

# High Performance Design



Tinkham Veale University Center  
Case Western Reserve University  
Architect: Perkins+Will  
Photo, © James Steinkamp, Steinkamp Photography

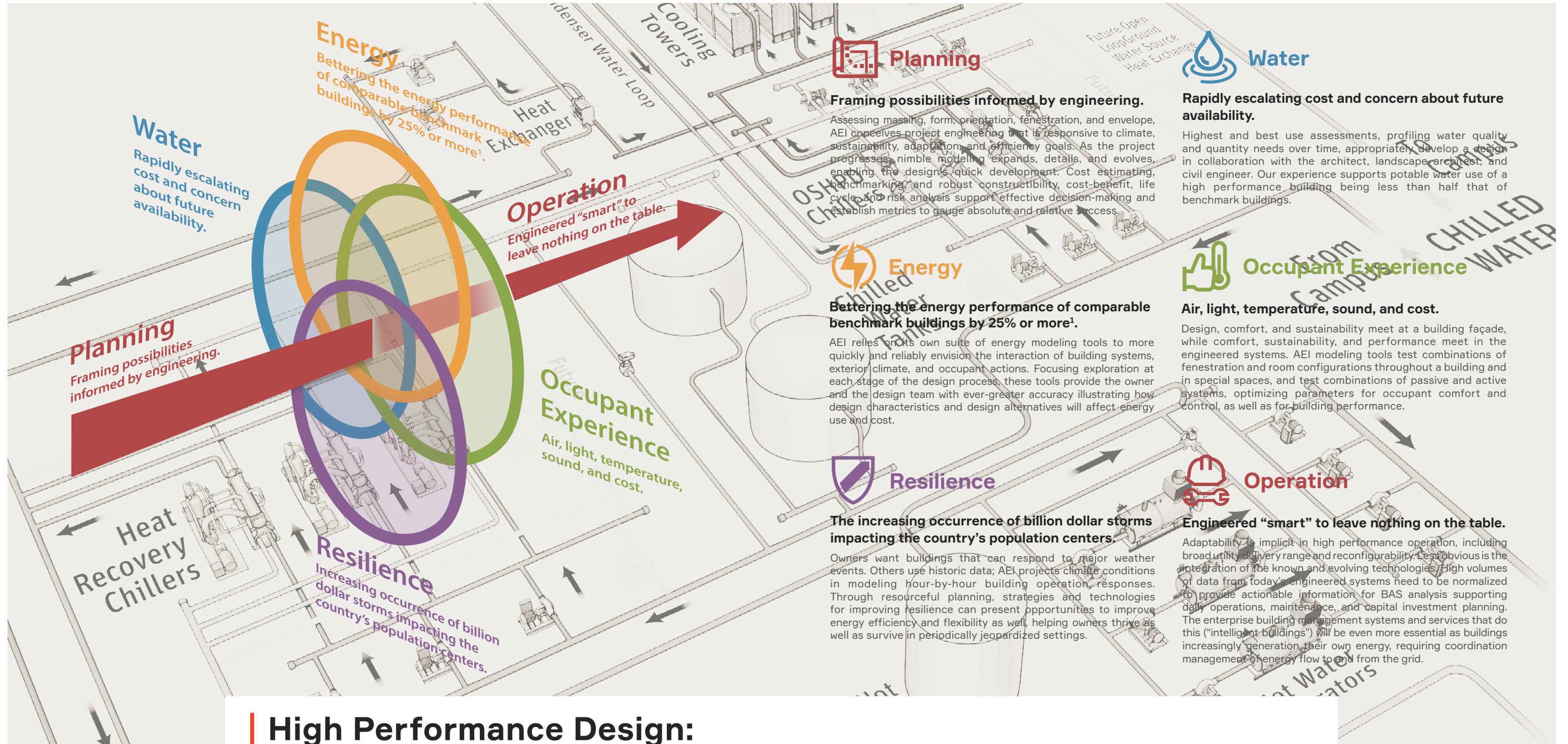


**AEI** Affiliated Engineers®

## **| Total Optimization for the life of the Facility**

At AEI, we believe that a high performance design addresses each stage of a building's life cycle through an approach that integrates planning and design. It establishes a suite of performance goals – looking to optimize use of energy and water, achieve excellence in occupant experience, mitigate climate impacts while adapting to climate change, provide for durability and flexibility, and be cost-effective. These goals are tested through dialogue and exploration and by using the metrics provided through our tools, such as building energy and water modeling, life cycle cost analysis, and risk analysis.

AEI's largest markets – Science + Technology, Healthcare, and Energy & Utilities – are those that demand the greatest rigor in the pursuit of high performance design. The goals are the same as they ever were, but the technology is better, the process is stronger, and the standards are much higher.



# High Performance Design: An Introduction

High Performance Design integrates the fundamental sustainable attributes of building design and applies their consideration across the life of the building, with energy use reduction as the key driver. AEI brings to this creative process its expertise in energy, water, occupant comfort, and resilience.

The projects profiled here illustrate our methods and techniques integrating energy and water efficiency, resilience, and user experience into high performing buildings, and optimizing their ongoing operations.

<sup>1</sup>US Department of Energy and National Institute of Standards and Technology definition of high performance buildings.



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## Stanford Energy System Innovations

Completion Date  
2015

Owner  
Stanford University

Location  
Palo Alto, California

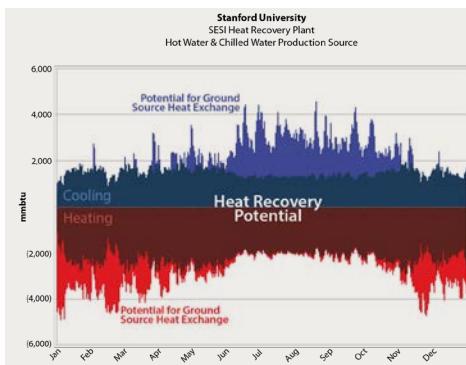
Gross Sq. Ft.  
17.3 M, campus and medical center

Design Architect  
ZGF Architects (Central Energy Facility)



As advisor to Stanford University on its 2009 Energy and Climate Action Plan, AEI then worked with the university to analyze energy production options, evaluate capital and operating costs, and assess financial and energy risk through 2050. From this the AEI-designed Stanford Energy System Innovation project was born. The Stanford Energy Center (peak load of 28,000 ton cooling, 250 mmbtu/hr heating) uses heat recovery chillers that - along with standard chillers and gas-fired hot water generators - capitalize on daily heating and cooling overlap to heat the campus and university hospital with recovered energy. Two million gallons of hot water and ten million gallons of chilled water Thermal Energy Storage accommodate high demand periods. A new 80 MVA, N+1, 60kV-12.47 substation will allow flexible future management of Stanford's energy supply platform. Conversion from steam to hot water includes district energy heat exchanger stations at nearly 200 buildings and over 20 miles of a direct buried low loss hot water piping system.

As a beacon to the system it represents, the SESI operations building is designed to be net zero energy ready.

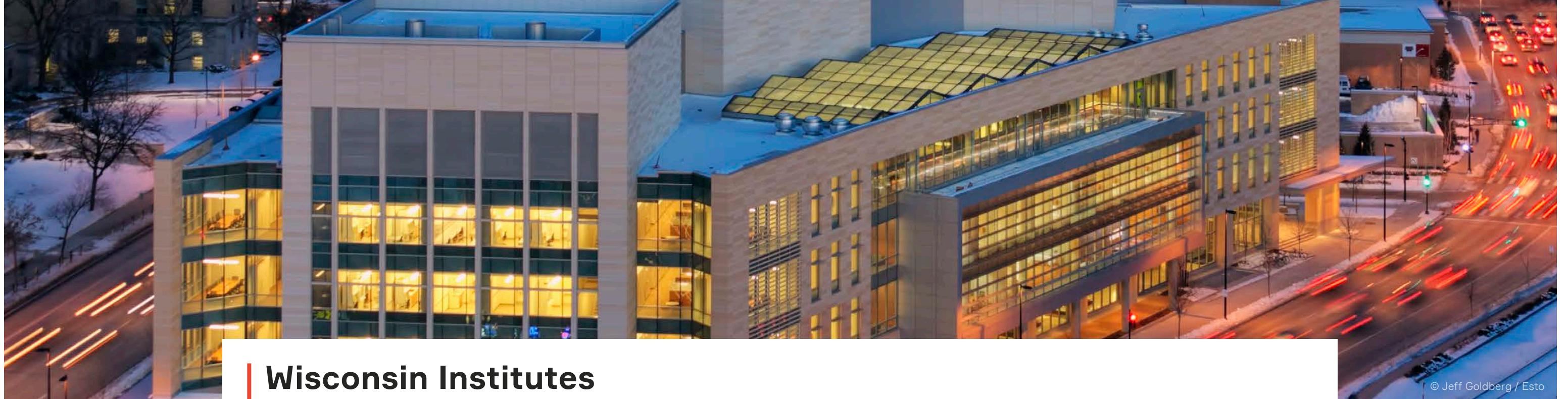


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**Heat recovery system: 70% gain on energy efficiency, reduces campus greenhouse gas emissions by 68%, and campus water use by 15%.**



2015 © Matthew G. Anderson



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## Wisconsin Institutes for Discovery

Completion Date  
2010

Owner  
University of Wisconsin and  
Wisconsin Alumni Research Foundation

Location  
Madison, Wisconsin

Gross Sq. Ft.  
300,000

Design Architect  
Ballinger

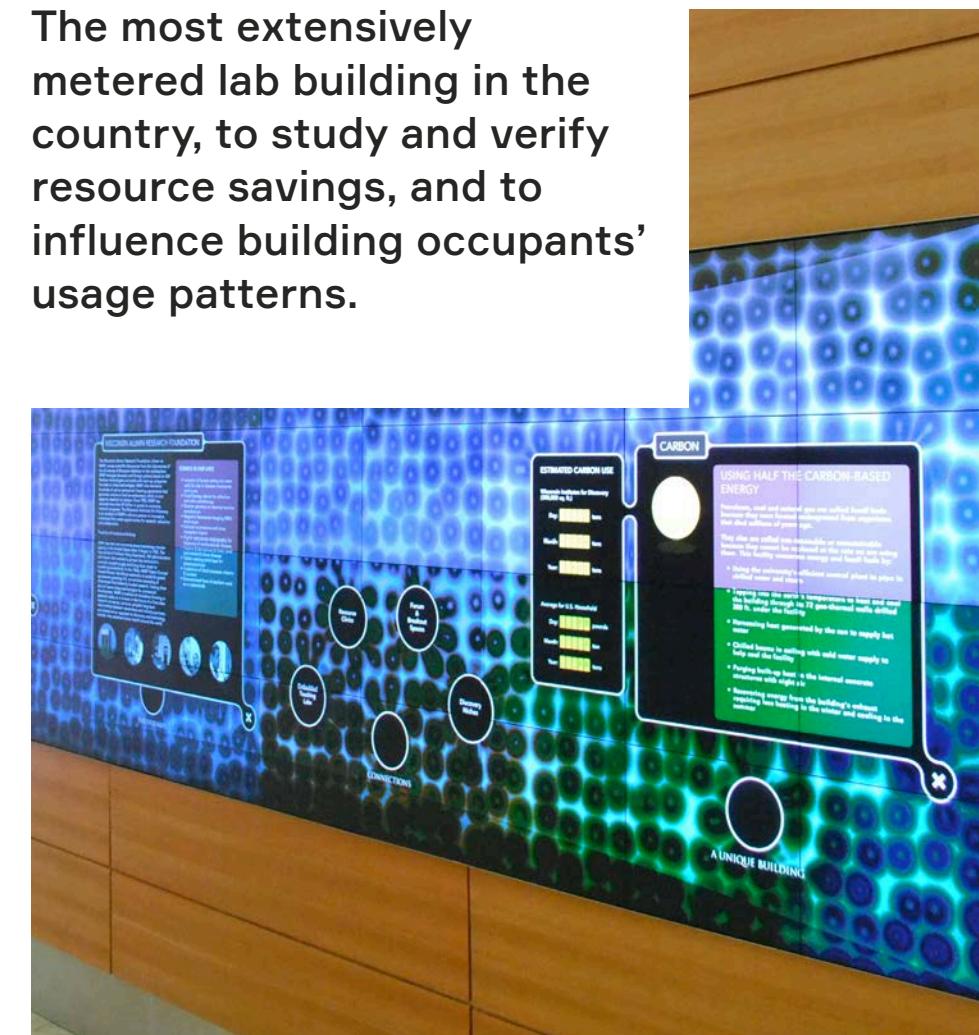
Architect of Record  
Uihlein Wilson Architects

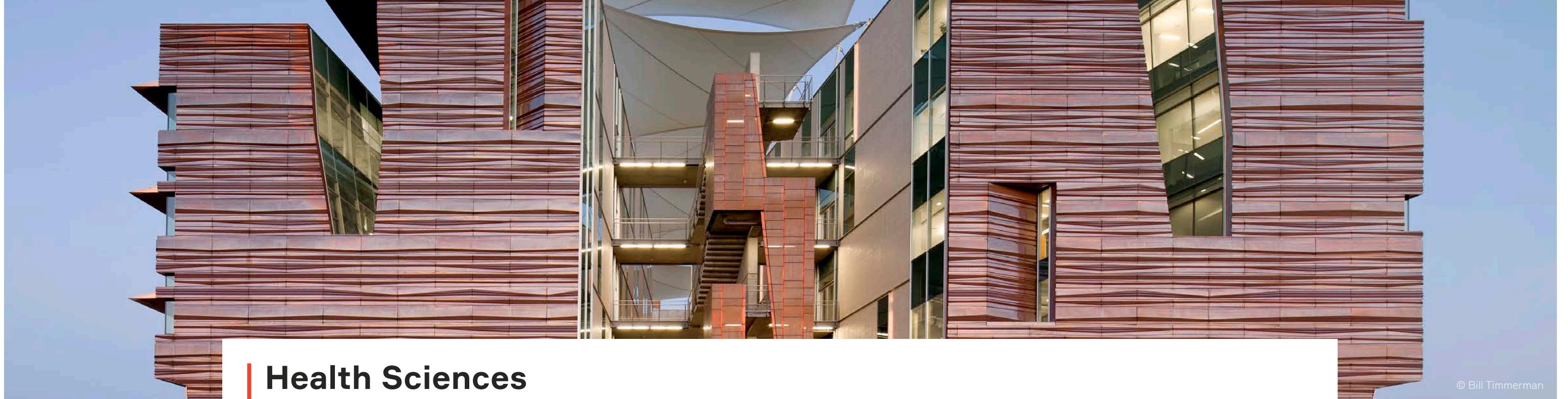
Certification  
LEED® Gold

Providing for the independent and collaborative translational and multidisciplinary research of two entities, the Wisconsin Institutes for Discovery has the most extensive metering and recording capability of any large lab building in the country. With a chilled beam system, heat wheel energy recovery, night flush cooling and ventilation, and energy efficient lighting and daylighting, the building's energy performance is 180 kBtu/gsf/yr. Intelligent Building systems integration provides for ease of management through a single access point for all controls, also monitoring the effectiveness of the building's sustainability features, HVAC system use, lab equipment monitoring, and the interaction of building systems. Public interfaces throughout the open ground floor draw from the Intelligent Building architecture to document building performance and resource use, providing informational content to the general public and impacting the behavior of building occupants.



**The most extensively  
metered lab building in the  
country, to study and verify  
resource savings, and to  
influence building occupants'  
usage patterns.**





© Bill Timmerman

## Health Sciences Education Building

Completion Date  
2012

Owner  
University of Arizona

Location  
Phoenix, Arizona

Gross Sq. Ft.  
268,000

Design Architect  
CO architects

Associate Architect  
Ayers Saint Gross

Certification  
LEED® Silver

Extensive orientation and massing analysis and energy modeling for the University of Arizona/Northern Arizona University Health Sciences Education Building helped create a high performance laboratory building that integrates indoor and outdoor environments in the desert climate of urban Phoenix. Two north-south wings are slotted to provide daylighting without direct east or west solar gain. A copper façade screen protects the building from direct exposure to sunlight and provides a ventilated air cavity. The central canyon created by the two wings is topped by a shading scrim and cooled with reclaimed relief air from the mechanical systems. Burnished concrete block provides reflectivity as well as cool thermal mass. Modeled energy use reduction strategies including distributed HVAC systems contribute to 22% reduction (28% cost savings) compared to the ASHRAE 90.1 standard.



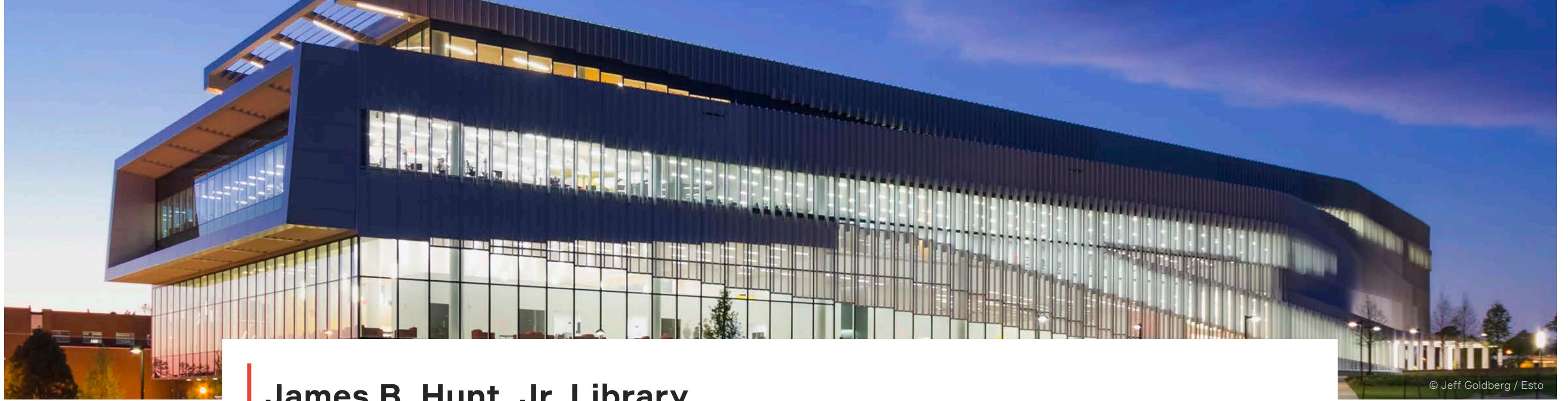
**“One of the most beautiful labs in the world”<sup>1</sup>  
– also one of the most astute.**

<sup>1</sup>Gizmodo



© Bill Timmerman





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## James B. Hunt, Jr. Library

Completion Date  
2013

Owner  
North Carolina State University

Location  
Raleigh, North Carolina

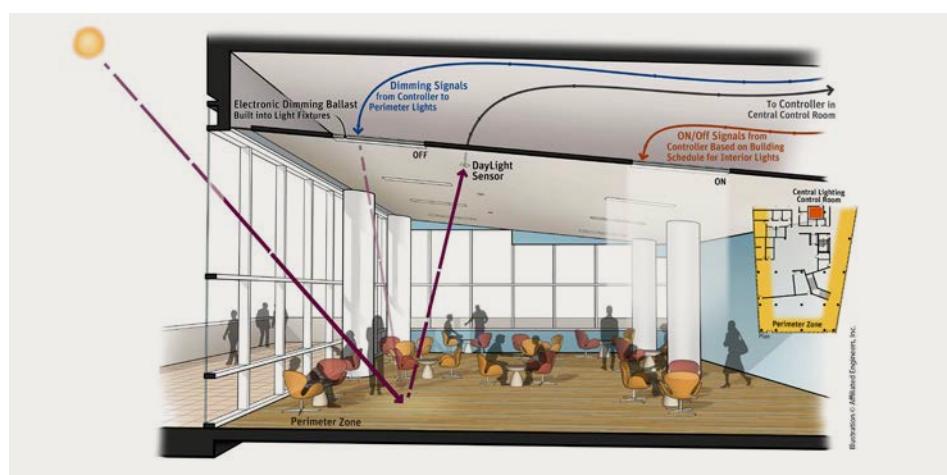
Gross Sq. Ft.  
264,000

Design Architect  
Snøhetta, Pearce Brinkley

Architect of Record  
Cease + Lee

Certification  
LEED® Silver

A paradigm-changing platform integrating informational and social infrastructures, the James B. Hunt Library operates up to twenty hours a day at the heart of North Carolina State University's sustainability-focused Centennial Campus. Optimizing space for physical comfort and intellectual stimulation, the design maximizes views and ambient natural light with multi-story expanses of exterior glass. AEI worked iteratively, modeling designs of the 800-fin, fritted-glass shading system to realize aesthetic intent while reducing heat gain. Efficiently, primary heating is supplied at the building's perimeter with radiant heat, and ceilings in multi-height spaces are fitted with radiant cooling panels. Notwithstanding, AEI's computational fluid dynamics analysis showed the building to be capable of adjusting from unoccupied to full capacity status within five minutes. An AIA/ALA Library Building Award winner in 2013, Hunt Library is engineered to provide approximately 30% energy savings.



**Highly efficient, highly responsive to occupancy levels.**



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Steve Hall © Hedrich Blessing

## UW Health at the American Center

Completion Date  
2015

Owner  
University of Wisconsin Hospital & Clinics

Location  
Madison, Wisconsin

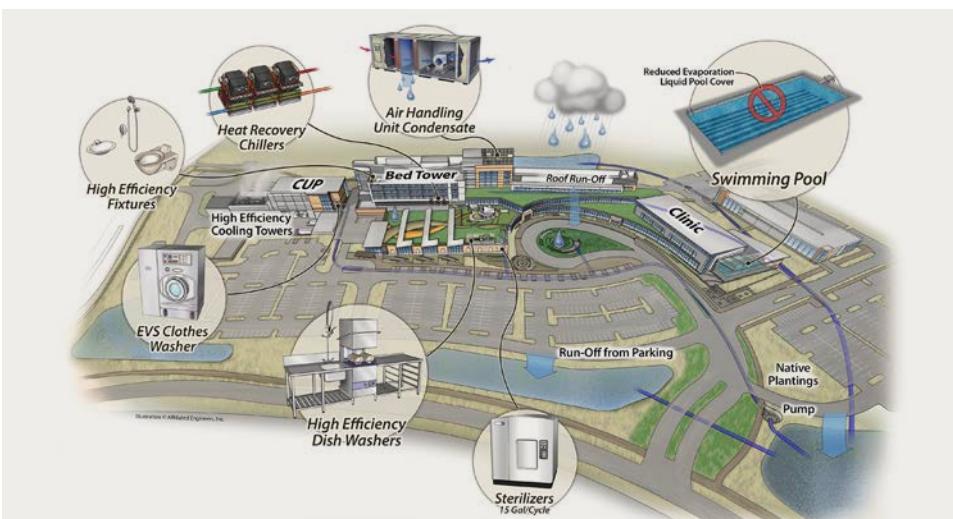
Gross Sq. Ft.  
498,000

Design Architect  
Stantec

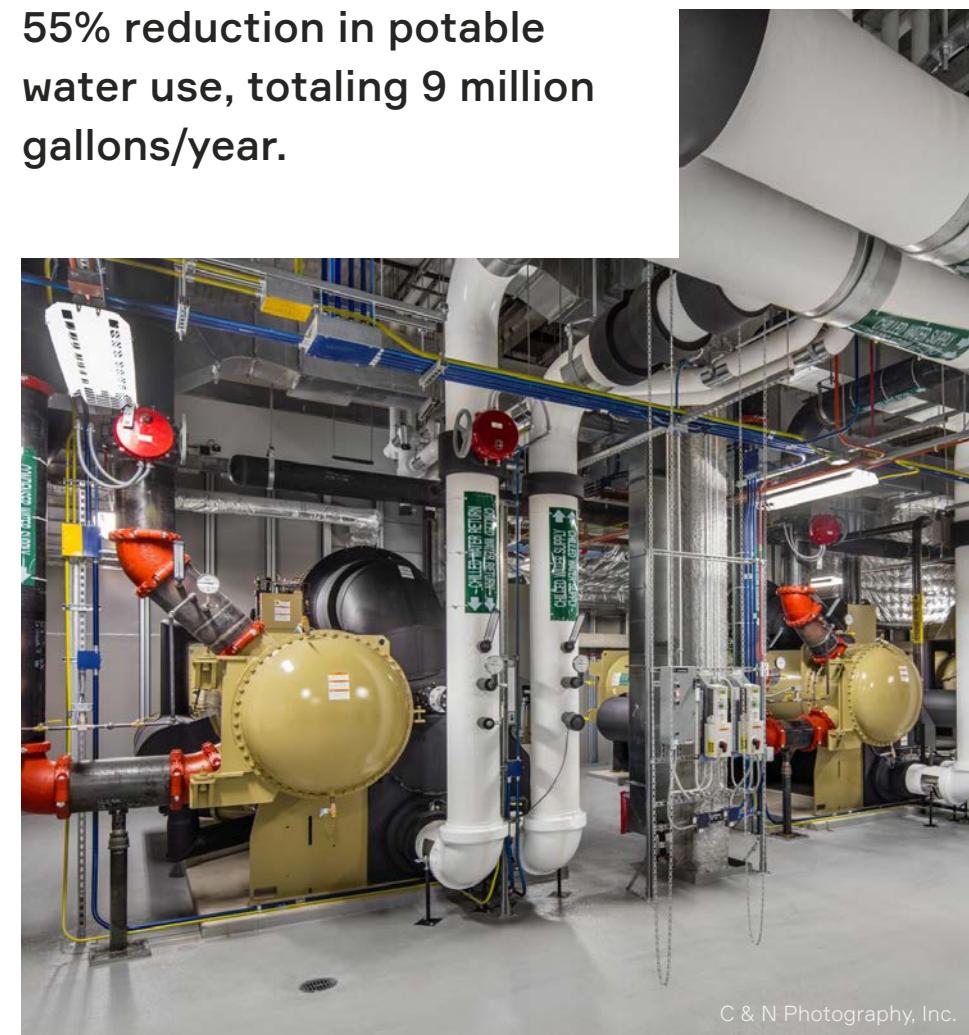
Architect of Record  
Flad Architects

Certification  
LEED® Gold

AEI engaged the integrated project team for this new hospital campus in applying a water hierarchy to the design approach, responding to the regional need to arrest groundwater depletion, and the local municipality's goal of reducing per capita water use. Despite modest local water utility costs, each innovation makes financial sense. Orientation, massing, and design reduce energy load, rightsizing building mechanical systems and selection of efficient equipment reduce water use, and water reuse is designed into the system. Base heating and cooling rely on heat recovery chillers, reducing energy demand 8% and, because heat recovery systems don't reject heat, reducing annual water by 1.3 million gallons. Connected ponds allow reuse of over 6 million gallons of water/year, supplying 80% of cooling tower and landscape needs. The facility's greywater need requires only 60% of captured air handling condensate and site rainwater.



**55% reduction in potable water use, totaling 9 million gallons/year.**



C & N Photography, Inc.



©2011 Mike Rebholz

## Green Technology Training and Enterprise Center

Completion Date  
2011

Owner  
Village of Plain

Location  
Plain, Wisconsin

Gross Sq. Ft.  
21,000

Design Architect  
Epstein Uhen Architects, Inc.

Certification  
LEED® Gold



Combining established sustainable technologies in an effective holistic system of planning and design, the 11,000 sf Green Technology Training and Enterprise Center in semi-rural Plain, Wisconsin, may be the least expensive net zero-ready commercial building in the U.S. to date. Significantly reducing energy loads through optimal building massing, a high-performance envelope, 1,800 hours/year of natural ventilation, and high-efficiency lighting and daylight harvesting made radiant heating and cooling and a 14-well geoexchange field feasible in a climate that ranges from 93°F to -26°F. A practical demonstration of sustainable design for local industries, the facility is used for training local workers in green technologies. Benefiting from modeling-based performance verification and controls sequencing, the building's first three years of metered operation achieved an annual EUI of 33 kBtu/gsf and WUI of 1.2 gallons/gsf.

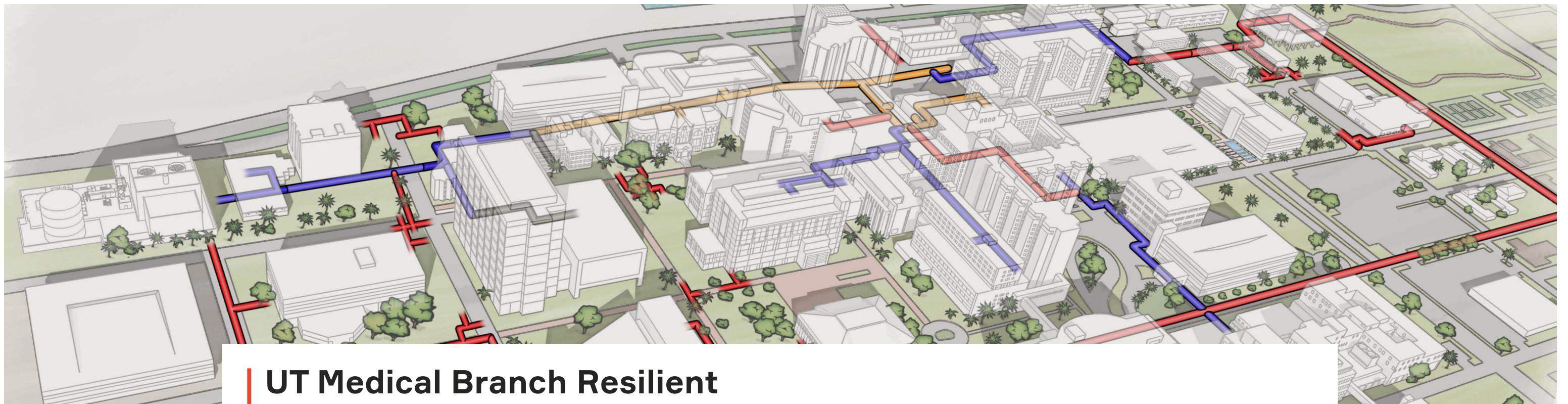


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**Net zero-ready commercial building for \$209/gsf project cost.**



17



## UT Medical Branch Resilient Campus Infrastructure

Completion Date  
2017

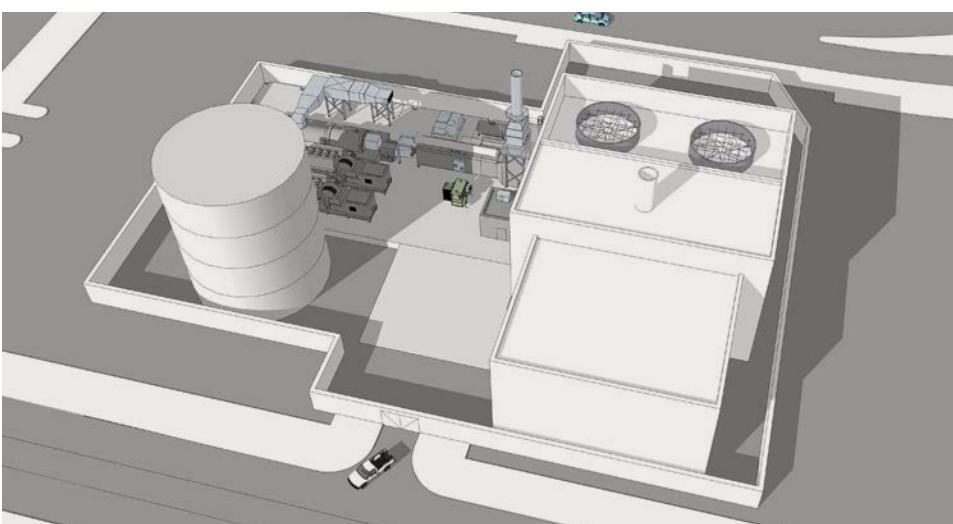
Owner  
The University of Texas System

Location  
Galveston, Texas

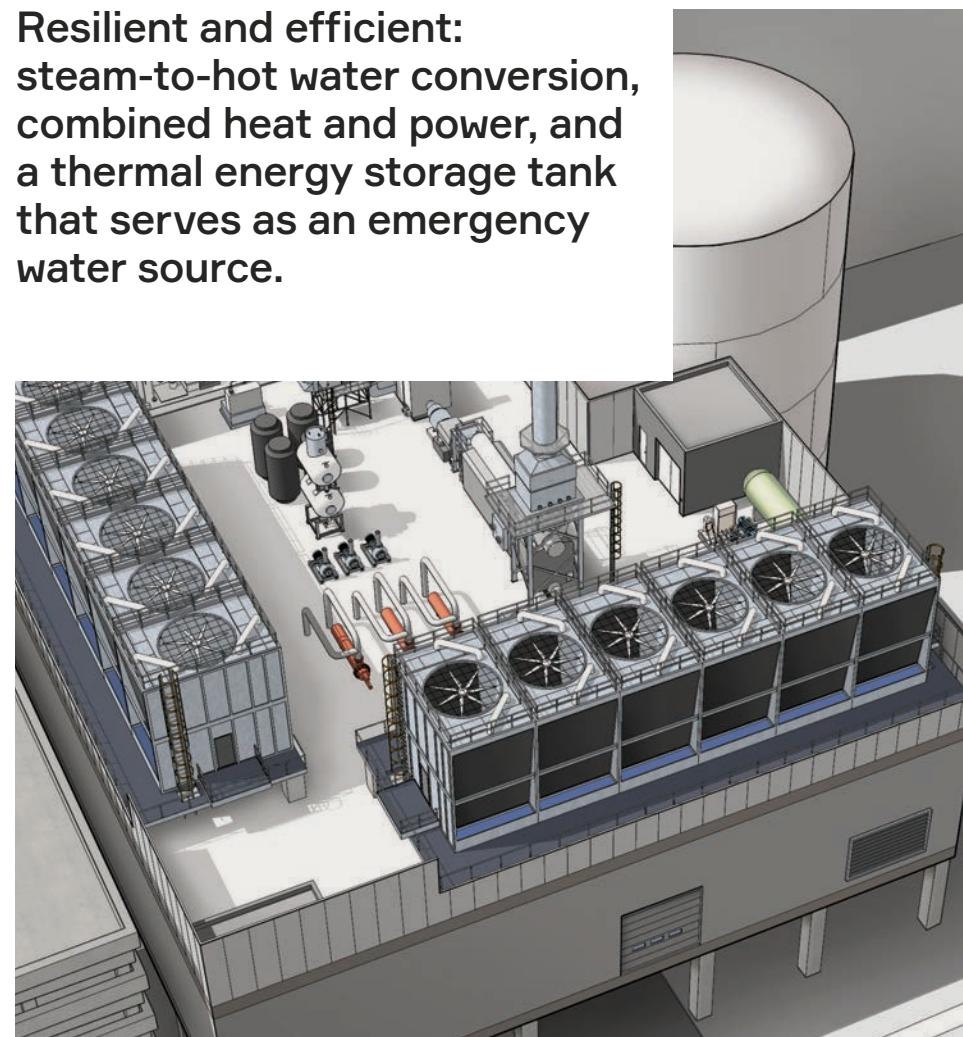
Gross Sq. Ft.  
17.3 M, campus



Hurricane Ike flooded over one million square feet of this Gulf Coast campus's buildings to depths of six feet, interrupting and damaging electrical power, emergency generators, natural gas, steam distribution, chilled water, and municipal water and sewer. With AEI's support, UTMB saw a long-term opportunity to optimize both resilience and efficiency. Utility sources – boilers and chillers – are elevated or protected with floodwalls. Outside electrical utilities are supplemented with 15MW of on-site combined heat and power, allowing microgrid islanding capability as needed or desired. The existing steam system is primarily replaced with a highly corrosion-resistant, direct-buried and overhead-routed district hot water system, expected to save over 10% through lower line losses alone. 50% more efficient than conventional systems, the two new CHP plants will save roughly \$3 million annually, with a 5-year simple payback.



**Resilient and efficient:  
steam-to-hot water conversion,  
combined heat and power, and  
a thermal energy storage tank  
that serves as an emergency  
water source.**



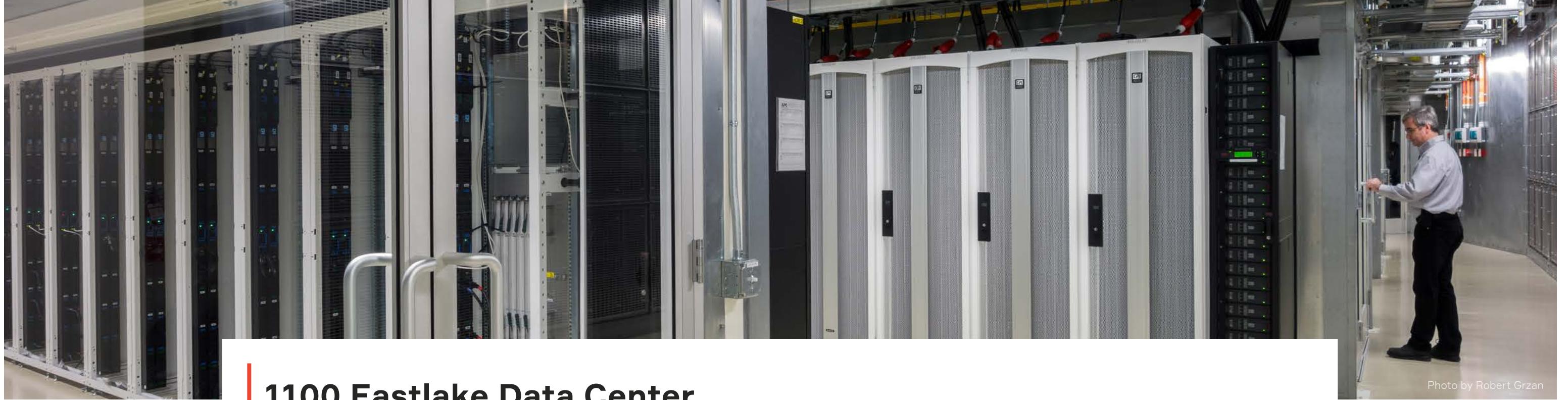


Photo by Robert Grzan

## 1100 Eastlake Data Center

Completion Date  
2012

Owner  
Fred Hutchinson Cancer Research Center

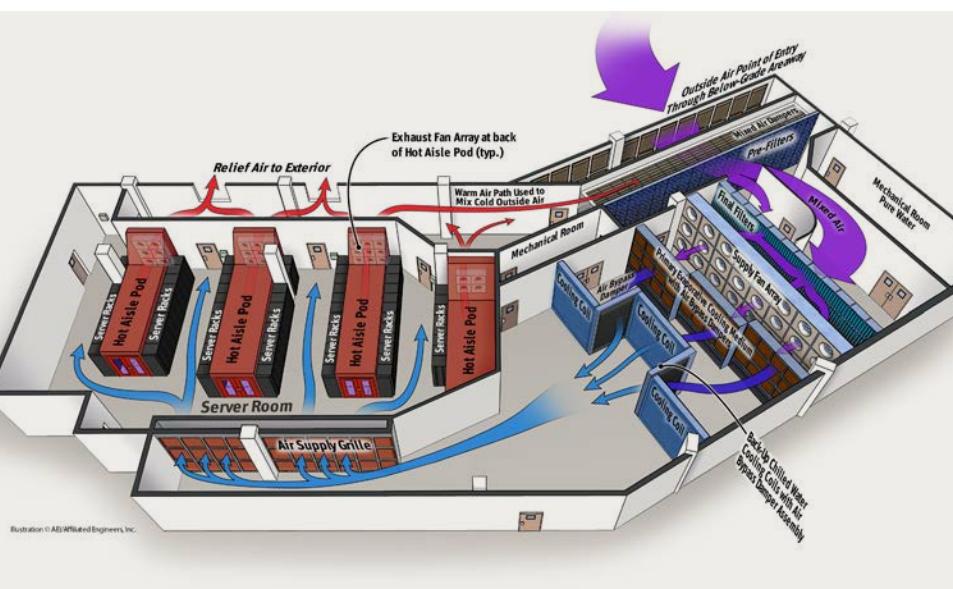
Location  
Seattle, Washington

Gross Sq. Ft.  
8,000

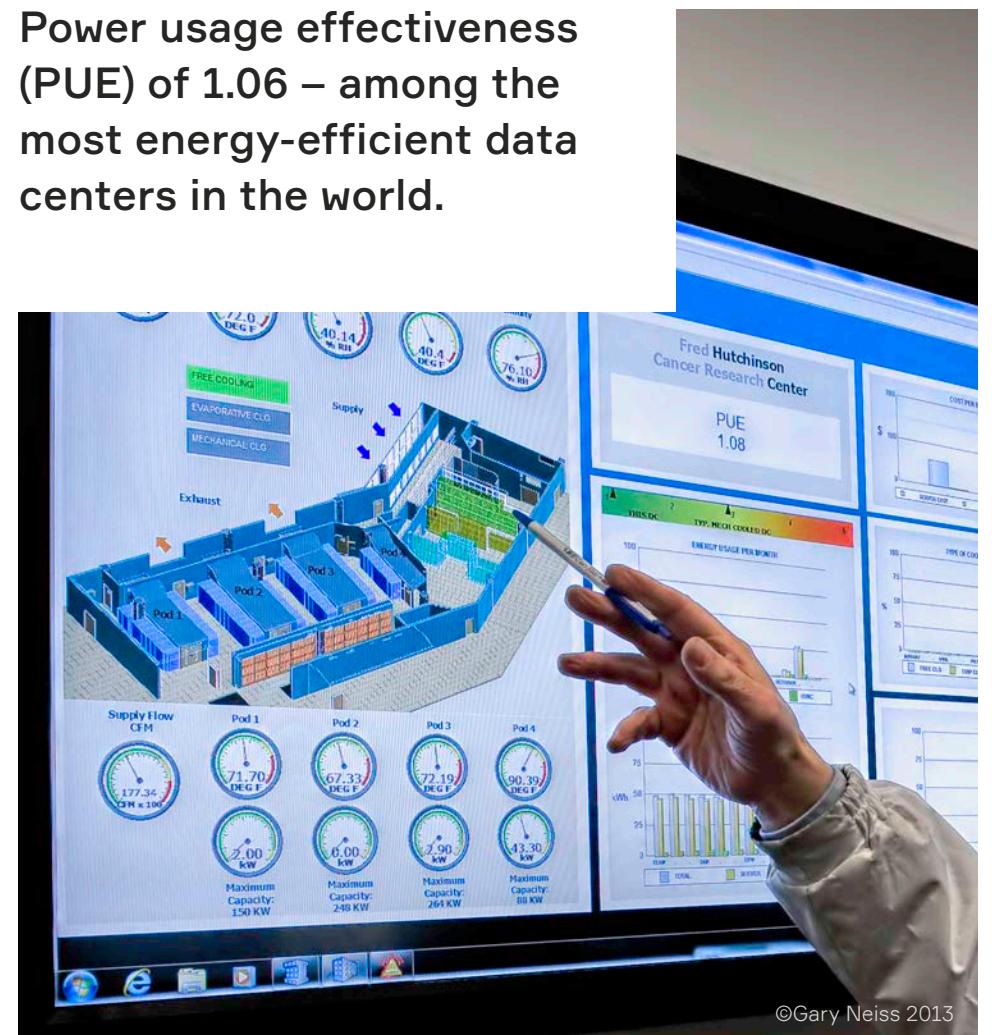
Design Architect  
ZGF Architects

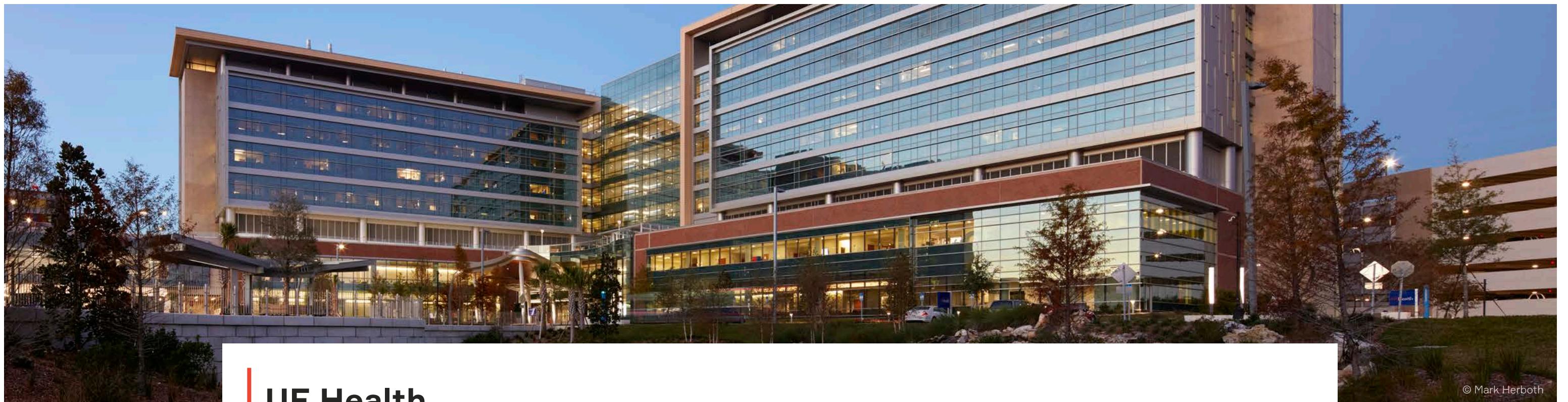


AEI successfully scaled and customized the climate-leveraging strategies of large-scale commercial server farms for this longtime client's consolidation of mission critical operations. Multi-fan arrays draw 100 percent outside supply air for "free cooling" during roughly 90% of annual hours. Direct evaporative cooling supplements and extends the economizer cycle, and traditional chilled water coils provide backup cooling for the remaining time. Designed and constructed in 18 months at the same cost of a mechanically cooled data center, it accommodates more than double the capacity. Increasing research volume, throughput, and the resiliency of Fred Hutch's IT infrastructure, the new data center has a power usage effectiveness of 1.06, making it one of the most energy-efficient data centers in the world.



**Power usage effectiveness (PUE) of 1.06 – among the most energy-efficient data centers in the world.**





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# UF Health

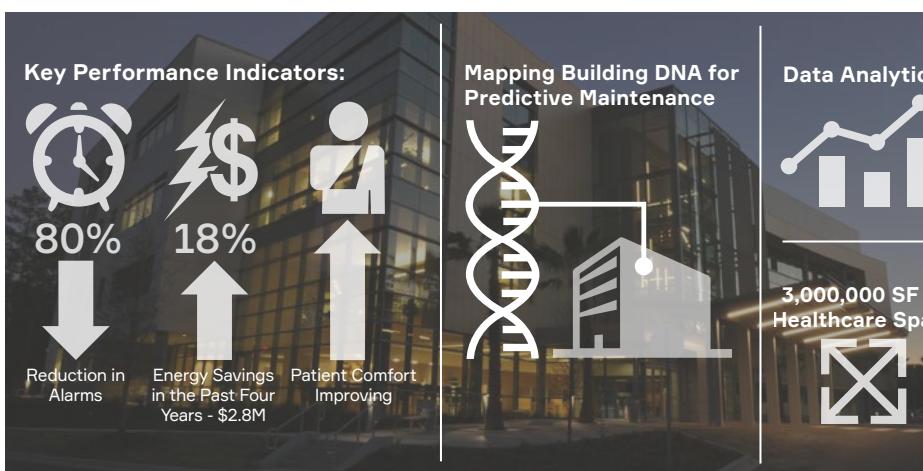
Completion Date  
2010

Owner  
UF Health

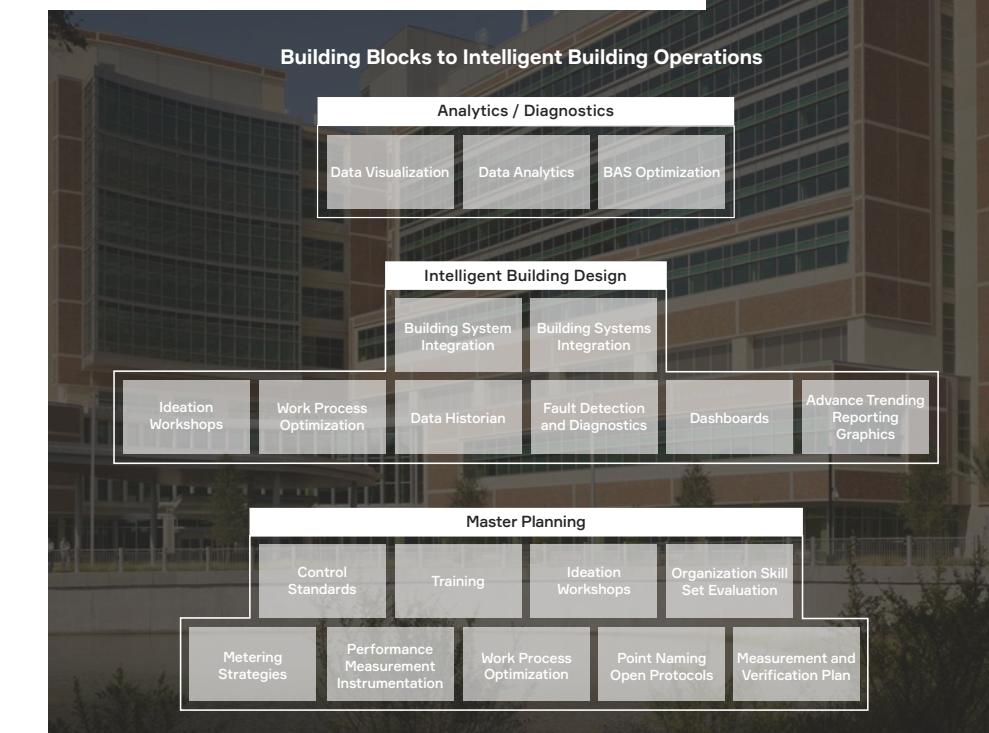
Location  
Gainesville, Florida



As part of a 15-year master plan, University of Florida Health looked to add one million square feet to an existing portfolio of two academic medical centers, a children's hospital, four community hospitals, and two specialty hospitals – while minimizing demands on staff capacity. AEI's master data plan identified new skill set requirements and realigned the organizational structure. A systems interdependency charrette showed which work processes to automate or optimize. Lifecycle cost analysis tools allowed business case evaluation of system integration opportunities. Today UF Health uses an integrated front-end operating system independent from building level controls for global energy management strategies, monitoring use, speeding up work orders, and finding comfort issues before they become patient complaints. Data analytics are used as an energy management tool and a robust data historian provides a basis for retro-commissioning queries and real-time energy models.



**Smart building solutions introduce proactive management strategies for high performance operation.**





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Completion Date  
2014

Owner  
Purdue University

Location  
West Lafayette, Indiana

## Herrick Labs Center for High Performance Buildings

As the prime consultant and lead engineer for Purdue University's LEED Gold Ray W. Herrick Laboratories for High Performance Buildings, AEI has a singular perspective on the future of high performance design. The new Herrick Labs building, completed in 2013, is enabling researchers to incubate and validate new building systems and concepts, such as the metered sustainability strategies in WID, allowing industry design and product manufacturing partners to test new ideas and their impacts on energy and the indoor environment. Herrick's innovative features ensure that technology and environmental control schemes that appear to work well computationally, in simulation, or in precisely controlled laboratory tests, will play out in practice. Reducing perceived risk associated with implementing high performance building technologies, Herrick facilities are accelerating the advance of new thinking that is transforming the built environment.



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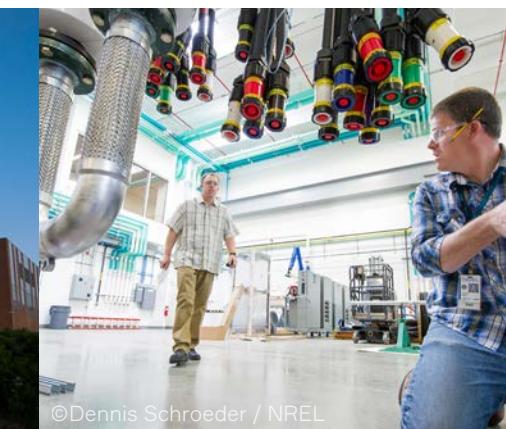
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## Energy Systems Integration Facility

Ongoing optimization of micro grid strategies – like those developed for UTMB's climate-vulnerable location – is taking place at the US DOE's premier smart grid/micro grid research facility in Golden, CO. AEI planned, designed, and engineered the research areas and laboratory systems of the Energy Systems Integration Facility for research focused on electrical distribution, energy storage, and fuel cell and cell component development, to standardize reliable two-way generation, delivery, and consumption of electric power. Localized micro grid electrical networks – capable of detaching from an outside electric utility at times of extreme weather events or when self-generation is more cost-effective – connect to the larger grid through a smart interface. NREL ESIF research is perfecting the real-time flow of information among grid components that is essential to assuring effective, efficient operations for generators and end users alike.



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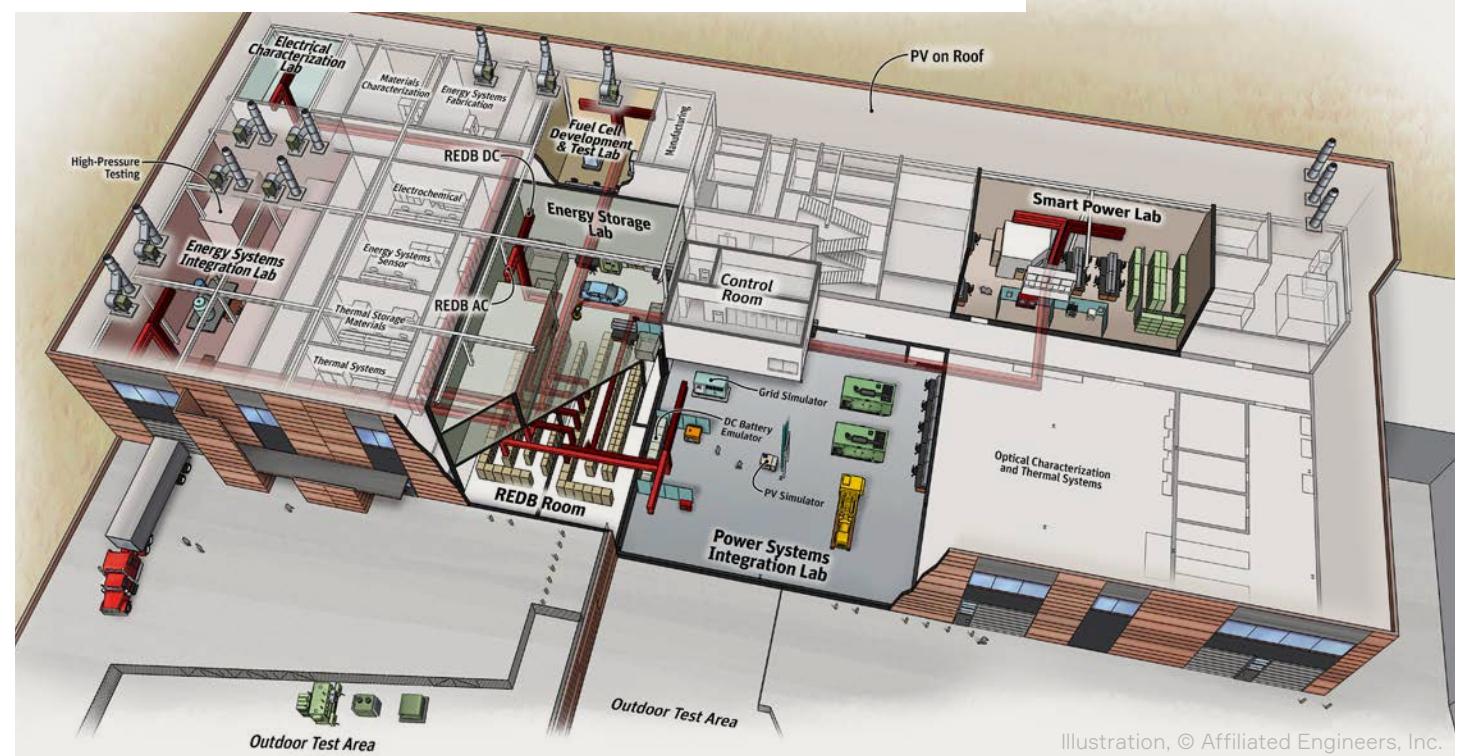


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Completion Date  
2014

Owner  
US Department of Energy

Location  
Golden, Colorado



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Building-scaled or campus-size, every plan and project is an opportunity for bold invention. With a basis in advanced engineering, energy technology insights, breakthrough research, and the perspectives of equally committed building owners worldwide, AEI pushes the market standards for high performance design and operation, advancing expectations for the efficiency, productivity, and sustainability of long-term capital investments.

## AEI Building Performance Practice Offerings

### Planning

- Campus sustainability planning
- Campus energy management planning
- Climate action (GHG emissions reduction) planning
- Resilience planning and design
- Performance benchmarking

### Operations & Experience

- Commissioning (Cx), retro-Cx, peer review, M&V planning
- Building performance tuning and optimization
- Intelligent building master plan and design
- Ventilation, indoor air quality assessment
- Energy and water assessments/audits
- Post-occupancy evaluation

### Design & Analysis

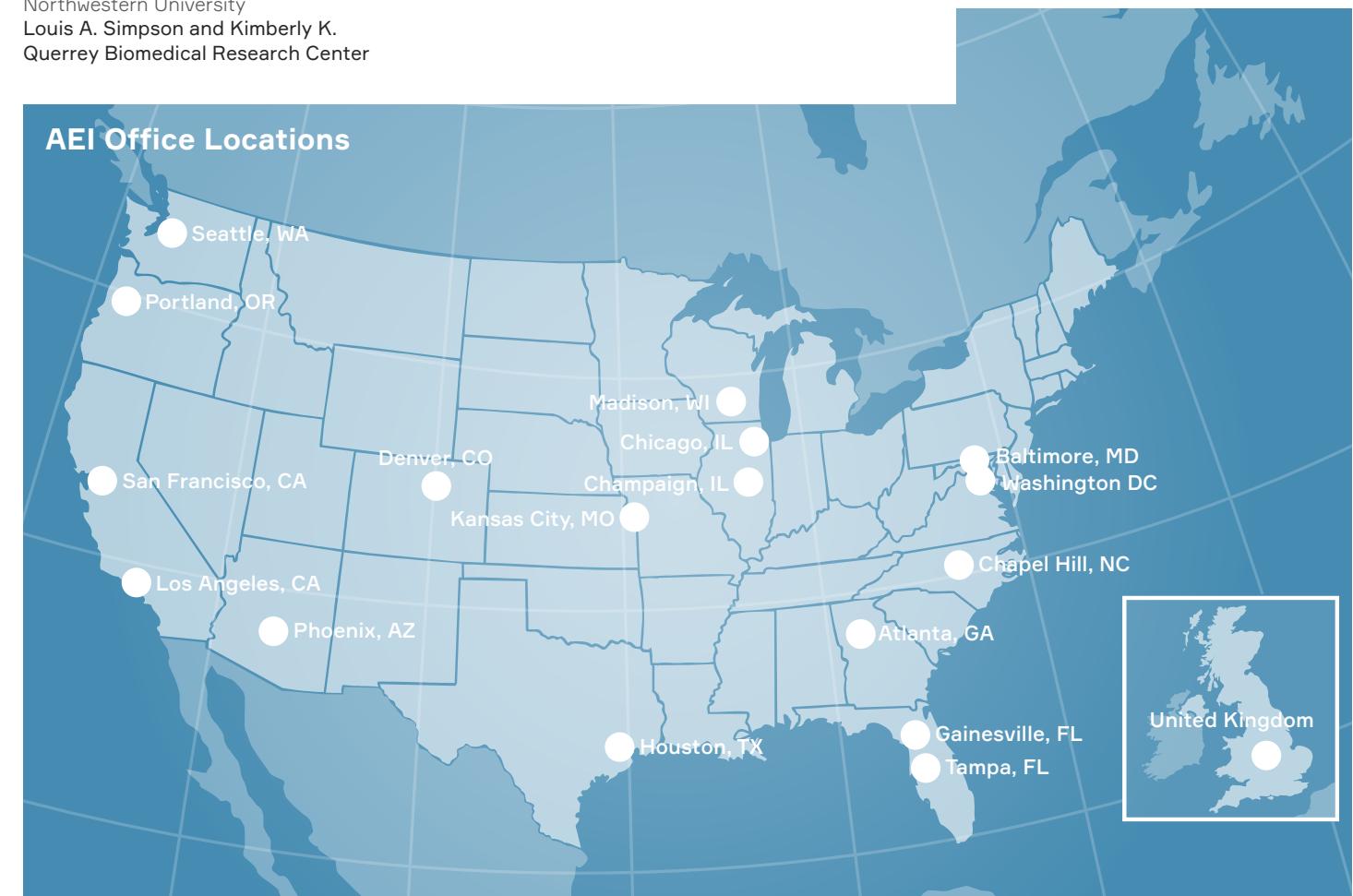
- Building siting, massing and orientation analysis
- Building performance modeling (energy, water, lighting, airflow, comfort, moisture)
- Computational fluid dynamics (CFD) modeling
- Daylighting analysis and lighting design
- Moisture transfer analysis
- Thermal comfort analysis
- Façade performance optimization
- Natural ventilation design
- Geothermal/geoexchange system analysis and design
- Renewable energy systems and alternative fuels analyses and design
- Sustainable design charrette facilitation
- High performance design consultation
- Third-party rating certification

# Maximizing the Performance of Long-Term Capital Investments

## Additional High Performance Design Projects:

- Ann & Robert H. Lurie Children's Hospital of Chicago Lurie Children's Hospital
- British Columbia Children's and British Columbia Women's Hospital Teck Acute Care Center
- College of Lake County Science & Engineering Building
- Cone Health System Cone Health North Tower
- Cornell University Cornell Climate Action Plan
- Houston Methodist Hospital North Campus Expansion
- Johnson Controls Glendale HQ Campus
- National Institutes of Health (NIH) Porter Neuroscience Research Center II
- North Carolina State Energy Study
- Northwestern University Louis A. Simpson and Kimberly K. Querrey Biomedical Research Center
- Oregon Department of Human Services Junction City and Salem Hospitals
- The George Washington University Milken Institute of Public Health
- The University of Kansas Measurement, Materials, and Sustainable Environment Center
- University of Houston Sustainability Study
- University of Minnesota Ambulatory Care Center
- University of North Carolina at Chapel Hill Energy Study
- University of Washington Molecular Engineering & Science Building
- Washington University in St. Louis Energy & Emissions Strategic Plan
- Winston-Salem State University Energy Study

### AEI Office Locations





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