: Providence Health System	**Date Completed:**	2008
MEP Engineer: GLUMAC International		

Selection of Climate Cities

Victor Olgyay, in his book "Design with Climate," described four different climate zones for the North American continent. The climate zones he described are noted below:

Temperate: Describes a region across the middle of the United States extending into Canada and the Pacific NW on the west coast. Typically this climate is milder than the others, with less extremes both on the high and low side. Rainfall varies greatly across the region depending on location.

Hot-Humid: Describes a region from Louisiana to the east coast of the United States. The zone extends from the Gulf of Mexico north to Virginia. This climate zone is characterized by hot, humid days, especially in the summer season. Rainfall varies across the region, depending on location.

Hot-Arid: Describes a region from Southern California, east to Texas and across the Southwestern portion of the United States. This climate zone is characterized by hot, dry days and cooler nights, although cold days are possible in the winter months. The average rainfall in this climate is very low throughout the region.

Cool: Often designated as a "cold climate region", this climate area describes a region that extends across most of Canada, New England and the northern portion of the Mid Western portion of the United States. This climate typically has cold winter days, but can also have hot, humid summer evenings. Rainfall varies across the region depending on location, with snow fall adding to total precipitation.

It's important to note that the North American version of these climate zones do not represent the extremes of climate possible in the world. The intent of the Living Building Financial Study was to review the cost of Living Buildings in the North American marketplace. The intent of this study is to take a representative building and redesign it to address the climate characteristics of each region with the North American marketplace.

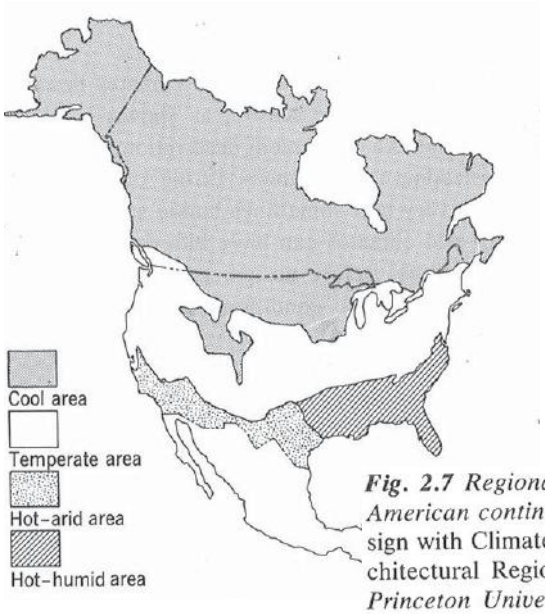


Fig. 2.7 Regional climate zones of the North American continent. (From Victor Olgyay, Design with Climate: Bioclimatic Approach to Architectural Regionalism, Copyright © 1963 by Princeton University Press. Reprinted by permission.)

The strategies employed in each region were somewhat generic. It's important to note that climate is modified by specific site surroundings – a term called microclimate. The effects of microclimate were not addressed as a part of this study.

Climate characteristics reviewed for each climate city included:

Temperature: The study looked at both average daily high and low dry bulb temperatures and seasonal extremes. Seasonal temperatures were used to understand heating / cooling loads and develop appropriate strategies based on the expected energy use for the building. Daily variation provided an indication of the effectiveness of thermal mass and night ventilation strategies.

Rainfall: The study reviewed specific rainfall data for the cities selected for five average years. Daily data provided valuable information, enabling the team to adequately size water tanks for areas which have rainfall characteristics which vary by season.

Sky Cover (% Cloudy): Sky Cover (or the percent cloud cover expected seasonly) was used to determine whether a climate was predominately overcast or sunny, which influenced the daylight design techniques employed.

Solar Radiation: The availability of solar radiation was used to size photovoltaics.

Wind was not reviewed because it is so specific to the surrounding microclimate of a specific site.

Design Approach

Members of the Design Subgroup included: Jason F. McLennan (Cascadia), Clark Brockman (SERA Architects), John Echlin (SERA Architects) and Lisa Petterson (SERA Architects).

The Design Subgroup was responsible for determining the design changes necessary for each reference building to achieve the sixteen prerequisites of the Living Building Challenge, and for documenting the changes in sufficient detail for the cost estimating group to price. The work of the design group included:

- Review of the nine reference buildings to determine which buildings did not meet specific criteria in the Living Building Challenge;
- Brainstorming about how to meet the net zero energy and net zero water prerequisites;
- Incorporation of the energy and water subgroups' strategies into the reference building; and
- Design of the how PV would be integrated into the buildings.

A more detailed description of the tasks of the Design Subgroup is noted below.

Construction document information (primarily site plans, floor plans, elevations, sections, and wall sections) was reviewed to determine which projects required design changes to meet the Living Building Challenge Prerequisites. Although achieving the goals of **prerequisite 4) Net Zero Energy** and **prerequisite 10) Net Zero Water** suggested some design modifications, the only prerequisite that mandated a design modification to meet the requirements of the Living Building Challenge was **prerequisite 12) Civilized Environment**. The Living Building Challenge v1.2 has a footnote that clarifies the maximum distance an occupant may be located from a window. The footnote, which states "work spaces can be no more than 30 feet from a window" was used as a test of whether a project met this prerequisite or not. Several of the reference buildings had workspaces further than 30' from a window including:

Mid Rise Office
Low Rise Office
Hospital
Mixed Use High Rise (housing / retail / office)
Mixed Use Renovation

Modifications on the above building types to achieve **prerequisite 12) Civilized Environment** included:

- Creatation of a long thin building on sites with ample area;
- Addition of an atrium (or expanding an existing atrium) to create a donut shaped building with work areas no more than 30' from windows; and
- Insertion of light shafts to bring light and ventilation to areas that were functionally required to have light, but are necessary to keep at the interior of the building (like the nurse's station in the hospital).

The **Multi-Family Residentia**l building also had some units with habitable rooms without direct access to a window, requiring redesign of portions of the building to create units with less depth.

These changes generally resulted in a reconfiguration of the base building's floor plate and generally added skin area to the building. In some cases the reference building also was refined to achieve a more favorable building orientation to allow passive strategies to be more easily applied.

Strategies the Design Subgroup employed in order of priority were:

1. **Reduction of building loads:** The design team first applied principles of good energy management, using Energy Conservation Measures (ECM's) to reduce demand. Strategies typically employed include: increasing building insulation, providing improved glazing, reducing plug loads and reducing lighting power density.
2. **Application of passive design strategies:** Each building design was analyzed to determine how the building could be reshaped to perform better in each climate zone – employing simple techniques like elongating the building in the west /east direction. Next, the design team employed passive design strategies applicable for the region. Although many of the base buildings employed basic orientation related strategies, design strategies to maximize daylighting particular to each climate city were applied. Passive heating strategies were applied in skin-dominated buildings in temperate and cool climates. Natural ventilation and evaporative cooling strategies were applied in the hot-arid climate, where technically appropriate.
3. **Application of active design strategies:** Mechanical systems were upgraded and optimized (and in some cases eliminated) for the building and climate.
4. **Addition of Renewables:** The final step in the path to Net Zero Energy was the incorporation of photovoltaics in sufficient quantity to meet the remaining energy demand.

For Net Zero Water, a similar approach was used, with all buildings first upgraded to include the highest water conserving fixtures available in the market today. The remaining water usage was offset, first by rainwater collected from the building's roof, then through greywater and blackwater reclaimation systems. Different building types required different levels of waste water treatment, depending on if the water was proposed to be reused as potable or not.

Approach to Net Zero Energy

Members of the Energy Subgroup included: Jason F. McLennan (Cascadia), Mark Frankel (New Buildings Institute), Omid Nabipoor (Interface Engineering), Andy Frichtl (Interface Engineering), Clark Brockman (SERA Architects), Lisa Petterson (SERA Architects) and Kate Turpin (SERA Architects).

The Energy Subgroup was responsible for determining the strategies that would allow the buildings to achieve Net Zero energy performance, while working with the cost estimating group to determine the anticipated premium costs for the various energy strategies employed.

The work of the energy subgroup included three major categories of tasks:

- Determining a baseline energy use for each building type that could be used as a point of comparison for evaluating building efficiency performance;
- Analyzing the energy profiles of the Portland-based reference buildings and translating these to the other climate cities; and
- Converting each reference building (in each climate zone) to a Net Zero energy building through application of both Energy Conservation Measures (ECMs) and on-site renewable energy.

The approach to each of these tasks is described below in greater detail.

Baseline Energy Use

The baseline Energy Use Intensity (EUI) for each building type was determined using data from the 2003 Commercial Buildings Energy Consumption Survey (CBECS) and the 2005 Residential Energy Consumption Survey (RECS). The Energy subgroup set a target percentage improvement over CBECS for each building type of between 50-65%, based upon what was realistic given the substantial collective experience of the group. Energy Conservation Measures (ECMs) were conceptually applied to each building (by climate city) until the goal or target EUI was reached. On-site renewable energy systems were sized to meet remaining building annual energy needs.

Some of the building types in the study were either not represented by CBECS/RECS data, or the particular circumstance of the reference building warranted a modification of the baseline EUI. For these buildings, the Energy Subgroup assigned a baseline EUI that was informed by available data and knowledge of the reference building.

Energy Profiles of Reference Buildings

Energy model results were obtained for each of the reference buildings where energy modeling was performed. These energy analysis reports (particularly LEED-NC Energy & Atmosphere Credit 1, EAc1, "Optimize Energy Performance" documentation) provided the Energy Subgroup with a basic knowledge of the energy performance for each reference building in Portland. The Energy Subgroup then developed a spreadsheet tool used for tracking the energy profiles of the reference buildings, modifying the energy performance to the other climate cities and converting the reference buildings to Net Zero Energy performance.

Reference Design EUIs & Normalized EUI

The Energy Subgroup chose to use a normalized building that reflected standard industry construction practices in Portland. The primary reason for creating the normalized EUI was that it greatly simplified the task of determining how much savings would be achieved by the ECM's that were applied. The procedure of using energy modeling to evaluate the cost-effectiveness of ECM's typically involves comparing each ECM to an alternate base system representing standard industry practice. The Energy Subgroup had greater expertise in predicting savings when applied to systems and buildings representing standard industry practice.

The normalized EUI was chosen by the Energy Subgroup for each reference building to reflect how that building would have performed if it had not pursued the energy efficiency measures associated with LEED Gold certification level. The normalized EUI assumes basic envelope, lighting and mechanical systems that are current standard industry practice in Portland. In addition, there were several other important reasons for using a normalized Design EUI rather than modeled results, including:

- The eight LEED projects had very different predicted performance in EAc1, each obtaining different quantities of points in this category, with some using LEED-NC v2.1 (comparing to the 1999 version of ASHRAE/IESNA Standard 90.1 following the "Energy Cost Budget" modeling methodology), and some using LEED-NC v2.2 (comparing to the 2004 version of ASHRAE/IESNA Standard 90.1 and following the Appendix G "Performance Rating" modeling methodology);
- Only two reference buildings have been certified by the USGBC, and received the 3rd party review of EAc1 that accompanies certification; and
- NBI's study "Energy Performance of LEED for New Construction Buildings" indicated that there is fairly poor correspondence between individual LEED energy model results as compared to measured performance of the buildings.

The cost estimating group used the actual designed systems of each reference building for the purposes of cost estimating; the normalized EUI was a tool created solely for the use of the Energy Subgroup in evaluating ECM's impact on energy performance.

The normalized Design EUI for Portland was modified for each of the remaining climate cities using variations determined through use of the EPA's Target Finder tool. The reference building size and usage was entered into Target Finder for each climate city's representative zip code to determine relative EUIs for each city.

End Use Breakdowns

Energy end use breakdown percentages (Lighting, Heating, Cooling, Domestic Hot Water, Fans & Pumps, and Misc Equip) were based on reference building model results; the results for some building types were modified by the energy Subgroup to reflect a more typical energy distribution for that building type in Portland. In translating these end-use breakdowns to the other climate cities required two basic assumptions: (1) Heating and Cooling end uses represent most of the difference in overall energy use for each city; (2) Energy use for Lighting, Misc Equipment and Domestic Hot Water is approximately the same in each climate city (i.e. the percentage of energy used in each of these categories changes from city to city in direct proportion to the change in overall energy use for that city). As a basic method, the relative proportion of heating degree days (HDD65) between Portland and the other climate cities was used to determine heating energy end use in each climate city, and cooling was adjusted as necessary to make up overall energy use.

Conversion to Living Building

The next task of the Energy Subgroup was to determine the energy conservation strategies to achieve the Net Zero Energy prerequisite.

Energy Conservation Measures

The first major task of the Energy Subgroup was to determine customized lists of ECMs that should theoretically be applied to each building type in each climate city, to allow the building to meet its target EUI before renewable energy systems were applied to cover the remaining energy use. These customized ECM lists were developed during a series of energy charrettes. Once the ECM lists were developed for each of the 36 buildings (nine types, four climate cities), the Energy subgroup was tasked with determining how much the suite of ECMs would reduce building energy consumption from that of the Normalized Design EUI.

As a first step in conversion to a Net Zero building, the changes to the building made by the Design Subgroup had to be reconciled with the Normalized Design EUI starting point. After both viewing sketches and reading a description of changes made by the Design subgroup, the Energy Subgroup determined a factor multiplier to modify the Normalized Design EUI. ECM reductions were then applied to the resulting Adjusted Design EUI.

ECM's were grouped into ten major impact categories, as follows: Glazing, Walls & Roof, Daylighting, Lighting, Plug Loads, Widen Setpoint Temperatures, Schedule Changes, Mechanical Distribution & Ventilation, Mechanical Plant Systems and Domestic Hot Water. Individual ECMs were then listed within their most relevant categories. Predicted energy savings were then applied as percent reductions to each energy end use category affected by that ECM.

A rolling baseline approach was taken in assigning ECM savings. The ECM's in the seven load reduction categories (Glazing, Walls & Roof, Daylighting, Lighting, Plug Loads, Widen Setpoint Temperatures, and Schedule Changes) were applied first. The new energy end use breakdown was then calculated before savings from Mechanical Distribution & Ventilation systems were

applied. A subtotal of energy end use breakdown was calculated before the impact of Mechanical Plant Systems and Domestic Hot Water Systems were determined. A reduced EUI and end-use breakdown were tabulated after these ECM categories were applied. This reduced EUI was then modified by two multiplying factors: (1) a Building Operating Factor which reduced the EUI further to account for engaged occupants who are well trained in building functions and are actively participating in the Net Zero goal through individual efforts in conservation, as well as the ongoing building commissioning and maintenance of system performance required to meet a Net Zero goal, and (2) an Interactive ECM effects factor which increased the EUI (this factor accounts for the fact that all ECMs when applied together save less energy than the sum of savings of individual ECMs). After application of these factors, the final reduced EUI was used to determine the total annual amount of energy required by on-site renewable systems to meet Net Zero Energy.

Sizing of Renewable Energy systems

For most buildings, the primary source of on-site renewable energy was chosen to be solar photovoltaic (PV). RETScreen 4-1 was used to determine the annual electricity production for each applicable tilt and orientation for each climate city. Solar panels were added to building design with a preference for roof area first. Additional site area was used for PV production, as necessary, to achieve each building's net zero annual energy use prediction. For reference buildings that did not include additional site area (e.g. high-rise mixed use, and mixed use renovation), it was assumed that PV could be added to the rooftops of nearby parking garages, with the energy consumed by those parking garages also included in overall energy production of the PV array. In reality this may not be a realistic, so projects with tight urban sites and high density should carefully understand this assumption.

Advising Cost Estimating Group on Mechanical System Sizing

Mechanical System Sizing for cost analysis

A final task of the Energy Subgroup involved assisting the Cost Estimating group in understanding relevant ECMs, particularly related to mechanical systems. Appropriate sizing of mechanical systems was important to obtaining accurate cost estimates for the Living Buildings. Due to aggressive load reduction strategies, efficient mechanical distribution (e.g. radiant heating/cooling), and a substantial widening of acceptable inside temperature ranges, the mechanical plant system sizes would be substantially reduced. In addition, one of the most expensive ECM's was the ground source heat pump vertical well field used for a number of buildings. Where dominated by heating loads, the well fields were sized to meet the majority of the (already reduced) annualized heating load, with peak heating (design days) met by back-up electric boilers.

Water Subgroup Methodology

Members of the Water Subgroup included: Jon Gray (Interface Engineering), Dennis Kangas (Interface Engineering), Dennis Wilde (Gerding Edlen), Christina Skellenger (Gerding Edlen), Lisa Petterson (SERA Architects) and Matthew Schuler (SERA Architects).

The Water Subgroup assumed responsibility for determining the strategies necessary to achieve **prerequisite 10) Net Zero Water** and **prerequisite 11) Sustainable Water Discharge** and worked with the cost estimating group to arrive at the anticipated cost preminum for each water strategy employed.

The work of the Water Subgroup included:

- Calculation of the base building's water use;
- Calculation of the reduction in water use from water conservation strategies;
- Addition of water conserving fixtures were applied;
- Calculation of the rainwater available for collection;
- Calculation of potable and non-potable water uses;
- Calculation of greywater and blackwater produced;
- Determination of the Net Zero water strategy; and
- Determination of the Sustainable Water Discharge strategy.

The study "Code and Regulatory Barriers to the Living Building Challenge for Sustainable, Affordable, Residential Development" prepared by Cascadia for the City of Vancouver, WA and Clark County, WA singles out **prerequisite 10) Net Zero Water** and **prerequisite 11) Sustainable Water Discharge** as one of the few prerequisites with absolute barriers to the Living Building Challenge. For the purposes of this study, it was assumed that all jurisdictional barriers to these prerequisites were eliminated. In reality, project teams need to carefully understand local and state jursidictional barriers to water use.

Base Water Use

Similar to for the Net Zero Energy prerequisite, water conservation was the first strategy employed to all buildings. Eight reference buildings anticipated achieving LEEDv2.2 credits WE 3-1 and 3-2, which means the reference projects already incorporated water saving devices that provided greater than 30% water savings when compared to a code building. Strategies most projects employ to achieve water use reduction, such as low flow fixtures for lavatories and showers, reduced flush or dual flush toilets, and waterless or reduced flush urinals, typically have little added cost. In determining the strategy for the Livings Building Modifications, additional conservation measures were applied first in the form of optical sensors for the office and classroom buildings and composting toilets for the single family residence. Research was done to determine the most efficient dishwasher and clothes washer for the residential buildings, with the cost premium for these appliances included in the cost estimate.

Because LEED has a well established calculation procedure for figuring water usage it was used as a starting point for the Water Subgroup to calculate water usage for each building. In addition to the uses specifically identified by LEED

as part of the calculation procedure the Water Subgroup also brainstormed other uses which needed to be accounted for in a Net Zero water building. The residential buildings' water use was adjusted to account for dishwashing and clothes washing. Residential buildings were assumed to be equipped with the most efficient tank type dual flush toilets (.8/ 1.1 gallon per flush), with office buildings and school projects using a flush valve dual flush mechanism (.8 / 1.6 gallons per flush). Because the primary system selected for heating and cooling was a closed loop ground source heat pump, no additional water was assumed for heating and cooling. Two of the nine reference buildings achieved the LEED threshold for exemplary performance - 40% less water usage than the water use baseline calculated for the building after meeting the Energy Policy Act of 1992 fixture performance requirements. These projects were normalized back to the LEED Gold standard - which the team established as 30% more efficent than existing code. The cost of the additional water saving measures to achieve the 40% reduction, was subtracted from the cost of the LEED Gold baseline cost model.

All of the reference projects achieved the first LEEDv2.2 Water Efficiency credit (WE 1.1) Water Efficient Landscaping, which requires a 50% reduction in water use for irrigation. To achieve the Living Building Challenge's Net Zero Water prerequisite the study team assumed that the existing landscaping for the reference building would be replaced by regionally appropriate native / adaptive landscaping. No irrigation was provided in any of the Living Building modifications.

Water Collection

After determining each building's water use, the amount of water available for collection from the building roof was calculated using daily precipitation data from the National Oceanagraphic and Atmospheric Association. The water subgroup created a water calculator based on the Rainwater Harvesting Model developed by the City of Portland Water Bureau. The purpose of the Portland Rainwater Harvesting Model is to estimate the effectiveness of rain water harvesting based on past weather conditions in the Portland area and estimated water consumption. The Portland Rainwater Harvesting Model uses daily precipitation data from 1963 to 2004 to calculate how much water could be harvested based on the size of the roof and the size of storage tank and calculates what percentage of the building's water use can be supplied from collected rainwater based on input provided by the user of the model.

For the Living Building Financial Study, the water calculator was reverse engineered to create a calculator that solves for tank size instead of number of gallons harvested. The calculator adds daily precipitation to the tank and subtracts out daily use. The calculator incorporates a 15% loss to account for the commonly applied first flush techniques, typically employed to eliminate containments. This factor also was intended to account for evaporation, processing and consumption losses. For the purposes of the Financial Study, the algorithm which selects "average" years was used. The calculator was adapted

with available rainfall data from the NOAA website for Atlanta, Phoenix and Boston.

The study group selected data from the folloiwing source as representative of rainfall.

National Climatic Data Center
Monthly Average Rainfall

PORTLAND INTL ARPT, MULTNOMAH COUNTY data derived from NCDC TD 9641 Clim 81 1961-1990 Normals. 30 years between 1961 and 1990
http://www4.ncdc.noaa.gov/cgi-win/wwcgidll?wwDI~StnSrch~StnID~20016428
Elevation : 5.8m (19') above s/l
Lat/Lon : 45°35'N / 122°36'W

ATLANTA HARTSFIELD INTL ARPT, FULTON COUNTY data derived from NCDC TD 9641 Clim 81 1961-1990 Normals. 30 years between 1961 and 1990
http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwDI~StnSrch~StnID~20004906
Elevation : 307.8m (1010') above s/l
Lat/Lon : 33°38'N / 84°27'W

BOSTON LOGAN INTL AP, SUFFOLK COUNTY data derived from NCDC TD 9641 Clim 81 1961-1990 Normals. 30 years between 1961 and 1990
http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwDI~StnSrch~StnID~20009288
Elevation : 6.1m (20') above s/l
Lat/Lon : 42°22'N / 71°01'W

SOUTH **PHOENIX**, MARICOPA COUNTY data derived from NCDC TD 9641 Clim 81 1961-1990 Normals. 30 years between 1961 and 1990
http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwDI~StnSrch~StnID~20001013
Elevation : 352.0m (1155') above s/l
Lat/Lon : 33°23'N / 112°04'W

Water Strategies

The way that each building could achieve Net Zero Water was calculated using a linear analysis model that checked strategies returning the result when the building's required water use was met.

Scenario One: Rain Only This scenario relied on rainwater only for both potable and non-potable uses

Scenario Two: Rain + Grey This scenario relied on rainwater for potable uses and added greywater collection and treatment to allow it to be reused for non-potable uses.

Scenario Three: Black for Non-potabl: This scenario relied on rainwater for as much potable use as possible, and provided additional treatment to the greywater to meet potable water standards. Blackwater was treated and reused for non-potable uses.

Scenario Four: Black for Potable For some buildings it was necessary to treat blackwater to potable standards creating a closed loop scenario. It is understood that in many jurisdictions this would not be allowed, but for the purposes of the study it was assumed black water reuse was able to be achieved.

Building Water Discharge

If rainwater was sufficient to meet demand, the team investigated simple options for addressing the Sustainable Water Discharge prerequisite – such as composting toilets and septic fields for projects with sufficient site area to meet demand. If rainwater could not meet the entire building's water demand, it was checked against potable usage, which for the purposes of the study was defined as all water used at the kitchen sink, dishwasher, shower, and lavatories. Treatment for a greywater-only system was provided in Scenario Two. Scenario Three typically used a membrane bioreactor to treat both grey and blackwater to class four levels. Scenario Four added an additional treatment module to bring the water to potable standards.

Water tanks smaller than 50,000 gallons were costed as a fiberglass tank; larger tanks were assumed to be built from poured in place concrete systems with treated walls. Typically tanks were located in the basement of projects – usually in place of mechanical rooms made smaller as a result of changes to the energy system. Costs for the tanks, UV treatment and water filtration were all added to the project above the line. Membrane bioreactors were added below the line as third party provided.

CASCADIA REGION GREEN BUILDING COUNCIL/SERA ARCHITECTS/SKANSKA USA BUILDING/GERDING EDLEN/INTERFACE ENGINEERING/NEW BUILDINGS INSTITUTE

Cost Estimating Approach

Members of the Cost Estimating Subgroup included: Beth Heider, Steve Clem, Mark Jones, Bob McGinnis, and Dave Jackman, all of SKANSKA.

The cost estimating process was divided into three main tasks: collection of data and baseline establishment, pricing of modifications to achieve Living Building prerequisites and calculation of payback.

Data Collection and Baseline Establishment

The level of detail and format of the estimates varied substantially due to differences in industry practice, scope of work and confidentiality concerns. Therefore, the first effort was to reconfigure the data into the standard Uniformat estimate model which is most universally accepted. This systems-based approach was also chosen because the Living Building revisions could be added and subtracted with much more transparency than in a CSI based model. When the available data was not in Uniformat, the costs were redistributed by manually sorting the individual estimate line items or applying historical percentages for that building type. For core and shell reference projects such as the mid rise office building, cost for an open office model tenant improvement (TI) were added since the Living Building presupposes a complete build out.

At the highest level, the estimates were divided into two areas: Construction Costs and Development Costs. The estimates were intended to provide a turnkey project including development, design, construction and improvements; excluding only land purchase costs. This holistic approach was consistent with the intent of the Living Building Challenge and allowed for the developer's incentives to offset changes in the direct construction cost.

Once the data was collected and formatted, the costs were adjusted to current January 2009 values. If detailed unit prices were available, the adjustments were made at that base level. If not, a global escalation factor derived from RS Means and Skanska's own cost database was applied. It is worthwhile to note that the timeline of this study straddled one of the most volatile pricing periods in history and that typical projects are not likely to experience offset of the record pricing of commodities of July 2008 by the record drop in construction inputs into the PPI in the winter of 2008.

In addition to these macro adjustments, adjustments were also made for abnormal bidding conditions, campus efficiencies, and unusual contractual arrangements. The original building designs are location-sensitive and an attempt was made to account for these differences by adding and removing scope in the baseline estimates. These minor changes were vetted through local offices of Skanska in each climate city, who also made recommendation of the items required to make the project meet local quality, environmental, and marketability standards.

The final step in creating the direct cost baseline was to review the LEED scorecards for each project and determine the cost to add or remove credit points so that the project scored in the Gold range. Adjustments were made based on the most commonly achieved points, but particular focus was placed on the Energy and Atmosphere (EA) credits. Where an adjustment for LEED

considerations, it is shown as a discrete line item in the estimate summary.

Once the above revisions were made, a city cost index multiplier was applied to adjust the construction costs to each template city. The basis of this multiplier was the RS Means city cost index which was verified through review of actual project costs of one project type across the three non- base climate regions.

Estimation of Living Building Costs

Recognizing that the decision to build a Living Building is not an option exercised when design is nearing completion, the costs for Living Building premiums were priced as if they were part of the original design, not incremental changes. Similar to the Value Engineering process during design, changes were analyzed on a net-impact basis across disciplines. Although corollary price impacts were considered, detailed engineering was not completed and downstream impacts were often assumed to be cost-neutral. Most of the strategies from the Design Subgroup fit within one of the established Uniformat systems; a select few mechanical items had architectural components priced separately.

The strategies employed were state of the shelf technology, using products and techniques currently in use, simply on a much more comprehensive scale. The only notable exception to this rule was the vertical rainwater collection system on the High Rise which was an entirely conceptual construct.

The Estimating Subgroup provided initial cost feedback to the design team to facilitate best value solutions to the prerequisite challenges. While each option did not undergo a rigorous Value Management process, a test of reasonableness was applied to ensure that the strategy, although challenging, wasn't absurd. Each of the strategies is discussed in further detail in the Strategies Narrative.

Where a single multiplier or formula was used to calculate the premium for a specific Prerequisite, it was applied per the method further described in the Prerequisite Summary.

Once the 36 individual estimates were completed, the results were reviewed for accuracy and completeness. Any anomalies in pricing were identified and either corrected or explained. The findings are discussed in the Findings Section.

Payback

In the US Federal Government's Whole Building Design Guide, Sieglinde Fuller of the National Institute of Standards and Technology (NIST) characterizes lowest life-cycle cost (LCC) as *"the most straightforward and easy-to-interpret measure of economic evaluation. Some other commonly used measures are Net Savings (or Net Benefits), Savings-to-Investment Ratio (or Savings Benefit-to-Cost Ratio), Internal Rate of Return, and Payback Period. They are consistent with the Lowest LCC measure of evaluation if they use the same parameters and length of study period. Building economists, certified value specialists, cost engineers, architects, quantity surveyors, operations researchers, and others might use any or several of these techniques to evaluate a project."*

"In order to be able to add and compare cash flows that are incurred at different times during the life cycle of a project, they have to be made time-equivalent. To make cash flows time-equivalent, the LCC method converts them to present values by discounting them to a common point in time."

The discount rate used for the LBC Financial Study was 4.5% in accordance with the Nominal Interest Rates on Treasury Notes and Bonds of Specified Maturities published in OMB Circular 94 for 2009.

"The interest rate used for discounting is a rate that reflects an investor's opportunity cost of money over time, meaning that an investor wants to achieve a return at least as high as that of her next best investment. Hence, the discount rate represents the investor's minimum acceptable rate of return."

The discount rate for federal energy and water conservation projects is determined annually by the Federal Energy Management Program (FEMP). The discount rate for energy is 3% in accordance with FEMP's rate for a 30 year time period.

"LCCA can be performed at various levels of complexity. Its scope might vary from a "back-of-the-envelope" study to a detailed analysis with thoroughly researched input data, supplementary measures of economic evaluation, complex uncertainty assessment, and extensive documentation. The extensiveness of the effort should be tailored to the needs of the project."

For the Living Building Financial study, we performed a simplified life cycle cost analysis. First the cost estimating team compared the LEED Gold building baseline costs to the costs projected for the Living Building Modification (adjusted to January 2009 dollars), to arrive at the present worth for each building. Energy and water for LEED Gold baseline building were calculated using a differential escalation rate of 3% for energy and water in accordance with FEMP. Current energy and water rates were multiplied by the present worth factor of 24.165. (This factor reflects a 30-year life-cycle, 4.5% discount rate and 3% differential escalation.) The total life cycle cost looks at both the annual cost and the present worth of the building to arrive at a Present worth for the LEED Gold building. The Living Building does not have costs added to it as it has Net-Zero Energy and Net-Zero Water usage.

We have used discount and differential escalation rates identified by the Federal Government as the basis of these analyses. In past and more conventional

economic times, Value Engineering/Value Analysis studies that incorporate Life Cycle Analysis might typically use a discount rate of 8%. The NIST tables indicate a discount rate lower than the 4.5% for the next several years. There is a possibility that if we end up with run-away inflation coming out of the depression (as was the case in the 80's early 90's) a discount rate of 12% would not be unreasonable. Consider the impact: The lower the future buying power of the dollar, the less it makes sense to invest in things that are more durable now, because, over the life of the investment, the value of the dollar is going down faster and it makes as much economic sense to replace something cheap today in cheap future dollars than to invest in something long-lived in current (high value) dollars.

By contrast – if energy costs skyrocket – it will have the opposite effect, because even if the building is properly maintained and in it's most efficient working order, the up front cost of high performance/low energy buildings will be offset over time more quickly through reduced energy costs. The higher and faster energy costs rise, the quicker the payback.

This analysis does not include the additional incentive value of carbon offsets or avoided future costs of low-performing buildings in a carbon-trade economy.

The big unknown and unknowable in these calculations is that no one knows what inflation will be, what energy prices will be or when/if carbon will be valued and at what price.

The calculations follow the Federal percentages which is a relatively conservative approach because, while runaway inflation is possible, it is even more likely that energy costs will rise and that carbon will play into the value equation soon.

For more on LCC see www.wbdg.org.

KEY FINDINGS SUMMARY

The study's primary finding that Living Buildings can be built cost effectively in today's market driven ecoonomy given the rising costs of energy and water is supported by the relatively short payback period reported by the study for many of the thirty six buildings. 24 of the 36 buildings had an average payback of less than twenty years. Across building types we saw the lowest payback for projects with the least first cost increase - the University Classroom Building and the Elementary School and for buildings with the largest energy and water usage - the hospital. Payback was also highly influenced by the cost of energy and water. Boston, which has roughly double the energy and water costs of Portland, saw a significantly shorter payback period, despite its much higher first cost increase. Incentives also played a significant role in the projects first cost premium which ultimately affected the payback interval. This study did not look at hard-to-quantify measures, such as productivity, focusing only on payback through tangible water and energy savings.

By isolating variables, we attempted to analyze which factors affect first cost increase the most and which affected it the least.

The role of the Client (Client Type Matters)

Who is developing the building and their goals and priorities affect the initial budget for the base building which in turn affects the first cost premium for creating a Living Building.

The market sector developing the building affects its funding parameters and how the initial budgets for the LEED Gold project were set. Perphaps one of the most important findings of this study is the how the significant investment we are seeing in our public buildings equates to lower first cost premiums for the Univerisity Cassroom and Elementary School, and the highest first cost premium for speculative office buildings, built without a client.

The role of Building Type (Building Type Matters)

The primary and secondary uses of a building greatly affect its energy and water usage, which in turn affects the cost premium to build a Living Building. Equally important is the longevity of the building type.

In comparing five of the nine buildings selected to be the same scale, and most importantly with the same relative floor to roof area ratio, we found that the cost premium for net zero energy and net zero water varied greatly. Some buildings, like the hospital inherently use more water and energy, which makes reducing their loads much more difficult and thus is more costly. The first cost premium for energy conservation measures for the hospital equated to over 40% for all four climate cities, and exceeded 50% in Boston. These buildings also saw a much greater benefit from the investment in Net Zero Energy and Net Zero Water technology, seeing a shorter return becuase of the huge energy and water savings a Living Building would have.

We also saw how buildings that are high water users, like the MultifFamily Residential building, had a considerably higher water premium than lower water using builidngs.

The role of Climate (Climate Matters)

Climate exerts a significant influence on the cost premium to create a Living Building.

Net Zero Energy

Energy usage for each building was analyzed using CBECS data as a baseline to arrive at an initial energy usage EUI for each building type and climate city. Atlanta typically had the lowest EUI for its base buildings, followed closely by Phoenix and Portland. The base EUI of Boston, a mixed climate with both very cold and very warm days was always greatest –on average about 25% greater than the base EUI of the reference building. The EUI of Portland, Atlanta and Phoenix were consistently within 5% of each other – however the energy use for Portland is more evenly divided between heating and cooling – with heating typically dominating. The relatively mild climate in Portland allowed for consideration of elimination of air conditioning for several building types (the elementary school, multifamily and single family residence), thus reducing costs. Atlanta also has both a heating and cooling load – but the mix is weighted more heavily toward cooling. In Phoenix, cooling is by far the largest load.

Available solar radiation per given area is another factor affecting the cost of achieving net zero energy. Phoenix had the highest solar incidence rate producing more kWh per panel than any other climates. The next highest production rate was Atlanta, followed by Portland, followed by Boston.

If net zero energy was isolated from the other costs of achieving the LBC are removed as a parameter in the study, not surprisingly the cost premiums would be dramatically differet. Boston with its abundant and seasonly consistent rainfall become the city with the least cost premium.

Net Zero Water

Water availability also contributes to increased costs. As anticipated Phoenix required the most creative (and most costly) strategies to achieve net zero water. What surprised many of us was the difference in storage volume required for net zero water in Portland compared to other climates. Rainfall average in Portland and Boston are similar in terms of absolute quantity, but Boston's rainfall happens throughout the year while Portland's typically occurs in the months of November to May.

The Role of Building Size

The scale of tbe building, both in absolute size and in the ratio of floor area to roof area, affects the cost premium to achieve a Living Building.

For our study, we had three different scaled buildings that were primarily residential in makeup and three buildings that were primarily office. One of the more interesting findings of this study is the interrelationship of building's size to the net zero energy and net zero water prerequisites within a climate city. Not surprisingly, the smallest buildings in the study had the greatest percentage increase in first costs due to lack of economies of scale. The largest buildings were the most able to take advantage of the economy of scale offered when the additional measures required to achieve Net Zero Energy and Net Zero Water were added.

As an interesting correlation to the absolute building size, whihc also looked at the ratio of the floor area to roof area. For the larger buildings, which did not have enough rooftop to provide supply energy their rooftops, the energy premium was greater than it was for buildings which could meet the net zero standard using only building mounted PV The state of technology, both in the renewable energy field and in the water reclaimation systems are responsible for creating a tipping point beyond which the cost of adding additional technology increases dramatically. For example, the High-Rise Mixed Use Residential building and the Mixed Use Renovation, it was not possible to achieve Net-Zero Energy without adding photovoltacis on adjacent buildings – which also then needed to have their energy usage accounted for. As technology improves this tipping point will increase allowing larger and larger buildings to be built using only the building to support the photovoltaics.

The role of Incentives (Incentives Matter)

The availability of incentives for green building projects can dramatically decrease the first cost of a project.

To test this hypothesis, we looked at the difference incentives make in reducing the premium cost between LEED Gold buildings and Living Buildings. Portland, has two additional incentives that are not available in the other climate cities. Those additional incentives are:

- The Energy Trust of Oregon offers a .$.10 kWh savings and has plans to increase the incentive greatly for buildings that achieve Net Zero Energy. For the purposes of the study, the assumption was this incentive would increase to $.20 kWh.
- The Business Energy Tax provides an additional incentive for Platinum (For the purposes of the study we calculated that all Living Buildings would also achieve LEED platinum) that equates to an additional $4.29 / sf for buildings less than $10,000 sf, $3.58 / sf for buildings between 10,000 and 40,000 sf and an additional $2.85 /sf for areas beyond 50,000 sf

In addition, incentives for Photovoltaics are also greater in Oregon due to the added incentive from the Energy Trust of Oregon. The final incentive, a Systems Development credit was uniformly applied to all buildings.

The CIty of Portland is considering a High Performance Green Building Policy which will give additional incentives for buildings which exceed the goals set by the 2030 Challenge. The incentive proposed for Living Buildings varies between $8.65 and $17.30 sf. If this incentive passes as currently proposed, the incentives for Portland increase further, decreasing the cost premium even further. This incentive was not included in the cost premiums for the report as noted in the matrix. On the Portland cost estimates this premium was calculated as a separate line item using the average of $12.97 / sf.

The anticipated construction cost for the translated LEED Gold base building, based on RS Means, is ranked as follows:

- Phoenix $.85
- Atlanta $.87
- Portland $1.00

- Boston $1.12

After incentives are applied, Portland was consistently the least expensive climate city, followed by Atlanta, Phoenix, and Boston. To address the question of whether it was incentives or climate that contributed the most to Portland's ranking, we looked at the cost premium before incentives were applied. This analysis showed that for all but, two of the Portland buildings, the cost before incentives ranked the same relative to the other climates as the LEED Gold Base. After incentives were applied the cost premium for the Portland building consistently dropped to making it the least expensive city.

The Cost of Energy and Water Matter

The cost of energy and water affect the payback.

Energy and water cost vary greatly among our four climate cities.

Average energy costs for each of the climate cities (not accounting for peak demand charges or time of use net metering) are:

- Portland $.08 kWh
- Atlanta $.10 kWh
- Phoenix $.10 kWh
- Boston $.17 kWh

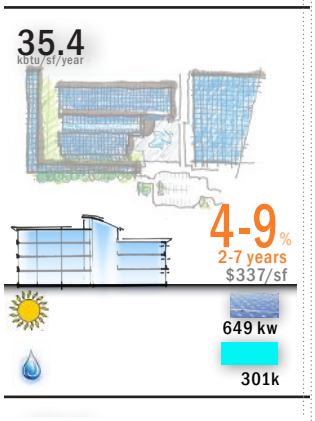
Assuming an average energy escalation rate of 3% annually and a discount rate of 4.5%, we see the huge affect changing the cost of energy has on payback. Once the payback analysis was complete, Boston, the city with the highest cost premium, changed to be the city with the quickest payback. Water was similarly analyzed utilizing the following rates per one hundred cubic feet of water.

The combined water and sewer rates were:

- Phoenix $6.63 CCF
- Portland $8.32 CCF
- Boston $10.27 CCF
- Atlanta $10.99 CCF

Because the water cost premium was less than the energy cost premium, and the volumes of water were not as great, we did not see a dramatic improvement in the payback for Altanta as compared to Boston.

UNIVERSITY CLASSROOM
PORTLAND temperate

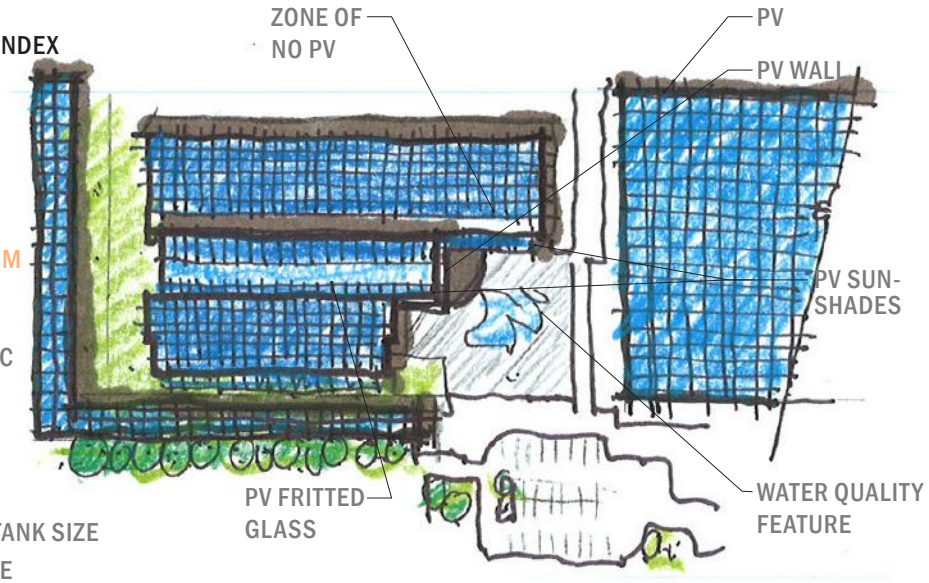


ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

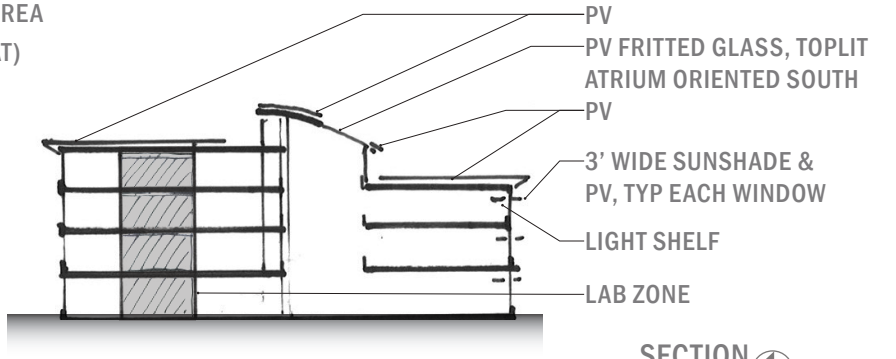
PHOTOVOLTAIC CAPACITY

WATER USE



SITE PLAN
NTS

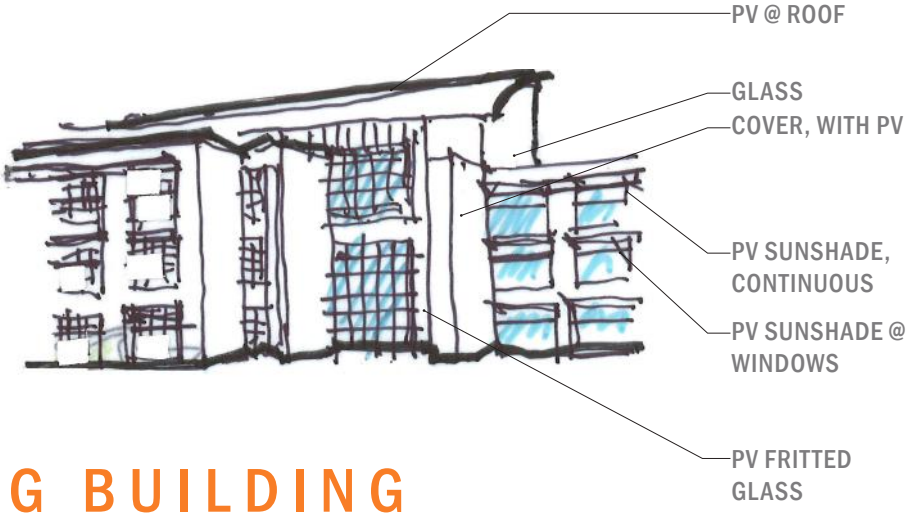
65,000 gal RAIN WATER TANK SIZE
153,531 sf BUILDING SIZE
4 floors BUILDING HEIGHT
2.75 acres SITE AREA
89,510 sf PHOTOVOLTAIC AREA
38,755 sf ROOF AREA (FLAT)



SECTION

MAJOR DESIGN STRATEGIES:

- ✓ Reorient building 180 degrees from current.
- ✓ Clip PV to Metal Roof
- ✓ Add fritted PV to glass at Atrium.
- ✓ Add PV sunshades to each south window.
- ✓ Provide additional PV at walkway canopy and on adjacent parking area



LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **UNIVERSITY CLASSROOM**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 153,531
Living Building Gross SF = 153,531
Site Gross Acreage = 2.75

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**2.6%**	**0.1%**	**$2,123,369**	**$13.83**	**$2,179,470**	**$14.20**
Baseline Building			$2,123,369	$13.83	$2,123,369	$13.83
W2 Rainwater Containment - 41,000 gal Rainwater Tank					$56,101	$0.37
B Shell	**7.0%**	**0.8%**	**$4,959,353**	**$32.30**	**$5,306,177**	**$34.56**
Baseline Building			$4,959,353	$32.30	$4,959,353	$32.30
E1A Improved Glazing (reduce solar heat gain)					$35,324	$0.23
E1B Exterior Shading Devices (outriggers for PV panels on south only)					($132,000)	($0.86)
D3B Change Roof at Atrium to Fritted PV Glass					$443,500	$2.89
C Interiors	**-3.8%**	**-1.4%**	**$16,495,934**	**$107.44**	**$15,868,139**	**$103.35**
Baseline Building			$16,495,934	$107.44	$16,495,934	$107.44
M2D Carpet Reduction (remove carpet and retroplate concrete)					$96,071	$0.63
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$153,531	$1.00
L1A Exposed Ceilings (white matte surfaces)					($160,397)	($1.04)
D3 Eliminate Raised Access Floor					($717,000)	($4.67)
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$297,968**	**$1.94**	**$297,968**	**$1.94**
Baseline Building			$297,968	$1.94	$297,968	$1.94
D.2 Services - Plumbing Systems	**5.3%**	**0.4%**	**$2,968,571**	**$19.34**	**$3,124,871**	**$20.35**
Baseline Building			$2,968,571	$19.34	$2,968,571	$19.34
W6 Low-Flow Fixtures / Optical Sensors					$6,300	$0.04
W2 Rain Harvesting (piping & pumps and filtration)					$150,000	$0.98
D.3 Services - HVAC Systems	**-1.1%**	**-0.1%**	**$5,646,851**	**$36.78**	**$5,586,171**	**$36.38**
Baseline Building			$5,646,851	$36.78	$5,646,851	$36.78
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,941,435)	($19.16)
M2A In-Slab Radiant Heating and Cooling					$767,655	$5.00
M3A Ground Source Heat Pump					$1,940,600	$12.64
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$172,500	$1.12
M2C Carbon Dioxide Sensors (in base building)					$0	
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$425,840**	**$2.77**	**$425,840**	**$2.77**
Baseline Building			$425,840	$2.77	$425,840	$2.77
D.5 Services - Electrical Systems	**2.9%**	**0.4%**	**$6,000,852**	**$39.09**	**$6,174,252**	**$40.22**
Baseline Building			$6,000,852	$39.09	$6,000,852	$39.09
PA Occupancy Sensor to Outlets					$14,100	$0.09
PE High Efficiency Transformers					$67,000	$0.44
L2E Occupancy Sensor for Transient and Egress Lighting					$37,500	$0.24

BUILDING TYPE: **UNIVERSITY CLASSROOM**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 153,531
Living Building Gross SF = 153,531
Site Gross Acreage = 2.75

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline Total	LEED™ Gold Baseline Cost/SF	Living Building Total	Living Building Cost/SF
L2F	Dimmable Direct/Indirect Fixtures					$54,800	$0.36
E	**Equipment and Furnishings**	**0.0%**	**0.0%**	**$257,958**	**$1.68**	**$257,958**	**$1.68**
	Baseline Building			$257,958	$1.68	$257,958	$1.68
F	**Special Construction**	**0.0%**	**0.0%**	**$79,247**	**$0.52**	**$79,247**	**$0.52**
	Baseline Building			$79,247	$0.52	$79,247	$0.52
G	**Sitework**	**2.0%**	**0.1%**	**$2,460,261**	**$16.02**	**$2,510,261**	**$16.35**
	Baseline Building			$2,460,261	$16.02	$2,460,261	$16.02
W4	Stormwater Retention / Building Water Discharge					$50,000	$0.33
W1	Remove Storm Drainage Connection to Public/Add sewer meter					$0	
H	**Logistics**	**0.0%**	**0.0%**	**$2,108,417**	**$13.73**	**$2,108,417**	**$13.73**
	Baseline Building			$2,108,417	$13.73	$2,108,417	$13.73
	Living Building Prerequisites			**$0**	**$0.00**	**$856,439**	**$5.58**
	PR5 - Materials Red List	**100.0%**	**0.8%**			$350,657	$2.28
	PR7 - Responsible Industry	**100.0%**	**0.2%**			$101,591	$0.66
	PR8 - Appropriate Materials / Services Radius	**100.0%**	**0.9%**			$404,191	$2.63
	PR9 - Leadership in Construction Waste	**0.0%**	**0.0%**			$0	
	Subtotal Direct Costs		2.2%	$43,824,622	$285.44	$44,775,212	$291.64
	General Conditions	8.0%	**2.2%**	**0.2%**	$3,512,022	$22.88	$3,588,200	$23.37
	Fee, Construction Contingency, Insurance	7.0%	**2.2%**	**0.2%**	$3,328,586	$21.68	$3,400,786	$22.15
	Location Modifier for PORTLAND, OR	1.00	**0.0%**	**0.0%**	$0		$0	
	TOTAL MODIFIED CONSTRUCTION COST		**2.2%**	**$50,665,230**	**$330.00**	**$51,764,198**	**$337.16**

BUILDING TYPE: **UNIVERSITY CLASSROOM**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 153,531
Living Building Gross SF = 153,531
Site Gross Acreage = 2.75

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.1%			$50,000	$0.33
PV1	Photovoltaic Panels and Infrastructure	649,000	Watts		100.0%	11.1%			$4,867,500	$31.70
LB Prerequisite Items										
	PR3 - Habitat Exchange	2.75482	acres		100.0%	0.0%			$13,774	$0.09
	PR6 - Construction Carbon Footprint	6,800	tons		100.0%	0.2%			$74,800	$0.49
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$73,750	$0.48
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	13.1%	4.2%	$14,186,264	$92.40	$16,046,901	$104.52
	Architecture & Engineering		7.00%	9.00%	31.4%	2.5%	$3,546,566	$23.10	$4,658,778	$30.34
Credits / Rebates / Incentives										
	BETC	35%			66.0%	-0.3%	($173,152)	($1.13)	($287,365)	($1.87)
	ETO - Energy Trust of Oregon				559.3%	-0.8%	($59,000)	($0.38)	($389,000)	($2.53)
	PV Credits-(state, city, utility)	80%			-100.0%	-8.9%	$0		($3,894,000)	($25.36)
	SDC Credits	50%			-100.0%	-0.8%	$0		($349,890)	($2.28)
TOTAL OWNER & DESIGN-BUILD COSTS						**19.2%**	**$17,500,679**	**$113.99**	**$20,865,249**	**$135.90**
					TOTAL CONCEPTUAL COST:		**$68,165,909**	**$443.99**	**$72,629,447**	**$473.06**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **4%** **TO** **9%**
UNIVERSITY CLASSROOM IN PORTLAND, OR

INCLUDING HIGH PERFORMING GREEN BUILDINGS OF PORTLAND (HPGBP): **2%** **TO** **7%**

University Classroom
Portland

Normalized Baseline Energy Use Intensity (kBtu/SF)	**85.0**	Normalized Baseline Energy Use (kWh)	3,612,251
Impact of Design Changes (see sketches)	0.97		
Adjusted Baseline EUI (kBtu/SF)	**82.5**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		20%	20%	18%	2%	10%	30%	100%
calc'd EUI		16.5	16.5	14.8	1.6	8.2	24.7	82.5
Energy Conservation Measures:								
Glazing	**E1**		3.0%	7.5%		2.9%		2.2%
Improve Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		6.0%	3.0%		2.1%		2.0%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	50.0%	-3.8%	5.0%		0.8%		10.2%
Daylight controls (continuous dimming)	L1c							
Orient windows to allow for illumination of teaching wall	L1f							
Top daylighting from Atrium	L1g							
Lighting	**L2**	20.0%	-1.5%	2.0%		0.3%		4.1%
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dimmable direct / indirect fixtures	L2f							
Occupancy sensor / time clock for corridor lighting	L2j							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	7.6%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Mechanical - Schedule	**M4**			7.0%				
Change of work hours (summer hours)	M4a							
Shift uses for time of day in summer (east vs west)	M4b							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.2%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*70.0%*	*6.9%*	*32.0%*	*0.0%*	*8.9%*	*25.0%*	*29.5%*
Subtotal Reduced EUI (kBTU/SF)		*4.9*	*15.4*	*10.1*	*1.6*	*7.5*	*18.6*	*58.1*
Mechanical - Distribution & Ventilation	**M2**		20.0%	100.0%		60.0%		21.4%
Radiant heating w/ dedicated outside air system (DOAS)	M2p							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Eliminate cooling	M2j							
Cascading make-up air	M2x							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*20.0%*	*100.0%*	*0.0%*	*60.0%*	*0.0%*	*21.4%*
Subtotal Reduced EUI (kBTU/SF)		*4.9*	*12.3*	*0.0*	*1.6*	*3.0*	*18.6*	*40.4*
Mechanical - Plant Systems	**M3**		20.0%			13.4%		3.5%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				50.0%			1.0%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from tankless electric water heater	Wd							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*0.0%*	*50.0%*	*13.4%*	*0.0%*	*4.5%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**4.9**	**9.8**	**0.0**	**0.8**	**2.6**	**18.6**	***36.8***
Final Energy Use Breakdown as Percentage of Baseline Use		**6%**	**12%**	**0%**	**1%**	**3%**	**23%**	**55%**

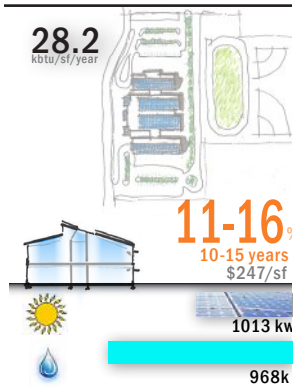
Building Operating Factor	0.90	100.0	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.06	60%	target reduction from CBECS
Total Reduced EUI (kBTU/sf)	**35.4**	Achievement:	
		65%	percent reduction from CBECS
		58%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	1,502,333	Incentives:	
		$ 400,884	ETO incentive for reduced EUI
Number of crystaline panels needed	3,164	$ 59,043	Estimated ETO incentive for original design bldg
Total kW of PV array	649	$ 114,213	BETC for Platinum (minus Gold), pass-thru

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	227.042	6617	35,840	2874	Panels at Parking lot + sunshade + covered walkwa
	15°	244.678	6141		0	
optimal angle:	32.5°	281.857	5331	2,400	192	Panels at sloping roof less atrium
	45°	247.953	6059		0	
	90°	175.198	8576	1,230	98	
				Total kWh =	**723,805**	
Cover Adjacent parking lot with PV			Additional area	50,040	4012	**panels at parking lot**
			Additional kWh Produced		**910,893**	1,634,697

SCHOOL K-8
PORTLAND temperate



ENERGY USE INDEX

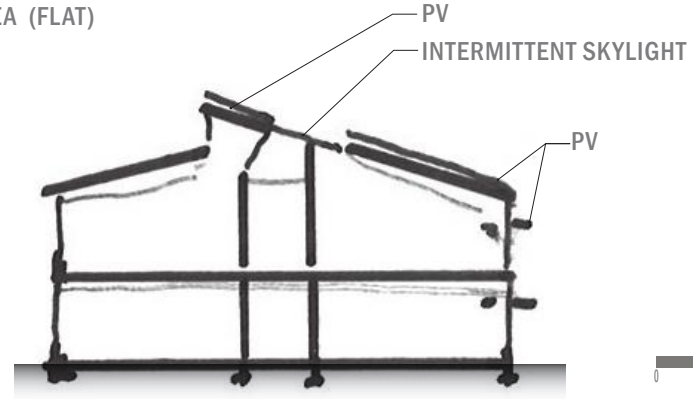
COST PREMIUM
PAYBACK
COST PER SF

PHOTOVOLTAIC CAPACITY

WATER USE

SITE PLAN
NTS

150,000 gal	RAIN WATER TANK SIZE
148,981 sf	BUILDING SIZE
2 floors	BUILDING HEIGHT
39.03 acres	SITE AREA
61,628 sf	PHOTOVOLTAIC AREA
97,650 sf	ROOF AREA (FLAT)



SECTION
0 10 20 30

PLAN
NTS

MAJOR DESIGN STRATEGIES:

- ✓ Reorganize plan to eliminate N/S portions of classroom wings.
- ✓ Relocate mass to inside of building wall.
- ✓ Eliminate ceilings in classrooms.
- ✓ Lower roof in media centers.
- ✓ Revise windows to illuminate teaching wall.
- ✓ Remove windows below 2'-6" in classrooms, 2'-0" in corridors.
- ✓ Add skylights in Gym; eliminate south side clerestory.
- ✓ Eliminate windows on west and east facades at classrooms.

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **ELEMENTARY SCHOOL**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 148,981
Living Building Gross SF = 148,981
Site Gross Acreage = 39.03

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**18.6%**	**0.9%**	**$1,466,210**	**$9.84**	**$1,738,337**	**$11.67**
Baseline Building			$1,466,210	$9.84	$1,466,210	$9.84
W2 Rainwater Containment - 150,000 gal Rainwater Tank					$272,127	$1.83
B Shell	**7.2%**	**2.3%**	**$9,540,845**	**$64.04**	**$10,225,720**	**$68.64**
Baseline Building			$9,540,845	$64.04	$9,540,845	$64.04
L1B Replace Roofing with Glazed Skylight					$412,800	$2.77
L1B Credit for Removing Clerestory Windows					($103,500)	($0.69)
D3 Lower Roof at Media Center (at both links)					($248,400)	($1.67)
D3 Reallocate South Wing (move SF to east-west wings)					($69,000)	($0.46)
E1A Improved Glazing (reduce solar heat gain at vision only)					$22,000	$0.15
E1B Exterior Shading Devices (credit reflecting PV as shading element)					($30,000)	($0.20)
M2H "High Mass" Concrete Inside Insulation (CMU to replace metal stud plus added reflective skin)					$467,700	$3.14
D2B Modifications to Roof Structure (sloped roof)					$233,275	$1.57
C Interiors	**3.1%**	**0.5%**	**$4,624,290**	**$31.04**	**$4,765,608**	**$31.99**
Baseline Building			$4,624,290	$31.04	$4,624,290	$31.04
M2D Carpet Reduction (replace with RetroPlate)					$108,466	$0.73
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$148,981	$1.00
L1A Exposed Ceilings (white matte surfaces)					($116,128)	($0.78)
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$100,000**	**$0.67**	**$100,000**	**$0.67**
Baseline Building			$100,000	$0.67	$100,000	$0.67
D.2 Services - Plumbing Systems	**10.4%**	**0.5%**	**$1,438,830**	**$9.66**	**$1,588,830**	**$10.66**
Baseline Building			$1,438,830	$9.66	$1,438,830	$9.66
W6 Low-Flow Fixtures / Optical Sensors					$0	
W2 Rain Harvesting (piping & pumps and filtration)					$150,000	$1.01
D.3 Services - HVAC Systems	**5.8%**	**0.7%**	**$3,684,937**	**$24.73**	**$3,900,270**	**$26.18**
Baseline Building			$3,684,937	$24.73	$3,684,937	$24.73
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,652,772)	($17.81)
M2A In-Slab Radiant Heating and Cooling					$744,905	$5.00
M2L Solar Wall Mechanical Screen					$145,000	$0.97
M3A Ground Source Heat Pump					$1,882,200	$12.63
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$80,000	$0.54
M2C Carbon Dioxide Sensors					$16,000	$0.11
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$345,589**	**$2.32**	**$345,589**	**$2.32**
Baseline Building			$345,589	$2.32	$345,589	$2.32
D.5 Services - Electrical Systems	**6.6%**	**0.7%**	**$3,044,694**	**$20.44**	**$3,246,194**	**$21.79**
Baseline Building			$3,044,694	$20.44	$3,044,694	$20.44
PA Occupancy Sensor to Outlets					$5,000	$0.03
PE High Efficiency Transformers					$97,500	$0.65
L1C Daylight Controls (continuous dimming 15' from perimeter)					$23,800	$0.16
L2F Dimmable Direct/Indirect fixtures					$47,500	$0.32
L2B Occupancy Sensor for Lighting (closed office / conference spaces)					$0	
L2C Individual Light Level Control (open spaces, classrooms)					$5,200	$0.03
L2E Occupancy Sensor for Transient and Egress Lighting					$22,500	$0.15

BUILDING TYPE: **ELEMENTARY SCHOOL**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 148,981
Living Building Gross SF = 148,981
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$1,555,517**	**$10.44**	**$1,555,517**	**$10.44**
Baseline Building				$1,555,517	$10.44	$1,555,517	$10.44
F Special Construction		**0.0%**	**0.0%**	**$58,000**	**$0.39**	**$58,000**	**$0.39**
Baseline Building				$58,000	$0.39	$58,000	$0.39
G Sitework		**1.6%**	**0.2%**	**$3,701,152**	**$24.84**	**$3,761,152**	**$25.25**
Baseline Building				$3,701,152	$24.84	$3,701,152	$24.84
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.34
E1B Trees for shading						$10,000	$0.07
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$524,694**	**$3.52**	**$524,694**	**$3.52**
Baseline Building				$524,694	$3.52	$524,694	$3.52
Living Building Prerequisites				**$0**	**$0.00**	**$581,109**	**$3.90**
PR5 - Materials Red List		**100.0%**	**0.8%**			$248,507	$1.67
PR7 - Responsible Industry		**100.0%**	**0.1%**			$41,508	$0.28
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.0%**			$291,094	$1.95
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**				
Subtotal Direct Costs			7.7%	$30,084,758	$201.94	$32,391,020	$217.42
General Conditions	3.7%	**7.7%**	**0.3%**	$1,098,511	$7.37	$1,182,722	$7.94
Fee, Contingency, Insurance, Bonding	9.6%	**7.7%**	**0.8%**	$3,008,433	$20.19	$3,239,056	$21.74
Location Modifier for PORTLAND, OR	1.00	**0.0%**	**0.0%**	$0		$0	
TOTAL MODIFIED CONSTRUCTION COST			**7.7%**	**$34,191,702**	**$229.50**	**$36,812,798**	**$247.10**

BUILDING TYPE: **ELEMENTARY SCHOOL**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 148,981
Living Building Gross SF = 148,981
Site Gross Acreage = 39.03

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.7%			$200,000	$1.34
PV1	Photovoltaic Panels and Infrastructure	1,013,000	Watts		100.0%	25.3%			$7,597,500	$51.00
LB Prerequisite Items										
	PR3 - Habitat Exchange	39.03	acres		100.0%	0.6%			$195,150	$1.31
	PR6 - Construction Carbon Footprint	4,400	tons		100.0%	0.2%			$48,400	$0.32
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$63,000	$0.42
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	19.2%	6.1%	$9,573,677	$64.26	$11,411,967	$76.60
	Architecture & Engineering		7.00%	9.00%	38.4%	3.1%	$2,393,419	$16.07	$3,313,152	$22.24
Credits / Rebates / Incentives										
	BETC	35%			66.4%	-0.4%	($167,753)	($1.13)	($279,116)	($1.87)
	ETO - Energy Trust of Oregon				426.1%	-0.7%	($49,944)	($0.34)	($262,764)	($1.76)
	PV Credits-(state, city, utility)	80%			-100.0%	-20.2%	$0		($6,078,000)	($40.80)
	SDC Credits	50%			-100.0%	-2.8%	$0		($848,565)	($5.70)
TOTAL OWNER & DESIGN-BUILD COSTS						**30.7%**	**$11,749,399**	**$78.87**	**$15,360,725**	**$103.11**

TOTAL CONCEPTUAL COST: **$45,941,101** **$308.37** **$52,173,523** **$350.20**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **11%** **TO** **16%**
ELEMENTARY SCHOOL IN PORTLAND, OR

INCLUDING HIGH PERFORMING GREEN BUILDINGS OF PORTLAND (HPGBP): **9%** **TO** **14%**

Elementary School
Portland

Normalized Baseline Energy Use Intensity (kBtu/SF) **62.3**

Normalized Baseline Energy Use (kWh) 2,575,564

Impact of Design Changes (see sketches) 0.96

Adjusted Baseline EUI (kBtu/SF) 59.6

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
	percent of load	20%	39%	5%	3%	12%	21%	100%
	calc'd EUI	11.9	23.3	2.7	1.7	7.1	12.8	59.6
Energy Conservation Measures:								
Glazing	**E1**		4.0%	9.0%		3.5%		2.4%
Improve Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		9.0%	4.0%		3.0%		4.1%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	75.0%	-5.6%	7.5%		1.1%		13.3%
Top daylighting with skylights	L1b							
Daylight controls (continuous dimming)	L1c							
Orient windows to allow for illumination of teaching wall	L1f							
Lighting	**L2**	9.8%	-0.7%	1.0%		0.1%		1.7%
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dimmable direct / indirect fixtures	L2f							
Occupancy sensor / time clock for corridor lighting	L2j							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	4.8%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Mechanical - Schedule	**M4**			7.0%				
Change of work hours (summer hours)	M4a							
Shift uses for time of day in summer (east vs west)	M4b							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.5%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		***84.8%***	***9.8%***	***36.0%***	***0.0%***	***10.6%***	***25.0%***	***29.1%***
Subtotal Reduced EUI (kBTU/SF)		***1.8***	***21.1***	***1.8***	***1.7***	***6.4***	***9.6***	***42.3***
Mechanical - Distribution & Ventilation	**M2**		15.0%	100.0%		60.0%		14.7%
Radiant heating w/ dedicated outside air system (DOAS)	M2p							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Eliminate cooling	M2j							
Displacement ventilation delivery for DOAS	M2k							
SolarWall mechanical screen or SolarDuct (pre-heat air)	M2l							
Subtotal from Mechanical Distribution strategies (percentage)		***0.0%***	***15.0%***	***100.0%***	***0.0%***	***60.0%***	***0.0%***	***14.7%***
Subtotal Reduced EUI (kBTU/SF)		***1.8***	***17.9***	***0.0***	***1.7***	***2.6***	***9.6***	***33.5***
Mechanical - Plant Systems	**M3**		20.0%			-13.4%		5.4%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				50.0%			1.4%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Subtotal from Mechanical Plant and DHW systems (percentage)		***0.0%***	***20.0%***	***0.0%***	***50.0%***	***-13.4%***	***0.0%***	***6.8%***
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**1.8**	**14.3**	**0.0**	**0.8**	**2.9**	**9.6**	***29.4***
Final Energy Use Breakdown as Percentage of Baseline Use		**3%**	**24%**	**0%**	**1%**	**5%**	**16%**	**51%**

Building Operating Factor 0.90
Impact of Interactive ECM effects 1.07

Total Reduced EUI (kBTU/sf) 28.2

Total reduced energy use (kWh) 1,165,228

Number of crystaline panels needed 4,941
Total kW of PV array 1013

83.1 CBECS Baseline EUI (kBTU/sf)
60% target reduction from CBECS

Achievement:
66% percent reduction from CBECS
55% percent reduction from Normalized Baseline Bldg

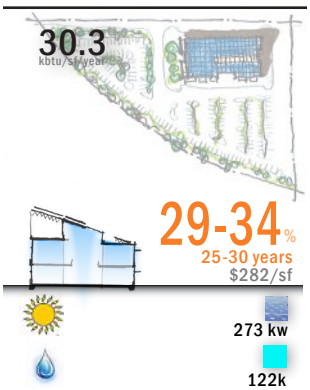
Incentives:
$ 267,964 ETO incentive for reduced EUI
$ 49,944 Estimated ETO incentive for original design bldg
$ 111,363 BETC for Platinum (minus Gold), pass-thru

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	227.042	5133	10,928	876	Panels at parking lot, sunshade, covered walkway
	15°	244.678	4763	50,700	4065	
optimal angle:	32.5°	281.857	4135		0	Panels at sloping roof less atrium
	45°	247.953	4700		0	
	90°	175.198	6651		0	
				Total kWh =	**1,193,505**	

LOW RISE OFFICE
PORTLAND temperate

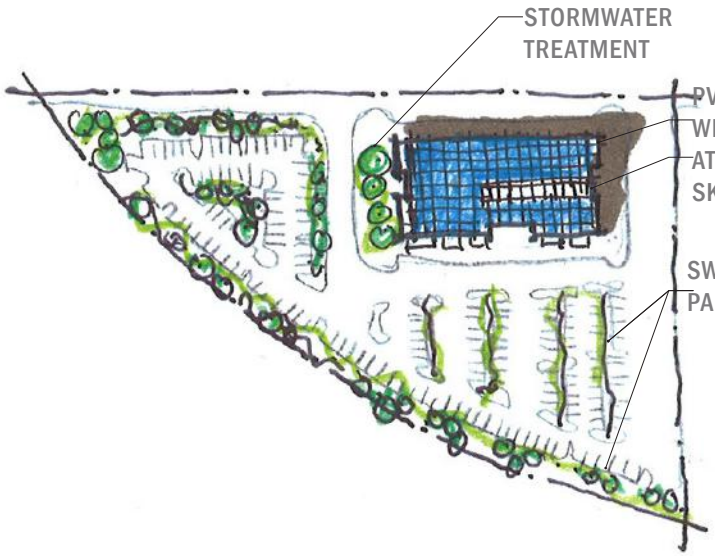


ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

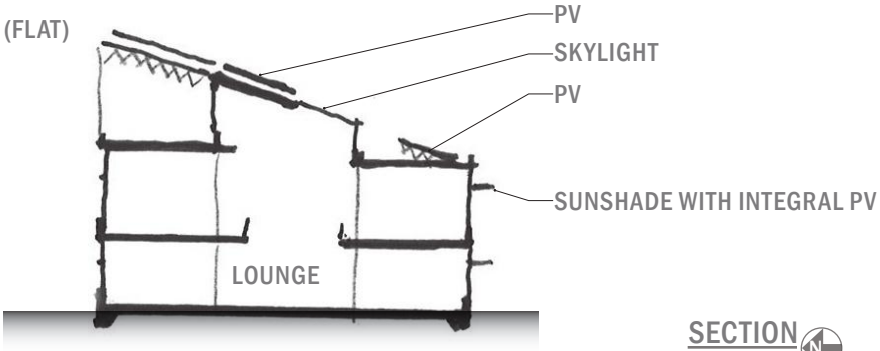
PHOTOVOLTAIC CAPACITY

WATER USE



SITE PLAN
NTS

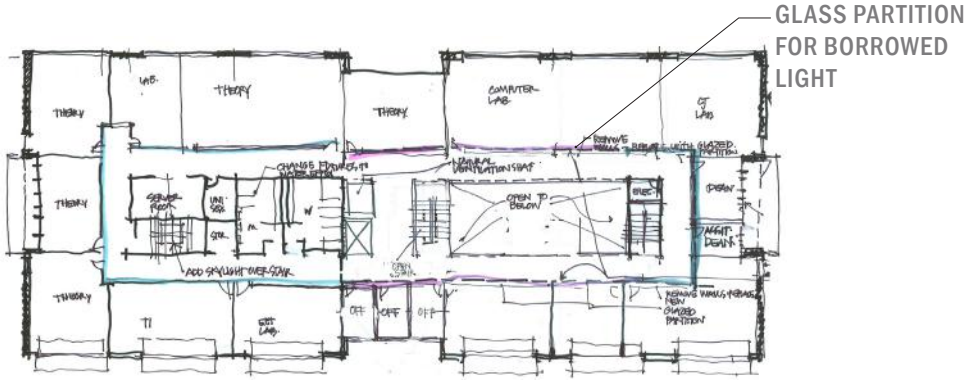
20,000 gal	RAIN WATER TANK SIZE
35,776 sf	BUILDING SIZE
2 floors	BUILDING HEIGHT
3.24 acres	SITE AREA
16,600 sf	PHOTOVOLTAIC AREA
17,888 sf	ROOF AREA (FLAT)



SECTION
0 10 20 30

MAJOR DESIGN STRATEGIES:

- ✓ Add sloping metal roof with PV to allow PV production to be achieved without additional structures.
- ✓ Open floor to allow light to penetrate to ground floor lounge.
- ✓ Reconfigure floor plan to ensure all spaces are within 30’ of an operable window.



PLAN
NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **LOWRISE OFFICE / CLASSROOMS**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 35,776
Living Building Gross SF = 35,776
Site Gross Acreage = 3.24

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**7.5%**	**0.6%**	**$625,892**	**$17.49**	**$672,576**	**$18.80**
Baseline Building			$625,892	$17.49	$625,892	$17.49
W2 Rainwater Containment - 20,000 gal Rainwater Tank					$46,684	$1.30
B Shell	**23.6%**	**10.1%**	**$3,237,848**	**$90.50**	**$4,001,612**	**$111.85**
Baseline Building			$3,237,848	$90.50	$3,237,848	$90.50
M2E Operable Windows (manual)					$31,680	$0.89
D3C Reallocate Glazing from East and West Façade to South (less spandrel panel, more skin)					($17,472)	($0.49)
L1B Replace Roofing with Glazed Skylight					$141,600	$3.96
E1A Improved Glazing (reduce solar heat gain)					$16,104	$0.45
E1B Exterior Shading Devices (windows and louvers at entry)					$70,460	$1.97
D2A Added Wall / Skin for Modified Design (not in base building design)					$274,560	$7.67
M2H "High Mass" Concrete Inside Insulation (added reflective skin)					$49,500	$1.38
D2B Modifications to Roof Structure and Roofing					$168,532	$4.71
L1D Interior Light Shelves (remove from N/E/W, keep south only)					$28,800	$0.81
C Interiors	**17.2%**	**2.4%**	**$1,076,571**	**$30.09**	**$1,261,402**	**$35.26**
Baseline Building			$1,076,571	$30.09	$1,076,571	$30.09
M2D Carpet Reduction (replace with RetroPlate)					$25,500	$0.71
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$48,264	$1.35
L1A Exposed Ceilings (white matte surfaces)					($68,213)	($1.91)
D3 Glass partitions in lieu of gypsum wallboard					$179,280	$5.01
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$55,000**	**$1.54**	**$55,000**	**$1.54**
Baseline Building			$55,000	$1.54	$55,000	$1.54
D.2 Services - Plumbing Systems	**73.8%**	**2.0%**	**$208,354**	**$5.82**	**$362,154**	**$10.12**
Baseline Building			$208,354	$5.82	$208,354	$5.82
W6 Low-Flow Fixtures / Optical Sensors					$3,800	$0.11
W2 Rain Harvesting (piping & pumps and filtration)					$150,000	$4.19
D.3 Services - HVAC Systems	**69.3%**	**5.4%**	**$591,095**	**$16.52**	**$1,000,475**	**$27.96**
Baseline Building			$575,095	$16.07	$575,095	$16.07
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($300,000)	($8.39)
M2A In-Slab Radiant Heating and Cooling					$178,880	$5.00
M3A Ground Source Heat Pump					$450,500	$12.59
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$80,000	$2.24
M2C Carbon Dioxide Sensors			$16,000	$0.45	$16,000	$0.45
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$75,177**	**$2.10**	**$75,177**	**$2.10**
Baseline Building			$75,177	$2.10	$75,177	$2.10
D.5 Services - Electrical Systems	**6.5%**	**0.6%**	**$723,416**	**$20.22**	**$770,116**	**$21.53**
Baseline Building			$603,016	$16.86	$603,016	$16.86
PA Occupancy Sensor to Outlets					$10,200	$0.29
PE High Efficiency Transformers					$36,500	$1.02
L1C Daylight Controls (continuous dimming 15' from perimeter)			$27,000	$0.75	$27,000	$0.75
L2A Efficient Light Fixture Optics Premium			$67,600	$1.89	$67,600	$1.89
L2B Occupancy Sensor for Lighting (closed office / conference spaces)			$12,000	$0.34	$12,000	$0.34
L2E Occupancy Sensor for Transient and Egress Lighting			$13,800	$0.39	$13,800	$0.39

BUILDING TYPE: **LOWRISE OFFICE / CLASSROOMS**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 35,776
Living Building Gross SF = 35,776
Site Gross Acreage = 3.24

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$149,348**	**$4.17**	**$149,348**	**$4.17**
Baseline Building				$149,348	$4.17	$149,348	$4.17
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**7.6%**	**0.8%**	**$791,671**	**$22.13**	**$851,671**	**$23.81**
Baseline Building				$791,671	$22.13	$791,671	$22.13
W4 Stormwater Retention / Building Water Discharge						$50,000	$1.40
E1B Trees for shading						$10,000	$0.28
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$40,261**	**$1.13**	**$40,261**	**$1.13**
Baseline Building				$40,261	$1.13	$40,261	$1.13
Living Building Prerequisites				**$0**	**$0.00**	**$188,025**	**$5.26**
PR5 - Materials Red List		**100.0%**	**0.9%**			$68,202	$1.91
PR7 - Responsible Industry		**100.0%**	**0.1%**			$6,707	$0.19
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.5%**			$113,116	$3.16
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**				
Subtotal Direct Costs			24.5%	$7,574,634	$211.72	$9,427,818	$263.52
General Conditions	4.0%	**24.5%**	**1.0%**	$302,985	$8.47	$377,113	$10.54
Fee, Construction Contingency, Insurance	3.0%	**24.5%**	**0.8%**	$238,965	$6.68	$297,429	$8.31
Location Modifier for PORTLAND, OR	1.00	**0.0%**	**0.0%**	$0		$0	
TOTAL MODIFIED CONSTRUCTION COST			**24.5%**	**$8,116,584**	**$226.87**	**$10,102,360**	**$282.38**

BUILDING TYPE: **LOWRISE OFFICE / CLASSROOMS**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 35,776
Living Building Gross SF = 35,776
Site Gross Acreage = 3.24

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.5%			$40,000	$1.12
PV1	Photovoltaic Panels and Infrastructure	273,000	Watts		100.0%	30.6%			$2,320,500	$64.86
LB Prerequisite Items										
	PR3 - Habitat Exchange	3.24	acres		100.0%	0.2%			$16,200	$0.45
	PR6 - Construction Carbon Footprint	2,700	tons		100.0%	0.4%			$29,700	$0.83
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.3%			$23,500	$0.66
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	37.8%	11.3%	$2,272,644	$63.52	$3,131,731	$87.54
	Architecture & Engineering		9.38%	11.38%	51.0%	5.1%	$760,930	$21.27	$1,149,143	$32.12
Credits / Rebates / Incentives										
	BETC	35%			82.1%	-0.4%	($39,000)	($1.09)	($71,000)	($1.98)
	ETO - Energy Trust of Oregon				939.5%	-0.9%	($7,600)	($0.21)	($79,000)	($2.21)
	PV Credits-(state, city, utility)	80%			-100.0%	-24.5%	$0		($1,856,400)	($51.89)
	SDC Credits	50%			-100.0%	-3.1%	$0		($231,353)	($6.47)
TOTAL OWNER & DESIGN-BUILD COSTS						**49.8%**	**$2,986,973**	**$83.49**	**$4,473,022**	**$125.03**

TOTAL CONCEPTUAL COST: **$11,103,558** **$310.36** **$14,575,382** **$407.41**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **29%** **TO** **34%**
LOWRISE OFFICE / CLASSROOMS IN PORTLAND, OR

INCLUDING HIGH PERFORMING GREEN BUILDINGS OF PORTLAND (HPGBP): **26%** **TO** **31%**

LowRiseOffice
Portland

Normalized Baseline Energy Use Intensity (kBtu/SF)	**74.3**	Normalized Baseline Energy Use (kWh)	740,586
Impact of Design Changes (see sketches)	1.03		
Adjusted Baseline EUI (kBtu/SF)	**76.2**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		21%	26%	17%	4%	9%	23%	100%
calc'd EUI		16.1	19.9	12.6	3.1	6.8	17.7	76.2
Energy Conservation Measures:								
Glazing	**E1**		12.0%	7.5%		4.7%		4.8%
Improve Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		8.0%	3.5%		2.7%		2.9%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	50.0%	-3.8%	5.0%		0.8%		10.5%
Remove ceiling, raise window head, add lightshelf	L1a							
Top daylighting with skylights	L1b							
Daylight controls (continuous dimming)	L1c							
Lighting	**L2**	25.0%	-1.9%	2.5%		0.4%		5.2%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	5.8%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.4%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*75.0%*	*17.5%*	*26.0%*	*0.0%*	*11.3%*	*25.0%*	*31.5%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*16.4*	*9.3*	*3.1*	*6.0*	*13.3*	*52.2*
Mechanical - Distribution & Ventilation	**M2**		25.0%	100.0%		60.0%		22.4%
Radiant heating w/ dedicated outside air system (DOAS)	M2p							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*25.0%*	*100.0%*	*0.0%*	*60.0%*	*0.0%*	*22.4%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*12.3*	*0.0*	*3.1*	*2.4*	*13.3*	*35.1*
Mechanical - Plant Systems	**M3**		20.0%			-15.0%		2.8%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				50.0%			2.1%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*0.0%*	*50.0%*	*-15.0%*	*0.0%*	*4.8%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**4.0**	**9.8**	**0.0**	**1.6**	**2.8**	**13.3**	***31.5***
Final Energy Use Breakdown as Percentage of Baseline Use		**5%**	**13%**	**0%**	**2%**	**4%**	**17%**	**59%**

Building Operating Factor	0.90	92.9	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.07	60%	target reduction from CBECS
Total Reduced EUI (kBTU/sf)	**30.3**	Achievement:	
		67%	percent reduction from CBECS
		59%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	301,985	Incentives:	
		$ 83,334	ETO incentive for reduced EUI
Number of crystaline panels needed	1,331	$ 7,623	Estimated ETO incentive for original design bldg
Total kW of PV array	273	$ 32,205	BETC for Platinum (minus Gold), pass-thru

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	227.042	1331		0	Panels at parking lot, sunshade, covered walkway
	15°	244.678	1235	16,600	1331	
optimal angle:	32.5°	281.857	1072		0	Panels at sloping roof less atrium
	45°	247.953	1218		0	
	90°	175.198	1724		0	
				Total kWh =	**325,666**	

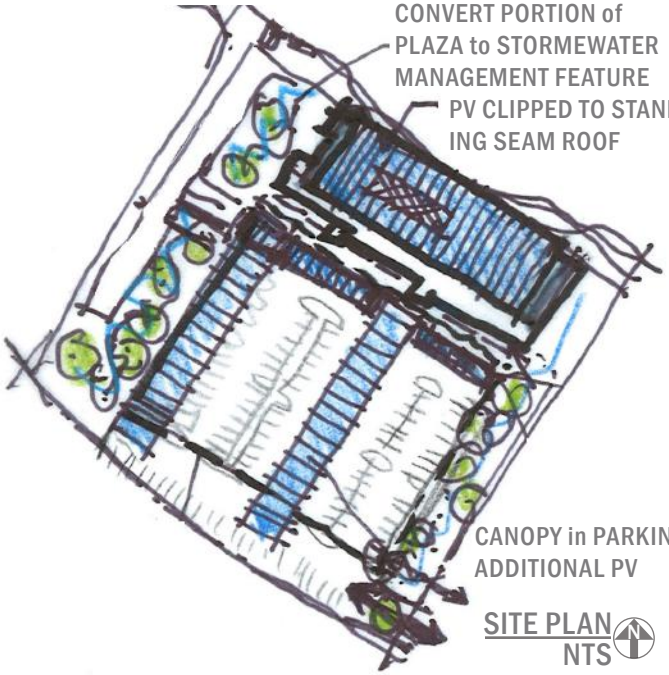
MID RISE OFFICE
PORTLAND temperate

ENERGY USE INDEX

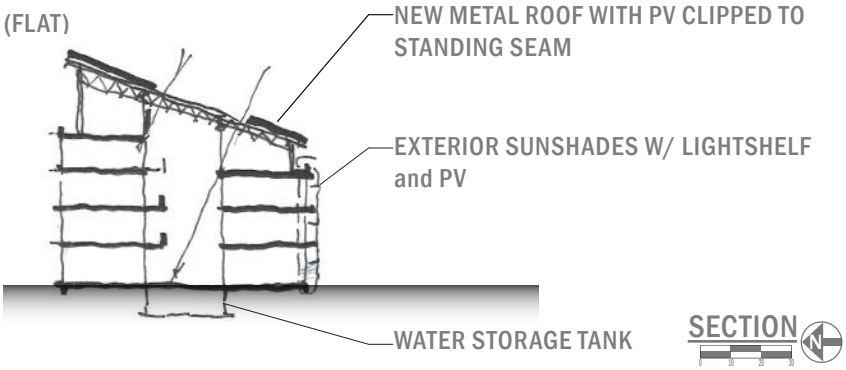
COST PREMIUM
PAYBACK
COST PER SF

PHOTOVOLTAIC CAPACITY

WATER USE

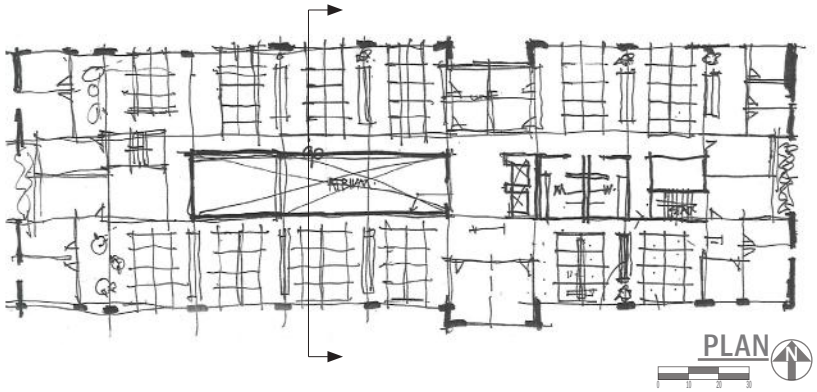


78,800 gal	RAIN WATER TANK SIZE
101,385 sf	BUILDING SIZE
5 floors	BUILDING HEIGHT
5.24 acres	SITE AREA
51,793 sf	PHOTOVOLTAIC AREA
23,941 sf	ROOF AREA (FLAT)



MAJOR DESIGN STRATEGIES:

- ✓ Reconfigure floor plan so all spaces are within 30; of an operable window.
- ✓ Add an atrium to for improved daylighting
- ✓ Slope the roof 20° for maximum PV production.
- ✓ Provide 5th level on north side to provide for additional area with 30' of operable windows.
- ✓ Add PV sunshades at exterior.
- ✓ Relocate windows on West and East to North and South - glass area to remain the same.
- ✓ Add fins at center bay - West and East - at remaining windows.



LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **MIDRISE OFFICE**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 99,385
Living Building Gross SF = 99,385
Site Gross Acreage = 5.24

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**9.6%**	**0.7%**	**$1,420,795**	**$14.30**	**$1,557,795**	**$15.67**
Baseline Building			$1,420,795	$14.30	$1,420,795	$14.30
W2 Rainwater Containment - 78,800 gal Rainwater Tank					$137,000	$1.38
B Shell	**6.7%**	**2.4%**	**$7,159,737**	**$72.04**	**$7,636,669**	**$76.84**
Baseline Building			$7,159,737	$72.04	$7,159,737	$72.04
M2E Operable Windows (manual)					$61,920	$0.62
D3C Reallocate Glazing from East and West Façade to South (less spandrel panel, more skin)					($48,115)	($0.48)
L1B Replace Roofing with Glazed Skylight					$168,750	$1.70
E1A Improved Glazing (reduce solar heat gain)					$42,098	$0.42
E1B Exterior Shading Devices					($207,300)	($2.09)
D2A Added Wall / Skin for Modified Design (not in base building design)					$315,040	$3.17
D2B Modifications to Roof Structure					$52,539	$0.53
L1D Interior Light Shelves					$92,000	$0.93
C Interiors	**10.4%**	**2.0%**	**$3,724,311**	**$37.47**	**$4,113,078**	**$41.39**
Baseline Building			$3,724,311	$37.47	$3,724,311	$37.47
M2D Carpet Reduction (Replaced with Retroplate)					$99,385	$1.00
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$149,078	$1.50
L1A Exposed Ceilings (white matte surfaces)					($210,696)	($2.12)
D3 Atrium Space (smoke curtain, glazing, guardrails)					$351,000	$3.53
D.1 Services - Conveying Systems	**24.1%**	**0.3%**	**$207,466**	**$2.09**	**$257,466**	**$2.59**
Baseline Building			$207,466	$2.09	$207,466	$2.09
D3 Added Stop for 5th Floor					$50,000	$0.50
D.2 Services - Plumbing Systems	**15.5%**	**0.7%**	**$838,297**	**$8.43**	**$968,097**	**$9.74**
Baseline Building			$838,297	$8.43	$838,297	$8.43
W6 Low-Flow Fixtures / Optical Sensors					$4,800	$0.05
W2 Rain Harvesting (piping & pumps and filtration)					$125,000	$1.26
D.3 Services - HVAC Systems	**57.2%**	**5.0%**	**$1,725,708**	**$17.36**	**$2,713,598**	**$27.30**
Baseline Building			$1,689,708	$17.00	$1,689,708	$17.00
Baseline HVAC System					($938,935)	($9.45)
M2A In-Slab Radiant Heating and Cooling					$496,925	$5.00
M3A Ground Source Heat Pump					$1,311,400	$13.20
M2B Energy Recovery Wheel / Plate & Frame					$118,500	$1.19
M2C Carbon Dioxide Sensors			$36,000	$0.36	$36,000	$0.36
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$272,482**	**$2.74**	**$272,482**	**$2.74**
Baseline Building			$272,482	$2.74	$272,482	$2.74
D.5 Services - Electrical Systems	**12.9%**	**1.5%**	**$2,307,176**	**$23.21**	**$2,604,176**	**$26.20**
Baseline Building			$2,024,176	$20.37	$2,024,176	$20.37
PA Occupancy Sensor to Outlets					$42,000	$0.42
PE High Efficiency Main Transformer					$43,000	$0.43
L1C Daylight Controls (continuous dimming 15' from perimeter)			$37,000	$0.37	$37,000	$0.37
L2A Efficient Light Fixture Optics Premium			$190,000	$1.91	$190,000	$1.91
L2B Occupancy Sensor for Lighting (closed office / conference spaces)			$22,000	$0.22	$22,000	$0.22
L2C Individual Light Level Control (open spaces)					$212,000	$2.13
L2E Occupancy Sensor for Transient and Egress Lighting			$34,000	$0.34	$34,000	$0.34
E Equipment and Furnishings	**0.0%**	**0.0%**	**$472,675**	**$4.76**	**$472,675**	**$4.76**
Baseline Building			$472,675	$4.76	$472,675	$4.76

BUILDING TYPE: **MIDRISE OFFICE**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 99,385
Living Building Gross SF = 99,385
Site Gross Acreage = 5.24

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline Total	LEED™ Gold Baseline Cost/SF	Living Building Total	Living Building Cost/SF
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**39.6%**	**2.9%**	**$1,465,612**	**$14.75**	**$2,046,362**	**$20.59**
Baseline Building				$1,465,612	$14.75	$1,465,612	$14.75
W4 Stormwater Retention						$50,000	$0.50
D3 Parking revisions (pervious, deletion of piping, deletion of AC, lighting)						$91,750	$0.92
D3 Parking shading/PV structure						$439,000	$4.42
H Logistics		**0.0%**	**0.0%**	**$218,298**	**$2.20**	**$218,298**	**$2.20**
Baseline Building				$218,298	$2.20	$218,298	$2.20
Living Building Prerequisites				**$0**	**$0.00**	**$478,863**	**$4.82**
PR5 - Materials Red List		**100.0%**	**0.9%**			$178,000	$1.79
PR7 - Responsible Industry		**100.0%**	**0.1%**			$18,863	$0.19
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.4%**			$282,000	$2.84
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**			$0	
Subtotal Direct Costs			17.8%	$19,812,558	$199.35	$23,339,559	$234.84
General Conditions	4.0%	**17.8%**	**0.7%**	$792,502	$7.97	$933,582	$9.39
Fee, Construction Contingency, Insurance	8.0%	**17.8%**	**1.5%**	$1,648,405	$16.59	$1,941,851	$19.54
Location Modifier for PORTLAND, OR	1.00	**0.0%**	**0.0%**	$0		$0	
TOTAL MODIFIED CONSTRUCTION COST			**17.8%**	**$22,253,465**	**$223.91**	**$26,214,993**	**$263.77**

BUILDING TYPE: **MIDRISE OFFICE**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 99,385
Living Building Gross SF = 99,385
Site Gross Acreage = 5.24

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.3%			$60,000	$0.60
PV1	Photovoltaic Panels and Infrastructure	876,000	Watts		100.0%	33.2%			$6,570,000	$66.11
LB Prerequisite Items										
	PR3 - Habitat Exchange	5.24	acres		100.0%	0.1%			$26,200	$0.26
	PR6 - Construction Carbon Footprint	2,700	tons		100.0%	0.1%			$29,700	$0.30
	PR15 - Beauty and Spirit (included in A/E fees above)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$43,500	$0.44
Development Costs			LEED	LBC						
	Develoment Costs		13.06%	16.06%	44.9%	6.6%	$2,906,502	$29.24	$4,210,363	$42.36
	Architecture & Engineering		6.09%	8.09%	56.5%	3.9%	$1,355,179	$13.64	$2,120,726	$21.34
Credits / Rebates / Incentives										
	BETC	35%			68.8%	-0.4%	($125,000)	($1.26)	($211,000)	($2.12)
	ETO - Energy Trust of Oregon				831.8%	-0.9%	($22,000)	($0.22)	($205,000)	($2.06)
	PV Credits-(state, city, utility)	80%			-100.0%	-26.5%			($5,256,000)	($52.89)
	SDC Credits	50%		0.00%	-100.0%	-1.5%	$0		($289,395)	($2.91)
TOTAL OWNER & DESIGN-BUILD COSTS						**72.5%**	**$4,114,681**	**$41.40**	**$7,099,094**	**$71.43**

TOTAL CONCEPTUAL COST: **$26,368,147** **$265.31** **$33,314,086** **$335.20**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **24%** **TO** **29%**
MIDRISE OFFICE IN PORTLAND, OR

INCLUDING HIGH PERFORMING GREEN BUILDINGS OF PORTLAND (HPGBP): **21%** **TO** **26%**

MidRiseOffice
Portland

Normalized Baseline Energy Use Intensity (kBtu/SF) **74.3**

Normalized Baseline Energy Use (kWh) 2,156,413

Impact of Design Changes (see sketches/narrative) 1.03

Adjusted Baseline EUI (kBtu/SF) 76.2

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of total use		21%	26%	17%	4%	9%	23%	100%
calc'd EUI		16.1	19.9	12.6	3.1	6.8	17.7	76.2
Energy Conservation Measures:								
Glazing	**E1**		12.0%	7.5%		4.7%		4.8%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		8.0%	3.0%		2.5%		2.8%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	50.0%	-3.8%	5.0%		0.8%		10.5%
Remove ceiling, raise window head, add lightshelf	L1a							
Top daylighting from Atrium	L1g							
Daylight controls (continuous dimming)	L1c							
Lighting	**L2**	25.0%	-1.9%	2.5%		0.4%		5.2%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	5.8%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.4%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*75%*	*18%*	*26%*	*0%*	*11%*	*25%*	*31%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*16.4*	*9.4*	*3.1*	*6.0*	*13.3*	*52.3*
Mechanical - Distribution & Ventilation	**M2**		25.0%	22.0%		60.0%		12.9%
Radiant heating w/ dedicated outside air system (DOAS)	M2p							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Subtotal from Mechanical Distribution strategies (percentage)		*0%*	*25%*	*22%*	*0%*	*60%*	*0%*	*13%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*12.3*	*7.3*	*3.1*	*2.4*	*13.3*	*42.5*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		4.7%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				50.0%			2.1%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*50.0%*	*-15.0%*	*0.0%*	*6.7%*
Reduced EUI from All Energy Conservation Measures (kBTU/SF)		**4.0**	**9.8**	**5.9**	**1.6**	**2.8**	**13.3**	***37.3***
Final Energy Use Breakdown as Percentage of Baseline Use		**5%**	**13%**	**8%**	**2%**	**4%**	**17%**	**51%**

Building Operating Factor	0.90
Impact of Interactive ECM effects	1.07
Total Reduced EUI (kBTU/sf)	**36.0**
Total reduced energy use (kWh)	1,043,334
Number of crystaline panels needed	4,153
Total kW of PV array	851

92.9	CBECS Baseline EUI (kBTU/sf)
60%	target reduction from CBECS

Achievement:

61%	percent reduction from CBECS
52%	percent reduction from Normalized Baseline Bldg

Incentives:

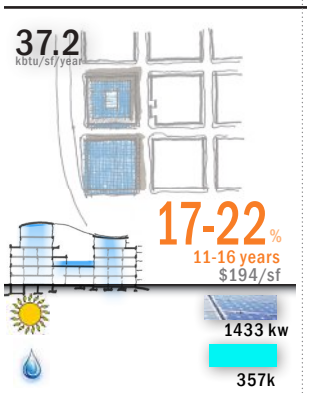
$ 211,485	ETO incentive for reduced EUI
$ 22,195	Estimated ETO incentive for original design bldg
$ 81,438	BETC for Platinum (minus Gold), pass-thru

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	227.042	4596	27,922	2239	Panels at parking lot, sunshade, covered walkway
	15°	244.678	4265	0	0	
optimal angle:	32.5°	281.857	3702	23,871	1914	Panels at sloping roof less atrium
	45°	247.953	4208		0	
	90°	175.198	5956		0	
				Total kWh =	**1,047,821**	

MIXED USE RENOVATION
PORTLAND temperate

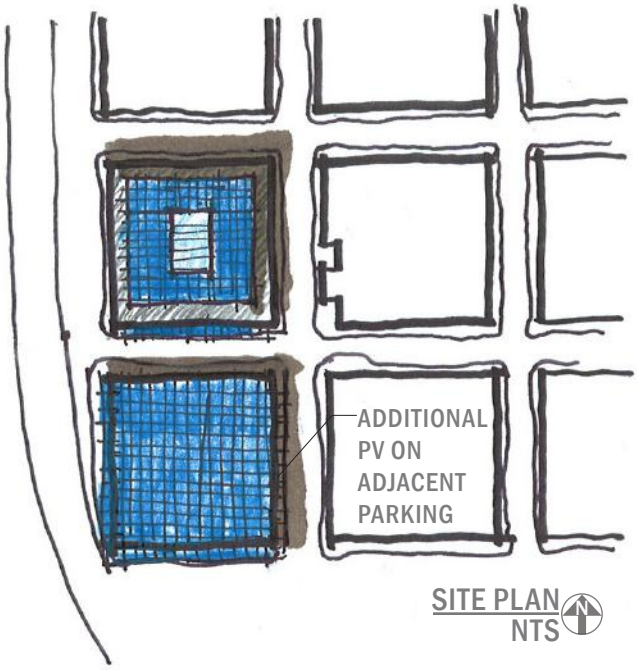


ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

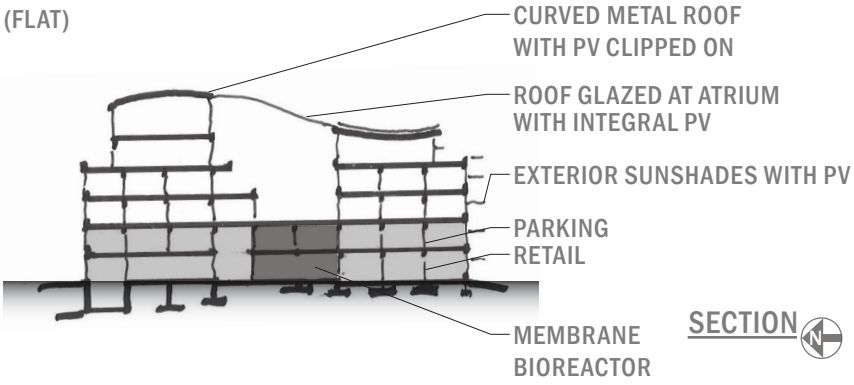
PHOTOVOLTAIC CAPACITY

WATER USE



SITE PLAN
NTS

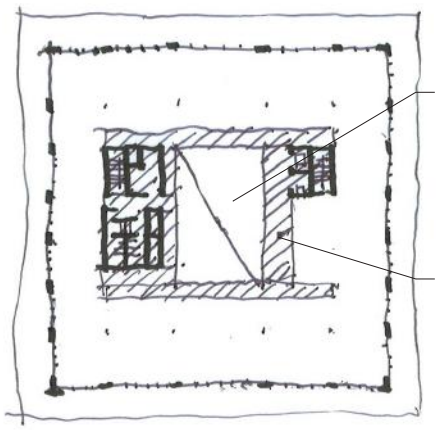
55,000 gal	RAIN WATER TANK SIZE
185,043 sf	BUILDING SIZE
6 floors	BUILDING HEIGHT
1.0 acres	SITE AREA
87,170 sf	PHOTOVOLTAIC AREA
40,000 sf	ROOF AREA (FLAT)



SECTION

MAJOR DESIGN STRATEGIES:

- ✓ Extend atrium down one level to allow access to operable windows for all workstations.
- ✓ Provide additional 1/2 level to make up for floor area lost with insertion of atrium.
- ✓ Change curved roof form to maximize PV production.
- ✓ Add PV sun shades on South.
- ✓ Add PV to adjacent parking garage to offset both the parking garage loads and the building's loads.



PLAN
NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **MIXED-USE RENOVATION**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 185,043
Living Building Gross SF = 185,043
Site Gross Acreage = 1.00

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**0.0%**	**0.0%**	**$579,458**	**$3.13**	**$579,458**	**$3.13**
Baseline Building			$579,458	$3.13	$579,458	$3.13
W2 Rainwater Containment - 55,000 gal Rainwater Tank (in base building)					$0	
B Shell	**17.5%**	**4.8%**	**$8,421,922**	**$45.51**	**$9,899,367**	**$53.50**
Baseline Building			$8,421,922	$45.51	$8,421,922	$45.51
M2E Operable Windows (manual, additional units beyond existing)					$32,000	$0.17
L1B Replace Roofing with Glazed PV Frit Skylight					$172,125	$0.93
E1A Improved Glazing (reduce solar heat gain)					$25,000	$0.14
E1B Exterior Shading Devices (PV as shading on South)					$109,375	$0.59
L1D Raise Window Head / Add Light Shelf (RAF removed)					$0	
M2H "High Mass" Concrete Inside Insulation (not included because this is a renovation)					$0	
D2B Modifications to Roof Structure and Roofing					$99,000	$0.54
E2C Structure to Mount PV on Adjacent Parking Structure					$349,945	$1.89
D3 Renovation Work at Atrium (demo floor, railings, interior walls, structure for balcony)					$150,000	$0.81
D3 Added SF for Additional Floor (at penthouse)					$240,000	$1.30
D2A Added Wall / Skin for Modified Design (not in base building design)					$300,000	$1.62
L1D Interior Light Shelves (not included)					$0	
C Interiors	**2.1%**	**0.5%**	**$7,723,877**	**$41.74**	**$7,883,877**	**$42.61**
Baseline Building			$7,723,877	$41.74	$7,723,877	$41.74
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$270,000	$1.46
M2D Retroplate Topping Slab (at TI locations)					$690,000	$3.73
L1A Exposed Ceilings (existing white matte surfaces)					$0	
D3 Remove Raised Access Flooring					($800,000)	($4.32)
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$385,400**	**$2.08**	**$385,400**	**$2.08**
Baseline Building			$385,400	$2.08	$385,400	$2.08
D.2 Services - Plumbing Systems	**19.4%**	**0.5%**	**$791,454**	**$4.28**	**$945,254**	**$5.11**
Baseline Building			$791,454	$4.28	$791,454	$4.28
W6 Low-Flow Fixtures / Optical Sensors					$3,800	$0.02
W2 Rain Harvesting (piping & pumps and filtration)					$150,000	$0.81
D.3 Services - HVAC Systems	**-2.4%**	**-0.2%**	**$2,767,999**	**$14.96**	**$2,701,518**	**$14.60**
Baseline Building			$2,767,999	$14.96	$2,767,999	$14.96
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,470,281)	($13.35)
M2A In-Slab Radiant Heating and Cooling					$600,000	$3.24
M3A Ground Source Heat Pump					$1,652,800	$8.93
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$135,000	$0.73
M2C Carbon Dioxide Sensors					$16,000	$0.09
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$343,553**	**$1.86**	**$343,553**	**$1.86**
Baseline Building			$343,553	$1.86	$343,553	$1.86
D.5 Services - Electrical Systems	**24.1%**	**3.6%**	**$4,539,215**	**$24.53**	**$5,631,885**	**$30.44**
Baseline Building			$4,571,685	$24.71	$4,571,685	$24.71
PA Occupancy Sensor to Outlets					$47,200	$0.26
PE High Efficiency Transformers					$158,000	$0.85
L1C Daylight Controls (continuous dimming 15' from perimeter)					$0	
L2A Efficient Light Fixture Optics Premium					$270,000	$1.46
L2B Occupancy Sensor for Lighting (closed office / conference spaces)					$0	
L2C Individual Light Level Control (open spaces, classrooms)					$585,000	$3.16
L2E Occupancy Sensor for Transient and Egress Lighting			($32,470)	($0.18)	$0	

BUILDING TYPE: **MIXED-USE RENOVATION**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 185,043
Living Building Gross SF = 185,043
Site Gross Acreage = 1.00

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$2,061,480**	**$11.14**	**$2,061,480**	**$11.14**
Baseline Building				$2,061,480	$11.14	$2,061,480	$11.14
F Special Construction		**0.0%**	**0.0%**	**$1,407,188**	**$7.60**	**$1,407,188**	**$7.60**
Baseline Building				$1,407,188	$7.60	$1,407,188	$7.60
G Sitework		**4.4%**	**0.2%**	**$1,131,528**	**$6.11**	**$1,181,528**	**$6.39**
Baseline Building				$1,131,528	$6.11	$1,131,528	$6.11
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.27
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$600,000**	**$3.24**	**$600,000**	**$3.24**
Baseline Building				$600,000	$3.24	$600,000	$3.24
Living Building Prerequisites				**$0**	**$0.00**	**$621,055**	**$3.36**
PR5 - Materials Red List		**100.0%**	**0.8%**			$242,636	$1.31
PR7 - Responsible Industry		**100.0%**	**0.1%**			$34,692	$0.19
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.0%**			$309,388	$1.67
PR9 - Leadership in Construction Waste		**100.0%**	**0.1%**			$34,339	$0.19
Subtotal Direct Costs			11.3%	$30,753,074	$166.19	$34,241,563	$185.05
General Conditions	4.0%	**11.3%**	**0.5%**	$1,230,123	$6.65	$1,369,663	$7.40
Fee, Construction Contingency, Insurance	0.7%	**11.3%**	**0.1%**	$238,965	$1.29	$266,072	$1.44
Location Modifier for PORTLAND, OR	1.00	**0.0%**	**0.0%**	$0		$0	
TOTAL MODIFIED CONSTRUCTION COST			**11.3%**	**$32,222,162**	**$174.13**	**$35,877,298**	**$193.89**

BUILDING TYPE: **MIXED-USE RENOVATION**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 185,043
Living Building Gross SF = 185,043
Site Gross Acreage = 1.00

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.2%			$60,000	$0.32
PV1	Photovoltaic Panels and Infrastructure	1,433,000	Watts		100.0%	34.9%			$10,747,500	$58.08
LB Prerequisite Items										
	PR3 - Habitat Exchange	1	acres		100.0%	0.0%			$5,000	$0.03
	PR6 - Construction Carbon Footprint	1,250	tons @ 50%		100.0%	0.0%			$13,750	$0.07
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$63,500	$0.34
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	23.3%	6.8%	$9,022,205	$48.76	$11,121,962	$60.10
	Architecture & Engineering		7.00%	9.00%	43.2%	3.2%	$2,255,551	$12.19	$3,228,957	$17.45
Credits / Rebates / Incentives										
	BETC	35%			66.0%	-0.4%	($173,152)	($0.94)	($287,365)	($1.55)
	ETO - Energy Trust of Oregon				193.0%	-0.8%	($132,211)	($0.71)	($387,340)	($2.09)
	PV Credits-(state, city, utility)	80%			-100.0%	-28.0%	$0		($8,598,000)	($46.46)
	SDC Credits	50%			-100.0%	-1.1%	$0		($349,890)	($1.89)
TOTAL OWNER & DESIGN-BUILD COSTS						**42.3%**	**$10,972,394**	**$59.30**	**$15,618,074**	**$84.40**
					TOTAL CONCEPTUAL COST:		**$43,194,556**	**$233.43**	**$51,495,372**	**$278.29**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **17%** **TO** **22%**
MIXED-USE RENOVATION IN PORTLAND, OR

INCLUDING HIGH PERFORMING GREEN BUILDINGS OF PORTLAND (HPGBP): **13%** **TO** **18%**

Complex Mixed Use Renovation
Portland

Normalized Baseline Energy Use Intensity (kBtu/SF)	**83.6**	Normalized Baseline Energy Use (kWh)	3,553,180
Impact of Design Changes (see sketches)	0.97		
Adjusted Baseline EUI (kBtu/SF)	**81.4**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		19%	30%	18%	4%	9%	21%	100%
calc'd EUI		15.3	24.4	14.7	3.0	7.3	16.8	81.4
Energy Conservation Measures:								
Glazing	**E1**		10.0%	10.0%		5.0%		5.2%
Improve Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		15.0%	6.0%		4.8%		6.0%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	38.0%	-2.9%	3.8%		0.6%		7.0%
Remove ceiling, raise window head, add lightshelf	L1a							
Daylight controls (continuous dimming)	L1c							
Floorplan renovation for daylighting	L1e							
Lighting	**L2**	38.5%	-2.9%	3.9%		0.6%		7.1%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
High color rendering metal halide retail lighting	L2h							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	5.1%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Parking: variable flow ventilation based on CO monitor	Pi							
Super-efficient elevators (hybrid)	Pk							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.6%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*76.5%*	*22.4%*	*31.2%*	*0.0%*	*13.8%*	*25.0%*	*33.1%*
Subtotal Reduced EUI (kBTU/SF)		*3.6*	*19.0*	*10.1*	*3.0*	*6.3*	*12.6*	*54.5*
Mechanical - Distribution & Ventilation	**M2**		15.0%	22.0%		60.0%		10.9%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Programmable thermostats	M2o							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*22.0%*	*0.0%*	*60.0%*	*0.0%*	*10.9%*
Subtotal Reduced EUI (kBTU/SF)		*3.6*	*16.1*	*7.9*	*3.0*	*2.5*	*12.6*	*45.7*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		15.0%		6.4%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				50.0%			1.8%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from tankless electric water heater	Wd							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*50.0%*	*15.0%*	*0.0%*	*8.2%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**3.6**	**12.9**	**6.3**	**1.5**	**2.1**	**12.6**	***39.0***
Final Energy Use Breakdown as Percentage of Baseline Use		**4%**	**16%**	**8%**	**2%**	**3%**	**15%**	**52%**

Building Operating Factor	0.90	92.9	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
Total Reduced EUI (kBTU/sf)	**37.2**	Achievement:	**TARGET REDUCTION NOT MET**
		60%	percent reduction from CBECS
		56%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	1,579,557	Incentives:	
		$ 374,988	ETO incentive for reduced EUI
Number of crystaline panels needed	6,989	$ 132,211	Estimated ETO incentive for original design bldg
Total kW of PV array	1433	$ 114,213	BETC for Platinum (minus Gold), pass-thru

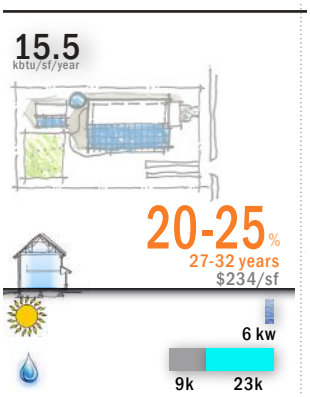
PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	227.042	6958	46,000	3688
	15°	244.678	6456		0
optimal angle:	32.5°	281.857	5605		0
Assume an equal area parking garage with an EUI of 1.7	45°	247.953	6371		0
	90°	175.198	9016		0
				Total kWh =	**837,331**

Entire parking garage roof less elevator	Additional area	41,170	3301	**Adjacent parking garage**
	Additional kWh Produced		**749,466**	1,586,797

SINGLE FAMILY RESIDENTIAL
PORTLAND temperate

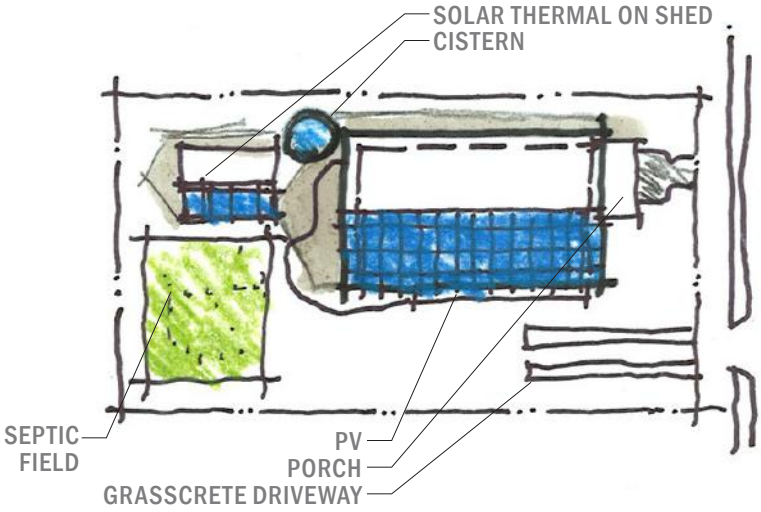


ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

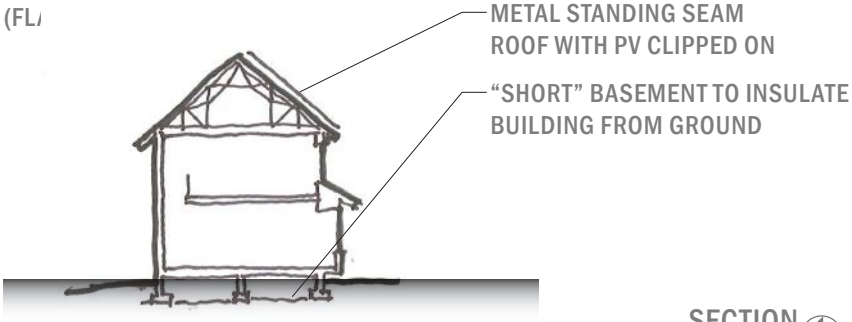
PHOTOVOLTAIC CAPACITY

WATER USE



10,000 gal RAIN WATER TANK SIZE
1,840 sf BUILDING SIZE
2 floors BUILDING HEIGHT
0.11 acres SITE AREA
398 sf PHOTOVOLTAIC AREA
1,031 sf ROOF AREA (FL/

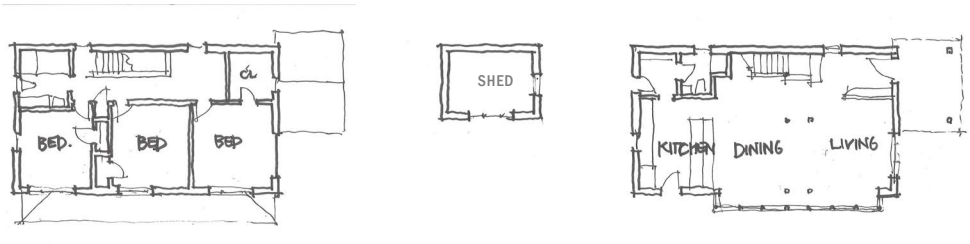
SITE PLAN NTS



SECTION

MAJOR DESIGN STRATEGIES:

- ✓ Insulated concrete units form walls for increased insulation.
- ✓ Composting toilets minimize water use and waste production.
- ✓ Cistern for water collection.
- ✓ Solar Thermal on Shed.
- ✓ Short Basement to insulate building from ground.



LEVEL 2

LEVEL 1

PLANS NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **SINGLE FAMILY RESIDENTIAL**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = **1,840**
Living Building Gross SF = **1,840**
Site Gross Acreage = **0.11**

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**0.0%**	**0.0%**	**$63,527**	**$34.53**	**$63,527**	**$34.53**
Baseline Building			$63,527	$34.53	$63,527	$34.53
W2 Rainwater Containment - 10,000 gal Rainwater Tank (included in base building)					$0	
B Shell	**8.3%**	**3.8%**	**$131,226**	**$71.32**	**$142,129**	**$77.24**
Baseline Building			$131,226	$71.32	$131,226	$71.32
E1A Improved Glazing (reduce solar heat gain)					$4,303	$2.34
E1B Exterior Shading Devices					$6,600	$3.59
M2H "High Mass" Concrete (existing exterior walls are ICF)					$0	
C Interiors	**11.6%**	**1.5%**	**$37,430**	**$20.34**	**$41,780**	**$22.71**
Baseline Building			$37,430	$20.34	$37,430	$20.34
M2A Thicken Lower Level Slab (2") and Gypcrete on Upper Level					$4,350	$2.36
L1A Exposed Ceilings (white matte surfaces)					$0	
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building			$0		$0	
D.2 Services - Plumbing Systems	**57.3%**	**2.1%**	**$10,654**	**$5.79**	**$16,754**	**$9.11**
Baseline Building			$10,654	$5.79	$10,654	$5.79
W6 Low-Flow Fixtures / Optical Sensors					$0	
W2 Rain Harvesting (piping & pumps and filtration)					$0	
W7 Composting Toilets					$6,100	$3.32
D.3 Services - HVAC Systems	**98.4%**	**4.1%**	**$12,008**	**$6.53**	**$23,827**	**$12.95**
Baseline Building			$12,008	$6.53	$12,008	$6.53
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($7,381)	($4.01)
M2A In-Slab Radiant Heating and Cooling					$9,200	$5.00
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$0	
M3C Solar Thermal System					$10,000	$5.43
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building			$0		$0	
D.5 Services - Electrical Systems	**68.1%**	**2.4%**	**$10,136**	**$5.51**	**$17,036**	**$9.26**
Baseline Building			$10,136	$5.51	$10,136	$5.51
L2K Provide hardwired compact fluorescent fixtures in all spaces					$2,200	$1.20
L2L Motion sensors for exterior lighting					$300	$0.16
M2Z Ceiling Fans and window box fans (five of each)					$4,400	$2.39

BUILDING TYPE: **SINGLE FAMILY RESIDENTIAL**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 1,840
Living Building Gross SF = 1,840
Site Gross Acreage = 0.11

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$1,011**	**$0.55**	**$1,011**	**$0.55**
Baseline Building				$1,011	$0.55	$1,011	$0.55
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**60.9%**	**4.2%**	**$20,208**	**$10.98**	**$32,508**	**$17.67**
Baseline Building				$20,208	$10.98	$20,208	$10.98
W4 Stormwater Retention / Building Water Discharge						$12,300	$6.68
H Logistics		**0.0%**	**0.0%**	**$3,280**	**$1.78**	**$3,280**	**$1.78**
Baseline Building				$3,280	$1.78	$3,280	$1.78
Living Building Prerequisites				**$0**	**$0.00**	**$13,603**	**$7.39**
PR5 - Materials Red List		**100.0%**	**1.0%**			$2,907	$1.58
PR7 - Responsible Industry		**100.0%**	**2.6%**			$7,488	$4.07
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.1%**			$3,208	$1.74
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**			$0	
Subtotal Direct Costs			22.8%	$289,480	$157.33	$355,456	$193.18
General Conditions	9.5%	**22.8%**	**2.2%**	$27,383	$14.88	$33,624	$18.27
Fee, Construction Contingency, Insurance	10.5%	**22.8%**	**2.6%**	$33,399	$18.15	$41,011	$22.29
Location Modifier for PORTLAND, OR	1.00	**0.0%**	**0.0%**	$0		$0	
TOTAL MODIFIED CONSTRUCTION COST			**22.8%**	**$350,263**	**$190.36**	**$430,091**	**$233.75**

BUILDING TYPE: **SINGLE FAMILY RESIDENTIAL**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = **1,840**
Living Building Gross SF = **1,840**
Site Gross Acreage = **0.11**

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				0.0%	0.0%			$0	
PV1	Photovoltaic Panels and Infrastructure	5,900	Watts		100.0%	18.3%			$53,100	$28.86
LB Prerequisite Items										
	PR3 - Habitat Exchange	0.114784	acres		100.0%	0.2%			$574	$0.31
	PR6 - Construction Carbon Footprint	50	tons		100.0%	0.2%			$550	$0.30
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.5%			$1,500	$0.82
Development Costs			LEED	LBC						
	Develoment Costs		3.43%	2.79%	0.0%	0.0%	$12,000	$6.52	$12,000	$6.52
	Architecture & Engineering		12.00%	15.00%	53.5%	7.8%	$42,032	$22.84	$64,514	$35.06
Credits / Rebates / Incentives										
	RETC	35%			-100.0%	-4.0%	$0		($11,590)	($6.30)
	ETO - Energy Trust of Oregon				-100.0%	-3.9%	$0		($11,400)	($6.20)
	HPGBP - High Performing Green Buildings of Portland		($5.19)	($12.87)	0.0%	0.0%	$0		$0	
	PV Credits-(state, city, utility)	80%			-100.0%	-14.7%	$0		($42,480)	($23.09)
	SDC Credits	50%			-100.0%	-1.0%	$0		($2,966)	($1.61)
TOTAL OWNER & DESIGN-BUILD COSTS						**18.1%**	**$54,032**	**$29.36**	**$63,802**	**$34.68**
							$404,294	**$219.73**	**$493,893**	**$268.42**

TOTAL CONCEPTUAL COST:

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **20%** **TO** **25%**
SINGLE FAMILY RESIDENTIAL IN PORTLAND, OR

INCLUDING HIGH PERFORMING GREEN BUILDINGS OF PORTLAND (HPGBP): **16%** **TO** **21%**

Single Family Residential
Portland

Normalized Baseline Energy Use Intensity (kBtu/SF)	**39.4**	Normalized Baseline Energy Use (kWh)	21,027
Impact of Design Changes (see sketches)	0.95		
Adjusted Baseline EUI (kBtu/SF)	**37.3**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		14%	38%	6%	10%	9%	23%	100%
calc'd EUI		5.2	14.2	2.2	3.7	3.4	8.6	37.3
Energy Conservation Measures:								
Glazing	**E1**		10.0%	8.0%		4.4%		4.7%
High performance residential glazing	E1f							
Add effective shading devices	E1b							
Insulated panels for glazing (thermal window shades)	E1g							
Walls & Roof	**E2**		7.0%	3.0%		2.3%		3.0%
Shaded roof from solar panels	E2a							
Optimize insulation - single family residential	E2i							
Lighting	**L2**	53.8%	-4.0%	5.4%		0.8%		6.4%
Provide hardwired compact fluorescent fixtures in all spaces.	L2k							
Motion sensors for exterior lighting	L2l							
Plug Loads	**P**		-2.3%	3.0%		0.5%	30.0%	6.3%
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Occupant buy-in / personal energy budget	Pf							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.4%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		***53.8%***	***15.7%***	***24.4%***	***0.0%***	***10.5%***	***30.0%***	***22.8%***
Subtotal Reduced EUI (kBTU/SF)		***2.4***	***11.9***	***1.7***	***3.7***	***3.0***	***6.0***	***28.8***
Mechanical - Distribution & Ventilation	**M2**		15.0%	100.0%		60.0%		14.2%
Radiant floor heating	M2y							
Energy recovery ventilation	M2b							
Natural ventilation: operable windows	M2e							
Eliminate cooling	M2j							
Ceiling fans and window box fans	M2z							
Subtotal from Mechanical Distribution strategies (percentage)		***0.0%***	***15.0%***	***100.0%***	***0.0%***	***60.0%***	***0.0%***	***14.2%***
Subtotal Reduced EUI (kBTU/SF)		***2.4***	***10.1***	***0.0***	***3.7***	***1.2***	***6.0***	***23.5***
Mechanical - Plant Systems	**M3**		40.0%					10.9%
Solar thermal (evacuated tubes) Heating System	M3c							
Domestic Hot Water	**W**				75.0%			7.5%
Solar-thermal domestic water	Wa							
Low flow fixtures (showers, lavs, sinks)	Wb							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		***0.0%***	***40.0%***	***0.0%***	***75.0%***	***0.0%***	***0.0%***	***18.4%***
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**2.4**	**6.1**	**0.0**	**0.9**	**1.2**	**6.0**	***16.6***
Final Energy Use Breakdown as Percentage of Baseline Use		**6%**	**16%**	**0%**	**3%**	**3%**	**16%**	**55%**

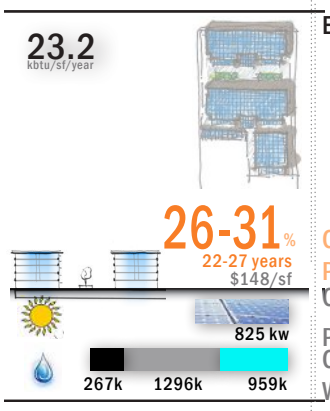
Building Operating Factor	0.90	43.8	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
Total Reduced EUI (kBTU/sf)	**15.5**	Achievement:	
		65%	percent reduction from CBECS
		61%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	8,294	Incentives:	
		$ 2,419	ETO incentive for reduced EUI
Number of crystaline panels needed	31	$ -	Estimated ETO incentive for original design bldg
Total kW of PV array	6	$ 1,952	BETC for Platinum (minus Gold), pass-thru

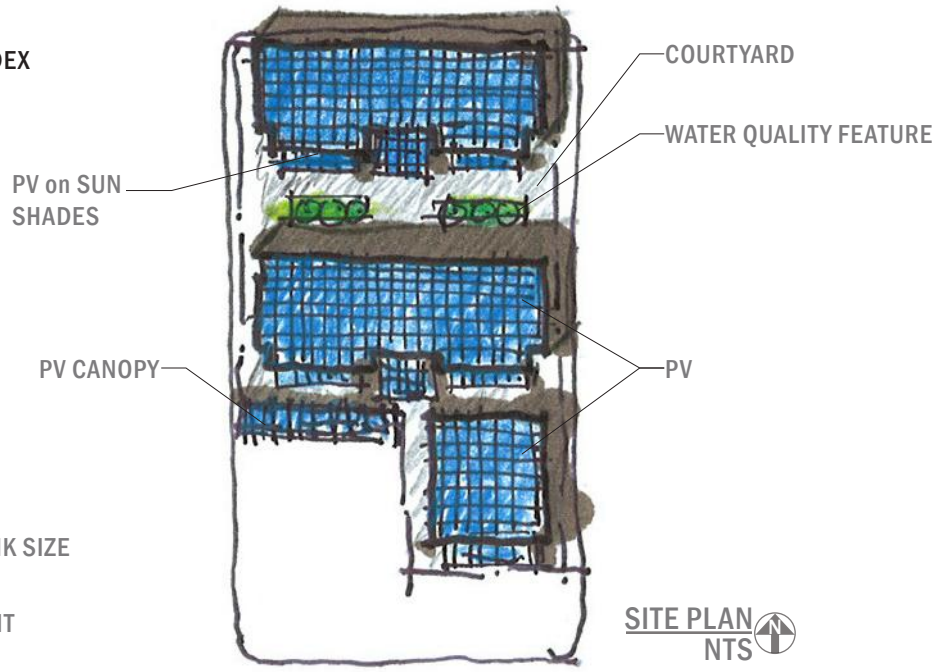
PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	227.042	37		0
	15°	244.678	34		0
optimal angle:	32.5°	281.857	30	398	31
	45°	247.953	34		0
	90°	175.198	48		0
				Total kWh =	**8,738**

MULTIFAMILY RESIDENTIAL
PORTLAND temperate

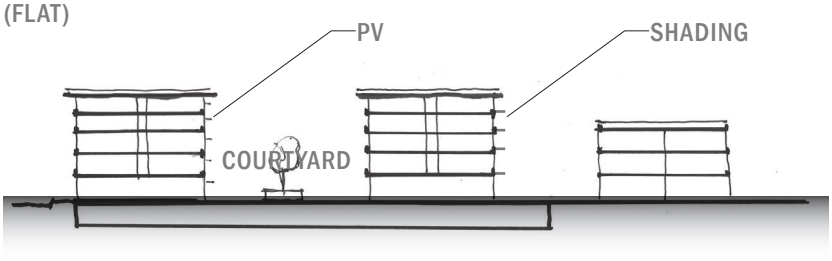




300,000 gal	RAIN WATER TANK SIZE
240,187 sf	BUILDING SIZE
5 floors	BUILDING HEIGHT
2.87 acres	SITE AREA
50,200 sf	PHOTOVOLTAIC AREA
42,393 sf	ROOF AREA (FLAT)

MAJOR DESIGN STRATEGIES:

- ✓ Increase floor to floor height to allow better daylight penetration.
- ✓ Reconfigure housing units to be oriented in N/S direction for better access to daylight.
- ✓ Reconfigure floor plans to allow units to have all habitable rooms within 30' of an operable window.



SECTION

LEVEL 1 LEVELS 2,3,4 LEVEL 5

PLANS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **MULTI-FAMILY HOUSING**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 209,678
Living Building Gross SF = 209,678
Site Gross Acreage = 2.87

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**10.3%**	**0.3%**	**$622,710**	**$2.97**	**$686,735**	**$3.28**
Baseline Building			$622,710	$2.97	$622,710	$2.97
W2 Rainwater Containment - 30,000 gal Rainwater Tank					$64,025	$0.31
B Shell	**5.0%**	**1.6%**	**$7,656,970**	**$36.52**	**$8,040,942**	**$38.35**
Baseline Building			$7,656,970	$36.52	$7,656,970	$36.52
E1D Reduce Glazing (30% of original window glazing)					$165,200	$0.79
E1A Improved Glazing (reduce solar heat gain)					$12,972	$0.06
E1B Exterior Shading Devices					$468,000	$2.23
D2A Reduce Wall / Skin for Modified Design (not in base building design)					($405,600)	($1.93)
D3 Relocate Elevator					$45,000	$0.21
D3 Covered Walkway					$98,400	$0.47
C Interiors	**5.3%**	**1.3%**	**$5,891,333**	**$28.10**	**$6,205,850**	**$29.60**
Baseline Building			$5,891,333	$28.10	$5,891,333	$28.10
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$314,517	$1.50
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$244,158**	**$1.16**	**$244,158**	**$1.16**
Baseline Building			$244,158	$1.16	$244,158	$1.16
D.2 Services - Plumbing Systems	**8.0%**	**0.6%**	**$1,900,476**	**$9.06**	**$2,052,276**	**$9.79**
Baseline Building			$1,900,476	$9.06	$1,900,476	$9.06
W6 Low-Flow Fixtures / Optical Sensors					$1,800	$0.01
W2 Rain Harvesting (piping & pumps and filtration)					$150,000	$0.72
D.3 Services - HVAC Systems	**387.3%**	**11.5%**	**$717,870**	**$3.42**	**$3,498,260**	**$16.68**
Baseline Building			$717,870	$3.42	$717,870	$3.42
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($535,000)	($2.55)
M2A In-Slab Radiant Heating and Cooling					$1,048,390	$5.00
M3A Ground Source Heat Pump					$1,959,000	$9.34
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$308,000	$1.47
M2C Carbon Dioxide Sensors					$0	
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$462,507**	**$2.21**	**$462,507**	**$2.21**
Baseline Building			$462,507	$2.21	$462,507	$2.21
D.5 Services - Electrical Systems	**0.6%**	**0.1%**	**$3,452,618**	**$16.47**	**$3,471,778**	**$16.56**
Baseline Building			$3,416,018	$16.29	$3,416,018	$16.29
L2E Occupancy Sensor for Transient Lighting (corridors/stairs)			$28,000	$0.13		
L2I Dual day/night light levels in corridors; occupancy sensors			$8,600	$0.04		
L2K Provide hardwired compact fluorescent fixtures in all spaces					$55,760	$0.27

BUILDING TYPE: **MULTI-FAMILY HOUSING**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 209,678
Living Building Gross SF = 209,678
Site Gross Acreage = 2.87

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$948,170**	**$4.52**	**$948,170**	**$4.52**
Baseline Building				$948,170	$4.52	$948,170	$4.52
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**6.2%**	**0.6%**	**$2,221,462**	**$10.59**	**$2,358,962**	**$11.25**
Baseline Building				$2,221,462	$10.59	$2,221,462	$10.59
W2 Stormwater Retention / Building Water Discharge						$50,000	$0.24
D3 Added Courtyard						$87,500	$0.42
H Logistics		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
Living Building Prerequisites				**$0**	**$0.00**	**$657,243**	**$3.13**
PR5 - Materials Red List		**100.0%**	**0.8%**			$194,424	$0.93
PR7 - Responsible Industry		**100.0%**	**0.8%**			$202,298	$0.96
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.1%**			$260,521	$1.24
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**				
Subtotal Direct Costs			18.7%	$24,118,274	$115.03	$28,626,881	$136.53
General Conditions	4.0%	**18.7%**	**0.7%**	$964,731	$4.60	$1,145,075	$5.46
Fee, Construction Contingency, Insurance	4.0%	**18.7%**	**0.8%**	$1,003,320	$4.79	$1,190,878	$5.68
Location Modifier for PORTLAND, OR	1.00	**0.0%**	**0.0%**	$0		$0	
TOTAL MODIFIED CONSTRUCTION COST			**18.7%**	**$26,086,325**	**$124.41**	**$30,962,834**	**$147.67**

BUILDING TYPE: **MULTI-FAMILY HOUSING**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 209,678
Living Building Gross SF = 209,678
Site Gross Acreage = 2.87

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	4.1%			$1,000,000	$4.77
PV1	Photovoltaic Panels and Infrastructure	825,000	Watts		100.0%	25.7%			$6,187,500	$29.51
LB Prerequisite Items										
	PR3 - Habitat Exchange	2.86961	acres		100.0%	0.1%			$14,348	$0.07
	PR6 - Construction Carbon Footprint	6,400	tons		100.0%	0.3%			$70,400	$0.34
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$43,500	$0.21
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	31.4%	9.5%	$7,304,171	$34.84	$9,598,479	$45.78
	Architecture & Engineering		7.00%	9.00%	52.6%	4.0%	$1,826,043	$8.71	$2,786,655	$13.29
Credits / Rebates / Incentives										
	BETC	35%			43.4%	-0.4%	($244,440)	($1.17)	($350,601)	($1.67)
	ETO - Energy Trust of Oregon				627.0%	-0.7%	($25,321)	($0.12)	($184,081)	($0.88)
	PV Credits-(state, city, utility)	80%			-100.0%	-20.5%	$0		($4,950,000)	($23.61)
	SDC Credits	50%			-100.0%	-1.4%	$0		($343,583)	($1.64)
TOTAL OWNER & DESIGN-BUILD COSTS						**56.6%**	**$8,860,453**	**$42.26**	**$13,872,617**	**$66.16**

TOTAL CONCEPTUAL COST: **$34,946,778** **$166.67** **$44,835,452** **$213.83**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **26%** **TO** **31%**
MULTI-FAMILY HOUSING IN PORTLAND, OR

INCLUDING HIGH PERFORMING GREEN BUILDINGS OF PORTLAND (HPGBP): **21%** **TO** **26%**

Multi- Family Residential
Portland

Normalized Baseline Energy Use Intensity (kBtu/SF)	**48.0**	Normalized Baseline Energy Use (kWh)	1,880,891
Impact of Design Changes (see sketches)	0.98		
Adjusted Baseline EUI (kBtu/SF)	**47.0**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		15%	30%	7%	13%	10%	25%	100%
calc'd EUI		7.1	14.1	3.3	6.1	4.7	11.8	47.0
Energy Conservation Measures:								
Glazing	**E1**		10.0%	10.0%		5.0%		4.2%
Improve Glazing	E1a							
Add effective shading devices	E1b							
Reduce glazing to 30%	E1d							
Walls & Roof	**E2**		6.0%	1.5%		1.7%		2.1%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Lighting	**L2**	56.6%	-4.2%	5.7%		0.8%		7.7%
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dual day/night light levels in corridors; occupancy sensors	L2i							
Provide hardwired compact fluorescent fixtures in all spaces.	L2k							
Plug Loads	**P**		-2.3%	3.0%		0.5%	30.0%	7.1%
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Parking: variable flow ventilation based on CO monitor	Pi							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.1%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*56.6%*	*14.5%*	*25.2%*	*0.0%*	*10.4%*	*30.0%*	*23.1%*
Subtotal Reduced EUI (kBTU/SF)		*3.1*	*12.1*	*2.5*	*6.1*	*4.2*	*8.2*	*36.2*
Mechanical - Distribution & Ventilation	**M2**		15.0%	20.0%		60.0%		10.3%
Water to water heat pumps, radiant slab heating/cooling	M2q							
Energy recovery ventilation	M2b							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*20.0%*	*0.0%*	*60.0%*	*0.0%*	*10.3%*
Subtotal Reduced EUI (kBTU/SF)		*3.1*	*10.3*	*2.0*	*6.1*	*1.7*	*8.2*	*31.3*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		4.7%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				75.0%			9.8%
Solar-thermal domestic water	Wa							
Low flow fixtures (showers, lavs, sinks)	Wb							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*75.0%*	*-15.0%*	*0.0%*	*14.4%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**3.1**	**8.2**	**1.6**	**1.5**	**1.9**	**8.2**	***24.5***
Final Energy Use Breakdown as Percentage of Baseline Use		**7%**	**17%**	**3%**	**3%**	**4%**	**18%**	**48%**

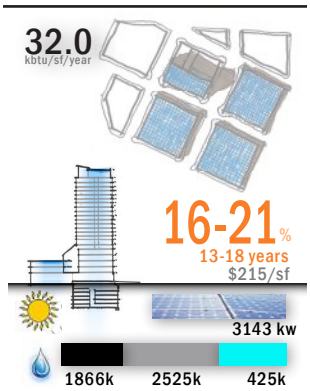
Building Operating Factor	0.90	60.0	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
Total Reduced EUI (kBTU/sf)	**23.2**	Achievement:	
		61%	percent reduction from CBECS
		52%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	908,801	Incentives:	
		$ 184,697	ETO incentive for reduced EUI
Number of crystaline panels needed	4,025	$ 25,321	Estimated ETO incentive for original design bldg
Total kW of PV array	825	$ 106,161	BETC for Platinum (minus Gold), pass-thru

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

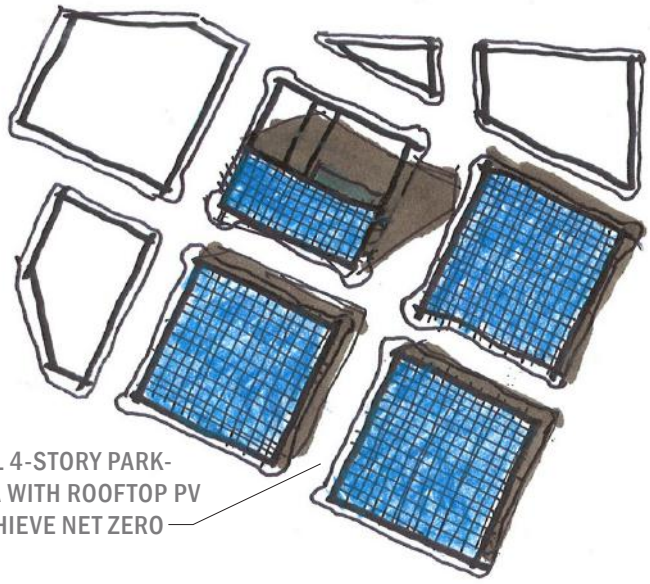
	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	227.042	4003	50,200	4025	Panels on roof + sun shades+ canopy
	15°	244.678	3715		0	
optimal angle:	32.5°	281.857	3225		0	
	45°	247.953	3666		0	
	90°	175.198	5188		0	
				Total kWh =	**913,844**	

HIGH RISE MIXED USE
PORTLAND temperate



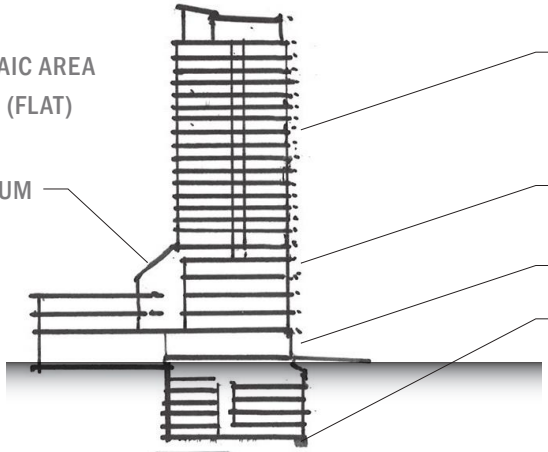
ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF
PHOTOVOLTAIC CAPACITY
WATER USE

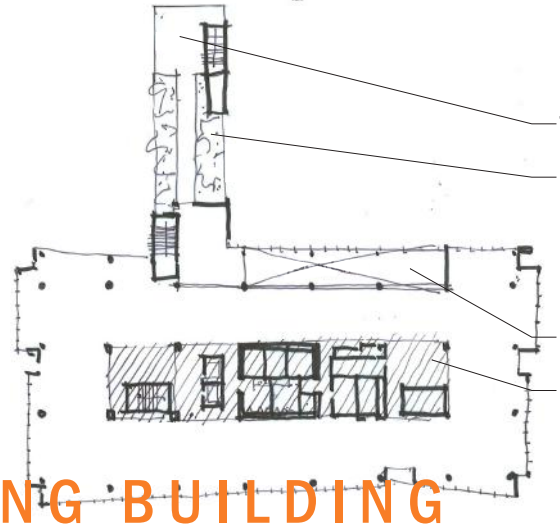


SITE PLAN
NTS

200,000 gal RAIN WATER TANK SIZE
547,624 sf BUILDING SIZE
22 floors BUILDING HEIGHT
0.92 acres SITE AREA
191,200 sf PHOTOVOLTAIC AREA
20,000 sf ROOF AREA (FLAT)



SECTION



PLAN
NTS

MAJOR DESIGN STRATEGIES:

- ✓ Increase floor to floor height to allow better daylight penetration.
- ✓ Add atrium at edge of the office portion of the building to increase daylight.
- ✓ Add an office floor to tower portion of building to ensure all workers are within 30' of operable window.
- ✓ PV integrated with the building skin on South and East facades.
- ✓ PV screen at building West facade.

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **HIGH RISE**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 547,624
Living Building Gross SF = 547,624
Site Gross Acreage = 0.92

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**0.5%**	**0.0%**	**$8,695,116**	**$15.88**	**$8,738,640**	**$15.96**
	Baseline Building			$8,695,116	$15.88	$8,695,116	$15.88
	Rainwater Containment - 200,000 gal Rainwater Tank (walls added to existing basement)					$43,524	$0.08
B	**Shell**	**6.0%**	**2.3%**	**$35,629,047**	**$65.06**	**$37,779,069**	**$68.99**
	Baseline Building			$35,629,047	$65.06	$35,629,047	$65.06
L1B	Replace Roofing with Glazed Skylight					$225,900	$0.41
D3A	Raise Floor to Floor Height					$918,000	$1.68
E1B	Exterior Shading Devices					$1,905,120	$3.48
W5	Water Collection on Vertical Surfaces / Top of Roof					$210,000	$0.38
D3	Relocate SF to additional 1/2 floor at top					$40,800	$0.07
D3	Remove Existing Green Roof					($30,000)	($0.05)
D3	Modifications to Lobby Space (structural and finishes)					$590,000	$1.08
L1E	Tracking Mirror above Atrium					$154,000	$0.28
D3	Added Elevator Stop for Additional Floor					$105,000	$0.19
E1D	Reduce Glazing to 30%					($2,315,798)	($4.23)
D3	Remove raised access flooring					($801,000)	($1.46)
PV3	Structure for PV on Adjacent Parking Structures					$986,000	$1.80
L1D	Interior Light Shelves (at office floors)					$162,000	$0.30
C	**Interiors**	**6.7%**	**1.6%**	**$22,739,127**	**$41.52**	**$24,272,474**	**$44.32**
	Baseline Building			$22,739,127	$41.52	$22,739,127	$41.52
M2D	Carpet Reduction (replace with RetroPlate)					$985,723	$1.80
M2O	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$547,624	$1.00
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$2,636,557**	**$4.81**	**$2,636,557**	**$4.81**
	Baseline Building			$2,636,557	$4.81	$2,636,557	$4.81
D.2	**Services - Plumbing Systems**	**0.0%**	**0.0%**	**$3,874,587**	**$7.08**	**$3,874,587**	**$7.08**
	Baseline Building			$3,874,587	$7.08	$3,874,587	$7.08
W6	Low-Flow Fixtures / Optical Sensors					$0	
W2	Rain Harvesting (piping & pumps and filtration)					$0	
D.3	**Services - HVAC Systems**	**44.0%**	**3.6%**	**$7,599,577**	**$13.88**	**$10,945,160**	**$19.99**
	Baseline Building			$7,599,577	$13.88	$8,449,577	$15.43
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($6,085,700)	($11.11)
M2A	In-Slab Radiant Heating and Cooling					$2,738,120	$5.00
M3A	Ground Source Heat Pump					$5,557,000	$10.15
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$286,163	$0.52
M2C	Carbon Dioxide Sensors					$0	
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$1,132,828**	**$2.07**	**$1,132,828**	**$2.07**
	Baseline Building			$1,132,828	$2.07	$1,132,828	$2.07
D.5	**Services - Electrical Systems**	**12.4%**	**0.8%**	**$6,138,326**	**$11.21**	**$6,901,276**	**$12.60**
	Baseline Building			$6,209,026	$11.34	$6,209,026	$11.34
PA	Occupancy Sensor to Outlets					$35,100	$0.06
PE	High Efficiency Transformers					$165,000	$0.30
L2A	Efficient light fixture optics					$160,200	$0.29
L2B	Occupancy Sensor for Lighting (closed office / conference spaces)					$18,850	$0.03
L2C	Individual Light Level Control (open spaces)					$179,000	$0.33
L2I	Dual day/night light levels in corridors; occupancy sensors					$134,100	$0.24
L2J	Occupancy sensor/time clock for corridor lighting					$0	
L2K	Provide hardwired compact fluorescent fixtures in all spaces			($70,700)	($0.13)	$0	

BUILDING TYPE: **HIGH RISE**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 547,624
Living Building Gross SF = 547,624
Site Gross Acreage = 0.92

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$3,326,853**	**$6.08**	**$3,326,853**	**$6.08**
Baseline Building				$3,326,853	$6.08	$3,326,853	$6.08
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**9.3%**	**0.1%**	**$537,417**	**$0.98**	**$587,417**	**$1.07**
Baseline Building				$537,417	$0.98	$537,417	$0.98
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.09
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$1,764,940**	**$3.22**	**$1,764,940**	**$3.22**
Baseline Building				$1,764,940	$3.22	$1,764,940	$3.22
Living Building Prerequisites				**$0**	**$0.00**	**$2,107,638**	**$3.85**
PR5 - Materials Red List		**100.0%**	**0.8%**			$746,050	$1.36
PR7 - Responsible Industry		**100.0%**	**0.2%**			$205,338	$0.37
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.2%**			$1,156,250	$2.11
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**			$0	
Subtotal Direct Costs			10.6%	$94,074,376	$171.79	$104,067,440	$190.03
General Conditions	3.2%	**10.6%**	**0.3%**	$3,005,271	$5.49	$3,324,506	$6.07
Fee, Contingency, Insurance, Bonding	9.8%	**10.6%**	**1.1%**	$9,471,412	$17.30	$10,477,514	$19.13
Location Modifier for PORTLAND, OR	1.00	**0.0%**	**0.0%**	$0		$0	
TOTAL MODIFIED CONSTRUCTION COST			**10.6%**	**$106,551,058**	**$194.57**	**$117,869,460**	**$215.24**

BUILDING TYPE: **HIGH RISE**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 547,624
Living Building Gross SF = 547,624
Site Gross Acreage = 0.92

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	1.1%			$1,000,000	$1.83
O1	Wind Turbines (net cost including credits)	14,800	Watts		-100.0%	0.1%	($82,000)		$0	
PV1	Photovoltaic Panels and Infrastructure	3,128,200	Watts		100.0%	24.9%			$23,461,500	$42.84
LB Prerequisite Items										
	PR3 - Habitat Exchange	0.918274	acres		100.0%	0.0%			$4,591	$0.01
	PR6 - Construction Carbon Footprint	24,100	tons		100.0%	0.3%			$265,100	$0.48
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.1%			$63,000	$0.12
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	22.5%	7.1%	$29,834,296	$54.48	$36,539,533	$66.72
	Architecture & Engineering		7.00%	9.00%	42.2%	3.3%	$7,458,574	$13.62	$10,608,251	$19.37
Credits / Rebates / Incentives										
	BETC	35%			49.7%	-0.3%	($566,795)	($1.04)	($848,446)	($1.55)
	ETO - Energy Trust of Oregon				347.2%	-0.7%	($198,103)	($0.36)	($885,976)	($1.62)
	PV Credits-(state, city, utility)	80%			-100.0%	-20.0%	$0		($18,769,200)	($34.27)
	SDC Credits (including stormwater)	50%			-100.0%	-0.5%	$0		($509,464)	($0.93)
TOTAL OWNER & DESIGN-BUILD COSTS						**39.7%**	**$36,445,973**	**$66.70**	**$50,928,890**	**$93.00**

TOTAL CONCEPTUAL COST: **$142,997,031** **$261.12** **$168,798,350** **$308.24**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **16%** **TO** **21%**
HIGH RISE IN PORTLAND, OR

INCLUDING HIGH PERFORMING GREEN BUILDINGS OF PORTLAND (HPGBP): **13%** **TO** **18%**

High Rise Mixed use
Portland

Normalized Baseline Energy Use Intensity (kBtu/SF)	**73.2**	Normalized Baseline Energy Use (kWh)	8,157,730
Impact of Design Changes (see sketches)	0.98		
Adjusted Baseline EUI (kBtu/SF)	**71.7**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		13%	33%	10%	11%	10%	23%	100%
calc'd EUI		9.3	23.7	7.2	7.9	7.2	16.5	71.7
Energy Conservation Measures:								
Glazing	**E1**		15.0%	15.0%		7.5%		7.2%
Improve Glazing	E1a							
Add effective shading devices	E1b							
Reduce glazing to 30%	E1d							
Walls & Roof	**E2**		6.0%	1.5%		1.7%		2.3%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	15.0%	-1.1%	1.5%		0.2%		1.8%
Remove ceiling, raise window head, add lightshelf	L1a							
Daylight controls (continuous dimming)	L1c							
Lighting	**L2**	69.7%	-5.2%	7.0%		1.0%		8.1%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dual day/night light levels in corridors; occupancy sensors	L2i							
Occupancy sensor / time clock for corridor lighting	L2j							
Provide hardwired compact fluorescent fixtures in all spaces.	L2k							
Plug Loads	**P**		-2.3%	3.0%		0.5%	30.0%	6.5%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Parking: variable flow ventilation based on CO monitor	Pi							
Super-efficient elevators (hybrid)	Pk							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.4%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*84.7%*	*17.4%*	*33.0%*	*0.0%*	*13.4%*	*30.0%*	*28.3%*
Subtotal Reduced EUI (kBTU/SF)		*1.4*	*19.5*	*4.8*	*7.9*	*6.2*	*11.5*	*51.4*
Mechanical - Distribution & Ventilation	**M2**		15.0%	20.0%		60.0%		10.6%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Displacement ventilation delivery for DOAS	M2k							
Water to water heat pumps, radiant slab heating/cooling	M2q							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*20.0%*	*0.0%*	*60.0%*	*0.0%*	*10.6%*
Subtotal Reduced EUI (kBTU/SF)		*1.4*	*16.6*	*3.8*	*7.9*	*2.5*	*11.5*	*43.8*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		5.2%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				75.0%			8.3%
Solar-thermal domestic water	Wa							
Low flow fixtures (showers, lavs, sinks)	Wb							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*75.0%*	*-15.0%*	*0.0%*	*13.4%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**1.4**	**13.3**	**3.1**	**2.0**	**2.9**	**11.5**	***34.2***
Final Energy Use Breakdown as Percentage of Baseline Use		**2%**	**19%**	**4%**	**3%**	**4%**	**16%**	**52%**

Building Operating Factor	0.90	86.2	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
Total Reduced EUI (kBTU/sf)	**32.0**	Achievement:	
		63%	percent reduction from CBECS
		56%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	3,559,206	Incentives:	
		$ 873,720	ETO incentive for reduced EUI
Number of crystaline panels needed	6,029	$ 198,103	Estimated ETO incentive for original design bldg
Total kW of PV array	3143	$ 281,650	BETC for Platinum (minus Gold), pass-thru

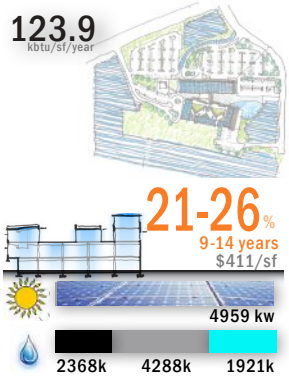
PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	227.042	15677	18,000	1443
	15°	244.678	14547	57,200	4586
optimal angle:	32.5°	281.857	12628		0
Assume an equal area parking garage with an EUI of 1.7	45°	247.953	14355		0
	90°	175.198	20316		0
				Total kWh =	**1,449,715**

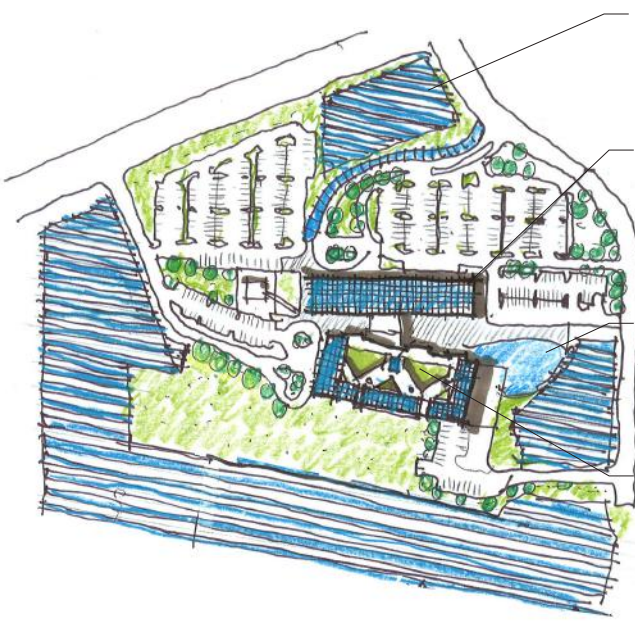
Parking garage required for net zero energy = 3 (40,000 sf garages)	Additional area	116,000	9302	
	Additional kWh Produced		**2,111,945**	3,561,660

HOSPITAL
PORTLAND temperate



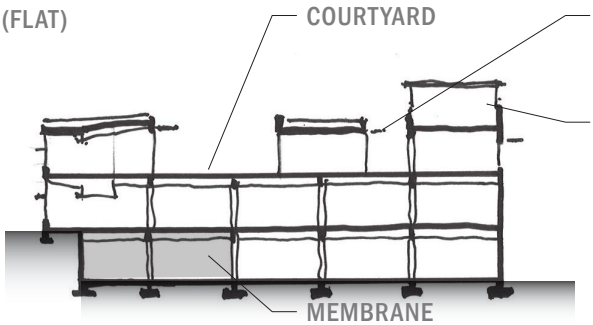
ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF
PHOTOVOLTAIC CAPACITY
WATER USE



SITE PLAN
NTS

120,000 gal	RAIN WATER TANK SIZE
180,231 sf	BUILDING SIZE
4 floors	BUILDING HEIGHT
39.03 acres	SITE AREA
301,700 sf	PHOTOVOLTAIC AREA
84,900 sf	ROOF AREA (FLAT)



SECTION

MAJOR DESIGN STRATEGIES:

- ✓ Add new light courts at Nurse's station.
- ✓ Add skylights at corridors for increased daylighting.
- ✓ Minimize screen at mechanical area, due to fact that mechanical is reduced
- ✓ Add fins to provide shading on west side of classrooms.
- ✓ Add shading devices on South side of hospital, office, etc.

PLAN
NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **HOSPITAL**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 180,231
Living Building Gross SF = 180,231
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**7.6%**	**0.4%**	**$2,895,319**	**$16.06**	**$3,115,421**	**$17.29**
	Baseline Building			$2,895,319	$16.06	$2,895,319	$16.06
W2	Rainwater Containment - 120,000 gal Rainwater Tank					$220,101	$1.22
B	**Shell**	**2.1%**	**0.5%**	**$14,789,139**	**$82.06**	**$15,102,359**	**$83.79**
	Baseline Building			$14,789,139	$82.06	$14,789,139	$82.06
L1B	Replace Roofing with Glazed Skylight					$15,000	$0.08
E1A	Improved Glazing (reduce solar heat gain at vision only)					$16,000	$0.09
E1B	Exterior Horizontal Shading Devices					$87,600	$0.49
L1D	Interior Light Shelf					$58,400	$0.32
E1B	Vertical Shading Fins (west end)					$26,900	$0.15
L1B	New Light Shafts to Nurse Stations					$387,000	$2.15
E2B	Infill Spandrel Panel with Framing and Insulation (replace glazed area)					$22,320	$0.12
D3	Reduce Mechanical Rooftop Screen					($300,000)	($1.66)
C	**Interiors**	**0.4%**	**0.1%**	**$9,710,678**	**$53.88**	**$9,746,724**	**$54.08**
	Baseline Building			$9,710,678	$53.88	$9,710,678	$53.88
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$36,046	$0.20
L1A	Raise Ceilings (no cost impact)					$0	
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$826,462**	**$4.59**	**$826,462**	**$4.59**
	Baseline Building			$826,462	$4.59	$826,462	$4.59
D.2	**Services - Plumbing Systems**	**7.5%**	**0.4%**	**$3,347,613**	**$18.57**	**$3,597,613**	**$19.96**
	Baseline Building			$3,347,613	$18.57	$3,347,613	$18.57
W6	Low-Flow Fixtures / Optical Sensors					$0	
W2	Rain Harvesting (piping & pumps and filtration)					$250,000	$1.39
D.3	**Services - HVAC Systems**	**43.9%**	**7.2%**	**$9,992,801**	**$55.44**	**$14,376,260**	**$79.77**
	Baseline Building			$9,992,801	$55.44	$9,992,801	$55.44
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,652,772)	($14.72)
M2A	In-Slab Radiant Heating and Cooling Common areas only					$180,231	$1.00
M3A	Open Well Ground Source Heat Pump					$6,276,000	$34.82
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS), Chilled Beams					$360,000	$2.00
M3C	Solar Thermal					$220,000	$1.22
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$444,259**	**$2.46**	**$444,259**	**$2.46**
	Baseline Building			$444,259	$2.46	$444,259	$2.46
D.5	**Services - Electrical Systems**	**6.2%**	**0.8%**	**$8,085,831**	**$44.86**	**$8,589,931**	**$47.66**
	Baseline Building			$8,085,831	$44.86	$8,085,831	$44.86
PA	Occupancy Sensor to Outlets					$21,500	$0.12
PE	High Efficiency Transformers					$217,000	$1.20
LIC	Daylight Controls (continuous dimming 15' from perimeter)					$160,800	$0.89
L2E	Occupancy Sensor for Transient and Egress Lighting					$44,500	$0.25
L2G	Patient Bed light with separate switching for ambient / task					$18,800	$0.10
L2M	Dual level light at egress stairs - off when not occupied					$19,000	$0.11
L2N	Stairwell lighting on daylighting					$22,500	$0.12

BUILDING TYPE: **HOSPITAL**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 180,231
Living Building Gross SF = 180,231
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$2,050,942**	**$11.38**	**$2,050,942**	**$11.38**
Baseline Building				$2,050,942	$11.38	$2,050,942	$11.38
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**0.6%**	**0.1%**	**$7,730,038**	**$42.89**	**$7,780,038**	**$43.17**
Baseline Building				$7,730,038	$42.89	$7,730,038	$42.89
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.28
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$920,558**	**$5.11**	**$920,558**	**$5.11**
Baseline Building				$920,558	$5.11	$920,558	$5.11
Living Building Prerequisites				**$0**	**$0.00**	**$1,163,734**	**$6.46**
PR5 - Materials Red List		**100.0%**	**0.8%**			$501,624	$2.78
PR7 - Responsible Industry		**100.0%**	**0.1%**			$67,580	$0.37
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.0%**			$594,530	$3.30
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**			$0	
Subtotal Direct Costs			11.4%	$60,793,639	$337.31	$67,714,299	$375.71
General Conditions	5.9%	**11.4%**	**0.7%**	$3,599,939	$19.97	$4,009,750	$22.25
Fee, Contingency, Insurance	6.7%	**11.4%**	**0.8%**	$4,309,196	$23.91	$4,799,749	$26.63
Location Modifier for PORTLAND, OR	1.00	**0.0%**	**0.0%**	$0		$0	
TOTAL MODIFIED CONSTRUCTION COST			**11.4%**	**$68,702,774**	**$381.19**	**$76,523,799**	**$424.59**

BUILDING TYPE: **HOSPITAL**
BUILDING LOCATION: **PORTLAND, OR**

SKANSKA

Base Building Gross SF = 180,231
Living Building Gross SF = 180,231
Site Gross Acreage = 39.03

						Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
								Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS											
Design/Build Owner Items											
W3	Biological Bio-Reactor					100.0%	2.5%			$1,500,000	$8.32
PV1	Photovoltaic Panels and Infrastructure	4,959,000	Watts			100.0%	61.2%			$37,192,500	$206.36
LB Prerequisite Items											
	PR3 - Habitat Exchange	39.03	acres			100.0%	0.3%			$195,150	$1.08
	PR6 - Construction Carbon Footprint	5,400	tons			100.0%	0.1%			$59,400	$0.33
	PR15 - Beauty and Spirit (included in A/E fees below)					0.0%	0.0%			$0	
	PR16 - Inspiration and Education					100.0%	0.1%			$63,000	$0.35
Development Costs			LEED	LBC							
	Develoment Costs		28.00%	31.00%		23.3%	7.4%	$19,236,777	$106.73	$23,722,378	$131.62
	Architecture & Engineering		7.00%	9.00%		43.2%	3.4%	$4,809,194	$26.68	$6,887,142	$38.21
Credits / Rebates / Incentives											
	BETC	35%				69.9%	-0.2%	($199,034)	($1.10)	($338,185)	($1.88)
	ETO - Energy Trust of Oregon					88.9%	-0.6%	($392,193)	($2.18)	($740,976)	($4.11)
	PV Credits-(state, city, utility)	80%				-100.0%	-48.9%	$0		($29,754,000)	($165.09)
	SDC Credits	50%				-100.0%	-2.3%	$0		($1,372,092)	($7.61)
TOTAL OWNER & DESIGN-BUILD COSTS							**59.5%**	**$23,454,744**	**$130.14**	**$37,414,317**	**$207.59**
					TOTAL CONCEPTUAL COST:			**$92,157,517**	**$511.33**	**$113,938,115**	**$632.18**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **21%** **TO** **26%**
HOSPITAL IN PORTLAND, OR

INCLUDING HIGH PERFORMING GREEN BUILDINGS OF PORTLAND (HPGBP): **20%** **TO** **25%**

Hospital
Portland

Normalized Baseline Energy Use Intensity (kBtu/SF) **199.4**

Normalized Baseline Energy Use (kWh) 10,517,233

Impact of Design Changes (see sketches) 1.02

Adjusted Baseline EUI (kBtu/SF) 203.3

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
	percent of load	15%	20%	10%	15%	15%	25%	100%
	calc'd EUI	30.5	40.7	20.3	30.5	30.5	50.8	203.3
Energy Conservation Measures:								
Glazing	**E1**		12.0%	1.0%		2.7%		2.9%
Improve Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		6.0%	1.0%		1.5%		1.5%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	13.3%	-1.0%	1.3%		0.2%		2.0%
Top daylighting with skylights	L1b							
Daylight controls (continuous dimming)	L1c							
Add new courtyards at Nurses's station								
Lighting	**L2**	31.1%	-2.3%	3.1%		0.5%		4.6%
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Patient bedlight with separate switching for ambient / task	L2g							
Dual level light at egress stairs - off when not occuppied	L2m							
Stairwell lighting on daylighting / occupancy sensors	L2n							
Plug Loads	**P**						10.0%	2.5%
EnergyStar appliances	Pb							
Energy efficient main transformer	Pe							
Super-efficient elevators (hybrid)	Pk							
Aggressive heat recapture - all equipment water cooled	Pl							
Widen Set Point Temperatures	**M1**		2.0%	2.0%		1.0%		0.8%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*44.4%*	*16.7%*	*8.4%*	*0.0%*	*5.9%*	*10.0%*	*14.2%*
Subtotal Reduced EUI (kBTU/SF)		*17.0*	*33.9*	*18.6*	*30.5*	*28.7*	*45.8*	*174.4*
Mechanical - Distribution & Ventilation	**M2**		20.0%	11.0%		20.0%		7.2%
Radiant slab heating/cooling in lobby/atrium spaces	M2r							
Chilled beams	M2s							
Displacement ventilation in exam rooms	M2t							
Natural ventilation in stairwells	M2u							
Low pressure drop air filters	M2v							
OSA/Exhaust runaround heat recovery	M2w							
Cascading make-up air	M2x							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*20.0%*	*11.0%*	*0.0%*	*20.0%*	*0.0%*	*7.2%*
Subtotal Reduced EUI (kBTU/SF)		*17.0*	*27.1*	*16.6*	*30.5*	*23.0*	*45.8*	*159.9*
Mechanical - Plant Systems	**M3**		20.0%	30.0%		13.4%		6.6%
Ground source heat pump with central heat pump chiller	M3e							
Chiller heat recovery	M3f							
Domestic Hot Water	**W**				50.0%			7.5%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*30.0%*	*50.0%*	*13.4%*	*0.0%*	*14.1%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**17.0**	**21.7**	**11.6**	**15.3**	**19.9**	**45.8**	***131.1***
Final Energy Use Breakdown as Percentage of Baseline Use		**8%**	**11%**	**6%**	**8%**	**10%**	**23%**	**36%**

Building Operating Factor 0.90
Impact of Interactive ECM effects 1.05

Total Reduced EUI (kBTU/sf) 123.9

Total reduced energy use (kWh) 6,538,000

Number of crystaline panels needed 24,192
Total kW of PV array 4959

249.2 CBECS Baseline EUI (kBTU/sf)
60% target reduction from CBECS

Achievement: **TARGET REDUCTION NOT MET**

50% percent reduction from CBECS
38% percent reduction from Normalized Baseline Bldg

Incentives:

$ 756,054 ETO incentive for reduced EUI
$ 392,193 Estimated ETO incentive for original design bldg
$ 139,150 BETC for Platinum (minus Gold), pass-thru

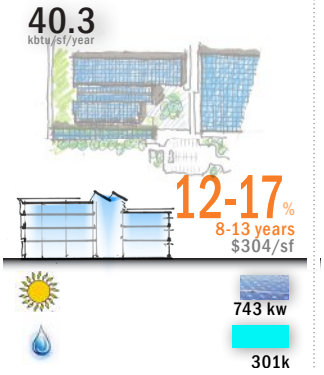
PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

Assume an equal area parking garage with an EUI of 1.7

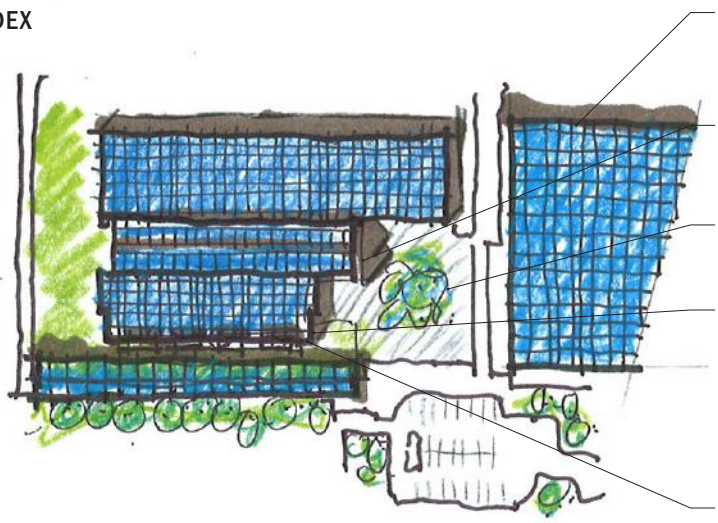
	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	227.042	28797	44,700	3584
	15°	244.678	26721		0
optimal angle:	32.5°	281.857	23197	257,000	20608
	45°	247.953	26368		0
	90°	175.198	37318		0
				Total kWh =	**6,622,228**

UNIVERSITY CLASSROOM
ATLANTA hot humid



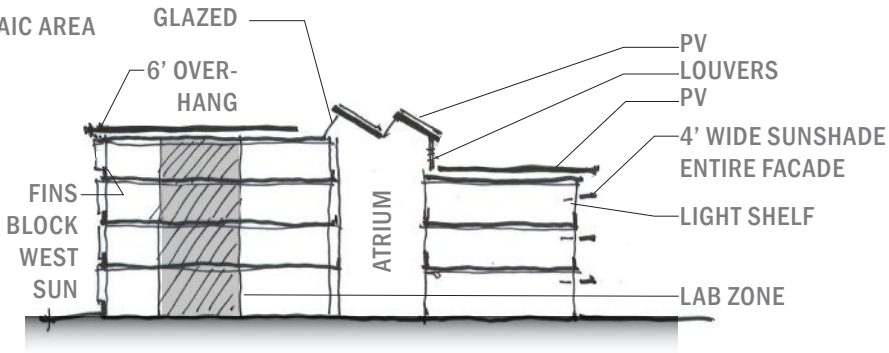
ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF
PHOTOVOLTAIC CAPACITY
WATER USE



TANK SIZE	10,000 gal
BUILDING SIZE	153,531 sf
BUILDING HEIGHT	4 floors
SITE AREA	2.75 acres
PHOTOVOLTAIC AREA	78,830 sf
ROOF AREA	38,755 sf

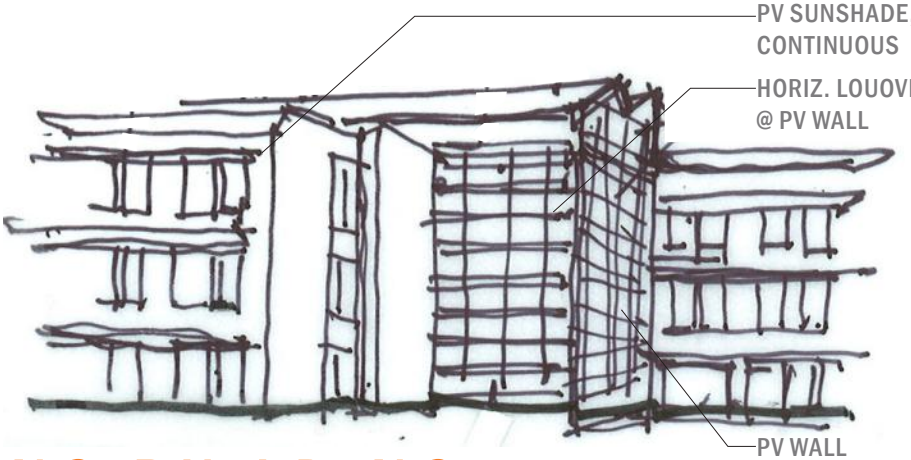
SITE PLAN
NTS



SECTION

MAJOR DESIGN STRATEGIES:

- ✓ Reorient the building 180 degrees.
- ✓ Add PV to entire roof.
- ✓ Add fritted PV to glass at Atrium.
- ✓ Add sunshades out of PV to each south window.
- ✓ North facing sawtooth skylight at Atrium. Horizontal louvers as shading devices for south wall
- ✓ 6' overhang at roof to shade façade.



LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **UNIVERSITY CLASSROOM**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 153,531
Living Building Gross SF = 153,531
Site Gross Acreage = 2.75

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
	A Substructure	**-0.5%**	**0.0%**	**$2,123,369**	**$13.83**	**$2,113,711**	**$13.77**
	Baseline Building			$2,123,369	$13.83	$2,123,369	$13.83
W2	Rainwater Containment - 10,000 gal Rainwater Tank					($9,658)	($0.06)
	B Shell	**3.6%**	**0.4%**	**$4,959,353**	**$32.30**	**$5,137,677**	**$33.46**
	Baseline Building			$4,959,353	$32.30	$4,959,353	$32.30
E1A	Improved Glazing (reduce solar heat gain)					$35,324	$0.23
E1B	Exterior Shading Devices (outriggers for PV panels on south only)					($116,000)	($0.76)
E1B	Exterior Shading Devices (vertical sun shades at north windows)					$54,000	$0.35
E1B	Exterior Shading Devices (solid horizontal sun shades)					$35,000	$0.23
D2B	Revised Atrium Roof Structure (sawtooth)					$170,000	$1.11
	C Interiors	**-3.8%**	**-1.4%**	**$16,495,934**	**$107.44**	**$15,868,139**	**$103.35**
	Baseline Building			$16,495,934	$107.44	$16,495,934	$107.44
M2D	Carpet Reduction (remove carpet and retroplate concrete)					$96,071	$0.63
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$153,531	$1.00
L1A	Exposed Ceilings (white matte surfaces)					($160,397)	($1.04)
D3	Eliminate Raised Access Floor					($717,000)	($4.67)
	D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$297,968**	**$1.94**	**$297,968**	**$1.94**
	Baseline Building			$297,968	$1.94	$297,968	$1.94
	D.2 Services - Plumbing Systems	**5.2%**	**0.4%**	**$2,968,571**	**$19.34**	**$3,122,371**	**$20.34**
	Baseline Building			$2,968,571	$19.34	$2,968,571	$19.34
W6	Low-Flow Fixtures / Optical Sensors					$3,800	$0.02
W2	Rain Harvesting (piping & pumps and filtration)					$150,000	$0.98
	D.3 Services - HVAC Systems	**32.2%**	**4.1%**	**$5,646,851**	**$36.78**	**$7,464,706**	**$48.62**
	Baseline Building			$5,646,851	$36.78	$5,646,851	$36.78
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($1,000,000)	($6.51)
M2A	In-Slab Radiant Heating and Cooling					$767,655	$5.00
M3A	Ground Source Heat Pump					$1,970,200	$12.83
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$80,000	$0.52
M2C	Carbon Dioxide Sensors (in base building)					$0	
	D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$425,840**	**$2.77**	**$425,840**	**$2.77**
	Baseline Building			$425,840	$2.77	$425,840	$2.77
	D.5 Services - Electrical Systems	**2.9%**	**0.4%**	**$6,000,852**	**$39.09**	**$6,174,252**	**$40.22**
	Baseline Building			$6,000,852	$39.09	$6,000,852	$39.09
PA	Occupancy Sensor to Outlets					$14,100	$0.09
PE	High Efficiency Transformers					$67,000	$0.44
L2E	Occupancy Sensor for Transient and Egress Lighting					$37,500	$0.24

BUILDING TYPE: **UNIVERSITY CLASSROOM**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 153,531
Living Building Gross SF = 153,531
Site Gross Acreage = 2.75

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline Total	LEED™ Gold Baseline Cost/SF	Living Building Total	Living Building Cost/SF
L2F	Dimmable Direct/Indirect Fixtures					$54,800	$0.36
E	**Equipment and Furnishings**	**0.0%**	**0.0%**	**$257,958**	**$1.68**	**$257,958**	**$1.68**
	Baseline Building			$257,958	$1.68	$257,958	$1.68
F	**Special Construction**	**0.0%**	**0.0%**	**$79,247**	**$0.52**	**$79,247**	**$0.52**
	Baseline Building			$79,247	$0.52	$79,247	$0.52
G	**Sitework**	**2.0%**	**0.1%**	**$2,460,261**	**$16.02**	**$2,510,261**	**$16.35**
	Baseline Building			$2,460,261	$16.02	$2,460,261	$16.02
W4	Stormwater Retention / Building Water Discharge					$50,000	$0.33
W1	Remove Storm Drainage Connection to Public/Add sewer meter					$0	
H	**Logistics**	**0.0%**	**0.0%**	**$2,108,417**	**$13.73**	**$2,108,417**	**$13.73**
	Baseline Building			$2,108,417	$13.73	$2,108,417	$13.73
Living Building Prerequisites				**$7,677**	**$0.05**	**$905,401**	**$5.90**
	PR5 - Materials Red List	**100.0%**	**0.7%**			$315,805	$2.06
	PR7 - Responsible Industry	**100.0%**	**0.4%**			$162,546	$1.06
	PR8 - Appropriate Materials / Services Radius	**100.0%**	**1.0%**			$419,374	$2.73
	PR9 - Leadership in Construction Waste	**0.0%**	**0.0%**	$7,677	$0.05	$7,677	$0.05
Subtotal Direct Costs			6.0%	$43,832,298	$285.49	$46,465,950	$302.65
	General Conditions 8.0%	**6.0%**	**0.5%**	$3,512,022	$22.88	$3,723,041	$24.25
	Fee, Construction Contingency, Insurance 7.0%	**6.0%**	**0.5%**	$3,328,586	$21.68	$3,528,583	$22.98
	Location Modifier for ATLANTA, GA 0.87	**6.0%**	**-0.9%**	($6,587,478)	($42.91)	($6,983,285)	($45.48)
TOTAL MODIFIED CONSTRUCTION COST			**6.0%**	**$44,085,429**	**$287.14**	**$46,734,289**	**$304.40**

BUILDING TYPE: **UNIVERSITY CLASSROOM**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 153,531
Living Building Gross SF = 153,531
Site Gross Acreage = 2.75

						Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
								Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS											
Design/Build Owner Items											
W3	Biological Bio-Reactor					100.0%	0.1%			$50,000	$0.33
PV1	Photovoltaic Panels and Infrastructure	743,000	Watts			100.0%	12.7%			$5,572,500	$36.30
LB Prerequisite Items											
	PR3 - Habitat Exchange	2.75482	acres			100.0%	0.0%			$13,774	$0.09
	PR6 - Construction Carbon Footprint	6,800	tons			100.0%	0.2%			$74,800	$0.49
	PR15 - Beauty and Spirit (included in A/E fees below)					0.0%	0.0%			$0	
	PR16 - Inspiration and Education					100.0%	0.2%			$73,750	$0.48
Development Costs			LEED	LBC							
	Develoment Costs		28.00%	31.00%		17.4%	4.9%	$12,343,920	$80.40	$14,487,630	$94.36
	Architecture & Engineering		7.00%	9.00%		36.3%	2.6%	$3,085,980	$20.10	$4,206,086	$27.40
Credits / Rebates / Incentives											
	PV Credits-(state, city, utility)	50%				-100.0%	-6.4%	$0		($2,786,250)	($18.15)
	SDC Credits	50%				-100.0%	-0.8%	$0		($349,890)	($2.28)
TOTAL OWNER & DESIGN-BUILD COSTS							**38.3%**	**$15,429,900**	**$100.50**	**$21,342,400**	**$139.01**
					TOTAL CONCEPTUAL COST:			**$59,515,329**	**$387.64**	**$68,076,689**	**$443.41**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **12%** **TO** **17%**
UNIVERSITY CLASSROOM IN ATLANTA, GA

University Classroom
Atlanta

Normalized Baseline Energy Use Intensity (kBtu/SF)	**82.1**	Normalized Baseline Energy Use (kWh)	3,487,559
Impact of Design Changes (see sketches)	0.98		
Adjusted Baseline EUI (kBtu/SF)	**80.8**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		21%	13%	23%	2%	10%	31%	100%
calc'd EUI		16.7	10.6	18.6	1.7	8.1	25.1	80.8
Energy Conservation Measures:								
Glazing	**E1**		2.0%	10.0%		3.4%		2.9%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		5.0%	3.0%		1.9%		1.5%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
PV mounted 30"' up to allow for shading	E2c							
Highly reflective exterior siding	E2d							
Move vapor barrier to outside of building	E2e							
Daylighting (incorporates tuned glazing/shading)	**L1**	50.0%	-3.8%	5.0%		0.8%		11.1%
Daylight controls (continuous dimming)	L1c							
Orient windows to allow for illumination of teaching wall	L1f							
Top daylighting from Atrium	L1g							
Lighting	**L2**	20.0%	-1.5%	2.0%		0.3%		4.4%
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dimmable direct / indirect fixtures	L2f							
Occupancy sensor / time clock for corridor lighting	L2j							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	8.1%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Mechanical - Schedule	**M4**			7.0%				0.3%
Change of work hours (summer hours)	M4a							
Shift uses for time of day in summer (east vs west)	M4b							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.1%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*70.0%*	*4.9%*	*34.5%*	*0.0%*	*9.2%*	*25.0%*	*31.8%*
Subtotal Reduced EUI (kBTU/SF)		*5.0*	*10.1*	*12.2*	*1.7*	*7.3*	*18.8*	*55.1*
Mechanical - Distribution & Ventilation	**M2**		15.0%	20.0%		70.0%		11.2%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Cascading make-up air	M2x							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*20.0%*	*0.0%*	*70.0%*	*0.0%*	*11.2%*
Subtotal Reduced EUI (kBTU/SF)		*5.0*	*8.6*	*9.7*	*1.7*	*2.2*	*18.8*	*46.0*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		4.1%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				50.0%			1.0%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from tankless electric water heater	Wd							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*50.0%*	*-15.0%*	*0.0%*	*5.2%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**5.0**	**6.9**	**7.8**	**0.8**	**2.5**	**18.8**	***41.9***
Final Energy Use Breakdown as Percentage of Baseline Use		**6%**	**9%**	**10%**	**1%**	**3%**	**23%**	**48%**

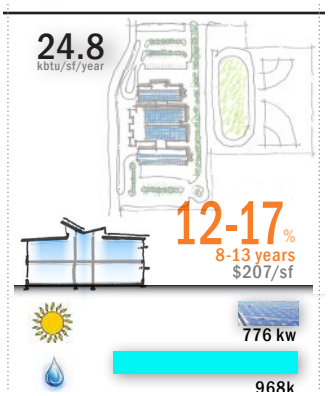
Building Operating Factor	0.90	100.0	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.06	60%	target reduction from CBECS
		Achievement:	**TARGET REDUCTION NOT MET**
Total Reduced EUI (kBTU/sf)	**40.3**	60%	percent reduction from CBECS
		50%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	1,710,846		
Number of crystaline panels needed	3,624		
Total kW of PV array	743		

PV Panel Analysis:

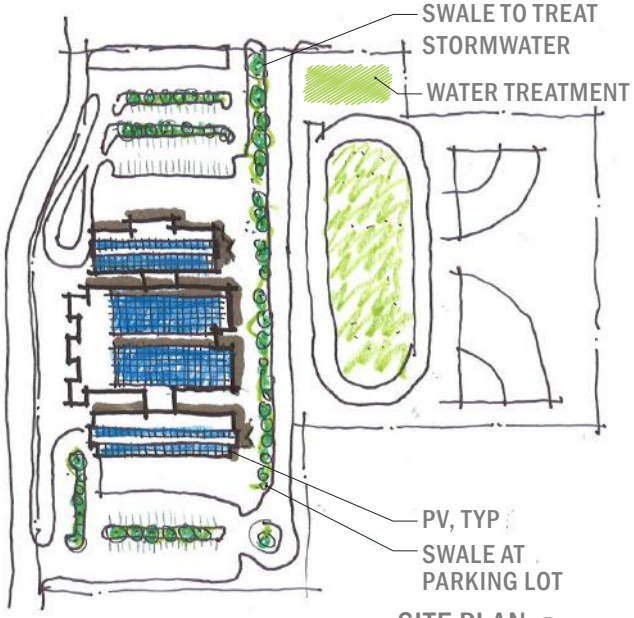
From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	269.31	6353	38,800	3111	Panels on roof, walkway, plaza
	15°	284.95	6005		0	
optimal angle:	25.7°	288.74	5926	6,400	513	
	45°	278.92	6134		0	
	90°	183.21	9339		0	
				Total kWh =	**985,947**	
Additional Parking Garage Offset Needed			Additional area	33,630	2696	
			Additional kWh Produced		**726,060**	1,712,007

SCHOOL K-8
ATLANTA hot humid



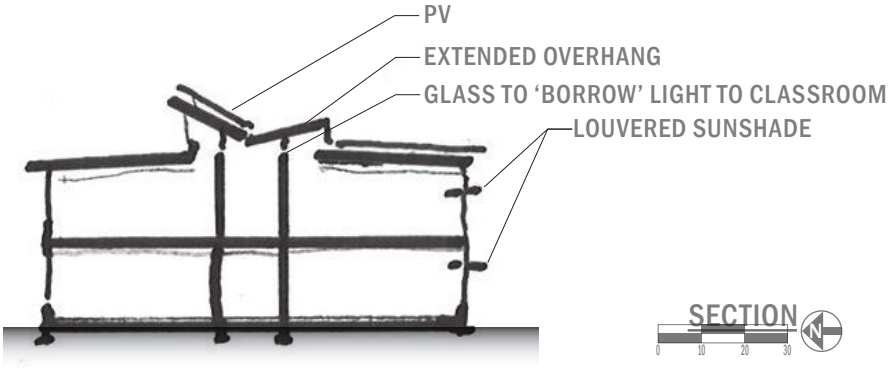
ENERGY USE INDEX	
COST PREMIUM	
PAYBACK	
COST PER SF	
PHOTOVOLTAIC CAPACITY	
WATER USE	
10,000 gal	TANK SIZE
148,981 sf	BUILDING SIZE
2 floors	BUILDING HEIGHT
39.03 acres	SITE AREA
47,180 sf	PHOTOVOLTAIC AREA
97,650 sf	ROOF AREA



SITE PLAN
NTS

MAJOR DESIGN STRATEGIES:

- ✓ Reorganize plan to eliminate N/S portions of classrooms wings.
- ✓ Remove windows below 2'-6" in classrooms.
- ✓ Remove windows below 2'-0" in corridors.
- ✓ Tune glazing to have high performance glass at vision glass only.
- ✓ Reconfigure roof at clerestory.
- ✓ Add metal roofing for clipping of PV at Classroom and gym.
- ✓ Eliminate windows on west and east facades at classrooms.



SECTION

PLAN
NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **ELEMENTARY SCHOOL**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 148,981
Living Building Gross SF = 148,981
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**2.0%**	**0.1%**	**$1,466,210**	**$9.84**	**$1,495,552**	**$10.04**
	Baseline Building			$1,466,210	$9.84	$1,466,210	$9.84
	Rainwater Containment - 10,000 gal Rainwater Tank					$29,342	$0.20
B	**Shell**	**-1.7%**	**-0.5%**	**$9,540,845**	**$64.04**	**$9,379,920**	**$62.96**
	Baseline Building			$9,540,845	$64.04	$9,540,845	$64.04
D3	Lower Roof at Media Center (at both links)					($248,400)	($1.67)
D3	Reallocate South Wing (move SF to east-west wings)					($69,000)	($0.46)
E1A	Improved Glazing (reduce solar heat gain at vision only)					$22,000	$0.15
E1B	Additional Exterior Shading Devices					$37,500	$0.25
D2B	Modify Roof Structure at Clerestory (butterfly roof)					$99,975	$0.67
D3C	Relocate Clerestory (2 sides of 1 gym > 1 side of 2 gyms)					($3,000)	($0.02)
C	**Interiors**	**3.1%**	**0.5%**	**$4,624,290**	**$31.04**	**$4,765,608**	**$31.99**
	Baseline Building			$4,624,290	$31.04	$4,624,290	$31.04
M2D	Carpet Reduction (replace with RetroPlate)					$108,466	$0.73
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$148,981	$1.00
L1A	Exposed Ceilings (white matte surfaces)					($116,128)	($0.78)
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$100,000**	**$0.67**	**$100,000**	**$0.67**
	Baseline Building			$100,000	$0.67	$100,000	$0.67
D.2	**Services - Plumbing Systems**	**10.4%**	**0.5%**	**$1,438,830**	**$9.66**	**$1,588,830**	**$10.66**
	Baseline Building			$1,438,830	$9.66	$1,438,830	$9.66
W6	Low-Flow Fixtures / Optical Sensors					$0	
W2	Rain Harvesting (piping & pumps and filtration)					$150,000	$1.01
D.3	**Services - HVAC Systems**	**6.6%**	**0.8%**	**$3,684,937**	**$24.73**	**$3,929,870**	**$26.38**
	Baseline Building			$3,684,937	$24.73	$3,684,937	$24.73
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,652,772)	($17.81)
M2A	In-Slab Radiant Heating and Cooling					$744,905	$5.00
M2L	Solar Wall Mechanical Screen					$145,000	$0.97
M3A	Ground Source Heat Pump					$1,911,800	$12.83
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$80,000	$0.54
M2C	Carbon Dioxide Sensors					$16,000	$0.11
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$345,589**	**$2.32**	**$345,589**	**$2.32**
	Baseline Building			$345,589	$2.32	$345,589	$2.32
D.5	**Services - Electrical Systems**	**6.6%**	**0.7%**	**$3,044,694**	**$20.44**	**$3,246,194**	**$21.79**
	Baseline Building			$3,044,694	$20.44	$3,044,694	$20.44
PA	Occupancy Sensor to Outlets					$5,000	$0.03
PE	High Efficiency Transformers					$97,500	$0.65
LIC	Daylight Controls (continuous dimming 15' from perimeter)					$23,800	$0.16
L2F	Dimmable Direct/Indirect fixtures					$47,500	$0.32
L2B	Occupancy Sensor for Lighting (closed office / conference spaces)					$0	
L2C	Individual Light Level Control (open spaces, classrooms)					$5,200	$0.03
L2E	Occupancy Sensor for Transient and Egress Lighting					$22,500	$0.15

BUILDING TYPE: **ELEMENTARY SCHOOL**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 148,981
Living Building Gross SF = 148,981
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$1,555,517**	**$10.44**	**$1,555,517**	**$10.44**
Baseline Building				$1,555,517	$10.44	$1,555,517	$10.44
F Special Construction		**0.0%**	**0.0%**	**$58,000**	**$0.39**	**$58,000**	**$0.39**
Baseline Building				$58,000	$0.39	$58,000	$0.39
G Sitework		**1.4%**	**0.2%**	**$3,701,152**	**$24.84**	**$3,751,152**	**$25.18**
Baseline Building				$3,701,152	$24.84	$3,701,152	$24.84
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.34
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$524,694**	**$3.52**	**$524,694**	**$3.52**
Baseline Building				$524,694	$3.52	$524,694	$3.52
Living Building Prerequisites				**$7,449**	**$0.05**	**$563,860**	**$3.78**
PR5 - Materials Red List		**100.0%**	**0.7%**			$208,779	$1.40
PR7 - Responsible Industry		**100.0%**	**0.2%**			$66,413	$0.45
PR8 - Appropriate Materials / Services Radius		**100.0%**	**0.9%**			$281,219	$1.89
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$7,449	$0.05	$7,449	$0.05
Subtotal Direct Costs			4.0%	$30,092,207	$201.99	$31,304,787	$210.13
General Conditions	3.7%	**4.0%**	**0.1%**	$1,098,511	$7.37	$1,142,776	$7.67
Fee, Contingency, Insurance, Bonding	9.6%	**4.0%**	**0.4%**	$3,009,175	$20.20	$3,130,431	$21.01
Location Modifier for ATLANTA, GA	0.87	**4.0%**	**-0.6%**	($4,445,986)	($29.84)	($4,625,139)	($31.05)
TOTAL MODIFIED CONSTRUCTION COST			**4.0%**	**$29,753,907**	**$199.72**	**$30,952,854**	**$207.76**

BUILDING TYPE: **ELEMENTARY SCHOOL**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 148,981
Living Building Gross SF = 148,981
Site Gross Acreage = 39.03

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.7%			$200,000	$1.34
PV1	Photovoltaic Panels and Infrastructure	776,000	Watts		100.0%	19.3%			$5,820,000	$39.07
LB Prerequisite Items										
	PR3 - Habitat Exchange	39.03	acres		100.0%	0.6%			$195,150	$1.31
	PR6 - Construction Carbon Footprint	4,400	tons		100.0%	0.2%			$48,400	$0.32
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$63,000	$0.42
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	15.2%	4.2%	$8,331,094	$55.92	$9,595,385	$64.41
	Architecture & Engineering		7.00%	9.00%	33.8%	2.3%	$2,082,773	$13.98	$2,785,757	$18.70
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-9.7%	$0		($2,910,000)	($19.53)
	SDC Credits	50%			-100.0%	-2.8%	$0		($848,565)	($5.70)
TOTAL OWNER & DESIGN-BUILD COSTS						43.6%	**$10,413,867**	**$69.90**	**$14,949,127**	**$100.34**
TOTAL CONCEPTUAL COST:							**$40,167,774**	**$269.62**	**$45,901,981**	**$308.11**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: 12% TO 17%
ELEMENTARY SCHOOL IN ATLANTA, GA

ElementarySchool
Atlanta

Normalized Baseline Energy Use Intensity (kBtu/SF)	**60.2**	Normalized Baseline Energy Use (kWh)	2,486,658
Impact of Design Changes (see sketches)	0.96		
Adjusted Baseline EUI (kBtu/SF)	**57.5**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		21%	22%	20%	3%	12%	22%	100%
calc'd EUI		11.9	12.8	11.5	1.7	6.9	12.8	57.5
Energy Conservation Measures:								
Glazing	**E1**		2.0%	15.0%		4.9%		4.0%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		5.0%	7.0%		3.1%		2.9%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
PV mounted 30"' up to allow for shading	E2c							
Highly reflective exterior siding	E2d							
Move vapor barrier to outside of building	E2e							
Daylighting (incorporates tuned glazing/shading)	**L1**	75.0%	-5.6%	7.5%		1.1%		15.9%
Top daylighting with skylights	L1b							
Daylight controls (continuous dimming)	L1c							
Orient windows to allow for illumination of teaching wall	L1f							
Lighting	**L2**	9.8%	-0.7%	1.0%		0.1%		2.1%
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dimmable direct / indirect fixtures	L2f							
Occupancy sensor / time clock for corridor lighting	L2j							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	5.7%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Mechanical - Schedule	**M4**			7.0%				0.1%
Change of work hours (summer hours)	M4a							
Shift uses for time of day in summer (east vs west)	M4b							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.4%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		***84.8%***	***3.8%***	***45.0%***	***0.0%***	***12.1%***	***25.0%***	***34.4%***
Subtotal Reduced EUI (kBTU/SF)		***1.8***	***12.3***	***6.3***	***1.7***	***6.1***	***9.6***	***37.7***
Mechanical - Distribution & Ventilation	**M2**		15.0%	20.0%		70.0%		12.8%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Eliminate cooling	M2j							
Subtotal from Mechanical Distribution strategies (percentage)		***0.0%***	***15.0%***	***20.0%***	***0.0%***	***70.0%***	***0.0%***	***12.8%***
Subtotal Reduced EUI (kBTU/SF)		***1.8***	***10.4***	***5.1***	***1.7***	***1.8***	***9.6***	***30.3***
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		4.9%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				60.0%			1.7%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Subtotal from Mechanical Plant and DHW systems (percentage)		***0.0%***	***20.0%***	***20.0%***	***60.0%***	***-15.0%***	***0.0%***	***6.6%***
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**1.8**	**8.3**	**4.0**	**0.7**	**2.1**	**9.6**	***26.5***
Final Energy Use Breakdown as Percentage of Baseline Use		**3%**	**15%**	**7%**	**1%**	**4%**	**17%**	**54%**

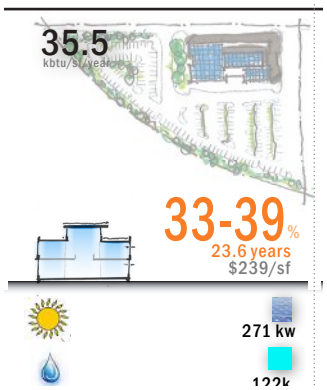
Building Operating Factor	0.90	83.1	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
		Achievement:	
Total Reduced EUI (kBTU/sf)	**24.8**	70%	percent reduction from CBECS
		57%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	1,025,335		
Number of crystaline panels needed	3,783		
Total kW of PV array	776		

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	269.31	3808	40,580	3254	Panels on roof, walkway, plaza
	15°	284.95	3599		0	
optimal angle:	25.7°	288.74	3552	6,600	529	
	45°	278.92	3677		0	
	90°	183.21	5597		0	
				Total kWh =	**1,029,078**	

LOW RISE OFFICE
ATLANTA hot humid



ENERGY USE INDEX

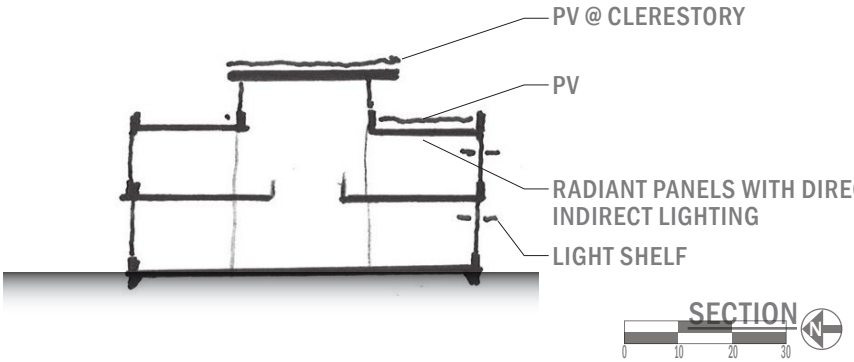
COST PREMIUM
PAYBACK
COST PER SF

PHOTOVOLTAIC CAPACITY

WATER USE

SITE PLAN
NTS

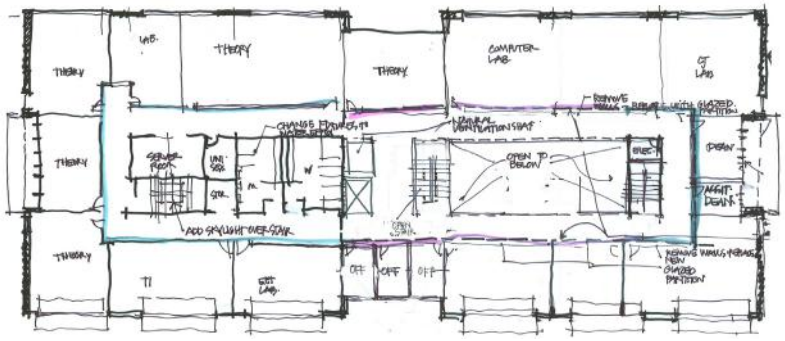
10,000 gal	TANK SIZE
35,776 sf	BUILDING SIZE
2 floors	BUILDING HEIGHT
3.24 acres	SITE AREA
16,480 sf	PHOTOVOLTAIC AREA
17,888 sf	ROOF AREA



SECTION
0 10 20 30

MAJOR DESIGN STRATEGIES:

- ✓ Add shading devices to South side of building.
- ✓ Reduce windows on East and West; add fins.
- ✓ Add clerestory at center of building, to bring daylight into building.
- ✓ Reconfigure plan so all worspaces are within 30’ of a window.



PLAN
NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **LOWRISE OFFICE / CLASSROOMS**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 35,776
Living Building Gross SF = 35,776
Site Gross Acreage = 3.24

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**4.7%**	**0.4%**	**$625,892**	**$17.49**	**$655,234**	**$18.31**
	Baseline Building			$625,892	$17.49	$625,892	$17.49
W2	Rainwater Containment - 10,000 gal Rainwater Tank					$29,342	$0.82
B	**Shell**	**16.1%**	**6.9%**	**$3,237,848**	**$90.50**	**$3,758,980**	**$105.07**
	Baseline Building			$3,237,848	$90.50	$3,237,848	$90.50
M2E	Operable Windows (manual)					$31,680	$0.89
D3C	Reallocate Glazing from East and West Façade to South (less spandrel panel, more skin)					($17,472)	($0.49)
E1A	Improved Glazing (reduce solar heat gain)					$16,104	$0.45
E1B	Exterior Shading Devices (windows and louvers at entry)					$70,460	$1.97
D2A	Added Wall / Skin for Modified Design (clerestory)					$187,200	$5.23
M2H	"High Mass" Concrete Inside Insulation (added reflective skin)					$49,500	$1.38
D2B	Modifications to Roof Structure					$154,860	$4.33
L1D	Interior Light Shelves (remove from N/E/W, keep south only)					$28,800	$0.81
C	**Interiors**	**17.2%**	**2.4%**	**$1,076,571**	**$30.09**	**$1,261,402**	**$35.26**
	Baseline Building			$1,076,571	$30.09	$1,076,571	$30.09
M2D	Carpet Reduction (replace with RetroPlate)					$25,500	$0.71
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$48,264	$1.35
L1A	Exposed Ceilings (white matte surfaces)					($68,213)	($1.91)
D3	Glass partitions in lieu of gypsum wallboard					$179,280	$5.01
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$55,000**	**$1.54**	**$55,000**	**$1.54**
	Baseline Building			$55,000	$1.54	$55,000	$1.54
D.2	**Services - Plumbing Systems**	**73.8%**	**2.0%**	**$208,354**	**$5.82**	**$362,154**	**$10.12**
	Baseline Building			$208,354	$5.82	$208,354	$5.82
W6	Low-Flow Fixtures / Optical Sensors					$3,800	$0.11
W2	Rain Harvesting (piping & pumps and filtration)					$150,000	$4.19
D.3	**Services - HVAC Systems**	**74.9%**	**5.8%**	**$591,095**	**$16.52**	**$1,033,875**	**$28.90**
	Baseline Building			$575,095	$16.07	$575,095	$16.07
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($300,000)	($8.39)
M2A	In-Slab Radiant Heating and Cooling					$178,880	$5.00
M3A	Ground Source Heat Pump					$457,900	$12.80
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$106,000	$2.96
M2C	Carbon Dioxide Sensors			$16,000	$0.45	$16,000	$0.45
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$75,177**	**$2.10**	**$75,177**	**$2.10**
	Baseline Building			$75,177	$2.10	$75,177	$2.10
D.5	**Services - Electrical Systems**	**6.5%**	**0.6%**	**$723,416**	**$20.22**	**$770,116**	**$21.53**
	Baseline Building			$603,016	$16.86	$603,016	$16.86
PA	Occupancy Sensor to Outlets					$10,200	$0.29
PE	High Efficiency Transformers					$36,500	$1.02
L1C	Daylight Controls (continuous dimming 15' from perimeter)			$27,000	$0.75	$27,000	$0.75
L2A	Efficient Light Fixture Optics Premium			$67,600	$1.89	$67,600	$1.89
L2B	Occupancy Sensor for Lighting (closed office / conference spaces)			$12,000	$0.34	$12,000	$0.34
L2E	Occupancy Sensor for Transient and Egress Lighting			$13,800	$0.39	$13,800	$0.39

BUILDING TYPE: **LOWRISE OFFICE / CLASSROOMS**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 35,776
Living Building Gross SF = 35,776
Site Gross Acreage = 3.24

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline Total	LEED™ Gold Baseline Cost/SF	Living Building Total	Living Building Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$149,348**	**$4.17**	**$149,348**	**$4.17**
Baseline Building				$149,348	$4.17	$149,348	$4.17
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**7.6%**	**0.8%**	**$791,671**	**$22.13**	**$851,671**	**$23.81**
Baseline Building				$791,671	$22.13	$791,671	$22.13
W4 Stormwater Retention / Building Water Discharge						$50,000	$1.40
E1B Trees for shading						$10,000	$0.28
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$40,261**	**$1.13**	**$40,261**	**$1.13**
Baseline Building				$40,261	$1.13	$40,261	$1.13
Living Building Prerequisites				**$5,366**	**$0.15**	**$190,144**	**$5.31**
PR5 - Materials Red List		**100.0%**	**0.8%**			$59,877	$1.67
PR7 - Responsible Industry		**100.0%**	**0.1%**			$10,732	$0.30
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.5%**			$114,169	$3.19
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$5,366	$0.15	$5,366	$0.15
Subtotal Direct Costs			21.4%	$7,580,000	$211.87	$9,203,363	$257.25
General Conditions	4.0%	**21.4%**	**0.9%**	$303,200	$8.47	$368,135	$10.29
Fee, Construction Contingency, Insurance	3.0%	**21.4%**	**0.7%**	$238,965	$6.68	$290,143	$8.11
Location Modifier for ATLANTA, GA	0.87	**21.4%**	**-3.0%**	($1,055,882)	($29.51)	($1,282,013)	($35.83)
TOTAL MODIFIED CONSTRUCTION COST			**21.4%**	**$7,066,284**	**$197.51**	**$8,579,627**	**$239.82**

BUILDING TYPE: **LOWRISE OFFICE / CLASSROOMS**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = **35,776**
Living Building Gross SF = **35,776**
Site Gross Acreage = **3.24**

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.5%			$40,000	$1.12
PV1	Photovoltaic Panels and Infrastructure	250,000	Watts		100.0%	28.0%			$2,125,000	$59.40
LB Prerequisite Items										
	PR3 - Habitat Exchange	3.24	acres		100.0%	0.2%			$16,200	$0.45
	PR6 - Construction Carbon Footprint	2,700	tons		100.0%	0.4%			$29,700	$0.83
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.3%			$23,500	$0.66
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	34.4%	9.0%	$1,978,560	$55.30	$2,659,684	$74.34
	Architecture & Engineering		9.38%	11.38%	47.3%	4.1%	$662,464	$18.52	$975,933	$27.28
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-14.0%	$0		($1,062,500)	($29.70)
	SDC Credits	50%			-100.0%	-3.1%	$0		($231,353)	($6.47)
TOTAL OWNER & DESIGN-BUILD COSTS						**73.3%**	**$2,641,024**	**$73.82**	**$4,576,164**	**$127.91**
						TOTAL CONCEPTUAL COST:	**$9,707,308**	**$271.34**	**$13,155,791**	**$367.73**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **33%** **TO** **38%**
LOWRISE OFFICE / CLASSROOMS IN ATLANTA, GA

MidRiseOffice
Atlanta

Normalized Baseline Energy Use Intensity (kBtu/SF)	**72.1**	Normalized Baseline Energy Use (kWh)	718,454
Impact of Design Changes (see sketches)	1.03		
Adjusted Baseline EUI (kBtu/SF)	**73.9**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		22%	17%	24%	4%	9%	24%	100%
calc'd EUI		16.1	12.6	17.7	3.1	6.9	17.7	74.2
Energy Conservation Measures:								
Glazing	**E1**		3.0%	10.0%		3.6%		3.3%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		6.0%	3.0%		2.1%		1.9%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
PV mounted 30"' up to allow for shading	E2c							
Highly reflective exterior siding	E2d							
Move vapor barrier to outside of building	E2e							
Daylighting (incorporates tuned glazing/shading)	**L1**	50.0%	-3.8%	5.0%		0.8%		11.5%
Remove ceiling, raise window head, add lightshelf	L1a							
Top daylighting from Atrium	L1g							
Daylight controls (continuous dimming)	L1c							
Add light shelf	L1d							
Lighting	**L2**	25.0%	-1.9%	2.5%		0.4%		5.7%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	6.3%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.3%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*75.0%*	*6.5%*	*28.0%*	*0.0%*	*9.7%*	*25.0%*	*31.0%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*11.8*	*12.8*	*3.1*	*6.3*	*13.3*	*51.3*
Mechanical - Distribution & Ventilation	**M2**		15.0%	20.0%		70.0%		11.8%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*20.0%*	*0.0%*	*70.0%*	*0.0%*	*11.8%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*10.0*	*10.2*	*3.1*	*1.9*	*13.3*	*42.5*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		5.1%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				60.0%			2.5%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*60.0%*	*-15.0%*	*0.0%*	*7.6%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**4.0**	**8.0**	**8.2**	**1.3**	**2.2**	**13.3**	***36.9***
Final Energy Use Breakdown as Percentage of Baseline Use		**5%**	**11%**	**11%**	**2%**	**3%**	**18%**	**50%**

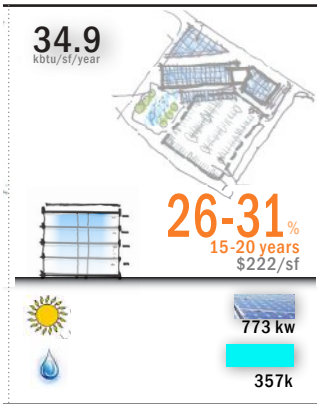
Building Operating Factor	0.90	92.9	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.07	60%	target reduction from CBECS
Total Reduced EUI (kBTU/sf)	**35.5**	Achievement:	
		62%	percent reduction from CBECS
		52%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	354,077		
Number of crystaline panels needed	1,321		
Total kW of PV array	271		

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	269.31	1315	16,480	1321	Panels on roof, walkway, plaza
	15°	284.95	1243		0	
optimal angle:	25.7°	288.74	1227		0	
	45°	278.92	1270		0	
	90°	183.21	1933		0	
				Total kWh =	**355,759**	

MID RISE OFFICE
ATLANTA hot humid

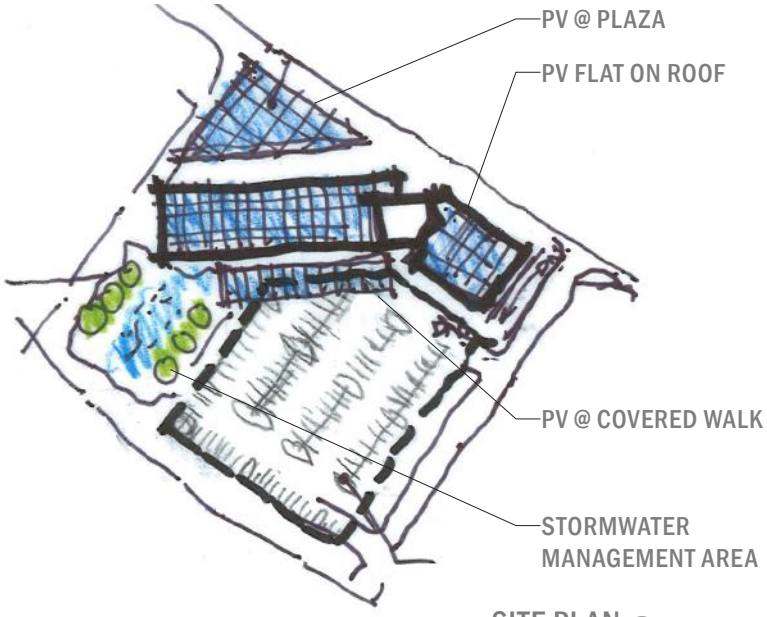


ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

PHOTOVOLTAIC CAPACITY

WATER USE

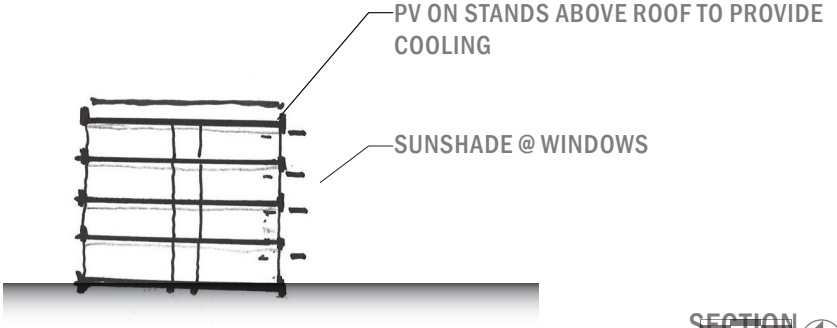


SITE PLAN
NTS

10,000 gal	TANK SIZE
99,385 sf	BUILDING SIZE
4 floors	BUILDING HEIGHT
5.24 acres	SITE AREA
47,025 sf	PHOTOVOLTAIC AREA
23,941 sf	ROOF AREA

MAJOR DESIGN STRATEGIES:

- ✓ Reorient building to be on axis with sun.
- ✓ Create long thin building for operable windows and daylight.
- ✓ Add shading devices to South side of building.
- ✓ Add PV cover at plaza.
- ✓ Reduce windows on East and West; add fins.
- ✓ Create stormwater management area for excess rainfall.



SECTION

PLAN

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **MIDRISE OFFICE**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 99,385
Living Building Gross SF = 99,385
Site Gross Acreage = 5.24

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**2.5%**	**0.2%**	**$1,420,795**	**$14.30**	**$1,456,136**	**$14.65**
Baseline Building			$1,420,795	$14.30	$1,420,795	$14.30
W2 Rainwater Containment - 10,000 gal Rainwater Tank					$35,342	$0.36
B Shell	**5.4%**	**2.0%**	**$7,159,737**	**$72.04**	**$7,548,232**	**$75.95**
Baseline Building			$7,159,737	$72.04	$7,159,737	$72.04
M2E Operable Windows (manual)					$79,877	$0.80
D3C Reallocate Glazing from East and West Façade to South (less spandrel panel, more skin)					($62,069)	($0.62)
E1A Improved Glazing (reduce solar heat gain)					$54,306	$0.55
E1B Exterior Shading Devices					($207,300)	($2.09)
PV2 Added Structure for Roof Mounted PV Panels					$405,000	$4.08
L1D Interior Light Shelves					$118,680	$1.19
C Interiors	**1.0%**	**0.2%**	**$3,724,311**	**$37.47**	**$3,762,078**	**$37.85**
Baseline Building			$3,724,311	$37.47	$3,724,311	$37.47
M2D Carpet Reduction (Replaced with Retroplate)					$99,385	$1.00
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$149,078	$1.50
L1A Exposed Ceilings (white matte surfaces)					($210,696)	($2.12)
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$207,466**	**$2.09**	**$207,466**	**$2.09**
Baseline Building			$207,466	$2.09	$207,466	$2.09
D.2 Services - Plumbing Systems	**18.5%**	**0.8%**	**$838,297**	**$8.43**	**$993,097**	**$9.99**
Baseline Building			$838,297	$8.43	$838,297	$8.43
W6 Low-Flow Fixtures / Optical Sensors					$4,800	$0.05
W2 Rain Harvesting (piping & pumps and filtration)					$150,000	$1.51
D.3 Services - HVAC Systems	**63.9%**	**5.6%**	**$1,725,708**	**$17.36**	**$2,829,298**	**$28.47**
Baseline Building			$1,689,708	$17.00	$1,689,708	$17.00
Baseline HVAC System					($938,935)	($9.45)
M2A In-Slab Radiant Heating and Cooling					$496,925	$5.00
M3A Ground Source Heat Pump					$1,347,600	$13.56
M2B Energy Recovery Wheel / Plate & Frame					$198,000	$1.99
M2C Carbon Dioxide Sensors			$36,000	$0.36	$36,000	$0.36
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$272,482**	**$2.74**	**$272,482**	**$2.74**
Baseline Building			$272,482	$2.74	$272,482	$2.74
D.5 Services - Electrical Systems	**16.8%**	**2.0%**	**$2,339,676**	**$23.54**	**$2,733,076**	**$27.50**
Baseline Building			$2,024,176	$20.37	$2,024,176	$20.37
PA Occupancy Sensor to Outlets					$59,200	$0.60
PE High Efficiency Main Transformer					$53,700	$0.54
L1C Daylight Controls (continuous dimming 15' from perimeter)			$44,500	$0.45	$44,500	$0.45
L2A Efficient Light Fixture Optics Premium			$210,000	$2.11	$210,000	$2.11
L2B Occupancy Sensor for Lighting (closed office / conference spaces)			$22,000	$0.22	$22,000	$0.22
L2C Individual Light Level Control (open spaces)					$280,500	$2.82
L2E Occupancy Sensor for Transient and Egress Lighting			$39,000	$0.39	$39,000	$0.39
E Equipment and Furnishings	**0.0%**	**0.0%**	**$472,675**	**$4.76**	**$472,675**	**$4.76**
Baseline Building			$472,675	$4.76	$472,675	$4.76
F Special Construction	**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building			$0		$0	

BUILDING TYPE: **MIDRISE OFFICE**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 99,385
Living Building Gross SF = 99,385
Site Gross Acreage = 5.24

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
G Sitework		**17.6%**	**1.3%**	**$1,465,612**	**$14.75**	**$1,722,862**	**$17.34**
Baseline Building				$1,465,612	$14.75	$1,465,612	$14.75
W4 Stormwater Retention						$50,000	$0.50
D3 Parking revisions (pervious, deletion of piping, deletion of AC, lighting)						($30,750)	($0.31)
PV2 Plaza PV Structure						$238,000	$2.39
H Logistics		**0.0%**	**0.0%**	**$218,298**	**$2.20**	**$218,298**	**$2.20**
Baseline Building				$218,298	$2.20	$218,298	$2.20
Living Building Prerequisites				**$4,969**	**$0.05**	**$456,505**	**$4.59**
PR5 - Materials Red List		**100.0%**	**0.8%**			$149,453	$1.50
PR7 - Responsible Industry		**100.0%**	**0.2%**			$30,181	$0.30
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.4%**			$271,902	$2.74
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$4,969	$0.05	$4,969	$0.05
Subtotal Direct Costs			14.2%	$19,850,027	$199.73	$22,672,206	$228.13
General Conditions	4.0%	**14.2%**	**0.6%**	$794,001	$7.99	$906,888	$9.13
Fee, Construction Contingency, Insurance	8.0%	**14.2%**	**1.2%**	$1,651,522	$16.62	$1,886,328	$18.98
Location Modifier for ATLANTA, GA	0.87	**14.2%**	**-2.1%**	($2,898,422)	($29.16)	($3,310,505)	($33.31)
TOTAL MODIFIED CONSTRUCTION COST			**14.2%**	**$19,397,129**	**$195.17**	**$22,154,917**	**$222.92**

BUILDING TYPE: **MIDRISE OFFICE**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = **99,385**
Living Building Gross SF = **99,385**
Site Gross Acreage = **5.24**

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.3%			$60,000	$0.60
PV1	Photovoltaic Panels and Infrastructure	724,000	Watts		100.0%	27.4%			$5,430,000	$54.64
LB Prerequisite Items										
	PR3 - Habitat Exchange	5.24	acres		100.0%	0.1%			$26,200	$0.26
	PR6 - Construction Carbon Footprint	2,500	tons		100.0%	0.1%			$27,500	$0.28
	PR15 - Beauty and Spirit (included in A/E fees above)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$43,500	$0.44
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	26.5%	7.2%	$5,431,196	$54.65	$6,868,024	$69.11
	Architecture & Engineering		6.09%	8.09%	51.7%	3.1%	$1,181,235	$11.89	$1,792,276	$18.03
Credits / Rebates / Incentives										
	Photovoltaic Credits-(state, city, utility)	50%			-100.0%	-13.7%			($2,715,000)	($27.32)
	SDC Credits	50%		0.00%	-100.0%	-1.5%	$0		($289,395)	($2.91)
TOTAL OWNER & DESIGN-BUILD COSTS						70.0%	**$6,612,432**	**$66.53**	**$11,243,105**	**$113.13**
TOTAL CONCEPTUAL COST:							**$26,009,561**	**$261.71**	**$33,398,022**	**$336.05**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **26%** **TO** **31%**
MIDRISE OFFICE IN ATLANTA, GA

MidRiseOffice
Atlanta

Normalized Baseline Energy Use Intensity (kBtu/SF) **71.9**

Normalized Baseline Energy Use (kWh) 2,086,285

Impact of Design Changes (see sketches) 1.02

Adjusted Baseline EUI (kBtu/SF) 73.3

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		22%	17%	24%	4%	9%	24%	100%
calc'd EUI		16.0	12.6	17.6	3.1	6.6	17.6	73.5
Energy Conservation Measures:								
Glazing	**E1**		3.0%	10.0%		3.6%		3.2%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		6.0%	3.0%		2.1%		1.9%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
PV mounted 30"' up to allow for shading	E2c							
Highly reflective exterior siding	E2d							
Move vapor barrier to outside of building	E2e							
Daylighting (incorporates tuned glazing/shading)	**L1**	50.0%	-3.8%	5.0%		0.8%		11.5%
Remove ceiling, raise window head, add lightshelf	L1a							
Top daylighting from Atrium	L1g							
Daylight controls (continuous dimming)	L1c							
Add light shelf	L1d							
Lighting	**L2**	25.0%	-1.9%	2.5%		0.4%		5.8%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	6.3%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.3%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*75.0%*	*6.5%*	*28.0%*	*0.0%*	*9.7%*	*25.0%*	*31.1%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*11.7*	*12.7*	*3.1*	*6.0*	*13.2*	*50.7*
Mechanical - Distribution & Ventilation	**M2**		15.0%	20.0%		70.0%		11.5%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*20.0%*	*0.0%*	*70.0%*	*0.0%*	*11.5%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*10.0*	*10.1*	*3.1*	*1.8*	*13.2*	*42.2*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		5.1%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				60.0%			2.5%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*60.0%*	*-15.0%*	*0.0%*	*7.7%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**4.0**	**8.0**	**8.1**	**1.2**	**2.1**	**13.2**	***36.6***
Final Energy Use Breakdown as Percentage of Baseline Use		**5%**	**11%**	**11%**	**2%**	**3%**	**18%**	**50%**

Building Operating Factor	0.90
Impact of Interactive ECM effects	1.07
Total Reduced EUI (kBTU/sf)	**34.9**
Total reduced energy use (kWh)	1,012,192
Number of crystaline panels needed	3,770
Total kW of PV array	773

92.9	CBECS Baseline EUI (kBTU/sf)
60%	target reduction from CBECS

Achievement:

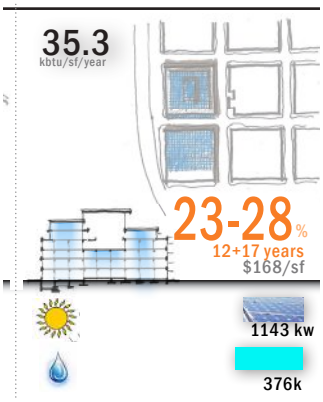
62%	percent reduction from CBECS
52%	percent reduction from Normalized Baseline Bldg

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	269.31	3759	47,025	3770	Panels on roof roof + walkway + plaza
	15°	284.95	3553		0	
optimal angle:	25.7°	288.74	3506		0	
	45°	278.92	3629		0	
	90°	183.21	5525		0	
				Total kWh =	**1,015,299**	

MIXED USE RENOVATION
ATLANTA hot humid

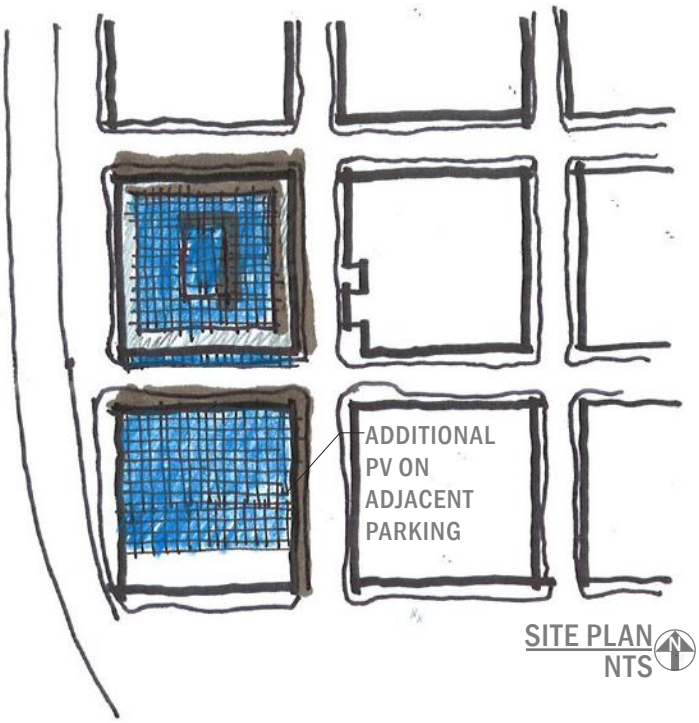


ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

PHOTOVOLTAIC CAPACITY

WATER USE

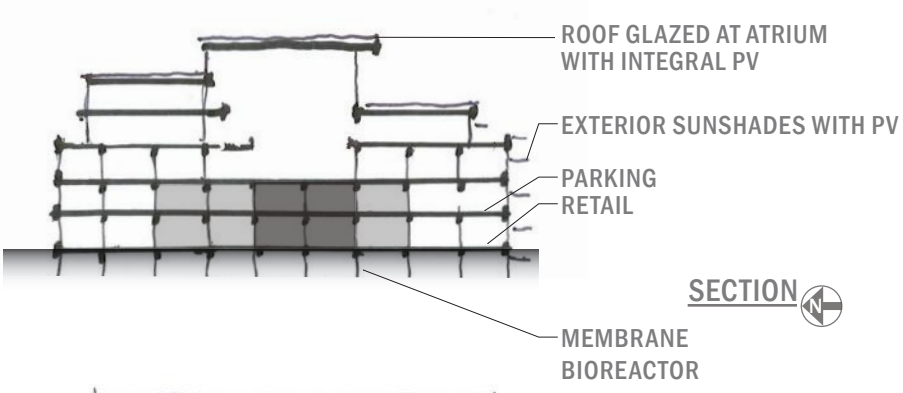


SITE PLAN
NTS

10,000 gal	TANK SIZE
185,043 sf	BUILDING SIZE
5 floors	BUILDING HEIGHT
1.0 acres	SITE AREA
69,570 sf	PHOTOVOLTAIC AREA
40,000 sf	ROOF AREA

MAJOR DESIGN STRATEGIES:

- ✓ Extend open-air atrium down one level to allow access to operable windows.
- ✓ Add extra 10,000sf of additional floor area.
- ✓ Add PV sun shades on South.
- ✓ Add PV to adjacent parking garage to offset both the parking garage loads and the building's loads.



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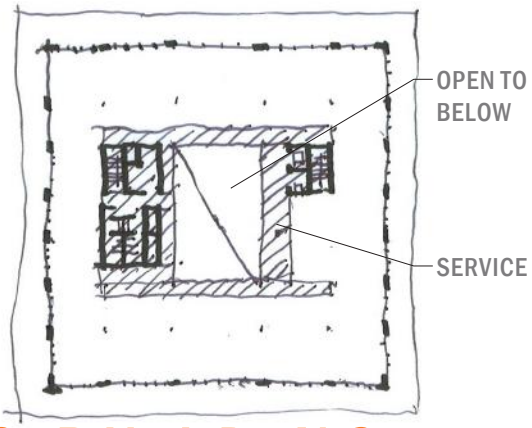


PLAN
NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **MIXED-USE RENOVATION**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 185,043
Living Building Gross SF = 185,043
Site Gross Acreage = 1.00

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**5.1%**	**0.1%**	**$579,458**	**$3.13**	**$608,800**	**$3.29**
	Baseline Building			$579,458	$3.13	$579,458	$3.13
W2	Rainwater Containment - 10,000 gal Rainwater Tank					$29,342	$0.16
B	**Shell**	**13.8%**	**3.8%**	**$8,421,922**	**$45.51**	**$9,586,517**	**$51.81**
	Baseline Building			$8,421,922	$45.51	$8,421,922	$45.51
M2E	Operable Windows (manual, additional units beyond existing)					$32,000	$0.17
L1B	Add Glazed Clerestory at Atrium (and remove skylight)					$108,375	$0.59
E1A	Improved Glazing (reduce solar heat gain)					$25,000	$0.14
E1B	Exterior Shading Devices (PV as shading on South)					$126,875	$0.69
L1D	Raise Window Head / Add Light Shelf (RAF removed)					$0	
M2H	"High Mass" Concrete Inside Insulation (not included because this is a renovation)					$0	
D2B	Modifications to Roof Structure and Roofing					$56,000	$0.30
E2C	Structure to Mount PV on Adjacent Parking Structure					$200,345	$1.08
D3	Renovation Work at Atrium (demo floor, railings, interior walls, structure for balcony)					$130,000	$0.70
D3	Added SF for Additional Floor (at penthouse)					$246,000	$1.33
D2A	Added Wall / Skin for Modified Design (not in base building design)					$240,000	$1.30
L1D	Interior Light Shelves (not included)					$0	
C	**Interiors**	**2.1%**	**0.5%**	**$7,723,877**	**$41.74**	**$7,883,877**	**$42.61**
	Baseline Building			$7,723,877	$41.74	$7,723,877	$41.74
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$270,000	$1.46
M2D	Retroplate Topping Slab (at TI locations)					$690,000	$3.73
L1A	Exposed Ceilings (existing white matte surfaces)					$0	
D3	Remove Raised Access Flooring					($800,000)	($4.32)
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$385,400**	**$2.08**	**$385,400**	**$2.08**
	Baseline Building			$385,400	$2.08	$385,400	$2.08
D.2	**Services - Plumbing Systems**	**19.4%**	**0.5%**	**$791,454**	**$4.28**	**$945,254**	**$5.11**
	Baseline Building			$791,454	$4.28	$791,454	$4.28
W6	Low-Flow Fixtures / Optical Sensors					$3,800	$0.02
W2	Rain Harvesting (piping & pumps and filtration)					$150,000	$0.81
D.3	**Services - HVAC Systems**	**-1.6%**	**-0.1%**	**$2,767,999**	**$14.96**	**$2,723,718**	**$14.72**
	Baseline Building			$2,767,999	$14.96	$2,767,999	$14.96
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,470,281)	($13.35)
M2A	In-Slab Radiant Heating and Cooling					$600,000	$3.24
M3A	Ground Source Heat Pump					$1,675,000	$9.05
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$135,000	$0.73
M2C	Carbon Dioxide Sensors					$16,000	$0.09
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$343,553**	**$1.86**	**$343,553**	**$1.86**
	Baseline Building			$343,553	$1.86	$343,553	$1.86
D.5	**Services - Electrical Systems**	**24.1%**	**3.6%**	**$4,539,215**	**$24.53**	**$5,631,885**	**$30.44**
	Baseline Building			$4,571,685	$24.71	$4,571,685	$24.71
PA	Occupancy Sensor to Outlets					$47,200	$0.26
PE	High Efficiency Transformers					$158,000	$0.85
L1C	Daylight Controls (continuous dimming 15' from perimeter)					$0	
L2A	Efficient Light Fixture Optics Premium					$270,000	$1.46
L2B	Occupancy Sensor for Lighting (closed office / conference spaces)					$0	
L2C	Individual Light Level Control (open spaces, classrooms)					$585,000	$3.16
L2E	Occupancy Sensor for Transient and Egress Lighting			($32,470)	($0.18)	$0	

BUILDING TYPE: **MIXED-USE RENOVATION**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 185,043
Living Building Gross SF = 185,043
Site Gross Acreage = 1.00

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$2,061,480**	**$11.14**	**$2,061,480**	**$11.14**
Baseline Building				$2,061,480	$11.14	$2,061,480	$11.14
F Special Construction		**0.0%**	**0.0%**	**$1,407,188**	**$7.60**	**$1,407,188**	**$7.60**
Baseline Building				$1,407,188	$7.60	$1,407,188	$7.60
G Sitework		**4.4%**	**0.2%**	**$1,131,528**	**$6.11**	**$1,181,528**	**$6.39**
Baseline Building				$1,131,528	$6.11	$1,131,528	$6.11
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.27
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$600,000**	**$3.24**	**$600,000**	**$3.24**
Baseline Building				$600,000	$3.24	$600,000	$3.24
Living Building Prerequisites				**$4,626**	**$0.03**	**$657,517**	**$3.55**
PR5 - Materials Red List		**100.0%**	**0.7%**			$209,552	$1.13
PR7 - Responsible Industry		**100.0%**	**0.2%**			$55,507	$0.30
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.0%**			$307,354	$1.66
PR9 - Leadership in Construction Waste		**1739.6%**	**0.3%**	$4,626	$0.03	$85,103	$0.46
Subtotal Direct Costs			10.6%	$30,757,700	$166.22	$34,016,716	$183.83
General Conditions	4.0%	**10.6%**	**0.4%**	$1,230,308	$6.65	$1,360,669	$7.35
Fee, Construction Contingency, Insurance	0.7%	**10.6%**	**0.1%**	$238,965	$1.29	$264,285	$1.43
Location Modifier for ATLANTA, GA	0.87	**10.6%**	**-1.4%**	($4,189,507)	($22.64)	($4,633,417)	($25.04)
TOTAL MODIFIED CONSTRUCTION COST			**10.6%**	**$28,037,467**	**$151.52**	**$31,008,253**	**$167.57**

BUILDING TYPE: **MIXED-USE RENOVATION**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 185,043
Living Building Gross SF = 185,043
Site Gross Acreage = 1.00

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.2%			$60,000	$0.32
PV1	Photovoltaic Panels and Infrastructure	1,143,000	Watts		100.0%	27.9%			$8,572,500	$46.33
LB Prerequisite Items										
	PR3 - Habitat Exchange	1	acres		100.0%	0.0%			$5,000	$0.03
	PR6 - Construction Carbon Footprint	1,250	tons @ 50%		100.0%	0.0%			$13,750	$0.07
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$63,500	$0.34
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	22.4%	5.7%	$7,850,491	$42.43	$9,612,558	$51.95
	Architecture & Engineering		7.00%	9.00%	42.2%	2.7%	$1,962,623	$10.61	$2,790,743	$15.08
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-13.9%	$0		($4,286,250)	($23.16)
	SDC Credits	50%			-100.0%	-1.1%	$0		($349,890)	($1.89)
TOTAL OWNER & DESIGN-BUILD COSTS						**68.0%**	**$9,813,113**	**$53.03**	**$16,481,911**	**$89.07**
						TOTAL CONCEPTUAL COST:	**$37,850,580**	**$204.55**	**$47,490,164**	**$256.64**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **23%** **TO** **28%**
MIXED-USE RENOVATION IN ATLANTA, GA

Complex Mixed Use Renovation
Atlanta

Normalized Baseline Energy Use Intensity (kBtu/SF) **81.0**

Normalized Baseline Energy Use (kWh) 3,442,311

Impact of Design Changes (see sketches) 0.97

Adjusted Baseline EUI (kBtu/SF) 78.6

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		19%	20%	27%	4%	9%	21%	100%
calc'd EUI		15.2	15.4	21.2	3.0	7.0	16.7	78.6
Energy Conservation Measures:								
Glazing	**E1**		10.0%	15.0%		6.5%		6.6%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		10.0%	6.0%		3.8%		3.9%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	38.0%	-2.9%	3.8%		0.6%		7.9%
Remove ceiling, raise window head, add lightshelf	L1a							
Daylight controls (continuous dimming)	L1c							
Add light shelf	L1d							
Floorplan renovation for daylighting	L1e							
Lighting	**L2**	38.5%	-2.9%	3.9%		0.6%		8.0%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
High color rendering metal halide retail lighting	L2h							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	5.7%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Parking: variable flow ventilation based on CO monitor	Pi							
Super-efficient elevators (hybrid)	Pk							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.6%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		***76.5%***	***17.4%***	***36.2%***	***0.0%***	***14.3%***	***25.0%***	***34.6%***
Subtotal Reduced EUI (kBTU/SF)		***3.6***	***12.8***	***13.5***	***3.0***	***6.0***	***12.6***	***51.4***
Mechanical - Distribution & Ventilation	**M2**		15.0%	20.0%		60.0%		10.5%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Programmable thermostats	M2o							
Subtotal from Mechanical Distribution strategies (percentage)		***0.0%***	***15.0%***	***20.0%***	***0.0%***	***60.0%***	***0.0%***	***10.5%***
Subtotal Reduced EUI (kBTU/SF)		***3.6***	***10.8***	***10.8***	***3.0***	***2.4***	***12.6***	***43.2***
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		5.1%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				50.0%			1.9%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from tankless electric water heater	Wd							
Subtotal from Mechanical Plant and DHW systems (percentage)		***0.0%***	***20.0%***	***20.0%***	***50.0%***	***-15.0%***	***0.0%***	***6.9%***
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**3.6**	**8.7**	**8.7**	**1.5**	**2.8**	**12.6**	***37.7***
Final Energy Use Breakdown as Percentage of Baseline Use		**5%**	**11%**	**11%**	**2%**	**4%**	**16%**	**52%**

Building Operating Factor 0.90
Impact of Interactive ECM effects 1.05

Total Reduced EUI (kBTU/sf) 35.3

Total reduced energy use (kWh) 1,498,995

Number of crystaline panels needed 5,578
Total kW of PV array 1143

92.9 CBECS Baseline EUI (kBTU/sf)
60% target reduction from CBECS

Achievement:
62% percent reduction from CBECS
55% percent reduction from Normalized Baseline Bldg

PV Panel Analysis:

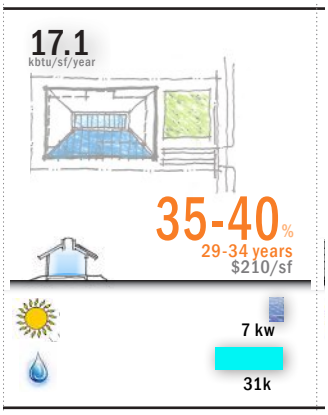
From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	269.31	5567	46,000	3688	Roof + Sunshades
	15°	284.95	5261		0	
optimal angle:	25.7°	288.74	5192		0	
	45°	278.92	5375		0	
	90°	183.21	8182		0	
				Total kWh =	**993,215**	

Additional Parking Garage Offset Needed

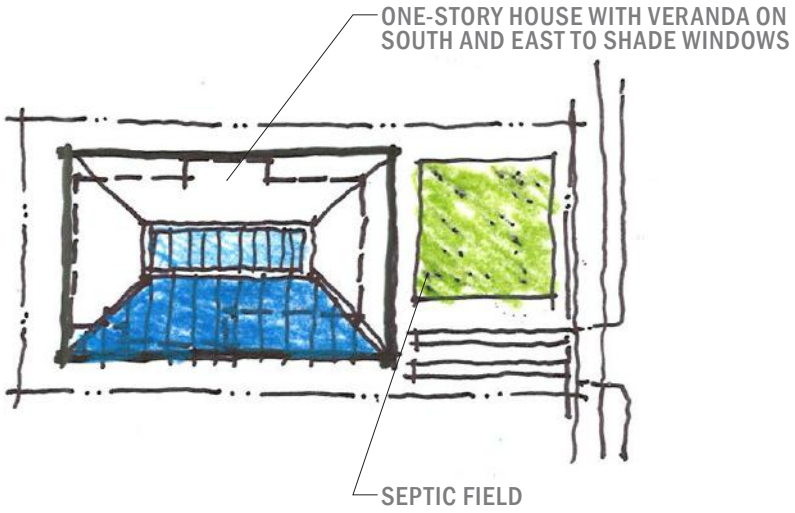
Additional area 23,570 1890 **Adjacent partial parking garage**
Additional kWh Produced **508,996** 1,502,211

SINGLE FAMILY RESIDENTIAL
ATLANTA hot humid



ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF
PHOTOVOLTAIC CAPACITY
WATER USE

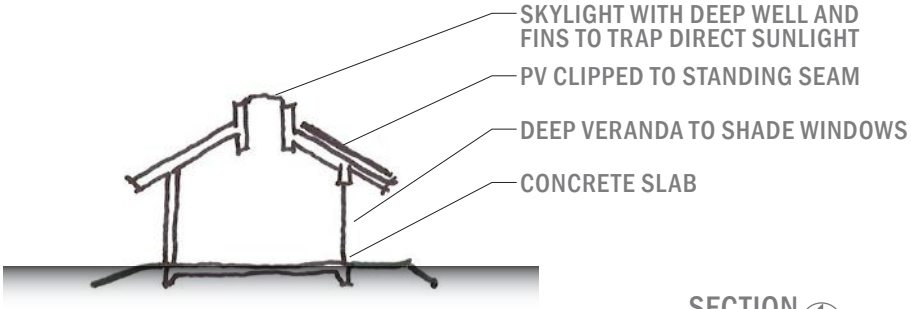


10,000 gal	TANK SIZE
1,840 sf	BUILDING SIZE
1 floors	BUILDING HEIGHT
0.11 acres	SITE AREA
400 sf	PHOTOVOLTAIC AREA
2,000	ROOF AREA

SITE PLAN
NTS

MAJOR DESIGN STRATEGIES:

- ✓ Add deep veranda to shade windows.
- ✓ Add PV on South side of building.
- ✓ Add cistern.
- ✓ Ground source heat pump.



SECTION

PLAN
NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **SINGLE FAMILY RESIDENTIAL**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = **1,840**
Living Building Gross SF = **1,840**
Site Gross Acreage = **0.11**

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**0.0%**	**0.0%**	**$63,527**	**$34.53**	**$63,527**	**$34.53**
Baseline Building			$63,527	$34.53	$63,527	$34.53
W2 Rainwater Containment - 10,000 gal Rainwater Tank (included in base building)					$0	
B Shell	**3.3%**	**1.5%**	**$131,226**	**$71.32**	**$135,558**	**$73.67**
Baseline Building			$131,226	$71.32	$131,226	$71.32
E1A Improved Glazing (reduce solar heat gain)					$4,303	$2.34
D3 Added Porch and Roofing (including credit for front porch removed)					$16,060	$8.73
D3 Modify Building to Single Story					($16,031)	($8.71)
C Interiors	**11.6%**	**1.5%**	**$37,430**	**$20.34**	**$41,780**	**$22.71**
Baseline Building			$37,430	$20.34	$37,430	$20.34
M2A Thicken Lower Level Slab (2") and Gypcrete on Upper Level					$4,350	$2.36
L1A Exposed Ceilings (white matte surfaces)					$0	
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building			$0		$0	
D.2 Services - Plumbing Systems	**57.3%**	**2.1%**	**$10,654**	**$5.79**	**$16,754**	**$9.11**
Baseline Building			$10,654	$5.79	$10,654	$5.79
W6 Low-Flow Fixtures / Optical Sensors					$0	
W2 Rain Harvesting (piping & pumps and filtration)					$0	
W7 Composting Toilets					$6,100	$3.32
D.3 Services - HVAC Systems	**190.0%**	**7.9%**	**$12,008**	**$6.53**	**$34,827**	**$18.93**
Baseline Building			$12,008	$6.53	$12,008	$6.53
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($7,381)	($4.01)
M2A In-Slab Radiant Heating and Cooling					$9,200	$5.00
M3A Ground Source Heat Pump					$21,000	$11.41
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building			$0		$0	
D.5 Services - Electrical Systems	**68.1%**	**2.4%**	**$10,136**	**$5.51**	**$17,036**	**$9.26**
Baseline Building			$10,136	$5.51	$10,136	$5.51
L2K Provide hardwired compact fluorescent fixtures in all spaces					$2,200	$1.20
L2L Motion sensors for exterior lighting					$300	$0.16
M2Z Ceiling Fans and window box fans (five of each)					$4,400	$2.39

BUILDING TYPE: **SINGLE FAMILY RESIDENTIAL**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 1,840
Living Building Gross SF = 1,840
Site Gross Acreage = 0.11

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline Total	LEED™ Gold Baseline Cost/SF	Living Building Total	Living Building Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$1,011**	**$0.55**	**$1,011**	**$0.55**
Baseline Building				$1,011	$0.55	$1,011	$0.55
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**69.8%**	**4.9%**	**$20,208**	**$10.98**	**$34,308**	**$18.65**
Baseline Building				$20,208	$10.98	$20,208	$10.98
W4 Stormwater Retention / Building Water Discharge						$14,100	$7.66
H Logistics		**0.0%**	**0.0%**	**$3,280**	**$1.78**	**$3,280**	**$1.78**
Baseline Building				$3,280	$1.78	$3,280	$1.78
Living Building Prerequisites				**$1,150**	**$0.63**	**$19,338**	**$10.51**
PR5 - Materials Red List		**100.0%**	**0.9%**			$2,737	$1.49
PR7 - Responsible Industry		**100.0%**	**4.1%**			$11,981	$6.51
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.2%**			$3,470	$1.89
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$1,150.00	$0.63	$1,150	$0.63
Subtotal Direct Costs			26.4%	$290,630	$157.95	$367,420	$199.68
General Conditions	10.0%	**26.4%**	**2.6%**	$29,063	$15.80	$36,742	$19.97
Fee, Construction Contingency, Insurance	10.0%	**26.4%**	**2.9%**	$31,969	$17.37	$40,416	$21.97
Location Modifier for ATLANTA, GA	0.87	**26.4%**	**-4.2%**	($45,716)	($24.85)	($57,795)	($31.41)
TOTAL MODIFIED CONSTRUCTION COST			**26.4%**	**$305,947**	**$166.28**	**$386,783**	**$210.21**

BUILDING TYPE: **SINGLE FAMILY RESIDENTIAL**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = **1,840**
Living Building Gross SF = **1,840**
Site Gross Acreage = **0.11**

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				0.0%	0.0%			$0	
PV1	Photovoltaic Panels and Infrastructure	7,000	Watts		100.0%	21.7%			$63,000	$34.24
LB Prerequisite Items										
	PR3 - Habitat Exchange	0.114784	acres		100.0%	0.2%			$574	$0.31
	PR6 - Construction Carbon Footprint	50	tons		100.0%	0.2%			$550	$0.30
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.5%			$1,500	$0.82
Development Costs			LEED	LBC						
	Develoment Costs		3.41%	2.70%	0.0%	0.0%	$10,440	$5.67	$10,440	$5.67
	Architecture & Engineering		12.00%	15.00%	58.0%	7.3%	$36,714	$19.95	$58,017	$31.53
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-10.8%	$0		($31,500)	($17.12)
	SDC Credits	50%			-100.0%	-1.0%	$0		($2,966)	($1.61)
TOTAL OWNER & DESIGN-BUILD COSTS						**111.3%**	**$47,154**	**$25.63**	**$99,616**	**$54.14**
TOTAL CONCEPTUAL COST:							**$353,100**	**$191.90**	**$486,399**	**$264.35**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **35%** **TO** **40%**
SINGLE FAMILY RESIDENTIAL IN ATLANTA, GA

Single Family Residential
Atlanta

Normalized Baseline Energy Use Intensity (kBtu/SF)	**36.5**	Normalized Baseline Energy Use (kWh)	19,470
Impact of Design Changes (see sketches)	0.95		
Adjusted Baseline EUI (kBtu/SF)	**34.8**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		15%	26%	14%	11%	9%	25%	100%
calc'd EUI		5.3	9.1	4.9	3.8	3.1	8.6	34.8
Energy Conservation Measures:								
Glazing	**E1**		10.0%	15.0%		6.5%		5.3%
High performance residential glazing	E1f							
Add effective shading devices	E1b							
Insulated panels for glazing (thermal window shades)	E1g							
Walls & Roof	**E2**		7.0%	6.0%		3.2%		3.0%
Shaded roof from solar panels	E2a							
Optimize insulation - single family residential	E2i							
Highly reflective exterior siding	E2d							
Lighting	**L2**	53.8%	-4.0%	5.4%		0.8%		7.9%
Provide hardwired compact fluorescent fixtures in all spaces.	L2k							
Motion sensors for exterior lighting	L2l							
Plug Loads	**P**		-2.3%	3.0%		0.5%	30.0%	7.3%
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Occupant buy-in / personal energy budget	Pf							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.2%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*53.8%*	*15.7%*	*34.4%*	*0.0%*	*13.5%*	*30.0%*	*25.8%*
Subtotal Reduced EUI (kBTU/SF)		*2.4*	*7.6*	*3.2*	*3.8*	*2.7*	*6.1*	*25.8*
Mechanical - Distribution & Ventilation	**M2**		15.0%	20.0%		60.0%		9.8%
Water to water heat pumps, radiant slab heating/cooling	M2q							
Energy recovery ventilation	M2b							
Natural ventilation: operable windows	M2e							
Ceiling fans and window box fans	M2z							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*20.0%*	*0.0%*	*60.0%*	*0.0%*	*9.8%*
Subtotal Reduced EUI (kBTU/SF)		*2.4*	*6.5*	*2.6*	*3.8*	*1.1*	*6.1*	*22.4*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		4.8%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				75.0%			8.1%
Solar-thermal domestic water	Wa							
Low flow fixtures (showers, lavs, sinks)	Wb							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*75.0%*	*-15.0%*	*0.0%*	*12.9%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**2.4**	**5.2**	**2.1**	**0.9**	**1.2**	**6.1**	***17.9***
Final Energy Use Breakdown as Percentage of Baseline Use		**7%**	**15%**	**6%**	**3%**	**4%**	**17%**	**48%**

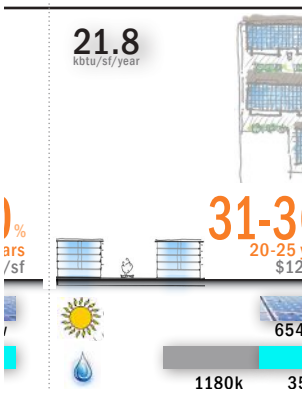
Building Operating Factor	0.91	43.8	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
		Achievement:	
Total Reduced EUI (kBTU/sf)	**17.1**	61%	percent reduction from CBECS
		51%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	9,133		
Number of crystaline panels needed	32		
Total kW of PV array	7		

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	269.31	34		0	Panels on roof roof + walkway + plaza
	15°	284.95	33		0	
optimal angle:	25.7°	288.74	32	400	32	
	45°	278.92	33		0	
	90°	183.21	50		0	
				Total kWh =	**9,240**	

MULTIFAMILY RESIDENTIAL
ATLANTA hot humid

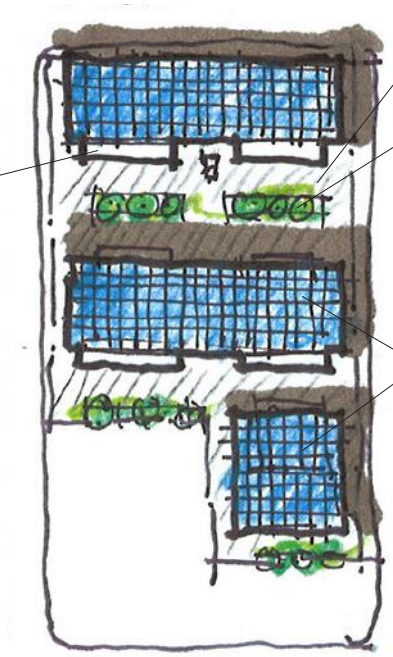


ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

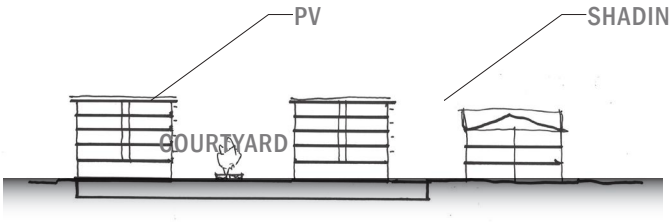
PHOTOVOLTAIC CAPACITY

WATER USE



SITE PLAN
NTS

10,000 gal	TANK SIZE
240,187 sf	BUILDING SIZE
5 floors	BUILDING HEIGHT
2.87 acres	SITE AREA
39,800 sf	PHOTOVOLTAIC AREA
42,393 sf	ROOF AREA



MAJOR DESIGN STRATEGIES:

- ✓ Increase floor to floor height to allow better daylight penetration.
- ✓ Reconfigure housing units to be oriented in N/S direction for better access to daylight.
- ✓ Reconfigure floor plans to allow units to have all habitable rooms within 30' of an operable window.

LEVEL 1 LEVELS 2,3,4 LEVEL 5

PLAN
NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **MULTI-FAMILY HOUSING**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 209,678
Living Building Gross SF = 209,678
Site Gross Acreage = 2.87

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**4.7%**	**0.1%**	**$622,710**	**$2.97**	**$652,052**	**$3.11**
Baseline Building			$622,710	$2.97	$622,710	$2.97
W2 Rainwater Containment - 10,000 gal Rainwater Tank					$29,342	$0.14
B Shell	**5.0%**	**1.6%**	**$7,656,970**	**$36.52**	**$8,040,942**	**$38.35**
Baseline Building			$7,656,970	$36.52	$7,656,970	$36.52
E1D Reduce Glazing (30% of original window glazing)					$165,200	$0.79
E1A Improved Glazing (reduce solar heat gain)					$12,972	$0.06
E1B Exterior Shading Devices					$468,000	$2.23
D2A Reduce Wall / Skin for Modified Design (not in base building design)					($405,600)	($1.93)
D3 Relocate Elevator					$45,000	$0.21
D3 Covered Walkway					$98,400	$0.47
C Interiors	**5.3%**	**1.3%**	**$5,891,333**	**$28.10**	**$6,205,850**	**$29.60**
Baseline Building			$5,891,333	$28.10	$5,891,333	$28.10
M2O Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$314,517	$1.50
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$244,158**	**$1.16**	**$244,158**	**$1.16**
Baseline Building			$244,158	$1.16	$244,158	$1.16
D.2 Services - Plumbing Systems	**8.0%**	**0.6%**	**$1,900,476**	**$9.06**	**$2,052,276**	**$9.79**
Baseline Building			$1,900,476	$9.06	$1,900,476	$9.06
W6 Low-Flow Fixtures / Optical Sensors					$1,800	$0.01
W2 Rain Harvesting (piping & pumps and filtration)					$150,000	$0.72
D.3 Services - HVAC Systems	**387.3%**	**11.5%**	**$717,870**	**$3.42**	**$3,498,260**	**$16.68**
Baseline Building			$717,870	$3.42	$717,870	$3.42
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($535,000)	($2.55)
M2A In-Slab Radiant Heating and Cooling					$1,048,390	$5.00
M3A Ground Source Heat Pump					$1,959,000	$9.34
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$308,000	$1.47
M2C Carbon Dioxide Sensors					$0	
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$462,507**	**$2.21**	**$462,507**	**$2.21**
Baseline Building			$462,507	$2.21	$462,507	$2.21
D.5 Services - Electrical Systems	**-1.6%**	**-0.2%**	**$3,530,018**	**$16.84**	**$3,471,778**	**$16.56**
Baseline Building			$3,416,018	$16.29	$3,416,018	$16.29
L2E Occupancy Sensor for Transient Lighting (corridors/stairs)			$28,000	$0.13		
L2I Dual day/night light levels in corridors; occupancy sensors			$86,000	$0.41		
L2K Provide hardwired compact fluorescent fixtures in all spaces					$55,760	$0.27

BUILDING TYPE: **MULTI-FAMILY HOUSING**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 209,678
Living Building Gross SF = 209,678
Site Gross Acreage = 2.87

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$948,170**	**$4.52**	**$948,170**	**$4.52**
Baseline Building				$948,170	$4.52	$948,170	$4.52
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**6.2%**	**0.6%**	**$2,221,462**	**$10.59**	**$2,358,962**	**$11.25**
Baseline Building				$2,221,462	$10.59	$2,221,462	$10.59
W2 Stormwater Retention / Building Water Discharge						$50,000	$0.24
D3 Added Courtyard						$87,500	$0.42
H Logistics		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
Living Building Prerequisites				**$10,484**	**$0.05**	**$762,110**	**$3.63**
PR5 - Materials Red List		**100.0%**	**0.7%**			$177,292	$0.85
PR7 - Responsible Industry		**100.0%**	**1.3%**			$323,676	$1.54
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.1%**			$261,142	$1.25
PR9 - Leadership in Construction Waste		**-100.0%**	**0.0%**	$10,484	$0.05		
Subtotal Direct Costs			18.6%	$24,206,158	$115.44	$28,697,065	$136.86
General Conditions	4.0%	**18.6%**	**0.7%**	$968,246	$4.62	$1,147,883	$5.47
Fee, Construction Contingency, Insurance	4.0%	**18.6%**	**0.8%**	$1,006,976	$4.80	$1,193,798	$5.69
Location Modifier for ATLANTA, GA	0.87	**18.6%**	**-2.6%**	($3,403,579)	($16.23)	($4,035,037)	($19.24)
TOTAL MODIFIED CONSTRUCTION COST			**18.6%**	**$22,777,801**	**$108.63**	**$27,003,708**	**$128.79**

BUILDING TYPE: **MULTI-FAMILY HOUSING**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 209,678
Living Building Gross SF = 209,678
Site Gross Acreage = 2.87

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	4.1%			$1,000,000	$4.77
PV1	Photovoltaic Panels and Infrastructure	654,000	Watts		100.0%	20.3%			$4,905,000	$23.39
LB Prerequisite Items										
	PR3 - Habitat Exchange	2.86961	acres		100.0%	0.1%			$14,348	$0.07
	PR6 - Construction Carbon Footprint	6,400	tons		100.0%	0.3%			$70,400	$0.34
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.1%			$23,500	$0.11
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	31.3%	8.2%	$6,377,784	$30.42	$8,371,150	$39.92
	Architecture & Engineering		7.00%	9.00%	52.4%	3.5%	$1,594,446	$7.60	$2,430,334	$11.59
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-10.1%	$0		($2,452,500)	($11.70)
	SDC Credits	50%			-100.0%	-1.4%	$0		($343,583)	($1.64)
TOTAL OWNER & DESIGN-BUILD COSTS						75.8%	$7,972,230	$38.02	$14,018,649	$66.86
TOTAL CONCEPTUAL COST:							$30,750,031	$146.65	$41,022,357	$195.64

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **31%** **TO** **36%**
MULTI-FAMILY HOUSING IN ATLANTA, GA

Multi- Family Residential
Atlanta

Normalized Baseline Energy Use Intensity (kBtu/SF)	**46.1**	Normalized Baseline Energy Use (kWh)	1,807,944
Impact of Design Changes (see sketches)	0.99		
Adjusted Baseline EUI (kBtu/SF)	**45.7**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		16%	20%	15%	14%	10%	26%	100%
calc'd EUI		7.1	9.0	6.9	6.2	4.6	11.9	45.7
Energy Conservation Measures:								
Glazing	**E1**		5.0%	15.0%		5.5%		3.8%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		5.0%	3.0%		1.9%		1.6%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Highly reflective exterior siding	E2d							
Move vapor barrier to outside of building	E2e							
Lighting	**L2**	56.6%	-4.2%	5.7%		0.8%		8.9%
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dual day/night light levels in corridors; occupancy sensors	L2i							
Provide hardwired compact fluorescent fixtures in all spaces.	L2k							
Plug Loads	**P**		-2.3%	3.0%		0.5%	30.0%	7.9%
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Occupant buy-in / personal energy budget	Pf							
Parking: variable flow ventilation based on CO monitor	Pi							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.0%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*56.6%*	*8.5%*	*31.7%*	*0.0%*	*11.2%*	*30.0%*	*24.2%*
Subtotal Reduced EUI (kBTU/SF)		*3.1*	*8.3*	*4.7*	*6.2*	*4.1*	*8.3*	*34.6*
Mechanical - Distribution & Ventilation	**M2**		20.0%	20.0%		70.0%		11.9%
Water to water heat pumps, radiant slab heating/cooling	M2q							
Energy recovery ventilation	M2b							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*20.0%*	*20.0%*	*0.0%*	*70.0%*	*0.0%*	*11.9%*
Subtotal Reduced EUI (kBTU/SF)		*3.1*	*6.6*	*3.8*	*6.2*	*1.2*	*8.3*	*29.2*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		4.1%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				75.0%			10.1%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from tankless electric water heater	Wd							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*75.0%*	*-15.0%*	*0.0%*	*14.3%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**3.1**	**5.3**	**3.0**	**1.5**	**1.4**	**8.3**	***22.7***
Final Energy Use Breakdown as Percentage of Baseline Use		**7%**	**12%**	**7%**	**3%**	**3%**	**18%**	**50%**

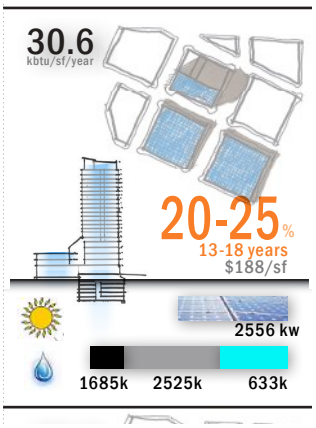
Building Operating Factor	0.90	60.0	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.07	60%	target reduction from CBECS
		Achievement:	
Total Reduced EUI (kBTU/sf)	**21.8**	64%	percent reduction from CBECS
		52%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	855,050		
Number of crystaline panels needed	3,191		
Total kW of PV array	654		

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	269.31	3175	39,800	3191	Panels on roof only
	15°	284.95	3001		0	
optimal angle:	25.7°	288.74	2962		0	
	45°	278.92	3066		0	
	90°	183.21	4668		0	
				Total kWh =	**859,368**	

HIGH RISE MIXED USE
ATLANTA hot humid

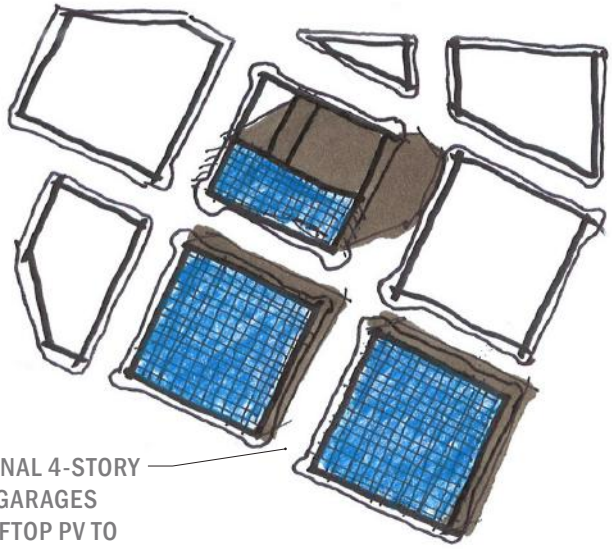


ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

PHOTOVOLTAIC CAPACITY

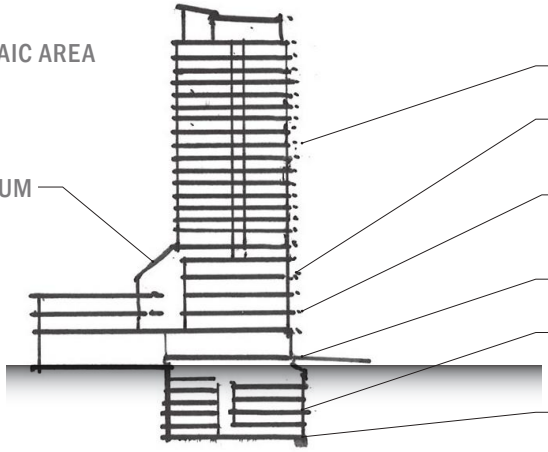
WATER USE



2 ADDITIONAL 4-STORY PARKING GARAGES WITH ROOFTOP PV TO ACHIEVE NET ZERO

SITE PLAN NTS

10,000 gal	TANK SIZE
547,624 sf	BUILDING SIZE
22 floors	BUILDING HEIGHT
0.92 acres	SITE AREA
155,500 sf	PHOTOVOLTAIC AREA
20,000 sf	ROOF AREA



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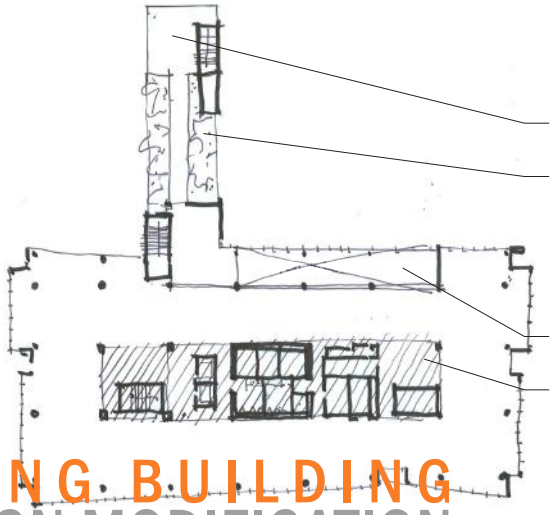


PLAN NTS

MAJOR DESIGN STRATEGIES:

- ✓ Increase floor to floor height to allow better daylight penetration.
- ✓ Add atrium at edge of the office portion of the building to increase daylight.
- ✓ Add an office floor to tower portion of building to ensure all workers are within 30' of operable window.
- ✓ PV integrated with the building skin on South and East facades.
- ✓ PV screen at building West facade.

LIVING BUILDING DESIGN MODIFICATION

BUILDING TYPE: **HIGH RISE**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 547,624
Living Building Gross SF = 547,624
Site Gross Acreage = 0.92

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**0.1%**	**0.0%**	**$8,695,116**	**$15.88**	**$8,707,505**	**$15.90**
	Baseline Building			$8,695,116	$15.88	$8,695,116	$15.88
W2	Rainwater Containment - 10,000 gal Rainwater Tank					$12,389	$0.02
B	**Shell**	**4.6%**	**1.7%**	**$35,629,047**	**$65.06**	**$37,267,319**	**$68.05**
	Baseline Building			$35,629,047	$65.06	$35,629,047	$65.06
L1B	Replace Roofing with Glazed Skylight					$225,900	$0.41
D3A	Raise Floor to Floor Height					$918,000	$1.68
E1B	Exterior Shading Devices					$1,905,120	$3.48
W5	Water Collection on Vertical Surfaces / Top of Roof					$0	
D3	Relocate SF to additional 1/2 floor at top					$40,800	$0.07
D3	Remove Existing Green Roof					($30,000)	($0.05)
D3	Modifications to Lobby Space (structural and finishes)					$590,000	$1.08
L1E	Tracking Mirror above Atrium					$154,000	$0.28
D3	Added Elevator Stop for Additional Floor					$105,000	$0.19
E1D	Reduce Glazing to 30%					($2,315,798)	($4.23)
D3	Remove raised access flooring					($801,000)	($1.46)
PV3	Structure for PV on Adjacent Parking Structures					$684,250	$1.25
L1D	Interior Light Shelves (at office floors)					$162,000	$0.30
C	**Interiors**	**6.7%**	**1.6%**	**$22,739,127**	**$41.52**	**$24,272,474**	**$44.32**
	Baseline Building			$22,739,127	$41.52	$22,739,127	$41.52
M2D	Carpet Reduction (replace with RetroPlate)					$985,723	$1.80
M2O	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$547,624	$1.00
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$2,636,557**	**$4.81**	**$2,636,557**	**$4.81**
	Baseline Building			$2,636,557	$4.81	$2,636,557	$4.81
D.2	**Services - Plumbing Systems**	**0.0%**	**0.0%**	**$3,874,587**	**$7.08**	**$3,874,587**	**$7.08**
	Baseline Building			$3,874,587	$7.08	$3,874,587	$7.08
W6	Low-Flow Fixtures / Optical Sensors					$0	
W2	Rain Harvesting (piping & pumps and filtration)					$0	
D.3	**Services - HVAC Systems**	**45.0%**	**3.6%**	**$7,599,577**	**$13.88**	**$11,022,160**	**$20.13**
	Baseline Building			$7,599,577	$13.88	$8,449,577	$15.43
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($6,085,700)	($11.11)
M2A	In-Slab Radiant Heating and Cooling					$2,738,120	$5.00
M3A	Ground Source Heat Pump					$5,634,000	$10.29
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$286,163	$0.52
M2C	Carbon Dioxide Sensors					$0	
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$1,132,828**	**$2.07**	**$1,132,828**	**$2.07**
	Baseline Building			$1,132,828	$2.07	$1,132,828	$2.07
D.5	**Services - Electrical Systems**	**12.4%**	**0.8%**	**$6,138,326**	**$11.21**	**$6,901,276**	**$12.60**
	Baseline Building			$6,209,026	$11.34	$6,209,026	$11.34
PA	Occupancy Sensor to Outlets					$35,100	$0.06
PE	High Efficiency Transformers					$165,000	$0.30
L2A	Efficient light fixture optics					$160,200	$0.29
L2B	Occupancy Sensor for Lighting (closed office / conference spaces)					$18,850	$0.03
L2C	Individual Light Level Control (open spaces)					$179,000	$0.33
L2I	Dual day/night light levels in corridors; occupancy sensors					$134,100	$0.24
L2J	Occupancy sensor/time clock for corridor lighting					$0	
L2K	Provide hardwired compact fluorescent fixtures in all spaces			($70,700)	($0.13)	$0	

BUILDING TYPE: **HIGH RISE**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 547,624
Living Building Gross SF = 547,624
Site Gross Acreage = 0.92

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$3,326,853**	**$6.08**	**$3,326,853**	**$6.08**
Baseline Building				$3,326,853	$6.08	$3,326,853	$6.08
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**9.3%**	**0.1%**	**$537,417**	**$0.98**	**$587,417**	**$1.07**
Baseline Building				$537,417	$0.98	$537,417	$0.98
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.09
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$1,764,940**	**$3.22**	**$1,764,940**	**$3.22**
Baseline Building				$1,764,940	$3.22	$1,764,940	$3.22
Living Building Prerequisites				**$27,381**	**$0.05**	**$2,211,880**	**$4.04**
PR5 - Materials Red List		**100.0%**	**0.7%**			$667,660	$1.22
PR7 - Responsible Industry		**100.0%**	**0.3%**			$328,542	$0.60
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.3%**			$1,188,297	$2.17
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$27,381	$0.05	$27,381	$0.05
Subtotal Direct Costs			10.2%	$94,101,757	$171.84	$103,705,797	$189.37
General Conditions	3.2%	**10.2%**	**0.3%**	$3,005,271	$5.49	$3,311,989	$6.05
Fee, Contingency, Insurance, Bonding	9.8%	**10.2%**	**1.0%**	$9,471,412	$17.30	$10,438,065	$19.06
Location Modifier for ATLANTA, GA	0.87	**10.2%**	**-1.5%**	($13,855,197)	($25.30)	($15,269,261)	($27.88)
TOTAL MODIFIED CONSTRUCTION COST			**10.2%**	**$92,723,242**	**$169.32**	**$102,186,590**	**$186.60**

BUILDING TYPE: **HIGH RISE**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 547,624
Living Building Gross SF = 547,624
Site Gross Acreage = 0.92

						Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
								Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS											
Design/Build Owner Items											
W3	Biological Bio-Reactor					100.0%	1.1%			$1,000,000	$1.83
O1	Wind Turbines (net cost including credits)	14,800	Watts			0.0%	0.0%	($82,000)		($82,000)	($0.15)
PV1	Photovoltaic Panels and Infrastructure	2,556,000	Watts			100.0%	20.4%			$19,170,000	$35.01
LB Prerequisite Items											
	PR3 - Habitat Exchange	0.918274	acres			100.0%	0.0%			$4,591	$0.01
	PR6 - Construction Carbon Footprint	24,100	tons			100.0%	0.3%			$265,100	$0.48
	PR15 - Beauty and Spirit (included in A/E fees below)					0.0%	0.0%			$0	
	PR16 - Inspiration and Education					100.0%	0.1%			$63,000	$0.12
Development Costs			LEED	LBC							
	Develoment Costs		28.00%	31.00%		22.0%	6.1%	$25,962,508	$47.41	$31,677,843	$57.85
	Architecture & Engineering		7.00%	9.00%		41.7%	2.9%	$6,490,627	$11.85	$9,196,793	$16.79
Credits / Rebates / Incentives											
	PV Credits-(state, city, utility)	50%				-100.0%	-10.2%	$0		($9,585,000)	($17.50)
	SDC Credits	50%				-100.0%	-0.5%	$0		($509,464)	($0.93)
TOTAL OWNER & DESIGN-BUILD COSTS							**58.2%**	**$32,371,135**	**$59.26**	**$51,200,864**	**$93.50**

TOTAL CONCEPTUAL COST: **$125,094,377** **$228.43** **$153,387,455** **$280.10**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **20%** **TO** **25%**
HIGH RISE IN ATLANTA, GA

High Rise Mixed use
Atlanta

Normalized Baseline Energy Use Intensity (kBtu/SF)	**70.4**	Normalized Baseline Energy Use (kWh)	7,841,346
Impact of Design Changes (see sketches)	0.99		
Adjusted Baseline EUI (kBtu/SF)	**69.4**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		14%	20%	21%	11%	10%	24%	100%
calc'd EUI		9.4	13.7	14.8	7.9	6.9	16.6	69.4
Energy Conservation Measures:								
Glazing	**E1**		5.0%	15.0%		5.5%		4.7%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		5.0%	3.0%		1.9%		1.8%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Highly reflective exterior siding	E2d							
Daylighting (incorporates tuned glazing/shading)	**L1**	15.0%	-1.1%	1.5%		0.2%		2.1%
Remove ceiling, raise window head, add lightshelf	L1a							
Daylight controls (continuous dimming)	L1c							
Lighting	**L2**	69.7%	-5.2%	7.0%		1.0%		10.0%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dual day/night light levels in corridors; occupancy sensors	L2i							
Occupancy sensor / time clock for corridor lighting	L2j							
Provide hardwired compact fluorescent fixtures in all spaces.	L2k							
Plug Loads	**P**		-2.3%	3.0%		0.5%	30.0%	7.4%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Parking: variable flow ventilation based on CO monitor	Pi							
Super-efficient elevators (hybrid)	Pk							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.3%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*84.7%*	*6.4%*	*34.5%*	*0.0%*	*11.6%*	*30.0%*	*28.4%*
Subtotal Reduced EUI (kBTU/SF)		*1.4*	*12.8*	*9.7*	*7.9*	*6.1*	*11.6*	*49.7*
Mechanical - Distribution & Ventilation	**M2**		15.0%	20.0%		70.0%		11.8%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Displacement ventilation delivery for DOAS	M2k							
Water to water heat pumps, radiant slab heating/cooling	M2q							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*20.0%*	*0.0%*	*70.0%*	*0.0%*	*11.8%*
Subtotal Reduced EUI (kBTU/SF)		*1.4*	*10.9*	*7.7*	*7.9*	*1.8*	*11.6*	*41.5*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		5.0%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				75.0%			8.6%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from tankless electric water heater	Wd							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*75.0%*	*-15.0%*	*0.0%*	*13.6%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**1.4**	**8.7**	**6.2**	**2.0**	**2.1**	**11.6**	***32.1***
Final Energy Use Breakdown as Percentage of Baseline Use		**2%**	**13%**	**9%**	**3%**	**3%**	**17%**	**54%**

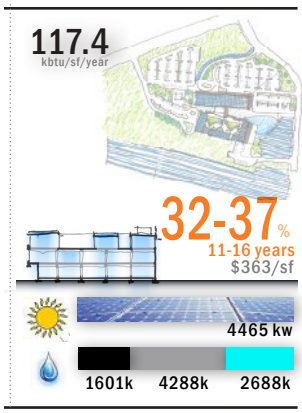
Building Operating Factor	0.90	86.2	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
		Achievement:	
Total Reduced EUI (kBTU/sf)	**30.6**	65%	percent reduction from CBECS
		56%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	3,404,765		
Number of crystaline panels needed	12,468		
Total kW of PV array	2556		

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	269.31	12643	18,000	1443	Panels on roof roof + walkway + plaza
	15°	284.95	11949	57,000	4570	
optimal angle:	25.7°	288.74	11792		0	
	45°	278.92	12207		0	
	90°	183.21	18584		0	
				Total kWh =	**1,690,836**	
Additional Parking Garage Offset Needed			Additional area	80,500	6455	
			Additional kWh Produced		**1,738,396**	3,429,232

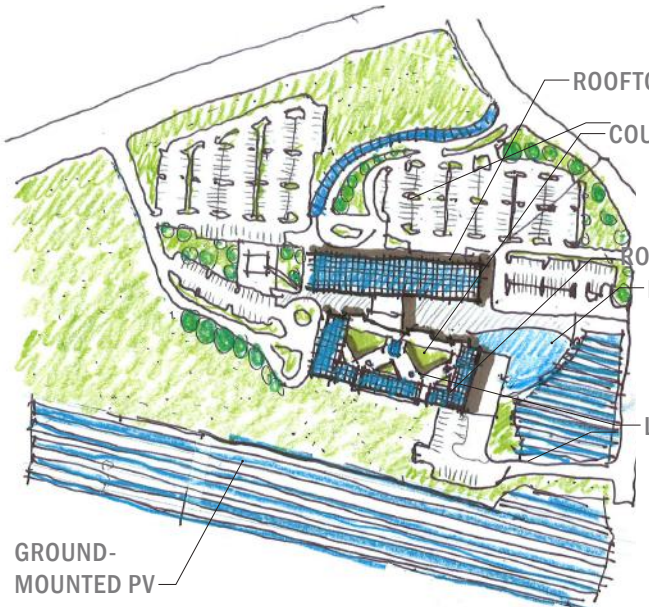
HOSPITAL
ATLANTA hot humid



ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF
PHOTOVOLTAIC CAPACITY
WATER USE

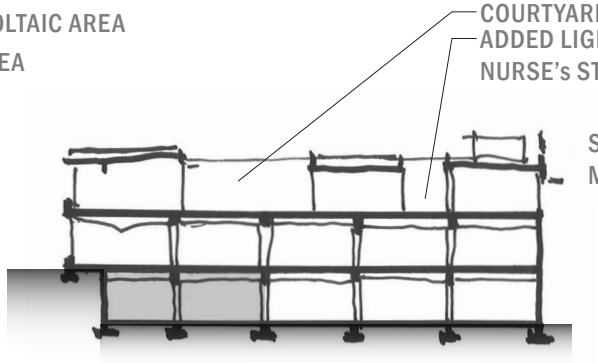
10,000 gal TANK SIZE
180,231 sf BUILDING SIZE
3 floors BUILDING HEIGHT
39.03 acres SITE AREA
271,600 sf PHOTOVOLTAIC AREA
84,900 sf ROOF AREA



SITE PLAN NTS

MAJOR DESIGN STRATEGIES:

- ✓ Add new light courts at Nurse's station.
- ✓ Add skylights at corridors for increased daylighting.
- ✓ Minimize screen at mechanical area, due to fact that mechanical is reduced
- ✓ Add fins to provide shading on west side of classrooms.
- ✓ Add shading devices on South side of hospital, office, etc.



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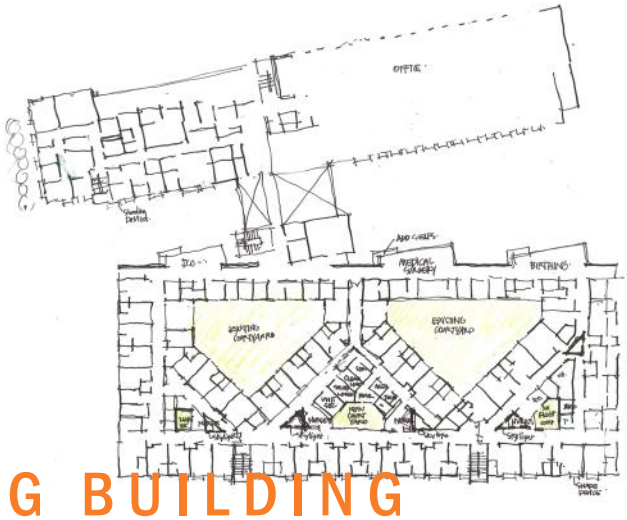


PLAN NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **HOSPITAL**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 180,231
Living Building Gross SF = 180,231
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**1.0%**	**0.0%**	**$2,895,319**	**$16.06**	**$2,924,661**	**$16.23**
	Baseline Building			$2,895,319	$16.06	$2,895,319	$16.06
W2	Rainwater Containment - 10,000 gal Rainwater Tank					$29,342	$0.16
B	**Shell**	**2.1%**	**0.5%**	**$14,789,139**	**$82.06**	**$15,102,359**	**$83.79**
	Baseline Building			$14,789,139	$82.06	$14,789,139	$82.06
L1B	Replace Roofing with Glazed Skylight					$15,000	$0.08
E1A	Improved Glazing (reduce solar heat gain at vision only)					$16,000	$0.09
E1B	Exterior Horizontal Shading Devices					$87,600	$0.49
L1D	Interior Light Shelf					$58,400	$0.32
E1B	Vertical Shading Fins (west end)					$26,900	$0.15
L1B	New Light Shafts to Nurse Stations					$387,000	$2.15
E2B	Infill Spandrel Panel with Framing and Insulation (replace glazed area)					$22,320	$0.12
D3	Reduce Mechanical Rooftop Screen					($300,000)	($1.66)
C	**Interiors**	**0.4%**	**0.1%**	**$9,710,678**	**$53.88**	**$9,746,724**	**$54.08**
	Baseline Building			$9,710,678	$53.88	$9,710,678	$53.88
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$36,046	$0.20
L1A	Raise Ceilings (no cost impact)					$0	
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$826,462**	**$4.59**	**$826,462**	**$4.59**
	Baseline Building			$826,462	$4.59	$826,462	$4.59
D.2	**Services - Plumbing Systems**	**7.5%**	**0.4%**	**$3,347,613**	**$18.57**	**$3,597,613**	**$19.96**
	Baseline Building			$3,347,613	$18.57	$3,347,613	$18.57
W6	Low-Flow Fixtures / Optical Sensors					$0	
W2	Rain Harvesting (piping & pumps and filtration)					$250,000	$1.39
D.3	**Services - HVAC Systems**	**34.5%**	**5.7%**	**$9,992,801**	**$55.44**	**$13,438,384**	**$74.56**
	Baseline Building			$9,992,801	$55.44	$9,992,801	$55.44
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,652,772)	($14.72)
M2A	In-Slab Radiant Heating and Cooling					$901,155	$5.00
M3A	Ground Source Heat Pump					$5,101,200	$28.30
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$80,000	$0.44
M2C	Carbon Dioxide Sensors					$16,000	$0.09
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$444,259**	**$2.46**	**$444,259**	**$2.46**
	Baseline Building			$444,259	$2.46	$444,259	$2.46
D.5	**Services - Electrical Systems**	**6.2%**	**0.8%**	**$8,085,831**	**$44.86**	**$8,589,931**	**$47.66**
	Baseline Building			$8,085,831	$44.86	$8,085,831	$44.86
PA	Occupancy Sensor to Outlets					$21,500	$0.12
PE	High Efficiency Transformers					$217,000	$1.20
LIC	Daylight Controls (continuous dimming 15' from perimeter)					$160,800	$0.89
L2E	Occupancy Sensor for Transient and Egress Lighting					$44,500	$0.25
L2G	Patient Bed light with separate switching for ambient / task					$18,800	$0.10
L2M	Dual level light at egress stairs - off when not occupied					$19,000	$0.11
L2N	Stairwell lighting on daylighting					$22,500	$0.12

BUILDING TYPE: **HOSPITAL**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 180,231
Living Building Gross SF = 180,231
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$2,050,942**	**$11.38**	**$2,050,942**	**$11.38**
Baseline Building				$2,050,942	$11.38	$2,050,942	$11.38
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**0.6%**	**0.1%**	**$7,730,038**	**$42.89**	**$7,780,038**	**$43.17**
Baseline Building				$7,730,038	$42.89	$7,730,038	$42.89
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.28
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$920,558**	**$5.11**	**$920,558**	**$5.11**
Baseline Building				$920,558	$5.11	$920,558	$5.11
Living Building Prerequisites				**$9,012**	**$0.05**	**$1,160,573**	**$6.44**
PR5 - Materials Red List		**100.0%**	**0.7%**			$443,365	$2.46
PR7 - Responsible Industry		**100.0%**	**0.2%**			$108,128	$0.60
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.0%**			$600,069	$3.33
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$9,012	$0.05	$9,012	$0.05
Subtotal Direct Costs			9.5%	$60,802,650	$337.36	$66,582,503	$369.43
General Conditions	5.9%	**9.5%**	**0.6%**	$3,599,939	$19.97	$3,942,146	$21.87
Fee, Contingency, Insurance	6.7%	**9.5%**	**0.7%**	$4,309,196	$23.91	$4,718,825	$26.18
Location Modifier for ATLANTA, GA	0.87	**9.5%**	**-1.4%**	($8,932,532)	($49.56)	($9,781,652)	($54.27)
TOTAL MODIFIED CONSTRUCTION COST			**9.5%**	**$59,779,253**	**$331.68**	**$65,461,823**	**$363.21**

BUILDING TYPE: **HOSPITAL**
BUILDING LOCATION: **ATLANTA, GA**

SKANSKA

Base Building Gross SF = 180,231
Living Building Gross SF = 180,231
Site Gross Acreage = 39.03

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	2.5%			$1,500,000	$8.32
PV1	Photovoltaic Panels and Infrastructure	4,465,000	Watts		100.0%	55.1%			$33,487,500	$185.80
LB Prerequisite Items										
	PR3 - Habitat Exchange	39.03	acres		100.0%	0.3%			$195,150	$1.08
	PR6 - Construction Carbon Footprint	5,400	tons		100.0%	0.1%			$59,400	$0.33
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.1%			$63,000	$0.35
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	21.2%	5.8%	$16,738,191	$92.87	$20,293,165	$112.60
	Architecture & Engineering		7.00%	9.00%	40.8%	2.8%	$4,184,548	$23.22	$5,891,564	$32.69
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-27.5%	$0		($16,743,750)	($92.90)
	SDC Credits	50%			-100.0%	-2.3%	$0		($1,372,092)	($7.61)
TOTAL OWNER & DESIGN-BUILD COSTS						**107.3%**	**$20,922,739**	**$116.09**	**$43,373,937**	**$240.66**
TOTAL CONCEPTUAL COST:							**$80,701,992**	**$447.77**	**$108,835,760**	**$603.87**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **32%** **TO** **37%**
HOSPITAL IN ATLANTA, GA

Hospital
Atlanta

Normalized Baseline Energy Use Intensity (kBtu/SF) **191.2**

Normalized Baseline Energy Use (kWh) 10,084,425

Impact of Design Changes (see sketches) 1.00

Adjusted Baseline EUI (kBtu/SF) 191.2

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
	percent of load	16%	13%	14%	16%	15%	26%	100%
	calc'd EUI	29.9	25.3	27.5	29.9	28.7	49.8	191.2
Energy Conservation Measures:								
Glazing	**E1**		5.0%	10.0%		4.0%		2.7%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		4.0%	3.0%		1.7%		1.2%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Highly reflective exterior siding	E2d							
Daylighting (incorporates tuned glazing/shading)	**L1**	13.3%	-1.0%	1.3%		0.2%		2.2%
Top daylighting with skylights	L1b							
Daylight controls (continuous dimming)	L1c							
Lighting	**L2**	31.1%	-2.3%	3.1%		0.5%		5.1%
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Patient bedlight with separate switching for ambient / task	L2g							
Plug Loads	**P**						10.0%	2.5%
EnergyStar appliances	Pb							
Energy efficient main transformer	Pe							
Super-efficient elevators (hybrid)	Pk							
Aggressive heat recapture - all equipment water cooled	Pl							
Widen Set Point Temperatures	**M1**		2.0%	2.0%		1.0%		0.7%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		***44.4%***	***7.7%***	***19.4%***	***0.0%***	***7.4%***	***10.0%***	***14.5%***
Subtotal Reduced EUI (kBTU/SF)		***16.6***	***23.4***	***22.2***	***29.9***	***26.6***	***44.9***	***163.5***
Mechanical - Distribution & Ventilation	**M2**		15.0%	13.0%		19.0%		6.4%
Radiant slab heating/cooling in lobby/atrium spaces	M2r							
Chilled beams	M2s							
Displacement ventilation in exam rooms	M2t							
Natural ventilation in stairwells	M2u							
Low pressure drop air filters	M2v							
OSA/Exhaust runaround heat recovery	M2w							
Cascading make-up air	M2x							
Subtotal from Mechanical Distribution strategies (percentage)		***0.0%***	***15.0%***	***13.0%***	***0.0%***	***19.0%***	***0.0%***	***6.0%***
Subtotal Reduced EUI (kBTU/SF)		***16.6***	***19.9***	***19.3***	***29.9***	***21.5***	***44.9***	***152.1***
Mechanical - Plant Systems	**M3**		25.0%	30.0%		-7.5%		4.8%
Ground source heat pump with central heat pump chiller	M3e							
Chiller heat recovery	M3f							
Domestic Hot Water	**W**				60.0%			9.4%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		***0.0%***	***25.0%***	***30.0%***	***60.0%***	***-7.5%***	***0.0%***	***14.2%***
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**16.6**	**14.9**	**13.5**	**12.0**	**23.1**	**44.9**	***125.0***
Final Energy Use Breakdown as Percentage of Baseline Use		**9%**	**8%**	**7%**	**6%**	**12%**	**23%**	**35%**

Building Operating Factor 0.90
Impact of Interactive ECM effects 1.05

Total Reduced EUI (kBTU/sf) 117.4

Total reduced energy use (kWh) 6,195,772

Number of crystaline panels needed 21,779
Total kW of PV array 4465

249.2 CBECS Baseline EUI (kBTU/sf)
60% target reduction from CBECS

Achievement: **TARGET REDUCTION NOT MET**

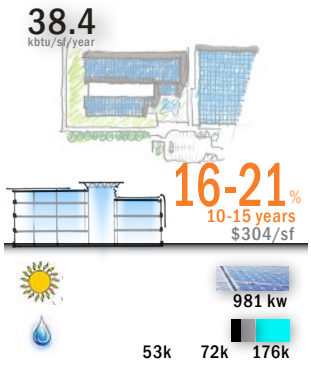
53% percent reduction from CBECS
39% percent reduction from Normalized Baseline Bldg

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	269.31	23007	44,700	3584	Panels on roof roof + walkway + plaza
	15°	284.95	21744		0	
optimal angle:	25.7°	288.74	21458	226,900	18195	
	45°	278.92	22214		0	
	90°	183.21	33818		0	
				Total kWh =	**6,218,831**	

UNIVERSITY CLASSROOM
PHOENIX hot arid



ENERGY USE INDEX

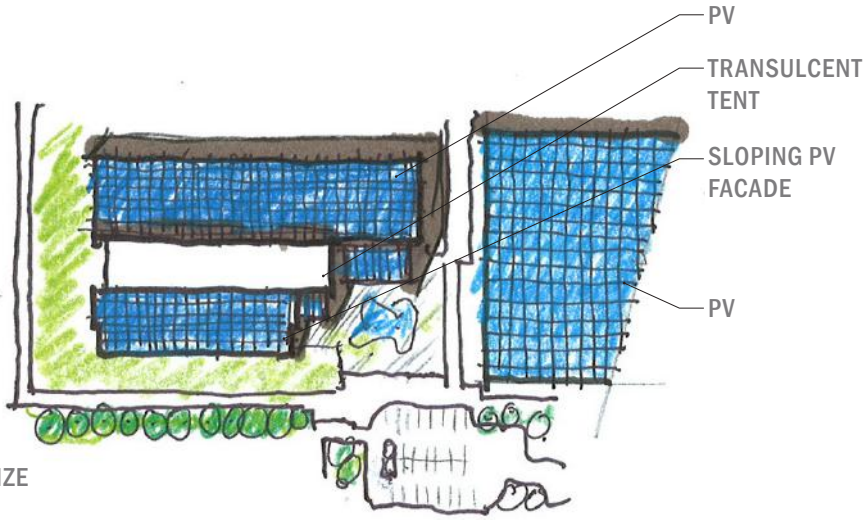
COST PREMIUM

PAYBACK

COST PER SF

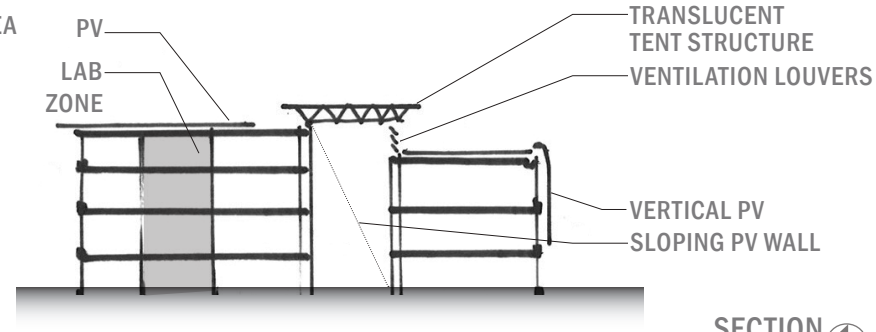
PHOTOVOLTAIC CAPACITY

WATER USE



RAINWATER TANK SIZE	30,000 gal
BUILDING SIZE	153,531 sf
BUILDING HEIGHT	4 floors
SITE AREA	2.75 acres
PHOTOVOLTAIC AREA	56,700 sf
ROOF AREA	38,755 sf

SITE PLAN NTS



SECTION

MAJOR DESIGN STRATEGIES:

- ✓ Reorient the building 180 degrees.
- ✓ Add PV to entire roof.
- ✓ Add fritted PV to glass at Atrium.
- ✓ Add sunshades out of PV to each south window.
- ✓ Translucent tent structure over atrium.
- ✓ PV facade wall - supported by struts from building on East end of building.
- ✓ Vertical PV sunshades.

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **UNIVERSITY CLASSROOM**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 153,531
Living Building Gross SF = 153,531
Site Gross Acreage = 2.75

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**1.7%**	**0.1%**	**$2,123,369**	**$13.83**	**$2,160,394**	**$14.07**
Baseline Building			$2,123,369	$13.83	$2,123,369	$13.83
W2 Rainwater Containment - 30,000 gal Rainwater Tank					$37,025	$0.24
B Shell	**5.9%**	**0.7%**	**$4,959,353**	**$32.30**	**$5,252,677**	**$34.21**
Baseline Building			$4,959,353	$32.30	$4,959,353	$32.30
E1A Improved Glazing (reduce solar heat gain)					$35,324	$0.23
E1B Exterior PV Vertical Screen Wall Supports					$72,000	$0.47
E1B Exterior PV Sloping Wall Structure					$133,000	$0.87
E1B Exterior Shading Devices (vertical sun shades at north windows)					$54,000	$0.35
E1B Exterior Shading Devices (solid horizontal sun shades)					$21,000	$0.14
D2B Revised Atrium Roof Structure (with transluscent roofing)					($22,000)	($0.14)
C Interiors	**-3.8%**	**-1.4%**	**$16,495,934**	**$107.44**	**$15,868,139**	**$103.35**
Baseline Building			$16,495,934	$107.44	$16,495,934	$107.44
M2D Carpet Reduction (remove carpet and retroplate concrete)					$96,071	$0.63
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$153,531	$1.00
L1A Exposed Ceilings (white matte surfaces)					($160,397)	($1.04)
D3 Eliminate Raised Access Floor					($717,000)	($4.67)
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$297,968**	**$1.94**	**$297,968**	**$1.94**
Baseline Building			$297,968	$1.94	$297,968	$1.94
D.2 Services - Plumbing Systems	**5.2%**	**0.4%**	**$2,968,571**	**$19.34**	**$3,122,371**	**$20.34**
Baseline Building			$2,968,571	$19.34	$2,968,571	$19.34
W6 Low-Flow Fixtures / Optical Sensors					$3,800	$0.02
W2 Rain Harvesting (piping & pumps and filtration)					$150,000	$0.98
D.3 Services - HVAC Systems	**45.3%**	**5.8%**	**$5,646,851**	**$36.78**	**$8,204,706**	**$53.44**
Baseline Building			$5,646,851	$36.78	$5,646,851	$36.78
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($1,000,000)	($6.51)
M2A In-Slab Radiant Heating and Cooling					$767,655	$5.00
M3A Ground Source Heat Pump					$2,710,200	$17.65
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$80,000	$0.52
M2C Carbon Dioxide Sensors (in base building)					$0	
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$425,840**	**$2.77**	**$425,840**	**$2.77**
Baseline Building			$425,840	$2.77	$425,840	$2.77
D.5 Services - Electrical Systems	**2.9%**	**0.4%**	**$6,000,852**	**$39.09**	**$6,174,252**	**$40.22**
Baseline Building			$6,000,852	$39.09	$6,000,852	$39.09
PA Occupancy Sensor to Outlets					$14,100	$0.09
PE High Efficiency Transformers					$67,000	$0.44
L2E Occupancy Sensor for Transient and Egress Lighting					$37,500	$0.24

BUILDING TYPE: **UNIVERSITY CLASSROOM**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 153,531
Living Building Gross SF = 153,531
Site Gross Acreage = 2.75

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline Total	LEED™ Gold Baseline Cost/SF	Living Building Total	Living Building Cost/SF
L2F	Dimmable Direct/Indirect Fixtures					$54,800	$0.36
E	**Equipment and Furnishings**	**0.0%**	**0.0%**	**$257,958**	**$1.68**	**$257,958**	**$1.68**
	Baseline Building			$257,958	$1.68	$257,958	$1.68
F	**Special Construction**	**0.0%**	**0.0%**	**$79,247**	**$0.52**	**$79,247**	**$0.52**
	Baseline Building			$79,247	$0.52	$79,247	$0.52
G	**Sitework**	**1.0%**	**0.1%**	**$2,460,261**	**$16.02**	**$2,485,261**	**$16.19**
	Baseline Building			$2,460,261	$16.02	$2,460,261	$16.02
W4	Stormwater Retention / Building Water Discharge					$25,000	$0.16
W1	Remove Storm Drainage Connection to Public/Add sewer meter					$0	
H	**Logistics**	**0.0%**	**0.0%**	**$2,108,417**	**$13.73**	**$2,108,417**	**$13.73**
	Baseline Building			$2,108,417	$13.73	$2,108,417	$13.73
	Living Building Prerequisites			**$7,677**	**$0.05**	**$1,123,676**	**$7.32**
	PR5 - Materials Red List	**100.0%**	**0.7%**			$314,345	$2.05
	PR7 - Responsible Industry	**100.0%**	**0.4%**			$162,546	$1.06
	PR8 - Appropriate Materials / Services Radius	**100.0%**	**1.5%**			$639,109	$4.16
	PR9 - Leadership in Construction Waste	**0.0%**	**0.0%**	$7,677	$0.05	$7,677	$0.05
	Subtotal Direct Costs		8.5%	$43,832,298	$285.49	$47,560,908	$309.78
	General Conditions	8.0%	**8.5%**	**0.7%**	$3,512,022	$22.88	$3,810,773	$24.82
	Fee, Construction Contingency, Insurance	7.0%	**8.5%**	**0.6%**	$3,328,586	$21.68	$3,611,733	$23.52
	Location Modifier for PHOENIX, AZ	0.85	**8.5%**	**-1.5%**	($7,600,936)	($49.51)	($8,247,512)	($53.72)
	TOTAL MODIFIED CONSTRUCTION COST		**8.5%**	**$43,071,971**	**$280.54**	**$46,735,903**	**$304.41**

BUILDING TYPE: **UNIVERSITY CLASSROOM**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 153,531
Living Building Gross SF = 153,531
Site Gross Acreage = 2.75

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.1%			$50,000	$0.33
PV1	Photovoltaic Panels and Infrastructure	932,000	Watts		100.0%	15.9%			$6,990,000	$45.53
LB Prerequisite Items										
	PR3 - Habitat Exchange	2.75482	acres		100.0%	0.0%			$13,774	$0.09
	PR6 - Construction Carbon Footprint	6,800	tons		100.0%	0.2%			$74,800	$0.49
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$73,750	$0.48
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	20.1%	5.5%	$12,060,152	$78.55	$14,488,130	$94.37
	Architecture & Engineering		7.00%	9.00%	39.5%	2.7%	$3,015,038	$19.64	$4,206,231	$27.40
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-8.0%	$0		($3,495,000)	($22.76)
	SDC Credits	50%			-100.0%	-0.8%	$0		($349,890)	($2.28)
TOTAL OWNER & DESIGN-BUILD COSTS						**46.3%**	**$15,075,190**	**$98.19**	**$22,051,795**	**$143.63**
					TOTAL CONCEPTUAL COST:		**$58,147,160**	**$378.73**	**$68,787,698**	**$448.04**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **16%** **TO** **21%**
UNIVERSITY CLASSROOM IN PHOENIX, AZ

University Classroom
Phoenix

Normalized Baseline Energy Use Intensity (kBtu/SF) **87.0**

Normalized Baseline Energy Use (kWh) 3,699,271

Impact of Design Changes (see sketches) 0.97

Adjusted Baseline EUI (kBtu/SF) 84.0

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		20%	5%	34%	2%	10%	29%	100%
calc'd EUI		16.4	4.1	28.8	1.6	8.4	24.6	84.0
Energy Conservation Measures:								
Glazing	**E1**		2.0%	10.0%		3.4%		3.9%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		5.0%	8.0%		3.4%		3.3%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
PV mounted 30"' up to allow for shading	E2c							
Highly reflective exterior siding	E2d							
Daylighting (incorporates tuned glazing/shading)	**L1**	50.0%	-3.8%	5.0%		0.8%		11.4%
Top daylighting with skylights	L1b							
Daylight controls (continuous dimming)	L1c							
Orient windows to allow for illumination of teaching wall	L1f							
Lighting	**L2**	20.0%	-1.5%	2.0%		0.3%		4.5%
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dimmable direct / indirect fixtures	L2f							
Occupancy sensor / time clock for corridor lighting	L2j							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	8.1%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Mechanical - Schedule	**M4**			7.0%				0.3%
Change of work hours (summer hours)	M4a							
Shift uses for time of day in summer (east vs west)	M4b							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.2%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*70.0%*	*4.9%*	*39.5%*	*0.0%*	*10.7%*	*25.0%*	*35.9%*
Subtotal Reduced EUI (kBTU/SF)		*4.9*	*3.9*	*17.4*	*1.6*	*7.5*	*18.5*	*53.9*
Mechanical - Distribution & Ventilation	**M2**		15.0%	25.0%		60.0%		11.2%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Cascading make-up air	M2x							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*25.0%*	*0.0%*	*60.0%*	*0.0%*	*11.2%*
Subtotal Reduced EUI (kBTU/SF)		*4.9*	*3.3*	*13.1*	*1.6*	*3.0*	*18.5*	*44.4*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		3.4%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				50.0%			1.0%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from tankless electric water heater	Wd							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*50.0%*	*-15.0%*	*0.0%*	*4.4%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**4.9**	**2.7**	**10.5**	**0.8**	**3.4**	**18.5**	***40.8***
Final Energy Use Breakdown as Percentage of Baseline Use		**6%**	**3%**	**12%**	**1%**	**4%**	**22%**	**51%**

Building Operating Factor 0.90
Impact of Interactive ECM effects 1.05

Total Reduced EUI (kBTU/sf) 38.4

Total reduced energy use (kWh) 1,630,260

Number of crystaline panels needed 4,785
Total kW of PV array 981

100.0 CBECS Baseline EUI (kBTU/sf)
60% target reduction from CBECS

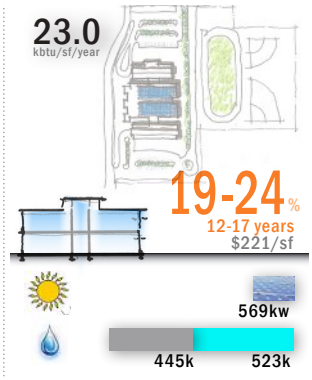
Achievement:
62% percent reduction from CBECS
54% percent reduction from Normalized Baseline Bldg

PV Panel Analysis:

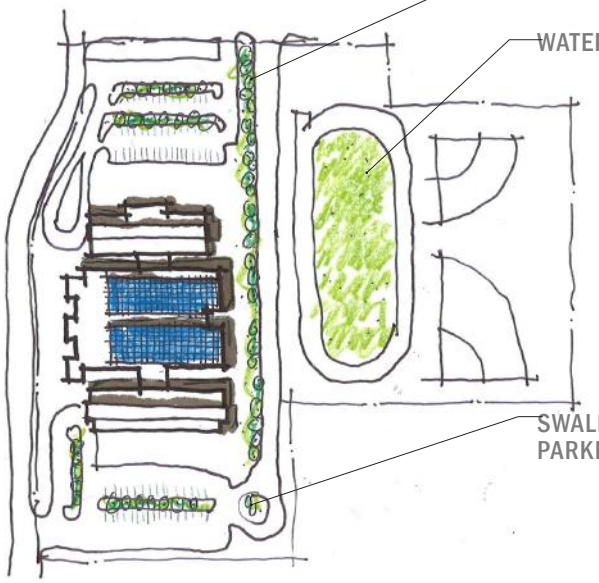
From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	345.73	4716	44,470	3566	Panels at umbrella roof and as shading devices in glazing
	15°	372.11	4382		0	
optimal angle:	29.7°	381.27	4276	10,100	809	
	45°	371.61	4388		0	
	90°	244.19	6677	5,120	410	
				Total kWh =	**1,641,439**	

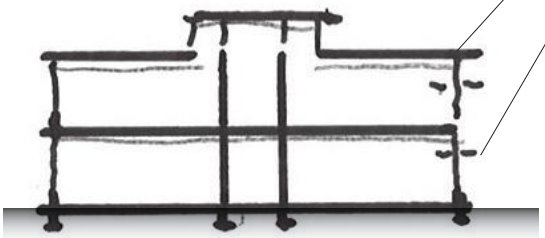
SCHOOL K-8
PHOENIX hot arid



ENERGY USE INDEX	
COST PREMIUM	
PAYBACK	
COST PER SF	
PHOTOVOLTAIC CAPACITY	
WATER USE	
RAINWATER TANK SIZE	300,000 gal
BUILDING SIZE	148,981 sf
BUILDING HEIGHT	2 floors
SITE AREA	39.03 acres
PHOTOVOLTAIC AREA	74,470 sf
ROOF AREA	97,650 sf



SITE PLAN
NTS



SECTION

EXTEND WING

ELIMINATE SOUTH WING

MAJOR DESIGN STRATEGIES:

- ✓ Reorganize plan to eliminate N/S portions of classrooms wings.
- ✓ Remove windows below 2'-6" in classrooms.
- ✓ Remove windows below 2'-0" in corridors.
- ✓ Tune glazing to have high performance glass at vision glass only.
- ✓ Add overhang at clere-story windows.
- ✓ Add skids for support of PV.
- ✓ Eliminate windows on West and East facades at classrooms.

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **ELEMENTARY SCHOOL**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 148,981
Living Building Gross SF = 148,981
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**36.3%**	**1.8%**	**$1,466,210**	**$9.84**	**$1,998,463**	**$13.41**
	Baseline Building			$1,466,210	$9.84	$1,466,210	$9.84
	Rainwater Containment - 300,000 gal Rainwater Tank					$532,253	$3.57
B	**Shell**	**-1.9%**	**-0.6%**	**$9,540,845**	**$64.04**	**$9,363,445**	**$62.85**
	Baseline Building			$9,540,845	$64.04	$9,540,845	$64.04
D3	Lower Roof at Media Center (at both links)					($248,400)	($1.67)
D3	Reallocate South Wing (move SF to east-west wings)					($69,000)	($0.46)
E1A	Improved Glazing (reduce solar heat gain at vision only)					$22,000	$0.15
E1B	Additional Exterior Shading Devices					$37,500	$0.25
D2B	Extend Roof Structure at Clerestory (to the south)					$80,500	$0.54
C	**Interiors**	**3.1%**	**0.5%**	**$4,624,290**	**$31.04**	**$4,765,608**	**$31.99**
	Baseline Building			$4,624,290	$31.04	$4,624,290	$31.04
M2D	Carpet Reduction (replace with RetroPlate)					$108,466	$0.73
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$148,981	$1.00
L1A	Exposed Ceilings (white matte surfaces)					($116,128)	($0.78)
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$100,000**	**$0.67**	**$100,000**	**$0.67**
	Baseline Building			$100,000	$0.67	$100,000	$0.67
D.2	**Services - Plumbing Systems**	**10.4%**	**0.5%**	**$1,438,830**	**$9.66**	**$1,588,830**	**$10.66**
	Baseline Building			$1,438,830	$9.66	$1,438,830	$9.66
W6	Low-Flow Fixtures / Optical Sensors					$0	
W2	Rain Harvesting (piping & pumps and filtration)					$150,000	$1.01
D.3	**Services - HVAC Systems**	**26.1%**	**3.2%**	**$3,684,937**	**$24.73**	**$4,647,670**	**$31.20**
	Baseline Building			$3,684,937	$24.73	$3,684,937	$24.73
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,652,772)	($17.81)
M2A	In-Slab Radiant Heating and Cooling					$744,905	$5.00
M2L	Solar Wall Mechanical Screen					$145,000	$0.97
M3A	Ground Source Heat Pump					$2,629,600	$17.65
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$80,000	$0.54
M2C	Carbon Dioxide Sensors					$16,000	$0.11
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$345,589**	**$2.32**	**$345,589**	**$2.32**
	Baseline Building			$345,589	$2.32	$345,589	$2.32
D.5	**Services - Electrical Systems**	**6.6%**	**0.7%**	**$3,044,694**	**$20.44**	**$3,246,194**	**$21.79**
	Baseline Building			$3,044,694	$20.44	$3,044,694	$20.44
PA	Occupancy Sensor to Outlets					$5,000	$0.03
PE	High Efficiency Transformers					$97,500	$0.65
LIC	Daylight Controls (continuous dimming 15' from perimeter)					$23,800	$0.16
L2F	Dimmable Direct/Indirect fixtures					$47,500	$0.32
L2B	Occupancy Sensor for Lighting (closed office / conference spaces)					$0	
L2C	Individual Light Level Control (open spaces, classrooms)					$5,200	$0.03
L2E	Occupancy Sensor for Transient and Egress Lighting					$22,500	$0.15

BUILDING TYPE: **ELEMENTARY SCHOOL**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 148,981
Living Building Gross SF = 148,981
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$1,555,517**	**$10.44**	**$1,555,517**	**$10.44**
Baseline Building				$1,555,517	$10.44	$1,555,517	$10.44
F Special Construction		**0.0%**	**0.0%**	**$58,000**	**$0.39**	**$58,000**	**$0.39**
Baseline Building				$58,000	$0.39	$58,000	$0.39
G Sitework		**41.9%**	**5.2%**	**$3,701,152**	**$24.84**	**$5,251,152**	**$35.25**
Baseline Building				$3,701,152	$24.84	$3,701,152	$24.84
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.34
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
W2 Additional Onsite Water Collection (in addition to roof)						$1,500,000	$10.07
H Logistics		**0.0%**	**0.0%**	**$524,694**	**$3.52**	**$524,694**	**$3.52**
Baseline Building				$524,694	$3.52	$524,694	$3.52
Living Building Prerequisites				**$7,449**	**$0.05**	**$722,737**	**$4.85**
PR5 - Materials Red List		**100.0%**	**0.7%**			$211,872	$1.42
PR7 - Responsible Industry		**100.0%**	**0.2%**			$66,413	$0.45
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.5%**			$437,003	$2.93
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$7,449	$0.05	$7,449	$0.05
Subtotal Direct Costs			13.5%	$30,092,207	$201.99	$34,167,900	$229.34
General Conditions	3.7%	**13.5%**	**0.5%**	$1,098,511	$7.37	$1,247,293	$8.37
Fee, Contingency, Insurance, Bonding	9.6%	**13.5%**	**1.4%**	$3,009,175	$20.20	$3,416,738	$22.93
Location Modifier for PHOENIX, AZ	0.85	**13.5%**	**-2.3%**	($5,129,984)	($34.43)	($5,824,790)	($39.10)
TOTAL MODIFIED CONSTRUCTION COST			**13.5%**	**$29,069,909**	**$195.12**	**$33,007,141**	**$221.55**

BUILDING TYPE: **ELEMENTARY SCHOOL**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 148,981
Living Building Gross SF = 148,981
Site Gross Acreage = 39.03

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.7%			$200,000	$1.34
PV1	Photovoltaic Panels and Infrastructure	499,000	Watts		100.0%	12.4%			$3,742,500	$25.12
LB Prerequisite Items										
	PR3 - Habitat Exchange	39.03	acres		100.0%	0.6%			$195,150	$1.31
	PR6 - Construction Carbon Footprint	4,400	tons		100.0%	0.2%			$48,400	$0.32
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$63,000	$0.42
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	25.7%	7.0%	$8,139,574	$54.63	$10,232,214	$68.68
	Architecture & Engineering		7.00%	9.00%	46.0%	3.1%	$2,034,894	$13.66	$2,970,643	$19.94
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-6.2%	$0		($1,871,250)	($12.56)
	SDC Credits	50%			-100.0%	-2.8%	$0		($848,565)	($5.70)
TOTAL OWNER & DESIGN-BUILD COSTS						44.8%	**$10,174,468**	**$68.29**	**$14,732,092**	**$98.89**
TOTAL CONCEPTUAL COST:							**$39,244,377**	**$263.42**	**$47,739,233**	**$320.44**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **19%** **TO** **24%**
ELEMENTARY SCHOOL IN PHOENIX, AZ

ElementarySchool
Phoenix

Normalized Baseline Energy Use Intensity (kBtu/SF) **63.8**

Normalized Baseline Energy Use (kWh) 2,637,610

Impact of Design Changes (see sketches) 0.96

Adjusted Baseline EUI (kBtu/SF) 61.0

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
	percent of load	20%	5%	40%	3%	12%	21%	100%
	calc'd EUI	11.9	2.9	24.4	1.7	7.3	12.8	61.0
Energy Conservation Measures:								
Glazing	**E1**		2.0%	15.0%		4.9%		6.7%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		7.0%	8.0%		3.8%		4.0%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
PV mounted 30"' up to allow for shading	E2c							
Highly reflective exterior siding	E2d							
Daylighting (incorporates tuned glazing/shading)	**L1**	75.0%	-5.6%	7.5%		1.1%		17.5%
Top daylighting with skylights	L1b							
Daylight controls (continuous dimming)	L1c							
Orient windows to allow for illumination of teaching wall	L1f							
Lighting	**L2**	9.8%	-0.7%	1.0%		0.1%		2.3%
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dimmable direct / indirect fixtures	L2f							
Occupancy sensor / time clock for corridor lighting	L2j							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	6.2%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Mechanical - Schedule	**M4**			7.0%				0.1%
Change of work hours (summer hours)	M4a							
Shift uses for time of day in summer (east vs west)	M4b							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.5%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*84.8%*	*5.8%*	*46.0%*	*0.0%*	*12.8%*	*25.0%*	*42.0%*
Subtotal Reduced EUI (kBTU/SF)		*1.8*	*2.8*	*13.2*	*1.7*	*6.4*	*9.6*	*35.3*
Mechanical - Distribution & Ventilation	**M2**		15.0%	25.0%		60.0%		12.4%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*25.0%*	*0.0%*	*60.0%*	*0.0%*	*12.4%*
Subtotal Reduced EUI (kBTU/SF)		*1.8*	*2.4*	*9.9*	*1.7*	*2.5*	*9.6*	*27.8*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		3.4%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				70.0%			1.9%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*70.0%*	*-15.0%*	*0.0%*	*5.3%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**1.8**	**1.9**	**7.9**	**0.5**	**2.9**	**9.6**	***24.6***
Final Energy Use Breakdown as Percentage of Baseline Use		**3%**	**3%**	**13%**	**1%**	**5%**	**16%**	**60%**

Building Operating Factor 0.90
Impact of Interactive ECM effects 1.05

Total Reduced EUI (kBTU/sf) 23.0

Total reduced energy use (kWh) 950,643

Number of crystaline panels needed 2,774
Total kW of PV array 569

83.1 CBECS Baseline EUI (kBTU/sf)
60% target reduction from CBECS

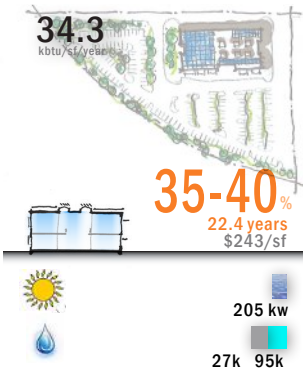
Achievement:
72% percent reduction from CBECS
62% percent reduction from Normalized Baseline Bldg

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	345.73	2750	34,600	2774	Panels at gym roof only
	15°	372.11	2555		0	
optimal angle:	29.7°	381.27	2494		0	
	45°	371.61	2559		0	
	90°	244.19	3894		0	
				Total kWh =	**959,055**	

LOW RISE OFFICE
PHOENIX hot arid



ENERGY USE INDEX

COST PREMIUM
PAYBACK

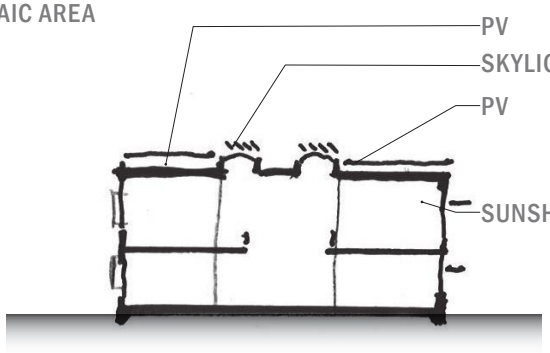
COST PER SF

PHOTOVOLTAIC CAPACITY

WATER USE

15,000 gal	RAINWATER TANK SIZE
35,776 sf	BUILDING SIZE
2 floors	BUILDING HEIGHT
3.24 acres	SITE AREA
12,450 sf	PHOTOVOLTAIC AREA
17,888 sf	ROOF AREA

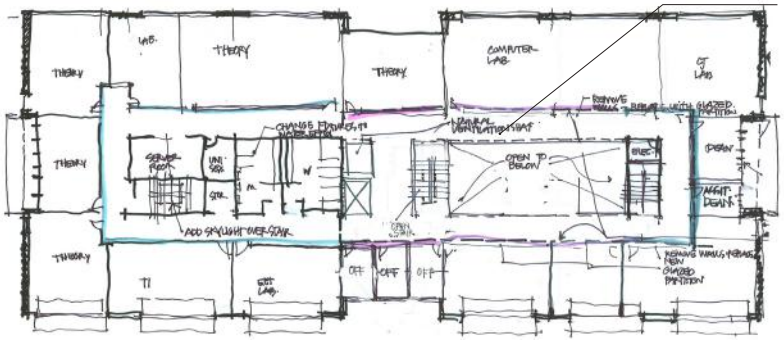
SITE PLAN
NTS



SECTION
0 10 20 30

MAJOR DESIGN STRATEGIES:

- ✓ Add an atrium to provide daylighting deep into the building
- ✓ Add a 6' overhang to provide additional water catchment area.
- ✓ Add 6' wide shading devices.
- ✓ Relocate windows on East and West sides of the building to North and South; glass area to remain the same.
- ✓ Add fins at center bay - East - where windows not eliminated.
- ✓ Provide evergreen trees on West side.



PLAN
NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **LOWRISE OFFICE / CLASSROOMS**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 35,776
Living Building Gross SF = 35,776
Site Gross Acreage = 3.24

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**13.3%**	**1.1%**	**$625,892**	**$17.49**	**$708,993**	**$19.82**
	Baseline Building			$625,892	$17.49	$625,892	$17.49
W2	Rainwater Containment - 41,000 gal Rainwater Tank					$83,101	$2.32
B	**Shell**	**18.1%**	**7.7%**	**$3,237,848**	**$90.50**	**$3,824,935**	**$106.91**
	Baseline Building			$3,237,848	$90.50	$3,237,848	$90.50
M2E	Operable Windows (manual)					$31,680	$0.89
D3C	Reallocate Glazing from East and West Façade to South (less spandrel panel, more skin)					($17,472)	($0.49)
L1B	Replace Roofing with Glazed Skylight					$94,200	$2.63
E1A	Improved Glazing (reduce solar heat gain)					$16,104	$0.45
E1B	Exterior Shading Devices (windows and louvers at entry)					$70,460	$1.97
D2A	Added Wall / Skin for Modified Design (not in base building design)					$274,560	$7.67
M2H	"High Mass" Concrete Inside Insulation (added reflective skin)					$49,500	$1.38
D2B	Modifications to Roof Structure					$39,255	$1.10
L1D	Interior Light Shelves (remove from N/E/W, keep south only)					$28,800	$0.81
C	**Interiors**	**17.2%**	**2.4%**	**$1,076,571**	**$30.09**	**$1,261,402**	**$35.26**
	Baseline Building			$1,076,571	$30.09	$1,076,571	$30.09
M2D	Carpet Reduction (replace with RetroPlate)					$25,500	$0.71
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$48,264	$1.35
L1A	Exposed Ceilings (white matte surfaces)					($68,213)	($1.91)
D3	Glass partitions in lieu of gypsum wallboard					$179,280	$5.01
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$55,000**	**$1.54**	**$55,000**	**$1.54**
	Baseline Building			$55,000	$1.54	$55,000	$1.54
D.2	**Services - Plumbing Systems**	**90.6%**	**2.5%**	**$208,354**	**$5.82**	**$397,154**	**$11.10**
	Baseline Building			$208,354	$5.82	$208,354	$5.82
W6	Low-Flow Fixtures / Optical Sensors					$3,800	$0.11
W2	Rain Harvesting (piping & pumps and filtration)					$185,000	$5.17
D.3	**Services - HVAC Systems**	**100.6%**	**7.8%**	**$591,095**	**$16.52**	**$1,185,475**	**$33.14**
	Baseline Building			$575,095	$16.07	$575,095	$16.07
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($300,000)	($8.39)
M2A	In-Slab Radiant Heating and Cooling					$178,880	$5.00
M3A	Ground Source Heat Pump					$635,500	$17.76
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$80,000	$2.24
M2C	Carbon Dioxide Sensors			$16,000	$0.45	$16,000	$0.45
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$75,177**	**$2.10**	**$75,177**	**$2.10**
	Baseline Building			$75,177	$2.10	$75,177	$2.10
D.5	**Services - Electrical Systems**	**6.5%**	**0.6%**	**$723,416**	**$20.22**	**$770,116**	**$21.53**
	Baseline Building			$603,016	$16.86	$603,016	$16.86
PA	Occupancy Sensor to Outlets					$10,200	$0.29
PE	High Efficiency Transformers					$36,500	$1.02
LIC	Daylight Controls (continuous dimming 15' from perimeter)			$27,000	$0.75	$27,000	$0.75
L2A	Efficient Light Fixture Optics Premium			$67,600	$1.89	$67,600	$1.89
L2B	Occupancy Sensor for Lighting (closed office / conference spaces)			$12,000	$0.34	$12,000	$0.34
L2E	Occupancy Sensor for Transient and Egress Lighting			$13,800	$0.39	$13,800	$0.39

BUILDING TYPE: **LOWRISE OFFICE / CLASSROOMS**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 35,776
Living Building Gross SF = 35,776
Site Gross Acreage = 3.24

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline Total	LEED™ Gold Baseline Cost/SF	Living Building Total	Living Building Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$149,348**	**$4.17**	**$149,348**	**$4.17**
Baseline Building				$149,348	$4.17	$149,348	$4.17
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**7.6%**	**0.8%**	**$791,671**	**$22.13**	**$851,671**	**$23.81**
Baseline Building				$791,671	$22.13	$791,671	$22.13
W4 Stormwater Retention / Building Water Discharge						$50,000	$1.40
E1B Cacti for shading						$10,000	$0.28
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$40,261**	**$1.13**	**$40,261**	**$1.13**
Baseline Building				$40,261	$1.13	$40,261	$1.13
Living Building Prerequisites				**$5,366**	**$0.15**	**$246,767**	**$6.90**
PR5 - Materials Red List		**100.0%**	**0.8%**			$58,739	$1.64
PR7 - Responsible Industry		**100.0%**	**0.1%**			$10,732	$0.30
PR8 - Appropriate Materials / Services Radius		**100.0%**	**2.3%**			$171,930	$4.81
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$5,366	$0.15	$5,366	$0.15
Subtotal Direct Costs			26.2%	$7,580,000	$211.87	$9,566,301	$267.39
General Conditions	4.0%	**26.2%**	**1.0%**	$303,200	$8.47	$382,652	$10.70
Fee, Construction Contingency, Insurance	3.0%	**26.2%**	**0.8%**	$238,965	$6.68	$301,585	$8.43
Location Modifier for PHOENIX, AZ	0.85	**26.2%**	**-4.2%**	($1,218,325)	($34.05)	($1,537,581)	($42.98)
TOTAL MODIFIED CONSTRUCTION COST			**26.2%**	**$6,903,841**	**$192.97**	**$8,712,957**	**$243.54**

BUILDING TYPE: **LOWRISE OFFICE / CLASSROOMS**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 35,776
Living Building Gross SF = 35,776
Site Gross Acreage = 3.24

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.5%			$40,000	$1.12
PV1	Photovoltaic Panels and Infrastructure	175,000	Watts		100.0%	19.6%			$1,487,500	$41.58
LB Prerequisite Items										
	PR3 - Habitat Exchange	3.24	acres		100.0%	0.2%			$16,200	$0.45
	PR6 - Construction Carbon Footprint	2,700	tons		100.0%	0.4%			$29,700	$0.83
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.3%			$23,500	$0.66
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	39.7%	10.1%	$1,933,075	$54.03	$2,701,017	$75.50
	Architecture & Engineering		9.38%	11.38%	53.1%	4.5%	$647,235	$18.09	$991,099	$27.70
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-9.8%	$0		($743,750)	($20.79)
	SDC Credits	50%			-100.0%	-3.1%	$0		($231,353)	($6.47)
TOTAL OWNER & DESIGN-BUILD COSTS						67.2%	**$2,580,310**	**$72.12**	**$4,313,913**	**$120.58**
TOTAL CONCEPTUAL COST:							**$9,484,151**	**$265.10**	**$13,026,869**	**$364.12**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **35%** **TO** **40%**
LOWRISE OFFICE / CLASSROOMS IN PHOENIX, AZ

LowRiseOffice
Phoenix

Normalized Baseline Energy Use Intensity (kBtu/SF) **76.0**

Normalized Baseline Energy Use (kWh) 757,611

Impact of Design Changes (see sketches) 1.03

Adjusted Baseline EUI (kBtu/SF) 77.9

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
	percent of load	21%	6%	36%	4%	9%	23%	100%
	calc'd EUI	16.1	5.0	28.4	3.1	7.3	17.7	77.6
Energy Conservation Measures:								
Glazing	**E1**		3.0%	15.0%		5.1%		6.1%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		6.0%	5.0%		2.7%		2.5%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
PV mounted 30"' up to allow for shading	E2c							
Highly reflective exterior siding	E2d							
Daylighting (incorporates tuned glazing/shading)	**L1**	50.0%	-3.8%	5.0%		0.8%		12.0%
Remove ceiling, raise window head, add lightshelf	L1a							
Top daylighting from Atrium	L1g							
Daylight controls (continuous dimming)	L1c							
Add light shelf	L1d							
Lighting	**L2**	25.0%	-1.9%	2.5%		0.4%		6.0%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	6.5%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.4%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*75.0%*	*6.5%*	*35.0%*	*0.0%*	*11.8%*	*25.0%*	*35.4%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*4.7*	*18.4*	*3.1*	*6.5*	*13.3*	*50.0*
Mechanical - Distribution & Ventilation	**M2**		15.0%	25.0%		60.0%		11.8%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*25.0%*	*0.0%*	*60.0%*	*0.0%*	*11.8%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*4.0*	*13.8*	*3.1*	*2.6*	*13.3*	*40.8*
Mechanical - Plant Systems	**M3**		15.0%	20.0%		-15.0%		3.8%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				70.0%			2.8%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*15.0%*	*20.0%*	*70.0%*	*-15.0%*	*0.0%*	*6.6%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**4.0**	**3.4**	**11.1**	**0.9**	**3.0**	**13.3**	***35.6***
Final Energy Use Breakdown as Percentage of Baseline Use		**5%**	**4%**	**14%**	**1%**	**4%**	**17%**	**54%**

Building Operating Factor 0.90
Impact of Interactive ECM effects 1.07

Total Reduced EUI (kBTU/sf) 34.3

92.9 CBECS Baseline EUI (kBTU/sf)
60% target reduction from CBECS

Achievement:
63% percent reduction from CBECS
56% percent reduction from Normalized Baseline Bldg

Total reduced energy use (kWh) 342,057

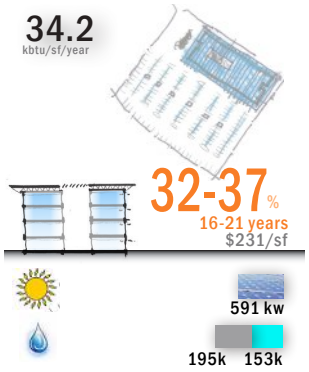
Number of crystaline panels needed 998
Total kW of PV array 205

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

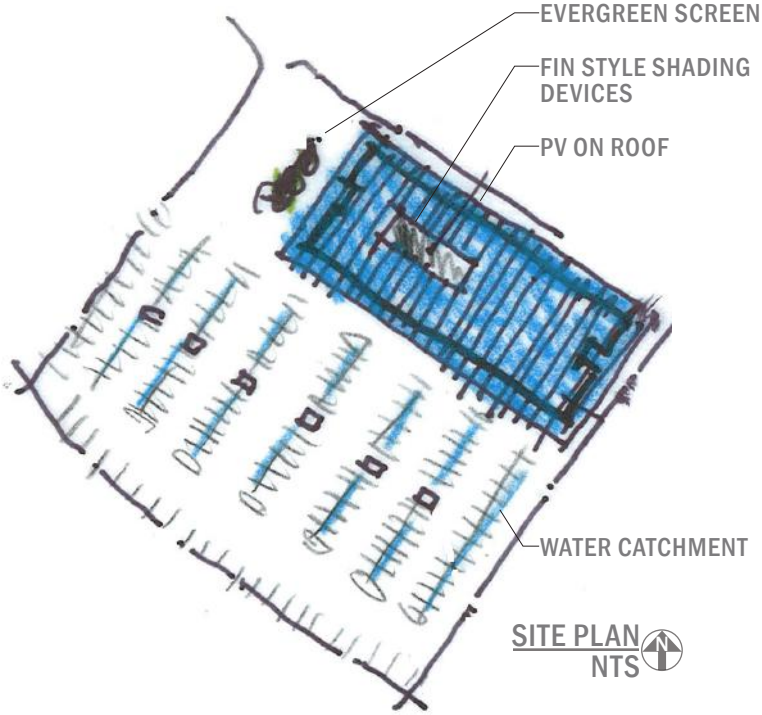
	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	345.73	990	12,450	998	Panels at umbrella roof and as shading devices in glazing
	15°	372.11	920		0	
optimal angle:	29.7°	381.27	898		0	
	45°	371.61	921		0	
	90°	244.19	1401		0	
				Total kWh =	**345,039**	

MID RISE OFFICE
PHOENIX hot arid



ENERGY USE INDEX

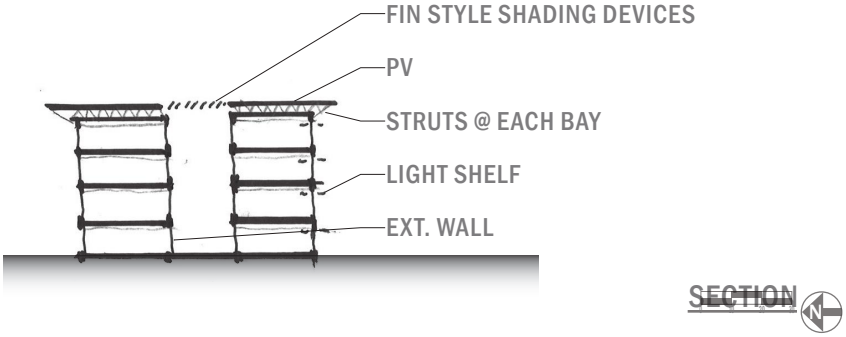
COST PREMIUM
PAYBACK
COST PER SF
PHOTOVOLTAIC CAPACITY
WATER USE

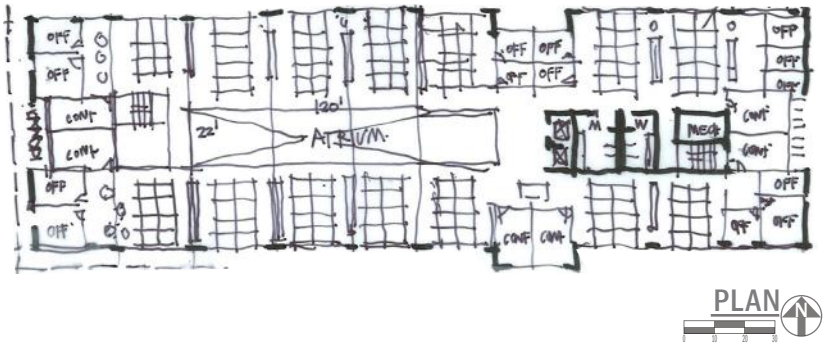


35,000 gal	RAINWATER TANK SIZE
101,185 sf	BUILDING SIZE
5 floors	BUILDING HEIGHT
5.24 acres	SITE AREA
35,940 sf	PHOTOVOLTAIC AREA
28,941 sf	ROOF AREA

MAJOR DESIGN STRATEGIES:

- ✓ Add an atrium to provide daylighting deep into the building
- ✓ Add a 6' overhang to provide additional water catchment area.
- ✓ Add 4' wide shading devices.
- ✓ Relocate windows on East and West sides of the building to North and South; glass area to remain the same.
- ✓ Add fins at center bay on East where windows not eliminated.
- ✓ Provide evergreen trees on West side where windows not eliminated.





LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **MIDRISE OFFICE**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 99,385
Living Building Gross SF = 99,385
Site Gross Acreage = 5.24

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**6.4%**	**0.5%**	**$1,420,795**	**$14.30**	**$1,511,895**	**$15.21**
Baseline Building			$1,420,795	$14.30	$1,420,795	$14.30
W2 Rainwater/Graywater Containment - 41,000 gal Split Tank					$91,100	$0.92
B Shell	**16.3%**	**5.9%**	**$7,159,737**	**$72.04**	**$8,326,645**	**$83.78**
Baseline Building			$7,159,737	$72.04	$7,159,737	$72.04
M2E Operable Windows (manual)					$61,920	$0.62
D3C Reallocate Glazing from East and West Façade to South (less spandrel panel, more skin)					($48,115)	($0.48)
E1A Improved Glazing (reduce solar heat gain)					$42,098	$0.42
D2A Added Wall / Skin for Modified Design (not in base building design)					$194,700	$1.96
W5 Additional 6' Roof Overhang and Structure for Water Collection					$154,845	$1.56
D2A Added Skin at Atrium					$1,005,360	$10.12
D3 Reduced Roofing Area at Atrium					($26,400)	($0.27)
D3 Courtyard Space at Atrium					$79,200	$0.80
E2D Change Skin to Highly Reflective Siding (White Stucco)					($480,700)	($4.84)
L1D Interior Double Light Shelves					$184,000	$1.85
C Interiors	**1.0%**	**0.2%**	**$3,724,311**	**$37.47**	**$3,762,078**	**$37.85**
Baseline Building			$3,724,311	$37.47	$3,724,311	$37.47
M2D Carpet Reduction (replace with Retroplate)					$99,385	$1.00
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$149,078	$1.50
L1A Exposed Ceilings (white matte surfaces)					($210,696)	($2.12)
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$207,466**	**$2.09**	**$207,466**	**$2.09**
Baseline Building			$207,466	$2.09	$207,466	$2.09
D.2 Services - Plumbing Systems	**42.3%**	**1.8%**	**$838,297**	**$8.43**	**$1,193,097**	**$12.00**
Baseline Building			$838,297	$8.43	$838,297	$8.43
W6 Low-Flow Fixtures / Optical Sensors					$4,800	$0.05
W2 Rain Harvesting (piping & pumps and filtration) plus gray plus black					$350,000	$3.52
D.3 Services - HVAC Systems	**93.1%**	**8.1%**	**$1,725,708**	**$17.36**	**$3,332,498**	**$33.53**
Baseline Building			$1,689,708	$17.00	$1,689,708	$17.00
Baseline HVAC System					($938,935)	($9.45)
M2A In-Slab Radiant Heating and Cooling					$496,925	$5.00
M3A Ground Source Heat Pump					$1,850,800	$18.62
M2B Energy Recovery Wheel / Plate & Frame					$198,000	$1.99
M2C Carbon Dioxide Sensors			$36,000	$0.36	$36,000	$0.36
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$272,482**	**$2.74**	**$272,482**	**$2.74**
Baseline Building			$272,482	$2.74	$272,482	$2.74
D.5 Services - Electrical Systems	**12.9%**	**1.5%**	**$2,308,176**	**$23.22**	**$2,605,676**	**$26.22**
Baseline Building			$2,024,176	$20.37	$2,024,176	$20.37
PA Occupancy Sensor to Outlets					$42,000	$0.42
PE High Efficiency Main Transformer					$43,000	$0.43
L1C Daylight Controls (continuous dimming 15' from perimeter)			$38,000	$0.38	$38,000	$0.38
L2A Efficient Light Fixture Optics Premium			$190,000	$1.91	$190,000	$1.91
L2B Occupancy Sensor for Lighting (closed office / conference spaces)			$22,000	$0.22	$22,000	$0.22
L2C Individual Light Level Control (open spaces)					$212,500	$2.14
L2E Occupancy Sensor for Transient and Egress Lighting			$34,000	$0.34	$34,000	$0.34
E Equipment and Furnishings	**0.0%**	**0.0%**	**$472,675**	**$4.76**	**$472,675**	**$4.76**
Baseline Building			$472,675	$4.76	$472,675	$4.76

BUILDING TYPE: **MIDRISE OFFICE**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 99,385
Living Building Gross SF = 99,385
Site Gross Acreage = 5.24

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**8.9%**	**0.7%**	**$1,465,612**	**$14.75**	**$1,595,612**	**$16.05**
Baseline Building				$1,465,612	$14.75	$1,465,612	$14.75
W6 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
W2 Rain Collection and Treatment						$130,000	$1.31
H Logistics		**0.0%**	**0.0%**	**$218,298**	**$2.20**	**$218,298**	**$2.20**
Baseline Building				$218,298	$2.20	$218,298	$2.20
Living Building Prerequisites				**$4,969**	**$0.05**	**$629,094**	**$6.33**
PR5 - Materials Red List		**100.0%**	**0.8%**			$156,477	$1.57
PR7 - Responsible Industry		**100.0%**	**0.2%**			$30,181	$0.30
PR8 - Appropriate Materials / Services Radius		**100.0%**	**2.2%**			$437,467	$4.40
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$4,969	$0.05	$4,969	$0.05
Subtotal Direct Costs			21.7%	$19,818,527	$199.41	$24,127,516	$242.77
General Conditions	4.0%	**21.7%**	**0.9%**	$792,741	$7.98	$965,101	$9.71
Fee, Construction Contingency, Insurance	8.0%	**21.7%**	**1.8%**	$1,648,901	$16.59	$2,007,409	$20.20
Location Modifier for PHOENIX, AZ	0.85	**21.7%**	**-3.7%**	($3,339,026)	($33.60)	($4,065,004)	($40.90)
TOTAL MODIFIED CONSTRUCTION COST			**21.7%**	**$18,921,145**	**$190.38**	**$23,035,023**	**$231.78**

BUILDING TYPE: **MIDRISE OFFICE**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = **99,385**
Living Building Gross SF = **99,385**
Site Gross Acreage = **5.24**

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.3%			$60,000	$0.60
PV1	Photovoltaic Panels and Infrastructure	453,000	Watts		100.0%	19.4%			$3,850,500	$38.74
LB Prerequisite Items										
	PR3 - Habitat Exchange	5.24	acres		100.0%	0.1%			$26,200	$0.26
	PR6 - Construction Carbon Footprint	2,500	tons		100.0%	0.1%			$27,500	$0.28
	PR15 - Beauty and Spirit (included in A/E fees above)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$43,500	$0.44
Development Costs			LEED	LBC						
	Develoment Costs		13.06%	16.06%	49.7%	6.2%	$2,471,271	$24.87	$3,699,631	$37.23
	Architecture & Engineering		6.09%	8.09%	61.7%	3.6%	$1,152,249	$11.59	$1,863,474	$18.75
Credits / Rebates / Incentives										
	Photovoltaic Credits-(state, city, utility)	50%			-100.0%	-9.7%			($1,925,250)	($19.37)
	SDC Credits	50%		0.00%	-100.0%	-1.5%	$0		($289,395)	($2.91)
TOTAL OWNER & DESIGN-BUILD COSTS						**103.0%**	**$3,623,520**	**$36.46**	**$7,356,161**	**$74.02**

TOTAL CONCEPTUAL COST: **$22,544,665** **$226.84** **$30,391,183** **$305.79**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **32%** **TO** **37%**
MIDRISE OFFICE IN PHOENIX, AZ

LowRiseOffice
Phoenix

Normalized Baseline Energy Use Intensity (kBtu/SF) **76.0**

Normalized Baseline Energy Use (kWh) 757,611

Impact of Design Changes (see sketches) 1.03

Adjusted Baseline EUI (kBtu/SF) 77.9

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		21%	6%	36%	4%	9%	23%	100%
calc'd EUI		16.1	5.0	28.4	3.1	7.3	17.7	77.6
Energy Conservation Measures:								
Glazing	**E1**		3.0%	15.0%		5.1%		6.1%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		6.0%	5.0%		2.7%		2.5%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
PV mounted 30"' up to allow for shading	E2c							
Highly reflective exterior siding	E2d							
Daylighting (incorporates tuned glazing/shading)	**L1**	50.0%	-3.8%	5.0%		0.8%		12.0%
Remove ceiling, raise window head, add lightshelf	L1a							
Top daylighting from Atrium	L1g							
Daylight controls (continuous dimming)	L1c							
Add light shelf	L1d							
Lighting	**L2**	25.0%	-1.9%	2.5%		0.4%		6.0%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	6.5%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.4%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		***75.0%***	***6.5%***	***35.0%***	***0.0%***	***11.8%***	***25.0%***	***35.4%***
Subtotal Reduced EUI (kBTU/SF)		***4.0***	***4.7***	***18.4***	***3.1***	***6.5***	***13.3***	***50.0***
Mechanical - Distribution & Ventilation	**M2**		15.0%	25.0%		60.0%		11.8%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Subtotal from Mechanical Distribution strategies (percentage)		***0.0%***	***15.0%***	***25.0%***	***0.0%***	***60.0%***	***0.0%***	***11.8%***
Subtotal Reduced EUI (kBTU/SF)		***4.0***	***4.0***	***13.8***	***3.1***	***2.6***	***13.3***	***40.8***
Mechanical - Plant Systems	**M3**		15.0%	20.0%		-15.0%		3.8%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				70.0%			2.8%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Subtotal from Mechanical Plant and DHW systems (percentage)		***0.0%***	***15.0%***	***20.0%***	***70.0%***	***-15.0%***	***0.0%***	***6.6%***
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**4.0**	**3.4**	**11.1**	**0.9**	**3.0**	**13.3**	***35.6***
Final Energy Use Breakdown as Percentage of Baseline Use		**5%**	**4%**	**14%**	**1%**	**4%**	**17%**	**54%**

Building Operating Factor 0.90
Impact of Interactive ECM effects 1.07

Total Reduced EUI (kBTU/sf) 34.3

92.9 CBECS Baseline EUI (kBTU/sf)
60% target reduction from CBECS

Achievement:
63% percent reduction from CBECS
56% percent reduction from Normalized Baseline Bldg

Total reduced energy use (kWh) 342,057

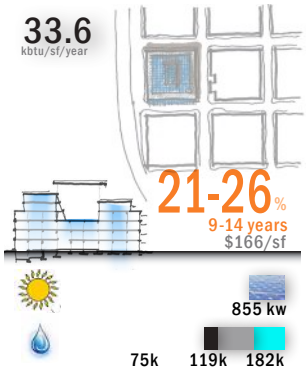
Number of crystaline panels needed 998
Total kW of PV array 205

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	345.73	990	12,450	998	Panels at umbrella roof and as shading devices in glazing
	15°	372.11	920		0	
optimal angle:	29.7°	381.27	898		0	
	45°	371.61	921		0	
	90°	244.19	1401		0	
				Total kWh =	**345,039**	

MIXED USE RENOVATION
PHOENIX hot arid

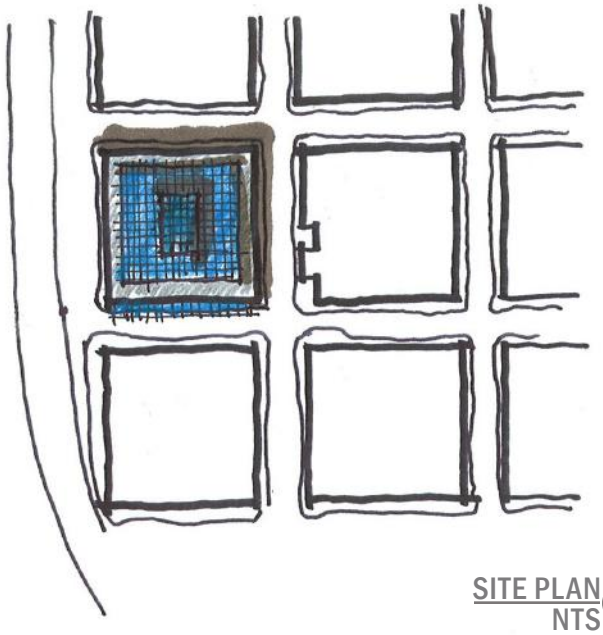


ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

PHOTOVOLTAIC CAPACITY

WATER USE

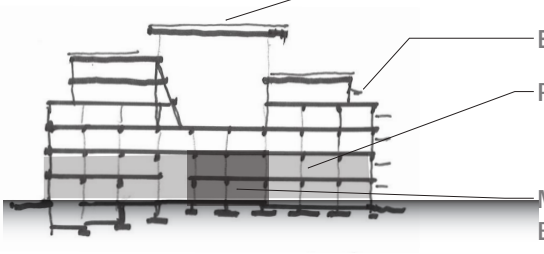


SITE PLAN
NTS

29,000 gal	RAINWATER TANK SIZE
185,043 sf	BUILDING SIZE
6 floors	BUILDING HEIGHT
1.0 acres	SITE AREA
45,110 sf	PHOTOVOLTAIC AREA
40,000 sf	ROOF AREA

MAJOR DESIGN STRATEGIES:

- ✓ Extend atrium down one level allow access to operable windows for all workstations.
- ✓ Open air atrium.
- ✓ Add PV sun shades on South.
- ✓ Provide additional 1/2 level to make up for floor area lost with insertion of atrium.
- ✓ Add a roof cover and PV struts similar to the renovated building.



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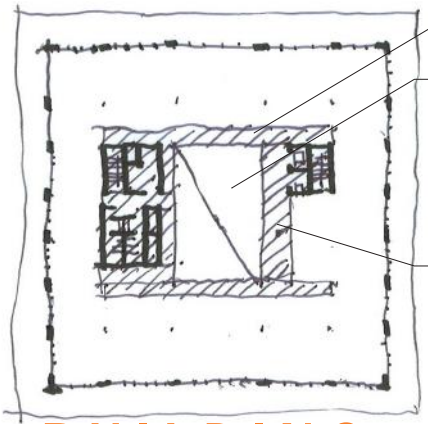


PLAN
NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **MIXED-USE RENOVATION**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 185,043
Living Building Gross SF = 185,043
Site Gross Acreage = 1.00

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**5.1%**	**0.1%**	**$579,458**	**$3.13**	**$608,800**	**$3.29**
Baseline Building			$579,458	$3.13	$579,458	$3.13
W2 Rainwater Containment - 10,000 gal Rainwater Tank					$29,342	$0.16
B Shell	**11.4%**	**3.1%**	**$8,421,922**	**$45.51**	**$9,386,172**	**$50.72**
Baseline Building			$8,421,922	$45.51	$8,421,922	$45.51
M2E Operable Windows (manual, additional units beyond existing)					$32,000	$0.17
L1B Add Glazed Clerestory at Atrium (and remove skylight)					$108,375	$0.59
E1A Improved Glazing (reduce solar heat gain)					$25,000	$0.14
E1B Exterior Shading Devices (PV as shading on South)					$126,875	$0.69
L1D Raise Window Head / Add Light Shelf (RAF removed)					$0	
M2H "High Mass" Concrete Inside Insulation (not included because this is a renovation)					$0	
D2B Modifications to Roof Structure and Roofing					$56,000	$0.30
D3 Renovation Work at Atrium (demo floor, railings, interior walls, structure for balcony)					$130,000	$0.70
D3 Added SF for Additional Floor (at penthouse)					$246,000	$1.33
D2A Added Wall / Skin for Modified Design (not in base building design)					$240,000	$1.30
L1D Interior Light Shelves (not included)					$0	
C Interiors	**2.1%**	**0.5%**	**$7,723,877**	**$41.74**	**$7,883,877**	**$42.61**
Baseline Building			$7,723,877	$41.74	$7,723,877	$41.74
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$270,000	$1.46
M2D Retroplate Topping Slab (at TI locations)					$690,000	$3.73
L1A Exposed Ceilings (existing white matte surfaces)					$0	
D3 Remove Raised Access Flooring					($800,000)	($4.32)
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$385,400**	**$2.08**	**$385,400**	**$2.08**
Baseline Building			$385,400	$2.08	$385,400	$2.08
D.2 Services - Plumbing Systems	**19.4%**	**0.5%**	**$791,454**	**$4.28**	**$945,254**	**$5.11**
Baseline Building			$791,454	$4.28	$791,454	$4.28
W6 Low-Flow Fixtures / Optical Sensors					$3,800	$0.02
W2 Rain Harvesting (piping & pumps and filtration)					$150,000	$0.81
D.3 Services - HVAC Systems	**20.6%**	**1.9%**	**$2,767,999**	**$14.96**	**$3,337,918**	**$18.04**
Baseline Building			$2,767,999	$14.96	$2,767,999	$14.96
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,470,281)	($13.35)
M2A In-Slab Radiant Heating and Cooling					$600,000	$3.24
M3A Ground Source Heat Pump					$2,289,200	$12.37
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$135,000	$0.73
M2C Carbon Dioxide Sensors					$16,000	$0.09
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$343,553**	**$1.86**	**$343,553**	**$1.86**
Baseline Building			$343,553	$1.86	$343,553	$1.86
D.5 Services - Electrical Systems	**24.1%**	**3.6%**	**$4,539,215**	**$24.53**	**$5,631,885**	**$30.44**
Baseline Building			$4,571,685	$24.71	$4,571,685	$24.71
PA Occupancy Sensor to Outlets					$47,200	$0.26
PE High Efficiency Transformers					$158,000	$0.85
L1C Daylight Controls (continuous dimming 15' from perimeter)					$0	
L2A Efficient Light Fixture Optics Premium					$270,000	$1.46
L2B Occupancy Sensor for Lighting (closed office / conference spaces)					$0	
L2C Individual Light Level Control (open spaces, classrooms)					$585,000	$3.16
L2E Occupancy Sensor for Transient and Egress Lighting			($32,470)	($0.18)	$0	

BUILDING TYPE: **MIXED-USE RENOVATION**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 185,043
Living Building Gross SF = 185,043
Site Gross Acreage = 1.00

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$2,061,480**	**$11.14**	**$2,061,480**	**$11.14**
Baseline Building				$2,061,480	$11.14	$2,061,480	$11.14
F Special Construction		**0.0%**	**0.0%**	**$1,407,188**	**$7.60**	**$1,407,188**	**$7.60**
Baseline Building				$1,407,188	$7.60	$1,407,188	$7.60
G Sitework		**4.4%**	**0.2%**	**$1,131,528**	**$6.11**	**$1,181,528**	**$6.39**
Baseline Building				$1,131,528	$6.11	$1,131,528	$6.11
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.27
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$600,000**	**$3.24**	**$600,000**	**$3.24**
Baseline Building				$600,000	$3.24	$600,000	$3.24
Living Building Prerequisites				**$4,626**	**$0.03**	**$814,111**	**$4.40**
PR5 - Materials Red List		**100.0%**	**0.7%**			$207,176	$1.12
PR7 - Responsible Industry		**100.0%**	**0.2%**			$55,507	$0.30
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.5%**			$465,283	$2.51
PR9 - Leadership in Construction Waste		**1762.1%**	**0.3%**	$4,626	$0.03	$86,144	$0.47
Subtotal Direct Costs			12.5%	$30,757,700	$166.22	$34,587,165	$186.91
General Conditions	4.0%	**12.5%**	**0.5%**	$1,230,308	$6.65	$1,383,487	$7.48
Fee, Construction Contingency, Insurance	0.7%	**12.5%**	**0.1%**	$238,965	$1.29	$268,717	$1.45
Location Modifier for PHOENIX, AZ	0.85	**12.5%**	**-2.0%**	($4,834,046)	($26.12)	($5,435,905)	($29.38)
TOTAL MODIFIED CONSTRUCTION COST			**12.5%**	**$27,392,927**	**$148.04**	**$30,803,464**	**$166.47**

BUILDING TYPE: **MIXED-USE RENOVATION**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 185,043
Living Building Gross SF = 185,043
Site Gross Acreage = 1.00

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.2%			$60,000	$0.32
PV1	Photovoltaic Panels and Infrastructure	741,000	Watts		100.0%	18.1%			$5,557,500	$30.03
LB Prerequisite Items										
	PR3 - Habitat Exchange	1	acres		100.0%	0.0%			$5,000	$0.03
	PR6 - Construction Carbon Footprint	1,250	tons @ 50%		100.0%	0.0%			$13,750	$0.07
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$63,500	$0.34
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	24.5%	6.1%	$7,670,020	$41.45	$9,549,074	$51.60
	Architecture & Engineering		7.00%	9.00%	44.6%	2.8%	$1,917,505	$10.36	$2,772,312	$14.98
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-9.0%	$0		($2,778,750)	($15.02)
	SDC Credits	50%			-100.0%	-1.1%	$0		($349,890)	($1.89)
TOTAL OWNER & DESIGN-BUILD COSTS						55.3%	**$9,587,524**	**$51.81**	**$14,892,496**	**$80.48**
TOTAL CONCEPTUAL COST:							**$36,980,452**	**$199.85**	**$45,695,959**	**$246.95**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **21%** **TO** **26%**
MIXED-USE RENOVATION IN PHOENIX, AZ

Complex Mixed Use Renovation
Phoenix

Normalized Baseline Energy Use Intensity (kBtu/SF) **84.9**
Normalized Baseline Energy Use (kWh) 3,608,465

Impact of Design Changes (see sketches) 0.97
Adjusted Baseline EUI (kBtu/SF) 81.9

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		18%	7%	41%	4%	9%	20%	100%
calc'd EUI		15.1	6.1	33.8	2.9	7.3	16.6	81.9
Energy Conservation Measures:								
Glazing	**E1**		10.0%	15.0%		6.5%		7.5%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		10.0%	10.0%		5.0%		5.3%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	38.0%	-2.9%	3.8%		0.6%		8.4%
Remove ceiling, raise window head, add lightshelf	L1a							
Top daylighting with skylights	L1b							
Daylight controls (continuous dimming)	L1c							
Add light shelf	L1d							
Floorplan renovation for daylighting	L1e							
Lighting	**L2**	38.5%	-2.9%	3.9%		0.6%		8.5%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occupanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
High color rendering metal halide retail lighting	L2h							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	6.0%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Parking: variable flow ventilation based on CO monitor	Pi							
Super-efficient elevators (hybrid)	Pk							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.7%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*76.5%*	*17.4%*	*40.2%*	*0.0%*	*15.5%*	*25.0%*	*38.4%*
Subtotal Reduced EUI (kBTU/SF)		*3.6*	*5.0*	*20.2*	*2.9*	*6.2*	*12.5*	*50.4*
Mechanical - Distribution & Ventilation	**M2**		15.0%	25.0%		60.0%		11.6%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Programmable thermostats	M2o							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*25.0%*	*0.0%*	*60.0%*	*0.0%*	*11.6%*
Subtotal Reduced EUI (kBTU/SF)		*3.6*	*4.3*	*15.2*	*2.9*	*2.5*	*12.5*	*40.9*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		4.3%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				50.0%			1.8%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from tankless electric water heater	Wd							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*50.0%*	*-15.0%*	*0.0%*	*6.1%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**3.6**	**3.4**	**12.1**	**1.5**	**2.9**	**12.5**	***35.9***
Final Energy Use Breakdown as Percentage of Baseline Use		**4%**	**4%**	**15%**	**2%**	**3%**	**15%**	**56%**

Building Operating Factor 0.90
Impact of Interactive ECM effects 1.05

Total Reduced EUI (kBTU/sf) 33.6

Total reduced energy use (kWh) 1,427,923

Number of crystaline panels needed 4,169
Total kW of PV array 855

92.9 CBECS Baseline EUI (kBTU/sf)
60% target reduction from CBECS

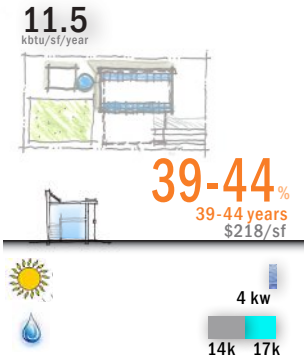
Achievement:
64% percent reduction from CBECS
59% percent reduction from Normalized Baseline Bldg

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

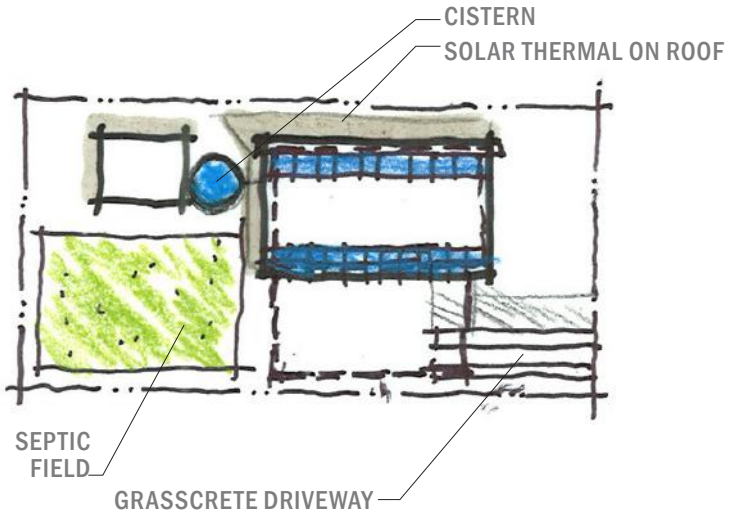
	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	345.73	4131	52,000	4169	Additional overhang +sunshades
	15°	372.11	3838		0	
optimal angle:	29.7°	381.27	3746		0	
	45°	371.61	3843		0	
	90°	244.19	5848		0	
				Total kWh =	**1,441,348**	

SINGLE FAMILY RESIDENTIAL
PHOENIX hot arid



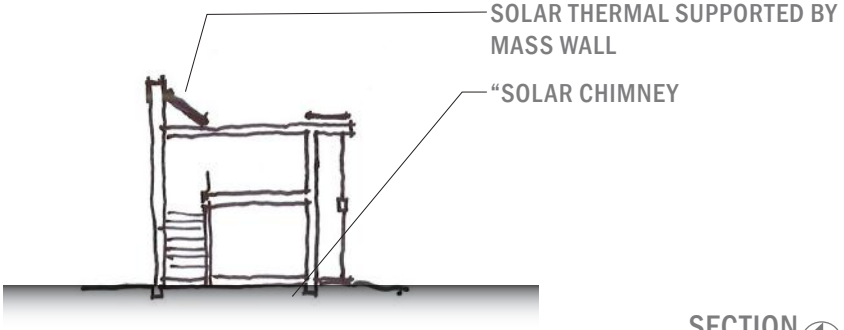
ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF
PHOTOVOLTAIC CAPACITY
WATER USE



3,000 gal	RAINWATER TANK SIZE
1,970 sf	BUILDING SIZE
2 floors	BUILDING HEIGHT
0.11 acres	SITE AREA
212 sf	PHOTOVOLTAIC AREA
1,031 sf	ROOF AREA

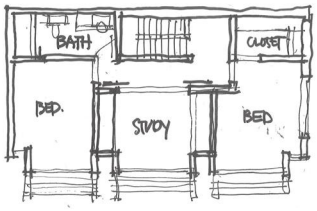
SITE PLAN NTS



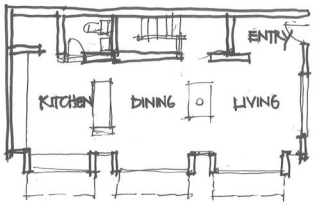
SECTION

MAJOR DESIGN STRATEGIES:

- ✓ Mass Wall
- ✓ Composting toilets minimize water use and waste production.
- ✓ Cistern for water collection.
- ✓ Solar Thermal.
- ✓ Solar Chimney on South.



LEVEL 2



LEVEL 1

PLAN NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **SINGLE FAMILY RESIDENTIAL**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = **1,840**
Living Building Gross SF = **1,840**
Site Gross Acreage = **0.11**

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**0.0%**	**0.0%**	**$63,527**	**$34.53**	**$63,527**	**$34.53**
Baseline Building			$63,527	$34.53	$63,527	$34.53
W2 Rainwater Containment - 3,000 gal Rainwater Tank (included in base building)					$0	
B Shell	**-2.6%**	**-1.2%**	**$131,226**	**$71.32**	**$127,778**	**$69.44**
Baseline Building			$131,226	$71.32	$131,226	$71.32
L1B Replace Roofing with Glazed Skylight					$3,000	$1.63
E1A Improved Glazing (reduce solar heat gain)					$4,303	$2.34
E1B Exterior Shading Devices					$7,200	$3.91
D3 Delete Porch					($1,920)	($1.04)
D3 Modify Building to Single Story					($16,031)	($8.71)
C Interiors	**11.6%**	**1.5%**	**$37,430**	**$20.34**	**$41,780**	**$22.71**
Baseline Building			$37,430	$20.34	$37,430	$20.34
M2A Thicken Lower Level Slab (2") and Gypcrete on Upper Level					$4,350	$2.36
L1A Exposed Ceilings (white matte surfaces)					$0	
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building			$0		$0	
D.2 Services - Plumbing Systems	**57.3%**	**2.1%**	**$10,654**	**$5.79**	**$16,754**	**$9.11**
Baseline Building			$10,654	$5.79	$10,654	$5.79
W6 Low-Flow Fixtures / Optical Sensors					$0	
W2 Rain Harvesting (piping & pumps and filtration)					$0	
W7 Composting Toilets					$6,100	$3.32
D.3 Services - HVAC Systems	**98.4%**	**4.1%**	**$12,008**	**$6.53**	**$23,827**	**$12.95**
Baseline Building			$12,008	$6.53	$12,008	$6.53
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($7,381)	($4.01)
M2A In-Slab Radiant Heating and Cooling					$9,200	$5.00
M3C Solar Thermal System					$10,000	$5.43
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building			$0		$0	
D.5 Services - Electrical Systems	**68.1%**	**2.4%**	**$10,136**	**$5.51**	**$17,036**	**$9.26**
Baseline Building			$10,136	$5.51	$10,136	$5.51
L2K Provide hardwired compact fluorescent fixtures in all spaces					$2,200	$1.20
L2L Motion sensors for exterior lighting					$300	$0.16
M2Z Ceiling Fans and window box fans (five of each)					$4,400	$2.39

BUILDING TYPE: **SINGLE FAMILY RESIDENTIAL**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = **1,840**
Living Building Gross SF = **1,840**
Site Gross Acreage = **0.11**

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$1,011**	**$0.55**	**$1,011**	**$0.55**
Baseline Building				$1,011	$0.55	$1,011	$0.55
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**277.6%**	**19.3%**	**$20,208**	**$10.98**	**$76,308**	**$41.47**
Baseline Building				$20,208	$10.98	$20,208	$10.98
W4 Stormwater Retention / Building Water Discharge						$14,100	$7.66
W2 Additional Rainwater Collection (in addition to roof)						$42,000	$22.83
H Logistics		**0.0%**	**0.0%**	**$3,280**	**$1.78**	**$3,280**	**$1.78**
Baseline Building				$3,280	$1.78	$3,280	$1.78
Living Building Prerequisites				**$920**	**$0.50**	**$20,316**	**$11.04**
PR5 - Materials Red List		**100.0%**	**0.9%**			$2,521	$1.37
PR7 - Responsible Industry		**100.0%**	**4.1%**			$11,981	$6.51
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.7%**			$4,894	$2.66
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$920.00	$0.50	$920	$0.50
Subtotal Direct Costs			34.9%	$290,400	$157.83	$391,618	$212.84
General Conditions	10.0%	**34.9%**	**3.5%**	$29,040	$15.78	$39,162	$21.28
Fee, Construction Contingency, Insurance	10.0%	**34.9%**	**3.8%**	$31,944	$17.36	$43,078	$23.41
Location Modifier for PHOENIX, AZ	0.85	**34.9%**	**-6.3%**	($52,708)	($28.65)	($71,079)	($38.63)
TOTAL MODIFIED CONSTRUCTION COST			**34.9%**	**$298,677**	**$162.32**	**$402,779**	**$218.90**

BUILDING TYPE: **SINGLE FAMILY RESIDENTIAL**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = **1,840**
Living Building Gross SF = **1,840**
Site Gross Acreage = **0.11**

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				0.0%	0.0%			$0	
PV1	Photovoltaic Panels and Infrastructure	3,000	Watts		100.0%	9.3%			$27,000	$14.67
LB Prerequisite Items										
	PR3 - Habitat Exchange	0.114784	acres		100.0%	0.2%			$574	$0.31
	PR6 - Construction Carbon Footprint	50	tons		100.0%	0.2%			$550	$0.30
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.5%			$1,500	$0.82
Development Costs			LEED	LBC						
	Develoment Costs		3.42%	2.53%	0.0%	0.0%	$10,200	$5.54	$10,200	$5.54
	Architecture & Engineering		12.00%	15.00%	68.6%	8.5%	$35,841	$19.48	$60,417	$32.84
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-4.6%	$0		($13,500)	($7.34)
	SDC Credits	50%			-100.0%	-1.0%	$0		($2,966)	($1.61)
TOTAL OWNER & DESIGN-BUILD COSTS						82.0%	**$46,041**	**$25.02**	**$83,775**	**$45.53**
TOTAL CONCEPTUAL COST:							**$344,718**	**$187.35**	**$486,554**	**$264.43**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **39%** **TO** **44%**
SINGLE FAMILY RESIDENTIAL IN PHOENIX, AZ

Single Family Residential
Phoenix

Normalized Baseline Energy Use Intensity (kBtu/SF)	**30.8**	Normalized Baseline Energy Use (kWh)	16,426
Impact of Design Changes (see sketches)	0.95		
Adjusted Baseline EUI (kBtu/SF)	**29.1**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		18%	12%	19%	13%	9%	29%	100%
calc'd EUI		5.2	3.6	5.4	3.7	2.6	8.6	29.1
Energy Conservation Measures:								
Glazing	**E1**		5.0%	20.0%		7.0%		5.0%
High performance residential glazing	E1f							
Add effective shading devices	E1b							
Walls & Roof	**E2**		7.0%	10.0%		4.4%		3.1%
Shaded roof from solar panels	E2a							
Optimize insulation - single family residential	E2i							
Highly reflective exterior siding	E2d							
Lighting	**L2**	53.8%	-4.0%	5.4%		0.8%		10.2%
Provide hardwired compact fluorescent fixtures in all spaces.	L2k							
Motion sensors for exterior lighting	L2l							
Plug Loads	**P**		-2.3%	3.0%		0.5%	30.0%	9.2%
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Occupant buy-in / personal energy budget	Pf							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		1.8%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		***53.8%***	***10.7%***	***43.4%***	***0.0%***	***15.2%***	***30.0%***	***29.2%***
Subtotal Reduced EUI (kBTU/SF)		***2.4***	***3.2***	***3.1***	***3.7***	***2.2***	***6.0***	***20.6***
Mechanical - Distribution & Ventilation	**M2**		15.0%	100.0%		60.0%		16.7%
Radiant floor heating	M2y							
Energy recovery ventilation	M2b							
Natural ventilation: operable windows	M2e							
Eliminate cooling	M2j							
Ceiling fans and window box fans	M2z							
Subtotal from Mechanical Distribution strategies (percentage)		***0.0%***	***15.0%***	***100.0%***	***0.0%***	***60.0%***	***0.0%***	***16.7%***
Subtotal Reduced EUI (kBTU/SF)		***2.4***	***2.7***	***0.0***	***3.7***	***0.9***	***6.0***	***15.7***
Mechanical - Plant Systems	**M3**		74.3%					6.9%
Solar thermal (evacuated tubes) Heating System	M3c							
Domestic Hot Water	**W**				75.0%			9.6%
Solar-thermal domestic water	Wa							
Low flow fixtures (showers, lavs, sinks)	Wb							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		***0.0%***	***74.3%***	***0.0%***	***75.0%***	***0.0%***	***0.0%***	***16.5%***
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**2.4**	**0.7**	**0.0**	**0.9**	**0.9**	**6.0**	***10.9***
Final Energy Use Breakdown as Percentage of Baseline Use		**8%**	**2%**	**0%**	**3%**	**3%**	**21%**	**62%**

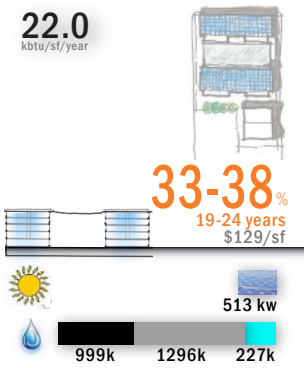
Building Operating Factor	0.90	43.8	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
		Achievement:	
Total Reduced EUI (kBTU/sf)	**10.2**	77%	percent reduction from CBECS
		65%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	5,450		
Number of crystaline panels needed	18		
Total kW of PV array	4		

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	345.73	16	225	18
	15°	372.11	15		0
optimal angle:	29.7°	381.27	15		0
	45°	371.61	15		0
	90°	244.19	23		0
				Total kWh =	**6,223**

MULTIFAMILY RESIDENTIAL
PHOENIX hot arid

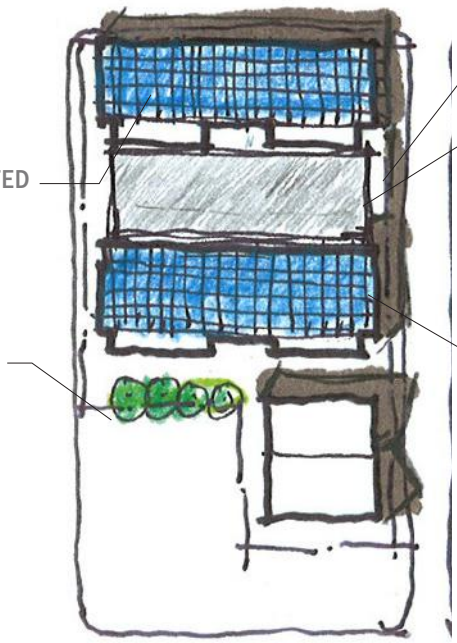


ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

PHOTOVOLTAIC CAPACITY

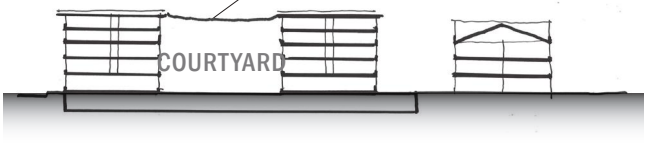
WATER USE



SITE PLAN
NTS

40,000 gal	RAINWATER TANK SIZE
240,187 sf	BUILDING SIZE
5 floors	BUILDING HEIGHT
2.87 acres	SITE AREA
30,500 sf	PHOTOVOLTAIC AREA
42,393 sf	ROOF AREA

RETRACTABLE AWNING TO SPAN BETWEEN BUILDING FOR ADDITIONAL WATER COLLECTION AREA



MAJOR DESIGN STRATEGIES:

- ✓ Increase floor to floor height to allow better daylight penetration.
- ✓ Reconfigure housing units to be oriented in N/S direction for better access to daylight.
- ✓ Reconfigure floor plans to allow units to have all habitable rooms within 30' of an operable window.
- ✓ Add retractable awning to provide additional water collection.

SECTION

LEVEL 1 LEVELS 2,3,4 LEVEL 5

PLANS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **MULTI-FAMILY HOUSING**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 209,678
Living Building Gross SF = 209,678
Site Gross Acreage = 2.87

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**13.1%**	**0.3%**	**$622,710**	**$2.97**	**$704,077**	**$3.36**
Baseline Building			$622,710	$2.97	$622,710	$2.97
W2 Rainwater Containment - 40,000 gal Rainwater Tank					$81,367	$0.39
B Shell	**12.3%**	**3.9%**	**$7,656,970**	**$36.52**	**$8,600,942**	**$41.02**
Baseline Building			$7,656,970	$36.52	$7,656,970	$36.52
E1D Reduce Glazing (30% of original window glazing)					$165,200	$0.79
E1A Improved Glazing (reduce solar heat gain)					$12,972	$0.06
E1B Exterior Shading Devices					$468,000	$2.23
D2A Reduce Wall / Skin for Modified Design (not in base building design)					($405,600)	($1.93)
D3 Relocate Elevator					$45,000	$0.21
D3 Covered Walkway					$98,400	$0.47
W5 Rain Harvesting Canopy					$560,000	$2.67
C Interiors	**5.3%**	**1.3%**	**$5,891,333**	**$28.10**	**$6,205,850**	**$29.60**
Baseline Building			$5,891,333	$28.10	$5,891,333	$28.10
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$314,517	$1.50
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$244,158**	**$1.16**	**$244,158**	**$1.16**
Baseline Building			$244,158	$1.16	$244,158	$1.16
D.2 Services - Plumbing Systems	**8.0%**	**0.6%**	**$1,900,476**	**$9.06**	**$2,052,276**	**$9.79**
Baseline Building			$1,900,476	$9.06	$1,900,476	$9.06
W6 Low-Flow Fixtures / Optical Sensors					$1,800	$0.01
W2 Rain Harvesting (piping & pumps and filtration)					$150,000	$0.72
D.3 Services - HVAC Systems	**387.3%**	**11.5%**	**$717,870**	**$3.42**	**$3,498,260**	**$16.68**
Baseline Building			$717,870	$3.42	$717,870	$3.42
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($535,000)	($2.55)
M2A In-Slab Radiant Heating and Cooling					$1,048,390	$5.00
M3A Ground Source Heat Pump					$1,959,000	$9.34
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$308,000	$1.47
M2C Carbon Dioxide Sensors					$0	
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$462,507**	**$2.21**	**$462,507**	**$2.21**
Baseline Building			$462,507	$2.21	$462,507	$2.21
D.5 Services - Electrical Systems	**0.6%**	**0.1%**	**$3,452,618**	**$16.47**	**$3,471,778**	**$16.56**
Baseline Building			$3,416,018	$16.29	$3,416,018	$16.29
L2E Occupancy Sensor for Transient Lighting (corridors/stairs)			$28,000	$0.13		
L2I Dual day/night light levels in corridors; occupancy sensors			$8,600	$0.04		
L2K Provide hardwired compact fluorescent fixtures in all spaces					$55,760	$0.27

BUILDING TYPE: **MULTI-FAMILY HOUSING**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 209,678
Living Building Gross SF = 209,678
Site Gross Acreage = 2.87

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$948,170**	**$4.52**	**$948,170**	**$4.52**
Baseline Building				$948,170	$4.52	$948,170	$4.52
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**6.2%**	**0.6%**	**$2,221,462**	**$10.59**	**$2,358,962**	**$11.25**
Baseline Building				$2,221,462	$10.59	$2,221,462	$10.59
W2 Stormwater Retention / Building Water Discharge						$50,000	$0.24
D3 Added Courtyard						$87,500	$0.42
H Logistics		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
Living Building Prerequisites				**$10,484**	**$0.05**	**$899,738**	**$4.29**
PR5 - Materials Red List		**100.0%**	**0.7%**			$177,145	$0.84
PR7 - Responsible Industry		**100.0%**	**1.3%**			$323,676	$1.54
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.7%**			$398,917	$1.90
PR9 - Leadership in Construction Waste		**-100.0%**	**0.0%**	$10,484	$0.05		
Subtotal Direct Costs			22.0%	$24,128,758	$115.08	$29,446,718	$140.44
General Conditions	4.0%	**22.0%**	**0.9%**	$965,150	$4.60	$1,177,869	$5.62
Fee, Construction Contingency, Insurance	4.0%	**22.0%**	**0.9%**	$1,003,756	$4.79	$1,224,983	$5.84
Location Modifier for PHOENIX, AZ	0.85	**22.0%**	**-3.6%**	($3,914,650)	($18.67)	($4,777,436)	($22.78)
TOTAL MODIFIED CONSTRUCTION COST			**22.0%**	**$22,183,015**	**$105.80**	**$27,072,135**	**$129.11**

BUILDING TYPE: **MULTI-FAMILY HOUSING**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 209,678
Living Building Gross SF = 209,678
Site Gross Acreage = 2.87

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	4.1%			$1,000,000	$4.77
PV1	Photovoltaic Panels and Infrastructure	501,000	Watts		100.0%	15.6%			$3,757,500	$17.92
LB Prerequisite Items										
	PR3 - Habitat Exchange	2.86961	acres		100.0%	0.1%			$14,348	$0.07
	PR6 - Construction Carbon Footprint	6,400	tons		100.0%	0.3%			$70,400	$0.34
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.1%			$23,500	$0.11
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	35.1%	9.0%	$6,211,244	$29.62	$8,392,362	$40.02
	Architecture & Engineering		7.00%	9.00%	56.9%	3.7%	$1,552,811	$7.41	$2,436,492	$11.62
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-7.8%	$0		($1,878,750)	($8.96)
	SDC Credits	50%			-100.0%	-1.4%	$0		($343,583)	($1.64)
TOTAL OWNER & DESIGN-BUILD COSTS						73.5%	$7,764,055	$37.03	$13,472,269	$64.25

TOTAL CONCEPTUAL COST: **$29,947,070** **$142.82** **$40,544,404** **$193.37**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **33%** **TO** **38%**
MULTI-FAMILY HOUSING IN PHOENIX, AZ

Multi- Family Residential
Phoenix

Normalized Baseline Energy Use Intensity (kBtu/SF)	**49.7**	Normalized Baseline Energy Use (kWh)	1,947,354
Impact of Design Changes (see sketches)	0.98		
Adjusted Baseline EUI (kBtu/SF)	**48.5**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		14%	7%	31%	13%	10%	24%	100%
calc'd EUI		7.0	3.5	15.3	6.1	4.8	11.7	48.5
Energy Conservation Measures:								
Glazing	**E1**		5.0%	15.0%		5.5%		5.6%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		4.0%	4.0%		2.0%		1.8%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Highly reflective exterior siding	E2d							
Lighting	**L2**	56.6%	-4.2%	5.7%		0.8%		9.8%
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dual day/night light levels in corridors; occupancy sensors	L2i							
Provide hardwired compact fluorescent fixtures in all spaces.	L2k							
Plug Loads	**P**		-2.3%	3.0%		0.5%	30.0%	8.1%
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Occupant buy-in / personal energy budget	Pf							
Parking: variable flow ventilation based on CO monitor	Pi							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.2%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		***56.6%***	***7.5%***	***32.7%***	***0.0%***	***11.3%***	***30.0%***	***27.4%***
Subtotal Reduced EUI (kBTU/SF)		***3.0***	***3.3***	***10.3***	***6.1***	***4.3***	***8.2***	***35.2***
Mechanical - Distribution & Ventilation	**M2**		15.0%	20.0%		60.0%		10.6%
Water to water heat pumps, radiant slab heating/cooling	M2q							
Energy recovery ventilation	M2b							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Subtotal from Mechanical Distribution strategies (percentage)		***0.0%***	***15.0%***	***20.0%***	***0.0%***	***60.0%***	***0.0%***	***10.6%***
Subtotal Reduced EUI (kBTU/SF)		***3.0***	***2.8***	***8.2***	***6.1***	***1.7***	***8.2***	***30.0***
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		4.0%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				75.0%			9.4%
Solar-thermal domestic water	Wa							
Low flow fixtures (showers, lavs, sinks)	Wb							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		***0.0%***	***20.0%***	***20.0%***	***75.0%***	***-15.0%***	***0.0%***	***13.4%***
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**3.0**	**2.2**	**6.6**	**1.5**	**2.0**	**8.2**	***23.5***
Final Energy Use Breakdown as Percentage of Baseline Use		**6%**	**5%**	**14%**	**3%**	**4%**	**17%**	**51%**

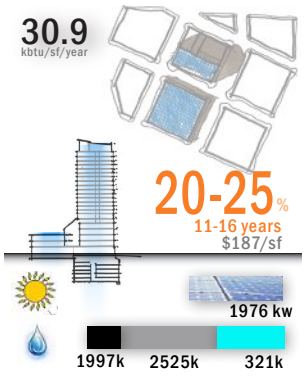
Building Operating Factor	0.90	60.0	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
		Achievement:	
Total Reduced EUI (kBTU/sf)	**22.0**	63%	percent reduction from CBECS
		55%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	862,735		
Number of crystaline panels needed	2,501		
Total kW of PV array	513		

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

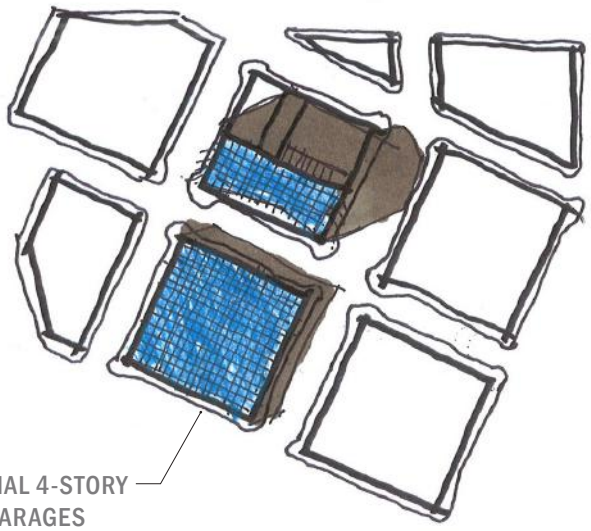
	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	345.73	2496	31,200	2501	Panels on two buildings only
	15°	372.11	2319		0	
optimal angle:	29.7°	381.27	2263		0	
	45°	371.61	2322		0	
	90°	244.19	3534		0	
				Total kWh =	**864,671**	

HIGH RISE MIXED USE
PHOENIX hot arid



ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF
PHOTOVOLTAIC CAPACITY
WATER USE



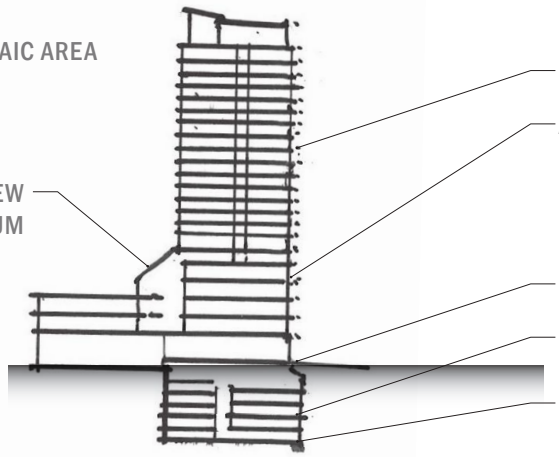
1 ADDITIONAL 4-STORY PARKING GARAGES WITH ROOFTOP PV TO ACHIEVE NET ZERO

SITE PLAN
NTS

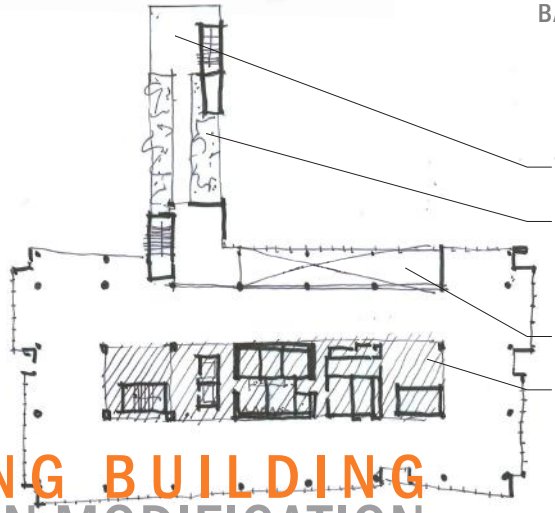
350,000 gal	RAINWATER TANK SIZE
547,624 sf	BUILDING SIZE
22 floors	BUILDING HEIGHT
0.92 acres	SITE AREA
115,200 sf	PHOTOVOLTAIC AREA
20,000 sf	ROOF AREA

MAJOR DESIGN STRATEGIES:

- ✓ Increase floor to floor height to allow better daylight penetration.
- ✓ Add atrium at edge of building.
- ✓ PV integrated with the building skin on South and East facades.
- ✓ PV screen at building West facade.
- ✓ Add office floor.



SECTION



PLAN
NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **HIGH RISE**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 547,624
Living Building Gross SF = 547,624
Site Gross Acreage = 0.92

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline Total	LEED™ Gold Baseline Cost/SF	Living Building Total	Living Building Cost/SF
CONSTRUCTION COST						
A Substructure	**0.7%**	**0.1%**	**$8,695,116**	**$15.88**	**$8,754,929**	**$15.99**
Baseline Building			$8,695,116	$15.88	$8,695,116	$15.88
W2 Rainwater Containment - 350,000 gal Rainwater Tank					$59,814	$0.11
B Shell	**7.6%**	**2.9%**	**$35,629,047**	**$65.06**	**$38,323,069**	**$69.98**
Baseline Building			$35,629,047	$65.06	$35,629,047	$65.06
L1B Replace Roofing with Glazed Skylight					$225,900	$0.41
D3A Raise Floor to Floor Height					$918,000	$1.68
E1B Exterior Shading Devices					$1,905,120	$3.48
W5 Water Collection on Vertical Surfaces / Top of Roof					$1,400,000	$2.56
D3 Relocate SF to additional 1/2 floor at top					$40,800	$0.07
D3 Remove Existing Green Roof					($30,000)	($0.05)
D3 Modifications to Lobby Space (structural and finishes)					$590,000	$1.08
L1E Tracking Mirror above Atrium					$154,000	$0.28
D3 Added Elevator Stop for Additional Floor					$105,000	$0.19
E1D Reduce Glazing to 30% (need to define strategy)					($2,315,798)	($4.23)
D3 Remove raised access flooring					($801,000)	($1.46)
PV3 Structure for PV on Adjacent Parking Structures					$340,000	$0.62
L1D Interior Light Shelves (at office floors)					$162,000	$0.30
C Interiors	**6.7%**	**1.6%**	**$22,739,127**	**$41.52**	**$24,272,474**	**$44.32**
Baseline Building			$22,739,127	$41.52	$22,739,127	$41.52
M2D Carpet Reduction (replace with RetroPlate)					$985,723	$1.80
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$547,624	$1.00
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$2,636,557**	**$4.81**	**$2,636,557**	**$4.81**
Baseline Building			$2,636,557	$4.81	$2,636,557	$4.81
D.2 Services - Plumbing Systems	**0.0%**	**0.0%**	**$3,874,587**	**$7.08**	**$3,874,587**	**$7.08**
Baseline Building			$3,874,587	$7.08	$3,874,587	$7.08
W6 Low-Flow Fixtures / Optical Sensors					$0	
W2 Rain Harvesting (piping & pumps and filtration)					$0	
D.3 Services - HVAC Systems	**69.2%**	**5.6%**	**$7,599,577**	**$13.88**	**$12,856,160**	**$23.48**
Baseline Building			$7,599,577	$13.88	$8,449,577	$15.43
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($6,085,700)	($11.11)
M2A In-Slab Radiant Heating and Cooling					$2,738,120	$5.00
M3A Ground Source Heat Pump					$7,468,000	$13.64
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$286,163	$0.52
M2C Carbon Dioxide Sensors					$0	
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$1,132,828**	**$2.07**	**$1,132,828**	**$2.07**
Baseline Building			$1,132,828	$2.07	$1,132,828	$2.07
D.5 Services - Electrical Systems	**12.4%**	**0.8%**	**$6,138,326**	**$11.21**	**$6,901,276**	**$12.60**
Baseline Building			$6,209,026	$11.34	$6,209,026	$11.34
PA Occupancy Sensor to Outlets					$35,100	$0.06
PE High Efficiency Transformers					$165,000	$0.30
L2A Efficient light fixture optics					$160,200	$0.29
L2B Occupancy Sensor for Lighting (closed office / conference spaces)					$18,850	$0.03
L2C Individual Light Level Control (open spaces)					$179,000	$0.33
L2I Dual day/night light levels in corridors; occupancy sensors					$134,100	$0.24
L2J Occupancy sensor/time clock for corridor lighting					$0	
L2K Provide hardwired compact fluorescent fixtures in all spaces			($70,700)	($0.13)	$0	

BUILDING TYPE: **HIGH RISE**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 547,624
Living Building Gross SF = 547,624
Site Gross Acreage = 0.92

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$3,326,853**	**$6.08**	**$3,326,853**	**$6.08**
Baseline Building				$3,326,853	$6.08	$3,326,853	$6.08
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**9.3%**	**0.1%**	**$537,417**	**$0.98**	**$587,417**	**$1.07**
Baseline Building				$537,417	$0.98	$537,417	$0.98
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.09
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$1,764,940**	**$3.22**	**$1,764,940**	**$3.22**
Baseline Building				$1,764,940	$3.22	$1,764,940	$3.22
Living Building Prerequisites				**$27,381**	**$0.05**	**$2,967,929**	**$5.42**
PR5 - Materials Red List		**100.0%**	**0.7%**			$686,294	$1.25
PR7 - Responsible Industry		**100.0%**	**0.3%**			$328,542	$0.60
PR8 - Appropriate Materials / Services Radius		**100.0%**	**2.0%**			$1,925,712	$3.52
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$27,381	$0.05	$27,381	$0.05
Subtotal Direct Costs			14.1%	$94,101,757	$171.84	$107,399,021	$196.12
General Conditions	3.2%	**14.1%**	**0.5%**	$3,005,271	$5.49	$3,429,937	$6.26
Fee, Contingency, Insurance, Bonding	9.8%	**14.1%**	**1.4%**	$9,471,412	$17.30	$10,809,791	$19.74
Location Modifier for PHOENIX, AZ	0.85	**14.1%**	**-2.4%**	($15,986,766)	($29.19)	($18,245,812)	($33.32)
TOTAL MODIFIED CONSTRUCTION COST			**14.1%**	**$90,591,673**	**$165.43**	**$103,392,936**	**$188.80**

BUILDING TYPE: **HIGH RISE**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 547,624
Living Building Gross SF = 547,624
Site Gross Acreage = 0.92

						Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
								Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS											
Design/Build Owner Items											
W3	Biological Bio-Reactor					100.0%	1.1%			$1,000,000	$1.83
O1	Wind Turbines (net cost including credits)	14,800	Watts			0.0%	0.0%	($82,000)		($82,000)	($0.15)
PV1	Photovoltaic Panels and Infrastructure	1,236,000	Watts			100.0%	9.9%			$9,270,000	$16.93
LB Prerequisite Items											
	PR3 - Habitat Exchange	0.9182736	acres			100.0%	0.0%			$4,591	$0.01
	PR6 - Construction Carbon Footprint	24,100	tons			100.0%	0.3%			$265,100	$0.48
	PR15 - Beauty and Spirit (included in A/E fees below)					0.0%	0.0%			$0	
	PR16 - Inspiration and Education					100.0%	0.1%			$63,000	$0.12
Development Costs			LEED	LBC							
	Develoment Costs		28.00%	31.00%		26.4%	7.1%	$25,365,669	$46.32	$32,051,810	$58.53
	Architecture & Engineering		7.00%	9.00%		46.7%	3.1%	$6,341,417	$11.58	$9,305,364	$16.99
Credits / Rebates / Incentives											
	PV Credits-(state, city, utility)	50%				-100.0%	-4.9%	$0		($4,635,000)	($8.46)
	SDC Credits	50%				-100.0%	-0.5%	$0		($509,464)	($0.93)
TOTAL OWNER & DESIGN-BUILD COSTS							**47.8%**	**$31,625,086**	**$57.90**	**$46,733,402**	**$85.34**

TOTAL CONCEPTUAL COST: **$122,216,759** **$223.18** **$150,126,339** **$274.14**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **20%** **TO** **25%**
HIGH RISE IN PHOENIX, AZ

High Rise Mixed use
Phoenix

Normalized Baseline Energy Use Intensity (kBtu/SF)	**75.8**	Normalized Baseline Energy Use (kWh)	8,445,989
Impact of Design Changes (see sketches)	0.98		
Adjusted Baseline EUI (kBtu/SF)	**73.9**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		13%	8%	37%	11%	10%	22%	100%
calc'd EUI		9.3	5.9	27.0	7.9	7.4	16.4	73.9
Energy Conservation Measures:								
Glazing	**E1**		5.0%	15.0%		5.5%		6.4%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		4.0%	4.0%		2.0%		2.0%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Highly reflective exterior siding	E2d							
Daylighting (incorporates tuned glazing/shading)	**L1**	15.0%	-1.1%	1.5%		0.2%		2.4%
Remove ceiling, raise window head, add lightshelf	L1a							
Daylight controls (continuous dimming)	L1c							
Lighting	**L2**	65.1%	-4.9%	6.5%		1.0%		10.3%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dual day/night light levels in corridors; occupancy sensors	L2i							
Occupancy sensor / time clock for corridor lighting	L2j							
Provide hardwired compact fluorescent fixtures in all spaces.	L2k							
Plug Loads	**P**		-2.3%	3.0%		0.5%	30.0%	7.6%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Parking: variable flow ventilation based on CO monitor	Pi							
Super-efficient elevators (hybrid)	Pk							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.5%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		***80.1%***	***5.7%***	***35.0%***	***0.0%***	***11.7%***	***30.0%***	***31.1%***
Subtotal Reduced EUI (kBTU/SF)		***1.8***	***5.6***	***17.6***	***7.9***	***6.5***	***11.5***	***50.9***
Mechanical - Distribution & Ventilation	**M2**		15.0%	22.0%		60.0%		11.7%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Displacement ventilation delivery for DOAS	M2k							
Water to water heat pumps, radiant slab heating/cooling	M2q							
Subtotal from Mechanical Distribution strategies (percentage)		***0.0%***	***15.0%***	***22.0%***	***0.0%***	***60.0%***	***0.0%***	***11.7%***
Subtotal Reduced EUI (kBTU/SF)		***1.8***	***4.8***	***13.7***	***7.9***	***2.6***	***11.5***	***42.3***
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		4.5%
Ground source heat pump system	M3a							
Domestic Hot Water	**W**				75.0%			8.0%
Solar-thermal domestic water	Wa							
Low flow fixtures (showers, lavs, sinks)	Wb							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		***0.0%***	***20.0%***	***20.0%***	***75.0%***	***-15.0%***	***0.0%***	***12.4%***
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**1.8**	**3.8**	**11.0**	**2.0**	**3.0**	**11.5**	***33.1***
Final Energy Use Breakdown as Percentage of Baseline Use		**2%**	**5%**	**15%**	**3%**	**4%**	**16%**	**55%**

Building Operating Factor	0.90	86.2	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
		Achievement:	
Total Reduced EUI (kBTU/sf)	**30.9**	64%	percent reduction from CBECS
		58%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	3,446,711		
Number of crystaline panels needed	9,637		
Total kW of PV array	1976		

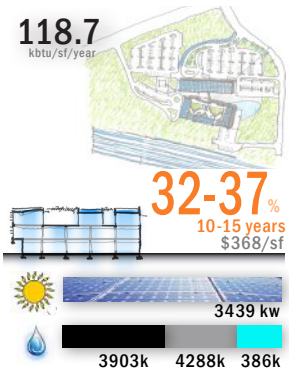
PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	345.73	9970	18,000	1443
	15°	372.11	9263	57,200	4586
optimal angle:	29.7°	381.27	9041		0
	45°	371.61	9276		0
	90°	244.19	14115		0
				Total kWh =	**2,205,385**
One Parking garage required for net zero energy				45,000	3608
					1,247,394

Actual kWh Produced
3,452,779

HOSPITAL
PHOENIX hot arid



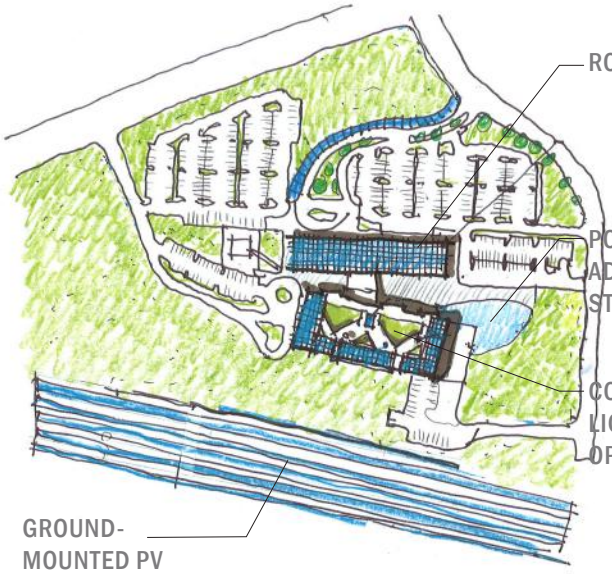
ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

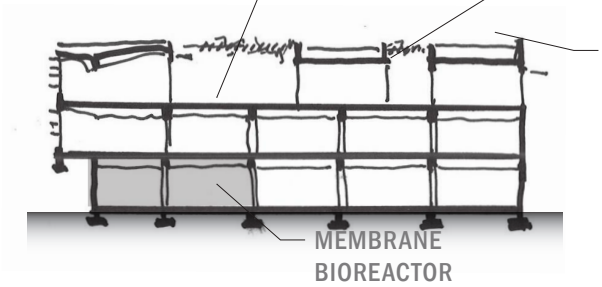
PHOTOVOLTAIC CAPACITY

WATER USE

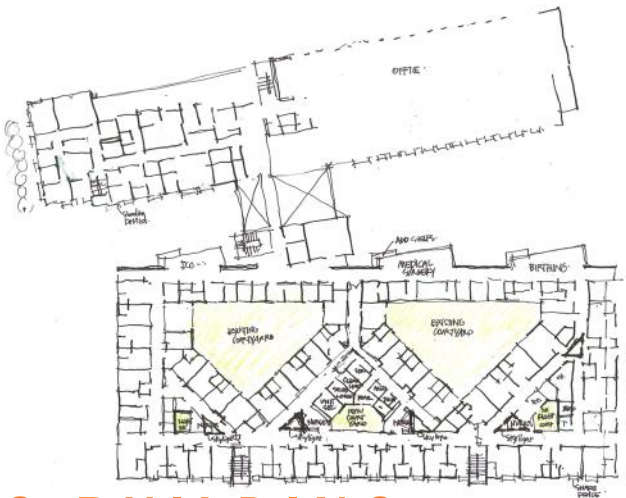
130,000 gal RAINWATER TANK SIZE
180,231 sf BUILDING SIZE
3 floors BUILDING HEIGHT
39.03 acres SITE AREA
208,200 sf PHOTOVOLTAIC AREA
84,900 sf ROOF AREA



SITE PLAN NTS



SECTION



PLAN NTS

MAJOR DESIGN STRATEGIES:

- ✓ Add new light shafts with louvered shades at Nurse's station.
- ✓ Add skylights at corridors for increased lighting.
- ✓ Minimize screen at mechanical area - not needed.
- ✓ West shading at classrooms.
- ✓ Add shading devices on South side of hospital, office, etc.
- ✓ Add shading at patient courtyards.

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **HOSPITAL**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 180,231
Living Building Gross SF = 180,231
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**8.2%**	**0.4%**	**$2,895,319**	**$16.06**	**$3,132,762**	**$17.38**
	Baseline Building			$2,895,319	$16.06	$2,895,319	$16.06
W2	Rainwater Containment - 130,000 gal Rainwater Tank					$237,443	$1.32
B	**Shell**	**2.4%**	**0.6%**	**$14,789,139**	**$82.06**	**$15,138,359**	**$83.99**
	Baseline Building			$14,789,139	$82.06	$14,789,139	$82.06
L1B	Replace Roofing with Glazed Skylight					$15,000	$0.08
E1A	Improved Glazing (reduce solar heat gain at vision only)					$16,000	$0.09
E1B	Exterior Horizontal Shading Devices					$87,600	$0.49
E1B	Exterior Fins at West End of Curtainwall					$36,000	$0.20
L1D	Interior Light Shelf					$58,400	$0.32
E1B	Vertical Shading Fins (west end)					$26,900	$0.15
L1B	New Light Shafts to Nurse Stations					$387,000	$2.15
E2B	Infill Spandrel Panel with Framing and Insulation (replace glazed area)					$22,320	$0.12
D3	Reduce Mechanical Rooftop Screen					($300,000)	($1.66)
C	**Interiors**	**0.4%**	**0.1%**	**$9,710,678**	**$53.88**	**$9,746,724**	**$54.08**
	Baseline Building			$9,710,678	$53.88	$9,710,678	$53.88
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$36,046	$0.20
L1A	Raise Ceilings (no cost impact)					$0	
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$826,462**	**$4.59**	**$826,462**	**$4.59**
	Baseline Building			$826,462	$4.59	$826,462	$4.59
D.2	**Services - Plumbing Systems**	**7.5%**	**0.4%**	**$3,347,613**	**$18.57**	**$3,597,613**	**$19.96**
	Baseline Building			$3,347,613	$18.57	$3,347,613	$18.57
W6	Low-Flow Fixtures / Optical Sensors					$0	
W2	Rain Harvesting (piping & pumps and filtration)					$250,000	$1.39
D.3	**Services - HVAC Systems**	**42.4%**	**7.0%**	**$9,992,801**	**$55.44**	**$14,230,184**	**$78.96**
	Baseline Building			$9,992,801	$55.44	$9,992,801	$55.44
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,652,772)	($14.72)
M2A	In-Slab Radiant Heating and Cooling					$901,155	$5.00
M3A	Ground Source Heat Pump					$5,893,000	$32.70
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$80,000	$0.44
M2C	Carbon Dioxide Sensors					$16,000	$0.09
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$444,259**	**$2.46**	**$444,259**	**$2.46**
	Baseline Building			$444,259	$2.46	$444,259	$2.46
D.5	**Services - Electrical Systems**	**6.3%**	**0.8%**	**$8,085,831**	**$44.86**	**$8,597,131**	**$47.70**
	Baseline Building			$8,085,831	$44.86	$8,085,831	$44.86
PA	Occupancy Sensor to Outlets					$21,500	$0.12
PE	High Efficiency Transformers					$217,000	$1.20
LIC	Daylight Controls (continuous dimming 15' from perimeter)					$168,000	$0.93
L2E	Occupancy Sensor for Transient and Egress Lighting					$44,500	$0.25
L2G	Patient Bed light with separate switching for ambient / task					$18,800	$0.10
L2M	Dual level light at egress stairs - off when not occupied					$19,000	$0.11
L2N	Stairwell lighting on daylighting					$22,500	$0.12

BUILDING TYPE: **HOSPITAL**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 180,231
Living Building Gross SF = 180,231
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$2,050,942**	**$11.38**	**$2,050,942**	**$11.38**
Baseline Building				$2,050,942	$11.38	$2,050,942	$11.38
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**16.2%**	**2.1%**	**$7,730,038**	**$42.89**	**$8,980,038**	**$49.83**
Baseline Building				$7,730,038	$42.89	$7,730,038	$42.89
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.28
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
W2 Rainwater Collection from Solar Panel Array						$1,200,000	$6.66
H Logistics		**0.0%**	**0.0%**	**$920,558**	**$5.11**	**$920,558**	**$5.11**
Baseline Building				$920,558	$5.11	$920,558	$5.11
Living Building Prerequisites				**$9,012**	**$0.05**	**$1,468,485**	**$8.15**
PR5 - Materials Red List		**100.0%**	**0.7%**			$439,890	$2.44
PR7 - Responsible Industry		**100.0%**	**0.2%**			$108,128	$0.60
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.5%**			$911,456	$5.06
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$9,012	$0.05	$9,012	$0.05
Subtotal Direct Costs			13.7%	$60,802,650	$337.36	$69,133,516	$383.58
General Conditions	5.9%	**13.7%**	**0.8%**	$3,599,939	$19.97	$4,093,184	$22.71
Fee, Contingency, Insurance	6.7%	**13.7%**	**1.0%**	$4,309,196	$23.91	$4,899,620	$27.19
Location Modifier for PHOENIX, AZ	0.85	**13.7%**	**-2.3%**	($10,306,768)	($57.19)	($11,718,948)	($65.02)
TOTAL MODIFIED CONSTRUCTION COST			**13.7%**	**$58,405,018**	**$324.06**	**$66,407,372**	**$368.46**

BUILDING TYPE: **HOSPITAL**
BUILDING LOCATION: **PHOENIX, AZ**

SKANSKA

Base Building Gross SF = 180,231
Living Building Gross SF = 180,231
Site Gross Acreage = 39.03

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	2.5%			$1,500,000	$8.32
PV1	Photovoltaic Panels and Infrastructure	3,422,000	Watts		100.0%	42.2%			$25,665,000	$142.40
LB Prerequisite Items										
	PR3 - Habitat Exchange	39.03	acres		100.0%	0.3%			$195,150	$1.08
	PR6 - Construction Carbon Footprint	5,400	tons		100.0%	0.1%			$59,400	$0.33
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.1%			$63,000	$0.35
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	25.9%	7.0%	$16,353,405	$90.74	$20,586,285	$114.22
	Architecture & Engineering		7.00%	9.00%	46.2%	3.1%	$4,088,351	$22.68	$5,976,664	$33.16
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-21.1%	$0		($12,832,500)	($71.20)
	SDC Credits	50%			-100.0%	-2.3%	$0		($1,372,092)	($7.61)
TOTAL OWNER & DESIGN-BUILD COSTS						**94.9%**	**$20,441,756**	**$113.42**	**$39,840,907**	**$221.05**
TOTAL CONCEPTUAL COST:							**$78,846,774**	**$437.48**	**$106,248,279**	**$589.51**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **32%** **TO** **37%**
HOSPITAL IN PHOENIX, AZ

Hospital
Phoenix

Normalized Baseline Energy Use Intensity (kBtu/SF) **207.6**

Normalized Baseline Energy Use (kWh) 10,950,041

Impact of Design Changes (see sketches) 1.00

Adjusted Baseline EUI (kBtu/SF) 207.6

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		14%	5%	27%	14%	15%	24%	100%
calc'd EUI		29.9	10.1	56.7	29.9	31.1	49.8	207.6
Energy Conservation Measures:								
Glazing	**E1**		5.0%	10.0%		4.0%		3.6%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		4.0%	4.0%		2.0%		1.6%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Highly reflective exterior siding	E2d							
Daylighting (incorporates tuned glazing/shading)	**L1**	13.3%	-1.0%	1.3%		0.2%		2.0%
Top daylighting with skylights	L1b							
Daylight controls (continuous dimming)	L1c							
Add new courtyards at Nurses's station								
Lighting	**L2**	31.1%	-2.3%	3.1%		0.5%		4.6%
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Patient bedlight with separate switching for ambient / task	L2g							
Dual level light at egress stairs - off when not occuppied	L2m							
Stairwell lighting on daylighting / occupancy sensors	L2n							
Plug Loads	**P**						10.0%	2.5%
EnergyStar appliances	Pb							
Energy efficient main transformer	Pe							
Super-efficient elevators (hybrid)	Pk							
Aggressive heat recapture - all equipment water cooled	Pl							
Widen Set Point Temperatures	**M1**		2.0%	2.0%		1.0%		0.8%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*44.4%*	*7.7%*	*20.4%*	*0.0%*	*7.7%*	*10.0%*	*15.9%*
Subtotal Reduced EUI (kBTU/SF)		*16.6*	*9.3*	*45.1*	*29.9*	*28.7*	*44.9*	*174.6*
Mechanical - Distribution & Ventilation	**M2**		17.0%	14.0%		20.0%		6.9%
Radiant slab heating/cooling in lobby/atrium spaces	M2r							
Chilled beams	M2s							
Displacement ventilation in exam rooms	M2t							
Natural ventilation in stairwells	M2u							
Low pressure drop air filters	M2v							
OSA/Exhaust runaround heat recovery	M2w							
Cascading make-up air	M2x							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*17.0%*	*14.0%*	*0.0%*	*20.0%*	*0.0%*	*6.6%*
Subtotal Reduced EUI (kBTU/SF)		*16.6*	*7.7*	*38.8*	*29.9*	*23.0*	*44.9*	*160.9*
Mechanical - Plant Systems	**M3**		15.0%	35.0%		-7.5%		4.0%
Ground source heat pump with central heat pump chiller	M3e							
Chiller heat recovery	M3f							
Domestic Hot Water	**W**				70.0%			10.5%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*15.0%*	*35.0%*	*70.0%*	*-7.5%*	*0.0%*	*16.4%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**16.6**	**6.6**	**25.2**	**9.0**	**24.7**	**44.9**	***127.0***
Final Energy Use Breakdown as Percentage of Baseline Use		**8%**	**3%**	**12%**	**4%**	**12%**	**22%**	**39%**

Building Operating Factor 0.90
Impact of Interactive ECM effects 1.05

Total Reduced EUI (kBTU/sf) 118.7

Total reduced energy use (kWh) 6,264,106

Number of crystaline panels needed 16,775
Total kW of PV array 3439

249.2 CBECS Baseline EUI (kBTU/sf)
60% target reduction from CBECS

Achievement: **TARGET REDUCTION NOT MET**

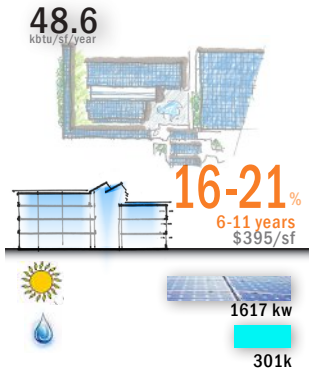
52% percent reduction from CBECS
43% percent reduction from Normalized Baseline Bldg

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

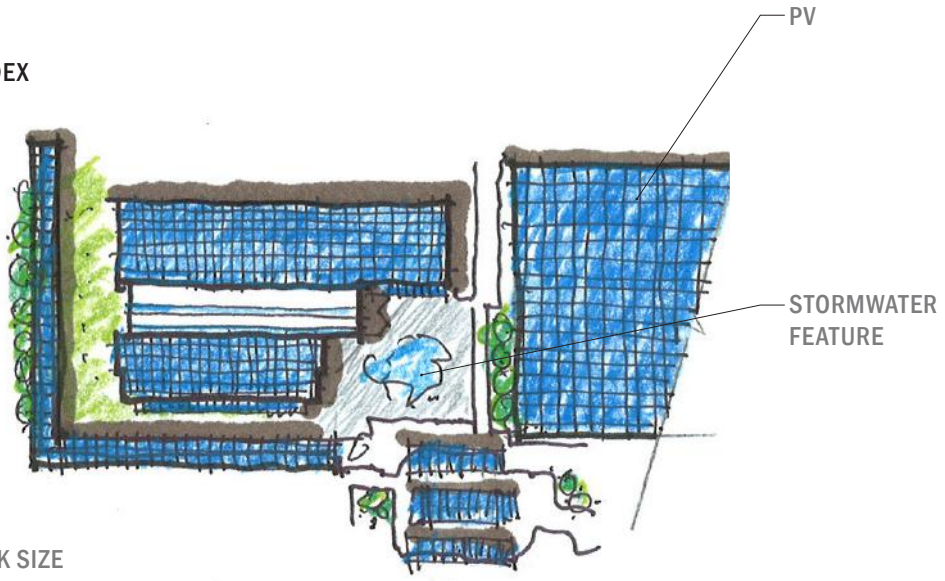
	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	345.73	18119	44,700	3584
	15°	372.11	16835		0
optimal angle:	29.7°	381.27	16430	164,500	13191
	45°	371.61	16857		0
	90°	244.19	25653		0
				Total kWh =	**6,268,429**

UNIVERSITY CLASSROOM
BOSTON mixed



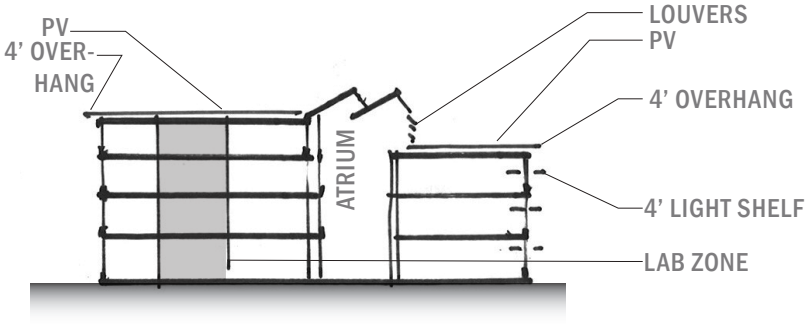
ENERGY USE INDEX

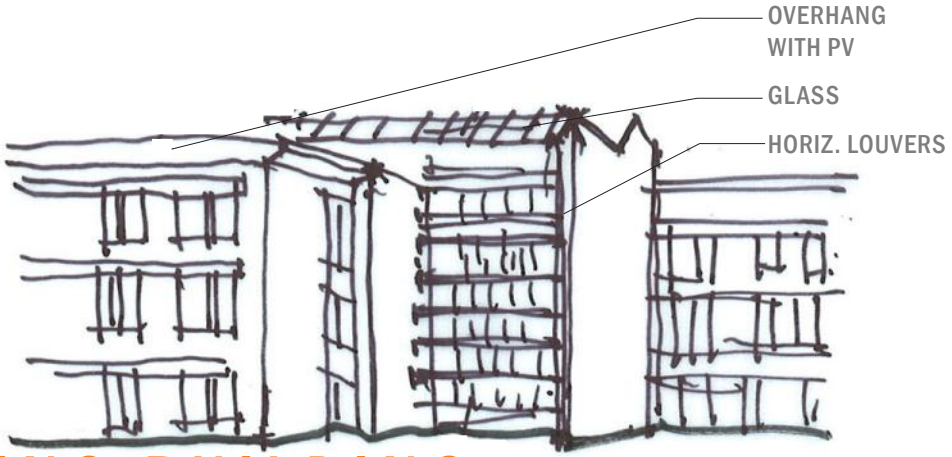
COST PREMIUM
PAYBACK
COST PER SF
PHOTOVOLTAIC CAPACITY
WATER USE



25,000 gal	RAINWATER TANK SIZE
153,531 sf	BUILDING SIZE
4 floors	BUILDING HEIGHT
2.75 acres	SITE AREA
98,400 sf	PHOTOVOLTAIC AREA
38,755 sf	ROOF AREA

- ✓ Reorient building 180 degrees.
- ✓ Add PV to entire roof.
- ✓ Add fritted PV to glass at Atrium.
- ✓ Add sunshades out of PV to each south window.
- ✓ South facing sawtooth skylight at Atrium.
- ✓ Horizontal louvers as shading devices for south wall
- ✓ 4’ overhange at roof to shade façade.





LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **UNIVERSITY CLASSROOM**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 153,531
Living Building Gross SF = 153,531
Site Gross Acreage = 2.75

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**1.1%**	**0.1%**	**$2,123,369**	**$13.83**	**$2,145,723**	**$13.98**
Baseline Building			$2,123,369	$13.83	$2,123,369	$13.83
W2 Rainwater Containment - 25,000 gal Rainwater Tank					$22,354	$0.15
B Shell	**2.5%**	**0.3%**	**$4,959,353**	**$32.30**	**$5,083,677**	**$33.11**
Baseline Building			$4,959,353	$32.30	$4,959,353	$32.30
E1A Improved Glazing (reduce solar heat gain)					$35,324	$0.23
E1B Exterior Shading Devices (outriggers for PV panels on south only)					($116,000)	($0.76)
E1B Exterior Shading Devices (solid horizontal sun shades)					$35,000	$0.23
D2B Revised Atrium Roof Structure (sawtooth)					$170,000	$1.11
C Interiors	**-3.8%**	**-1.4%**	**$16,495,934**	**$107.44**	**$15,868,139**	**$103.35**
Baseline Building			$16,495,934	$107.44	$16,495,934	$107.44
M2D Carpet Reduction (remove carpet and retroplate concrete)					$96,071	$0.63
M2A Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$153,531	$1.00
L1A Exposed Ceilings (white matte surfaces)					($160,397)	($1.04)
D3 Eliminate Raised Access Floor					($717,000)	($4.67)
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$297,968**	**$1.94**	**$297,968**	**$1.94**
Baseline Building			$297,968	$1.94	$297,968	$1.94
D.2 Services - Plumbing Systems	**5.2%**	**0.4%**	**$2,968,571**	**$19.34**	**$3,122,371**	**$20.34**
Baseline Building			$2,968,571	$19.34	$2,968,571	$19.34
W6 Low-Flow Fixtures / Optical Sensors					$3,800	$0.02
W2 Rain Harvesting (piping & pumps and filtration)					$150,000	$0.98
D.3 Services - HVAC Systems	**39.3%**	**5.1%**	**$5,646,851**	**$36.78**	**$7,864,306**	**$51.22**
Baseline Building			$5,646,851	$36.78	$5,646,851	$36.78
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($1,000,000)	($6.51)
M2A In-Slab Radiant Heating and Cooling					$767,655	$5.00
M3A Ground Source Heat Pump					$2,369,800	$15.44
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$80,000	$0.52
M2C Carbon Dioxide Sensors (in base building)					$0	
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$425,840**	**$2.77**	**$425,840**	**$2.77**
Baseline Building			$425,840	$2.77	$425,840	$2.77
D.5 Services - Electrical Systems	**2.9%**	**0.4%**	**$6,000,852**	**$39.09**	**$6,174,252**	**$40.22**
Baseline Building			$6,000,852	$39.09	$6,000,852	$39.09
PA Occupancy Sensor to Outlets					$14,100	$0.09
PE High Efficiency Transformers					$67,000	$0.44
L2E Occupancy Sensor for Transient and Egress Lighting					$37,500	$0.24

BUILDING TYPE: **UNIVERSITY CLASSROOM**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 153,531
Living Building Gross SF = 153,531
Site Gross Acreage = 2.75

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline Total	LEED™ Gold Baseline Cost/SF	Living Building Total	Living Building Cost/SF
L2F	Dimmable Direct/Indirect Fixtures					$54,800	$0.36
E	**Equipment and Furnishings**	**0.0%**	**0.0%**	**$257,958**	**$1.68**	**$257,958**	**$1.68**
	Baseline Building			$257,958	$1.68	$257,958	$1.68
F	**Special Construction**	**0.0%**	**0.0%**	**$79,247**	**$0.52**	**$79,247**	**$0.52**
	Baseline Building			$79,247	$0.52	$79,247	$0.52
G	**Sitework**	**2.0%**	**0.1%**	**$2,460,261**	**$16.02**	**$2,510,261**	**$16.35**
	Baseline Building			$2,460,261	$16.02	$2,460,261	$16.02
W4	Stormwater Retention / Building Water Discharge					$50,000	$0.33
W1	Remove Storm Drainage Connection to Public/Add sewer meter					$0	
H	**Logistics**	**0.0%**	**0.0%**	**$2,108,417**	**$13.73**	**$2,108,417**	**$13.73**
	Baseline Building			$2,108,417	$13.73	$2,108,417	$13.73
	Living Building Prerequisites			**$6,397**	**$0.04**	**$1,003,256**	**$6.53**
	PR5 - Materials Red List	**100.0%**	**0.9%**			$410,636	$2.67
	PR7 - Responsible Industry	**100.0%**	**0.4%**			$162,546	$1.06
	PR8 - Appropriate Materials / Services Radius	**100.0%**	**1.0%**			$423,677	$2.76
	PR9 - Leadership in Construction Waste	**0.0%**	**0.0%**	$6,397	$0.04	$6,397	$0.04
	Subtotal Direct Costs		7.1%	$43,831,019	$285.49	$46,941,417	$305.75
	General Conditions	8.0%	**7.1%**	**0.6%**	$3,512,022	$22.88	$3,761,247	$24.50
	Fee, Construction Contingency, Insurance	7.0%	**7.1%**	**0.5%**	$3,328,586	$21.68	$3,564,794	$23.22
	Location Modifier for BOSTON, MA	1.12	**7.1%**	**1.0%**	$6,080,595	$39.61	$6,512,095	$42.42
	TOTAL MODIFIED CONSTRUCTION COST		**7.1%**	**$56,752,222**	**$369.65**	**$60,779,553**	**$395.88**

BUILDING TYPE: **UNIVERSITY CLASSROOM**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 153,531
Living Building Gross SF = 153,531
Site Gross Acreage = 2.75

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.1%			$50,000	$0.33
PV1	Photovoltaic Panels and Infrastructure	1,617,000	Watts		100.0%	27.7%			$12,127,500	$78.99
LB Prerequisite Items										
	PR3 - Habitat Exchange	2.7548209	acres		100.0%	0.0%			$13,774	$0.09
	PR6 - Construction Carbon Footprint	6,800	tons		100.0%	0.2%			$74,800	$0.49
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$73,750	$0.48
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	18.6%	6.7%	$15,890,622	$103.50	$18,841,661	$122.72
	Architecture & Engineering		7.00%	9.00%	37.7%	3.4%	$3,972,656	$25.88	$5,470,160	$35.63
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-13.8%	$0		($6,063,750)	($39.50)
	SDC Credits	50%			-100.0%	-0.8%	$0		($349,890)	($2.28)
TOTAL OWNER & DESIGN-BUILD COSTS						**52.2%**	**$19,863,278**	**$129.38**	**$30,238,005**	**$196.95**
					TOTAL CONCEPTUAL COST:		**$76,615,500**	**$499.02**	**$91,017,558**	**$592.83**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **16%** **TO** **21%**
UNIVERSITY CLASSROOM IN BOSTON, MA

University Classroom
Boston

Normalized Baseline Energy Use Intensity (kBtu/SF)	**105.8**
Impact of Design Changes (see sketches)	0.97
Adjusted Baseline EUI (kBtu/SF)	**102.1**

Normalized Baseline Energy Use (kWh)

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
	percent of load	16%	28%	20%	2%	10%	24%	100%
	calc'd EUI	16.4	28.9	20.3	1.6	10.2	24.6	102.1
Energy Conservation Measures:								
Glazing	**E1**		*15.0%*	10.0%		6.0%		6.8%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Reduce glazing to 30%	E1d							
Walls & Roof	**E2**		*6.0%*	3.0%		2.1%		2.5%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	50.0%	-3.8%	5.0%		0.8%		8.0%
Daylight controls (continuous dimming)	L1c							
Orient windows to allow for illumination of teaching wall	L1f							
Top daylighting from Atrium	L1g							
Lighting	**L2**	20.0%	-1.5%	2.0%		0.3%		3.2%
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dimmable direct / indirect fixtures	L2f							
Occupancy sensor / time clock for corridor lighting	L2j							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	6.0%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Mechanical - Schedule	**M4**			7.0%				
Change of work hours (summer hours)	M4a							
Shift uses for time of day in summer (east vs west)	M4b							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.7%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*70.0%*	*18.9%*	*34.5%*	*0.0%*	*12.0%*	*25.0%*	*30.7%*
Subtotal Reduced EUI (kBTU/SF)		*4.9*	*23.4*	*13.3*	*1.6*	*9.0*	*18.5*	*70.8*
Mechanical - Distribution & Ventilation	**M2**		*15.0%*	20.0%		70.0%		12.2%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Cascading make-up air	M2x							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*20.0%*	*0.0%*	*70.0%*	*0.0%*	*12.2%*
Subtotal Reduced EUI (kBTU/SF)		*4.9*	*19.9*	*10.7*	*1.6*	*2.7*	*18.5*	*58.3*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		5.6%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				50.0%			0.8%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from tankless electric water heater	Wd							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*50.0%*	*-15.0%*	*0.0%*	*6.4%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**4.9**	**15.9**	**8.5**	**0.8**	**3.1**	**18.5**	***51.8***
Final Energy Use Breakdown as Percentage of Baseline Use		**5%**	**16%**	**8%**	**1%**	**3%**	**18%**	**49%**

Building Operating Factor	0.90
Impact of Interactive ECM effects	1.05
Total Reduced EUI (kBTU/sf)	**48.6**

100.0	CBECS Baseline EUI (kBTU/sf)
60%	target reduction from CBECS

Achievement: **TARGET REDUCTION NOT MET**

51%	percent reduction from CBECS
54%	percent reduction from Normalized Baseline Bldg

Total reduced energy use (kWh)	2,066,972

Number of crystaline panels needed	7,889
Total kW of PV array	1617

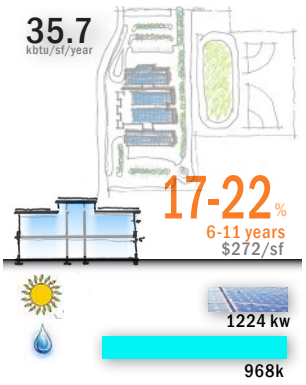
PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	252.778	8178	38,800	3111
	15°	272.61	7583		0
optimal angle:	35.0°	286.98	7203		0
	45°	284.06	7277	33,590	2693
	90°	205.17	10075		0
				Total kWh =	**1,551,366**

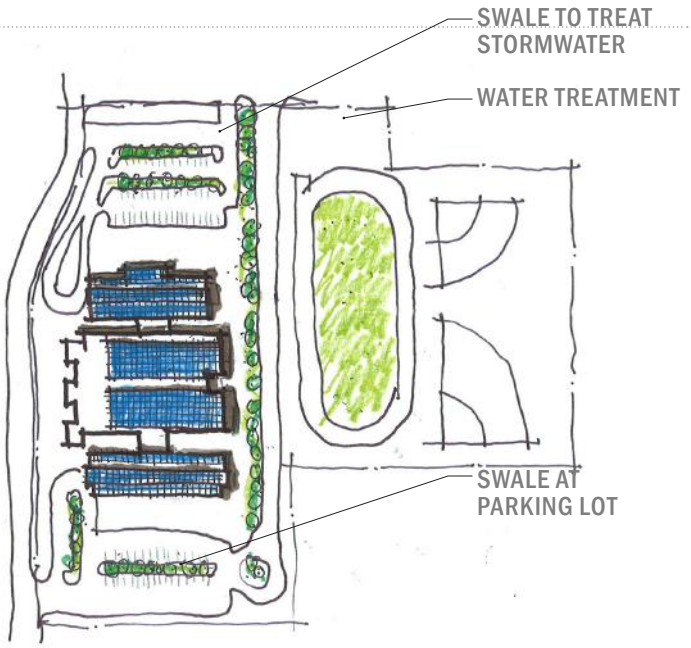
Additional Parking Garage Offset Needed	Additional area	26,010	2085	**Parking lot**
	Additional kWh Produced		**527,042**	2,078,408

SCHOOL K-8
BOSTON mixed

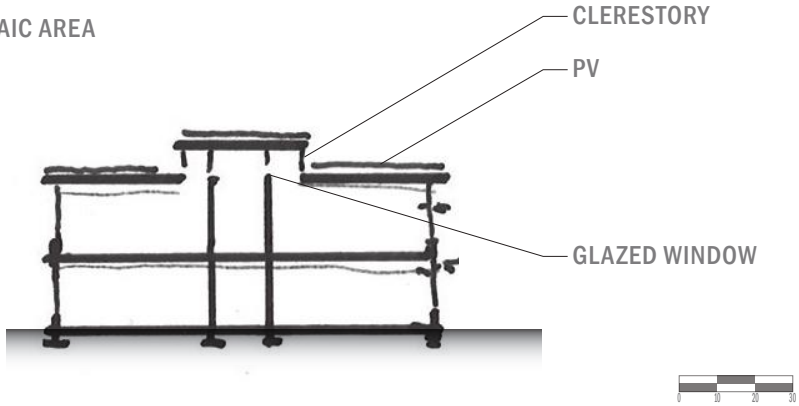


ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF
PHOTOVOLTAIC CAPACITY
WATER USE



80,000 gal RAINWATER TANK SIZE
148,981 sf BUILDING SIZE
2 floors BUILDING HEIGHT
39.03 acres SITE AREA
74,470 sf PHOTOVOLTAIC AREA
97,650 sf ROOF AREA



- ✓ Reorganize plan to eliminate N/S portions of classrooms wings.
- ✓ Remove windows below 2'-6" in classrooms.
- ✓ Remove windows below 2'-0" in corridors.
- ✓ Tune glazing to have high performance glass at vision glass only.
- ✓ Reconfigure roof at clerestory.
- ✓ Add metal roofing for clipping of PV at class-room and gym.
- ✓ Eliminate windows on West and East facades at classrooms.

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **ELEMENTARY SCHOOL**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 148,981
Living Building Gross SF = 148,981
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**10.3%**	**0.5%**	**$1,466,210**	**$9.84**	**$1,616,944**	**$10.85**
	Baseline Building			$1,466,210	$9.84	$1,466,210	$9.84
	Rainwater Containment - 80,000 gal Rainwater Tank					$150,734	$1.01
B	**Shell**	**0.9%**	**0.3%**	**$9,540,845**	**$64.04**	**$9,627,945**	**$64.63**
	Baseline Building			$9,540,845	$64.04	$9,540,845	$64.04
D3	Lower Roof at Media Center (at both links)					($248,400)	($1.67)
D3	Reallocate South Wing (move SF to east-west wings)					($69,000)	($0.46)
E1A	Improved Glazing (reduce solar heat gain at vision only)					$22,000	$0.15
E1B	Exterior Shading Devices (credit reflecting PV as shading element)					($30,000)	($0.20)
M2H	"High Mass" Concrete Inside Insulation (CMU to replace metal stud plus added reflective skin)					$467,700	$3.14
D2B	Reduce Overhang above Clerestory Glazing					($55,200)	($0.37)
C	**Interiors**	**3.1%**	**0.5%**	**$4,624,290**	**$31.04**	**$4,765,608**	**$31.99**
	Baseline Building			$4,624,290	$31.04	$4,624,290	$31.04
M2D	Carpet Reduction (replace with RetroPlate)					$108,466	$0.73
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$148,981	$1.00
L1A	Exposed Ceilings (white matte surfaces)					($116,128)	($0.78)
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$100,000**	**$0.67**	**$100,000**	**$0.67**
	Baseline Building			$100,000	$0.67	$100,000	$0.67
D.2	**Services - Plumbing Systems**	**10.4%**	**0.5%**	**$1,438,830**	**$9.66**	**$1,588,830**	**$10.66**
	Baseline Building			$1,438,830	$9.66	$1,438,830	$9.66
W6	Low-Flow Fixtures / Optical Sensors					$0	
W2	Rain Harvesting (piping & pumps and filtration)					$150,000	$1.01
D.3	**Services - HVAC Systems**	**17.3%**	**2.1%**	**$3,684,937**	**$24.73**	**$4,322,070**	**$29.01**
	Baseline Building			$3,684,937	$24.73	$3,684,937	$24.73
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,652,772)	($17.81)
M2A	In-Slab Radiant Heating and Cooling					$744,905	$5.00
M2L	Solar Wall Mechanical Screen					$145,000	$0.97
M3A	Ground Source Heat Pump					$2,304,000	$15.47
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$80,000	$0.54
M2C	Carbon Dioxide Sensors					$16,000	$0.11
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$345,589**	**$2.32**	**$345,589**	**$2.32**
	Baseline Building			$345,589	$2.32	$345,589	$2.32
D.5	**Services - Electrical Systems**	**6.6%**	**0.7%**	**$3,044,694**	**$20.44**	**$3,246,194**	**$21.79**
	Baseline Building			$3,044,694	$20.44	$3,044,694	$20.44
PA	Occupancy Sensor to Outlets					$5,000	$0.03
PE	High Efficiency Transformers					$97,500	$0.65
LIC	Daylight Controls (continuous dimming 15' from perimeter)					$23,800	$0.16
L2F	Dimmable Direct/Indirect fixtures					$47,500	$0.32
L2B	Occupancy Sensor for Lighting (closed office / conference spaces)					$0	
L2C	Individual Light Level Control (open spaces, classrooms)					$5,200	$0.03
L2E	Occupancy Sensor for Transient and Egress Lighting					$22,500	$0.15

BUILDING TYPE: **ELEMENTARY SCHOOL**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 148,981
Living Building Gross SF = 148,981
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$1,555,517**	**$10.44**	**$1,555,517**	**$10.44**
Baseline Building				$1,555,517	$10.44	$1,555,517	$10.44
F Special Construction		**0.0%**	**0.0%**	**$58,000**	**$0.39**	**$58,000**	**$0.39**
Baseline Building				$58,000	$0.39	$58,000	$0.39
G Sitework		**1.6%**	**0.2%**	**$3,701,152**	**$24.84**	**$3,761,152**	**$25.25**
Baseline Building				$3,701,152	$24.84	$3,701,152	$24.84
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.34
E1B Trees for shading						$10,000	$0.07
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$524,694**	**$3.52**	**$524,694**	**$3.52**
Baseline Building				$524,694	$3.52	$524,694	$3.52
Living Building Prerequisites				**$6,208**	**$0.04**	**$637,472**	**$4.28**
PR5 - Materials Red List		**100.0%**	**0.9%**			$275,991	$1.85
PR7 - Responsible Industry		**100.0%**	**0.2%**			$66,413	$0.45
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.0%**			$288,860	$1.94
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$6,208	$0.04	$6,208	$0.04
Subtotal Direct Costs			6.8%	$30,090,966	$201.98	$32,150,016	$215.80
General Conditions	3.7%	**6.8%**	**0.2%**	$1,098,511	$7.37	$1,173,679	$7.88
Fee, Contingency, Insurance, Bonding	9.6%	**6.8%**	**0.7%**	$3,009,051	$20.20	$3,214,953	$21.58
Location Modifier for BOSTON, MA	1.12	**6.8%**	**0.9%**	$4,103,823	$27.55	$4,384,638	$29.43
TOTAL MODIFIED CONSTRUCTION COST			**6.8%**	**$38,302,351**	**$257.10**	**$40,923,286**	**$274.69**

BUILDING TYPE: **ELEMENTARY SCHOOL**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 148,981
Living Building Gross SF = 148,981
Site Gross Acreage = 39.03

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.7%			$200,000	$1.34
PV1	Photovoltaic Panels and Infrastructure	1,224,000	Watts		100.0%	30.5%			$9,180,000	$61.62
LB Prerequisite Items										
	PR3 - Habitat Exchange	39.03	acres		100.0%	0.6%			$195,150	$1.31
	PR6 - Construction Carbon Footprint	4,400	tons		100.0%	0.2%			$48,400	$0.32
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$63,000	$0.42
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	18.3%	6.5%	$10,724,658	$71.99	$12,686,219	$85.15
	Architecture & Engineering		7.00%	9.00%	37.4%	3.3%	$2,681,165	$18.00	$3,683,096	$24.72
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-15.3%	$0		($4,590,000)	($30.81)
	SDC Credits	50%			-100.0%	-2.8%	$0		($848,565)	($5.70)
TOTAL OWNER & DESIGN-BUILD COSTS						53.8%	**$13,405,823**	**$89.98**	**$20,617,299**	**$138.39**
TOTAL CONCEPTUAL COST:							**$51,708,174**	**$347.08**	**$61,540,585**	**$413.08**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: 17% TO 22%
ELEMENTARY SCHOOL IN BOSTON, MA

ElementarySchool
Boston

Normalized Baseline Energy Use Intensity (kBtu/SF)	**77.6**	Normalized Baseline Energy Use (kWh)	3,205,369
Impact of Design Changes (see sketches)	0.96		
Adjusted Baseline EUI (kBtu/SF)	**74.5**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
	percent of load	16%	44%	8%	2%	12%	17%	100%
	calc'd EUI	12.0	33.1	6.0	1.7	8.9	12.8	74.5
Energy Conservation Measures:								
Glazing	**E1**		*4.0%*	9.0%		3.5%		2.9%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		*9.0%*	4.0%		3.0%		4.7%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	75.0%	-5.6%	7.5%		1.1%		10.3%
Top daylighting with skylights	L1b							
Daylight controls (continuous dimming)	L1c							
Orient windows to allow for illumination of teaching wall	L1f							
Lighting	**L2**	9.8%	-0.7%	1.0%		0.1%		1.3%
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dimmable direct / indirect fixtures	L2f							
Occupancy sensor / time clock for corridor lighting	L2j							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	3.7%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Mechanical - Schedule	**M4**			7.0%				0.1%
Change of work hours (summer hours)	M4a							
Shift uses for time of day in summer (east vs west)	M4b							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.9%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*84.8%*	*9.8%*	*36.0%*	*0.0%*	*10.6%*	*25.0%*	*26.4%*
Subtotal Reduced EUI (kBTU/SF)		*1.8*	*29.9*	*3.8*	*1.7*	*8.0*	*9.6*	*54.8*
Mechanical - Distribution & Ventilation	**M2**		*15.0%*	20.0%		70.0%		14.5%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
SolarWall mechanical screen or SolarDuct (pre-heat air)	M2l							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*20.0%*	*0.0%*	*70.0%*	*0.0%*	*14.5%*
Subtotal Reduced EUI (kBTU/SF)		*1.8*	*25.4*	*3.1*	*1.7*	*2.4*	*9.6*	*43.9*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		7.2%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				50.0%			1.1%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*50.0%*	*-15.0%*	*0.0%*	*8.3%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**1.8**	**20.3**	**2.4**	**0.8**	**2.8**	**9.6**	***37.8***
Final Energy Use Breakdown as Percentage of Baseline Use		**2%**	**27%**	**3%**	**1%**	**4%**	**13%**	**49%**

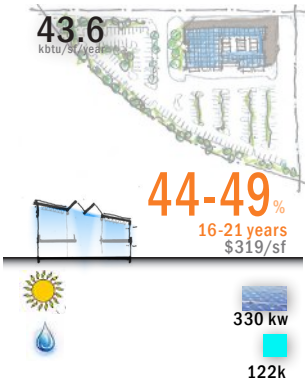
Building Operating Factor	0.90	83.1	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
		Achievement:	**TARGET REDUCTION NOT MET**
Total Reduced EUI (kBTU/sf)	**35.7**	57%	percent reduction from CBECS
		54%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	1,475,601		
Number of crystaline panels needed	5,971		
Total kW of PV array	1224		

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	252.778	5838	74,470	5971
	15°	272.61	5413		0
optimal angle:	35.0°	286.98	5142		0
	45°	284.06	5195		0
	90°	205.17	7193		0
				Total kWh =	**1,509,337**

LOW RISE OFFICE
BOSTON mixed



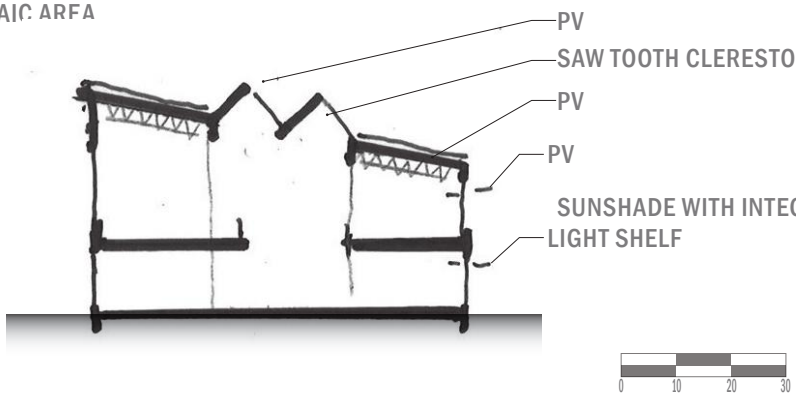
ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

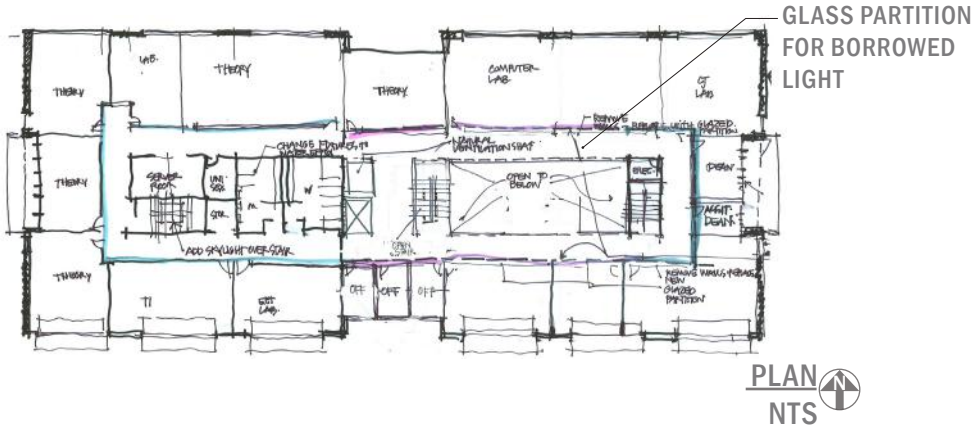
PHOTOVOLTAIC CAPACITY

WATER USE

10,000 gal RAINWATER TANK SIZE
35,776 sf BUILDING SIZE
2 floors BUILDING HEIGHT
3.24 acres SITE AREA
20,070 sf PHOTOVOLTAIC AREA
17,888 sf ROOF AREA



- ✓ Add sloping metal roof with PV to allow PV production to be achieved without additional structures.
- ✓ Open floor to allow light to penetrate to ground floor lounge.
- ✓ Reconfigure floor plan to ensure all spaces are within 30’ of an operable window.
- ✓ Add sawtooth shaped cleestory to allow natural light to interior of building



LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **LOWRISE OFFICE / CLASSROOMS**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 35,776
Living Building Gross SF = 35,776
Site Gross Acreage = 3.24

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**9.1%**	**0.8%**	**$625,892**	**$17.49**	**$682,981**	**$19.09**
	Baseline Building			$625,892	$17.49	$625,892	$17.49
W2	Rainwater Containment - 26,000 gal Rainwater Tank					$57,089	$1.60
B	**Shell**	**21.6%**	**9.2%**	**$3,237,848**	**$90.50**	**$3,937,735**	**$110.07**
	Baseline Building			$3,237,848	$90.50	$3,237,848	$90.50
M2E	Operable Windows (manual)					$31,680	$0.89
D3C	Reallocate Glazing from East and West Façade to South (less spandrel panel, more skin)					($17,472)	($0.49)
L1B	Replace Roofing with Glazed Skylight					$207,000	$5.79
E1A	Improved Glazing (reduce solar heat gain)					$16,104	$0.45
E1B	Exterior Shading Devices (windows and louvers at entry)					$70,460	$1.97
E2A	Added Wall / Skin for Modified Design (not in base building design)					$274,560	$7.67
M2H	"High Mass" Concrete Inside Insulation (added reflective skin)					$49,500	$1.38
D2B	Modifications to Roof Structure					$39,255	$1.10
L1D	Interior Light Shelves (remove from N/E/W, keep south only)					$28,800	$0.81
C	**Interiors**	**17.2%**	**2.4%**	**$1,076,571**	**$30.09**	**$1,261,402**	**$35.26**
	Baseline Building			$1,076,571	$30.09	$1,076,571	$30.09
M2D	Carpet Reduction (replace with RetroPlate)					$25,500	$0.71
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$48,264	$1.35
L1A	Exposed Ceilings (white matte surfaces)					($68,213)	($1.91)
D3	Glass partitions in lieu of gypsum wallboard					$179,280	$5.01
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$55,000**	**$1.54**	**$55,000**	**$1.54**
	Baseline Building			$55,000	$1.54	$55,000	$1.54
D.2	**Services - Plumbing Systems**	**73.8%**	**2.0%**	**$208,354**	**$5.82**	**$362,154**	**$10.12**
	Baseline Building			$208,354	$5.82	$208,354	$5.82
W6	Low-Flow Fixtures / Optical Sensors					$3,800	$0.11
W2	Rain Harvesting (piping & pumps and filtration)					$150,000	$4.19
D.3	**Services - HVAC Systems**	**91.2%**	**7.1%**	**$591,095**	**$16.52**	**$1,130,075**	**$31.59**
	Baseline Building			$575,095	$16.07	$575,095	$16.07
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($300,000)	($8.39)
M2A	In-Slab Radiant Heating and Cooling					$178,880	$5.00
M3A	Ground Source Heat Pump					$554,100	$15.49
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$106,000	$2.96
M2C	Carbon Dioxide Sensors			$16,000	$0.45	$16,000	$0.45
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$75,177**	**$2.10**	**$75,177**	**$2.10**
	Baseline Building			$75,177	$2.10	$75,177	$2.10
D.5	**Services - Electrical Systems**	**6.5%**	**0.6%**	**$723,416**	**$20.22**	**$770,116**	**$21.53**
	Baseline Building			$603,016	$16.86	$603,016	$16.86
PA	Occupancy Sensor to Outlets					$10,200	$0.29
PE	High Efficiency Transformers					$36,500	$1.02
L1C	Daylight Controls (continuous dimming 15' from perimeter)			$27,000	$0.75	$27,000	$0.75
L2A	Efficient Light Fixture Optics Premium			$67,600	$1.89	$67,600	$1.89
L2B	Occupancy Sensor for Lighting (closed office / conference spaces)			$12,000	$0.34	$12,000	$0.34
L2E	Occupancy Sensor for Transient and Egress Lighting			$13,800	$0.39	$13,800	$0.39

BUILDING TYPE: **LOWRISE OFFICE / CLASSROOMS**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 35,776
Living Building Gross SF = 35,776
Site Gross Acreage = 3.24

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline Total	LEED™ Gold Baseline Cost/SF	Living Building Total	Living Building Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$149,348**	**$4.17**	**$149,348**	**$4.17**
Baseline Building				$149,348	$4.17	$149,348	$4.17
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**7.6%**	**0.8%**	**$791,671**	**$22.13**	**$851,671**	**$23.81**
Baseline Building				$791,671	$22.13	$791,671	$22.13
W4 Stormwater Retention / Building Water Discharge						$50,000	$1.40
E1B Trees for shading						$10,000	$0.28
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$40,261**	**$1.13**	**$40,261**	**$1.13**
Baseline Building				$40,261	$1.13	$40,261	$1.13
Living Building Prerequisites				**$4,472**	**$0.13**	**$211,042**	**$5.90**
PR5 - Materials Red List		**100.0%**	**1.0%**			$78,927	$2.21
PR7 - Responsible Industry		**100.0%**	**0.1%**			$10,732	$0.30
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.5%**			$116,911	$3.27
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$4,472	$0.13	$4,472	$0.13
Subtotal Direct Costs			25.7%	$7,579,106	$211.85	$9,526,963	$266.29
General Conditions	4.0%	**25.7%**	**1.0%**	$303,164	$8.47	$381,079	$10.65
Fee, Construction Contingency, Insurance	3.0%	**25.7%**	**0.8%**	$238,965	$6.68	$300,380	$8.40
Location Modifier for BOSTON, MA	1.12	**25.7%**	**3.3%**	$974,548	$27.24	$1,225,011	$34.24
TOTAL MODIFIED CONSTRUCTION COST			**25.7%**	**$9,095,784**	**$254.24**	**$11,433,431**	**$319.58**

BUILDING TYPE: **LOWRISE OFFICE / CLASSROOMS**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 35,776
Living Building Gross SF = 35,776
Site Gross Acreage = 3.24

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.5%			$40,000	$1.12
PV1	Photovoltaic Panels and Infrastructure	564,000	Watts		100.0%	55.8%			$4,230,000	$118.24
LB Prerequisite Items										
	PR3 - Habitat Exchange	3.24	acres		100.0%	0.2%			$16,200	$0.45
	PR6 - Construction Carbon Footprint	2,700	tons		100.0%	0.4%			$29,700	$0.83
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.3%			$23,500	$0.66
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	39.2%	13.2%	$2,546,819	$71.19	$3,544,364	$99.07
	Architecture & Engineering		9.38%	11.38%	52.5%	5.9%	$852,730	$23.84	$1,300,553	$36.35
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-27.9%	$0		($2,115,000)	($59.12)
	SDC Credits	50%			-100.0%	-3.1%	$0		($231,353)	($6.47)
TOTAL OWNER & DESIGN-BUILD COSTS						**101.1%**	**$3,399,549**	**$95.02**	**$6,837,964**	**$191.13**
TOTAL CONCEPTUAL COST:							**$12,495,333**	**$349.27**	**$18,271,395**	**$510.72**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **44%** **TO** **49%**
LOWRISE OFFICE / CLASSROOMS IN BOSTON, MA

MidRiseOffice
Boston

Normalized Baseline Energy Use Intensity (kBtu/SF)	**93.3**	Normalized Baseline Energy Use (kWh)	929,563
Impact of Design Changes (see sketches)	1.03		
Adjusted Baseline EUI (kBtu/SF)	**95.6**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		17%	32%	20%	3%	9%	18%	100%
calc'd EUI		16.1	30.2	19.1	3.1	9.0	17.7	95.2
Energy Conservation Measures:								
Glazing	**E1**		*12.0%*	7.5%		4.7%		5.7%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		*10.0%*	3.0%		2.9%		4.0%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	50.0%	-3.8%	5.0%		0.8%		8.3%
Remove ceiling, raise window head, add lightshelf	L1a							
Top daylighting from Atrium	L1g							
Daylight controls (continuous dimming)	L1c							
Lighting	**L2**	25.0%	-1.9%	2.5%		0.4%		4.1%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	4.6%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.8%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*75.0%*	*19.5%*	*25.5%*	*0.0%*	*11.6%*	*25.0%*	*29.6%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*24.3*	*14.2*	*3.1*	*7.9*	*13.3*	*66.9*
Mechanical - Distribution & Ventilation	**M2**		*25.0%*	20.0%		70.0%		15.2%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*25.0%*	*20.0%*	*0.0%*	*70.0%*	*0.0%*	*15.2%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*18.2*	*11.4*	*3.1*	*2.4*	*13.3*	*52.4*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		5.8%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				50.0%			1.6%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*50.0%*	*-15.0%*	*0.0%*	*7.5%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**4.0**	**14.6**	**9.1**	**1.6**	**2.7**	**13.3**	***45.3***
Final Energy Use Breakdown as Percentage of Baseline Use		**4%**	**15%**	**10%**	**2%**	**3%**	**14%**	**52%**

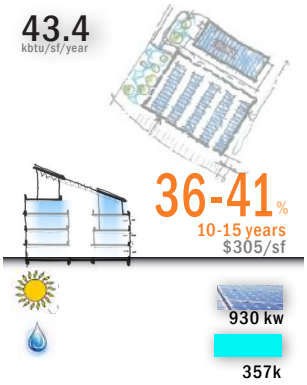
Building Operating Factor	0.90	92.9	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.07	60%	target reduction from CBECS
		Achievement:	**TARGET REDUCTION NOT MET**
Total Reduced EUI (kBTU/sf)	**43.6**	53%	percent reduction from CBECS
		53%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	434,611		
Number of crystaline panels needed	1,608		
Total kW of PV array	330		

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

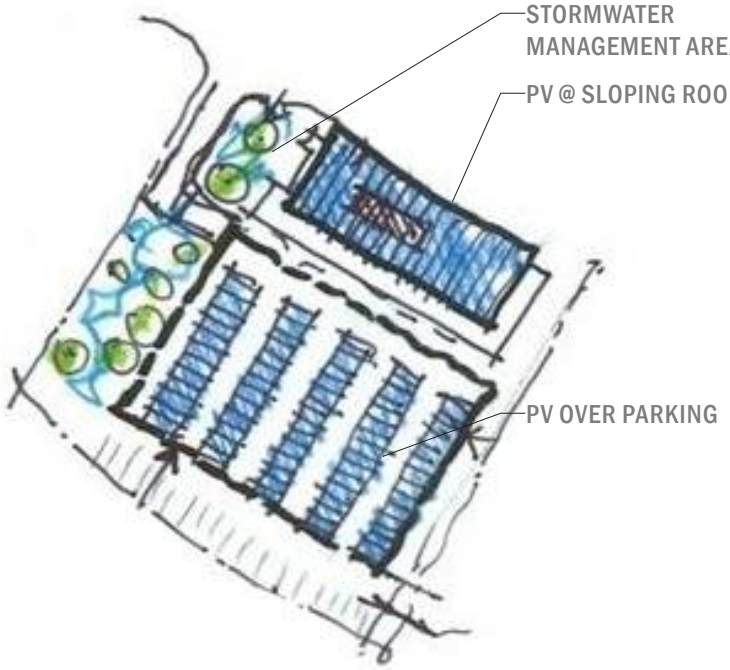
	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	252.778	1720	720	57
	15°	272.61	1595	19,350	1551
optimal angle:	35.0°	286.98	1515		0
	45°	284.06	1530		0
	90°	205.17	2119		0
				Total kWh =	**437,226**

MID RISE OFFICE
BOSTON mixed

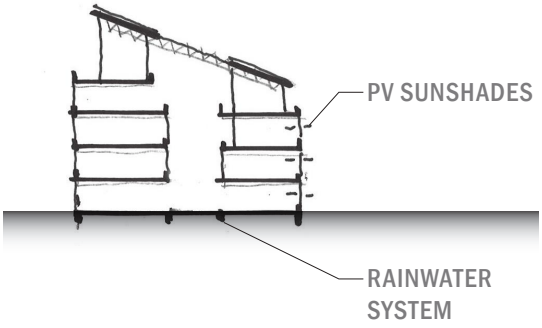


ENERGY USE INDEX

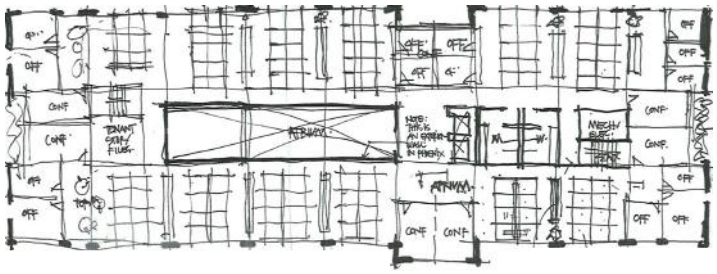
COST PREMIUM
PAYBACK
COST PER SF
PHOTOVOLTAIC CAPACITY
WATER USE



40,000 gal	RAINWATER TANK SIZE
101,385 sf	BUILDING SIZE
5 floors	BUILDING HEIGHT
5.24 acres	SITE AREA
56,594 sf	PHOTOVOLTAIC AREA
23,941 sf	ROOF AREA



SECTION



PLAN

- ✓ Reconfigure floor plan so all spaces are within 30’ of an operable window.
- ✓ Add an atrium to for improved daylighting
- ✓ Slope the roof 20° for maximum PV production.
- ✓ Provide 5th level on north side to provide for additional area.
- ✓ Add PV sunshades
- ✓ Relocate windows on West and East to North and South - glass area to remain the same.
- ✓ Add fins at center bay windows.
- ✓ Additional parking lot cover for PV.

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **MIDRISE OFFICE**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 99,385
Living Building Gross SF = 99,385
Site Gross Acreage = 5.24

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**4.2%**	**0.3%**	**$1,420,795**	**$14.30**	**$1,480,883**	**$14.90**
	Baseline Building			$1,420,795	$14.30	$1,420,795	$14.30
W2	Rainwater Containment - 26,000 gal Rainwater Tank					$60,089	$0.60
B	**Shell**	**7.4%**	**2.7%**	**$7,159,737**	**$72.04**	**$7,686,669**	**$77.34**
	Baseline Building			$7,159,737	$72.04	$7,159,737	$72.04
M2E	Operable Windows (manual)					$61,920	$0.62
D3C	Reallocate Glazing from East and West Façade to South (less spandrel panel, more skin)					($48,115)	($0.48)
L1B	Replace Roofing with Glazed Skylight					$168,750	$1.70
E1A	Improved Glazing (reduce solar heat gain)					$42,098	$0.42
E1B	Exterior Shading Devices					($207,300)	($2.09)
D2A	Added Wall / Skin for Modified Design (not in base building design)					$365,040	$3.67
D2B	Modifications to Roof Structure					$52,539	$0.53
L1D	Interior Light Shelves					$92,000	$0.93
C	**Interiors**	**10.4%**	**2.0%**	**$3,724,311**	**$37.47**	**$4,113,078**	**$41.39**
	Baseline Building			$3,724,311	$37.47	$3,724,311	$37.47
M2D	Carpet Reduction (Corridors Carpeted Only)					$99,385	$1.00
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$149,078	$1.50
L1A	Exposed Ceilings (white matte surfaces)					($210,696)	($2.12)
L1B	Atrium Space (smoke curtain, glazing, guardrails)					$351,000	$3.53
D.1	**Services - Conveying Systems**	**24.1%**	**0.3%**	**$207,466**	**$2.09**	**$257,466**	**$2.59**
	Baseline Building			$207,466	$2.09	$207,466	$2.09
D3	Added Stop for 5th Floor					$50,000	$0.50
D.2	**Services - Plumbing Systems**	**18.5%**	**0.8%**	**$838,297**	**$8.43**	**$993,097**	**$9.99**
	Baseline Building			$838,297	$8.43	$838,297	$8.43
W6	Low-Flow Fixtures / Optical Sensors					$4,800	$0.05
W2	Rain Harvesting (piping & pumps and filtration)					$150,000	$1.51
D.3	**Services - HVAC Systems**	**77.7%**	**6.8%**	**$1,725,708**	**$17.36**	**$3,067,098**	**$30.86**
	Baseline Building			$1,689,708	$17.00	$1,689,708	$17.00
	Baseline HVAC System					($938,935)	($9.45)
M2A	In-Slab Radiant Heating and Cooling					$496,925	$5.00
M3A	Ground Source Heat Pump					$1,621,400	$16.31
M2B	Energy Recovery Wheel / Plate & Frame					$198,000	$1.99
M2C	Carbon Dioxide Sensors			$36,000	$0.36		
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$272,482**	**$2.74**	**$272,482**	**$2.74**
	Baseline Building			$272,482	$2.74	$272,482	$2.74
D.5	**Services - Electrical Systems**	**12.9%**	**1.5%**	**$2,307,176**	**$23.21**	**$2,604,676**	**$26.21**
	Baseline Building			$2,024,176	$20.37	$2,024,176	$20.37
PA	Occupancy Sensor to Outlets					$42,000	$0.42
PE	High Efficiency Main Transformer					$43,000	$0.43
L1C	Daylight Controls (continuous dimming 15' from perimeter)			$37,000	$0.37	$37,000	$0.37
L2A	Efficient Light Fixture Optics Premium			$190,000	$1.91	$190,000	$1.91
L2B	Occupancy Sensor for Lighting (closed office / conference spaces)			$22,000	$0.22	$22,000	$0.22
L2C	Individual Light Level Control (open spaces)					$212,500	$2.14
L2E	Occupancy Sensor for Transient and Egress Lighting			$34,000	$0.34	$34,000	$0.34

BUILDING TYPE: **MIDRISE OFFICE**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 99,385
Living Building Gross SF = 99,385
Site Gross Acreage = 5.24

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$472,675**	**$4.76**	**$472,675**	**$4.76**
Baseline Building				$472,675	$4.76	$472,675	$4.76
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**68.0%**	**5.0%**	**$1,465,612**	**$14.75**	**$2,462,362**	**$24.78**
Baseline Building				$1,465,612	$14.75	$1,465,612	$14.75
W4 Stormwater Retention						$50,000	$0.50
D3 Parking revisions (pervious, deletion of piping, deletion of AC, lighting)						$91,750	$0.92
D3 Shading Structure over Parking with Rain Collection Piping (45,000 sf)						$855,000	$8.60
H Logistics		**0.0%**	**0.0%**	**$218,298**	**$2.20**	**$218,298**	**$2.20**
Baseline Building				$218,298	$2.20	$218,298	$2.20
Living Building Prerequisites				**$4,141**	**$0.04**	**$537,491**	**$5.41**
PR5 - Materials Red List		**100.0%**	**1.1%**			$208,500	$2.10
PR7 - Responsible Industry		**100.0%**	**0.2%**			$30,181	$0.30
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.5%**			$294,669	$2.96
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$4,141	$0.04	$4,141	$0.04
Subtotal Direct Costs			21.9%	$19,816,699	$199.39	$24,166,275	$243.16
General Conditions	4.0%	**21.9%**	**0.9%**	$792,668	$7.98	$966,651	$9.73
Fee, Construction Contingency, Insurance	8.0%	**21.9%**	**1.8%**	$1,648,749	$16.59	$2,010,634	$20.23
Location Modifier for BOSTON, MA	1.12	**21.9%**	**3.0%**	$2,670,974	$26.88	$3,257,227	$32.77
TOTAL MODIFIED CONSTRUCTION COST			**21.9%**	**$24,929,091**	**$250.83**	**$30,400,788**	**$305.89**

BUILDING TYPE: **MIDRISE OFFICE**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = **99,385**
Living Building Gross SF = **99,385**
Site Gross Acreage = **5.24**

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Membrane Bio-Reactor				100.0%	0.3%			$60,000	$0.60
PV1	Photovoltaic Panels and Infrastructure	944,000	Watts		100.0%	35.7%			$7,080,000	$71.24
LB Prerequisite Items										
	PR3 - Habitat Exchange	5.24	acres		100.0%	0.1%			$26,200	$0.26
	PR6 - Construction Carbon Footprint	2,600	tons		100.0%	0.1%			$28,600	$0.29
	PR15 - Beauty and Spirit (included in A/E fees above)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$43,500	$0.44
Development Costs			LEED	LBC						
	Develoment Costs		13.06%	16.06%	50.0%	8.2%	$3,255,963	$32.76	$4,882,639	$49.13
	Architecture & Engineering		6.09%	8.09%	62.0%	4.7%	$1,518,118	$15.28	$2,459,346	$24.75
Credits / Rebates / Incentives										
	Photovoltaic Credits-(state, city, utility)	50%			-100.0%	-17.9%			($3,540,000)	($35.62)
	SDC Credits	50%		0.00%	-100.0%	-1.5%	$0		($289,395)	($2.91)
TOTAL OWNER & DESIGN-BUILD COSTS						**125.2%**	**$4,774,081**	**$48.04**	**$10,750,890**	**$108.17**

TOTAL CONCEPTUAL COST: **$29,703,171** **$298.87** **$41,151,678** **$414.06**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **36%** **TO** **41%**
MIDRISE OFFICE IN BOSTON, MA

MidRiseOffice
Boston

Normalized Baseline Energy Use Intensity (kBtu/SF) **92.7**

Normalized Baseline Energy Use (kWh) 2,691,133

Impact of Design Changes (see sketches) 1.03

Adjusted Baseline EUI (kBtu/SF) 95.1

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		17%	32%	20%	3%	9%	19%	100%
calc'd EUI		16.1	30.2	19.0	3.1	8.6	17.7	94.6
Energy Conservation Measures:								
Glazing	**E1**		*12.0%*	7.5%		4.7%		5.7%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		*10.0%*	3.0%		2.9%		4.0%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	50.0%	-3.8%	5.0%		0.8%		8.3%
Remove ceiling, raise window head, add lightshelf	L1a							
Top daylighting from Atrium	L1g							
Daylight controls (continuous dimming)	L1c							
Lighting	**L2**	25.0%	-1.9%	2.5%		0.4%		4.2%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	4.6%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.8%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*75.0%*	*19.5%*	*25.5%*	*0.0%*	*11.6%*	*25.0%*	*29.7%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*24.3*	*14.2*	*3.1*	*7.6*	*13.3*	*66.4*
Mechanical - Distribution & Ventilation	**M2**		*25.0%*	20.0%		70.0%		14.9%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*25.0%*	*20.0%*	*0.0%*	*70.0%*	*0.0%*	*14.9%*
Subtotal Reduced EUI (kBTU/SF)		*4.0*	*18.2*	*11.3*	*3.1*	*2.3*	*13.3*	*52.2*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		5.9%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				50.0%			1.6%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*50.0%*	*-15.0%*	*0.0%*	*7.5%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**4.0**	**14.6**	**9.1**	**1.6**	**2.6**	**13.3**	***45.1***
Final Energy Use Breakdown as Percentage of Baseline Use		**4%**	**15%**	**10%**	**2%**	**3%**	**14%**	**52%**

Building Operating Factor	0.90
Impact of Interactive ECM effects	1.07

Total Reduced EUI (kBTU/sf)	**43.4**

Total reduced energy use (kWh)	1,260,045

Number of crystaline panels needed	4,538
Total kW of PV array	930

92.9	CBECS Baseline EUI (kBTU/sf)
60%	target reduction from CBECS

Achievement: **TARGET REDUCTION NOT MET**

53%	percent reduction from CBECS
53%	percent reduction from Normalized Baseline Bldg

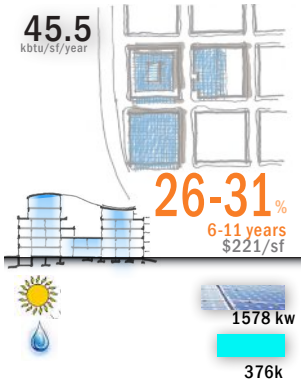
PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	252.778	4985		0
	15°	272.61	4623	32,723	2624
optimal angle:	35.0°	286.98	4391	23,871	1914
	45°	284.06	4436		0
	90°	205.17	6142		0
				Total kWh =	**1,264,608**

- ✓ Extend atrium down level to allow access operable windows fo workstations.
- ✓ Provide additional 1 level to make up for area lost with inserti of atrium.
- ✓ Change curved roof t to maximize PV prod tion.
- ✓ Add PV sun shades o South.
- ✓ Add PV to adjacent p ing garage to offset the parking garage l and the building's lo

MIXED USE RENOVATION
BOSTON mixed

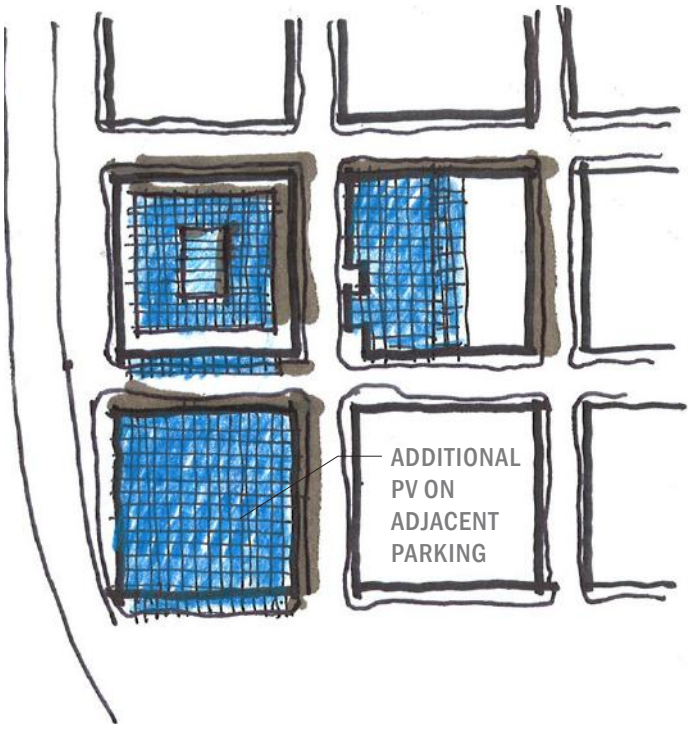


ENERGY USE INDEX

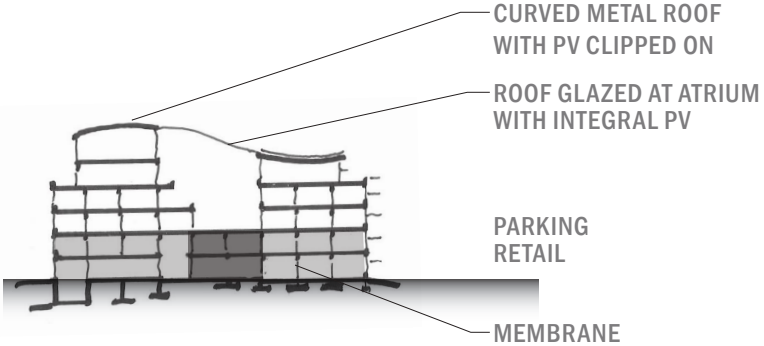
COST PREMIUM
PAYBACK
COST PER SF

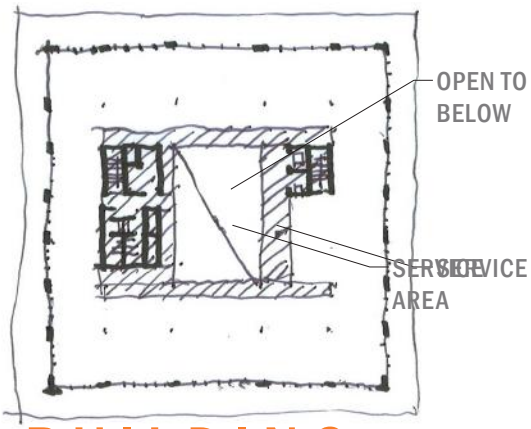
PHOTOVOLTAIC CAPACITY

WATER USE



30,000 gal RAINWATER TANK SIZE
185,043 sf BUILDING SIZE
5 floors BUILDING HEIGHT
1.0 acres SITE AREA
90,960 sf PHOTOVOLTAIC AREA
40,000 sf ROOF AREA





PLAN
NTS

- ✓ Extend atrium down one level to allow access to operable windows for all workstations.
- ✓ Provide additional 1/2 level to make up for floor area lost with insertion of atrium.
- ✓ Change curved roof form to maximize PV production.
- ✓ Add PV sun shades on South.
- ✓ Add PV to adjacent parking garage to offset both the parking garage loads and the building's loads.
- ✓ Two parking garages needed for Net zero energy.

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **MIXED-USE RENOVATION**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 185,043
Living Building Gross SF = 185,043
Site Gross Acreage = 1.00

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**0.0%**	**0.0%**	**$579,458**	**$3.13**	**$579,458**	**$3.13**
	Baseline Building			$579,458	$3.13	$579,458	$3.13
W2	Rainwater Containment - 30,000 gal Rainwater Tank (included in base)					$0	
B	**Shell**	**19.1%**	**5.2%**	**$8,421,922**	**$45.51**	**$10,033,922**	**$54.22**
	Baseline Building			$8,421,922	$45.51	$8,421,922	$45.51
M2E	Operable Windows (manual, additional units beyond existing)					$32,000	$0.17
L1B	Replace Roofing with Glazed PV Frit Skylight					$172,125	$0.93
E1A	Improved Glazing (reduce solar heat gain)					$25,000	$0.14
E1B	Exterior Shading Devices (PV as shading on South)					$109,375	$0.59
L1D	Raise Window Head / Add Light Shelf (RAF removed)					$0	
M2H	"High Mass" Concrete Inside Insulation (not included because this is a renovation)					$0	
D2B	Modifications to Roof Structure and Roofing					$99,000	$0.54
E2C	Structure to Mount PV on Adjacent Parking Structure					$484,500	$2.62
D3	Renovation Work at Atrium (demo floor, railings, interior walls, structure for balcony)					$150,000	$0.81
D3	Added SF for Additional Floor (at penthouse)					$240,000	$1.30
D2A	Added Wall / Skin for Modified Design (not in base building design)					$300,000	$1.62
L1D	Interior Light Shelves (not included)					$0	
C	**Interiors**	**2.1%**	**0.5%**	**$7,723,877**	**$41.74**	**$7,883,877**	**$42.61**
	Baseline Building			$7,723,877	$41.74	$7,723,877	$41.74
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$270,000	$1.46
M2D	Retroplate Topping Slab (at TI locations)					$690,000	$3.73
L1A	Exposed Ceilings (existing white matte surfaces)					$0	
D3	Remove Raised Access Flooring					($800,000)	($4.32)
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$385,400**	**$2.08**	**$385,400**	**$2.08**
	Baseline Building			$385,400	$2.08	$385,400	$2.08
D.2	**Services - Plumbing Systems**	**19.4%**	**0.5%**	**$791,454**	**$4.28**	**$945,254**	**$5.11**
	Baseline Building			$791,454	$4.28	$791,454	$4.28
W6	Low-Flow Fixtures / Optical Sensors					$3,800	$0.02
W2	Rain Harvesting (piping & pumps and filtration)					$150,000	$0.81
D.3	**Services - HVAC Systems**	**11.2%**	**1.0%**	**$2,767,999**	**$14.96**	**$3,078,918**	**$16.64**
	Baseline Building			$2,767,999	$14.96	$2,767,999	$14.96
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,470,281)	($13.35)
M2A	In-Slab Radiant Heating and Cooling					$600,000	$3.24
M3A	Ground Source Heat Pump					$2,030,200	$10.97
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$135,000	$0.73
M2C	Carbon Dioxide Sensors					$16,000	$0.09
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$343,553**	**$1.86**	**$343,553**	**$1.86**
	Baseline Building			$343,553	$1.86	$343,553	$1.86
D.5	**Services - Electrical Systems**	**24.1%**	**3.6%**	**$4,539,215**	**$24.53**	**$5,631,885**	**$30.44**
	Baseline Building			$4,571,685	$24.71	$4,571,685	$24.71
PA	Occupancy Sensor to Outlets					$47,200	$0.26
PE	High Efficiency Transformers					$158,000	$0.85
L1C	Daylight Controls (continuous dimming 15' from perimeter)						
L2A	Efficient Light Fixture Optics Premium					$270,000	$1.46
L2B	Occupancy Sensor for Lighting (closed office / conference spaces)						
L2C	Individual Light Level Control (open spaces, classrooms)					$585,000	$3.16
L2E	Occupancy Sensor for Transient and Egress Lighting			($32,470)	($0.18)	$0	

BUILDING TYPE: **MIXED-USE RENOVATION**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 185,043
Living Building Gross SF = 185,043
Site Gross Acreage = 1.00

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$2,061,480**	**$11.14**	**$2,061,480**	**$11.14**
Baseline Building				$2,061,480	$11.14	$2,061,480	$11.14
F Special Construction		**0.0%**	**0.0%**	**$1,407,188**	**$7.60**	**$1,407,188**	**$7.60**
Baseline Building				$1,407,188	$7.60	$1,407,188	$7.60
G Sitework		**4.4%**	**0.2%**	**$1,131,528**	**$6.11**	**$1,181,528**	**$6.39**
Baseline Building				$1,131,528	$6.11	$1,131,528	$6.11
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.27
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$600,000**	**$3.24**	**$600,000**	**$3.24**
Baseline Building				$600,000	$3.24	$600,000	$3.24
Living Building Prerequisites				**$3,855**	**$0.02**	**$733,817**	**$3.97**
PR5 - Materials Red List		**100.0%**	**0.9%**			$276,063	$1.49
PR7 - Responsible Industry		**100.0%**	**0.2%**			$55,507	$0.30
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.0%**			$315,019	$1.70
PR9 - Leadership in Construction Waste		**2162.7%**	**0.3%**	$3,855	$0.02	$87,227	$0.47
Subtotal Direct Costs			13.4%	$30,756,929	$166.22	$34,866,280	$188.42
General Conditions	4.0%	**13.4%**	**0.5%**	$1,230,277	$6.65	$1,394,651	$7.54
Fee, Construction Contingency, Insurance	0.7%	**13.4%**	**0.1%**	$238,965	$1.29	$270,892	$1.46
Location Modifier for BOSTON, MA	1.12	**13.4%**	**1.7%**	$3,867,141	$20.90	$4,383,819	$23.69
TOTAL MODIFIED CONSTRUCTION COST			**13.4%**	**$36,093,312**	**$195.05**	**$40,915,642**	**$221.11**

BUILDING TYPE: **MIXED-USE RENOVATION**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 185,043
Living Building Gross SF = 185,043
Site Gross Acreage = 1.00

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	0.2%			$60,000	$0.32
PV1	Photovoltaic Panels and Infrastructure	1,433,000	Watts		100.0%	34.9%			$10,747,500	$58.08
LB Prerequisite Items										
	PR3 - Habitat Exchange	1	acres		100.0%	0.0%			$5,000	$0.03
	PR6 - Construction Carbon Footprint	1,250	tons @ 50%		100.0%	0.0%			$13,750	$0.07
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.2%			$63,500	$0.34
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	25.5%	8.4%	$10,106,127	$54.62	$12,683,849	$68.55
	Architecture & Engineering		7.00%	9.00%	45.7%	3.8%	$2,526,532	$13.65	$3,682,408	$19.90
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-17.5%	$0		($5,373,750)	($29.04)
	SDC Credits	50%			-100.0%	-1.1%	$0		($349,890)	($1.89)
TOTAL OWNER & DESIGN-BUILD COSTS						70.4%	**$12,632,659**	**$68.27**	**$21,532,367**	**$116.36**
						TOTAL CONCEPTUAL COST:	**$48,725,971**	**$263.32**	**$62,448,009**	**$337.48**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **26%** **TO** **31%**
MIXED-USE RENOVATION IN BOSTON, MA

Complex Mixed Use Renovation
Boston

Normalized Baseline Energy Use Intensity (kBtu/SF) **104.6**

Normalized Baseline Energy Use (kWh) 4,447,053

Impact of Design Changes (see sketches) 0.97

Adjusted Baseline EUI (kBtu/SF) 101.0

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		15%	37%	20%	3%	9%	16%	100%
calc'd EUI		15.1	37.1	20.1	2.9	9.1	16.6	101.0
Energy Conservation Measures:								
Glazing	**E1**		*10.0%*	10.0%		5.0%		6.1%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		*15.0%*	6.0%		4.8%		7.1%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	38.0%	-2.9%	3.8%		0.6%		5.4%
Remove ceiling, raise window head, add lightshelf	L1a							
Daylight controls (continuous dimming)	L1c							
Floorplan renovation for daylighting	L1e							
Lighting	**L2**	38.5%	-2.9%	3.9%		0.6%		5.5%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
High color rendering metal halide retail lighting	L2h							
Plug Loads	**P**		-1.9%	2.5%		0.4%	25.0%	4.0%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Optimize printer layout/use	Pc							
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Parking: variable flow ventilation based on CO monitor	Pi							
Super-efficient elevators (hybrid)	Pk							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		3.1%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*76.5%*	*22.4%*	*31.2%*	*0.0%*	*13.8%*	*25.0%*	*31.2%*
Subtotal Reduced EUI (kBTU/SF)		*3.6*	*28.8*	*13.8*	*2.9*	*7.8*	*12.5*	*69.4*
Mechanical - Distribution & Ventilation	**M2**		*15.0%*	20.0%		70.0%		12.4%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Programmable thermostats	M2o							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*20.0%*	*0.0%*	*70.0%*	*0.0%*	*12.4%*
Subtotal Reduced EUI (kBTU/SF)		*3.6*	*24.5*	*11.1*	*2.9*	*2.3*	*12.5*	*56.9*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		6.7%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				50.0%			1.5%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from tankless electric water heater	Wd							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*50.0%*	*-15.0%*	*0.0%*	*8.2%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**3.6**	**19.6**	**8.8**	**1.5**	**2.7**	**12.5**	***48.6***
Final Energy Use Breakdown as Percentage of Baseline Use		**4%**	**19%**	**9%**	**1%**	**3%**	**12%**	**52%**

Building Operating Factor 0.90
Impact of Interactive ECM effects 1.05

Total Reduced EUI (kBTU/sf) 45.5

92.9 CBECS Baseline EUI (kBTU/sf)
60% target reduction from CBECS

Achievement: **TARGET REDUCTION NOT MET**

51% percent reduction from CBECS
57% percent reduction from Normalized Baseline Bldg

Total reduced energy use (kWh) 1,933,654

Number of crystaline panels needed 7,697
Total kW of PV array 1578

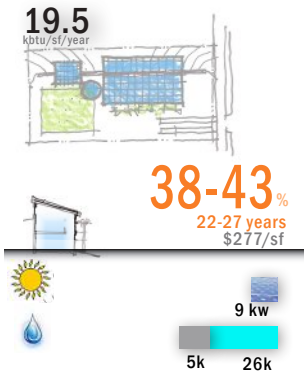
PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	252.778	7650	40,000	3207	Roof only
	15°	272.61	7094		0	
optimal angle:	35.0°	286.98	6738		0	
	45°	284.06	6808		0	
	90°	205.17	9425		0	
				Total kWh =	**810,659**	
Additional area				56,000	4490	
Additional kWh Produced				**1,134,973**	1,945,632	

Additional Parking Garage Offset Needed, EUI of 1.7

SINGLE FAMILY RESIDENTIAL
BOSTON mixed



ENERGY USE INDEX

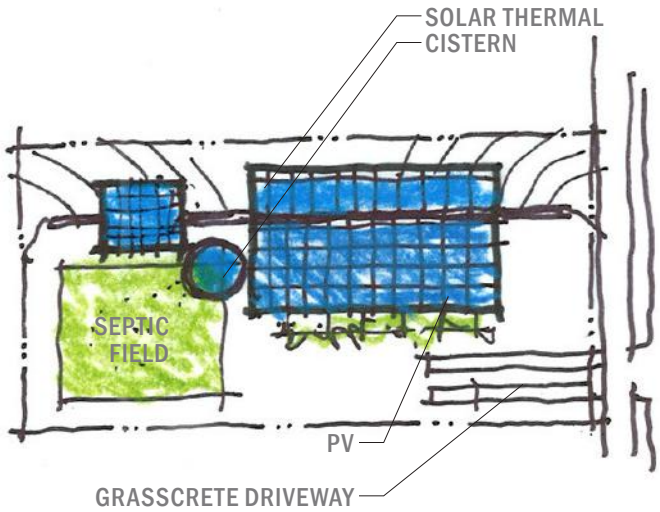
COST PREMIUM

PAYBACK

COST PER SF

PHOTOVOLTAIC CAPACITY

WATER USE



8,000 gal RAINWATER TANK SIZE

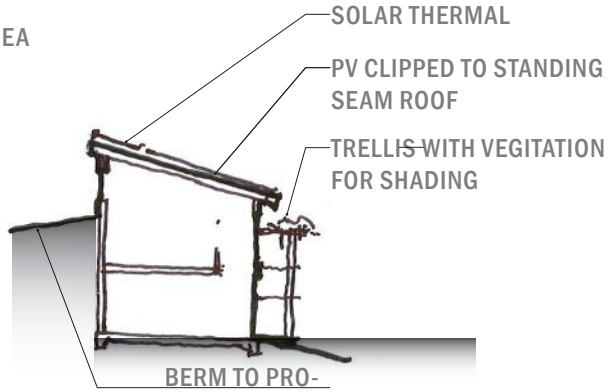
1,970 sf BUILDING SIZE

2 floors BUILDING HEIGHT

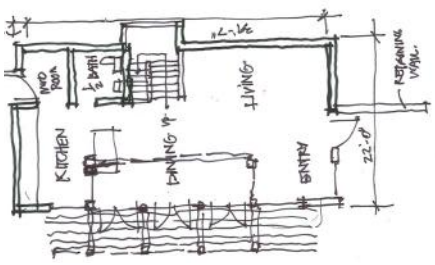
0.11 acres SITE AREA

530 sf PHOTOVOLTAIC AREA

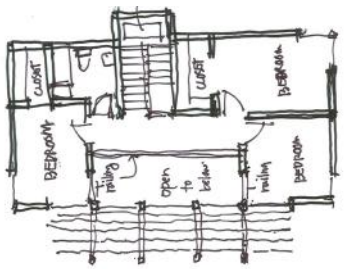
1,031 sf ROOF AREA



- ✓ Berm house into earth for maximum heat retention.
- ✓ Composting toilets minimize water use and waste production.
- ✓ Cistern for water collection.
- ✓ Solar Thermal on edge of building.
- ✓ Trellis for shading on South.



LEVEL 2



LEVEL 1

PLANS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **SINGLE FAMILY RESIDENTIAL**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 1,840
Living Building Gross SF = 1,840
Site Gross Acreage = 0.11

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**0.0%**	**0.0%**	**$63,527**	**$34.53**	**$63,527**	**$34.53**
Baseline Building			$63,527	$34.53	$63,527	$34.53
W2 Rainwater Containment - 8,000 gal Rainwater Tank (included in base building)					$0	
B Shell	**13.7%**	**6.2%**	**$131,226**	**$71.32**	**$149,258**	**$81.12**
Baseline Building			$131,226	$71.32	$131,226	$71.32
L1B Replace Roofing with Glazed Skylight					$960	$0.52
E1A Improved Glazing (reduce solar heat gain)					$4,303	$2.34
E1B Exterior Shading Devices					$10,800	$5.87
D3 Retaining Wall / Footings (house into hill)					$18,000	$9.78
D3 Modify Building to Single Story					($16,031)	($8.71)
C Interiors	**14.4%**	**1.9%**	**$37,430**	**$20.34**	**$42,810**	**$23.27**
Baseline Building			$37,430	$20.34	$37,430	$20.34
M2A Thicken Lower Level Slab (2") and Gypcrete on Upper Level					$4,350	$2.36
L1A Exposed Ceilings (white matte surfaces)					$0	
D3 Additional Railings and Beams (including credit for modified stair railing)					$1,030	$0.56
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building			$0		$0	
D.2 Services - Plumbing Systems	**57.3%**	**2.1%**	**$10,654**	**$5.79**	**$16,754**	**$9.11**
Baseline Building			$10,654	$5.79	$10,654	$5.79
W6 Low-Flow Fixtures / Optical Sensors					$0	
W2 Rain Harvesting (piping & pumps and filtration)					$0	
W7 Composting Toilets					$6,100	$3.32
D.3 Services - HVAC Systems	**98.4%**	**4.1%**	**$12,008**	**$6.53**	**$23,827**	**$12.95**
Baseline Building			$12,008	$6.53	$12,008	$6.53
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($7,381)	($4.01)
M2A In-Slab Radiant Heating and Cooling					$9,200	$5.00
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$0	
M3C Solar Thermal System					$10,000	$5.43
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building			$0		$0	
D.5 Services - Electrical Systems	**68.1%**	**2.4%**	**$10,136**	**$5.51**	**$17,036**	**$9.26**
Baseline Building			$10,136	$5.51	$10,136	$5.51
L2K Provide hardwired compact fluorescent fixtures in all spaces					$2,200	$1.20
L2L Motion sensors for exterior lighting					$300	$0.16
M2Z Ceiling Fans and window box fans (five of each)					$4,400	$2.39

BUILDING TYPE: **SINGLE FAMILY RESIDENTIAL**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 1,840
Living Building Gross SF = 1,840
Site Gross Acreage = 0.11

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline Total	LEED™ Gold Baseline Cost/SF	Living Building Total	Living Building Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$1,011**	**$0.55**	**$1,011**	**$0.55**
Baseline Building				$1,011	$0.55	$1,011	$0.55
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**92.9%**	**6.5%**	**$20,208**	**$10.98**	**$38,988**	**$21.19**
Baseline Building				$20,208	$10.98	$20,208	$10.98
W4 Stormwater Retention / Building Water Discharge						$14,100	$7.66
D3 Trellis Parking Structure						$4,680	$2.54
H Logistics		**0.0%**	**0.0%**	**$3,280**	**$1.78**	**$3,280**	**$1.78**
Baseline Building				$3,280	$1.78	$3,280	$1.78
Living Building Prerequisites				**$920**	**$0.50**	**$20,064**	**$10.90**
PR5 - Materials Red List		**100.0%**	**1.2%**			$3,608	$1.96
PR7 - Responsible Industry		**100.0%**	**4.1%**			$11,981	$6.51
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.2%**			$3,555	$1.93
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$920.00	$0.50	$920	$0.50
Subtotal Direct Costs			29.7%	$290,400	$157.83	$376,556	$204.65
General Conditions	9.4%	**29.7%**	**2.8%**	$27,383	$14.88	$35,507	$19.30
Fee, Construction Contingency, Insurance	10.6%	**29.7%**	**3.4%**	$33,591	$18.26	$43,557	$23.67
Location Modifier for BOSTON, MA	1.12	**29.7%**	**4.3%**	$42,165	$22.92	$54,674	$29.71
TOTAL MODIFIED CONSTRUCTION COST			**29.7%**	**$393,540**	**$213.88**	**$510,295**	**$277.33**

BUILDING TYPE: **SINGLE FAMILY RESIDENTIAL**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = **1,840**
Living Building Gross SF = **1,840**
Site Gross Acreage = **0.11**

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				0.0%	0.0%			$0	
PV1	Photovoltaic Panels and Infrastructure	8,600	Watts		100.0%	26.7%			$77,400	$42.07
LB Prerequisite Items										
	PR3 - Habitat Exchange	0.114784	acres		100.0%	0.2%			$574	$0.31
	PR6 - Construction Carbon Footprint	50	tons		100.0%	0.2%			$550	$0.30
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.5%			$1,500	$0.82
Development Costs			LEED	LBC						
	Develoment Costs		3.42%	2.63%	0.0%	0.0%	$13,440	$7.30	$13,440	$7.30
	Architecture & Engineering		12.00%	15.00%	62.1%	10.1%	$47,225	$25.67	$76,544	$41.60
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-13.3%	$0		($38,700)	($21.03)
	SDC Credits	50%			-100.0%	-1.0%	$0		($2,966)	($1.61)
TOTAL OWNER & DESIGN-BUILD COSTS						111.6%	**$60,665**	**$32.97**	**$128,343**	**$69.75**
TOTAL CONCEPTUAL COST:							**$454,205**	**$246.85**	**$638,637**	**$347.09**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **38%** **TO** **43%**
SINGLE FAMILY RESIDENTIAL IN BOSTON, MA

Single Family Residential
Boston

Normalized Baseline Energy Use Intensity (kBtu/SF)	**41.5**	Normalized Baseline Energy Use (kWh)	22,121
Impact of Design Changes (see sketches)	0.96		
Adjusted Baseline EUI (kBtu/SF)	**39.6**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		13%	42%	6%	10%	7%	22%	100%
calc'd EUI		5.3	16.6	2.4	3.8	2.9	8.7	39.6
Energy Conservation Measures:								
Glazing	**E1**		*10.0%*	8.0%		4.4%		5.0%
High performance residential glazing	E1f							
Add effective shading devices	E1b							
Insulated panels for glazing (thermal window shades)	E1g							
Walls & Roof	**E2**		*7.0%*	3.0%		2.3%		3.3%
Shaded roof from solar panels	E2a							
Optimize insulation - single family residential	E2i							
Lighting	**L2**	53.8%	-4.0%	5.4%		0.8%		5.9%
Provide hardwired compact fluorescent fixtures in all spaces.	L2k							
Motion sensors for exterior lighting	L2l							
Plug Loads	**P**		-2.3%	3.0%		0.5%	30.0%	5.8%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
Occupant buy-in / personal energy budget	Pf							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.6%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*53.8%*	*15.7%*	*24.4%*	*0.0%*	*10.5%*	*30.0%*	*22.5%*
Subtotal Reduced EUI (kBTU/SF)		*2.4*	*14.0*	*1.8*	*3.8*	*2.6*	*6.1*	*30.7*
Mechanical - Distribution & Ventilation	**M2**		*15.0%*	100.0%		60.0%		13.8%
Radiant floor heating	M2y							
Energy recovery ventilation	M2b							
Natural ventilation: operable windows	M2e							
Eliminate cooling	M2j							
Ceiling fans and window box fans	M2z							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*100.0%*	*0.0%*	*60.0%*	*0.0%*	*13.8%*
Subtotal Reduced EUI (kBTU/SF)		*2.4*	*11.9*	*0.0*	*3.8*	*1.1*	*6.1*	*25.2*
Mechanical - Plant Systems	**M3**		20.0%					6.0%
Solar thermal (evacuated tubes) Heating System	M3c							
Domestic Hot Water	**W**				75.0%			7.1%
Solar-thermal domestic water	Wa							
Low flow fixtures (showers, lavs, sinks)	Wb							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*0.0%*	*75.0%*	*0.0%*	*0.0%*	*13.1%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**2.4**	**9.5**	**0.0**	**0.9**	**1.1**	**6.1**	***20.0***
Final Energy Use Breakdown as Percentage of Baseline Use		**6%**	**24%**	**0%**	**2%**	**3%**	**15%**	**50%**

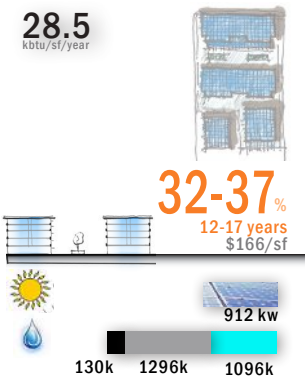
Building Operating Factor	0.90	43.8	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
		Achievement:	**TARGET REDUCTION NOT MET**
Total Reduced EUI (kBTU/sf)	**19.1**	56%	percent reduction from CBECS
		54%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	10,165		
Number of crystaline panels needed	43		
Total kW of PV array	9		

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	252.778	41	540	43
	15°	272.61	38		0
optimal angle:	35.0°	286.98	36		0
	45°	284.06	36		0
	90°	205.17	50		0
				Total kWh =	**10,869**

MULTIFAMILY RESIDENTIAL
BOSTON mixed

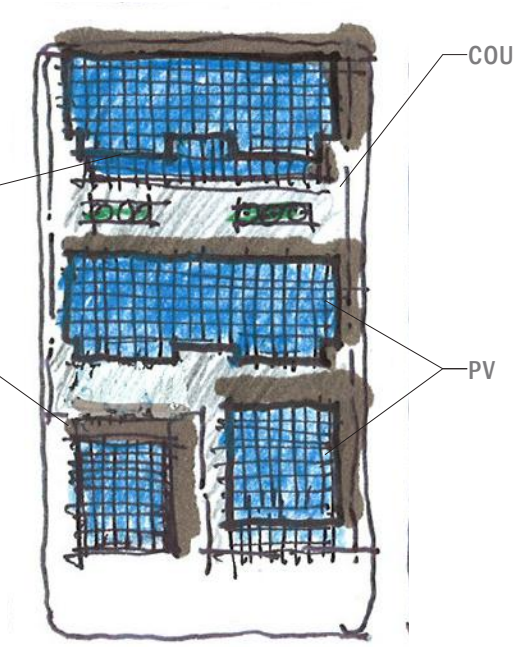


ENERGY USE INDEX

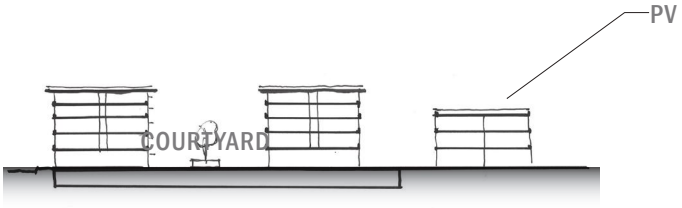
COST PREMIUM
PAYBACK
COST PER SF

PHOTOVOLTAIC CAPACITY

WATER USE



20,000 gal RAINWATER TANK SIZE
240,187 sf BUILDING SIZE
5 floors BUILDING HEIGHT
2.87 acres SITE AREA
55,500 sf PHOTOVOLTAIC AREA
42,393 sf ROOF AREA



- ✓ Increase floor to floor height to allow better daylight penetration.
- ✓ Reconfigure housing units to be oriented in N/S direction for better access to daylight.
- ✓ Reconfigure floor plans to allow units to have all habitable rooms within 30' of an operable window.
- ✓ Additional PV on adjacent parking garage.

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **MULTI-FAMILY HOUSING**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 209,678
Living Building Gross SF = 209,678
Site Gross Acreage = 2.87

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**7.5%**	**0.2%**	**$622,710**	**$2.97**	**$669,394**	**$3.19**
Baseline Building			$622,710	$2.97	$622,710	$2.97
W2 Rainwater Containment - 20,000 gal Rainwater Tank					$46,684	$0.22
B Shell	**5.0%**	**1.6%**	**$7,656,970**	**$36.52**	**$8,040,942**	**$38.35**
Baseline Building			$7,656,970	$36.52	$7,656,970	$36.52
E1D Reduce Glazing (30% of original window glazing)					$165,200	$0.79
E1A Improved Glazing (reduce solar heat gain)					$12,972	$0.06
E1B Exterior Shading Devices					$468,000	$2.23
D2A Reduce Wall / Skin for Modified Design (not in base building design)					($405,600)	($1.93)
D3 Relocate Elevator					$45,000	$0.21
D3 Covered Walkway					$98,400	$0.47
C Interiors	**5.3%**	**1.3%**	**$5,891,333**	**$28.10**	**$6,205,850**	**$29.60**
Baseline Building			$5,891,333	$28.10	$5,891,333	$28.10
M2O Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$314,517	$1.50
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$244,158**	**$1.16**	**$244,158**	**$1.16**
Baseline Building			$244,158	$1.16	$244,158	$1.16
D.2 Services - Plumbing Systems	**8.0%**	**0.6%**	**$1,900,476**	**$9.06**	**$2,052,276**	**$9.79**
Baseline Building			$1,900,476	$9.06	$1,900,476	$9.06
W6 Low-Flow Fixtures / Optical Sensors					$1,800	$0.01
W2 Rain Harvesting (piping & pumps and filtration)					$150,000	$0.72
D.3 Services - HVAC Systems	**387.3%**	**11.5%**	**$717,870**	**$3.42**	**$3,498,260**	**$16.68**
Baseline Building			$717,870	$3.42	$717,870	$3.42
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($535,000)	($2.55)
M2A In-Slab Radiant Heating and Cooling					$1,048,390	$5.00
M3A Ground Source Heat Pump					$1,959,000	$9.34
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$308,000	$1.47
M2C Carbon Dioxide Sensors					$0	
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$462,507**	**$2.21**	**$462,507**	**$2.21**
Baseline Building			$462,507	$2.21	$462,507	$2.21
D.5 Services - Electrical Systems	**0.6%**	**0.1%**	**$3,452,618**	**$16.47**	**$3,471,778**	**$16.56**
Baseline Building			$3,416,018	$16.29	$3,416,018	$16.29
L2E Occupancy Sensor for Transient Lighting (corridors/stairs)			$28,000	$0.13		
L2I Dual day/night light levels in corridors; occupancy sensors			$8,600	$0.04		
L2K Provide hardwired compact fluorescent fixtures in all spaces					$55,760	$0.27

BUILDING TYPE: **MULTI-FAMILY HOUSING**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 209,678
Living Building Gross SF = 209,678
Site Gross Acreage = 2.87

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$948,170**	**$4.52**	**$948,170**	**$4.52**
Baseline Building				$948,170	$4.52	$948,170	$4.52
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**6.2%**	**0.6%**	**$2,221,462**	**$10.59**	**$2,358,962**	**$11.25**
Baseline Building				$2,221,462	$10.59	$2,221,462	$10.59
W2 Stormwater Retention / Building Water Discharge						$50,000	$0.24
D3 Added Courtyard						$87,500	$0.42
H Logistics		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
Living Building Prerequisites				**$8,737**	**$0.04**	**$814,089**	**$3.88**
PR5 - Materials Red List		**100.0%**	**0.9%**			$228,644	$1.09
PR7 - Responsible Industry		**100.0%**	**1.3%**			$323,676	$1.54
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.1%**			$261,769	$1.25
PR9 - Leadership in Construction Waste		**-100.0%**	**0.0%**	$8,737	$0.04		
Subtotal Direct Costs			19.2%	$24,127,011	$115.07	$28,766,386	$137.19
General Conditions	4.0%	**19.2%**	**0.8%**	$965,080	$4.60	$1,150,655	$5.49
Fee, Construction Contingency, Insurance	4.0%	**19.2%**	**0.8%**	$1,003,684	$4.79	$1,196,682	$5.71
Location Modifier for BOSTON, MA	1.12	**19.2%**	**2.5%**	$3,131,493	$14.93	$3,733,647	$17.81
TOTAL MODIFIED CONSTRUCTION COST			**19.2%**	**$29,227,268**	**$139.39**	**$34,847,369**	**$166.19**

BUILDING TYPE: **MULTI-FAMILY HOUSING**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 209,678
Living Building Gross SF = 209,678
Site Gross Acreage = 2.87

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	4.1%			$1,000,000	$4.77
PV1	Photovoltaic Panels and Infrastructure	912,000	Watts		100.0%	28.3%			$6,840,000	$32.62
LB Prerequisite Items										
	PR3 - Habitat Exchange	2.86961	acres		100.0%	0.1%			$14,348	$0.07
	PR6 - Construction Carbon Footprint	6,400	tons		100.0%	0.3%			$70,400	$0.34
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.1%			$23,500	$0.11
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	32.0%	10.9%	$8,183,635	$39.03	$10,802,684	$51.52
	Architecture & Engineering		7.00%	9.00%	53.3%	4.5%	$2,045,909	$9.76	$3,136,263	$14.96
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-14.2%	$0		($3,420,000)	($16.31)
	SDC Credits	50%			-100.0%	-1.4%	$0		($343,583)	($1.64)
TOTAL OWNER & DESIGN-BUILD COSTS						77.2%	**$10,229,544**	**$48.79**	**$18,123,613**	**$86.44**
TOTAL CONCEPTUAL COST:							**$39,456,811**	**$188.18**	**$52,970,983**	**$252.63**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: 32% TO 37%
MULTI-FAMILY HOUSING IN BOSTON, MA

Multi- Family Residential
Boston

Normalized Baseline Energy Use Intensity (kBtu/SF)	**59.3**	Normalized Baseline Energy Use (kWh)	2,323,374
Impact of Design Changes (see sketches)	0.97		
Adjusted Baseline EUI (kBtu/SF)	**57.2**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		12%	38%	9%	11%	10%	20%	100%
calc'd EUI		6.9	21.9	5.1	6.0	5.7	11.6	57.2
Energy Conservation Measures:								
Glazing	**E1**		*10.0%*	10.0%		5.0%		5.2%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Reduce glazing to 30%	E1d							
Insulated panels for glazing (thermal window shades)	E1g							
Walls & Roof	**E2**		*6.0%*	1.5%		1.7%		2.6%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Lighting	**L2**	56.6%	-4.2%	5.7%		0.8%		5.8%
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dual day/night light levels in corridors; occupancy sensors	L2i							
Provide hardwired compact fluorescent fixtures in all spaces.	L2k							
Plug Loads	**P**		-2.3%	3.0%		0.5%	30.0%	5.5%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
#N/A								
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Parking: variable flow ventilation based on CO monitor	Pi							
Super-efficient elevators (hybrid)	Pk							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.6%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*56.6%*	*14.5%*	*25.2%*	*0.0%*	*10.4%*	*30.0%*	*21.8%*
Subtotal Reduced EUI (kBTU/SF)		*3.0*	*18.7*	*3.8*	*6.0*	*5.1*	*8.1*	*44.8*
Mechanical - Distribution & Ventilation	**M2**		*15.0%*	20.0%		60.0%		11.6%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Displacement ventilation delivery for DOAS	M2k							
Water to water heat pumps, radiant slab heating/cooling	M2q							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*20.0%*	*0.0%*	*60.0%*	*0.0%*	*11.6%*
Subtotal Reduced EUI (kBTU/SF)		*3.0*	*15.9*	*3.0*	*6.0*	*2.0*	*8.1*	*38.1*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		6.1%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				75.0%			7.9%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from tankless electric water heater	Wd							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*75.0%*	*-15.0%*	*0.0%*	*14.0%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**3.0**	**12.7**	**2.4**	**1.5**	**2.4**	**8.1**	***30.1***
Final Energy Use Breakdown as Percentage of Baseline Use		**5%**	**22%**	**4%**	**3%**	**4%**	**14%**	**47%**

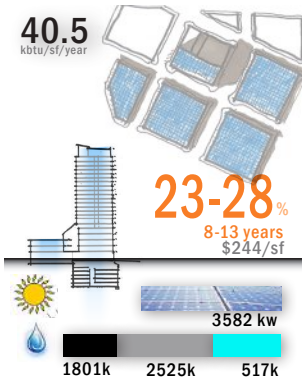
Building Operating Factor	0.90	60.0	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
		Achievement:	**TARGET REDUCTION NOT MET**
Total Reduced EUI (kBTU/sf)	**28.5**	53%	percent reduction from CBECS
		52%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	1,115,634		
Number of crystaline panels needed	4,450		
Total kW of PV array	912		

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

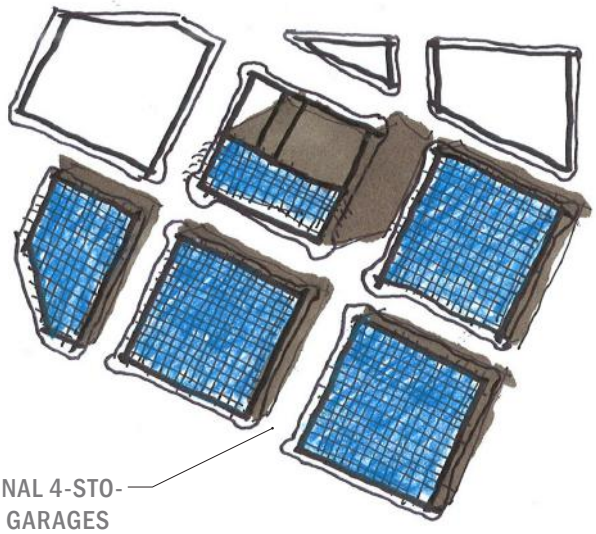
	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels	
	0°	252.778	4414	50,200	4025	Panels on roof + Sunshade+ canopy
	15°	272.61	4093		0	
optimal angle:	35.0°	286.98	3888		0	
	45°	284.06	3928		0	
	90°	205.17	5438		0	
				Total kWh =	**1,017,431**	
			Additional area	5,300	425	**panels on adjacent parking s**
			Additional kWh Produced		**107,431**	

HIGH RISE MIXED USE
BOSTON mixed



ENERGY USE INDEX

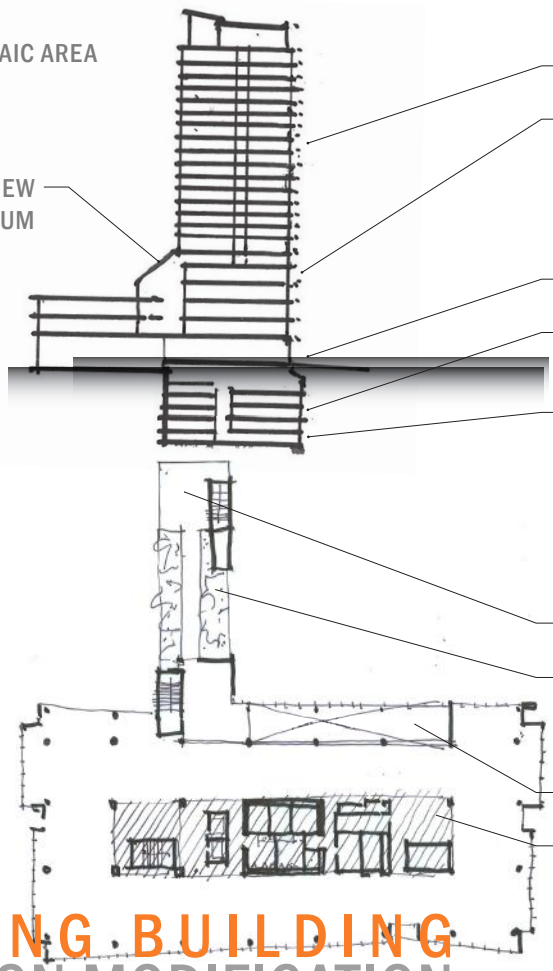
COST PREMIUM
PAYBACK
COST PER SF
PHOTOVOLTAIC CAPACITY
WATER USE



3.5 ADDITIONAL 4-STORY PARKING GARAGES WITH ROOFTOP PV TO ACHIEVE NET ZERO

92,000 gal RAINWATER TANK SIZE
547,624 sf BUILDING SIZE
22 floors BUILDING HEIGHT
0.92 acres SITE AREA
217,900 sf PHOTOVOLTAIC AREA
20,000 sf ROOF AREA

- ✓ Increase floor to floor height to allow better daylight penetration.
- ✓ Add atrium at edge of building.
- ✓ PV integrated with the building on South and East facades.
- ✓ PV screen at building West facade.
- ✓ Add office floor.



PLAN NTS

LIVING BUILDING DESIGN MODIFICATION

BUILDING TYPE: **HIGH RISE**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 547,624
Living Building Gross SF = 547,624
Site Gross Acreage = 0.92

	Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
			Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST						
A Substructure	**0.3%**	**0.0%**	**$8,695,116**	**$15.88**	**$8,724,082**	**$15.93**
Baseline Building			$8,695,116	$15.88	$8,695,116	$15.88
Rainwater Containment - 92,000 gal Rainwater Tank					$28,967	$0.05
B Shell	**6.1%**	**2.3%**	**$35,629,047**	**$65.06**	**$37,794,319**	**$69.02**
Baseline Building			$35,629,047	$65.06	$35,629,047	$65.06
L1B Replace Roofing with Glazed Skylight					$225,900	$0.41
D3A Raise Floor to Floor Height					$918,000	$1.68
E1B Exterior Shading Devices					$1,905,120	$3.48
W5 Water Collection on Vertical Surfaces / Top of Roof					$0	
D3 Relocate SF to additional 1/2 floor at top					$40,800	$0.07
D3 Remove Existing Green Roof					($30,000)	($0.05)
D3 Modifications to Lobby Space (structural and finishes)					$590,000	$1.08
L1E Tracking Mirror above Atrium					$154,000	$0.28
D3 Added Elevator Stop for Additional Floor					$105,000	$0.19
E1D Reduce Glazing to 30%					($2,315,798)	($4.23)
D3 Remove raised access flooring					($801,000)	($1.46)
PV3 Structure for PV on Adjacent Parking Structures					$1,211,250	$2.21
L1D Interior Light Shelves (at office floors)					$162,000	$0.30
C Interiors	**6.7%**	**1.6%**	**$22,739,127**	**$41.52**	**$24,272,474**	**$44.32**
Baseline Building			$22,739,127	$41.52	$22,739,127	$41.52
M2D Carpet Reduction (replace with RetroPlate)					$985,723	$1.80
M2O Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$547,624	$1.00
D.1 Services - Conveying Systems	**0.0%**	**0.0%**	**$2,636,557**	**$4.81**	**$2,636,557**	**$4.81**
Baseline Building			$2,636,557	$4.81	$2,636,557	$4.81
D.2 Services - Plumbing Systems	**0.0%**	**0.0%**	**$3,874,587**	**$7.08**	**$3,874,587**	**$7.08**
Baseline Building			$3,874,587	$7.08	$3,874,587	$7.08
W6 Low-Flow Fixtures / Optical Sensors					$0	
W2 Rain Harvesting (piping & pumps and filtration)					$0	
D.3 Services - HVAC Systems	**58.2%**	**4.7%**	**$7,599,577**	**$13.88**	**$12,023,160**	**$21.96**
Baseline Building			$7,599,577	$13.88	$8,449,577	$15.43
Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($6,085,700)	($11.11)
M2A In-Slab Radiant Heating and Cooling					$2,738,120	$5.00
M3A Ground Source Heat Pump					$6,635,000	$12.12
M2B Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$286,163	$0.52
M2C Carbon Dioxide Sensors					$0	
D.4 Services - Fire Protection Systems	**0.0%**	**0.0%**	**$1,132,828**	**$2.07**	**$1,132,828**	**$2.07**
Baseline Building			$1,132,828	$2.07	$1,132,828	$2.07
D.5 Services - Electrical Systems	**12.4%**	**0.8%**	**$6,138,326**	**$11.21**	**$6,901,276**	**$12.60**
Baseline Building			$6,209,026	$11.34	$6,209,026	$11.34
PA Occupancy Sensor to Outlets					$35,100	$0.06
PE High Efficiency Transformers					$165,000	$0.30
L2A Efficient light fixture optics					$160,200	$0.29
L2B Occupancy Sensor for Lighting (closed office / conference spaces)					$18,850	$0.03
L2C Individual Light Level Control (open spaces)					$179,000	$0.33
L2I Dual day/night light levels in corridors; occupancy sensors					$134,100	$0.24
L2J Occupancy sensor/time clock for corridor lighting					$0	
L2K Provide hardwired compact fluorescent fixtures in all spaces			($70,700)	($0.13)	$0	

BUILDING TYPE: **HIGH RISE**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 547,624
Living Building Gross SF = 547,624
Site Gross Acreage = 0.92

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$3,326,853**	**$6.08**	**$3,326,853**	**$6.08**
Baseline Building				$3,326,853	$6.08	$3,326,853	$6.08
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**9.3%**	**0.1%**	**$537,417**	**$0.98**	**$587,417**	**$1.07**
Baseline Building				$537,417	$0.98	$537,417	$0.98
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.09
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$1,764,940**	**$3.22**	**$1,764,940**	**$3.22**
Baseline Building				$1,764,940	$3.22	$1,764,940	$3.22
Living Building Prerequisites				**$22,818**	**$0.04**	**$2,426,415**	**$4.43**
PR5 - Materials Red List		**100.0%**	**0.9%**			$869,927	$1.59
PR7 - Responsible Industry		**100.0%**	**0.3%**			$328,542	$0.60
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.3%**			$1,205,129	$2.20
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$22,818	$0.04	$22,818	$0.04
Subtotal Direct Costs			12.1%	$94,097,194	$171.83	$105,464,910	$192.59
General Conditions	3.2%	**12.1%**	**0.4%**	$3,005,271	$5.49	$3,368,332	$6.15
Fee, Contingency, Insurance, Bonding	9.8%	**12.1%**	**1.2%**	$9,471,412	$17.30	$10,615,636	$19.38
Location Modifier for BOSTON, MA	1.12	**12.1%**	**1.6%**	$12,788,865	$23.35	$14,333,865	$26.17
TOTAL MODIFIED CONSTRUCTION COST			**12.1%**	**$119,362,741**	**$217.96**	**$133,782,743**	**$244.30**

BUILDING TYPE: **HIGH RISE**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 547,624
Living Building Gross SF = 547,624
Site Gross Acreage = 0.92

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	1.1%			$1,000,000	$1.83
O1	Wind Turbines (net cost including credits)	14,800	Watts		-100.0%	0.1%	($82,000)		$0	
PV1	Photovoltaic Panels and Infrastructure	3,567,200	Watts		100.0%	28.4%			$26,754,000	$48.85
LB Prerequisite Items										
	PR3 - Habitat Exchange	0.918274	acres		100.0%	0.0%			$4,591	$0.01
	PR6 - Construction Carbon Footprint	24,100	tons		100.0%	0.3%			$265,100	$0.48
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.1%			$63,000	$0.12
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	24.1%	8.6%	$33,421,567	$61.03	$41,472,650	$75.73
	Architecture & Engineering		7.00%	9.00%	44.1%	3.9%	$8,355,392	$15.26	$12,040,447	$21.99
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-14.2%	$0		($13,377,000)	($24.43)
	SDC Credits	50%			-100.0%	-0.5%	$0		($509,464)	($0.93)
TOTAL OWNER & DESIGN-BUILD COSTS						**62.4%**	**$41,694,959**	**$76.29**	**$67,713,325**	**$123.65**

TOTAL CONCEPTUAL COST: **$161,057,700** **$294.10** **$201,496,068** **$367.95**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **23%** **TO** **28%**
HIGH RISE IN BOSTON, MA

High Rise Mixed use
Boston

Normalized Baseline Energy Use Intensity (kBtu/SF)	**90.5**	Normalized Baseline Energy Use (kWh)	10,076,852
Impact of Design Changes (see sketches)	0.98		
Adjusted Baseline EUI (kBtu/SF)	**88.7**		

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		11%	40%	12%	9%	10%	19%	100%
calc'd EUI		9.3	35.8	10.2	7.9	8.9	16.5	88.7
Energy Conservation Measures:								
Glazing	**E1**		*15.0%*	15.0%		7.5%		8.5%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		*6.0%*	1.5%		1.7%		2.8%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	15.0%	-1.1%	1.5%		0.2%		1.3%
Remove ceiling, raise window head, add lightshelf	L1a							
Daylight controls (continuous dimming)	L1c							
Lighting	**L2**	69.7%	-5.2%	7.0%		1.0%		6.1%
Efficient fixture optics	L2a							
Individual occupancy sensors & dimming controls: closed offices/low occucpanc	L2b							
Individual light level control (dimming) at open office areas	L2c							
Light colors on walls, ceiling surfaces	L2d							
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Dual day/night light levels in corridors; occupancy sensors	L2i							
Occupancy sensor / time clock for corridor lighting	L2j							
Provide hardwired compact fluorescent fixtures in all spaces.	L2k							
Plug Loads	**P**		-2.3%	3.0%		0.5%	30.0%	5.1%
Occupancy sensor controlled plug loads	Pa							
EnergyStar appliances	Pb							
#N/A								
Remove phantom load / transformers	Pd							
Energy efficient main transformer	Pe							
Occupant buy-in / personal energy budget	Pf							
Centralized power management	Pg							
Parking: variable flow ventilation based on CO monitor	Pi							
Super-efficient elevators (hybrid)	Pk							
Widen Set Point Temperatures	**M1**		5.0%	5.0%		2.5%		2.8%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*84.7%*	*17.4%*	*33.0%*	*0.0%*	*13.4%*	*30.0%*	*26.7%*
Subtotal Reduced EUI (kBTU/SF)		*1.4*	*29.6*	*6.9*	*7.9*	*7.7*	*11.6*	*65.0*
Mechanical - Distribution & Ventilation	**M2**		*15.0%*	18.0%		60.0%		11.6%
Radiant heating/cooling w dedicated outside air system (DOAS)	M2a							
Energy recovery ventilation	M2b							
Demand-based ventilation	M2c							
Minimize carpet (insulates against radiant system)	M2d							
Natural ventilation: operable windows	M2e							
Fan assisted natural ventilation	M2f							
Night flush	M2g							
High mass - concrete block on inside of insulation	M2h							
Displacement ventilation delivery for DOAS	M2k							
Water to water heat pumps, radiant slab heating/cooling	M2q							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*15.0%*	*18.0%*	*0.0%*	*60.0%*	*0.0%*	*11.6%*
Subtotal Reduced EUI (kBTU/SF)		*1.4*	*25.2*	*5.6*	*7.9*	*3.1*	*11.6*	*54.7*
Mechanical - Plant Systems	**M3**		20.0%	20.0%		-15.0%		6.4%
Ground source heat pump system	M3a							
Cascading chilled water system	M3b							
Domestic Hot Water	**W**				75.0%			6.7%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from tankless electric water heater	Wd							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*20.0%*	*75.0%*	*-15.0%*	*0.0%*	*13.1%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**1.4**	**20.1**	**4.5**	**2.0**	**3.5**	**11.6**	***43.1***
Final Energy Use Breakdown as Percentage of Baseline Use		**2%**	**23%**	**5%**	**2%**	**4%**	**13%**	**51%**

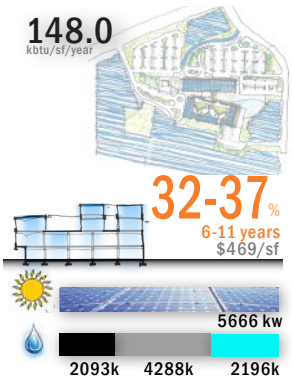
Building Operating Factor	0.90	86.2	CBECS Baseline EUI (kBTU/sf)
Impact of Interactive ECM effects	1.05	60%	target reduction from CBECS
		Achievement:	**TARGET REDUCTION NOT MET**
Total Reduced EUI (kBTU/sf)	**40.5**	53%	percent reduction from CBECS
		55%	percent reduction from Normalized Baseline Bldg
Total reduced energy use (kWh)	4,506,489		
Number of crystaline panels needed	17,472		
Total kW of PV array	3582		

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	252.778	17828	18,000	1443
	15°	272.61	16531	57,400	4602
optimal angle:	35.0°	286.98	15704		0
	45°	284.06	15865		0
	90°	205.17	21965		0
				Total kWh =	**1,619,310**
Additional Parking Garage Offset Needed, EUI of 1.7			Additional area	142,500	11427
			Additional kWh Produced		**2,888,494** 4,507,804

HOSPITAL
BOSTON mixed



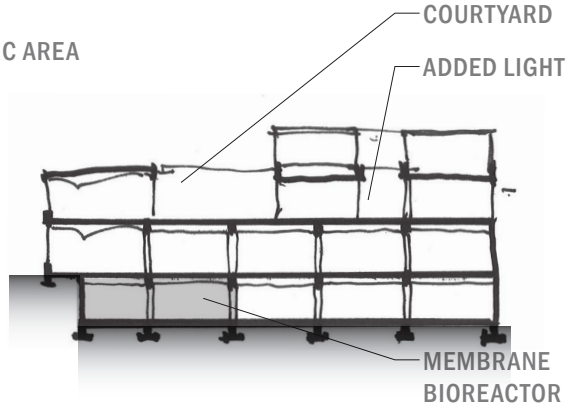
ENERGY USE INDEX

COST PREMIUM
PAYBACK
COST PER SF

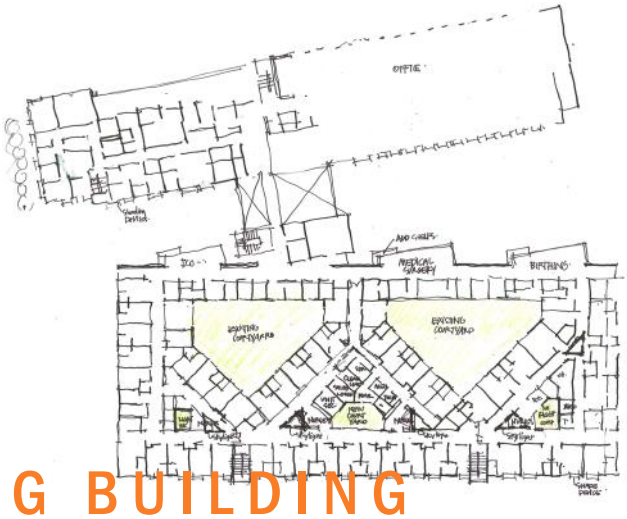
PHOTOVOLTAIC CAPACITY

WATER USE

70,000 gal	RAINWATER TANK SIZE
180,231 sf	BUILDING SIZE
4 floors	BUILDING HEIGHT
39.03 acres	SITE AREA
339,400 sf	PHOTOVOLTAIC AREA
84,900 sf	ROOF AREA



- ✓ Add new light courts at Nurse's station.
- ✓ Add skylights at corridors for increased daylighting.
- ✓ Minimize screen at mechanical area, due to fact that mechancial is reduced
- ✓ Add fins to provide shading on west side of classrooms.
- ✓ Add shading devices on South side of hospital, office, etc.



PLAN NTS

LIVING BUILDING
DESIGN MODIFICATION

BUILDING TYPE: **HOSPITAL**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 180,231
Living Building Gross SF = 180,231
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
CONSTRUCTION COST							
A	**Substructure**	**4.6%**	**0.2%**	**$2,895,319**	**$16.06**	**$3,028,712**	**$16.80**
	Baseline Building			$2,895,319	$16.06	$2,895,319	$16.06
W2	Rainwater Containment - 70,000 gal Rainwater Tank					$133,392	$0.74
B	**Shell**	**2.1%**	**0.5%**	**$14,789,139**	**$82.06**	**$15,102,359**	**$83.79**
	Baseline Building			$14,789,139	$82.06	$14,789,139	$82.06
L1B	Replace Roofing with Glazed Skylight					$15,000	$0.08
E1A	Improved Glazing (reduce solar heat gain at vision only)					$16,000	$0.09
E1B	Exterior Horizontal Shading Devices					$87,600	$0.49
L1D	Interior Light Shelf					$58,400	$0.32
E1B	Vertical Shading Fins (west end)					$26,900	$0.15
L1B	New Light Shafts to Nurse Stations					$387,000	$2.15
E2B	Infill Spandrel Panel with Framing and Insulation (replace glazed area)					$22,320	$0.12
D3	Reduce Mechanical Rooftop Screen					($300,000)	($1.66)
C	**Interiors**	**0.4%**	**0.1%**	**$9,710,678**	**$53.88**	**$9,746,724**	**$54.08**
	Baseline Building			$9,710,678	$53.88	$9,710,678	$53.88
M2A	Topping Slab / Stair Premium for Underfloor Radiant System (3" concrete)					$36,046	$0.20
L1A	Raise Ceilings (no cost impact)					$0	
D.1	**Services - Conveying Systems**	**0.0%**	**0.0%**	**$826,462**	**$4.59**	**$826,462**	**$4.59**
	Baseline Building			$826,462	$4.59	$826,462	$4.59
D.2	**Services - Plumbing Systems**	**7.5%**	**0.4%**	**$3,347,613**	**$18.57**	**$3,597,613**	**$19.96**
	Baseline Building			$3,347,613	$18.57	$3,347,613	$18.57
W6	Low-Flow Fixtures / Optical Sensors					$0	
W2	Rain Harvesting (piping & pumps and filtration)					$250,000	$1.39
D.3	**Services - HVAC Systems**	**34.5%**	**5.7%**	**$9,992,801**	**$55.44**	**$13,438,384**	**$74.56**
	Baseline Building			$9,992,801	$55.44	$9,992,801	$55.44
	Baseline HVAC System Reduction (2/3 reduction in Air Handler and Ducting)					($2,652,772)	($14.72)
M2A	In-Slab Radiant Heating and Cooling					$901,155	$5.00
M3A	Ground Source Heat Pump					$5,101,200	$28.30
M2B	Energy Recovery Wheel / Plate & Frame/Dedicated Outside Air System(DOAS)					$80,000	$0.44
M2C	Carbon Dioxide Sensors					$16,000	$0.09
D.4	**Services - Fire Protection Systems**	**0.0%**	**0.0%**	**$444,259**	**$2.46**	**$444,259**	**$2.46**
	Baseline Building			$444,259	$2.46	$444,259	$2.46
D.5	**Services - Electrical Systems**	**6.2%**	**0.8%**	**$8,085,831**	**$44.86**	**$8,589,931**	**$47.66**
	Baseline Building			$8,085,831	$44.86	$8,085,831	$44.86
PA	Occupancy Sensor to Outlets					$21,500	$0.12
PE	High Efficiency Transformers					$217,000	$1.20
LIC	Daylight Controls (continuous dimming 15' from perimeter)					$160,800	$0.89
L2E	Occupancy Sensor for Transient and Egress Lighting					$44,500	$0.25
L2G	Patient Bed light with separate switching for ambient / task					$18,800	$0.10
L2M	Dual level light at egress stairs - off when not occupied					$19,000	$0.11
L2N	Stairwell lighting on daylighting					$22,500	$0.12

BUILDING TYPE: **HOSPITAL**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 180,231
Living Building Gross SF = 180,231
Site Gross Acreage = 39.03

		Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
				Total	Cost/SF	Total	Cost/SF
E Equipment and Furnishings		**0.0%**	**0.0%**	**$2,050,942**	**$11.38**	**$2,050,942**	**$11.38**
Baseline Building				$2,050,942	$11.38	$2,050,942	$11.38
F Special Construction		**0.0%**	**0.0%**	**$0**	**$0.00**	**$0**	**$0.00**
Baseline Building				$0		$0	
G Sitework		**0.6%**	**0.1%**	**$7,730,038**	**$42.89**	**$7,780,038**	**$43.17**
Baseline Building				$7,730,038	$42.89	$7,730,038	$42.89
W4 Stormwater Retention / Building Water Discharge						$50,000	$0.28
W1 Remove Storm Drainage Connection to Public/Add sewer meter						$0	
H Logistics		**0.0%**	**0.0%**	**$920,558**	**$5.11**	**$920,558**	**$5.11**
Baseline Building				$920,558	$5.11	$920,558	$5.11
Living Building Prerequisites				**$7,510**	**$0.04**	**$1,289,480**	**$7.15**
PR5 - Materials Red List		**100.0%**	**0.9%**			$571,658	$3.17
PR7 - Responsible Industry		**100.0%**	**0.2%**			$108,128	$0.60
PR8 - Appropriate Materials / Services Radius		**100.0%**	**1.0%**			$602,185	$3.34
PR9 - Leadership in Construction Waste		**0.0%**	**0.0%**	$7,510	$0.04	$7,510	$0.04
Subtotal Direct Costs			9.9%	$60,801,148	$337.35	$66,815,461	$370.72
General Conditions	5.9%	**9.9%**	**0.6%**	$3,599,939	$19.97	$3,956,036	$21.95
Fee, Contingency, Insurance	6.7%	**9.9%**	**0.7%**	$4,309,196	$23.91	$4,735,452	$26.27
Location Modifier for BOSTON, MA	1.12	**9.9%**	**1.3%**	$8,245,234	$45.75	$9,060,834	$50.27
TOTAL MODIFIED CONSTRUCTION COST			**9.9%**	**$76,955,517**	**$426.98**	**$84,567,784**	**$469.22**

BUILDING TYPE: **HOSPITAL**
BUILDING LOCATION: **BOSTON, MA**

SKANSKA

Base Building Gross SF = 180,231
Living Building Gross SF = 180,231
Site Gross Acreage = 39.03

					Division Premium (%)	Building Premium (%)	LEED™ Gold Baseline		Living Building	
							Total	Cost/SF	Total	Cost/SF
OWNER & DESIGN-BUILD COSTS										
Design/Build Owner Items										
W3	Biological Bio-Reactor				100.0%	2.5%			$1,500,000	$8.32
PV1	Photovoltaic Panels and Infrastructure	5,579,000	Watts		100.0%	68.8%			$41,842,500	$232.16
LB Prerequisite Items										
	PR3 - Habitat Exchange	39.03	acres		100.0%	0.3%			$195,150	$1.08
	PR6 - Construction Carbon Footprint	5,400	tons		100.0%	0.1%			$59,400	$0.33
	PR15 - Beauty and Spirit (included in A/E fees below)				0.0%	0.0%			$0	
	PR16 - Inspiration and Education				100.0%	0.1%			$63,000	$0.35
Development Costs			LEED	LBC						
	Develoment Costs		28.00%	31.00%	21.7%	7.7%	$21,547,545	$119.56	$26,216,013	$145.46
	Architecture & Engineering		7.00%	9.00%	41.3%	3.7%	$5,386,886	$29.89	$7,611,101	$42.23
Credits / Rebates / Incentives										
	PV Credits-(state, city, utility)	50%			-100.0%	-34.4%	$0		($20,921,250)	($116.08)
	SDC Credits	50%			-100.0%	-2.3%	$0		($1,372,092)	($7.61)
TOTAL OWNER & DESIGN-BUILD COSTS						**104.9%**	**$26,934,431**	**$149.44**	**$55,193,821**	**$306.24**

TOTAL CONCEPTUAL COST: **$103,889,948** **$576.43** **$139,761,605** **$775.46**

LIVING BUILDING CONCEPTUAL PREMIUM RANGE: **32%** **TO** **37%**
HOSPITAL IN BOSTON, MA

Hospital
Boston

Normalized Baseline Energy Use Intensity (kBtu/SF) **245.3**

Normalized Baseline Energy Use (kWh) 12,940,958

Impact of Design Changes (see sketches) 1.00

Adjusted Baseline EUI (kBtu/SF) 245.3

		LIGHTING	HEATING	COOLING	DOM. HOT WATER	FANS & PUMPS	MISC. EQUIP	TOTAL BLDG
percent of load		12%	26%	15%	12%	15%	20%	100%
calc'd EUI		29.9	62.7	36.2	29.9	36.8	49.8	245.3
Energy Conservation Measures:								
Glazing	**E1**		*12.0%*	1.0%		2.7%		3.6%
Improved Glazing	E1a							
Add effective shading devices	E1b							
Walls & Roof	**E2**		*6.0%*	1.0%		1.5%		1.9%
Shaded roof from solar panels	E2a							
Optimize insulation to core performance guide	E2b							
Daylighting (incorporates tuned glazing/shading)	**L1**	13.3%	-1.0%	1.3%		0.2%		1.6%
Top daylighting with skylights	L1b							
Daylight controls (continuous dimming)	L1c							
Lighting	**L2**	31.1%	-2.3%	3.1%		0.5%		3.7%
Occupancy sensors: transient lighting (corridors/stairs/bathrms)	L2e							
Patient bedlight with separate switching for ambient / task	L2g							
Plug Loads	**P**						10.0%	2.0%
EnergyStar appliances	Pb							
Energy efficient main transformer	Pe							
Super-efficient elevators (hybrid)	Pk							
Aggressive heat recapture - all equipment water cooled	Pl							
Widen Set Point Temperatures	**M1**		2.0%	2.0%		1.0%		1.0%
Widen Set Point Temperatures (expand ASHRAE 55)	M1a							
Subtotal from above Load Reduction strategies (percentage)		*44.4%*	*16.7%*	*8.4%*	*0.0%*	*5.9%*	*10.0%*	*13.8%*
Subtotal Reduced EUI (kBTU/SF)		*16.6*	*52.2*	*33.1*	*29.9*	*34.6*	*44.9*	*211.4*
Mechanical - Distribution & Ventilation	**M2**		*20.0%*	11.0%		20.0%		8.6%
Radiant slab heating/cooling in lobby/atrium spaces	M2r							
Chilled beams	M2s							
Displacement ventilation in exam rooms	M2t							
Natural ventilation in stairwells	M2u							
Low pressure drop air filters	M2v							
OSA/Exhaust runaround heat recovery	M2w							
Cascading make-up air	M2x							
Subtotal from Mechanical Distribution strategies (percentage)		*0.0%*	*20.0%*	*11.0%*	*0.0%*	*20.0%*	*0.0%*	*8.6%*
Subtotal Reduced EUI (kBTU/SF)		*16.6*	*41.8*	*29.5*	*29.9*	*27.7*	*44.9*	*190.4*
Mechanical - Plant Systems	**M3**		20.0%	30.0%				7.0%
Ground source heat pump with central heat pump chiller	M3e							
Chiller heat recovery	M3f							
Domestic Hot Water	**W**				50.0%			6.1%
Low flow fixtures (showers, lavs, sinks)	Wb							
Water heating from water to water heat pump (gshp)	Wc							
Wastewater heat recovery	We							
Subtotal from Mechanical Plant and DHW systems (percentage)		*0.0%*	*20.0%*	*30.0%*	*50.0%*	*0.0%*	*0.0%*	*13.1%*
Reduced EUI from Energy Conservation Measures (kBTU/SF)		**16.6**	**33.4**	**20.6**	**15.0**	**27.7**	**44.9**	***158.2***
Final Energy Use Breakdown as Percentage of Baseline Use		**7%**	**14%**	**8%**	**6%**	**11%**	**18%**	**36%**

Building Operating Factor 0.90
Impact of Interactive ECM effects 1.05

Total Reduced EUI (kBTU/sf) 148.0

Total reduced energy use (kWh) 7,806,154

Number of crystaline panels needed 27,640
Total kW of PV array 5666

249.2 CBECS Baseline EUI (kBTU/sf)
60% target reduction from CBECS

Achievement: **TARGET REDUCTION NOT MET**
41% percent reduction from CBECS
40% percent reduction from Normalized Baseline Bldg

PV Panel Analysis:

From RETScreen 4-1: method 2, 2% misc losses, 90% inverter efficiency, assumes Sanyo-205 panel, facing South (azimuth 0°)

	angle	kWh per panel	Total panels needed at °	Input Area (SF)	# of Panels
	0°	252.778	30882	44,700	3584
	15°	272.61	28635		0
optimal angle:	35.0°	286.98	27202	300,000	24056
	45°	284.06	27481		0
	90°	205.17	38048		0
				Total kWh =	**7,809,547**

LIVING BUILDING STRATEGIES NARRATIVE

D Design - Massing & Orientation

E1 Envelope - Glazing & Shading

E2 Envelope - Walls & Roof

L1 Lighting - Daylighting

L2 Lighting - Power Density & Controls

M1 Mechanical - Widen Temperature Setpoints

M2 Mechanical - Distribution & Ventilation

M3 Mechanical - Plant Systems

M4 Mechanical – Schedule & Load Shifting

P Plug Loads

PV Photovoltaic

W Water

O Other

Design - Massing and Orientation

D1: Idealized Massing / floor plan: Several reference buildings did not meet the Civilized Environment prerequisite with work spaces located more than 30' from the exterior wall. Buildings which required redesign were a) elongated to make a long, thin building if site conditions allowed or b) reorganized to be donut shaped with an atrium in the center or c) light shafts were added to bring light and ventilation to areas for which it was functionally required. These changes generally resulted in a reconfiguration of the floor plate and thus added skin to the building.

D1A: Operable Windows: were assumed to be 8-10 sf awning vent panes. They are manually operated without actuators or position switches.

D2: Idealized Roof Shape and Orientation: To maximize solar potential and daylight aperature orientation the roof shape and orientation of several buildings was redesigned. This change resulted in the following:

D2A: Added Wall/Skin for Modified Design: represents the net change in the skin as needed to enclose the added square footage in the modified design. These costs include the entire skin assembly from interior finish to exterior finish and structure to match the original building.

D2B: Modifications of Roof Structure and Roofing: reflect the changes made to the structural system, size and details when changing from a flat roof to a sloped shed roof. The structural system was changed from a wide flange steel system to an open-web joist structural system at the roof. The overall size of the roof is increased as a result of both the angle and overhangs being introduced. Credits include removal of the parapet and associated sheetmetal flashings and caps.

D3: Floor plan Modifications for Daylighting: Several strategies were employed to improve the daylighting in buildings both to reduce energy usage of the lighting and to improve the access for all occupants to light and air. The daylighting rule of thumb "to achieve effective distribution of light from unilateral daylighting, room depth should not exceed about 2.5 H, where H is the window height." Buildings that did not meet this basic rule were modified first by raising the window height, reducing the depth of the room, or by increasing the floor to floor height.

D3A: Raise Floor to Floor Heights: This was done as a last resort only if the daylighting rule of thumb was not achievable by any other means.

D3B: Replace Roofing with Glazed Skylight: represents the net cost or credit calculated by deducting the existing roofing assembly costs from the skylight costs. Pricing was based on an aluminum, pre-engineered, single-pitch skylight unit in most cases. In some climates, a more expensive, sawtooth skylight was included

D3C: Reallocation of Glazing: was done to move glazed areas of the building skin from the East side of the building to the South side, increasing the solar impact and daylight harvesting. It was assumed in the default scenario that there is a net zero cost impact since the existing skins are only changing locations on the building. Costs and credits in this category represent a net change in glazing as modified in the Living Building design for energy performance and / or light penetration into the space.

D4: Floor Plan Renovation: segregation use as classroom/office to maximize reuse of energy. Floor plans were revised using Living Building prerequisites as an additional criteria for space programming to optimize energy use and daylighting opportunities.

Envelope - Glazing & Shading

E1A: Improved Glazing Costs: were developed by identifying the price difference between the glazing used in the actual project, and those identified in the Energy Matrix to achieve the performance levels required for that project. No credits were assigned if the target efficiency levels were below those actually installed in the base building. See appendix for target glazing valves.

E1B: Add Effective Shading Devices: Different types of shading devices were added in different areas depending on the orientation of the windows and the anticipated sun exposure.

Horizontal Exterior Shading Device: for this building type were extruded aluminum horizontal sun shades manufacturers. Where applicable, a credit was provided to remove existing shading devices on non-critical facades of the building. Where PV panels were identified as the shading surface for the sun shade, only the cost of structural outriggers to support the PV panels was included.

Vertical Exterior Shading Devices: were included in several different styles and configurations. Some of these vertical devices were wall hung elements that were to be installed adjacent to particular window openings. In other strategies, there are entire fin walls designed to run the full height of a curtainwall from the ground. An additional configuration included shading elements to be hung from an engineered curtainwall system.

Trees for Shading: were included in the modified design to provide natural shading. Trees were deciduous to allow for solar heating in the cooler seasons.

E1C: PV Shading (Glazing): See E1B above.

E1D: Reduce glazing to 30%: Where a building type exceeded the recommended glazing percentage for a specific climate, the building was redesigned to achieve a reduction in the glazing area. Typically, reduced glazing was accomplished by substituting glazed curtain wall for a framed, insulated, and clad section across the percentage indicated.

E1E: Reduce glazing to 40%: See E1D above.

Insert chart of ideal glazing

E1F: High Performance Residential Glazing: The following glazing types were incorporated into the residential projects to improve energy performance.

E1G: Insulated Panels for Glazing (Thermal Window Shades): Investigated, but not used.

Envelope - Walls and Roof

E2A: Shaded Roof from Solar Panels - No construction cost impact (solar panel cost considered elsewhere).

E2B: Optimize Insulation to Core Performance Guide - See insulation levels required for each climate zone

Portland	Walls: R-13 stud + R-7.5 ci Roof R-25
Phoenix	Walls: R-13 stud + R-5 ci Roof: R-20
Atlanta	Walls: R-13 stud + R-5 ci Roof: R-20
Boston	Walls: R-13 stud + R-10 ci Roof: R-35

E2C: PV Mount AboveRoof to Allow for Shading: See E2a above.

E2D: Change Skin to Highly Reflective Siding: included costs to remove the exterior skin cladding as originally designed and replace it with a regionally-appropriate built-up finish (light color).

E2E: Move Vapor Barrier to Outside of Building: represents the cost to clad the framing which was previously on the interior of the concrete/brick mass. The high-mass concrete/masonry wall was redesigned to the interior side of the wall to better transfer the stored heating/cooling into the space.

E2F: Advanced Framing: Investigated, but not used

E2G: Double envelope south face: Solar chimney was implemented in the Boston single-family residence.

E2H: Straw Based SIPS: Investigated, but not used

E2I: Optimize Insulation Residential: Regionally appropriate insulation methods were applied for the single family residences. Base building was designed with Insulated Concrete Forms (ICF).

E2J: Infill Spandrel Panel with Framing and Insulation: includes costs to frame, insulate and drywall finish selected areas on the interior where curtainwall was previously designed.

Lighting - Daylighting

L1A: Remove Ceiling, Raise Window Head, Relocate Shading Device:to act as light shelf No Construction cost impact Exposed Ceilings were represented by the credit for removing the suspended ceiling tile and grid, and adding the cost to paint the structure above with a matte finished light color.

L1B: Top Daylighting with Skylights: Occurs in some scenarios in conjunction with the addition of an atrium space.

L1C: Continuous Daylighting Controls: are provided through the use of sensors and dimming ballasts at light fixtures within 25' of the perimeter wall in an open office environment.

L1D: Add Light Shelf: Provide light shelf on interior of space with exterior component to also shade glass. Interior light shelves were added to the windows along the south side of the building to help reflect the incoming light deeper into the space. The product included in this cost is similar to the combination aluminum and polycarbonate lightshelves currently available from several manufacturers.

L1E: Heliostat (Tracking Mirror above Atrium): is a series of mirrors installed on the roof to allow natural light to be selectively introduced into the interior space depending on the desired light levels.

L1F: Glass Partitions: were added to the modified design as a replacement separation between public and private spaces. This was done to increase the light penetration from the central skylight above into adjacent interior spaces. Costs reflect the replacement of standard interior partition wall framing and finished gypsum board with a butt-glazed and caulked glass panel system captured at the head and sill by aluminum channel. Replaced sections vary in elevation based on the design criteria. This revision also includes costs to add deluge fire sprinklers at rated partitions.

L1G: Add Glazed Clerestory: A section of roof was reconfigured to allow for clerestory glazing to provide natural daylighting opportunities.

L1H: Relocate Clerestory Clerestories: were relocated to correspond to skin condition.

Lighting – Power Density & Controls

L2A: Efficient Fixture Optics: are incorporated in the design through the use of light fixtures with advanced optical performance. Fixtures similar to the Ledalite Vectra 4' fixture were used for cost estimating purposes.

L2B: Individual Occupancy Sensors and Dimming Controls: are provided in closed offices and and other low occupancy spaces such as conference rooms

L2C: Individual Light Level Control and Dimming: at "open" office areas are employed through the use of a fixture similar to the Ledalite Edapt 4' fixture and includes individual control at each workstation.

L2D: Light Colors on Walls and Ceiling Surfaces: provided by paint with a minimum light reflectance of 80% for walls and 90% for ceilings was assumed. No costs were added for this strategy.

L2E: Occupancy Sensors for transient lighting in corridors, stairs, and bathrooms: achieves energy savings during unoccupied time frames.

L2F: Dimmable Direct/Indirect fixtures: includes the premium cost to provide daylighting control with dimmable ballasts in classroom light fixtures within 15' of the exterior glazing, while providing local control of nearest lighting at teaching wall.

L2G: Patient Bedlight with Separate Switching for Ambient/Task: Use fixture that allows for increase lighting on demand for examination purposes, but provides reduced lighting for patient use.

L2I: Dual Day/Night Light Levels: in corridors are achieved through the use of occupancy sensors wired to a secondary ballast in the light fixtures, which turn a portion of the fixture off during periods of no traffic, and some fixtures completely off at this time.

L2K: Provide Hardwired Compact Fluorescent Fixtures: in all spaces in lieu of incandescent options for residential building occupancies where not required by code.

L2L: Motion Sensors for Exterior Lighting: are incorporated to reduce energy costs when exterior traffic is not occurring.

L2M: Egress Lighting on Occupancy Sensors: becomes a proactive measure to reduce energy costs during low peak occupancy hours.

L2N: Stairwell Lighting: on daylighting sensors are incorporated to reduce energy costs when stairs are located next to the exterior of the building or an atrium. The cost estimate includes the premium to provide sensors and dimming ballasts.

Mechanical – Widen Temperature Setpoints

M1A: Widen Set Point Temperatures (expanded ASHRAE 55): Widened acceptable temperature and humidity set points allows for reduced mechanical equipment sizing (central plant, as well as distribution system) This was applied for all building types and regions except for the majority of the hospital environment.

Mechanical – Plant Systems

M2A: Radiant heating/Cooling with Dedicated Outside Sir System (DOAS): An in-slab, radiant floor heating & cooling system will be provided. Displacement ventilation will be provided by a heat recovery air handler providing 100% outside air, tempered, and dehumidified where climate appropriate (assume air volume of 0.1-0.4 CFM/SF conditioned area, depending on the region). The air handler will have a changeover hydronic heating/ cooling coil, supply and exhaust fan with VFD, and MERV 13 filtration. Air will be distributed through a galvanized steel duct system, and delivered low in space (displacement ventilation), using low-velocity diffusers.

Topping Slab for Underfloor Radiant System: includes the cost to thicken the floor slab for installation of radiant floor tubing for use with the ground source heating and cooling strategy. The existing superstructure was assumed to be sufficient to support this added weight.

Eliminate Raised Access Floor: For some buildings the existing raised access floor system was removed. All work associated with the raised access floor was removed in favor of the radiant HVAC system. Floor to floor heights were not reduced based on corollary daylighting benefits. It was assumed that the revisions to any other systems (ie low-voltage) relocated from under the access floor were cost-neutral.

M2B: Energy Recovery Ventilation: The air handler (described in M2a) will be equipped with an energy recovery wheel section. Relief/exhaust air will be recovered as it runs through the heat exchanger to preheat and precool the incoming outside air. ERVs for residential will have changeover heating/cooling coils only where required by climate, and will be central (one central ERV serving multiple units) constant volume units.

M2C: Demand Based Ventilation Carbon: dioxide sensors will be used to vary outside air rates supplied by the displacement system.

M2D: Minimize Carpet (Insulates Against Radiant System): Carpet Reduction costs were calculated by crediting the cost of carpeting for all public spaces, and replacing that flooring covering with a concrete sealer/densifier similar to RetroPlate. The assumption was that a standard concrete dustproofing finish would not be acceptable for long-term maintenance. This strategy eliminates the attenuating factor the carpet has on the efficiency of the in-floor radiant heating and cooling system.

M2E: Operable Windows: were assumed to be 8-10 sf awning vent panes. They are manually operated without actuators or position switches. (already in D1A)

M2F: Fan assisted Natural Ventilation: Additional exhaust capacity (assume up to 0.4 CFM/SF) will be available to be activated manually when outside air conditions are suitable for natural ventilation and operable windows are open. The HVAC system will be disabled during this mode.

M2G: Night Flush No construction cost impact. Night flush to precool the space will be accomplished with the radiant and fan system.

M2H: High Mass Concrete Inside Insulation: is a strategy that moves concrete elements of the exterior wall to the interior of the face of the wall assembly providing better coupling for thermal transfer. Pricing for this strategy includes additional costs for a highly-reflective exterior cladding over the existing framing and insulation that would be moved to the exterior of the building. The concrete itself was already included in the baseline as a stem wall or shear wall element.

M2I: Chimney: (80sf per 1000 sf) A solar chimney was investigated but not utilized.

M2J: Eliminate Cooling: Mechanical cooling is not provided for the educational and single family residences. This was done to reduce the energy usage which drove the renewable system size. This helped reduce the overall building costs.

M2K: Displacement Ventilation Delivery for DOAS Air Supply: to be low in the space (near floor level, but not underfloor) using low-velocity diffusers.

M2L: Solarwall Mechanical Screen or Solar Duct (preheat air): - A solar wall screen was used at the elementary school to preheat the ventilation air in cold and mild climates.

M2M: Optimize Fan Systems (Fan Wall): Provide FanWall system for the hospital air handler (see FanWall by Huntair)

M2N: Radiant Ceiling Panels for Heating/Cooling: For existing buildings, one option, which was investigated but not used, is radiant ceiling panels for heating and cooling (assume radiant panel coverage is approximately 1/2 of total ceiling area).

M2O: Radiant Heating/Cooling: For existing building only (complex mixed use renovation); use topping slab to install radiant floor heating and cooling system, rebuild stairs

M2Z: Ceiling Fans that are "Casablanca" Style Fans, and Window Box Fans:that are installed through window openings are employed to reduce artificial air conditioning energy costs.

Mechanical– Plant Systems

M3A: Ground Source Heat Pump System: Provide distributed ground source water to water heat pump. Ground source system will be vertical closed loop field of ~200 feet deep boreholes each with Polyethylene pipe (two pipes per borehole connected by U-shape elbow at bottom), filled with bentonite grout surrounding piping. All vertical pipes connect to buried horizontal main that carries fluid to building heat pump.

M3B: Cascading Chilled Water System: Chilled water from ground source heat pump systems is routed first to the air handling unit chilled water coils for dehumidification of ventilation air (using the lowest chilled water temperature), and the warmer chilled water is then routed to radiant slabs/panels (higher chilled water temperature will increase the system efficiency and help to avoid condensation on radiant slab/panels)

M3C: Solar Thermal (Evacuated Tubes Heating System): Solar thermal heating water panels are used for a portion of the Heating and DHW Plant at the hospital due to the large demand for energy.

M3D: Absorption Chillers using Solar Thermal: An absorption chiller with solar thermal input was investigated but not utilized. The heat source for the absorption chiller is the hot water from the solar thermal panels.

M3E: Ground Source Heat Pump with Central Heat Pump Chiller: Closed loop vertical well system (as for M3a) but use single central heat pump chiller for heating and chilled water (instead of multiple distributed water to water heat pumps)

M3F: Chilled Heat Recovery: The heat pump chiller at the hospital is used to capture the waste heat during the cooling mode for domestic hot water.

Plug Loads

PA: Occupancy Sensor controlled plug loads: are incorporated through the use of portable power strips (with motion sensors) in work spaces where normal activity assumes movement in and out of the individual workspace.

PE: Energy Efficient Transformers: are included where their long term efficiency will provide lower energy costs and reasonable payback periods.

Photovoltaic

PV1: Photovoltaic (PV) Panels and Infrastructure: is the design-build cost for the photovoltaic array providing electricity to the building. The size of array was determined by the required load for the building as calculated in the Energy Strategies.

PV2: Added Structure for Roof Mounted PV Panels: (where required) represents the costs, beyond typical pedestal mounted installation, to secure PV panels to the adjacent structure.

PV3: Added Structure for Mounting PV Panels to Adjacent Parking Structure represents the costs to install the PV panels atop a structure that provides shading over the parking areas.

Water Strategies

W1: Remove Storm Drainage Connection to Public: was a credit provided since all storm water would be treated and handled on site. The credit is zero because this line item also includes the addition of a sewer meter for verification purposes. Credits for removing connections to domestic water, sanitary sewer and fire water were not taken with the assumption that the jurisdictions would require them for emergency situations.

W2: Rainwater Containment: costs were calculated based on an underground concrete containment box (6" thick walls) with fluid-applied waterproofing membrane on the interior sides and bottom of the structure. It was assumed that the slab-on-grade would constitute the lid once structurally engineered for the span. Where FRP containment was identified for smaller tanks, material and installation costs were obtained from local subcontractors.

W3: Biological Bioreactor: is the design-build cost for the system to treat all water prior to discharge on-site. This system also is used to treat greywater and blackwater for re-use for certain building types as indicated on the Rainwater Matrix.

W4: Membrane bioreactors proposed combine "active aeration" together with "passive contact." The primary treatment section of the bioreactor is composed of multiple rotating drums with large surface areas. The effluent is drawn inside the drums through holes on its periphery surface and passes over a series of internal surfaces. It is the combined effect of being mixed with air and passing over bacterial surfaces which allow for high capacity treatment with minimal power consumption and small size footprint. These bioreactors should be inspected weekly for proper operation and possible biomass growth. Monthly greasing of the main bearings and other main components is recommended. Each bioreactor will retain approximately three months of bio-sludge which must be removed. The resulting sludge can be further processed to produce dry solids which can be used for fertilizer.

W4: Stormwater Retention/Building Discharge: includes the costs associated with building a retention area with landscaped swales for the water to collect upon discharge from the building's treatment system. The system is sized to detain the water long enough for it to recharge into the site aquifer.

W5: Additional Area for Water Collection:

6' Roof Overhang and Structure for Water Collection: for projects where a small amount of additional area was needed to meet the water usage budget and 6' overhang was added to increase water collection surface. The overhang was designed to double as a shading device.

Rain Harvesting Canopy: for projects where additional area was needed to met the water usage budget retractable canopies where designed to capture water during storm events.

Water Collection on Vertical Surfaces / Top of Roof: represents the costs to install various areas of water collection around the perimeter of and atop the high-rise building type. Costs reflect structural outriggers and catchment surface for several tiers of horizontal collection around the perimeter, and operable surfaces attached to vertical structural elements to capture precipitation from cross-winds.

W6: Plumbing Fixtures: will be served with a greywater system for flush water which is supplied by way of a rain harvesting system (Roof Washer). All plumbing fixtures are low flow with optical sensors.

W7: Composting Toilets: were implemented on the single family residence building type.

Other

01: Wind Turbines: were removed from the base cost of the high rise building in all climates to reflect the LEED Gold building. They were then added back into the Portland and Boston designs for the Living Building.

PREREQUISITE SUMMARY

As the project commenced, the team analyzed each Living Building Challenge prerequisite in order to determine which ones would have cost implications for the study. This section of the report provides a brief summary of assumptions related to each prerequisite of the Version 1.2 Living Building Challenge.

1 – Appropriate Site Selection
All sites selected met this criteria, therefore no costs were associated with this prerequisite.

2 – Limits to Growth
All sites selected met this criteria, therefore no costs were associated with this prerequisite.

3 – Habitat Exchange
All projects accounted for this cost at the same rate, $5.00/acre/year. The cost was set based on a 100-year commitment to programs available through the Nature Conservancy's "Adopt an Acre®" program.

4 – Net Zero Energy
Costs for all proposed energy improvements were added to the base costs, with redundant systems replaced or eliminated in the Living Building redesigns subtracted from the base cost estimate. Other on-site energy systems such as bio-fuels, bio-gas, geothermal,or wind were not considered because of prohibitions outlined in the Living Building Challenge or due to resource limitations too complex to deal with in a comparative review.

The cost of photovoltaic's (PV) and installation was added to the Owner & Design Build Costs at a sliding scale rate as follows:

Systems < 10 kW =	$9.00 / Installed Watt
Systems > 10 kW but < 0.5 MW =	$8.50 / Installed Watt
Systems > 0.5 MW =	$7.50 / Installed Watt

Much of the work associated with this prerequisite was determining the energy conservation strategies each building type and climate city would employ, and the design changes necessary to achieve the estimated resultant energy savings. A target of 50%-65% better than the baseline building was established as a goal, with the hospital at the low end of the scale and the single family residence expected to achieve the greatest percentage energy savings. PV panels were added to supply the remaining energy first to the building roofs, with outriggers that double as sunshades on the south and west. If energy usage was still not accounted for, canopies over the parking lot or ground mounted PV- in the case of the hospital - was added. Lastly of the site did not have enough area, parking garage roofs were used for additional pv area - but only after the parking garage energy use was also accounted for in the net zero equation. See Description of Net Zero Energy strategies for additional information.

5 – Materials Redlist
For the purposes of the cost study, it was assumed that Redlist free products would be available for all products currently containing Redlist materials. (The purpose of this study was not to determine market availabilities). Specific materials addressed directly in the cost estimating include PVC waste and vent piping, PVC site electrical raceways and PVC roofing. An added cost of 1.5% 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 Redlist

6 – Construction Carbon Footprint
The project's construction carbon footprint was estimated using the Mithun2 calculator for each climate city and building type. $11/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.

7 – Responsible Industry
The costs to meet this prerequisite 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. This premium was proportionately higher in regions other than Portland due to the lack of availability of FCS certified wood. Where the costs for the wood are dependent on a yet unbuilt tenant improvement, an estimate was made of the cost of wood-related work and the same premiums were applied. The additional costs for this prerequisite were discounted by slightly more than half for projects achieving LEEDv2.2 credit MRc7 in recognition the fact that some of the costs already included in the baseline. A straight 50% factor was not used in order to account for the premiums for the temporary wood (e.g. concrete formwork) that none of the LEED baseline projects included. It should be noted that most of the building types larger other than the single family residence and multi-familly residential use very little wood, and so the effect of this prerequisite on overall pricing is somewhat minimal.

8 – Appropriate Materials/Service Radius
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. The premium was increased to 12% for Phoenix due to lack of secondary market cities within the innermost 250 mile radius. In contrast, Portland, Boston, and Altanta all have other substantual secondary markets within 250 miles of the base city.

9 – Construction Waste Management
All of the baseline projects in Portland achieved or are projected to achieve construction waste management levels equal to or in excess of those required by the Living Building Challenge. Due to the number of LEED projects receiving the exemplary performance credit for construction waste management, no cost increase was added for this prerequisite in Portland. However, in Atlanta and Phoenix a 15 % increase was added for that section of the project budget, and in Boston a 12.5% increase was anticipated to achieve the LEED Gold baseline. The single family residential percentages were increased, in all climates, to

account for its significantly smaller scale. For the renovation project, additional items to be diverted include existing light fixtures, mechanical equipment, etc., resulting in additional premiums of 10% for Portland, 15% for Phoenix and Atlanta and 12.5% for Boston for the mixed use renovation building type.

10 – Net Zero Water

Costs for all proposed features required to achieve Net Zero water were added to the base construction. Rainfall data available from NOAA records was used to determine the amount of rainwater available using five average years of data. Similar to the Net Zero Energy prerequisite, conservation strategies were applied first. The following water strategies were applied in the following order:

1) rainwater storage and treatment,
2) greywater reuse for non-potable uses,
3) blackwater reuse for non-potable uses and
4) blackwater reuse for potable use.

Tanks, treatment and pumps were assumed to be co-located in existing structures. See net zero water strategies description for additional information.

11 – Sustainable Water Discharge

The sustainable water discharge strategy was directly linked to the net zero Water strategy employed. In buildings where all rainwater was collected and membrane bioreactors were used, it was assumed that no additional storm water or building water was needed. In other projects, strategies included permeable asphalt, swales, dry wells or other storm water management techniques to manage the building water discharge.

12 – Civilized Environment

Several of the base projects required redesign so that every occupiable space is located within 30 feet of an operable window. For some buildings additional costs were also added to make the existing fixed windows operable.

13 – Healthy Air / Source Control

Costs for this prerequisite were assumed to have been met by all projects achieving the LEED Gold baseline level.

14 – Healthy Air / Ventilation

Costs for this prerequisite were assumed to have been met by all projects achieving the LEED Gold baseline level.

15 – Beauty and Spirit

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

16 – 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.