PAE

Regenerative Design

pae-engineers.com

Contents

COVER IMAGE:
The Kendeda Building for Innovative Sustainable Design | ATLANTA, GA
Architects: Lord Aeck Sargent and Miller Hull Partnership
Photo: Jonathan Hillyer

Seattle Academy of Arts & Sciences, Cardinal Union Building | SEATTLE, WA
Architect: LMN Architects
Image courtesy of Lara Swimmer

Meet PAE

We’re all about people and nature.

Engineers have a reputation for complicating things. But at PAE, we like to keep it simple: People and nature are our driving forces. Internally, we look out for each other and the spaces we occupy—inside and out. And the same applies to our work. We design high-performing buildings that keep people comfortable, healthy, and productive inside, while restoring the natural world outside.

While some engineers may look for potential solutions right away, we know that before we start on the problem-solving path, we must first clearly define the problem, project goals, and what a successful outcome will look like. We believe the systems we design and engineer today can be the future model of sustainability for other institutions to emulate.

Our projects range from master plans, commercial high-rises, and museums to educational institutions, historic building renovations, healthcare facilities,and laboratories. We work on all project types at any point in its lifespan, even when it’s still just an idea.

Our vision

A world with clean air, energy, and water for all.

We believe

Climate change can be drastically reduced by changing our focus to minimize, decarbonize, and neutralize our carbon footprint.

It is our generation's responsibility to shift to all-electric, net-zero carbon buildings for all.

Water is a valuable resource, and we need to work within the site's natural water budget.

Environmental sustainability cannot be achieved without financial and economic sustainability.

Rocky Mountain Institute Innovation Center | BASALT, CO
Architect: ZGF Architects
Image courtesy of Tim Griffith

Why Regen?

We use our Regenerative Design services to establish and guide the project vision. It is a robust toolkit available to optimize building performance, sustainability, and occupant satisfaction. It helps provide an understanding to the interactions and connections between the architectural design and building systems. This is critical to make the invisible, visible because new solutions only become possible with a dynamic, data-driven approach and teamwork.

In Depth

PROJECT VISIONING

PAE relies on our Regenerative Design services to help clients make informed decisions in everything from sustainability goals for their projects to building performance and occupant satisfaction. This is done through careful analysis and our deep understanding of building science to show predictive performance and the value of the goals over time. It also enables us to advise against any mishaps *before* they happen. The quantitative analysis makes qualitative visions a reality and allows us to envision even more for the project than anticipated had we not used the tool in the first place.

A DATA-DRIVEN APPROACH

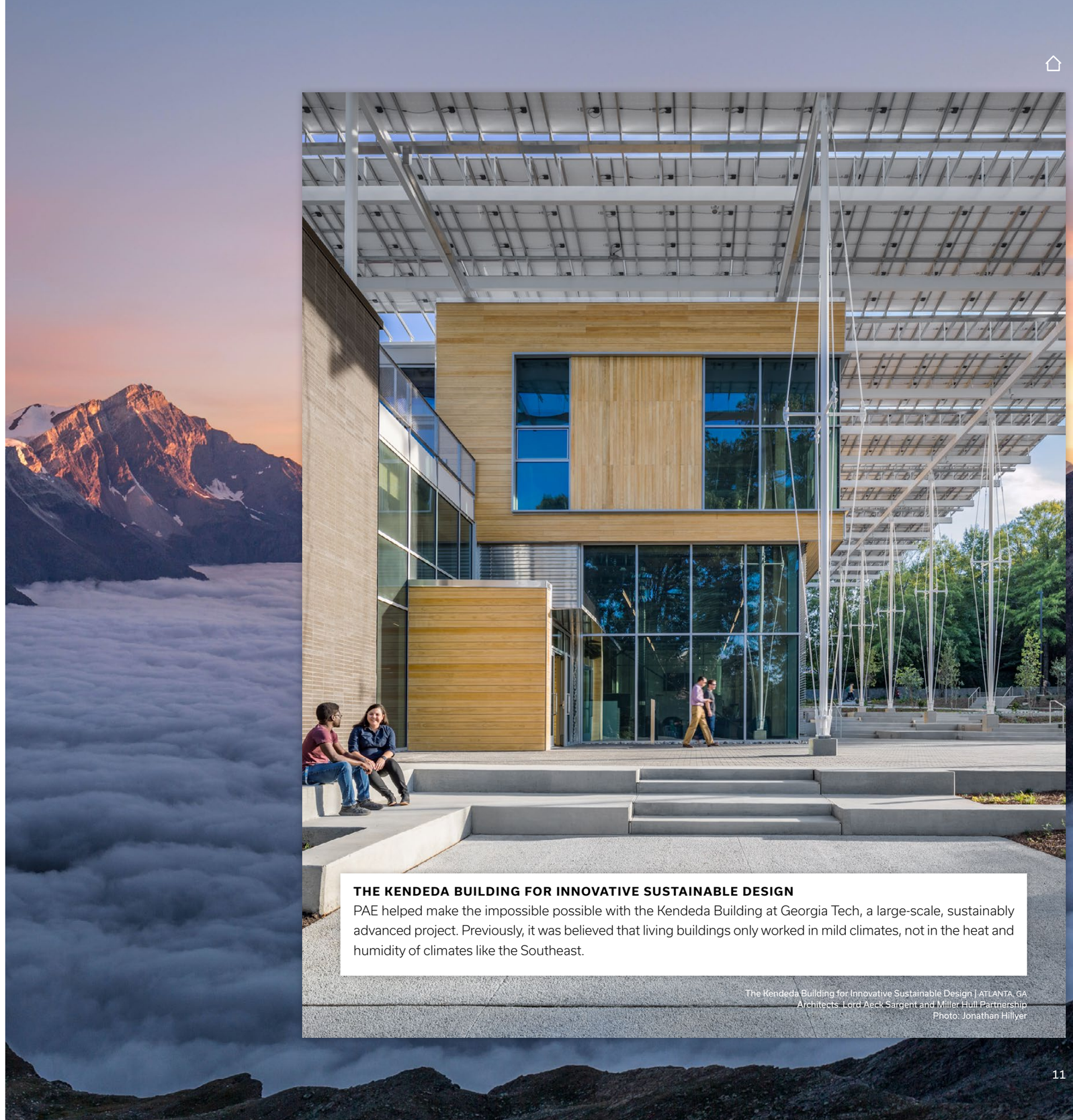
PAE uses Building Performance Analysis throughout the design process to inform the vision, implement details, and track performance. All of this is done with a data-driven approach that takes large data sets, like 8,760 hour files, and simulates performance for both current and future weather conditions for a building in a particular location. Data analytics are used to probe results and find optimal solutions to complex problems. This type of data-driven approach allows teams to test ideas and see how they can perform. It also creates far more confidence that a design can work once it is built.

By simulating many ideas and solutions, we discover designs that would previously never have been considered. These are often the big moves on projects that take them to the next level of performance allowing them to achieve lofty goals without needing lofty budgets.

MAKING THE IMPOSSIBLE POSSIBLE

We have heard many times that certain goals or outcomes are impossible. It is far too common for engineers to have preconceived notions of what is possible and write off solutions even before considering them. We strive to do the opposite – to make the impossible possible. This is done through rigorous analysis to find unified architectural and engineered solutions, and our Regen services are at the heart of making this a reality. Though there are limits to what is possible, we believe those limits are set far too low on most projects. All projects can be elevated with a great vision and great analysis work.

It is far too common for engineers to have preconceived notions of what is possible and write off solutions even before considering them. We strive to do the opposite – to make the impossible possible.



THE KENDEDA BUILDING FOR INNOVATIVE SUSTAINABLE DESIGN

PAE helped make the impossible possible with the Kendeda Building at Georgia Tech, a large-scale, sustainably advanced project. Previously, it was believed that living buildings only worked in mild climates, not in the heat and humidity of climates like the Southeast.

The Kendeda Building for Innovative Sustainable Design | ATLANTA, GA
Architects: Lord Aeck Sargent and Miller Hull Partnership
Photo: Jonathan Hillyer

WHY REGENERATIVE DESIGN

In Depth

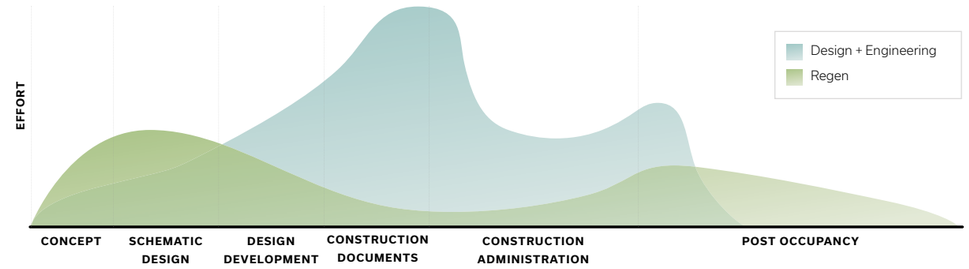
Using Regenerative Design Services (Regen) early in the design process is one of the most important ways a project can achieve high-performance goals. These measurable goals create a benchmark for the team to strive toward and is most impactful during the predesign and schematic design phases.

PAE provides our clients with information that allows projects to stay on budget while achieving optimal outcomes like increased productivity, employee attraction and retention, and energy and water conservation. Our Regen services help teams explore system alternatives in order to find an integrated design path that balances building performance with economic goals.

Regen lets us build *beyond* our most audacious sustainability goals.

A key concept of Regen is looking at performance through time. Traditional engineering takes a few snapshots in time and establishes sizing. Regen looks at performance through an entire year - 8,760 hours – and, as a result, allows us to create much better designs.

Project Timing and Integration



Smart project timing is essential to achieve high-performance goals. This is especially critical where integrated designs are needed crossing boundaries between disciplines.

THERE ARE THREE KEY PARTS OF REGEN ANALYSIS IN THIS SCENARIO:

- Inspiring and quantifying goals early in a project
- Showing how projects comply with project goals and performance codes
- Post occupancy verification

This can be done in traditional and new delivery models like design-build. Our best projects integrate our analysis with the entire team early so there is a clear vision. With this vision, the entire team can work together to find solutions that previously were considered too hard, too expensive, or too unconventional. It is very common that projects that achieve higher goals have minimal cost premiums and inspire change through the entire team and, potentially, the entire building industry.

REGENERATIVE DESIGN

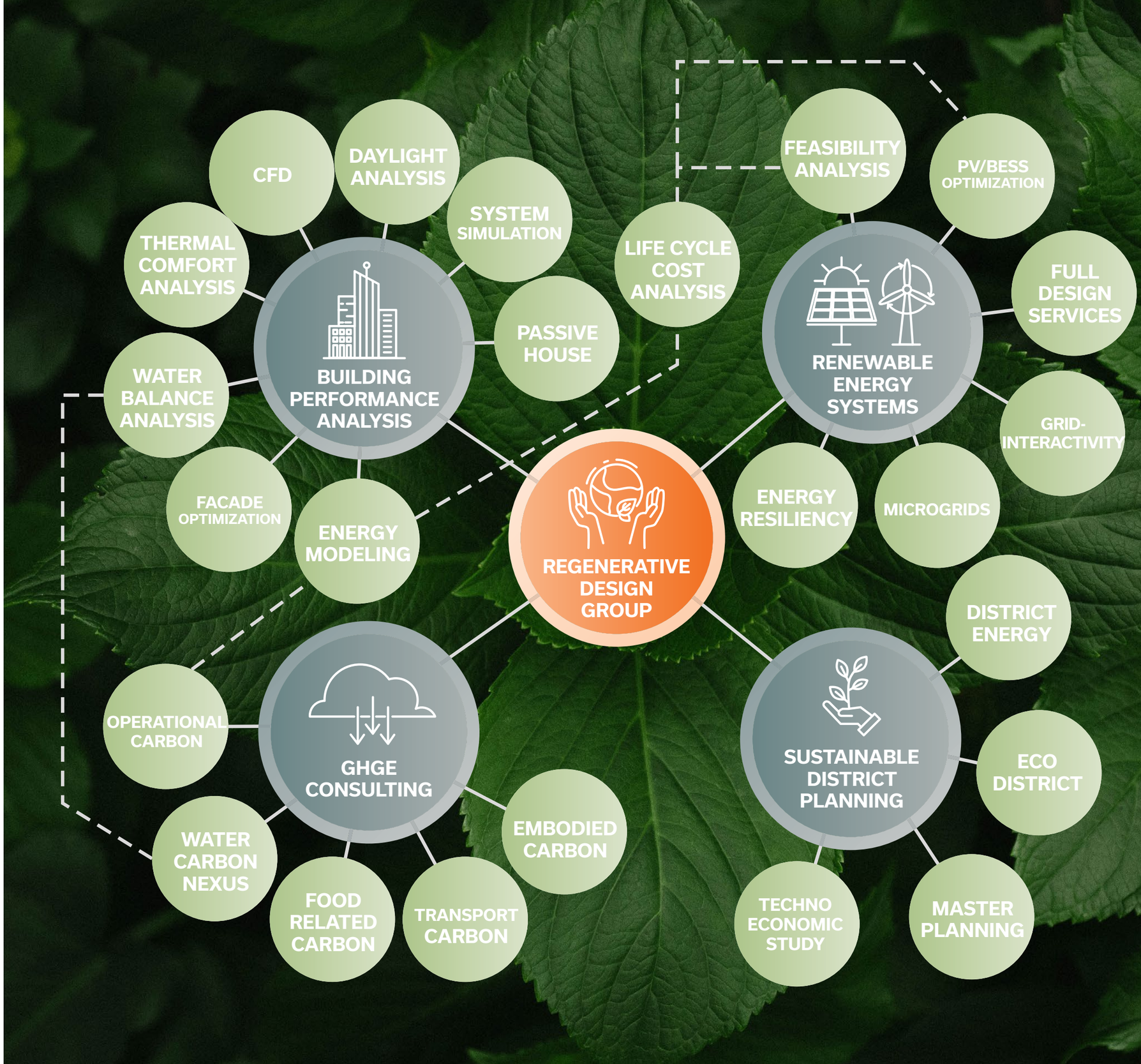
In Action

OUR REGENERATIVE DESIGN SERVICES

Regen optimizes building performance, sustainability, and occupant satisfaction. Our services provide an understanding to the interactions and connections between the architectural design and building systems.

OUR TOOLKIT INCLUDES THE FOLLOWING SERVICES:

- Energy analysis
- Water-cycle analysis
- Envelope and form optimization
- Natural ventilation design
- Computational Fluid Dynamics (CFD) modeling
- Indoor environmental quality, including comfort analysis, wellness, and productivity
- Benchmarking
- Climate-change sensitivity analysis
- Master planning
- Carbon and building portfolio management
- Measurement and verification
- Incentives program assistance
- Energy lifecycle cost analysis
- Building performance audits and retro commissioning



High Performance Façade

The design of the building façade is critical to the success of each project. Not only because it aesthetically defines the character of the building and is an expression of the owner's vision, it also drives long-term performance.

Founder's Hall, Foster School of Business, University of Washington | SEATTLE, WA
Architect: LMN Architects
Rendering courtesy of LMN Architects

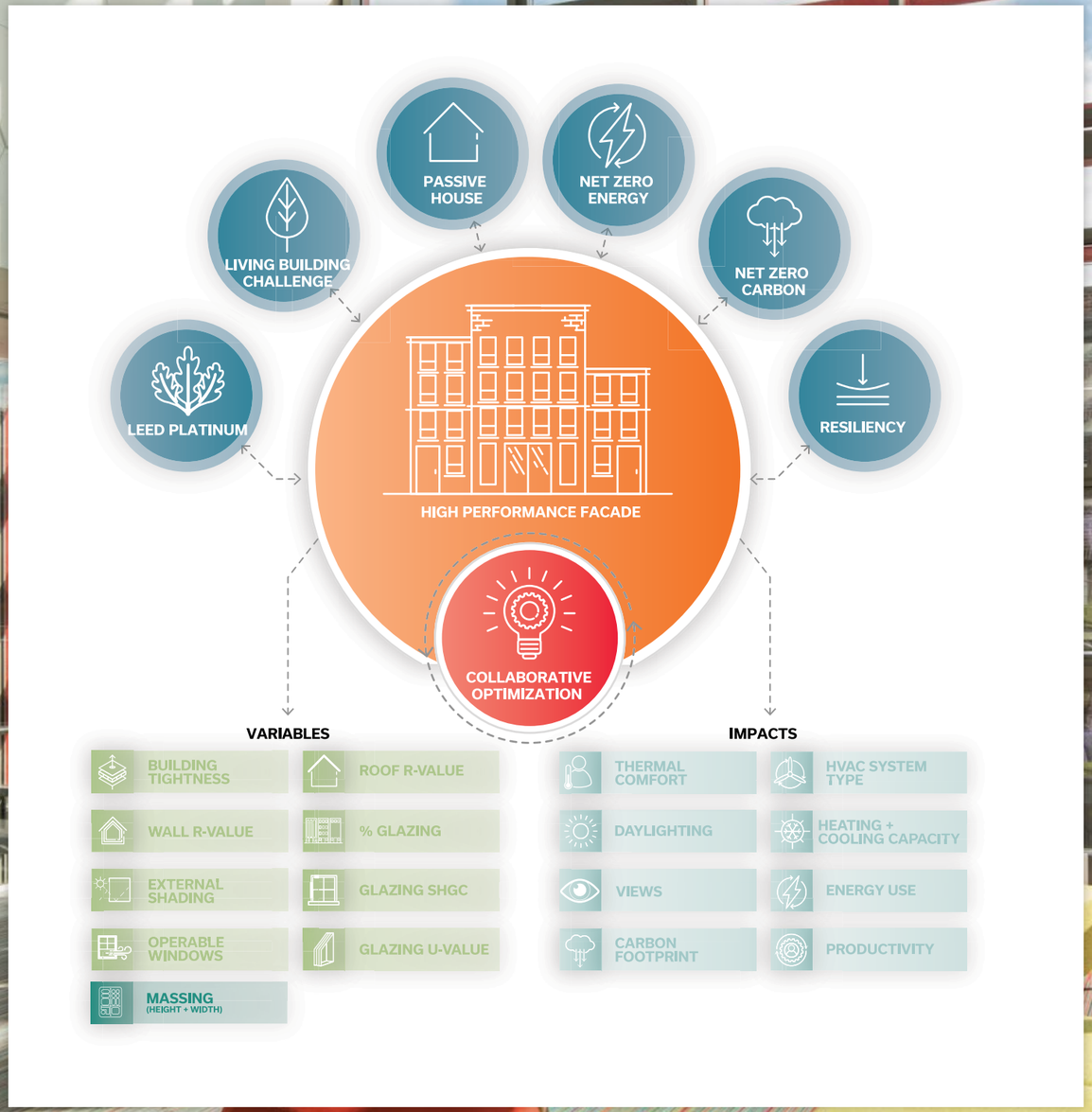
In Depth

The façade plays an integral role in the sustainability of a building. Natural ventilation, daylight harvesting, glare, views, heat loss, heat gain—these all influence the interactions between internal and external environments and play a key role in a building's performance.

Holistic energy modeling through Performance Analysis allows us to capture this complexity and develop façade solutions that maintain architectural character while delivering on energy, daylight, and comfort goals.

A well-designed envelope, integrated with the building mechanical system can not only save energy, it can also increase employee attraction, retention, and productivity by providing improved thermal comfort, daylighting, and connections to the outdoors with views and operable windows.

The façade will often stay in place for the life of the building. Because of this, it has a significant impact on things like energy use, thermal comfort, cost of mechanical systems, and occupant wellness and productivity. PAE will often advocate for more of the project construction budget to be allocated to the envelope. With a larger budget tied into it and the façade influencing even more systems such as HVAC and lighting, it cannot be understated how important it is to spend time early on to analyze and optimize it. Regen offers a critical eye to drivers of percentage of glazing and glazing performance, thermal bridging, building tightness, and external shading strategies. Not only can the end result offer increased occupant comfort and productivity, but it can also drive long-term performance.



Seattle Academy of Arts & Sciences, Cardinal Union Building | SEATTLE, WA
Architect: LMN Architects
Image courtesy of Lara Swimmer

Common Façade Challenges

What is the right balance of percent glazing to provide views and daylighting, while minimizing energy use and increasing thermal comfort?

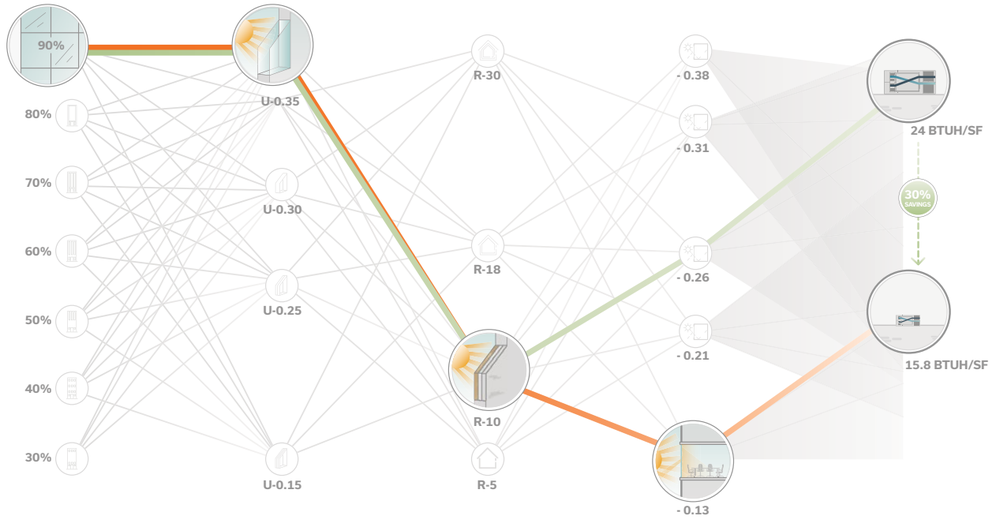
How can we optimize the envelope to be climate-responsive?

How can we design the façade to achieve Passive House standards, or a modified standard to suite our project type or location?

How far do we need to go with the envelope performance to achieve significant reductions in HVAC system heating and cooling capacity, or even eliminate an HVAC system all together?

Parametrics Tool

The Parametric Loads Tool is used to calculate is over 1,500 unique envelope combinations with a single push of a button. An analysis that would historically take weeks now takes merely hours and is presented as an easily digestible interactive dashboard for both technical and non-technical stakeholders.

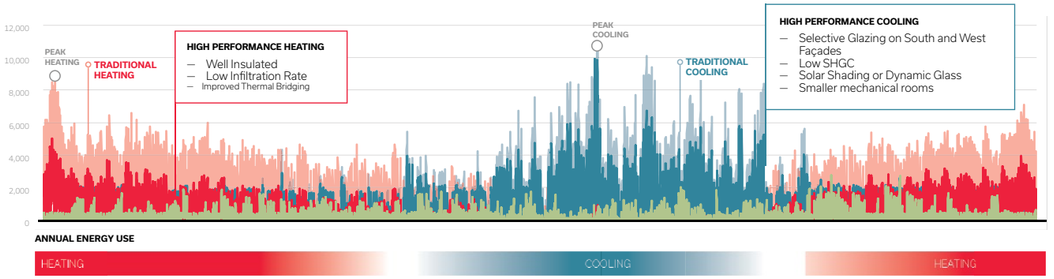


High-Performance Envelope

In traditional design, the peak heating and cooling loads of a building are used to size mechanical equipment with cooling loads dominating. By improving the design of the envelope, we can reduce the peak heating and cooling loads reducing the size or even need for a large and costly mechanical equipment system. Strategies to reduce the peak cooling load include selective glazing areas, low glazing SHGC, shading or solar responsive façades.

In the cooler Pacific Northwest, for example, the majority of energy use for a typical building comes from heating loads so the strategies to reduce heating energy differ from cooling.

In any region, a well-designed envelope directly contributes to spending less energy on occupant comfort, keeping a more consistent indoor temperature. By measuring the peak heating and cooling loads in any given region, we can determine which approach is best for a project.



Pacific Seas Aquarium, Point Defiance Zoo & Aquarium | TACOMA, WA
Architect: EHDD
Image courtesy of Sozinho Imagery

HIGH PERFORMANCE FAÇADE

In Action

Seattle Academy of Arts and Sciences Cardinal Union

LOCATION
Seattle, WA

SIZE
87,000 SF

BENCHMARKS
Pursuing LEED Gold

ARCHITECT
LMN Architects

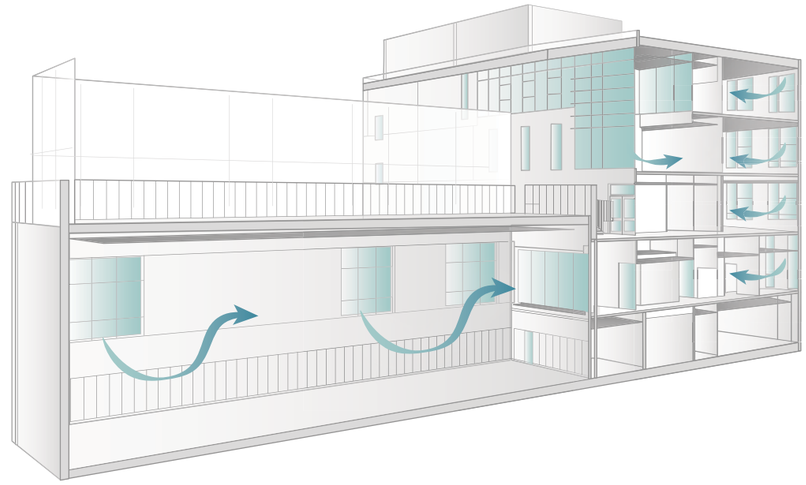
PROJECT GOALS
- EUI of 25 or lower
- 20-35% energy savings over code
- 50% water savings over code

The Cardinal Union Building at SAAS is a new middle school building located in the Capitol Hill neighborhood of Seattle. The new school houses foreign language classrooms, a gymnasium, a rooftop field, and underground parking. PAE set goals early in partnership with LMN Architects to have a passively cooled building for all classrooms. In order to achieve this, predictive future weather files were used to design the envelope and systems to measure how the school could adapt to a warming climate in Seattle.

Seattle Academy of Arts & Sciences, Cardinal Union Building | SEATTLE, WA
Architect: LMN Architects
Image courtesy of Lara Swimmer

Passive Cooling Schematic

The SAAS Cardinal Union building used operable windows and large ceiling fans for natural ventilation and a comfortable occupant temperature.



SAAS: Façades Supporting Passive Cooling

In order to implement a passive cooling system in a large, heavily-used space, the design team relied on predictive weather files to help measure how much cooling would be needed over the life of the building. As a school, it is largely unoccupied during the summer when cooling is most necessary. This helped reduce the need for a building-wide mechanical cooling system, and helped the project reach its goal of a passive system.

"After a year of operation, the teachers raved that they loved being able to open the windows and flush the space when middle school students come back from gym class."

— DANIELLA WAHLER, PROJECT MANAGER

Using a 2050 weather file, the team implemented detailed hourly simulations of thermal comfort in both the classrooms and gymnasium. From there the team worked with LMN Architects to establish glazing performance requirements and shading needs both externally and internally.

Each classroom has manual operable windows for natural ventilation installed with an active transfer system that allows the air from the classrooms to move through corridors up through a central exhaust for cooling. All classroom and other large spaces are equipped with appropriately sized ceiling fans to help air flow. This relieves the need for a large, costly, compressor-based cooling system. The envelope is so well integrated into the air flow of the cooling system that the façade plays a vital role in keeping the building at a comfortable occupant temperature.

All-Electric

All-Electric buildings are a cornerstone in the movement towards reducing the greenhouse gas (GhG) emissions impact of the built environment.

Aegis Living Lake Union | SEATTLE, WA
Architect: Ankrom Moisan
Rendering courtesy of Ankrom Moisan

ALL-ELECTRIC

In Depth

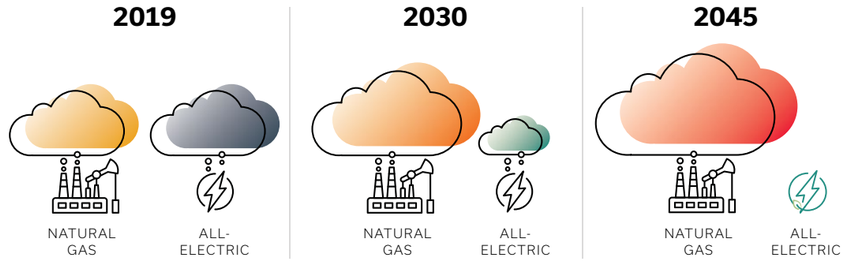
DECARBONIZING ENERGY

The electrification movement is rooted in a concept known as the “greening of the grid.” As a result of the increased adoption of renewable technologies and the retirement of coal, the electricity sector is now on an accelerated path towards becoming a decarbonized energy source. By linking buildings and transportation to this evolution through electrification, they now also have a clear and achievable path for decarbonization.

Alternatively, the other energy option for buildings - natural gas - is the greenhouse gas (GhG), methane. As a fossil fuel, natural gas has locked in emissions and, therefore, itself locks in emissions for any system that uses it. There is increasing data to indicate the emissions impacts of natural gas are higher than currently recorded and even alternate ideas such as Renewable Natural Gas (RNG) will never fully address the problem of emissions for the system lifetime. A shift towards all-electric buildings is the clear path forward.

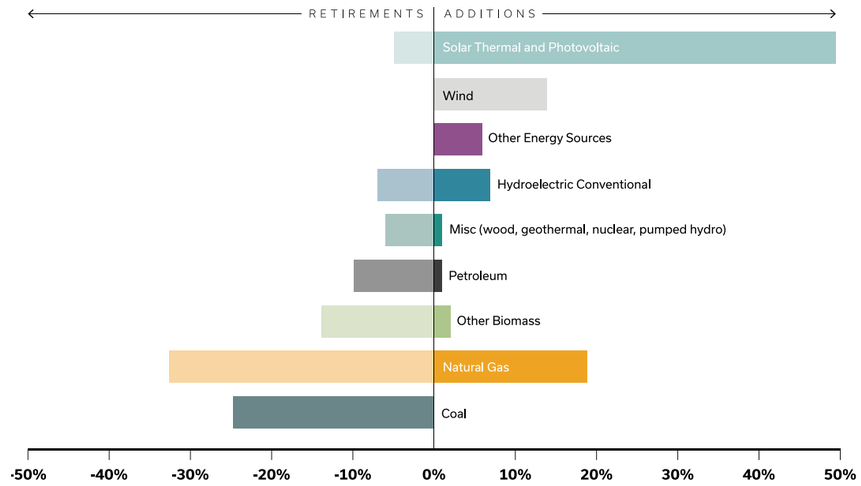
Our Regen group can provide projects with an understanding of the impacts of energy source decisions. A greenhouse gas analysis can quantify the emissions impacts of electric and natural gas systems.

Advancement Toward A Zero Emissions Grid



National Level | **ANTICIPATED GENERATION | 2019-2023**

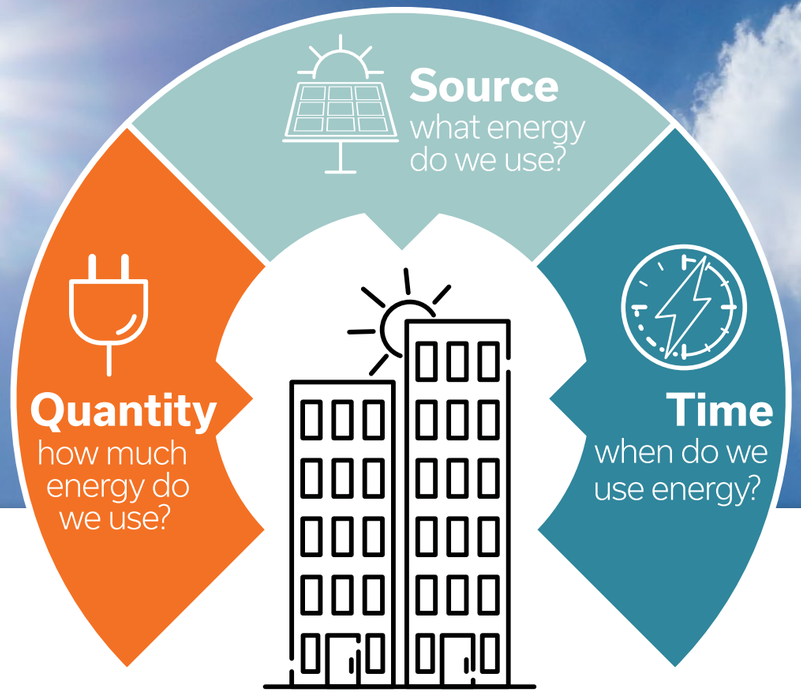
The nation is moving away from fossil fuels and toward an all-electric grid. This shift is expected to increase over the next 10-20 years.



Source: U.S. Energy Information Administration, Form EIA-860, ‘Annual Electric Generator Report.’ These data reflect plans as of December 31, 2018. Other Energy Sources include batteries, hydrogen, purchased steam, sulfur, tire-derived fuels and other miscellaneous energy sources. https://www.eia.gov/electricity/annual/html/epa_04_05.html

On the financial side, an Energy Lifecycle Cost Analysis (ELCCA) can provide information on the lifecycle costs of the two energy sources including impacts from the avoided cost of gas connections, lifetime system replacements, utility incentive programs, and future cost of carbon scenarios.

With this deeper understanding of the environmental and financial considerations of system decisions, projects can identify the best option before starting the design. Fossil fuels are quickly becoming a thing of the past, and it’s clear that all-electric buildings are a plan for our future.



Path Towards Zero Emissions Energy

There are three critical elements needed to decarbonize the electricity sector - renewable generation sources, long and short duration storage, and load flexibility. Renewables and storage often receive the most attention and are perhaps the best understood solutions.

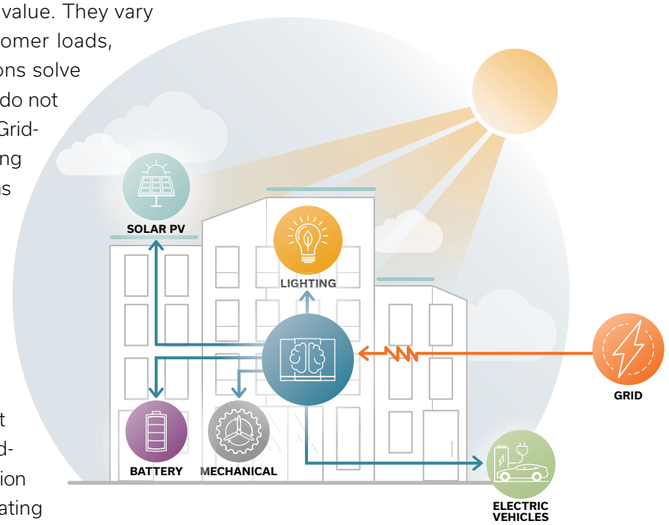
However, the third element - load flexibility - is of equal importance and one of the areas where buildings hold the most potential to enable grid decarbonization. Load flexibility is part of a larger concept known as grid-interactive buildings.

The key idea to this is that buildings are no longer static customers of the grid, but rather active, integrated, and dynamic participants in the operation and ultimate decarbonization of the electricity sector. By reacting to grid signals, buildings can adjust load profiles to better align with times of excess renewable generation and avoid times where zero carbon energy is limited. With smart controls and predictive algorithms, building systems are evolving to automatically adjust to grid signals often with little or no impact to the occupants.

Grid-Interactive Flexibility

The reason grid-interactive systems are crucial to electricity decarbonization is because the grid's emissions are not a static value. They vary over time depending on seasonal factors, customer loads, and weather conditions. Net zero energy solutions solve the energy question on the annual timescale, but do not address monthly, daily, and even hourly variations. Grid-interactive systems work towards optimizing building loads with real-time grid emissions so total emissions and often operating costs are reduced.

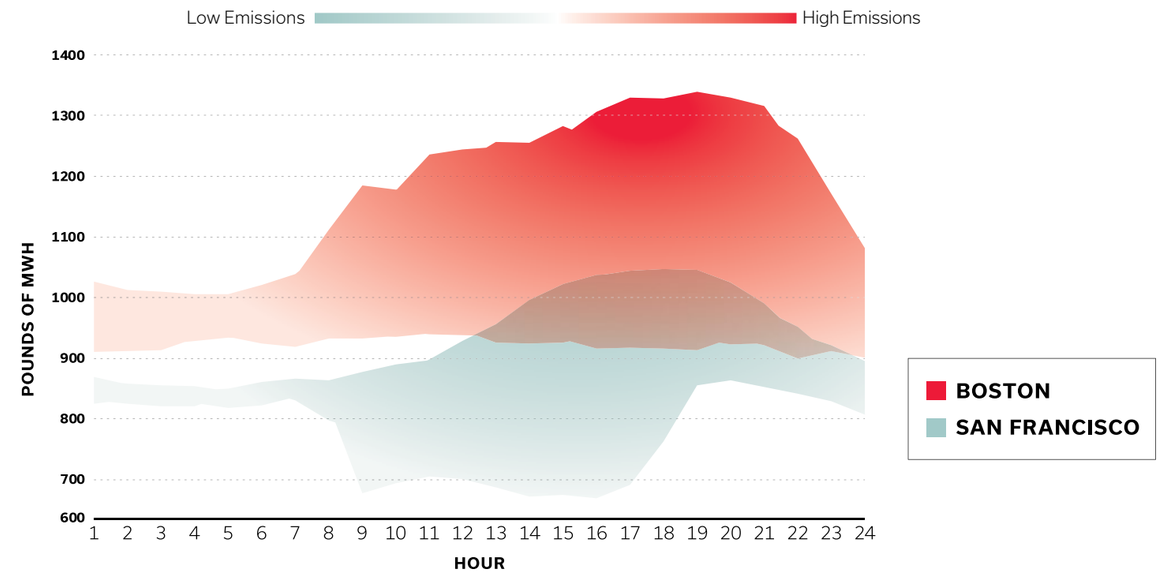
The tools for achieving emissions optimized buildings are familiar solutions - passive building design, onsite renewables, integrated storage, and building system controls - but the sizing and integration is unique to each project. Early performance analysis identifies the best combination of options to create a successful grid-interactive building and outlines the path for integration so the building can strategically reduce both operating emissions and costs.



Hourly Emissions Throughout the Year

Grid emissions vary by season and time of day. Each grid region has a unique time-of-use emissions profile.

Annual Utility Emissions | REGIONAL DIFFERENCE IN ANNUAL TOTALS (POUNDS/MWh)



Source: WattTime

ALL-ELECTRIC

In Action

CityView Plaza

LOCATION
San Jose, CA

SIZE
3.2 million SF

BENCHMARKS
Pursuing LEED Gold
All-Electric

ARCHITECT
Gensler

PROJECT GOALS

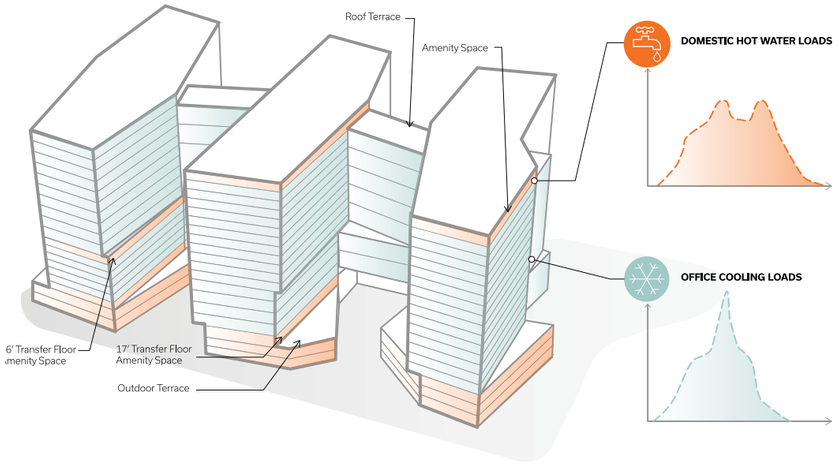
- Climate-responsive design
- Eliminate carbon emissions from building operations
- Comply with the San Jose Green Building Ordinance

This new multi-building development features a mix of commercial offices, parking, and retail space. With high-tech tenants occupying the building, our design allows for extended hours of operation and increased space flexibility.

CityView Plaza | SAN JOSE, CA
Architect: Gensler
Rendering courtesy of Gensler

Heat Recovery Schematic

The heat recovery heat pumps included in the central plant design allows for the recovery of heat from the cooling system and provides high efficiency heating to meet the domestic hot water demand, especially during summer months.



The six towers that make up CityView Plaza each rise 19 stories tall, creating an impressive 3.2 million square feet of office space. Connected by unique bridges punctuated by natural areas, the towers not only look stately on the San Jose, California skyline but they promise to eventually improve the air quality of city by running from all-electric plants. Building carbon emissions are considered a significant factor affecting the overall air quality of cities as well as majorly impacting climate change.

"CityView was a pioneer for large scale all-electric projects. The design proved that large scale all-electric design is achievable in a cost efficient way and as such paved the way for many similar future projects."

— ALPER ERTEN, MECHANICAL ENGINEER

Each of the six towers hold a central all-electric plant with a combination of heat recovery chillers and high-performance air-cooled chillers. By using all-electric systems, CityView Plaza has a direct pathway to eventually eliminating carbon emissions from the building operations and minimizing the carbon footprint of future tenants.

In order to design the most efficient all-electric systems, the design team developed climate responsive strategies from Regen analysis of San Jose. They found a dry, mild to warm climate with comfortable humidity, plenty of sun, and a consistent wind direction, which led to design decisions such as:

- High-performance façade to reduce solar heat gain
- Optimized external solar shading to reduce glare and solar heat gain
- Central plant and system configurations that take advantage of free-cooling opportunities
- Hourly load profile analysis to assess heat recovery opportunities
- Opportunities for natural ventilation based on consistent prevailing wind direction

CityView promises to be one of the largest office complexes not only in San Jose, but in Silicon Valley. By integrating all-electric capabilities into the six towers, the project is setting a precedent for what is achievable for high-performing offices in a competitive tech environment.

Net Zero Energy

Net Zero Energy buildings are the key to meeting global climate commitments, and they are feasible across every geographic region in every sector from new design to building renovations.

Education Center, Oregon Zoo | PORTLAND, OR
Architect: Opsis Architecture
Image courtesy of Fortis Construction and Shane Kucera

NET ZERO ENERGY

In Depth

BALANCING ENERGY EFFICIENCY AND PRODUCTION

PAE has worked on Net Zero Energy buildings in almost all climate zones, from semi-tropical and marine to alpine tundra.

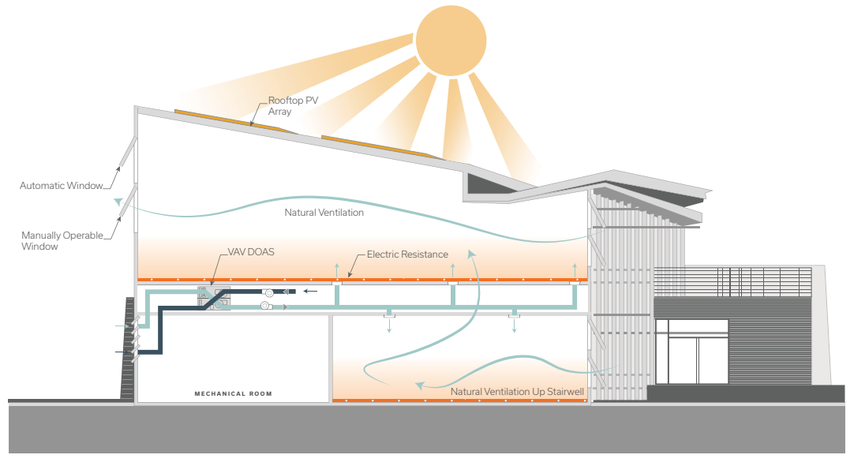
Net Zero Energy (NZE) buildings consume only as much energy as they produce onsite. Two factors contribute to this: producing energy through renewable resources and being highly efficient in how they use the energy.

Net Zero Energy (NZE) buildings consume only as much energy as they produce onsite. Two factors contribute to this: producing energy through renewable resources and being highly efficient in how they use the energy. Performance Analysis can help analyze and determine how to balance the energy efficiency and energy production that is right for each specific building in its environment. The deep analysis done with Regen results in a holistic solution that informs everything from systems and building orientation to glazing and solar sizing while delivering comfort and architectural beauty.

Rocky Mountain Institute Innovation Center | BASALT, CO
Architect: ZGF Architects
Image courtesy of Tim Griffith

Mechanical and Passive Schematic

Schematic diagram for the mechanical and passive systems for Rocky Mountain Institute Innovation Center.



Projects can include offsite solar arrays or wind turbines to achieve a goal of Net Zero Energy.

Inherent challenges encountered in Net Zero design come from things like the thermal comfort of the occupants and the climate that the building is located in. Clearly, a building in an alpine tundra will demand more energy use in terms of heating to keep occupants comfortable, while a semi-tropical climate will demand more cooling. Each climate requires unique systems designs in order to produce energy onsite and use it most efficiently. Taking into consideration the times of day and even year the building will be most heavily utilized can help achieve NZE as well.

Designing for NZE is often misunderstood as a lengthy and costly addition to the design process that complicates the delivery of otherwise high-performing buildings. Complexity isn't necessarily the key, but rather mitigating energy needs across the mechanical, electrical, and plumbing systems. Even small changes can impact the broader energy usage and contribute to this solution.

On a broader level, in order to meet global climate commitments, new buildings and renovations should always aim to be NZE. Surprisingly, this is not as much of a stretch to achieve as many may think, and PAE has shown how this is possible on many of our projects across geographic regions.

NET ZERO ENERGY

In Action

CalSTRS

LOCATION
West Sacramento, CA

SIZE
500,000 SF

BENCHMARKS
Pursuing LEED Platinum
Net Zero Energy
WELL Building

ARCHITECT
ZGF Architects

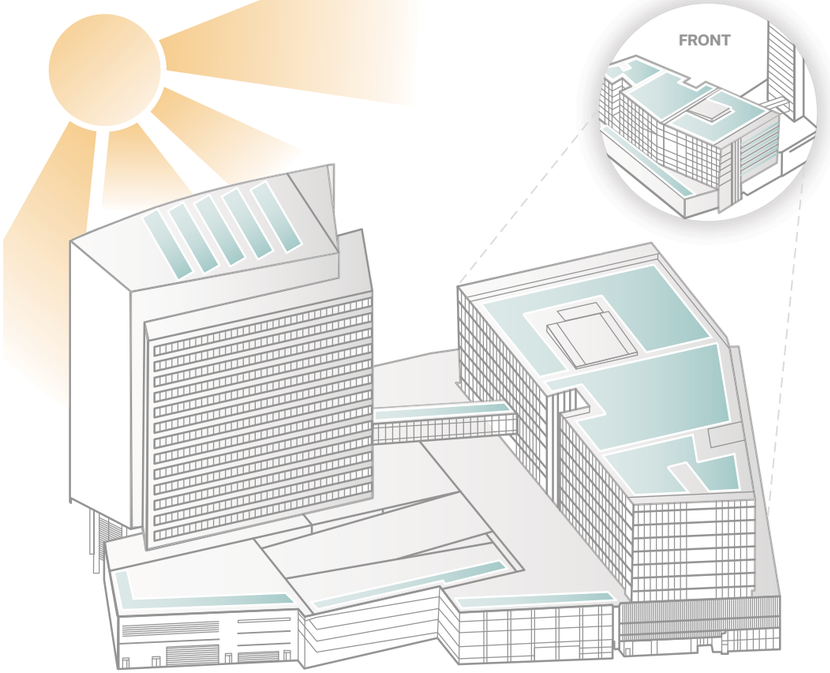
PROJECT GOALS
- Generate electricity onsite
- Zero waste building
- Pursuing Living Building Petal Certification - Materials

This expansion for the California State Teachers' Retirement System (CalSTRS) Headquarters is the world's largest educator-only pension fund, and the expansion will help accommodate the organization's planned growth.

CalSTRS | WEST SACRAMENTO, CA
Architect: ZGF Architects
Rendering courtesy of ZGF Architects

Photovoltaic Array Schematic

Utilizing our Regenerative Analysis in the initial phases of design, PV panels were an integral factor to achieve Net Zero Energy.



The expansion of the California State Teachers' Retirement System (CalSTRS) headquarters demonstrates how important it is for the entire team, owner included, to be dedicated to Net Zero Energy as well as the importance of utilizing Regen in the initial phases of design. For this project, it was core to the owner's values and mission, which led to active participation in thinking creatively and making space for new ideas.

That came into play when thinking about where to put PV panels onsite to reach Net Zero Energy (NZE) on the site. The usual way this is done is on a building's rooftop, but on this site there was no way to get to NZE solely with the roof of their own building. By creatively expanding how the site was defined, the organization was able to think about all the different surfaces around them from bridges and walkways to terraces and parking garages. The approach also invited the opportunity to achieve dual benefits: energy-generating PV panels also offered shade protection for cars, or a covered patio or walkway.

Through Regen, adding PV panels moved from an afterthought in design to an integral part of the system design process. Similar to how designers would not add plumbing halfway through construction, NZE systems must be designed as part of the architecture from day one. By becoming part of the conversation throughout the project the team knows how to account for it in design budget, construction schedule, and more, just like any other system. The willingness to commit to it and treat it like a regular system helps set it up to be successful in achieving aspirational goals.

Zero Carbon

Zero Carbon represents a powerful commitment to sustainability by focusing directly on the mitigation of carbon emissions.

Miller Hull Partnership | SAN DIEGO, CA
Architect: Miller Hull Partnership
Image courtesy of Chipper Hatter

ZERO CARBON

In Depth

WHY ZERO CARBON?

Zero Carbon represents a powerful commitment to sustainability by focusing directly on the mitigation of carbon emissions. Taking a step past Net Zero Energy, Zero Carbon accounts for the climate change impact associated with both energy usage and the built environment. Through analysis the design team is provided with a more holistic picture of carbon emissions for a project and how those emissions can be offset.

THE ZERO CARBON TARGETS ARE:

— Energy efficiency

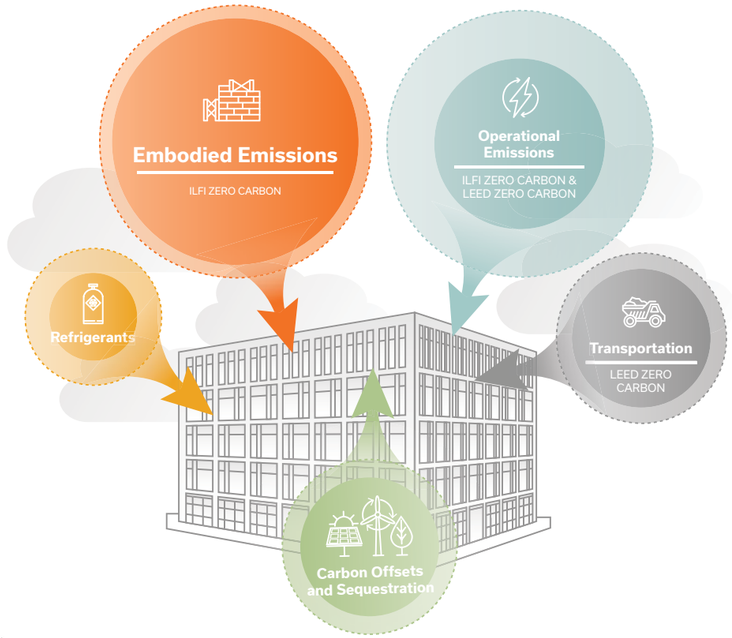
— Renewable energy offsets

— Carbon offsets for all embodied emissions in building materials

PAE is a known leader in carbon emission accounting, providing valuable insights into emissions reductions by utilizing energy modeling, life cycle analysis (LCA) and evaluation of carbon credit offsets. Additionally, PAE has developed proprietary tools to more precisely evaluate a project's actual carbon emissions potential, including local utility carbon emissions accounting and carbon equivalent emissions calculations for refrigerants.

Rocky Mountain Institute Innovation Center | BASALT, CO
Architect: ZGF Architects
Image courtesy of Tim Griffith

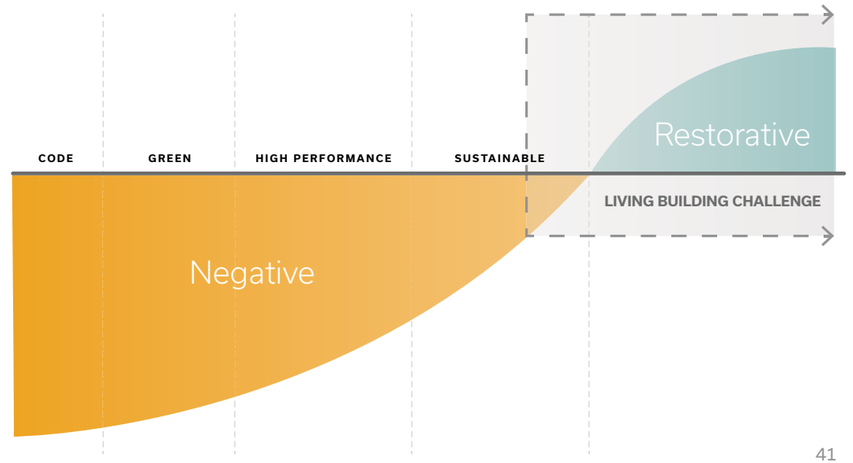
Holistic Carbon Analysis



SOLUTIONS

Environmental Impact

Even the most sustainable buildings have a negative environmental impact in terms of GhG and carbon emissions. A certified Living Building rises above the carbon neutral line to become environmentally restorative.



ZERO CARBON

In Action

The Kendeda Building for Innovative Sustainable Design

LOCATION
Atlanta, GA

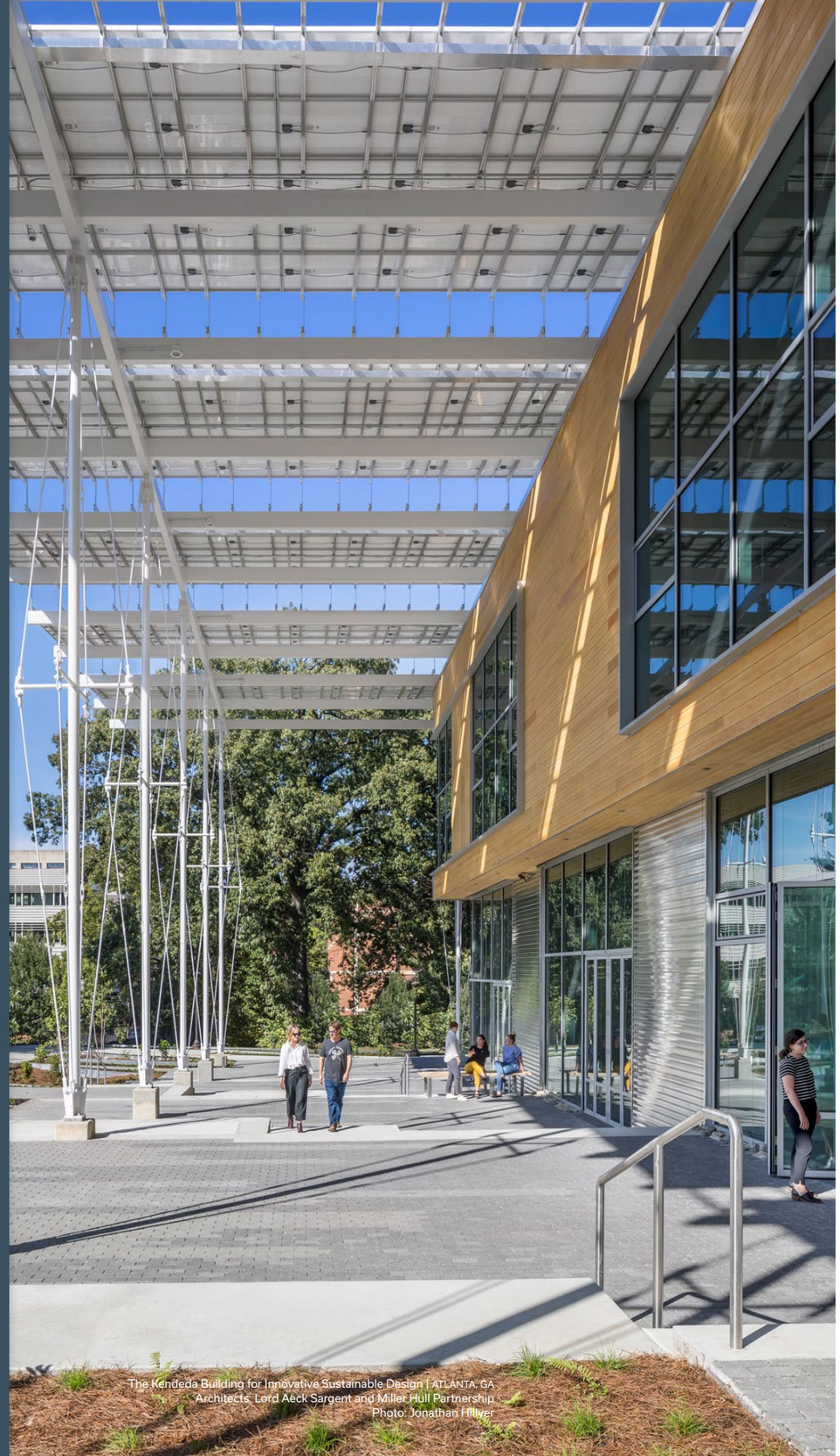
SIZE
42,500 SF

PURSUING BENCHMARKS:
Beyond Net-Zero Energy
Net-Zero Water
Living Building

PROJECT GOALS

- Onsite energy storage
- Rainwater reclamation for potable use
- Composting toilets
- The building will produce 120% of the energy it uses onsite

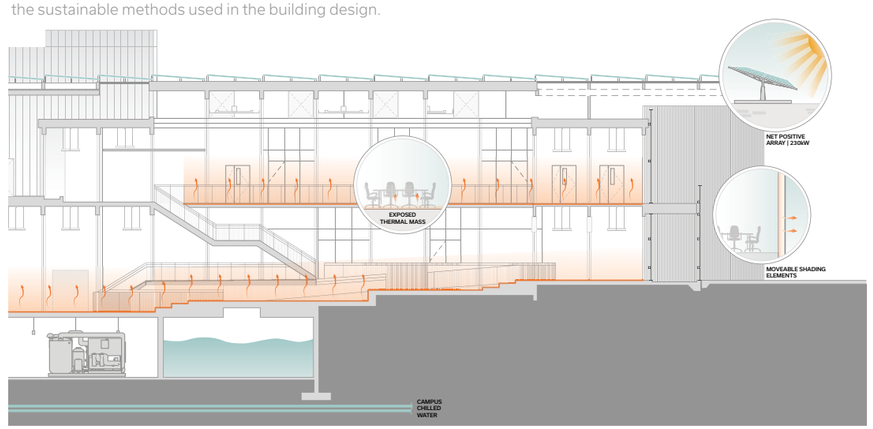
The Kendeda Building for Innovative Sustainable Design will support Georgia Tech's longstanding vision for its campus to serve as an educational center for innovation that transforms future generation. It is the first academic and research building in the Southeast to pursue Living Building Challenge 3.1 certification.



The Kendeda Building for Innovative Sustainable Design | ATLANTA, GA
Architects: Lord Aeck Sargent and Miller Hull Partnership
Photo: Jonathan Hillyer

Sustainability Schematic

Solar panels, radiant flooring, composting toilets, and onsite energy storage are just a few of the sustainable methods used in the building design.



The canopy of the The Kendeda Building for Innovative Sustainable Design is covered in 917 photovoltaic panels, generating 455 megawatt-hours a year. As they shade the sidewalk underneath from the hot Atlanta sun, the panels harvest energy that power the onsite usage. What's more, the building produces 120% of the energy that it uses and nearby buildings will receive its excess energy. The inspiration is taken directly from a natural ecosystem, mimicking how a tree canopy generates energy while also keeping the spaces below cooler. The solar panels also act as rain catchers, angling into gutters which feed a 50,000-gallon cistern in the basement where the water is then treated and used as drinking water and irrigation.

"Through careful analysis and collaboration with the entire design team, we created a building that operates as an integrated, net-positive system in Atlanta's hot and humid climate. It shows that Living Buildings are possible anywhere."

— MARC BRUNE, PROJECT MANAGER

These are just some of the many design achievements that will help the building achieve Net Zero Carbon along with the Living Building Challenge. The 42,500 square foot project is the largest in the southeast United States to pursue the certification, regarded as the most rigorous sustainable achievement for a building. As an academic and research building, the project supports the longstanding vision for Georgia Tech's campus to serve as an educational center for innovation that transforms future generation.

In addition to the PV array and a façade with glazing and shading, the building's sustainable systems include radiant flooring for heating and cooling, on-site energy storage, composting toilets, and campus condenser water heat recovery. Triple-pane windows keep the building warm in winter, while automated blinds reduce heat gain in summer. PAE integrated performance analysis with the architectural design to have the envelope act as the major building system.

Atlanta's climate is hot and humid, presenting an extra challenge to design systems that meet the stringent requirements of the challenge. Analysis and collaboration by the team was critical in designing successful radiant systems for cooling interior spaces, avoiding condensation, and providing superior occupant comfort with low energy output.

The Kendeda Building for Innovative Sustainable Design at Georgia Tech demonstrates the most sustainable building standards possible in the current built environment and proves that Net Zero Energy is feasible even in the most hot and humid climates.

Living Building

The Living Building Challenge is the world's most rigorous proven performance standard for buildings, creating regenerative spaces that are self-sufficient and remain within the resource limits of its site, produce more energy than it uses, and collect and treat all water onsite.

Bullitt Center | SEATTLE, WA
Architect: Miller Hull Partnership
Image courtesy of Nic Lehoux

LIVING BUILDING

In Depth

WHAT IS LIVING BUILDING CHALLENGE?

Living Buildings at their core give as much as they take. They strike an ecological balance with the environment in an attempt to mimic the original ecosystem for a given site, the true definition of sustainability. International Living Future Institute's Living Building Challenge (LBC) is a third party certification program developed to verify a building's "living" status. Recent versions of the LBC have moved beyond achieving equilibrium to requirements for net positive renewable energy, which pushes a building into a carbon negative, or "drawdown" position.

Among third party environmental sustainability certification programs, the LBC program is the only one with a yes/no certification process with no partial credits. In that sense, this certification path is the simplest to understand. However, finding the best path to achieve Living Building status is much more challenging. PAE is able to add the greatest value by leading project teams to identify, analyze, and evaluate all the possible systems and solutions to secure all seven Petals, or performance challenges, to achieve full certification: Place, Water, Energy, Health and Happiness, Materials, Equity, and Beauty. Each Petal is subdivided into a total of 20 imperatives, or requirements, that the building must meet. Finally, certification can only be achieved after the building is operational after twelve consecutive months. The real award is designing a building that achieves long-lasting results and inspires others in development and commercial real estate to do the same.

PAE Living Building | PORTLAND, OR
Architect: ZGF Architects
Rendering courtesy of ZGF Architects

Portland's First Living Building

The PAE Living Building is designed to meet the world's most stringent sustainability standard.

WATER
100% of the building's water demand is collected and treated onsite.

SEISMIC
The structure is designed to the same seismic performance required for hospitals and fire stations.

WORKPLACE
Daylight, views, operable windows, and other biophilic strategies support occupant health, comfort, and productivity.

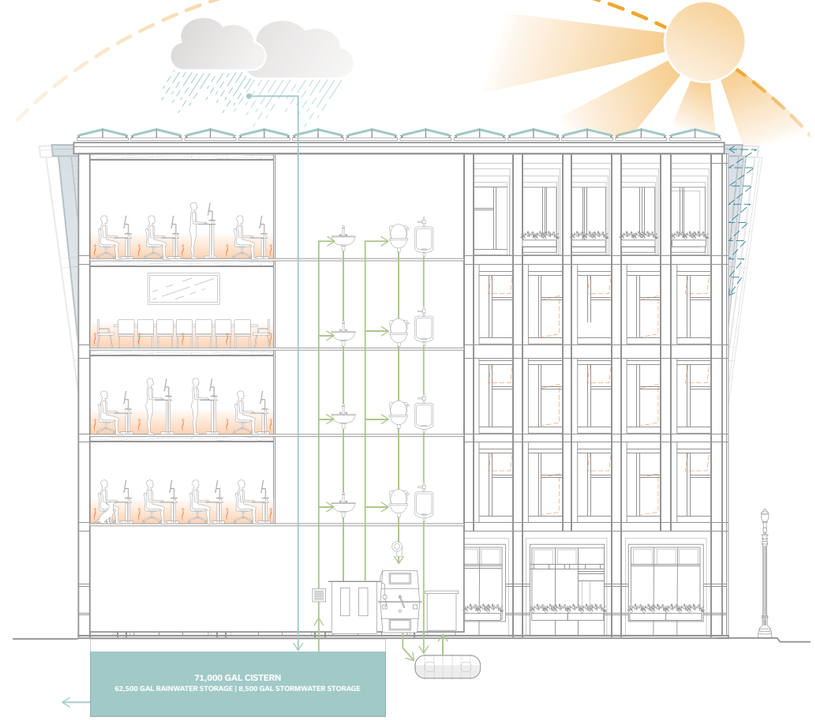
INVESTMENT
First developer-led commercial Living Building proves the business case and creates pathway for others.

MATERIALS
Sustainable and healthy building materials include Pacific Northwest cross-laminated timber certified by the Forest Stewardship Council.

ENERGY
Onsite and dedicated offsite solar, and onsite battery storage enables net positive energy production and connection to city grid.

NUTRIENTS
First-of-its-kind multi-story vacuum-flush composting toilets reduce water use and transform waste into a rich nutrient source.

EQUITY
Energy produced by solar PV will be shared by a local non-profit.



LIVING BUILDING

In Action

PAE Living Building

LOCATION
Portland, OR

SIZE
58,000 SF

PURSUING BENCHMARKS:
Living Building
Net Zero Water
Net Zero Energy
Architecture 2030
WELL

ARCHITECT
ZGF Architects

PROJECT GOALS

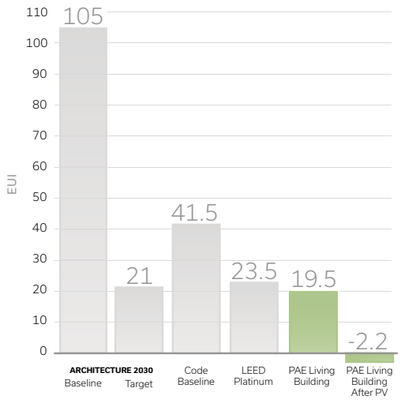
- Help achieve the city's 2050 renewable energy targets 30 years ahead of schedule
- Revitalize and compliment the neighborhood and Historic District
- Replicable, developer-led solution to inspire future living building development

The PAE Living Building tells the story of Portland: aspirational, progressive, and yet deeply rooted in Pacific Northwest history. Designed to last for 500 years, the architectural approach marries the look and feel of a historic neighborhood with the highest possible energy performance and sustainability standards. Inside, healthy materials meet ILFI's Red List requirements, ample daylight, views, operable windows, and other biophilic strategies support to occupant health, comfort, and productivity.

PAE Living Building | PORTLAND, OR
Architect: ZGF Architects
Rendering courtesy of ZGF Architects

Net Positive Energy

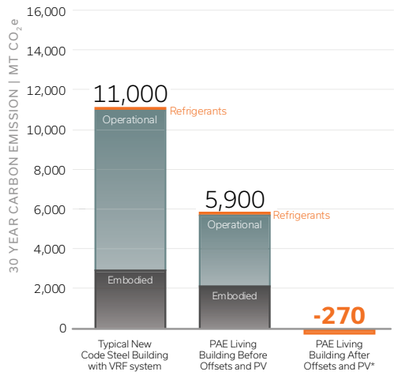
Fossil fuel free



103% GENERATES OF ANNUAL ENERGY NEEDS

Carbon Negative Lifecycle

30 year carbon emissions



110% TOTAL CARBON EMISSION SAVING

** Embodied Carbon Emissions are offset through purchasing carbon credits. Operational emissions are negative because we are generating 105% of the energy through PV and that more than offsets our refrigerant emissions.*

A Living Building is a working demonstration of what is possible: for the built environment, for communities who live in them, and for a better future. A building that achieves Living Building certification must meet all performance imperatives of seven Petals: Place, Water, Energy, Health and Happiness, Materials, Equity, and Beauty. All are equally important, but one notable Petal is the Energy Petal and the analysis used to achieve it.

"Staying true to the spirit of Living Building projects and what they are trying to achieve is actually what drove us think more creatively. The bigger the vision served as our north star when we faced new challenges."

— KARINA HERSHBERG, LEAD ELECTRICAL ENGINEER

To generate all of its own energy with a utility restriction on net-metering, the team needed an innovative approach. A detailed model of the project was built with every aspect of the building's energy use accounted for and then fine-tuned for ultra-high efficiency. The model included the natural energy flows of fresh air and light from the building's windows, and the energy generated by the rooftop PV. A battery storage system was also included and a logic for charging and discharging the battery to work with the utility constraints.

Early modeling showed that by using all faces of the building and extending the roof surface with overhangs, a path for net-positive was possible onsite. Although it was technically feasible, the bold PV design did not meet the city's needs for a building in Portland's historic district. It also left the team with a larger question about sustainability and equity: Did it truly achieve the goals of the project and larger vision?

In the quest to fulfill the mission, part of the solar array is donated to an affordable housing building. The 207 kW of PV reduces operating costs at the REACH Argyle building. By considering the building's place beyond its own footprint, the team was able to turn site limitations into a community opportunity by weaving social responsibility in with environmental sustainability.

Passive House

The design principles of Passive House emphasize durable, resilient solutions that provide efficiency throughout the lifetime of the building. The goal is to maximize the impacts of integrated renewable energy and minimize energy consumption.

Orchards ar Orenco | HILLSBORO, OR
Architect: Ankrom Moisan Architects, William Wilson Architects
Image courtesy of Casey Braugner

PASSIVE HOUSE

In Depth

DESIGNING TO A HIGHER STANDARD OF PERFORMANCE

Passive House is simple in principle: design and build to a higher standard of performance. By optimizing the building envelope, a building can be efficient, quiet, and comfortable without resorting to high-tech gadgetry or upgrading to complicated "active" solutions. The principles of Passive House emphasize durable, resilient solutions that will provide for efficiency throughout the lifetime of the building.

The core elements of Passive House are:

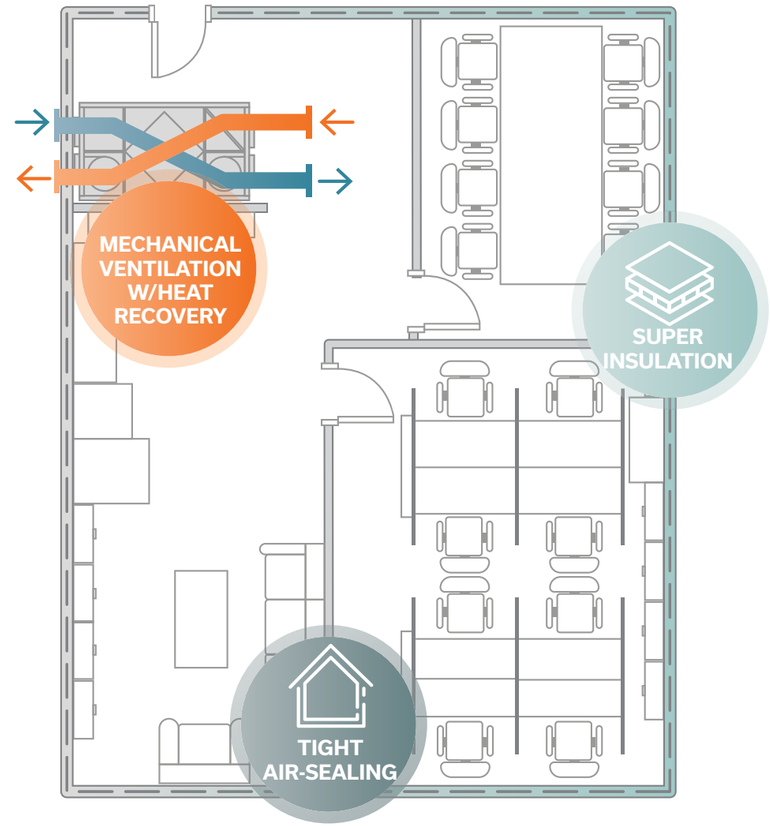
- Continuous building insulation with minimal thermal bridging
- Tight building construction with low air leakage
- Continuous filtered fresh air delivered through heat recovery ventilation
- Reduce energy use to a point where minimal renewable energy is needed to offset building operations

The PHIUS+ certification developed by the Passive House Institute US provides cost-optimized performance targets that minimize source energy and maximize the impact of renewable energy integration. Designing to passive house standards can also improve a project's performance in other sustainability programs, such as LEED, the Living Building Challenge, Zero Energy, and Zero Carbon.

The certification can be daunting to designers without a thorough understanding of thermal performance and load calculations as there is a lot of flexibility in design strategies that can help or hinder passive

The Bush School, Upper School | SEATTLE, WA
Architect: Mithun
Rendering courtesy of Mithun

Principles of Passive House



Energy Efficiency

Thermal Comfort

Improved Indoor Air Quality

design goals: Will be it better to add an extra inch of insulation or improve the heat pump efficiency? Do we need triple pane windows? How critical is the performance of any particular detail?

With in-house Certified Passive House Consultants (CPHCs), PAE adds the greatest value to PHIUS+ certification by evaluating thermal performance of individual components as well as the entire building and facilitating communication with PHIUS. With experience in envelope optimization, PAE is well positioned to assist with envelope design and integration of high efficiency MEP systems. By providing rapid feedback on performance, we help project teams understand the direct impact of different design options and develop a strategy that achieves passive design goals in a way that is cost effective and practical to implement.

PASSIVE HOUSE

In Action

Bush School, Upper School

LOCATION
Seattle, WA

SIZE
20,000 SF

BENCHMARKS:
Passive House
PHIUS 2018+
20 by 2020 Building Challenge
ILFI Zero Energy
Salmon Safe

ARCHITECT
Mithun

SERVICES
Mechanical Engineering
Electrical Engineering
Passive House Consulting
Architectural Lighting

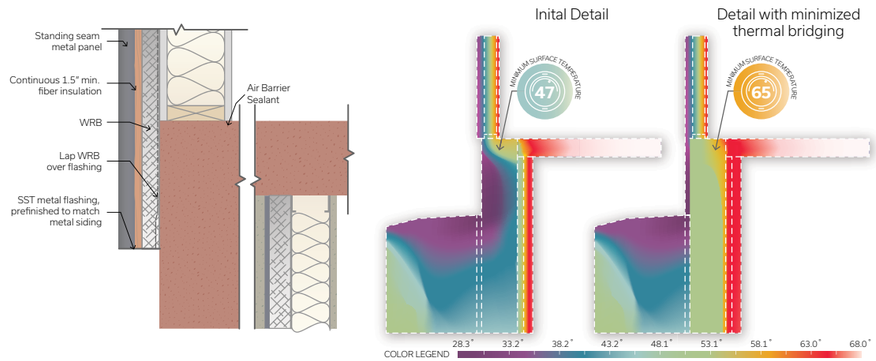
PROJECT GOALS

- Projected EUI of 23 compared to typical EUI of 48.5 for schools
- Energy savings of 73% from code baseline
- Dedicated Outside Air System (DOAS) with heat recovery
- Air-to-water heat pump with electric boiler backup
- Passive heating and cooling help the building stay energy efficient and improve thermal comfort
- Large windows offer an abundance of natural light, ventilation, foster a sense of connection to the outdoors, and add a learning component through operability
- Outdoor learning laboratory adds hands-on learning component for the students
- Rooftop photovoltaic solar panel array

The Bush School, Upper School | SEATTLE, WA
Architect: Mithun
Rendering courtesy of Mithun

Lasting Performance

Leveraging passive house techniques to improve the classroom experience.



Thermal Envelope Analysis

The Bush School, Upper School will become the largest Passive House school on the West Coast. A true learning laboratory, this 20,000 square-foot educational building includes classrooms, workrooms and multipurpose space, study lounges, administrative areas, and kitchenettes.

After reviewing many certification options, the design team chose Passive House as a means toward a low energy and low carbon goal. As a commercial building with high occupancy loads, the Passive House design strategies for a school had to shift beyond the typical concerns of airtightness, insulation, and minimal thermal bridging to include optimization for thermal comfort and occupant wellness.

The Regenerative team evaluated many options of balancing envelope performance with high efficiency mechanical, electrical, and plumbing systems utilizing passive cooling and ventilation strategies. The systems recovery waste heat and also incorporate a stormwater system. Energy efficiency was evaluated with additional consideration for solutions with low embodied carbon. The building also maximizes natural light and utilizes healthy materials.

"By applying the principles of Passive House, we were able to maximize the efficiency of the building envelope, which improves the resiliency and longevity of the design. This building will provide a healthy, comfortable, and sustainable space for years to come."

— DAN LUDDY, PAE PASSIVE HOUSE CONSULTANT

Working extensively with Mithun, the architectural partner, the team identified key, high-performance goals needed for Passive House and labeled them in order to protect them. They did this by naming the sustainability features as "protected resources" and marked them as allocations during the project design and value engineering process. Thus, the features could not be sacrificed in any way and they were not only kept, but also honored throughout the life of the project.

Throughout the process, the Regenerative team educated the design team and contractor on managing unrealistic cost estimates. This demonstrated that an innovative project could pencil out proving that sustainability, functionality, and beauty could be achieved cost effectively. In fact, the same methodology used for the school can be replicated within the development community for any project type to enable the building and advancement of more Passive House and high-performance projects.

PAE

Creating a better environment

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Portland, OR 97204

SAN FRANCISCO

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San Francisco, CA 94105

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Los Angeles, CA 90045

SEATTLE

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Seattle, WA 98122

EUGENE

44 W Broadway, Suite 430

Eugene, OR 97401

SPOKANE

520 West Main Avenue, Suite 202

Spokane, WA 99201