Achieving Energy-Efficient Design in Scientific Research Buildings

A case study on Emory University's Health Sciences Research Building II

Emory University targets aggressive energy use reduction for new Health Sciences Research Building

Emory University's new Health Sciences Research Building II (HSRB II) features 350,000 square feet of research space dedicated to biomedical science. The facility brings together translational researchers in the fields of cardiovascular health, vaccinology and immunotherapeutics, neurosciences, cancer research and pediatrics. The building will also serve as the new home for the university's Center for Systems Imaging, Division of Animal Resources and an Innovation Program to support and attract incubator and industry partners.

At eight stories tall, the building will include both laboratory and collaborative spaces for researchers and core functions such as integrated cellular imaging, flow cytometry, a biorepository, genomics and other technologies. These core facilities are spread across the building to foster collaboration among researchers. An accelerator space occupied by startups and entrepreneurs will spur the development of market-based innovations.

Aspirational Goals

The HSRB II reflects Emory's decades-long commitment to sustainability. In 2001, HOK designed the Whitehead Biomedical Research Building—the university's first LEED-certified building and the first project to achieve LEED Silver certification in the U.S. Southeast. Emory has since increased its total to 34 LEED-certified projects, with four more currently registered for certification.

Today, the university continues to set significant sustainability targets for all new buildings. It mandates a 50% reduction in both energy use intensity (EUI) and water use, and requires each to achieve a minimum of LEED Silver certification. Emory also seeks to integrate WELL and other certification methods on new projects.

For the HSRB II, the university set an ambitious EUI goal of 100 kbtu/sf-year and is targeting LEED Gold certification. Given the specific program of the building, which includes vivarium, imaging, computational research, as well as wet and dry lab-intensive spaces, this posed a complex challenge. Research buildings are typically resource-intensive, consuming five to 10 times more energy per square foot than office buildings. The average EUI for a building of this type is 302 kbtu/sf-yr.[1]

[1] Based on I2SL Labs21 average.

"We're excited when clients have aspirational goals. We don't always know if we're going to hit them, but we know we're going to get further along. It opens the door to interesting opportunities."

- Anica Landreneau
Director of Sustainable Design at HOK

HOK-designed Emory Whitehead Biomedical Research Building

Emory's 3-Step Process

Integrative Sustainable Design

IDEATION & BENCHMARKING
PROGRAMMING
IDEATION
BENCHMARKING
GOAL SETTING

ANALYSIS
ENERGY MODELING
COST ESTIMATING
QUALITATIVE ANALYSIS
SPACE ALLOCATION
SCHEDULE IMPLICATIONS
PAYBACK ANALYSIS
SYNERGIES

BUNDLES
BUNDLE OPPORTUNITIES
ENERGY MODELING
PARAMETRIC
OPTIMIZATION

DECISIONS & IMPLEMENTATION
DETAILED DESIGN
OPTIMIZATION
DETAILED ENERGY MODEL
VALUE ENGINEERING

STEP 0 | STEP 1 | STEP 2 | STEP 3

Step 0: Ideation/workshop - Emory identified key sustainability solutions to include in the design.

Step 1: Analysis of specific strategies, their associated costs and simple payback. The team analyzed each strategy and collaborated with the university to narrow the list of strategies based on their effectiveness and impact on cost.

Step 2: Bundles analysis - The team conducted a second round of analysis, bundling strategies together to determine the most cost-effective suite of strategies for selection.

Step 3: Application of selected bundle to the design - The team conducted a second round of analysis, bundling strategies together to determine the most cost-effective suite of strategies for selection.

An Integrated Approach

Site plan

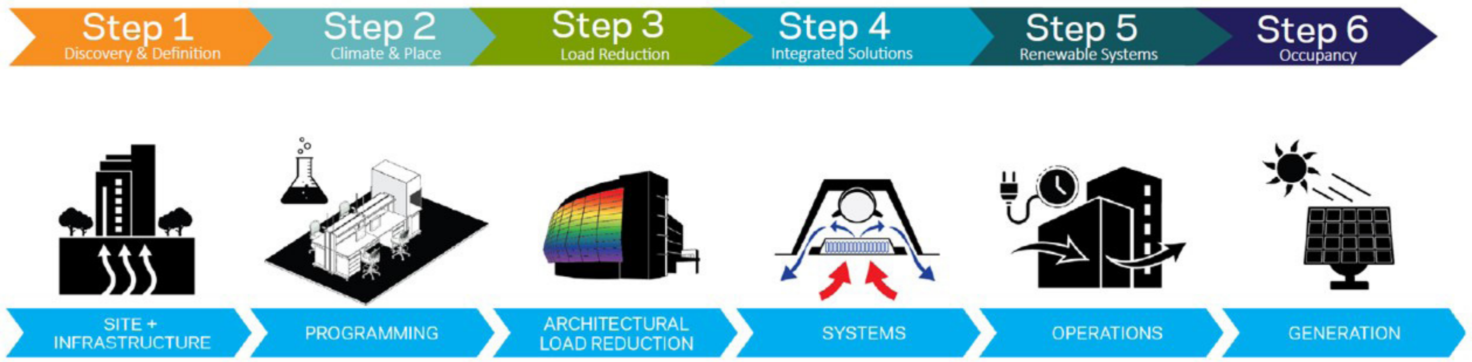
The team built on Emory's emerging sustainable design process and existing policies to determine strategies that aligned with the project's financial, building performance and energy reduction goals. Though the process was originally applied to a previous project, the HSRB II ultimately served as proof of concept. This led the team to develop and refine the university's approach throughout the design phase, regularly monitoring progress for EUI reduction and ensuring that all design decisions were data-driven and transparent to stakeholders.

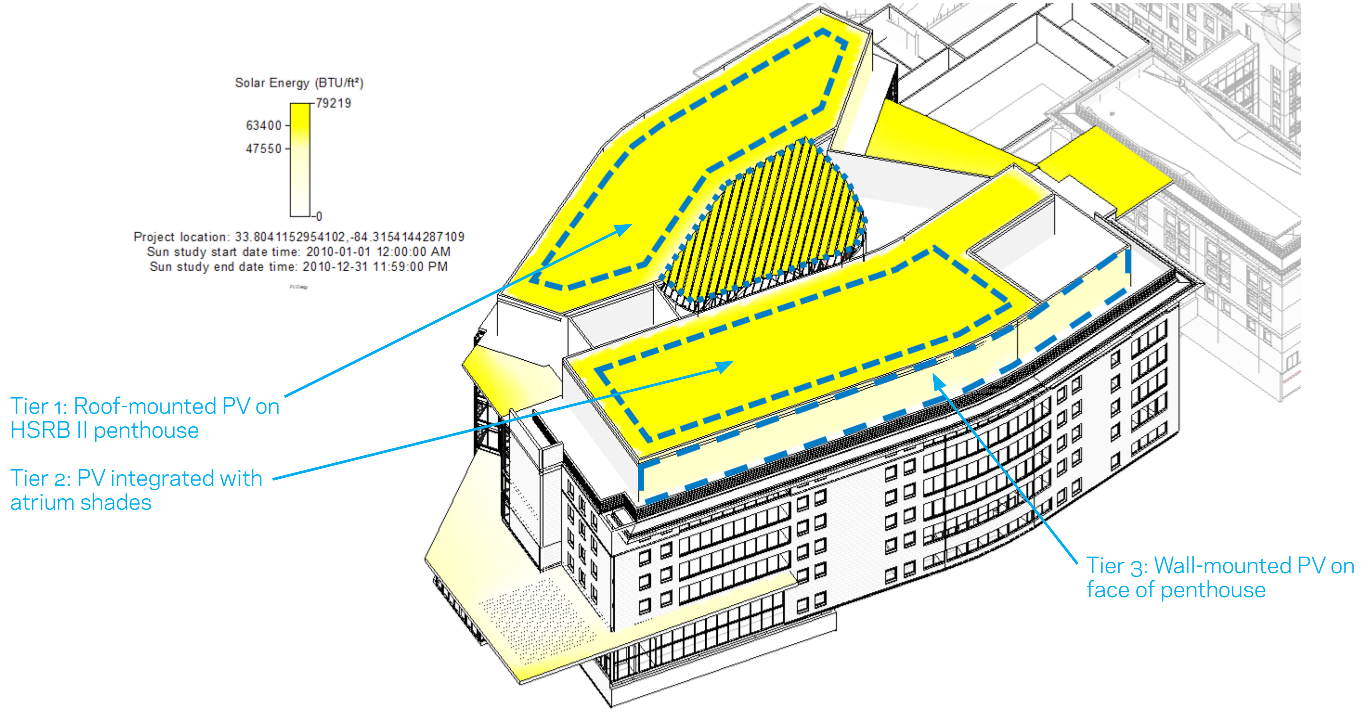

Lab and workplace

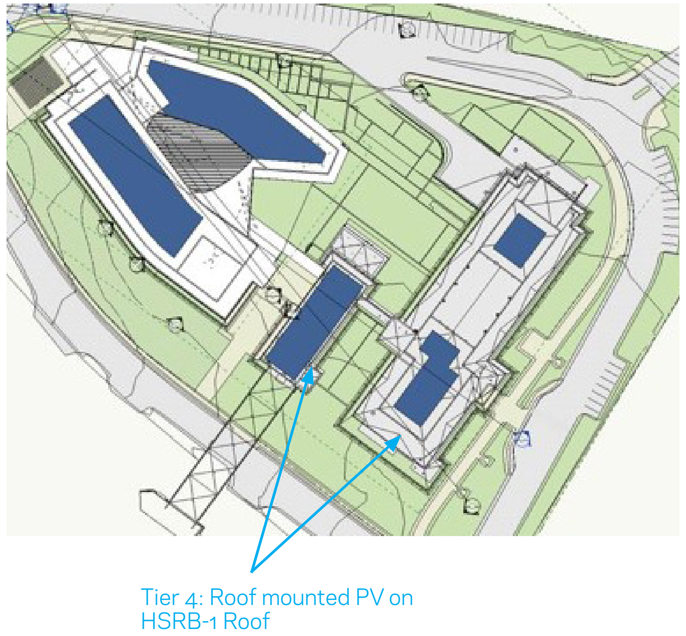
HOK's 6-Step Approach to High-Performance Design

As an overlay to the university's framework, HOK integrated its 6-step process to high performance design, adapted for complex buildings such as labs. With external load-driven projects, design typically would begin with climate and place (Step 2), load reduction, integrative systems, building performance, and occupant health and wellness. The process is geared toward developing project-specific solutions.

For the HSRB II and its internal load-driven energy profile, the team explored sustainable design strategies starting with the site and campus infrastructure. The team looked at programming-based solutions like blocking and stacking, adjacencies and thermal programming. They identified opportunities to reduce loads architecturally through optimized floor-to-floor height and building enclosure.







Solar photovoltaic studies

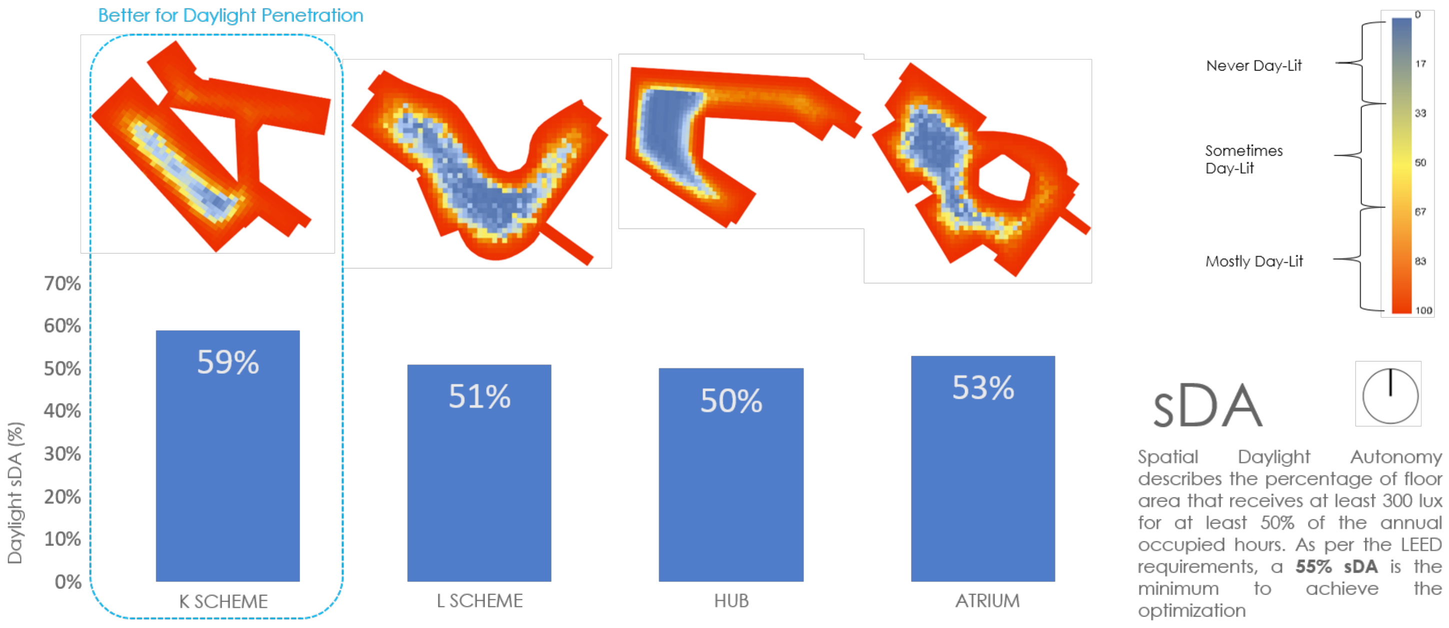
An Integrated Approach

After engaging in months-long discussions with Emory regarding operations and setbacks, the team conducted analysis to select and optimize building systems. Renewable energy systems were an important part of the discussion, as they are supporting Emory's campus-wide sustainability goals. The team assessed various innovative technologies and applications before selecting solar photovoltaics for their cost-effective energy generation. Ultimately, the team helped Emory establish a standard process for future campus projects.

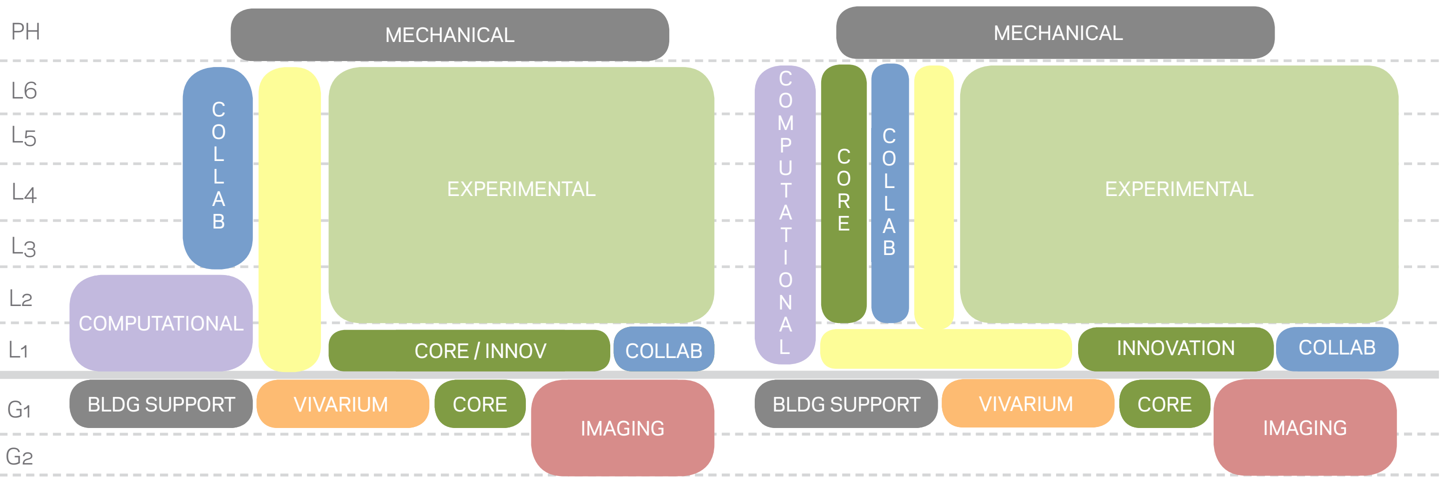
Ideation + Benchmarking

Beginning at the programming and early design phases, the team worked with Emory to explore innovative ideas, establish project goals and assess benchmarks for similar projects. The team built a matrix of potential design solutions that could address energy, water, transportation, campus ecology, human health and wellness.

The university, for example, voiced the need for bird-safe design given the HSRB II's proximity to the campus' Lullwater Preserve and its impact on ecology. Glare control was prioritized to ensure both visual and thermal comfort for occupants. Other solutions such as phase change materials and triple-pane thermal glazing were initially submitted for consideration, but ultimately rejected due to overlap with other strategies or their impact on cost and payback.



Daylight analysis by pattern R&D

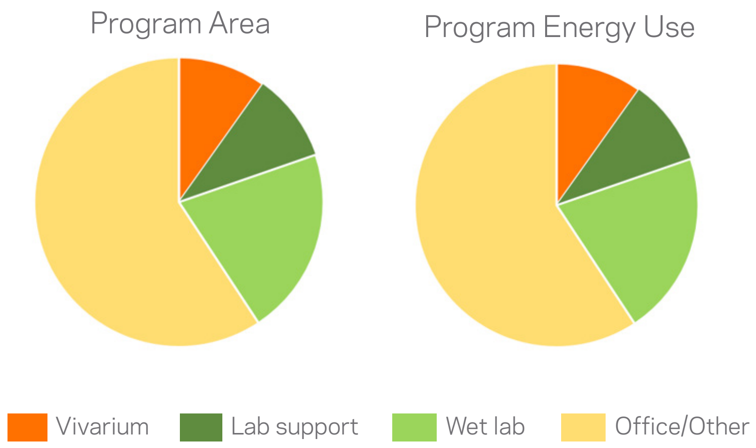


Blocking and stacking options

From an energy perspective, ventilation and plug loads have the highest impact on energy use in a typical research building. In the programming and blocking and stacking phases, adjacencies were important considerations as they enable opportunities for collaboration as well as cascading air to reduce outside makeup air volume. These adjacencies also permitted equipment sharing to reduce plug loads.

The design provides shared core facilities that maximize efficiencies and create serendipitous encounters among researchers. These core facilities include high-level containment suites (BSL3/ABSL3) and a central automated biorepository that can store up to one million biological samples used by principal investigators. This limits the use of individual freezers, which consume vast amounts of energy in research buildings.

A similar approach was applied to building systems. The team examined demand-controlled ventilation for non-lab spaces and sensor-based air change systems for labs. Plug load controls were also considered for lab benches and support spaces as well as offices and multi-occupant areas.



Ideation + Benchmarking

At the site and infrastructure level, the team explored geothermal energy generation early in the process as it would impact the construction schedule. The team scouted potential well field locations both on and near the site and worked with the project engineer to calculate energy offsets.

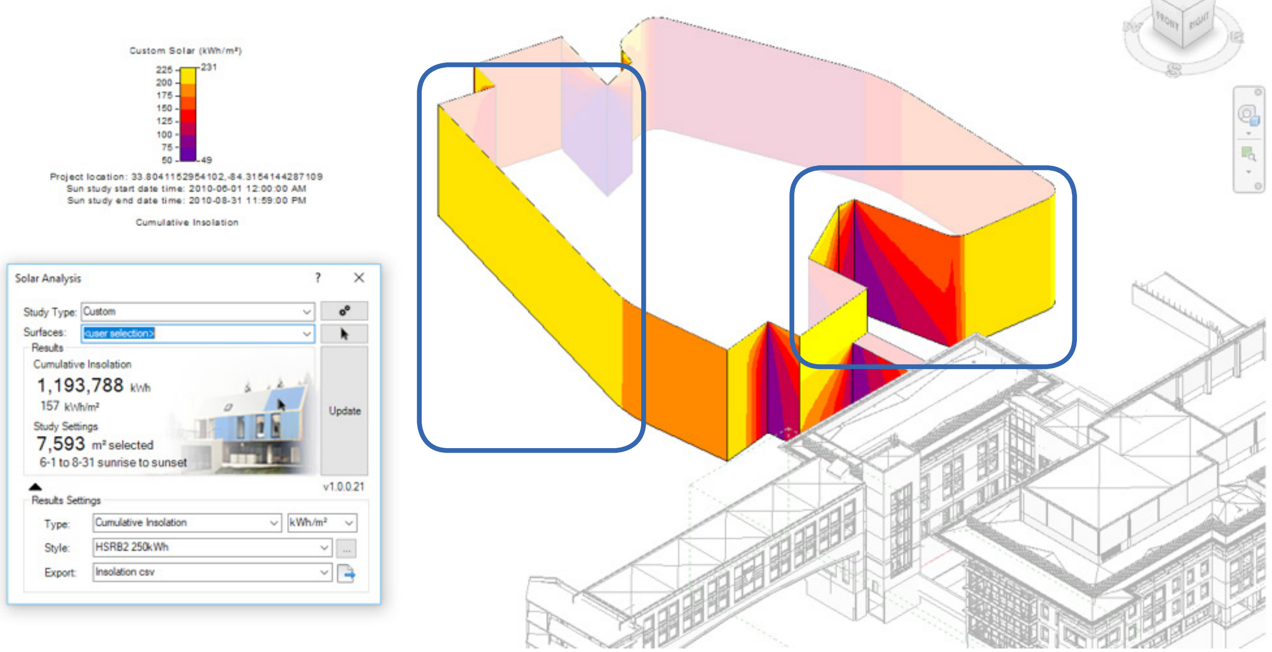
Other renewable energy generation strategies—from algae panels to fuel cells and flywheel storage—were assessed as opportunities. To reduce loads through architectural design, massing options were evaluated to determine the EUI impacts of floor-to-floor height, daylight optimization and glare reduction.

Well Field Option A
Up to ~100 wells
Up to ~125-150 tons

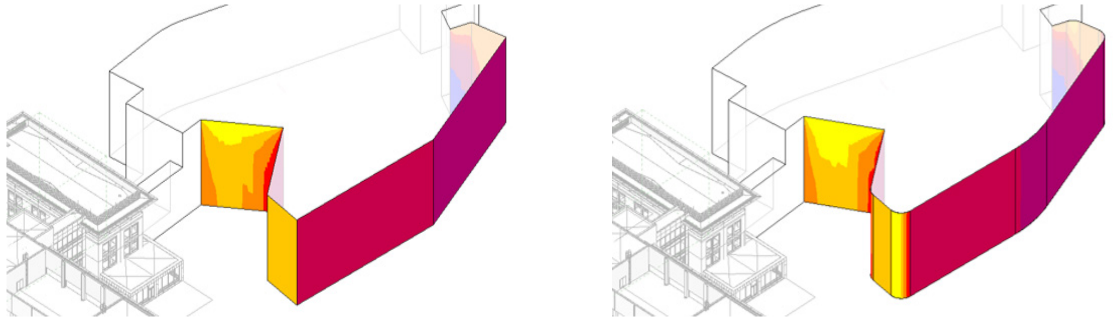
Well Field Option B
Up to ~200 wells
Up to ~250-300 tons

Well Field Option C
Approx. 360'x180'
~162 wells
~200-250 tons

Potential geothermal well field locations



Solar radiation facade analysis: Southwest and eastern facades by pattern R&D



North Bar
Rectangular Corners
Cumulative Isolation (Summer)
512,844 kWh

Baseline

North Bar
Rectangular Corners
Cumulative Isolation (Summer)
488,311 kWh

4.7%
Reduction

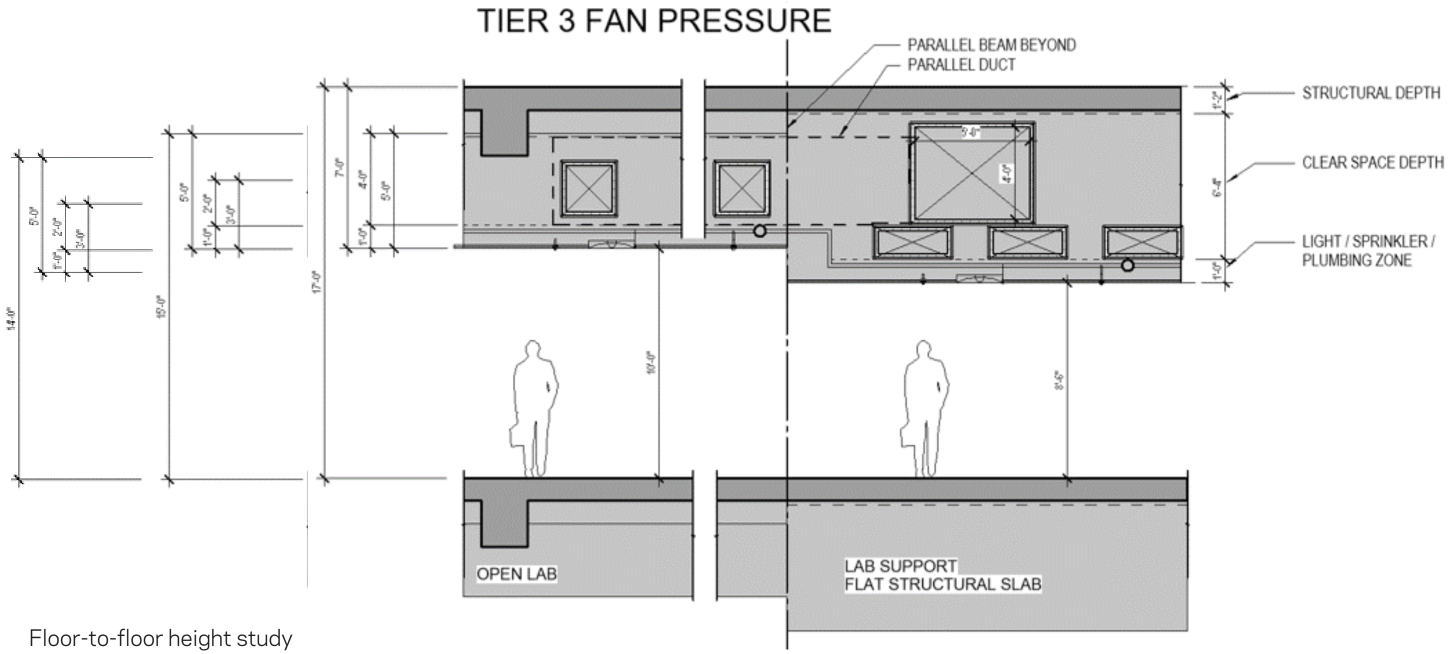
Solar radiation facade analysis: North bar corner shape by pattern R&D

Beyond energy and water use reduction, Emory sought to integrate sustainable strategies that promote occupant health and wellness. The team looked to biophilic design to achieve this, incorporating sweeping views to nature and a green wall in the building atrium. The feature wall encourages people to use the adjacent active stair and to gather at the atrium and informally collaborate. Glare control strategies were evaluated to improve visual and thermal comfort, particularly in lab and shared computational research environments.

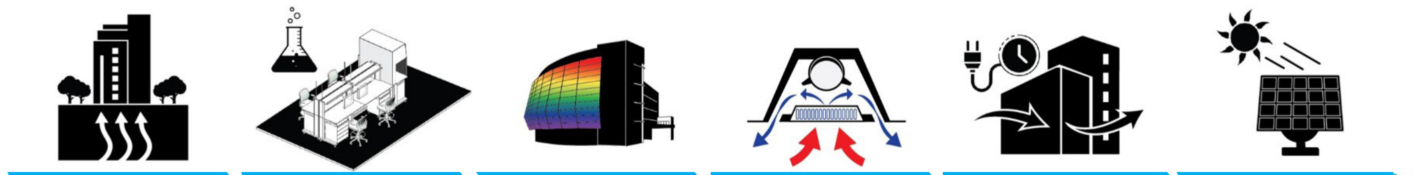
Analysis

After compiling a comprehensive list of solutions, the team analyzed each individual item in terms of EUI impact, first cost premiums, energy and water cost savings, and simple rate of return (payback). This required close coordination among the design team, engineers and the construction manager to conduct energy modeling and cost estimation, identify synergies and evaluate the qualitative and quantitative impacts of each strategy. The goal was to build a robust set of information to guide Emory's decision making.

Early design decisions such as floor-to-floor height and insulation specifications were subject to the same rigorous analysis as building systems for heat recovery, water conservation and green roof areas. The team presented the results for deliberation, guiding Emory through the selection process.



Floor-to-floor height study

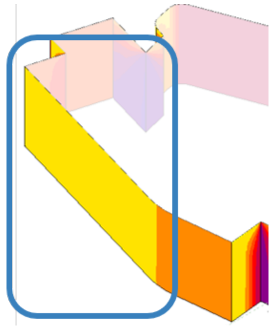


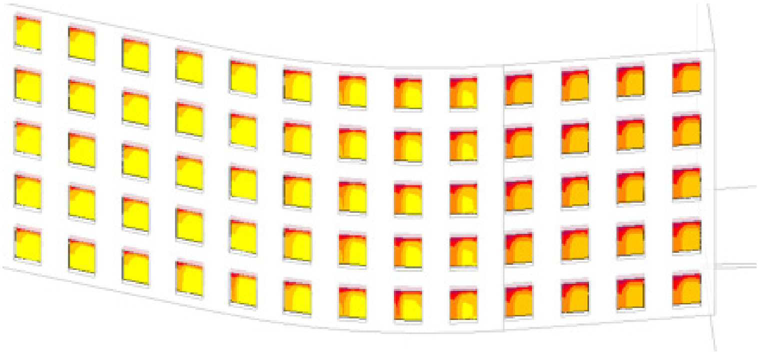
	SITE & INFRASTRUCTURE	PROGRAMMING	ARCHITECTURAL LOAD REDUCTION	SYSTEMS	OPERATIONS	GENERATION
ENERGY	▪ Shared cooling tower ▪ CHP ▪ Chillers that enable CHP ▪ Geo-exchange	▪ Blocking & stacking ▪ Cascading air & adjacencies ▪ Horizontal program Organization, passive reheat	▪ External loads ▪ Glare & heat gain control ▪ Daylight optimization ▪ Atrium ▪ Large porch overhangs ▪ Floor-to-floor height	▪ Natural ventilation ▪ Daylighting ▪ Phase change materials ▪ Passive humidification ▪ HVAC supply ▪ Demand control ventilation ▪ Regenerative systems	▪ Setbacks ▪ Sensors and setpoints ▪ Filter replacement frequency ▪ Plug loads ▪ Cloud computing	▪ Solar thermal H2o ▪ Solar PV - roof ▪ BIPV (louvers, fins) ▪ Battery, fly wheel storage ▪ Biogas fuel cells ▪ Algae
STORM WATER	▪ Landscape – Swales ▪ Hardscape – Swales ▪ Rain chains ▪ Green roofs			▪ Rainwater reclamation		
WATER	▪ Grey water reclamation ▪ Black water reclamation			▪ Low flow fixtures ▪ Condensate recovery		
HEALTH & WELLNESS	▪ Occupiable outdoor spaces ▪ Productive gardens ▪ Biodiversity	▪ Spaces for social engagement & collaboration ▪ Spaces with outdoor access ▪ Spaces for mindful eating ▪ Spaces for physical activity ▪ Places of respite	▪ Active design	▪ Daylighting ▪ Biophilic design ▪ Green walls ▪ Drinking water promotion ▪ Access to nature ▪ Acoustics ▪ Circadian lighting	▪ Enhanced air, water filtration ▪ Filter replacement frequency ▪ Occupant controls ▪ Occupant training, surveys & engagement ▪ Ongoing A/WQ testing ▪ Active furniture ▪ Healthy food options ▪ Fitness access	
TRANSPOR-TATION	▪ Transit ▪ Bicycle				▪ Next bus digital signage	

Matrix of potential sustainable design solutions

Analysis

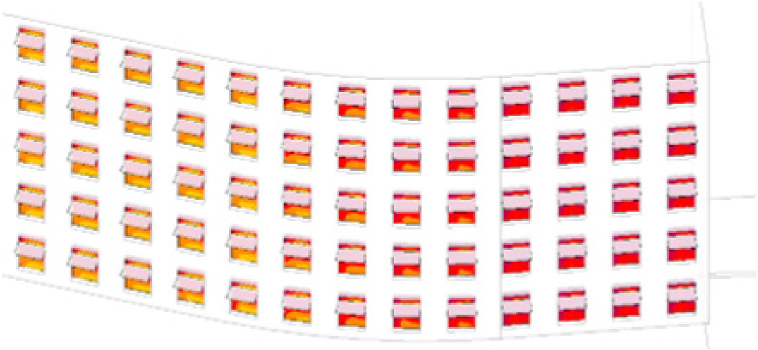
Southwest facade shading





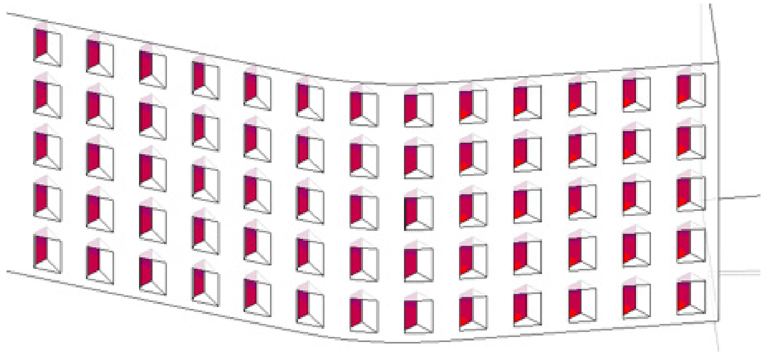
Punched window
154 kWh/sm

0%



Light shelf
108 kWh/sm

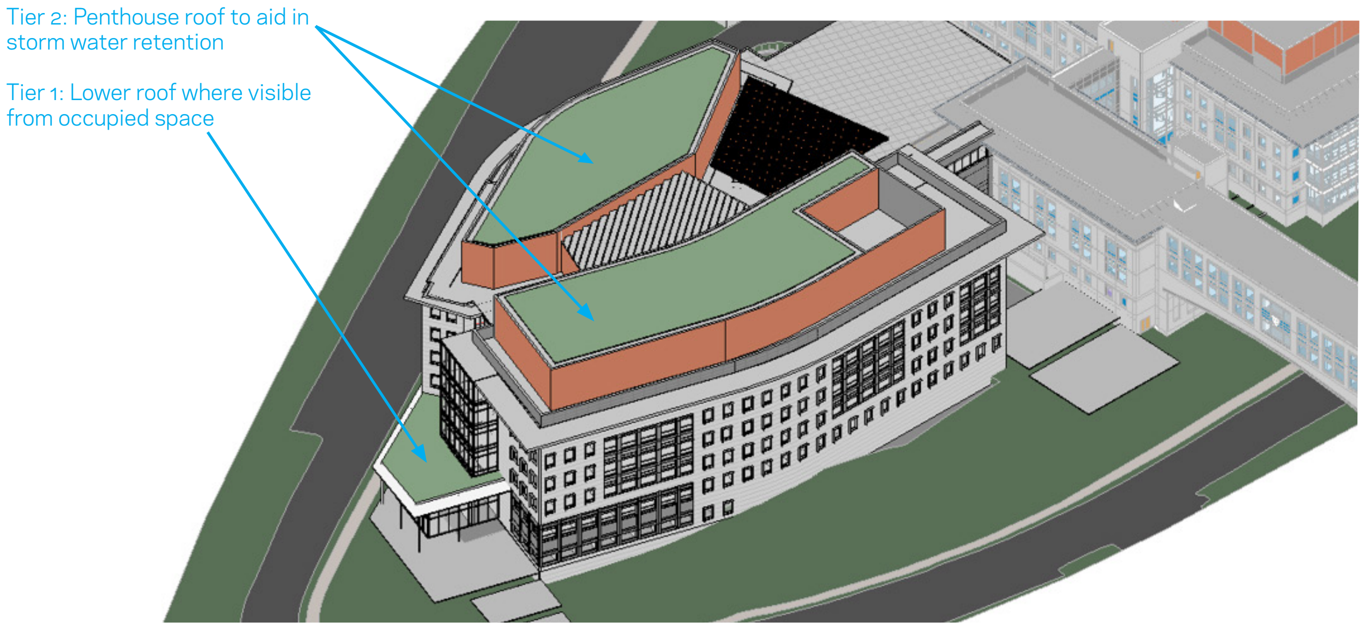
-29%



Folded window
79 kWh/sm

-48%

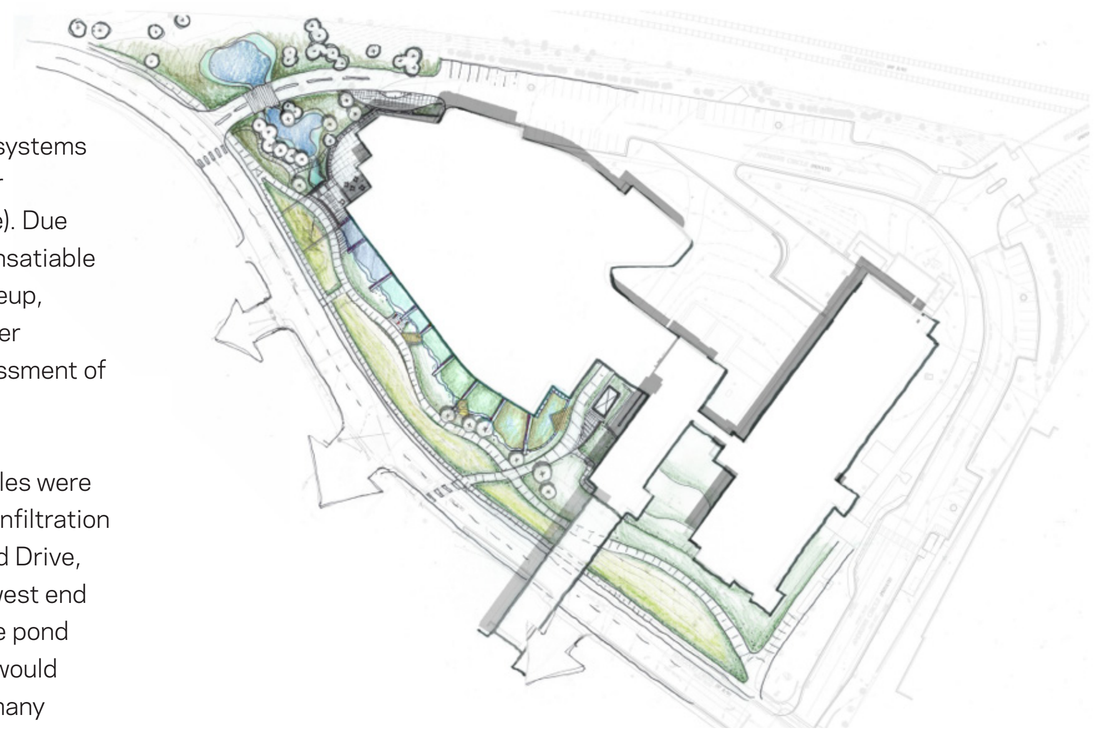
Southwest facade shading analysis by pattern R&D



Green roof system study

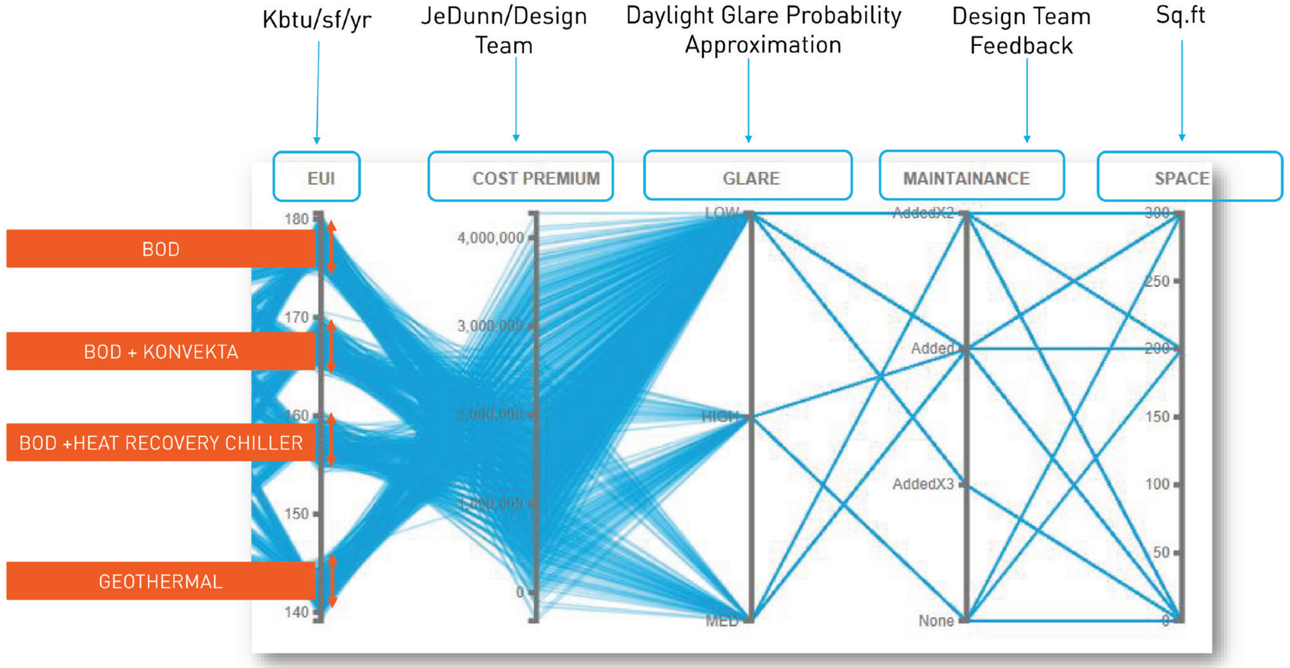
The team explored green roof systems in conjunction with stormwater management strategies (above). Due to extensive payback and an insatiable demand for cooling tower makeup, priority was given to stormwater collection, prompting a reassessment of the green roof system.

Hardscape and landscape swales were also considered along with an infiltration treatment basin along Haygood Drive, including a pond on the southwest end of the swale (left). However, the pond option was reconsidered as it would require the elimination of too many mature trees.

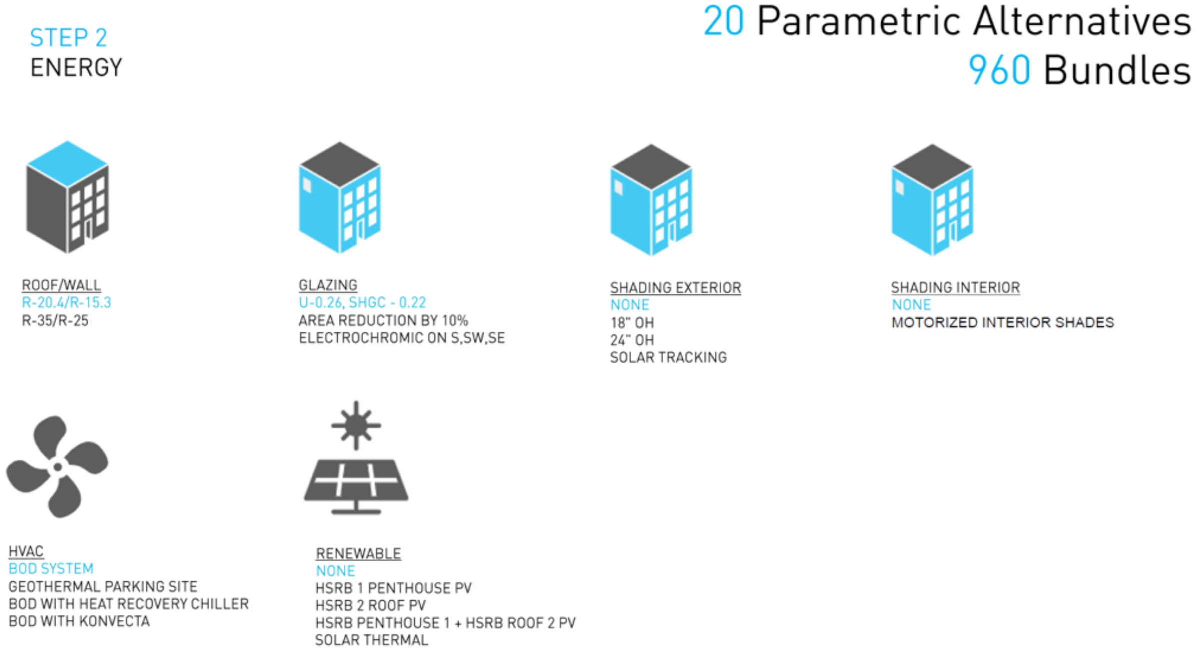


Proposed infiltration system along Haygood Drive


Emory Start-up Snapshot



Cost vs. energy optimization by pattern R&D

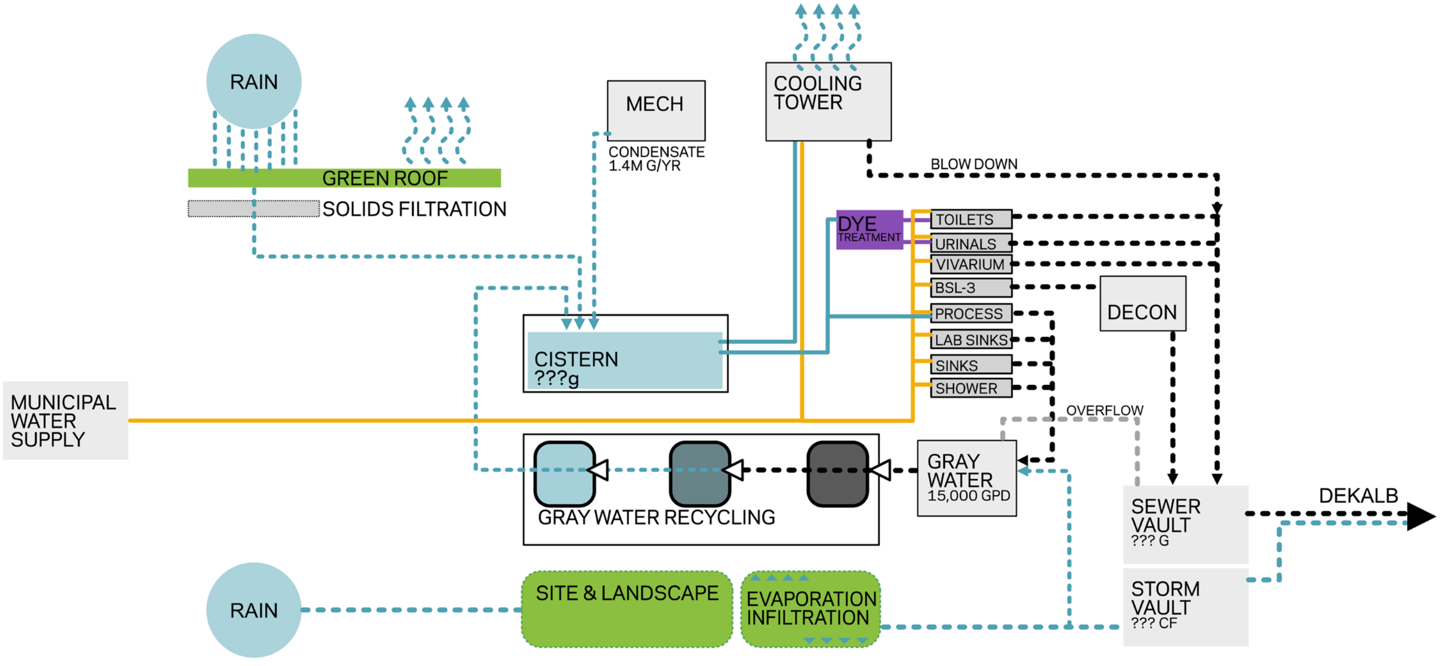


Bundled analysis by pattern R&D

Bundling Opportunities

The strategies were subject to a second tier of analysis to determine how they would work together to meet project goals. Through extensive parametric analysis, multiple attributes were optimized to determine the best possible combination of solutions. This included window-to-wall ratios, glazing and shading strategies, mechanical systems and renewables. The analysis demonstrated that a 40% EUI reduction was possible and indicated the associated costs to achieve it.

This bundled approach was also used to drive water reduction. Due to supply concerns for cooling tower makeup and large storage requirements for stormwater and sewer vaults, the team leaned toward an on-site water management system. Strategies such as water conservation and ultra-low flow fixtures, grey and blackwater systems, and condensate and rainwater capture were analyzed alongside building performance to generate practical options for meeting water efficiency targets.



Greywater system

Decision Making + Implementation

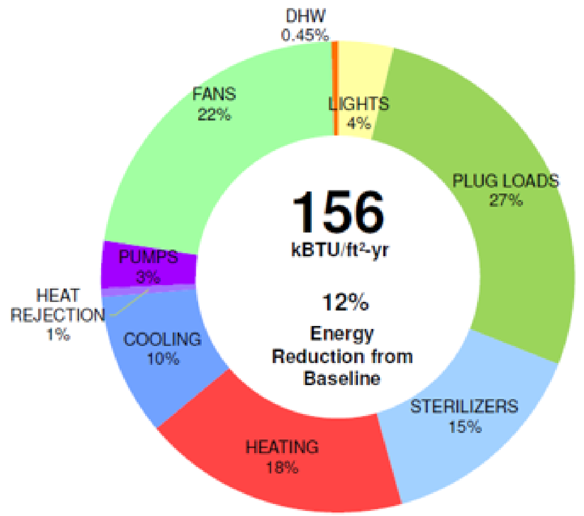
By the end of the schematic design phase, the HSRB II had a modeled EUI of 143 kbtu/sf/yr, achieving significant energy reductions for heating and cooling, ventilation and lighting.

As the project progressed, several decisions were made that had a significant impact on building performance. The on-site water treatment facility was reevaluated, shifting from a building-specific project toward a potential water treatment hub for multiple buildings. The university's decision to replace geothermal energy generation with a solar panel array resulted in a modeled EUI of 156 kbtu/sf/yr.

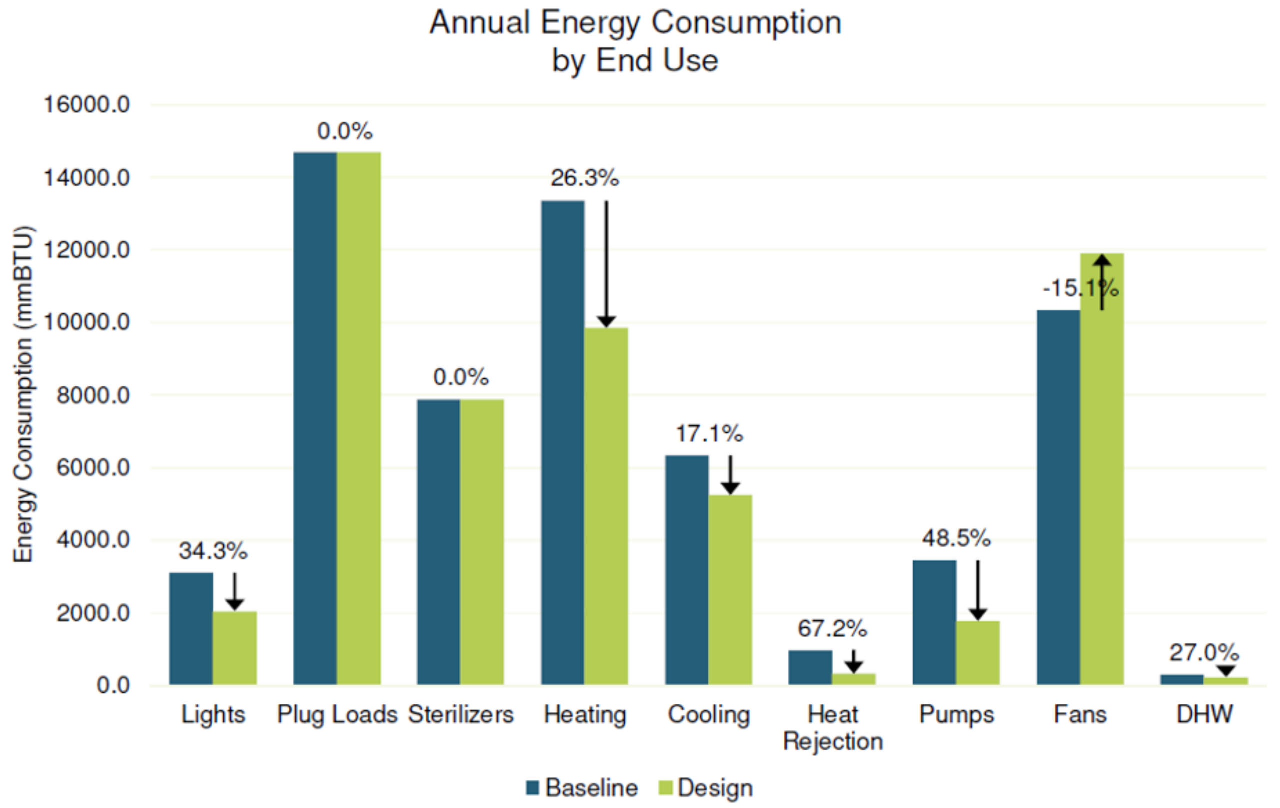
"Even with 156 EUI, this is one of the greenest lab facilities in the Southeast. It's a significant reduction from the baseline for a typical lab building."

- Chirag Mistry,
Regional Leader of Science
+ Technology at HOK

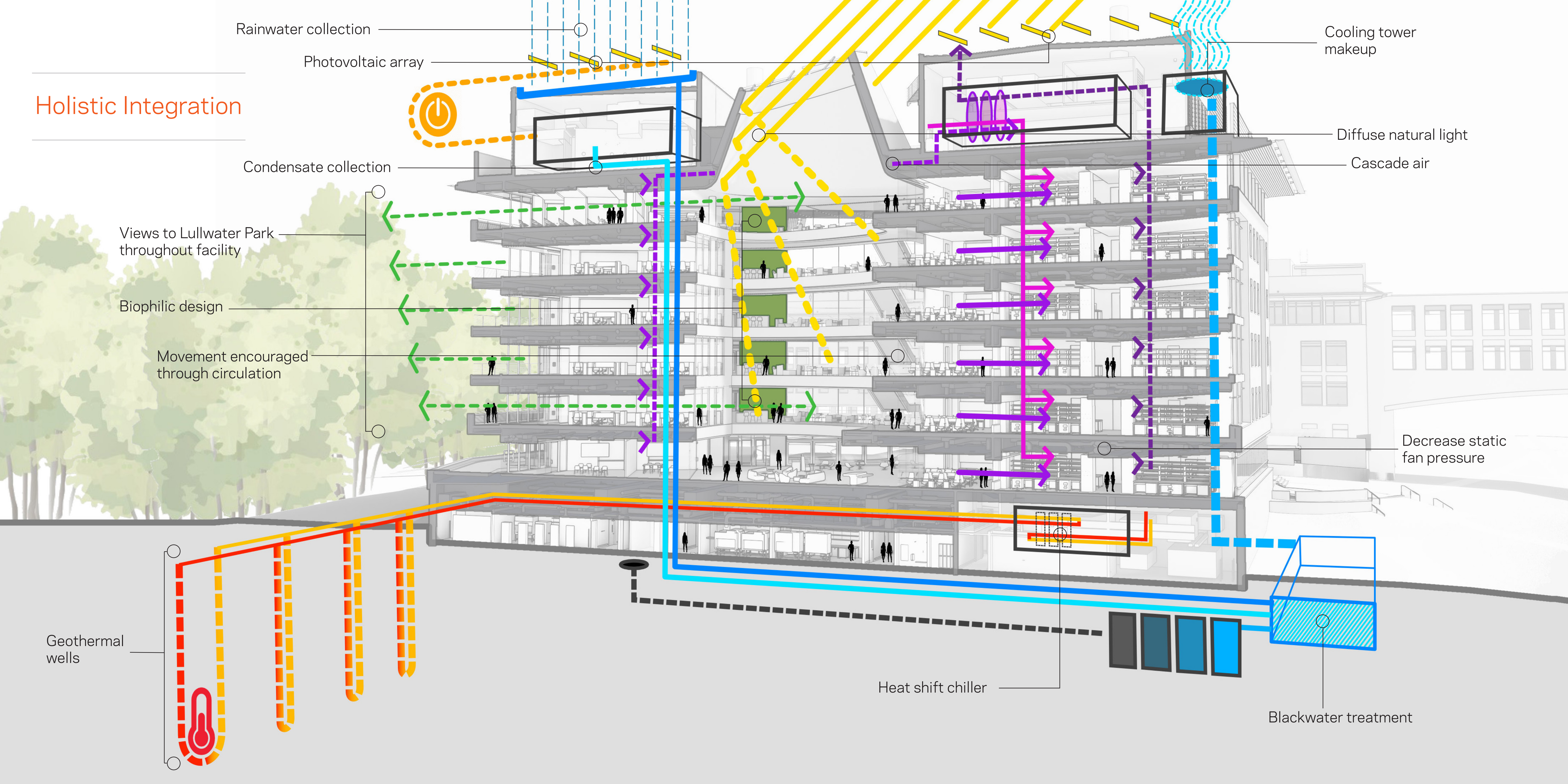
West entry



By HOK's standards, the resulting EUI is regarded as conservative. The energy model did not account for operational factors such as plug loads, sterilizers and other aspects such as human behavior, all of which provide additional opportunities for reducing energy demand. This indicates that the HSRB II could achieve an even higher energy reduction when fully operational. HOK recommends conducting a post-occupancy evaluation to gain a realistic understanding of energy consumption and recommend further measures for improving building performance.



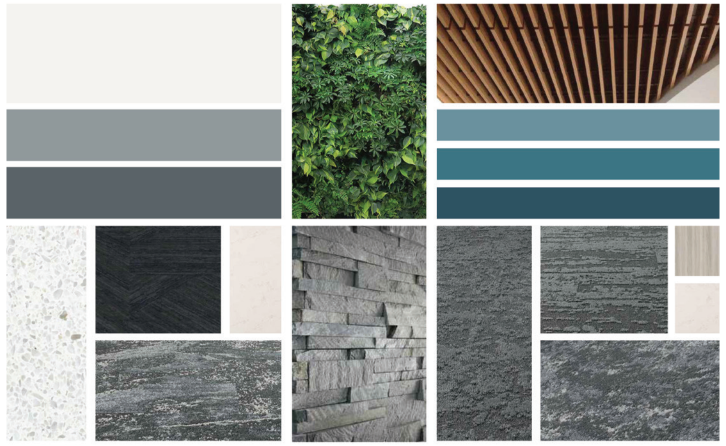
Holistic Integration



Green wall

Landscaped courtyard plaza

Atrium



Materiality for atrium and workplaces

Biophilic Design

Like all projects, during the preparation of construction documents the HSRB II went through value engineering to streamline costs while improving function and quality. Because they were clearly defined from the beginning, design elements for improving human health and wellness, biophilia and other sustainable strategies remained intact.

"When your goals are well-defined and anticipated early on, you can protect them."

- Anica Landreneau
Director of Sustainable Design at HOK

The HSRB II capitalizes on its proximity to the Lullwater Park, a 154-acre nature preserve on the eastern edge of the campus. The design incorporates sweeping views to the park, promoting openness and wellness through abundant natural light and connections with nature. Balconies on the north façade bring the outdoors into the interior and provide spaces of respite for occupants.

The new building brings the opportunity to create a landscaped courtyard plaza between HSRB I and II, channeling the Lullwater Preserve into the site. The courtyard serves as an outdoor gathering place and spills into the building through a large, six-story atrium glazing that showcases the activity and energy inside. Landscaping extends toward the southern edge of site, surrounding the building with nature.

Biophilic design elements reinforce occupant wellness and beautification while establishing a sense of place. A skylight at the center of the atrium permeates the interior with natural light that aids in maintaining occupants' circadian rhythms along with the dynamic interior lighting. A daily connection with nature is inspired through the incorporation of a six-story green wall that welcomes individuals into the space at the entrance and encourages use of an adjacent stair.

In addition to images of nature, the building interior features materials such as natural stone and wood with textures evocative of rough-hewn limestone and slabs of slate and sandy riverbed floors. The nature-inspired color palette includes stone greys, warm wooden hues, cool whites and serene blues. This further integrates the project with its surroundings, drawing nature indoors and providing spaces for respite and concentration.

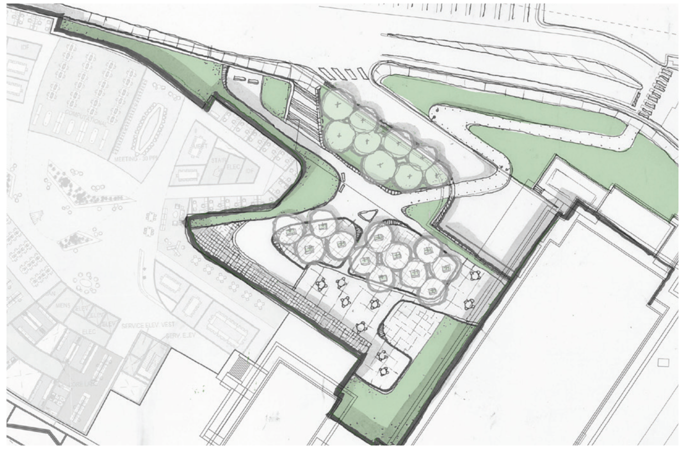
Decision Making + Implementation

The team is taking steps to reduce the building's embodied carbon during construction, exploring CarbonCure carbon sequestering concrete and aggregate, as well as cement replacement options.
The team is tracking the embodied carbon and environmental impacts of materials, prioritizing regional sourcing, recycled content and FSC-certified wood.
A construction waste management program ensures that a substantial amount of waste is diverted from landfills, per Emory's policy.

Slated for completion in 2022, the HSRB II presents Emory with a roadmap for achieving a sustainable, high-performance building and sets a precedent for future campus projects.

Campus quad landscape concept

Forest walk landscape concept



Urban plaza landscape concept


EMORY

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