Performative Threshold

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Threshold – Environmentally Responsible Public Architecture

Provide Space
Manage System
Power Building
Planning Economy
Experience Efficiency
Sustainability Environmentally Responsive Architecture

Refuelling Department of Water & Power (1965)

Threshold: How to Create Environmentally Responsive Public Architecture?
Threshold – Environmentally Responsive Public Architecture

Request for Approval of Thesis Research
Project Book Presented to:

Elizabeth Marèn

and to the
Faculty of the Department of Architecture
College of Architecture and Construction Management

by

Jin Hyung Park

In partial fulfillment of the requirements for the Degree

Bachelor of Architecture

Kennesaw State University
Marietta, Georgia

Spring 2018
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Threshold is defined by Limen as transitional between two fixed states in cultural rites of passage or between two dissimilar spaces in architecture. The study of rites of passage provides an analogy from which principles can be drawn for the design of a transformative space. The experience of liminal space poses a discontinuity and leads the occupant to question their surroundings, thus leading to heightened awareness of the space as a transformative threshold between distinct spaces.

All buildings have in-between space, the quality of life is directly affected by these spaces. The way of using space cannot be changed as long as architectural space is designed by its form, materials, details, and joints therefore the threshold becomes the key elements that defines the architecture.

Facade is exterior of the threshold that protecting environment inside. However with today’s advanced technologies and materials, we can design performative facade system that can create different yet comfortable space for people inside. The threshold of inside and outside can be integrated through performative facade system that can create different yet comfortable space for people inside. The threshold of inside and outside can be integrated through performative facade system to control heating and cooling, energy generation or other sustainable system through understanding architecture and movement.

As architects explore sustainable design in architecture, performative facade system work efficiently in saving energy consumption. Therefore the research started with 3 different case study involve with performative facade, first one was active surface which is deployable structure base facade that change shapes to create comfort area for people with different experience to people by dynamic movement of its nature. Second version of research is responsive surface, it evolving measures actual environmental conditions to enable building to adapt their form, shape, color or character responsively. This responsive system creates aesthetic quality to building to changes the experience of architecture that static form cannot not give. Third version is environmentally adaptive, this system changes surface by environmental changes. Instinct change of surface or shell will manage building better to increase life-cycle of building by protecting the structure.

Exploring Threshold will be measured by 3 different key elements which include energy and emission, adaptation, and resilience. The performative design will reduce or possibly produce no carbon dioxide emissions in building operations and minimize embodied carbon for building materials and construction. Research and exploring performative facade will project and respond to climate changes, such as responsive to climate changes, heat effect, heat waves, and extreme weather conditions. These factors will be considered in project site and context.
1.2 BACKGROUND

Environmental issue have been one of the hot plates in all industries. More and more technologies and materials have been developed and invented in order to reduce carbon dioxide and other harmful waste to environment. Previous architecture didn’t have to put too much thought into these, because energy costs were cheap enough that they could control comfortable environment inside with mechanical systems. Time has changed, and sustainability is key word that needs to be knowledge in all industries for not only environment but also for human society as well. The project will be demonstration and educational project which can be reflect life around sustainable architecture.
1.3 OBJECT

Study and research different performative facade system and develop further to help both people and environment. The goal of this study is to develop functional shell design that can applied to static structure to become sustainable and comfortable building for environments for surroundings.

1.3.1 Reduce consumption by over 35%

1.3.2 Transparency and opening

1.3.3 Creating a performative façade system that enhances architectural space.
1.4 Thesis Statement

Exploring the threshold of inside and outside through performative façade system to improve sustainability.

Questions

Way that I’m approaching this questions is by using modern tools such as innovative adaptable materials, action in surface and responsiveness of the design.
2.0 ENVIRONMENTALLY RESPONSIBLE PUBLIC ARCHITECTURE

2.1 Edith Green Wendell Wyatt (EGWW)
by SERA Architects INC.

2.2 Wayne N. Aspinall Federal Building and U.S. Courthouse
by Westlake Reed Leskosky & The Beck Group

2.3 New Orleans BioInnovation Center
by Eskew+Dumez+Ripple

2.4 Collaborative Life Sciences Building for OHSU, PSU & OSU
by SERA Architects
2.1 Edith Green Wendell Wyatt (EGWW)  
by SERA Architects INC.

The Edith Green-Wendell Wyatt (EGWW) Federal Building Project modernized an existing 18-story, 512,474-square-foot office tower located in downtown Portland. Completed in 1974, the building’s MEP systems were worn out and outdated. The project goals included upgrading building systems, updating work environments and improving accessibility, while also meeting the energy and water conservation requirements of the Energy Independence & Security Act (EISA), complying with federal standards for blast resistance, and providing new code compliant egress stairs, entries and rest rooms. The project has transformed the building into a modern, healthy workplace for 16 federal agencies, and was completed within 39 months.

Originally planned as an occupied remodel, the project was restarted in 2009 by the American Recovery & Reinvestment Act (ARRA). At that time, cost benefit analyses demonstrated that a strategy of vacating the building during construction provided the best value to the GSA.

EGWW is a model project for GSA nationwide, both as a premier federal office space and as an energy efficient renovation project. This LEED Platinum certified project is projected to exceed the performance requirements of the ARRA and is on track to become one of the highest performance federal buildings in the GSA’s portfolio.
DESIGN & INNOVATION

GSA’s primary design goal was to transform the existing building from an aging, uncomfortable energy hog to one of the premiere deep green retrofit projects in the nation. Starting with a High Performance Green Building Workshop that identified a variety of potential strategies, the design team embarked on a significant effort to analyze which energy and IEQ measures delivered the best value. They modeled the spaces virtually in BIM and physically by testing in the lighting lab, in addition to using very intensive energy modeling techniques. After completing the analyses, the design team translated the data and constraints into a synthesized aesthetic expression, whose focus was to communicate sustainability on an emotional and physical level, both inside and out.

With “reeds” and sunshades tuned for each facade to reduce solar gain and maximize daylight, a rainwater-collecting roof canopy that also supports a 180-kW photovoltaic array, and tenant programming based on solar orientation, the EGWW project pushes the boundaries and incorporates a number of innovative strategies that together resulted in an optimized, sustainable high-rise.

In addition to the energy improvements, the design reveals the history of the building, exposing the artifacts of EGWW’s original builders. Concrete with honeycombs and steel with roller marks was juxtaposed against tightly aligned glass railings and perfectly smooth walls to highlight the differences between new and old.

REGINAL & COMMUNITY DESIGN

Early in the design process a decision was made to renovate the existing building instead of erecting a new building in the suburbs. This was arguably the greenest decision the project made, as the existing EGWW site is less than two blocks from Portland’s bus mall and is within walking distance to four Max lines, which combine to deliver a possible 283 rides per day. As a result of the renovation, 1,200 Federal workers are not reliant on automobiles for transportation.

The area surrounding EGWW is rich with services that also reduce workers’ need to drive for lunch or errands. With an existing underground parking garage, the team was able to evaluate transit needs and reduce the parking count from 192 to 183, which resulted in a ratio of 0.17 spaces per occupant, far lower than the .8 spaces allowed by the zoning code. The building has a Walkscore rating of 97, a Transit Score of 92, and a Bike Score of 94.

In addition, this building modernization sets a precedent for how a mid-century high rise can be adapted and reused to new functions and requirements that wouldn’t have been achievable in its original form.
BIOCLIMATE DESIGN

Key to the building’s energy-efficient design was transforming the existing, uninsulated facade into a high-performance curtain wall with elevation-specific shading devices. These include the “reeds” that stretch up the entire 18-story height of the northwest face and an integrated sunshade/light reflector on the southwest and southeast faces. These shading strategies are integral to the success of the project’s primary energy conservation measure (ECM): a hydronic radiant heating and cooling system.

To arrive at the optimum combination of shading and daylighting, a parametric analysis evaluated peak cooling loads for each orientation to confirm shading requirements. Three glazing percentages (40%, 50% and 57%) with and without shading were modeled for a typical space. After determining which façades needed shading (west, south and east) and which did not (north), the next step was to determine the percentage of time each façade would need to be shaded. The depth and spacing of the shading devices were varied by the designers to arrive at both the desired performance metrics and the building’s aesthetic expression. A large canopy on the top of the building, provides additional shading for the taller 18th floor, as well as supporting optimally angled photovoltaics and providing a water collection area.

LIGHT & AIR

Because of the importance daylighting plays in human health and comfort, the project optimized daylighting in the perimeter zone and utilized a task/ambient approach to lighting. This resulted in a 50-60% (predicted) reduction in lighting energy and provided occupants with valuable connections to the outdoors. In addition to reviewing the effect the percent glazing has on required shading, a separate analysis was performed to understand the amount of daylight that could be harvested for each proposed shading system.

This parametric analysis led to the following high performance design requirements:

• 40-42% vision glazing on the tower, maximizing glazing where shading minimizes solar gain
• Full height shading devices on the northwest façade to address the potential for extensive solar gain caused by the low angle sun
• A combination of vertical and horizontal shading on the southeast and southwest facades—to address solar orientation.
• A light shelf reflector below the window sill to maximize daylight penetration.

Additionally the building program was tuned to optimize performance with an ideal plan, optimized at 70% open offices/30% closed offices, provided for each agency. Agencies with greater requirements for enclosed space are located lower in the building where surrounding buildings provide additional shading benefit.

Metrics
Daylighting at levels that allow lights to be off during daylight hours:
51%
Views to the Outdoors:
96%
Within 15 feet of an operable window: 0%
**WATER CYCLE**

The project’s detailed water usage modeling predicts greater than 60% water savings will be achieved through a combined strategy of incorporating water conserving plumbing fixtures and a rainwater catchment and re-use system.

The EGWW water conservation strategy started with an analysis of the existing building’s historical water usage. This analysis showed that 87% of the building’s water usage is for domestic uses and 13% is used for irrigation of surrounding vegetation. Because of this large interior use, the primary strategy focused on rainwater re-use for non-potable flush fixtures. Landscape irrigation water usage is reduced by over 50% through the use of drought resistance landscaping and the incorporation of subsurface irrigation.

A 165,000 gallon storage tank, created by repurposing an old firearm target range in the basement, allows rainwater to be stored and re-used for toilet flushing, irrigation, and mechanical cooling tower makeup water. The tank also supports another project goal: mitigating the negative effects of urban runoff. In addition, the water collecting “canopy” supports a 180-kW solar array that provides 4% of the building’s total energy.

**Metrics**

- Percent reduction of regulated potable water: 61%
- Is potable water used for irrigation: Yes
- Percent of rainwater from maximum anticipated 24 hour, 2-year storm event that can be managed onsite: 90%

**ENERGY FLOW & ENERGY FUTURE**

EGWW is predicted to achieve a 60% reduction in energy use compared to the existing building, exceeding the EISA performance goals which are in alignment with the AIA’s 2030 Commitment. These savings result directly from an integrated design process that prioritized comfort for the occupants and energy performance. Exterior shading, tuned by facade orientation, provides solar control while enhancing daylighting, thereby minimizing cooling load (and peak electric load) and improving thermal comfort. These integrated strategies allowed the primary ECM, a radiant ceiling heating and cooling system, to be realized. The building also provides enhanced indoor air quality through use of a 100% dedicated outdoor air system, resulting in above-code ventilation with excellent filtration. In six months of occupancy, the team has incorporated a series of “aftercare” measures to monitor energy use and help building operators tune the building to achieve its goals.

Whole building energy modeling predicts the following energy metrics:

- Energy Use Intensity of 30-35 kBTU/SF/year (+/- 10%)
- 55% reduction in energy usage compared to the regional average office building using Energy Star Target Finder
- 39% energy cost savings and 46% energy use savings compared to ASHRAE 90.1-2007
- 4% renewable energy generated by an on-site 180-kW Photovoltaic system

**Metrics**

- Total pEUI: 30 kBTU/sf/yr
- Net pEUI: 29 kBTU/sf/yr
- Percent Reduction from National Median EUI for Building Type (predicted): 55%
- Lighting Power Density: 0.60 watts/sf
2.2 Wayne N. Aspinall Federal Building and U.S. Courthouse by Westlake Reed Leskosky & The Beck Group

The Aspinall U.S. Courthouse modernization/high-performing green building renovation preserves an anchor in Grand Junction, and converts the 1918 landmark into one of the most energy efficient, sustainable historic buildings in the country. Funded by the American Recovery and Reinvestment Act, the $15 million project aims to be GSA’s first net-zero energy facility on the National Register. The project has achieved LEED® Platinum certification, and scores in the top 2% of LEED-NC v2009 projects on the U.S. Green Building Council’s Green Building Information Gateway (GBIG).

The project exemplifies sustainable preservation. It includes the restoration of historic volumes and finishes within both public and work spaces. Innovative building systems are incorporated to allow the building’s prominent spaces to be preserved and showcased, while drastically reducing energy consumption. The modernization provides contemporary design that promotes public interaction. Exterior upgrades and roof replacement featuring Energy Star membrane and photovoltaic arrays are sensitively designed to be compatible with historic assets. New design elements compliment preserved historic features while remaining clearly distinguished from them.
DESIGN INNOVATION

The design-build approach is responsive to the federal government’s goal of building carbon-neutral buildings by 2030, and creates a “green proving ground” demonstrating how to make an existing historic building perform at net-zero energy, 15 years ahead of schedule.

The project transforms the 1918 structure into an innovative sustainable model. To meet its lofty goals, including energy independence and energy efficiency (50% more efficient than code), the design included: building physics analysis; a roof canopy-mounted 123 kW photovoltaic array (generating electricity on-site to power 15 average homes), the addition of spray foam and rigid insulation to building shell; storm windows with solar control film to reduce demand on HVAC; variable-refrigerant flow heating and cooling systems; 32-well passive geo-exchange system for heating and cooling; dedicated ventilation units; wireless controls and state-of-the-art fluorescent and LED lighting upgrades; and post occupancy monitoring of occupant comfort.

New mechanical, electrical and life safety systems are sensitively integrated to avoid disturbing the historic fabric. Due to the highly restricted site and historic significance of the building’s exterior, photovoltaic panels were placed atop a new, elevated “canopy” with very thin profile; set back as far as possible from the principal south façade, and carefully positioned relative to classical west and east façades.

BIOCLIMATE DESIGN

Grand Junction is located in ASHRAE Climate Zone 5B, which experiences a wide range of temperatures and low overall relative humidity throughout the year. Rainfall is typically under ten inches per year. Solar insulation for renewable energy generation is high. Internal energy demands are typical for a federal office building, with a mix of cooling load from occupants, lighting, and computers. External demands include heat transfer and solar gain through the building enclosure. The existing building consists of a high thermal mass construction, which was augmented with interior insulation systems to retain the benefits of thermal capacitance to increase the thermal stability of the internal environment, while allowing HVAC systems to react more quickly during morning warm-up and cool-down.

The design team maintained the historic appearance of existing fenestration systems, while reducing solar gain and thermal conductance using new internal storm windows with a high-performance spectrally selective film.

MATERIALS & CONSTRUCTION

The project reuses and restores available existing materials (historic doors, wood floors, plaster moldings, walls, ceilings). Materials and finishes have low VOC content. Minimal exposure to chemicals and particulates is achieved with separate copy rooms and custodial areas, walk off mats, and green housekeeping practices.

The project also participates in the U.S. General Services Administration’s Green Lease program, a pilot, leaseback credit program for tenant agencies that are able to hit specific energy targets for plug load energy consumption.

Hygrothermal analysis helped ensure that the addition of new wall insulation would not have an adverse impact on existing masonry. Thermographic imaging was also utilized prior to the renovation, to help shape an appropriate level of renovation.

Construction scheduling was dynamic, with a critical requirement to schedule and complete the project while the building remained occupied by all but one of the existing tenants. Using a building information model (BIM), the team developed the project to graphically communicate and document phasing and sequencing of temporary tenant moves and build-out, demolition, historic preservation, construction and final occupancy.

Metrics:
Construction waste management: 56% waste diverted from landfill
Recycled content: 17%
Regional materials: 12%
Building structural/enclosure reuse: 100%
LIGHT & AIR

Lighting is upgraded to efficient state-of-the-art fluorescent and LED technology with wireless controls and integrated with HVAC to achieve visually comfortable work environments. All perimeter zones include design features to allow for balance of energy efficiency and visual comfort. Daylight sensors automatically dim ambient lighting to maintain the targeted 30 foot-candles on horizontal surfaces. Roller shades are available for occupant use to further control daylight and solar gain to match task needs. Natural ventilation was evaluated during concept design, but was determined to conflict with the need for increased building security, as well as regulation of HVAC systems. A skylight was installed over the main IRS tenant space on the first floor, to allow deeper daylight penetration in the largest open office area in the building. On the second and third floor perimeter ceiling zones are kept free of building services to allow maximum daylight penetration. Building services are installed in soft zones immediately outboard of double-loaded corridors. A healthy environment is promoted through a green cleaning program. Ventilation of spaces is tracked through direct measurement at variable-air volume (VAV) box zones, the main dedicated ventilation air unit, and by monitoring carbon dioxide levels in occupied spaces.

Metrics
Daylighting at levels that allow lights to be off during daylight hours: 50%
Views to the Outdoors: 92%
Within 15 feet of an operable window: 0%

Water Cycle

The design team researched methods to retain existing fixtures with new flush valves, but determined that performance would be compromised. The final design consist of low-flow fixtures, including one-pint-flush (0.125 gpf) urinals, 1.28 gpf toilets, 0.5 gpm metered faucets, and a 1.5 gpm shower. These measures are estimated to provide a 40% reduction over a LEED for New Construction 2009 baseline. No permanent landscape irrigation systems are installed.

Metrics
Percent reduction of regulated potable water: 40%

Materials & Construction

The project reuses and restores available existing materials (historic doors, wood floors, plaster moldings, walls, ceilings). Materials and finishes have low VOC content. Minimal exposure to chemicals and particulates is achieved with separate copy rooms and custodial areas, walk off mats, and green housekeeping practices.

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2.3 New Orleans BioInnovation Center
by Eskew+Dumez+Ripple

This non-profit lab/office facility serves as an incubator for biotech startups; helping ideas conceived locally to become local jobs and industries. The New Orleans BioInnovation Center (NOBIC) is a four-story, 64,000-square-foot structure adjacent to New Orleans’s historic French Quarter, downtown university campuses, and the Treme neighborhood. Built on a brownfield site, this LEED-Gold research facility is designed as ‘urban acupuncture’, a modest project that helped trigger the revitalization of a neighborhood, generating over 200 jobs. The program includes a flexible 100-person conferencing center, breakout spaces, and a 2,000-square-foot café. The design reinterprets vernacular regional climate-responsive strategies—the slatted shutter, the landscaped courtyard water feature, the sheltered porch—to provide a facility that is both of its place and of its time.

Key challenges:
• Laboratory buildings are among the most intense users of energy of all building types driven by the intense conditioning of outdoor air used to ensure occupant safety—an extreme challenge in the hot and humid Gulf South. By empowering user choice over temperature and ventilation at a granular scale, NOBIC achieves a measured energy use 1/3 that of a typical lab.
• Accommodating a wide range of potential lab users while promoting informal interactions that drive creativity.
DESIGN INNOVATION

Building a laboratory building in post-Katrina New Orleans raises three challenges: how to create a low-energy lab in a hot humid climate, handle water wisely in ways that connect people to their environment, and provide a modern, sleek facility that allows entrepreneurship to flourish in a resilient new economy.

The client challenged the team to deliver a facility that was not just functional, but as beautiful and distinctive as the city around it. The site—a former brownfield wedged between the city’s most prominent boulevard and a low-income housing project—interprets the architectural traditions of the nearby French Quarter.

The flow of water through the site is handled as a design opportunity rather than a plumbing problem. A ‘working water feature’ captures rainwater and diffuses it to plants and soils on site, evoking the flow of water in the regional ecosystem. The water feature is also fed by the AC condensate (up to 20,000 gallons per week!), which provides all landscape irrigation on site.

The incubator program provides a place for local ideas to turn into local jobs. By complementing private labs with shared equipment and amenities, NOBIC gets the most function and inspiration out of the least material.

REGINAL COMMUNITY DESIGN

New Orleans has suffered from a decades-long population decrease as talent and jobs have gone elsewhere. In its first 3 years of operation, this facility has hosted over 40 startups generating over 200 jobs at all skill levels.

New Orleans holds an outsized place in the nation’s cultural imagination—steeped in history and built on improvisation. This project helps local innovators develop new businesses in a very New Orleans way—with a spatial organization that promotes chance meeting, social interaction, and improvisational collaboration, inviting busy people to linger centered on the porch or the garden. The informal ties between people are key to the city’s resilience.

While many ‘incubator’ facilities are located in suburban office parks, NOBIC is distinctly urban, with major streetcar and bus lines stopping at its front door, steps from collaborating institutions and, most importantly, right on major Mardi Gras parade routes. Onsite parking is limited to the minimum required by zoning, while adjacency to 5 public transit lines, onsite accommodations for electric vehicle charging, and preferences for high-efficiency vehicles within limited onsite parking complement these strategies for urbanity. With a WalkScore of 94 and nearby housing under redevelopment, a walkable all-income live/work environment is becoming a reality.

Metrics

Estimated percent of occupants using public transit, cycling or walking: 26%
BIOCLIMATE DESIGN

The New Orleans climate alternately delights and exasperates: mild winters, hot humid summers with little wind, abundant sunshine punctuated by periods of intense rainfall and the occasional hurricane. Less than 1% of the hours in a typical year fall in the range of temperature and humidity required by the NIH for biotechnology labs, and 68% of the hours are either too hot or too humid. The provision of high air-change rates and once-through ventilation air with tight temperature and humidity control dominates lab building energy use, dwarving skin loads.

The building form is configured to provide a protected courtyard following French Quarter precedents. The glazing choices allow a strong connection to the city and the landscaped courtyard while limiting solar gain. While the building as a whole has a window/wall ratio of 35%, glass is deployed to maximum effect on the primary street façade and lobby atrium with their social areas on each floor. Playfully deployed louvers allow the southwest-facing Canal Street façade to be 63% glass yet have the summer solar gain of a façade with only 20% glass, while the other zone of extensive glazing (the atrium) connects social spaces to the courtyard via a northeast exposure.

LIGHT & AIR

The standard lab unit provides both daylight and views, while also providing lower-light entry zone for locating light-sensitive equipment such as microscopes. All meeting and common areas have extensive views to the outdoors, as are the dedicated offices facing the primary boulevard.

The safety standards of some lab tenants require that air be flushed through labs at rates up to 10 air changes per hour, and lofted far away from the building. They also require controlled temperature and humidity levels for reproducible experiments, making operable windows for labs generally inappropriate. By using the conditioned return air from offices as a diluent for lab air supply, conditioned comfort can be provided to office areas at negligible energy cost. Adjacent sheltered balconies provide for connection to climate.

Each cellular lab is provided with independent control of airflow and temperature, allowing each researcher to choose the ventilation level appropriate to their kind of research, and schedule ventilation setbacks when labs are unoccupied. In addition, a ‘panic’ button is provided which takes room flush-out and fume hood exhaust rates to maximum. Careful design and modeling of the air distribution system allows lower air change rates to be employed without compromising safety.

Metrics
Daylighting at levels that allow lights to be off during daylight hours:
75%
Views to the Outdoors:
77%
Within 15 feet of an operable window:
0%
WATER CYCLE

Located in a city that owes its existence to a river and its near-destruction to flooding, it was essential that the design embrace the theme of living with water. All phases of the water cycle were treated as a design opportunity, from dealing with the moisture that hangs heavy in the air on a summer day, to the frequent, intense rains, to the flow of surface water and its re-percolation into the city’s heavy soils.

While most parts of the country deal with an inch or two of rain in a 24h period, the Gulf Coast frequently receives up to 6 inches in a day, sometimes up to 2 inches in a single hour. The project feeds all rainfall from the roof into a prominent water feature whose depth fluctuates with the rains, allowing for biofiltration through water plants, then overflowing into a vegetated swale, detention in the parking lot sub-base, and percolation back into the soils. Simulations project that stormwater will leave the site only once every 20 years. The water feature is also fed by the AC condensate, which provides all landscape irrigation (the only use currently allowed for captured water by state regulation).

Metrics
Percent reduction of regulated potable water: 40%
Is potable water used for irrigation: No
Percent of rainwater from maximum anticipated 24 hour, 2-year storm event that can be managed onsite: 100%

ENERGY FLOWS & ENERGY FUTURE

This project uses less energy per square foot than 89% of the buildings in the Labs21 benchmarking database of over 400 lab/office buildings nationally. 67% below the median EUI (343kBtu/sf/yr). The actual utility bills for the initial 12 month period (119kBtu/sf/yr) closely track that projected by computer simulation (119kBtu/sf/yr). This savings of 224kBtu/sf/yr is like making a net-zero building of almost any other building type.

This level of verified performance has been achieved through a combination of an efficient building skin employing strategically deployed glazing with solar controls, highly targeted controls of airflow, temperature, and lighting for virtually every space, and an efficient central plant. It is reinforced at the operations level by fine-grained energy and comfort monitoring. Each ~1000sf lab + support area unit is individually metered, enabling the building owner to track and compare lighting and plug load consumption, identifying best-practice high performers. 73% of site energy use is electricity, with purchase agreements in place for carbon-neutral sources, and the roof has been made solar-ready with attachment footings and conduit in place for future PV.

Metrics
Total pEUI: 119 kBtu/sf/yr
Net pEUI: 119 kBtu/sf/yr
Percent Reduction from National Median EUI for Building Type (predicted): 67%
Lighting Power Density: 1.16 watts/sf
2.4 Collaborative Life Sciences Building for OHSU, PSU & OSU
by SERA Architects

Oregon Health & Science University, Portland State University, and Oregon State University partnered to create the Collaborative Life Sciences Building (CLSB), a new allied health, academic and research building. CLSB provides academic classrooms, lecture halls, teaching laboratories, clinical skills and simulation laboratories, medical research laboratories, retail space, and two levels of underground parking. Also part of the project is OHSU’s Skourtes Tower, which houses the School of Dentistry. Together, they comprise 650,000 gross square feet of new construction in two wings – one 5-story and one 12-story – joined by a central atrium.

CLSB is the first building in OHSU’s new Schnitzer Campus at Portland’s South Waterfront. Located on a brownfield site constrained by adjacent roadway and bridge construction, the building is conceived as an innovative model of interdisciplinary health sciences education, research, and education. Interior glazed walls foster “research and teaching on display,” allowing occupants and pedestrians to view the activity in labs and classrooms. The atrium offers dynamic connections between program elements through connecting bridges and informal study areas for students. This complex project was delivered via Construction Manager at Risk delivery method in just 37 months through the use of an IPD-like team effort.

DESIGN & INNOVATION

Early in the design process a decision was made to join the resources of three major universities to create a single building. Since each institution’s individually proposed spaces would not have been continuously occupied, the decision to share a single facility – versus each university creating its own – was arguably the greenest decision the project made. Today, the large 200 and 400-seat lecture halls are routinely scheduled for use from 7 a.m. to well into the evening; expensive laboratory teaching equipment gets triple use; and students have access to a single shared learning resource center.

As one of only two projects in the U.S. over a half-million square feet that has been certified Platinum under the LEED NC v2009 rating system, CLSB incorporates a number of sustainable design innovations. They include: transformation of an existing brownfield, light-pollution reduction, storm-water management, eco-roofs to reduce storm-water runoff, non-potable water for toilet flushing, atrium heat recovery, and low ventilation fume hoods. Innovative material re-use included salvaging oil drilling pipes for use as foundation piles, and re-purposing existing site fencing. And by incorporating energy efficiency measures throughout, CLSB is predicted to save 45% more energy than a typical code building would.
REGINAL & COMMUNITY DESIGN

Having three institutions collaborate to deliver a single building helped to greatly increase efficiencies and reduce the environmental impacts inherent in new construction. CLSB’s connection to public transit and a web of bike and pedestrian trails significantly reduces parking demands and contributes positively to improved air quality.

Located halfway between both OHSU’s and PSU’s main campuses, this new campus is designed to be highly transit-oriented. The site is currently well-served by a streetcar line, bus lines, bike paths, a pedestrian path and the nearby aerial tram linking it to OHSU’s main campus. There are five transit stops within a quarter mile radius of campus, with two located immediately adjacent to building entrances. Beginning in the fall of 2015, the site will become a hub for light rail users when the city’s newest bridge and light rail line open service across the Willamette River – instantly linking CLSB to Portland’s east side.

Recognizing the building’s prominent location on a major bikeway, the building also provides bike locker rooms, showers, and 400 bike parking spaces – well beyond code minimum. It has a Bike Score of 91, a Transit Score of 78 and a Walk Score rating of 50.

Metrics

Estimated percent of occupants using public transit, cycling or walking: 67%

BIOCLIMATE DESIGN

Although the zoning envelope dictated the building’s basic form – two towers joined by a central lecture-hall block – an analysis of solar resources, shading and wind patterns was performed to understand the micro-climatic influences and evaluate the opportunities and challenges they present. For example, surrounding the relatively opaque central classroom block with a top-lit atrium allowed the classrooms to receive filtered daylighting instead of glare from direct sun. Creating thin tower masses and offsetting them maximized the daylight penetrating into the laboratories, dental operatories, offices and classrooms, while still allowing the central atrium to have an unobstructed view of the southern sky and direct access to reflected light.

Because CLSB is primarily an internally loaded building, the facade design focused on providing shading from solar gain. To understand the solar impacts, the team did detailed studies of multiple facade schemes. Each option was explored using shoe box modeling to determine the scheme’s likely energy performance and its impact on shading, access to views, potential for cross ventilation, and solar access. Ultimately, the team employed an innovative solution – a perforated metal sun screen attached directly to the window mullions – that minimizes the negative impacts, while keeping glazing desired for view and light.
LIGHT & AIR

The massing of CLSB’s towers was studied in relationship to the natural forces of sun, wind and light. Creating thin masses and offsetting them allowed us to maximize daylight penetrating into the laboratories, dental operators, offices and classrooms, while still allowing the central atrium to have an unobstructed view of the southern sky and direct access to reflected light. Ceilings in the research labs were sloped in a butterfly configuration to further facilitate daylight penetration and reflection.

In addition to providing daylight and connecting the outdoors to the large lecture rooms, the atrium also serves as a collector of hot air as it rises in the space. By locating the mechanical floor level to the top of the atrium, heat recovery is easy and efficient. The atrium is also home to an amazing art piece, made of a series of LEDs of varying color temperature arranged in a sunburst pattern. Since daylight is so important to circadian health, it is very appropriate that this piece was selected for the main atrium space.

Attention to indoor air quality is demonstrated through increased ventilation, pollutant source control, and use of low-emitting materials.

Metrics
Daylighting at levels that allow lights to be off during daylight hours:
55%
Views to the Outdoors:
80%
Within 15 feet of an operable window:
0%

WATER CYCLE

Greater than 60% water savings is anticipated through a dual strategy of incorporating water-conserving plumbing fixtures with a rainwater reuse system. Low-flow fixtures and fittings are used throughout the building and result in a 35% water savings over a Code baseline building. By also incorporating a rainwater harvesting strategy, in the form of a 44,505-gallon underground tank, CLSB is able to capture 700,000 gallons of rain annually, which is reused to flush toilets in the north tower and central atrium. The south tower, which is primarily used for medical simulation, had water quality restrictions and was instead developed to ensure the minimization of storm water runoff via a green roof. This innovation minimizes the need to transport storm-water to wastewater treatment plants, saving off-site pumping energy.

The landscape was also designed with water conservation in mind, 16,500 square feet of the 27,000 square-foot landscape area is planted with non-irrigated native and adaptive species, which save water and provide habitat for local species. The remaining landscape incorporates minimal drip style irrigation.

Ultimately, the building is expected to save more than 1.5 million gallons of water annually – enough water to fill 17 Olympic-sized swimming pools.

Metrics
Percent reduction of regulated potable water:
62%
Is potable water used for irrigation:
Yes
Percent of rainwater from maximum anticipated 24 hour, 2-year storm event that can be managed onsite:
37%
CLSB is estimated to achieve a 45% energy use reduction compared to the LEED baseline. A number of design elements contribute to these savings, including high-performance lighting, daylighting and occupancy controls, low ventilation fume hoods, and an improved building envelope. The envelope boasts above-code insulation, high performance windows, a whole building air barrier and exterior shading strategies.

The building’s enhanced mechanical systems also play a big role in energy savings. This system focuses on high indoor air quality and energy efficiency with an air recovery system in the atrium that captures heat and reuses it elsewhere in the building.

Much of the energy savings are a result of technologies that allow the building to be tuned based on actual use. One example is demand control ventilation sensors in the large lecture halls that automatically adjust fresh air levels based on room population. Another is low-ventilation fume hoods that automatically reduce fan speeds when the hoods are closed. Daylight and occupancy sensors on select luminaries provides an estimated 30% energy savings as does the incorporation of a task ambient lighting strategy in the research labs. CLSB received over $1,000,000 in incentive dollars, helping to offset first costs of the energy efficiency measures.

**Metrics**

<table>
<thead>
<tr>
<th>Total pEUI:</th>
<th>110 kBtu/sf/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net pEUI:</td>
<td>110 kBtu/sf/yr</td>
</tr>
</tbody>
</table>

Percent Reduction from National Median EUI for Building Type (predicted):

45%

Lighting Power Density:

0.60 watts/sf

**MATERIALS & CONSTRUCTION**

As part of our design strategy, the team selected materials that are low-maintenance, durable, and low in VOCs. In many cases, the team was also able to choose products containing a high-recycled content, and products sourced regionally.

Helping reduce its environmental impact, CLSB’s use of recycled building materials topped an impressive 30%, based on cost. Additionally, building materials sourced regionally — within 500 miles of the site — accounted for 22% of all products in Divisions 3 to 12. These choices minimized the impacts of extracting and processing virgin materials, and helped reduce emissions associated with lengthy transportation.

During construction, the project diverted 85% of its construction waste away from landfills. That’s more than 1,000 tons of material recycled or reused instead of being landfilled. Not included in this waste diversion percentage is the reuse of old drilling rigs used as pipe piles in the foundation, which saved $3.3 million dollars in construction cost and prevented an additional 1,470 tons fr
3.0 PERFORMATIVE FACADE
3.1 THRESHOLD

Threshold is defined by Limen as transitional between two fixed states in cultural rites of passage or between two dissimilar spaces in architecture. The study of rites of passage provides an analogy from which principles can be drawn for the design of a transformative space. The experience of liminal space poses a discontinuity and leads the occupant to question their surroundings, thus leading to heightened awareness of the space as a transformative threshold between distinct spaces.

“The floor or ground at the bottom of doorway, considered as the entrance to a building or room”
< Oxford Advanced Learner’s Dictionary >
3.2 THE PERFORMANCE

PRINCIPLE OF FACADE PERFORMANCE

The performative facade should be simple and elegant, mix use of elements its and its movements should create space that is different from static buildings. The movement and its outcome should carry functional and aesthetic quality without and harm to people.

BALANCE

Balance is one of the most important key in Performative Facade because the movement should not stress the structure load, therefore performative facade should designed and calculated carefully.

TIME

The movement of surface should only performed when it is necessary, the movement should work to prove functional aspect for people around it.

RESPONSIVE

Performative Facade should response to people and environment to provide better comfort level for both. Minimal impact on environment while providing comfort level and different experience to people are key to responsiveness.
4.0 TYPES OF HIGH PERFORMANCE FACADE

CASE STUDY 1
ACTIVE SURFACE

A deployable structure is a structure that can change shape so as to significantly change its size. Examples of deployable structures are umbrellas, some tensegrity structures, bistable structures, some Origami shapes.

CASE STUDY 2
RESPONSIVE SURFACE

Responsive architecture is an evolving field of architectural practice and research. Responsive architectures are those that measure actual environmental conditions (via sensors) to enable buildings to adapt their form, shape, color or character responsively.

CASE STUDY 3
ENVIRONMENTALLY ADAPTIVE

Environmentally adaptive system is change of surface by environmental change. Most of times, these adaptive system works automatically and help to increase life-cycle of building by protecting the structure and inside.
4.1 ACTIVE SURFACE
A deployable structure is a structure that can change shape so as to significantly change its size. Examples of deployable structures are umbrellas, some tensegrity structures, bistable structures, some Origami shapes and scissor-like structures.

4.1.1. Al Bahr Towers
by Aedas Architects, Abu Dhabi, United Arab Emirates

This dynamic shading system reduce the building’s solar gain by 50% the towers manages to test the limits of responsive design.

4.1.2 Kiefer Technic Showroom
by Ernst Giselbrecht + Partner, Steiermark, Austria

Ernst Giselbrecht + Partner designed the Kiefer Technic Showroom as an office building and exhibition space.
4.1.1. Al Bahr Towers  
by Aedas Architects, Abu Dhabi, United Arab Emirates

This dynamic shading system reduce the building’s solar gain by 50% the towers manages to test the limits of responsive design. The element design was inspired and designed based on idea of traditional Islamic lattice shading system which is called Machrabiya. This shading elements are adjusted based on weather condition, and all of these devices are controled completely by computer.
**Al Bahar Tower**

A quick glimpse at the upcoming weather for Abu Dhabi will show a week of intense sunshine, temperatures steadily above 100 degrees Fahrenheit with 0% chance of rain. In such extreme weather conditions, even architects listing environmental design as their top priority are up against a tough battle. Never mind that the sand can compromise the structural integrity of the building, the intense heat and glare can render a comfortable indoor environment relatively impossible if not properly addressed. For Abu Dhabi’s newest pair of towers, Aedas Architects have designed a responsive facade which takes cultural cues from the “mashrabiya”, a traditional Islamic lattice shading device.

More about the towers’ shading system after the break.

Completed in June 2012, the 145 meter towers’ Mashrabiya shading system was developed by the computational design team at Aedas. Using a parametric description for the geometry of the actuated facade panels, the team was able to simulate their operation in response to sun exposure and changing incidence angles during the different days of the year.
4.1.2 Kiefer Technic Showroom
by Ernst Giselbrecht + Partner, Steiermark, Austria

Ernst Giselbrecht + Partner designed the Kiefer Technic Showroom as an office building and exhibition space with a façade that optimizes the building’s internal climate. The envelope is made from several layers — aluminum posts and transoms encased with an EIFS-façade in white plaster. Perforated aluminum panels are electronically operated and transform the building appearance from a solid monolithic volume to a playful combination of transparent and closed surfaces.
The open and closure of panels will control the light but when it is fully opened it also received light indirectly to prevent from heat gain. Also in night time it can reflect or control light to create different shape and experience for people around.
4.2 RESPONSIVE SURFACE

Responsive architecture is an evolving field of architectural practice and research. Responsive architectures are those that measure actual environmental conditions (via sensors) to enable buildings to adapt their form, shape, color or character responsively (via actuators).

4.2.1. MegaFaces by Asif Kahn, Sochi, Russia

Everybody remembers the huge kinetic façade built for the Sochi Winter Olympics. Architect Asif Khan created Mega-faces by placing 11,000 actuators underneath the building’s stretchy skin, creating a structure that can transform in three dimensions and form the faces of visitors.

4.2.2 Brisbane Domestic Terminal Car Park by Ned Kahn and Urban Art Projects, Brisbane, Australia

Artist Ned Kahn teamed up with Urban Art Projects (UAP) and designed a kinetic, wind-powered façade for a short-term car park at the Brisbane Airport.
4.2.1. MegaFaces by Asif Kahn

Architect Asif Khan, Sochi, Russia

Named Mega-faces and dubbed the “Mount Rushmore of the digital age”, Asif Khan’s facade is designed to function like a huge pin screen where narrow tubes move in and out, transforming a flat facade into an interactive three-dimensional surface capable of morphing into the shape of any face.

The facade will display up to three eight-metre-high faces at a time for a period of 20 seconds each, and anyone visiting the games will be able to participate by visiting a 3D photo booth and having their face digitally scanned. Five photographs will be taken of each participant’s face from different angles, before being assembled into a single 3D image.
After a scan has been made, the 3D image will be fed through to an engine and cable system attached to over 10,000 narrow cylinders, called actuators, that can extend out to lengths of up to two meters to recreate the shape of the face.

Each actuator will have an RGB-LED light at its tip, making it possible to precisely calculate the position of every pixel. A fabric membrane is to be stretched over the facade to give a smooth surface to the changing forms, and the actuators beneath will be laid out on a trigonal grid to disguise junctions between pixels.

“In the area of three-dimensional modeling of organic forms a trigonal structure is more suitable, because it makes three-dimensional forms appear natural and flowing even with only a small amount of pixels,” said Valentin Spiess, the chief engineer on the project.

The system will take approximately one minute to calculate a three-dimensional model from the five individual pictures taken.
4.2.2 Brisbane Domestic Terminal Car Park
by Ned Kahn and Urban Art Projects, Brisbane, Australia

Artist Ned Kahn teamed up with Urban Art Projects (UAP) and designed a kinetic, wind-powered façade for a short-term car park at the Brisbane Airport. No less than 250,000 aluminum plates were installed over a substructure, providing a kinetic shading system for the interior. The 53,000-square-foot surface moves with passing wind and creates ever-changing patterns that resemble the rippling of a disturbed water surface.
Pieces of aluminum panels move by the wind which creates fluid movement and gives live like experience to people outside the building. The light weight of material made it possible to create fluid facade system.
4.3 ENVIRONMENTALLY ADAPTIVE

is a system which changes its structure, behaviour or resources according to demand. The adaptation made is usually [always?] to non-functional characteristics rather than functional ones.

4.3.1 THE HYGROSkin-METEOROSENSITIVE PAVILION

Designed by Achim Menges Architect, Oliver David Krieg and Steffen Reichert

The HygroSkin-Meteorosensitive Pavilion is no ordinary box. Designed by Achim Menges Architects, Oliver David Krieg and Steffen Reichert

4.3.2 HOMEOSTATIC FACADE SYSTEM

A self-regulating façade system designed by architects in the USA automatically adjusts to suit changing exterior environments, such as sunlight and temperature variations.
4.3.1 THE HYGROSIN-METEOROSENSITIVE PAVILION
Designed by Achim Menges Architect, Oliver David Krieg and Steffen Reichert

The HygroSkin-Meteorosensitive Pavilion is no ordinary box. Designed by Achim Menges Architects, Oliver David Krieg and Steffen Reichert, the pavilion changes in response to prevailing weather conditions without any kind of mechanical or electronic controls. The flower-like modules on each surface open and close on their own, blooming and transforming in tandem with changing light and humidity conditions.

Hygroscopy

Hydroscopy is phenomenon of attracting and holding water molecules from surround environment. This can be achieved by either absorption or adsorption with a the substance become physically changed. This could increase volume, boiling point, viscosity, or other physical characteristic or properties of substance.
The pavilion was constructed as a box with varying curved surfaces made from thin modular plywood sheets. Combining high tech properties with mundane materials such as plywood, the designers embedded clusters of the blooming apertures that – through metereosensitive receptors – open and close with the changing humidity. Each of the apertures sense humidity changes from 30 to 90 percent and adjust themselves accordingly. Because the apertures move due to hygroscopicity, or their ability to take in and release moisture from the atmosphere, the opening and closing occurs without consuming any energy.

When the atmosphere reaches 30 percent humidity, or a classic dry and sunny day, the cone shaped apertures remain closed, keeping the interior cool while permitting light to permeate the thin plywood. As humidity increases, the cone’s petals open, becoming fully open at 75 percent humidity. During a rainy, overcast day, the apertures are fully open, allowing a lot of light to illuminate the interior.

The incredible humidity-responsive wooden material can be designed to operate in different shapes, and the design team plans to further explore the options of climate responsive materials in architecture.
4.3.2 HOMEOSTATIC FACADE SYSTEM

A self-regulating façade system designed by architects in the USA automatically adjusts to suit changing exterior environments, such as sunlight and temperature variations. The Homeostatic Façade System by Decker Yeadon operates on natural principles to keep interior conditions in check.

Homeostatic can be defined as the stable condition of an organism and of its internal environment.
The system comprises an engineered ribbon, inside the cavity of a double-skin glass façade. The ribbon is made of dielectric elastomers: polymer materials that can be polarized by applying an electrical current. These materials are also flexible and consume very little power.

Both sides of the dielectric material are coated with silver electrodes. This silver layer reflects light, and also distributes electrical charge across the material, causing it to deform. This helps the façade to regulate temperature inside the building.

As environmental conditions change, the charge in the silver layer causes motion using a sensitive actuator. An artificial muscle is created by wrapping the dielectric material over a flexible polymer core. Increased charge causes the elastomer to expand, making the core bend and pulling the elastomer material to one side. This in turn causes the paired halves of the ribbon to bend. The effect is that the façade closes up, with the opaque construction blocking out light.

Decker Yeadon is an architecture office based in New York that specialises in incorporating new material technologies in their design to help address contemporary issues. In particular, the architects show that smart materials and nanotechnology can offer solutions to a range of problems, from water conservation to security.
10 SUSTAINABILITY MEASURES
**Measure 1: DESIGN FOR INTEGRATION**

Sustainable design is an inherent aspect of design excellence. Projects should express sustainable design concepts and intentions, and take advantage of innovative programming opportunities.

**Narrative:** Describe how sustainability strategies are incorporated into the overall design. What are the major environmental issues and goals? How does the building respond to the local climate, site and occupant comfort?

May include:
- Key environmental issues; how and why they became important priorities
- Key ecological goals and concepts for your project and how they were expressed in the design
- How sustainability measures led to a better overall project design
- Process of program analysis; resource efficiencies realized by innovative programming
- Efforts to “right size” the project and to reduce unnecessary square footage
- Project response to local climate, sun path, prevailing breezes, soil, hydrology, and seasonal and daily cycles through passive design strategies
- Description of internal versus external building loads with regard to building massing, orientation, and fenestration/shading related to the sun’s path and prevailing winds
- Design strategies that reduce/eliminate the need for non-renewable energy resources
- How these strategies specifically shaped the plan, section, and massing

**Suggested Graphics:** Building section, or other appropriate diagram that demonstrates bioclimatic strategies and concepts. A profile of local climate that illustrates appropriate design strategies, or summary sustainability diagram (for building operations)

**Metric:** Percent of the year that occupants will be comfortable using passive systems.

**Measure 2: DESIGN FOR COMMUNITY**

Sustainable design values the unique cultural and natural character of a given region.

**Narrative:** How does the design respond to the region where it’s located? How does the design promote regional and community connectivity? What steps are taken to encourage alternative transportation?

May include:
- How the design relates to the local context and to larger regional issues
- How the design promotes regional and community connectivity
- How the design promotes a sense of place, public space and community interaction
- How the design educates its users about the environmental strategies it employs
- Efforts to provide for those using transportation alternatives
- Site selection criteria to reduce automobile use and parking requirements.

**Graphic:** Open

**Metric:** Walk score: (from Walkscore.com) and/or urban networks diagram (walk, transport, etc.)

**Measure 3: DESIGN FOR ECOLOGY**

Sustainable design protects and benefits ecosystems, watersheds, and wildlife habitat in the presence of human development.

**Narrative:** How does the development of the site respond to its ecological context? Consider water, air, plants, and animals at different scales.

May include:
- How the development of the site and program responds to its ecological context, including the watershed, air, and water quality at different scales from local to regional level
- How the design accommodates wildlife habitat preservation and creation
- How the design protects or creates on-site ecosystems
- How the design responds to local development density or conditions
- How the design encourages local food networks

**Suggested Graphics:** Natural systems diagram (onsite, context) and/or Native Landscape Profile (flora, fauna)

**Metric:** % site area designed to support vegetation.

**Measure 4: DESIGN FOR WATER**

Sustainable design conserves water and protects and improves water quality.

**Narrative:** How does the design manage storm water? How does the design conserve potable water? How is the project innovative in the way that it uses and treats water? May include:
- How building and site design strategies manage site water and drainage
- Design strategies that capitalize on renewable water sources (i.e. precipitation) on site
- Water-conserving landscape and building design strategies
- Reuse strategies for water including use of rainwater, graywater, and wastewater

**Suggested Graphics:** Diagram representing how water arrives onto the site, how it is used or re-
claimed, and how it leaves the site.

Metric: Percent of storm water that is managed onsite: (2 year, 24-hour event. Use supplied spreadsheet to calculate)

Measure 5: DESIGN FOR ECONOMY

Sustainable design celebrates affordable solutions around true economy—good first costs, good long term operations cost, and true benefits for occupant health and productivity.

Narrative: What do you think your project might cost to build? How would this construction cost compare with ‘typical’ buildings of the same building type? How does your design represent true economy by providing more value for what it costs? May include:

• An approach that uses less total area comprised of multi-use areas, instead of many single-use areas
• How savings are achieved for operating costs (energy, water...)
• How the design promotes occupant health, leading to lower absenteeism in the workplace and lower health care costs

Suggested Graphic: Lifecycle cost or value diagram

Measure 6: DESIGN FOR ENERGY

Sustainable design conserves energy and resources and reduces the carbon footprint while improving building performance and comfort. Sustainable design anticipates future energy sources and needs.

Narrative: How does the design seek to decrease the total energy use and carbon footprint of the building? Emphasize strategies to reduce heating and cooling loads, reduce electricity demand, reduce plug loads, and generate on-site carbon free energy. Describe your approach towards achieving carbon neutrality. May include:

• How the design reduces energy loads for heating, cooling, lighting, and water heating
• How the design and integration of building systems contributes to energy conservation and reduced use or elimination of fossil fuels, reduces greenhouse gas emissions and other pollution, and improves building performance and comfort.
• Use of on-site renewable and alternative energy systems.
• Strategies to reduce peak electrical demand.
• How the design remains functional during power outages or interruptions in fuel supply

Graphic: Open

Metric: Total energy use intensity (EUI) in kBTU/sf/yr: (build a simple energy model to calculate EUI using Design Builder, ArchSim, HoneyBee, eQuest, Sefaira, Autodesk® Insight 360, or another energy modeling program); Energy generation (if any) in kWh/yr.: (use PV Watts® Calculator or solar-estimate.org for solar or wind); Net EUI (with renewables if applicable).

Measure 7: DESIGN FOR WELLNESS

Sustainable design creates comfort, health, and wellness for people who inhabit or visit buildings.

Narrative: Discuss design strategies for optimizing daylight, indoor air quality, connections to the outdoors, and thermal, visual, and acoustical comfort. May include:

• How does design promote the health of the occupants?
• How does design promote activity or exercise, access to healthy food choices, etc.
• Outline of material health strategies, including selection strategies
• Design strategies for daylighting, task lighting, and views
• Design strategies for ventilation, indoor air quality, and personal control systems

Measure 7: DESIGN FOR WELLNESS (cont’d)

• How the project’s design enhances users’ connectedness to nature
• Design team approach to integration of natural systems and appropriate technology

Suggested Graphic: Model photos, drawings or diagrams of daylight and ventilation strategies; test models.

Metric: Percent of the building that can be daylight (only) during occupied hours; Percent of floor area with views to the outdoors; Percent of floor area within 15 ft. of an operable window.

Daylight performance using the following concepts: Daylight Availability, or Annual Sunlight Exposure along with Spatial Daylight: % of regularly occupied area achieving at least 300 lux at least 50% of the annual occupied hours.

Measure 8: DESIGN FOR RESOURCES

Sustainable design includes the informed selection of materials and products to reduce product life-cycle embodied energy and carbon, and environmental impacts while enhancing building performance and optimizing occupant health and comfort. Adaptive reuse and renovation/preservation dramatically reduces a building’s material consumption and carbon footprint.

Narrative: Describe the project’s construction, material selection criteria, considerations and constraints. What efforts were made to reduce the amount of material used and waste and
the environmental impact of materials over their lifetime? Discuss specific materials used. May include:

- Efforts to reduce the amount of material used on the project
- Materials selection criteria, considerations, and constraints for optimizing health, durability, maintenance, and energy use reducing the impacts of extraction, manufacturing, and transportation
- Enclosure performance in relation to air, moisture, water and thermal characteristics
- Consideration of life cycle embodied energy and carbon impacts and results of life-cycle assessment if available
- Construction waste reduction plans; strategies to promote recycling during occupancy Suggested Graphic: Wall section of the building envelope design and either a hydro-thermal analysis or life cycle assessment.

Metric: Estimated carbon emissions associated with building construction (lbs CO2/sf, using The Construction Carbon Calculator, Athena Impact Estimator for Buildings, Tally®, or other)

**Measure 9: DESIGN FOR CHANGE**

Sustainable design anticipates adapting to new uses, climate change, and resilient recovery from disasters.

**Narrative:** Describe how the design promotes long-term flexibility, re-use, adaptability, and resilience. May include:

- How the project was designed to promote long-term functionality and adaptability
- Anticipated project service life; description of components designed for disassembly
- Materials, systems, and design solutions developed to enhance versatility, durability, and adaptive reuse potential
- How does the design anticipate restoring or adapting function in the face of stress or shock, such as natural disasters, blackouts, etc.?
- How does the project address passive survivability (providing habitable conditions in case of loss of utility power or water)?
- How does the project anticipate and celebrate weathering over time
- How does the design for address adaptive climate: conditions in 2030 and in fifty years Suggested

**Graphic:** Specific hazard and climate analysis for project.

**Measure 10: DESIGN FOR DISCOVERY**

Sustainable design strategies and best practices evolve over time through documented performance and shared knowledge of lessons learned.

**Narrative:** What steps would you take to ensure that the building performs the way that it is designed? What lessons have you learned from this project that you will apply to the next project? What lessons have you learned from past projects that were applied to this project? May include:

- Modeling and evaluation of the design during the programming and design phases
- Collaborative efforts between design team, consultants, client, and community
- Lessons learned during the design of the building
- How these lessons would change your approach to this project or future projects
- A question that would be investigated in a post-occupancy evaluation of this project

**Graphic:** Open
6.0 CONCEPTUAL FRAMEWORK

- Light on Material for construction

- Insulation

- Can it be applied every building? or needs to be Customize in order to mount on it.

- Structure Load

- Building with conditions.

- Context.
6.1 DEPARTMENT OF WATER AND POWER BUILDING
Los Angeles, California

Designed by Albert C. Martin and Associates and completed in 1965, the seventeen-story Corporate International-style building rises from the center of an enormous reflecting pool punctuated by fountains.

Architect: A. C. Martin & Associates
Year of Completion: 1965
Street Address: 111 N. Hope St.
Los Angeles, CA 90012
Property Type: Government Public Works
Architectural Style: Mid-Century Modern
6.2.1 DEPARTMENT OF WATER AND POWER BUILDING
Los Angeles, California

The Department of Water and Power is located in LA downtown near major cultural town. The project site also has dense population area so there are high number of people traveling every day. The Dep. of Water & Power building is located along with other government buildings near by. The historical value of the area is very important for people from

6.2.2 GREEN SPACE AND WATER

There are two major park areas and Grand park is located South east of the project location where have coffee shops and municipal courts. The park and monumental buildings such as Disney Concert Hall, Museum of Contemporary Museum etc. attracts people around. Los Angeles River is running on the east side of the site. The green space and water are very limited in the area due to high dense buildings.
6.2.3 BUILDINGS

Project site is located in heart of downtown LA so around the site there are plenty residential and commercial building for people’s everyday lives. As in diagram south part of the town is filled with commercial and government building whereas west and North East part of the town is mostly residential area.

6.2.4 HIGHWAY CONNECTION

Project site is located near the high 101 and 110 for convenient access. This intersection gives vibrant atmosphere to the area while gives view access to countless people everyday.
6.2.5 CULTURAL INTERACTION

The Project site is surrounded by cultural diversity that brings multicultural environment.
6.3.1 CLIMATE OF LOS ANGELES

California, United States of America, 34.05°N 118.24°W 89m as

SOLSTICE DIAGRAM

Sun path and angle of the sun in summer and winter was studied for design

FINALS. THE PERFORMATIVE FACADE WILL BE DESIGNED TO PERFORM CONTROLING THE LIGHT

OR POSSIBLY RECEIVE LIGHTING DEPENDING ON WEATHER CONDITION.
6.3.2 GRAND AVE. ARCHITECTURE LANDMARKS

1. Department of Water & Power - A.C. Martin
2. Civic Park - Riad Clementi Hale
3. Walt Disney Concert Hall - Frank Gehry
4. Metro Regional Connector Station -
5. Library Tower - Pei Cobb Freed
6. Los Angeles Central Library
7. California Plaza - Arthur Erickson
8. MOCA - Arata Isozaki
9. The Colburn School - Hary Holzman and Pfeiffer
10. The Grand - Frank Gehry
11. Caltrans District 7 Headquarters - Thom Mayne
12. City Hall - A.C. Martin
13. Music Center - Welton Becket
15. Cathedral of our Lady of the Angels - Rafael Moneo
6.4.1 PROJECT DEVELOPMENT - Corri-

Design to provide Connection to the people and Community

Public Architecture (Government Building) is representative of power and therefore it makes people feel uncomfortable rather than feel welcome. Building Renovation and ecology features around within the building premises will be designed to provide opportunities to human tendencies to use.

Cultural Corridor

DWP building is located in the prime location in downtown Los Angeles. The Hope St. Around the building there is rich cultural diversity along with LA landmarks what draw people’s attention.

Ecology Corridor

Sustainable Features will be placed as educational and entertainment purpose and it can become part of the cultural aspect after established.

Diagram on the right shows people’s destination and pedestrian path around the cultural and government corridor area.
6.4.2 SUSTAINABLE DESIGN FOR COMMUNITY

Sustainable features and installation will generate power to run public amenities. These can be designed to control power and provide convenience to people while running on its own. These features will be located within the corridors to educate people what it is like to live in a sustainable city.

Regional connector transit will be connecting to downtown rail system to shift entire metro rail system away from the existing x-shape networking topology and provide more flexible and reliable transportation system. This transit system will help reduce traffic and energy use in downtown LA.
6.4.3 APPLYING SUSTAINABLE FEATURES

**Pavegan** - Pavegan is paving slab technology that convert energy from people’s footsteps into small amount of electrical power. These will installed under shading devices to generate power while solar panel shading generate power.

LA Region is great place for solar panels, since it is dry and sunny all year long. Therefore solar penal rest area can be placed in streets for pedestrian while generate power from sun.

Many research and design about solar panel is in progress, and there is design about solar panel roadway and walkway which can be placed in the city and provide power for public amenities.
6.5.1 ENERGY ANALYSIS AND EXISTING CONDITIONS

EXISTING CONDITION

EAST + WEST ELEVATION AREA
130’X(23’+11’X14)X2 = 46,020 SQ FT (GLAZING

NORTH + SOUTH AREA
310’X(23’+11’X14)X2 = 109,740 SQ FT

ROOF AREA
40,300 SQ FT

ANALYSIS SUMMARY

Building Type: Office
Location: 111 N. Hope St, Los Angeles, CA 90012, USA

Energy: 89

The current model does using ASHRAE 2015 energy model assumptions. The current design is better than the national average and can be significantly improved for higher performance of workable HVAC systems. The building load is driven by equipment and cooling.
**BENCHMARKS**

WHERE DO WE NEED TO BE?

- **Energy**
  - National Average: 100
  - 2030 Target: 30
  - Daylight: 55%
  -克莱恩: 34%

**ENERGY ANALYSIS**

**2030 CHALLENGE**

- **EUI**
  - 89.13 kWh/ft²

**ENERGY COST**

- New building: $2,338,225.31
- Renovation: $4,553,00

**EUI BREAKDOWN**

- **Spring:** $2,45.9
- **Summer:** $3,17.9
- **Autumn:** $2,52.9
- **Winter:** $2,21.9
- **Air:** $3.9
- **Hot Water:** $0.9

Generated by covetool
6.5.2 DEPARTMENT OF WATER & POWER FLOOR PLAN

Provided from Getty Research Institute
7.0 DESIGN
7.1 TYPES OF FACADE DESIGN FOR NORTH AND SOUTH SIDE

From the highway viewpoint north and east side of the building is perfect focal point. Therefore both side will be presented as media screen facade to show statistic and information about sustainable living.

South and west side are directly facing from both government and cultural corridor so both side needed to show sustainable and aesthetic parts of the design to create people’s interest about sustainable design.

The cultural and government corridor will draw much tension from people by its nature and it will benefit to exposing sustainable features to public.
7.2 SHAPE GRAMMAR + PATTERS
FLEXIBLE FACADE DESIGN PROCESS

ADAPABLE TO ENVIRONMENT
RESPONSIVE
AESTHETIC QUALITY
Design option 1 is facade made with flexible mesh that can be change its shape depending on angle of the sun. This repetitive pattern will create new feeling when it is no the operation while design option 2 will be expand its fin on the side to control the light. Design 2 stressed more toward base frame design rather than the complex moment.
7.3 PERFORMATIVE FACADE

Fig. 101

Fig. 102

MECHANICAL DIAGRAM

Gaps will be provided under the seating direction only.

Airflow required to provide fresh air to interior areas.

The service will be connected to the internal opening at the floor level. After the floor will be able to control the pressure in a room.

Air intake around the building.
Mechanical devices can be expanded to provide shelter depending on climate.
The sleeve will be located on the edge of the roof and insulated with light-weight structure frame to hold the facade device.
Middle part will be able to close to expand the sliding facade and the outside kinetic device to protect the mechanical device located inside from rain and wind.
simple mechanism but longer than complicated mechanism especially in outdoor environment conditions.
Solar Panel Electricity Production

5 hours of full sun the typical solar panel produce

250 watts x 45 hrs = 1.25 kWh/day

1 sq ft = 102.75 watts/day

DWP Solar Panel Area - 18,000 sq ft

18,000 x 102.75 = 1,849.5 kWh

Pedestrian Walkway

47,000 sq ft x 102.75 watt = 4,829.25 kWh

Solar Panel rest Area

100 sq ft x 10 = 1000 sq ft

1000 sq ft x 102.75 watt = 102.75 kWh

4,829.25 kWh + 102.75 kWh + 1849.5 kWh = 6,781.5 kWh/day

1 kWh = 3.142 kBtu

1 kBtu/sqft = 0.293 kWh/sqft

64.71 kBtu/sqft = 1.9 kWh/sqft

21,307.5 Kbtu generated in a day

639,224.19 Kbtu generated in a month

7,670,690.28 Kbtu generated in year

Each floor 40,300 sqft x 15 floor = 604,500 sqft

Power generated by Sustainable features / sqft

7,670,690.28 / 604,500 = 12.7 kBtu/sqft

With Facade = 58.08

After reduction from generated power

58.08 - 12.7 = 10 (cooling system) = 35.3 kBtu/sqft
Sustainability matters have been an important subject to the world for many years, and since the topic arose, many research and design has been produced and invented to improve sustainable measures in society. However many people do not know about sustainable systems and how can these systems can affect their lives because it does not affect them directly just yet. Carefully thought design with sustainable features can reduce greenhouse effect and conserving environment and improve the functionality of buildings. These systems installed in building or surrounds allow users to experience evolution of next phase of architecture.

From this project I have tried to come up with sustainable solution for not just building but context and environment around it. In order to do that project site and building had to be public building, enough to control the power around the city. I have analyzed map and climate to come up with most effective solution possible and research new sustainable technologies and features of design that can be placed in the city. Kinetic façade systems with natural shapes were used to represent sustainability while applying simple mechanism to control shading reduce light going into building by approximately 65% which reduces cooling energy by more than half. The initial calculation result shows 90% of the power was used on office equipment and cooling. Therefore I have placed solar panel on pedestrian walkway, and with its standard rate it produce more than enough power to run the building without consuming electricity from outside. For cooling, there is airway design installed on every floor to feed cool air from outside to inside for air circulation. These features were put into the building to maintain comfortable environment for people inside without high energy consumption.

There is a need for architects and designers to develop skills to understand and put new inventions in right place to improve not just building itself but also environment and people around it. Depth of understanding of these matters and how these systems can function, together, these help solve sustainability problems faster. A single research or development project cannot be enough to achieve the goals we are heading towards, but through developing an understanding of how to put these systems together so that it can be functional, I believe we might have better luck in solving these problems.
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