Urban Land Institute

ULI Tenant Energy Optimization Program

Case Study:
Reed Smith LLP

Executive Summary: Reed Smith's Story

In February 2014, Reed Smith LLP, a leading international law firm, moved into 129,996 square feet on six floors in Philadelphia's Three Logan Square, a 57-story tower and one of the city's architectural landmarks. Mirroring a trend in law offices nationwide, the new space simultaneously represented a downsizing, yet an upscaling of its Philadelphia presence.

"Although the square footage at Three Logan Square is less than at One Liberty Place, the new office was designed to use space more efficiently," said Pat Hiltibidal, Reed Smith's firmwide chief of office services. "We were trying to establish a sense of community with the environment we created, a place people would want to be and work, and we have definitely succeeded."

Among its goals: energy and cost reduction, and to make a positive impact on the environment and the health and wellness of the over 300 employees who work in the Philadelphia office.

That's why in 2012, a year after it signed the lease, Reed Smith chose to participate iin the Tenant Energy Optimization process—a proven, replicable approach that integrates energy efficiency into tenant space design and construction and delivers excellent financial returns through energy conservation. Working with landlord Brandywine Realty Trust and a team of experts assembled for this project, Reed Smith evaluated an integrated package of energy performance measures (EPMs)[2] for the six new floors. The chosen EPMs were incorporated into the space design to achieve substantial, cost-effective energy savings and a superior workplace environment.

Over the term of Reed Smith's 16-year-lease, the project is estimated to provide energy costs savings of more than $1.1 million[2], a 410% return on Reed Smith's investment[3], and a 57% internal rate of return (IRR)[4]. The projected payback: only 2.2 years.

The firm would use one-third less energy than a standard 2014 law firm build out, with the savings directly going to Reed Smith. Overall, the space is designed to perform more than 34% better than a standard code-compliant design.

Reed Smith's project is part of a series of case studies aimed at presenting the energy and cost savings impact of high-performance tenant design. The case studies and companion resource guides[5] provide the market a replicable model to expand the demand for high-performance tenant spaces and supply of market expertise to deliver strong results from such projects. Projects using this step-by-step design and construction process typically demonstrate energy savings between 30% to 50%,[6] have payback periods of three to five years, and average a 25% annual return.

1. EPMs are technologies and systems that aim to reduce energy use through efficiency and conservation. They are also frequently referred to as Energy Conservation Measures (ECMs).
2. Compared to an American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) 90.1-2007 code-compliant design.
3. Assuming zero escalation in electricity prices over the lease term and a 5% administrative fee per the terms of tenant's lease.
4. The discount rate often used in capital budgeting that makes the net present value of all cash flows from a particular project equal to zero. Generally speaking, the higher a project's internal rate of return, the more desirable it is to undertake the project. (See more: http://www.investopedia.com/terms/i/irr.asp)
5. The guides can be accessed at tenantenergy.uli.org.
6. Compared to American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 90.1-2007 code requirements.

What Is the 10-Step Tenant Energy Optimization Process?

The Tenant Energy Optimization process is a proven, replicable approach that integrates energy efficiency into tenant space design and construction and delivers excellent financial returns through energy conservation.

What Are the Benefits of the Tenant Energy Optimization Process?

It generates an attractive return on investment (ROI)—Tenants using the step-by-step design and construction process typically have experienced:
- ☐ Energy savings of 30 percent to 50 percent
- ☐ Payback in as little as three to five years
- ☐ An average annual internal return rate of 25 percent

It provides a competitive edge—Companies with more sustainable, energy-efficient workplaces enhance their ability to attract, retain and motivate workers who are healthier, happier, and more productive.

It is scalable and replicable—The process can provide energy and financial savings whether the tenant leases 2,500 or 250,000 square feet. Tenants and service providers who have gained expertise through implementation of the process have demonstrated that there is high potential for transferability beyond tenant office space to other property sectors.

It is proven—Through measurement and verification, tenants are able to demonstrate and communicate energy and financial savings.

It is environmentally critical—Energy use in buildings is the largest source of climate-changing carbon pollution and tenant spaces generally account for more than half of a building's total energy consumption, making this process essential to improving the environmental performance of buildings and addressing global climate change.

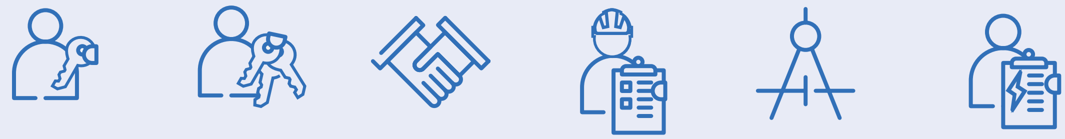
Overview: Reed Smith Project Information and Projected Performance

Building Information				
Tenant Name	Reed Smith LLP			
Building Owner	Brandywine Realty Trust			
Building Name	Three Logan Square			
Location	1717 Arch Street, Philadelphia CBD			
Building Size	1 million square feet (102 floors)			
Principal Use	Class-A office			
Construction Type	Modern Skyscraper			
U.S. EPA ENERGY STAR® Rating	93			
Reed Smith Lease Term	16 years			
Floors 28 to 33[7]	**Projected Design**		**M&V Calibration**	
Modeled Square Footage	117,000 square feet		117,000 square feet	
Modeled Energy Reduction	34.3%		44.5%[8]	
Annual Electricity Reduction	1,106,789 kWh	9.5 kWh/SF	692,292 kWh	5.9 kWh/SF
Total Electricity Savings over Lease Term	17.7 GWh	151.4 kWh/SF	11.1 GWh	94.7 kWh/SF
Incremental Implementation Cost: ***Energy Modeling Soft Cost:*** ***Incentives:***	$208,623 *$11,000* *$66,565*	$1.78/SF *$0.09/SF* *$0.57/SF*	$208,623 *$11,000* *$66,565*	$1.78/SF *$0.09/SF* *$0.57/SF*
Adjusted Incremental Implementation Cost	$153,058	$1.31/SF	$153,058	$1.31/SF
Total Electricity Costs Savings over Lease Term	$1,800,967	$15.39/SF	$1,126,498	$9.63/SF
Electricity Cost Savings over Lease Term (Present Value)	$1,247,614	$10.66/SF	$780,377	$6.67/SF
Net Present Value of Project Investment	$1,094,556	$9.36/SF	$627,319	$5.36/SF
Return on Investment over Lease Term	715%		410%	
Internal Rate of Return	104.2%		57.0%	
Payback Period (with incentives)	1.4 years		2.2 years	

7. Floor area assumptions: (1) 20,500 SF conference room floor, (4) 20,500 SF office floors, and (1) 14,500 SF partial office floor.
8. Differences in modeled energy reduction is usually due to a discovered underestimation or overestimation of energy use in the measurement and verification process.

Who Is Involved in the Tenant Energy Optimization Process?

It is collaborative—The process connects the dots between tenants, building owners, real estate brokers, project managers, architects, engineers, and other consultants to create energy-efficient workplaces. In this regard, the process reflects ULI's longstanding tradition of bringing together professionals from a variety of real estate disciplines to improve the built environment.



Tenants | Building Owners | Real Estate Brokers | Project Managers | Architects, Engineers, and Contractors | Energy Consultants

Supply and Demand: The Role of the Broker, Tenant, Building Owner, and Consultants

Leasing brokers are influential tenant advisers during the pre-lease phase. If experienced in energy efficiency conversations, brokers can help tenants demand and understand building energy performance information during the site-selection process. Brokers who highlight case studies or examples of work representing tenants in the selection of high-performance spaces may gain additional clients.

Tenants create demand for energy-efficient, high-performing space. Tenants also create demand for consultants who can advise them on how to reach their sustainability goals through the design and construction of energy-efficient space. By prioritizing energy-efficient space and working closely with their advisers, tenants can develop better workplaces to attract and motivate employees, attain recognition for sustainability leadership, and manage costs.

Building owners supply high-performance buildings that help tenants meet their energy performance and financial goals. Real estate owners can gain competitive advantages by marketing energy-efficient buildings' cost-saving energy and operations improvements to attract high-quality, sophisticated tenants. Tenants may prefer longer lease periods in highly efficient buildings that better align with their corporate environmental and social responsibility goals, provide financial benefits, and add recognition value.

Consultants (e.g., architects, engineers, project managers, energy consultants, and contractors) provide the expertise to optimize energy performance and present the technical options and economic case for a comprehensive, cost-effective, and high-performance space while meeting the tenant's schedule and budget. Consultants offering these services may attract additional clients by demonstrating cost savings and other benefits to tenant's business goals.

Key steps for choosing a high-performing space include:

1. Select a leasing broker experienced in energy efficiency.
2. Convene a workplace strategy and energy performance optimization workshop.
3. Perform a financial analysis.
4. Assess high-performance space feasibility.
5. Meet with the building owner to discuss collaboration to improve energy performance.

Selecting an Efficient Base Building

Good:

- ☐ Building reports ENERGY STAR score
- ☐ Ongoing tenant-landlord energy efficiency coordination
- ☐ Landlord willing to allow submetered tenant space

Better—includes all of Good, plus:

- ☐ Building ENERGY STAR score of 75 or higher
- ☐ Central building management system (BMS) with tie-in of tenant heating, ventilating, and air conditioning (HVAC) and lighting
- ☐ Building energy audit, ongoing commissioning activities, and energy capital projects completed
- ☐ Submetered tenant space with energy billed on actual usage

Best—includes all of Better, plus:

- ☐ Subpanels to measure tenant lighting, HVAC, and plug loads separately
- ☐ Tenant energy management program (such as a dashboard)

Questions to Ask the Building Owner

What is the building's ENERGY STAR score? The EPA recognizes top-performing buildings that meet or exceed a score of 75. Even if a building has not achieved ENERGY STAR recognition, an owner that tracks and reports the building's score may be more willing to collaborate on energy efficiency efforts than one who does not currently monitor energy performance.

Is the space submetered, and is the utility billing structure based on actual use? What is the utility rate and average energy cost per square foot? A recent study found that submetered spaces save 21 percent in energy compared to spaces without energy-use information.

What has the building done to improve and maintain energy efficiency and conservation, and when were the improvements installed? Buildings with excellent natural daylight, energy-efficient windows and lighting, envelope walls, advanced equipment controls, and efficient HVAC equipment reduce tenant equipment and energy costs.

Does the building have resources or programs to help with design, construction, and ongoing management of energy-efficient spaces? Request from ownership any design and energy efficiency criteria for the buildout of tenant spaces, recommended cost-effective energy measures with financial value analysis, or a building energy model for reference. Owner-provided resources are a starting point for sensible energy strategies and promote a collaborative relationship between the building owner and tenant. An existing energy model will reduce the upfront cost and effort of implementing the process. Experts can help identify opportunities for cost-saving lighting, outlet plug load, and HVAC opportunities throughout the lease term.

Why Reed Smith Chose Three Logan Square

When Reed Smith's lease was up, it considered re-leasing its space, but also explored the market for more energy-efficient space and better amenities.

It settled on Three Logan Square, formerly known as the Bell Atlantic Tower, which is one of Philadelphia's landmark skyscrapers and is located at 1717 Arch St. At 57 stories, the red granite trophy tower is located in the heart of the city's central business district.

Three Logan Square is also ENERGY STAR®-certified, with a building score of 93. It is one of many buildings in Brandywine's portfolio that demonstrate the REIT's overall commitment to sustainable practices within its office buildings; Brandywine received an ENERGY STAR® Partner of the Year – Sustained Excellence Award in 2015.

A 2014 survey[9] discovered that 36% of facility, real estate, and energy management executives said they were willing to pay a premium for space in a certified green building—a jump from 15% the previous year—and 28% planned to build out tenant space to high-performance standards, an increase from 18% in 2013. Project stakeholders can take advantage of the energy efficiency opportunity by gathering the right information and putting it in front of the right people at the right time during the tenant engagement and decision making process—the earlier the involvement, the more successful the project.

9. The 2014 Energy Efficiency Indicator Survey conducted by Johnson Controls' Institute for Building Efficiency can be found at http://www.institutebe.com/Energy-Efficiency-Indicator/2014-EEI-executive-summary.aspx.

Reed Smith's high-performance office in Philadelphia includes optimized lighting, plug load controls, and variable frequency drives, reducing energy use by 44.5% and providing Reed Smith with a 57% IRR. The space is an energy efficiency model for the design of Reed Smith office spaces across the U.S. portfolio. Photo by ©Halkin/Mason.

The Project's Key Stakeholders

The Tenant: Reed Smith

Reed Smith LLP is an international law firm whose focus spans transactional, regulatory, and litigation and dispute resolution disciplines across a variety of industries and practices, including energy and natural resources, entertainment and media, financial, and life sciences. It has 1,800 attorneys throughout the globe and represents many of the world's leading companies in complex litigation and other high-stakes disputes, cross-border and other strategic transactions, and crucial regulatory matters.

With lawyers from coast-to-coast in the United States, as well as in Europe, Asia and the Middle East, Reed Smith is known for its experience across a broad array of industry sectors. Reed Smith counsels 13 of the world's 15 largest commercial and savings banks; 25 of the world's 35 largest oil and gas companies; and the world's three largest pharmaceutical distribution and wholesale companies. Reed Smith's shipping practice has been designated among the most preeminent in the world, and its advertising law practice is regarded as among the legal industry's finest.

The Building Owner: Brandywine Realty Trust

Brandywine Realty Trust (NYSE: BDN) is a leading real estate investment trust that owns and manages office properties in Pennsylvania, New Jersey, Delaware, Maryland, metropolitan DC, Virginia, Texas, and California. Its services include asset management, development and construction, investment, marketing and leasing, and property management and tenant support. Brandywine, a recognized ENERGY STAR® Partner, has an overall commitment to provide excellent, sustainable office environments to its customers, employees, and vendors. Toward that end, it has established a Sustainability Advisory Group, also known as the "Green Team," which focuses on education, purchasing, waste reduction and recycling, energy, travel, commuting, and carbon credits/green power.

Reed Smith Integrates the Tenant Energy Optimization Process

Following the lease signing in 2011, and prior to the selection of Reed Smith's architect and engineering teams, Brandywine presented the tenant with the opportunity to use the Tenant Energy Optimization process to discover energy savings opportunities in the new space.

Wendy Fok, an early developer of the Tenant Energy Optimization process, had previously met Brandywine executive vice president Brad Molotsky. He knew of the tenant buildout projects at the Empire State Building (where tenants Global Brands Group[10], LinkedIn, Shutterstock, and Coty had utilized the Tenant Energy Optimization process). Empire State Realty Trust had also just put the 2.8 million-square-foot Empire State Building under a major retrofit and repositioning, transforming it into a Class-A, high-performance building. As the vice chairman of the Real Estate Roundtable's sustainability advisory committee, Molotsky continued to keep himself educated on the development of the process as it was introduced to more tenants.

Molotsky had a strong relationship with a partner at Reed Smith and mentioned the Tenant Energy Optimization process, since he knew Reed Smith was looking for space. As Reed Smith finalized its lease at Three Logan Square, Molotsky suggested the process to Reed Smith, which then went through the buy-in process with the law firm's facilities managers, partners, and corporate review panels.

"We had a great advocate through Brad—he knew about energy efficiency, made the case to the tenant, brought the partners in early, and gave us a heads up that the lease was happening," Fok said. "This is just one great example of the 'friend telling a friend' method that has helped the [Tenant Energy Optimization] process grow organically."

Lesson Learned: Start Discussing Before a Lease is Signed
Building owners should introduce case studies and the Tenant Energy Optimization process to tenant decision makers prior to the lease signing.

10. Formerly Li & Fung USA

Private offices include daylighting and optimized light levels with dimmers and sensor controls. Photo by ©Halkin/Mason.

At the same time, Wendy Fok and other team members were undergoing the process with Global Brands Group at the Empire State Building, and were able to relay the experience to Reed Smith's partners
and Three Logan Square's facilities managers.

"We talked to them step-by-step in how we would integrate the process and how it would affect their operations," Fok explained. "We provided them with a bullet-point list that explained the value of a high-performance build out, so they could go back to Reed Smith's Board of Directors and make the case for using the process."

Investing in cost-effective energy measures then allowed Reed Smith to take advantage of an energy-aligned lease structure, which sub-meters all direct energy use (lighting, equipment, and HVAC) and enables it to pay based on actual metered energy consumption, rather than an estimated allocation.

Lesson Learned: The Earlier the Buy In, the Better
Get both executive-level and facility managers to buy in to the process early, and engage with building operations teams early in the design.

The 10-Step Tenant Energy Optimization Process

PHASE I: PRE-LEASE

Step 1: Select a team

Step 2: Select an office space

PHASE II: DESIGN AND CONSTRUCTION

Step 3: Set energy performance goals

Step 4: Model energy reduction options

Step 5: Calulate projected financial returns

Step 6: Make final decisions

Step 7: Develop a post-occupancy plan

Step 8: Build out the space

PHASE III: POST-OCCUPANCY

Step 9: Execute the post occupancy plan

Step 10: Communicate results

A Collaborative Effort

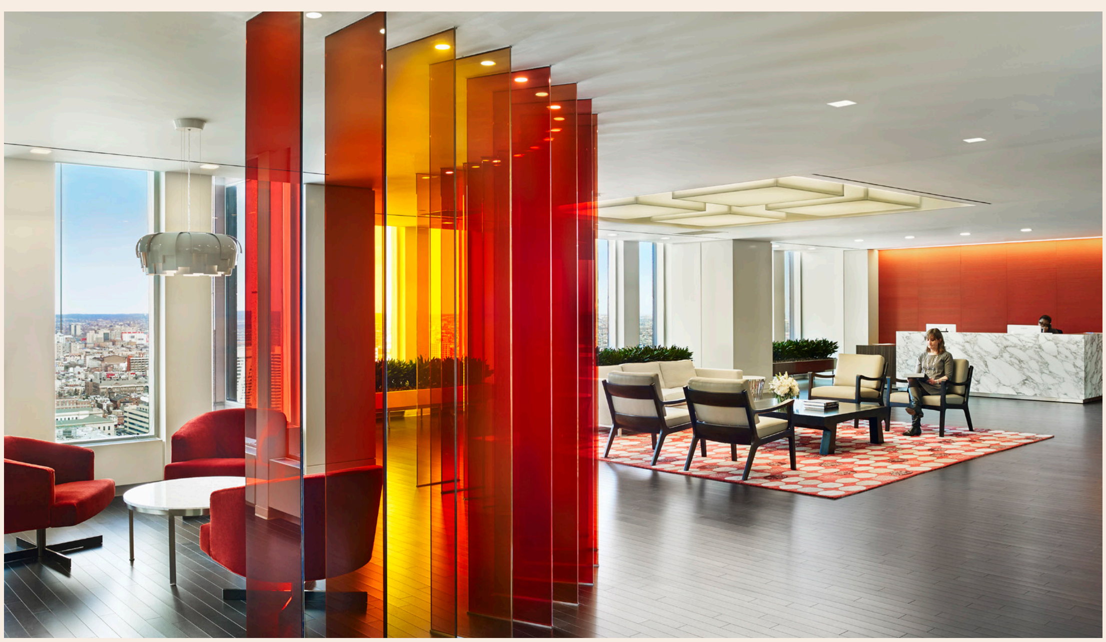
The entire Tenant Energy Optimization process emphasizes the importance of owner and tenant collaboration, particularly since tenant spaces typically account for more than half of a commercial office building's total energy. Overall, the process has seen the strongest results and most significant savings when the building owner engages with the tenant in the process; openly shares the building's energy information; and implements building-wide energy saving measures. The collaboration between Brandywine Realty Trust and Reed Smith is one of the best examples of this partnership.

Floors 28 through 33, leased for a term of 16 years, include a reception area, a high-end conference center space; attorney and support staff offices; and a café. All 191 perimeter offices would have eight-foot glass fronts providing natural lighting. The space also includes an all-purpose room, which can be configured as a moot court, or used for trial and other training sessions, exercise classes, and community meetings. Other features include two shower facilities, a mother's room, and a lounge.

Selecting the Buildout Team

Reed Smith Buildout Team

Company	Role
Watchdog	Project Manager
Gensler	Architect
Bala Engineers	Engineer
Bliss Fassman	Lighting Designer
Wendy Fok	Energy Project Director
Kugler Ning Lighting Design	Lighting Designer
Quest Energy	Energy Modeler
Integral Group	Energy Consultant
Hunter Roberts	Contractor/Costing
Brandywine Realty Trust	Building Owner



Reception areas include temperature and lighting controls to maintain comfortable, energy-efficient conditions throughout the day. Photo by ©Halkin/Mason.

Setting Energy Performance Goals and Developing a Menu of Measures

The process was kicked off with an energy design workshop in June 2012, which brought together the design and construction team that would be involved in Reed Smith's buildout. These groups worked in tandem to make sure all energy reduction strategies conformed to the goals and intent of Reed Smith's design.

During schematic design, Reed Smith outlined seven important factors for its buildout, which align with its ultimate goals of energy and cost reduction while making a positive impact on the environment and the health and wellness of its employees.

1. **Budget**
2. **Comfort**
3. **Controllability**
4. **Ventilation**
5. **Equipment reuse**
6. **Easy to use and maintain energy-efficient technology**
7. **Perimeter private offices**

With Reed Smith's objectives in mind, the project team put together base building and tenant space parameters, which formed the basis for the project's energy performance goals:

Base Building Parameters

Base Building (Shell): While Three Logan Square provided a good building shell with double-pane windows and a wall typical of modern construction, many features of a sustainable building, such as low-e windows with thermal breaks, were not present.

Base Building (Daylighting): The building configuration had good access to windows for daylighting, but the ceiling height reduced the depth of penetration slightly by blocking the top six to 12 inches of the window for return air collection. The perimeter offices had good daylighting characteristics, which could be extended into the interior through a combination of transparent internal partitions, interior lightshelves, and raising the ceiling.

Tenant Space Parameters

Plug Loads: The tenant practice was to shut off computers at night. Motion sensor controlled plugs would save energy by reducing parasitic loads during unoccupied hours.

Ventilation: Outside air was provided from a single central shaft that serves the entire building. The volume of outside air provided per floor was limited and was potentially inadequate for high outside air demands of the conference floor. Measures undertaken could include reducing outside air volume; reducing the introduction of unneeded air into the offices; and that unused ventilation air is made available to serve the conference floor (which would eliminate the need to condition it).

Power Monitoring: Sub-monitoring of power to break down power use by lighting, plug power, or HVAC power could be done economically provided that good practice was followed and separate panels were used for each load type. This would allow for ongoing optimization and maintenance of any efficiency measures introduced.

Daylight Controls: Zonal controls, at the time, were non-networked pneumatic controls that offered little opportunity for efficient controls. Conversion to a modern direct-digital control with a centralized control system would allow for more effective and efficient control of the space.

Lighting: Embracing low-ambient light levels with task lighting, as necessary, would minimize lighting energy. 0.5 W/SF would be a solid initial goal; advanced LED lighting technologies and fixtures could help achieve this.

The accompanying Menu of Measures summarizes the energy performance measures that were discussed at the design workshop, providing a preliminary assessment of their first cost to implement and their savings potential.[11]

Reed Smith's Menu of Measures

	Measure	Cost to Implement	Savings Potential	Target Area
1	Retrofit Low-E Windows	High	Medium	Base Building
2	Add to Shell Insulation	High	Low	Base Building
3	Low Lighting W/SF	Low	High	Lighting
4	Occupancy Sensor Lighting Control	Low	Medium	Lighting
5	Web-Based Lighting Controls	Medium	Medium	Lighting
6	Light-Colored Finishes to Maximize Daylighting	Low	Medium	Lighting
7	Internal Lightshelves	High	High	Lighting
8	Daylight Harvesting Control	Medium	High	Lighting
9	Occupancy Sensor Ventilation Control of Conference Rooms	Medium	Medium	HVAC
10	Dedicated Outside Air System for Conference Rooms	High	Medium	HVAC
11	Displacement Ventilation for Conference Rooms	Medium	Medium	HVAC
12	Variable Airflow Diffusers	Low	Low	HVAC
13	CO_2 Control of Outside Air Volume	Medium	High	HVAC
14	Personal or Ceiling Fans	Low	Medium	HVAC
15	Active Demand Management Plan	Low	Low	Plug Loads
16	Plug Load Controls	Low	Medium	Plug Loads
17	Sub-Metering	Low	Medium	Plug Loads
18	DC Power Distribution via Ceiling Grid	Medium	Medium	Plug Loads

Modeling the Projected Energy Performance

During design development, a predictive energy model[12] was created using eQuest software, which modeled energy consumption and EPM results for Reed Smith's new office space. The model was later calibrated using metered data gathered during tenant occupation.[13]

The energy performance analysis for Reed Smith's office space at Three Logan Square modeled energy use against a baseline that assumes the space was built out to minimal code-compliant energy performance with existing packaged air handler units (AHUs) in the space.[14]

11. These assessments are rough at this stage of design; it is likely that as the design develops some measures may become prohibitively expensive while others may be able to be implemented for little or no cost if they are designed in from the beginning.
12. There are three baselines shown in the energy model: the as-built baseline of Three Logan Square; an ASHRAE 90.1-2007 baseline, which has been used for the majority of the savings calculations; and an ASHRAE 90.1-2010 baseline
13. See Appendix A for detailed analysis.
14. Compared to ASHRAE 90.1-2007 and International Energy Conservation Code (IECC) 2009 lighting compliance standards. The modeled energy consumption of the code-compliant tenant space is estimated to be 3,231,013 kWh annually.

How Does Three Logan Square Compare to Reed Smith's Former Space?

The project team also compared energy consumption at Philadelphia's One Liberty Place—where Reed Smith was previously located in 123,546 SF—and Three Logan Square by normalizing the energy-use intensity (EUI) for direct tenant loads, including lighting and equipment.[1]

The analysis discovered that Reed Smith's EUI at Three Logan Square (9.5 kWh/SF annually) was projected to be higher than the measured EUI at One Liberty Place (6.9 kWh/SF annually). But given Reed Smith's design for increased occupancy density (from 496 SF per person to 393 SF per person, a 21% reduction) and increased A/V equipment loads, modeled operation assumptions may account for the difference in EUIs between the two spaces.

So while different design conditions in the two spaces made it difficult to compare them on an equal basis (compared to a standard code-compliant office space), the analysis concluded Reed Smith designed a high-performance office space at Three Logan Square that would optimize energy performance and provide improved lighting, equipment, and thermal control.

1. EUI expresses a building's energy use as a function of its size or other characteristics. Generally, a low EUI signifies good energy performance. For more, see: https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/what-energy

As part of the modeling process, the project team created several sets of measures, also known as "packages," which account for the interactive effects of various EPMs and how they impact payback periods, IRR, and ROI metrics.

In order to understand the interactive effects of measures within a package, the model must be run through repeated cycles incorporating a new EPM with each run, a process called iterative modeling. The results of iterative modeling predict the cumulative effect of implementing a package of EPMs, which accounts for interactions between individual measures that may affect overall energy consumption. For example, a unit of energy saved by utilizing daylight harvesting cannot be saved again through high-efficiency lighting, thus iterative modeling would show less energy savings for this package of EPMs compared to modeling the measures independently.

The output of the model will provide estimated annual energy savings based upon the selected package of measures as compared to the modeled baseline scenario, which can be broken out into identified savings for both the tenant space and the base building systems. For example, certain EPMs may reduce the overall demand on the central building systems, including centralized conditioned air, steam, condenser, and chilled water savings. Depending on the utility billing structure in the lease, such savings are likely to accrue to the building owner (or be shared with all of the other tenants in the building). Savings from lighting, plug load, and server room EPMs typically benefit the tenant directly.

The energy model estimated that the recommended EPM package had the potential to reduce energy used by over 34% for Reed Smith, compared to a code-compliant design. The optimized package would include an integrated lighting, receptacle plug load, and mechanical equipment energy reduction strategy for a high-performance space and greater occupant comfort.

Lighting Recommendations

The lighting design, as it stood (0.98 W/SF), had the potential to include energy-saving strategies that would reduce lighting energy used by 26% through practical, cost-effective strategies with minimal impact to function and overall design intent:

- Reducing light levels in the top five lighting energy drivers, including two ceiling light fixtures in enclosed offices;
- Tuning down to pre-set light levels with wireless controls;
- Daylight harvesting; and
- Relocating linear office fixtures directly into the circulation path with more effective fixtures that would yield higher light function, quality, and energy performance improvement while reducing initial lighting equipment costs.

However, architect Gensler did not agree with the last recommendation, noting that it would have a dramatic effect on the look of the frit pattern on the glass and clean lines of the corridors. But it did acknowledge that it would save 8.9% on the lighting energy load. Additionally, it recommended switching task lighting from a linear under-cabinet light to a mobile task lamp, which would not compromise design yet provide 8.5% in savings.

Plug Load Recommendations

- Reducing plug load through occupancy control and switches that would allow for active ongoing equipment energy-use management; and
- Utilizing ENERGY STAR® equipment.

Mechanical Equipment Recommendations

- Installing variable frequency drives to reduce fan-use power on mechanical equipment; and
- Using end-use sub-metering (lighting, plug, IT room, and HVAC loads) and a tenant energy management platform to keep energy savings in line and provide feedback for ongoing commissioning and system maintenance.

On-Site Lighting Mock-Up and Detailed Lighting Design Study

Reed Smith hired Kugler Ning Lighting Design to perform an on-site lighting mock-up and detailed lighting design study, which identified the top five lighting energy drivers by floor and for the project overall. Based on the lighting elements identified, the company proposed specific methods to lower the connected load for each fixture and appliance. After this study, Reed Smith reviewed the preliminary analysis and decided to implement the recommended package.

Notably, Reed Smith reduced the initially designed lighting power density from 0.98 W/SF to a substantially lower average of 0.84 W/SF in its final design. This high-performance design is 21% lower than allowed installed lighting power as determined by ASHRAE and IECC standards.[15] Additionally, the lighting study proved significant energy use from task lighting. Therefore, Gensler eliminated fixed linear under-cabinet lighting for desk lamps, resulting in an estimated 8.5% lighting energy reduction as compared to the previous design.

Lesson Learned: Review Alternative Solutions
A detailed on-site lighting peer review and field study helped Reed Smith further refine its choices for illumination.

15. When accounting for exemptions and decorative allowances.

Support areas benefit from natural daylight from glass-front perimeter offices. Photo by ©Halkin/Mason.

Reviewing Incremental Costs and Incentives

With the baseline standards in place, the project team moved on to the impact that potential EPMs would make on Reed Smith's space performance. The model analyzed a range of EPMs in terms of three types of quantifiable results: cost estimates for energy efficiency measures; projected energy savings for each measure and for packages of complementary measures; and projected payback period, return on investment, and other key financial metrics.

Recommended EPM[16]	Target Area	Incremental First Cost
Energy-Efficient Lighting Design	Lighting	$0
Daylight Harvesting Controls	Lighting	$80,000
Bi-Level Lighting Control	Lighting	$6,500
Dimmable Switching Controls	Lighting	$72,000
ENERGY STAR® Equipment	Plug Loads	$0
Occupancy Sensor Power Strips	Plug Loads	$19,000
Manually Controlled Quad Outlets	Plug Loads	$12,000
After-Hours Outlet Control	Plug Loads	$38,000
High-Efficiency Motors and Variable Frequency Drives on AHUs	HVAC	$70,000

16. For a more detailed analysis, see the next table, Reed Smith Preliminary Value Analysis.

Performing the Value Analysis

Using energy modeling and incremental costing information, the project team then performed a quantitative value analysis that determined the projected electricity cost savings annually and over the lease term; the resulting payback period; and the tenant's return on investment. This analysis enabled the team to package the energy performance measures to meet the simple payback threshold desired by Reed Smith.

Reed Smith's Space: The Preliminary Value Analysis

EPM ID	Energy Performance Measure	Electricity Reduction (kWh/year)	Eletricity Reduction	Annual Electricity Savings	Incremental First Cost	Simple Payback
2	Bi-Level Lighting Control in All Rooms with Vacancy Sensors	33,540	1.0%	$3,515	($6,500)	**1.8 years**
4	Dimming Lighting Control in All Rooms with Vacancy Sensors (by 25%)	16,616	0.5%	$1,741	($72,000)	**41.4 years**
7	Dimming with Daylighting Functionality	75,815	2.4%	$7,945	($80,000)	10.1 years
9	ENERGY STAR® Equipment	89,600	2.8%	$9,389	$0	0.0 years
10	Plug Load Management with Smart Power Strips (Special Equipment)	66,683	2.1%	$6,988	($19,000)	2.7 years
11	Plug Load Management with Switched Outlet for Special Receptacles	59,671	1.9%	$6,253	($12,000)	1.9 years
12	Plug Load with Two-Per-Floor Kill Switch System	115,684	3.6%	$12,123	($38,000)	3.1 years
13	Add Two Variable Frequency Drives Per Floor for High- and Low-Speed Fans	777,081	24.2%	$81,432	($70,000)	0.9 years
15	High-Performance Lighting Package (0.8)	59,478	1.9%	$6,233	$0	0.0 years
	Package of Measures (without Incentives)	**1,127,050**	**35.1%**	**$118,106**	**($297,500)**	**2.5 years**

Reviewing the Budget and Selecting the EPMs

After the on-site lighting mock up and detailed lighting design study, energy modeling and costing analysis determined the following nine EPMs would offer the best value for Reed Smith on floors 28 through 33.

1. **Energy Efficient Lighting Design (0.84 W/SF)**
2. **Daylight Harvesting Controls**
3. **Bi-Level Lighting Control**
4. **Dimmable Switching Controls (25% Dimming)**
5. **ENERGY STAR® Equipment**
6. **Plug Load Management (Occupancy Sensor Power Strips)**
7. **Plug Load Management (Manually Controlled Quad Outlets)**
8. **Plug Load Management (After-Hours Outlet Control)**
9. **High-Efficiency Motors and Variable Frequency Drives on AHUs**

Building the Space

Reed Smith team leaders reviewed the data and made the final decision to move forward on the energy recommendations. The EPMs were all implemented on schedule and within the anticipated timeframe.

As one of the final phases of the process, measurement and verification (M&V) was performed for Reed Smith on Floors 28 and 31.

This formalized process shows whether the EPMs have the effect on energy consumption as projected. Often the M&V process is not utilized, as it is assumed the measures were installed and commissioned to work. However, for the Reed Smith project, M&V was vital in demonstrating that the energy value analysis achieved the level of value projected.

Energy use projections are based on assumptions, and operations and behavior can alter design intent and projects. If the actual results diverge from the projected results, then something went wrong—savings were incorrectly calculated, a piece of equipment was incorrectly programmed or not operated as intended, or a product did not perform to its specifications. Naturally, Reed Smith wanted to be certain that the demonstration project yielded the projected ROI, and if the M&V process showed otherwise, the team would need to re-examine the analysis and implementation to account for the discrepancy between the simulated and measured results.

Monitoring of Floors 28 and 31 took place for 10 days between April 30, 2015 and May 12, 2015. Integral Group collected actual tenant energy consumption data and corresponding actual meteorological weather data, and has calibrated an existing energy model to correspond to observed usage. Due to the different functions, occupancy, and EPM implementation of the two floors considered, results have been broken out and reported separately. (Floor 28 included all recommended EPMs; the only EPMs implemented on Floor 31 were lighting power density, plug load management through installation of ENERGY STAR® equipment, and variable frequency drives on the AHUs.)

Reed Smith's Initial Energy Model (Floor 28) versus the Calibrated Model after the M&V Process

	Uncalibrated Model	Calibrated Model
Occupancy Hours (Weekday)	7 a.m.–6 p.m.	7 a.m.–6 p.m.
Peak Office Plug Load Power Connected (W/SF)	1.5	0.75
Peak Office Plug Load Power Actual: with Diversity (W/SF)	0.75	0.4
Peak Corridor Plug Load Power Connected (W/SF)	1.9	0.2
Peak Lighting Power Connected (W/SF)	0.84	0.84
Peak Lighting Power Actual: with Diversity (W/SF)	0.42	0.55
Minimum Lighting Power (W/SF)	0.08	0.17
HVAC Fan Schedule Hours	6 a.m.–9 p.m.	6 a.m.–7 p.m.
IDF Room Power Density (W/SF)	25	10
Total Tenant Electricity Consumption: As-Built Baseline (kWh)	432,001	290,189
Total Tenant Electricity Consumption: Implemented Package (kWh)	261,947	161,051

Floor 28

Results show that the original, uncalibrated energy model overestimated energy consumption by about 35%. This is largely due to overestimation of intermediate distribution frame room IT load and equipment plug loads.

A comparison summary of input parameters, total tenant energy consumption, and energy savings on Floor 28 by EPM can be found in Appendix A.

Cooling

Cooling was initially stated to operate two hours longer each day than actually observed and on Saturdays. Metered data shows that it only operated Monday through Friday and is shut off each evening at approximately 7 p.m.

Occupancy

The weekday occupancy profile remains unchanged between the original and calibrated models. The original model, however, assumes Saturday usage of plug loads, lighting and HVAC power, which was not observed.

Lighting

Lighting power was slightly underestimated, particularly during overnight hours. While overall energy savings of the implemented package have decreased by 40,000 kWh, when taken as a percentage of baseline energy, savings have increased by 5%.

Total connected lighting power was accurately modeled and taken from design electrical drawings. Actual usage, however, was underestimated; it was originally predicted to peak at 50% of total installed power. Baseline lighting schedules were adjusted to reflect actual usage, peaking at 65% of total.

Plug Loads/Equipment

Equipment power was originally modeled at 1.5 W/Sf for office spaces; 1.89 W/SF for pantry/ kitchens; 1.0 W/SF for conference spaces; 1.89 W/SF for corridors; and 0.2 W/SF for core areas and stairwells. Actual observed usage revealed about half as much office space usage, due to low-density private offices that were observed to not be fully utilized. Corridor areas (representing a significant percentage of total floor area) are believed to be mistakenly modeled at 1.89 W/ SF. The preliminary energy report detailed 0.2 W/SF in corridors, and the calibrated model was adjusted to match this assumption. Plug load diversity schedules were also adjusted to reflect a lack of observed weekend occupancy and increased turndown during unoccupied overnight and weekend hours.

Reed Smith's Initial Energy Model (Floor 31) versus the Calibrated Model after the M&V Process

	Uncalibrated Model	Calibrated Model
Occupancy Hours (Weekday)	7 a.m.–6 p.m.	7 a.m.–6 p.m.
Peak Plug Load Power Connected (W/SF)	1.5	0.75
Peak Lighting Power Connected (W/SF)	0.84	0.84
Peak Lighting Power Actual: with Diversity (W/SF)	0.42	0.80
Minimum Lighting Power (W/SF)	0.08	0.1
HVAN Fan Schedule Hours	6 a.m.–9 p.m.	6 a.m.–7 p.m.
IDF Room Power Density (W/SF)	30	1
Total Tenant Electricity Consumption: As-Built Baseline (kWh)	446,492	274,731
Total Tenant Electricity Consumption: Implemented Package (kWh)	323,452	189,929

Floor 31

The original, uncalibrated energy model overestimated energy consumption by about 40%. This was also largely due to overestimation of Intermediate distribution frame (IDF) room IT load and equipment plug loads.

A comparison summary of input parameters, total tenant energy consumption, and energy savings on Floor 31 by EPM can be found in Appendix A.

Cooling

Cooling was initially predicated to operate two hours longer each day than actually observed and on Saturdays. Metered data shows that HVAC is only operated Monday through Friday, and is shut off each evening at approximately 7 p.m.

Occupancy

Weekday occupancy profile remains unchanged between the original and calibrated models. The original model, however, assumes Saturday usage of plug loads, lighting, and HVAC power, which was not observed.

Lighting

Total connected lighting power was accurately modeled and taken from design electrical drawings. Actual usage however was underestimated, originally predicted to peak at 50% of total installed power. Baseline lighting schedules were adjusted to reflect actual usage, peaking at 85% of total. The original report also assumed savings from several lighting control EPMs. Metered data and discussion with operators revealed that none of these measure were implemented, due to the unique nature of the 31st floor occupancy.

Plug Loads/Equipment

Equipment power was originally modeled at 1.5 W/Sf for office spaces, 1.89 W/SF for pantry and kitchens, 1.0 W/SF for conference spaces, 1.89 W/SF for corridors, and 0.2 W/SF for core areas and stairwells. Actual observed usage revealed much lower plug load power than initially predicted. The 31st floor consists primarily of conference space. Due to the unique occupancy of the floor, the majority of plug load circuits serve convenience receptacles. Metered data reveals that these receptacles are used very sparingly. Total connected plug load power was assumed accurate.

On Floor 31, the original analysis included several plug load management measures that have interactive effects. As such, determining which exact measures were implemented is difficult through analyzing metered data alone. Plug load consumption was very low on Floor 31, due to low occupancy density/usage, therefore only the EPM related to ENERGY STAR® equipment was implemented.

The floor also contains a full kitchen, used to prepare food for all of Reed Smith's floors. Kitchen equipment is served by a dedicated panel and was metered separately. The calibrated model therefore breaks out this load from the remaining office equipment, and uses a dedicated schedule corresponding to observed use. Power density for this area was initially underestimated, and has been adjusted from 1.886 W/SF to 2.5 W/SF. Overall, kitchen and lighting loads are served by a common disconnect switch, and were therefore metered together. Assuming peak lighting demand at design conditions, kitchen equipment is slightly lower than expected based on the initial equipment list.

The project team recommended that ongoing energy management systems will help ensure energy use is well managed. Reed Smith's facilities team actively tracks monthly and annual energy consumption and engages opportunities to manage and improve energy performance and reduce expenses. End-use sub-metering (lighting, plug, IT room and HVAC loads) and a tenant energy management platform would provide feedback for ongoing commissioning and maintenance of the systems and help keep the energy savings in line.

The 31st floor consists primarily of conference space. Due to the unique occupancy of the floor, the majority of plug load circuits serve convenience receptacles. Metered data reveals that these receptacles are used very sparingly, with a low plug load power density of 0.75W/SF. Photo by ©Halkin/Mason.

Reed Smith's Sustainability Initiatives and Their Impacts on Employees

Beyond energy savings and strong ROI, other benefits of the Tenant Energy Optimization process include furthering corporate social responsibility goals and increasing employee attraction, retention, and productivity.

Reed Smith, after inhabiting its space since its delivery in early 2014, has found the environment to be very conducive to high productivity, said Pat Hiltibidal, Reed Smith's firmwide chief of office services. Its employees, however, did require a period of time to adapt to the change in the firm's energy use approach. Specifically, she noted, the daylighting and the switch handling required some education and regular use in order for the employees to become accustomed to the very different functionalities.

There is also a strong work ethos at Reed Smith's Philadelphia office, Hiltibidal continued. Spaces were built to enhance collaboration and team work, which the new setup promotes. "Generally, there is a strong sense of pride in playing a part in such a meaningful project, and the employees are proud to occupy facilities which strive to use forward-thinking energy conservation protocols," she said.

Reed Smith Going Forward

This project impacts how Reed Smith will look at designing and building space going forward, Hiltibidal noted.

For instance, the glass fronting in Philadelphia was a precursor to Reed Smith installing glass fronts and more energy-efficient spaces as it remakes its real estate portfolio. In previous projects, Reed Smith was not as invested in thorough considerations of best energy practices—this project created a much more intense focus and serious consideration of the benefits going forward, including the return on initial investment over time.

Lesson Learned: The Tenant Energy Optimization Process Can Go Further

Reed Smith's project at Three Logan Square will impact future office design standards for Reed Smith, which has offices all over the globe, including the United States, Europe, Middle East, and Asia.

Appendix A: Original and Final Energy Model Results for Tenant Electricity

Original (Uncalibrated) Model Results: Tenant Electricity, Floor 28

	Description	Total Tenant Electricity				% Savings
EPM ID	**Name**	**Total kWh**	**Lighting kWh**	**Equipment kWh**	**HVAC kWh**	**vs B-1**
BL	ASHRAE 90.1-2007 Baseline	335,224	51,962	133,242	150,020	N/A
B-1	HVAC - As-Built AHUs (Pre-Built BL)	432,001	51,962	133,242	246,797	N/A
T-1	High-Efficiency Lighting - Lighting Power Density to 0.84 W/SF	420,771	42,320	133,242	245,209	2.6%
T-2	High-Efficiency Lighting - Daylight Harvesting	422,114	43,567	133,242	245,305	2.3%
T-3	High-Efficiency Lighting - Bi-Level Dimming Controls	426,220	46,766	133,242	246,213	1.3%
T-4	High-Efficiency Lighting - Dimmable Switching Controls	429,111	49,369	133,242	246,499	0.7%
T-5	Plug Load Management - ENERGY STAR® Equipment	415,451	51,962	118,637	244,852	3.8%
T-6	Plug Load Management - OS Power Strips	421,085	51,962	123,449	245,673	2.5%
T-7	Plug Load Management - Kill Switch Controls	421,368	51,962	123,711	245,695	2.5%
T-8	Plug Load Management - Quads	422,347	51,962	124,680	245,704	2.2%
T-9	HVAC - VFDs on AHUs	318,959	51,962	133,242	133,755	26.2%
X-1	**All measures combined**	**261,947**	**27,437**	**103,242**	**131,267**	**39.4%**
	Savings by Measure (all runs based on B-1)					
BL	ASHRAE 90.1-2007 Baseline	N/A	N/A	N/A	N/A	N/A
B-1	HVAC - As-Built AHUs (Pre-Built BL)	N/A	N/A	N/A	N/A	N/A
T-1	High-Efficiency Lighting - Lighting Power Density to 0.84 W/SF	11,231	389,681	298,759	186,793	2.6%
T-2	High-Efficiency Lighting - Daylight Harvesting	9,887	388,434	298,759	186,696	2.3%
T-3	High-Efficiency Lighting - Bi-Level Dimming Controls	5,781	385,235	298,759	185,789	1.3%
T-4	High-Efficiency Lighting - Dimmable Switching Controls	2,891	382,632	298,759	185,502	0.7%
T-5	Plug Load Management - ENERGY STAR® Equipment	16,550	380,039	313,364	187,150	3.8%
T-6	Plug Load Management - OS Power Strips	10,916	380,039	308,552	186,328	2.5%
T-7	Plug Load Management - Kill Switch Controls	10,633	380,039	308,290	186,306	2.5%
T-8	Plug Load Management - Quads	9,655	380,039	307,321	186,297	2.2%
T-9	HVAC - VFDs on AHUs	113,042	380,039	298,759	298,246	26.2%
X-1	**All measures combined**	**170,055**	**404,564**	**328,759**	**300,734**	**39.4%**

Calibrated Model Results: Tenant Electricity, Floor 28

	Description	Total Tenant Electricity				% Savings
EPM ID	**Name**	**Total kWh**	**Lighting kWh**	**Equipment kWh**	**HVAC kWh**	**vs B-1**
BL	ASHRAE 90.1-2007 Baseline	204,736	69,369	35,532	99,834	N/A
B-1	HVAC - As-Built AHUs (Pre-Built BL)	290,189	69,369	35,532	185,287	N/A
T-1	High-Efficiency Lighting - Lighting Power Density to 0.84 W/SF	275,879	56,497	35,532	183,849	4.9%
T-2	High-Efficiency Lighting - Daylight Harvesting	278,418	59,128	35,532	183,757	4.1%
T-3	High-Efficiency Lighting - Bi-Level Dimming Controls	282,563	62,432	35,532	184,598	2.6%
T-4	High-Efficiency Lighting - Dimmable Switching Controls	286,356	65,908	35,532	184,916	1.3%
T-5	Plug Load Management - ENERGY STAR® Equipment	286,272	69,369	32,025	184,877	1.4%
T-6	Plug Load Management - OS Power Strips	287,492	69,369	33,156	184,966	0.9%
T-7	Plug Load Management - Kill Switch Controls	287,330	69,369	33,026	184,935	1.0%
T-8	Plug Load Management - Quads	288,233	69,369	33,777	185,087	0.7%
T-9	HVAC - VFDs on AHUs	203,811	69,369	35,532	98,910	29.8%
X-1	**All measures combined**	**161,051**	**37,248**	**28,386**	**95,417**	**44.5%**
	Savings by Measure (all runs based on B-1)					
BL	ASHRAE 90.1-2007 Baseline	N/A	N/A	N/A	N/A	N/A
B-1	HVAC - As-Built AHUs (Pre-Built BL)	N/A	N/A	N/A	N/A	N/A
T-1	High-Efficiency Lighting - Lighting Power Density to 0.84 W/SF	14,310	233,692	254,657	106,340	4.9%
T-2	High-Efficiency Lighting - Daylight Harvesting	11,771	231,061	254,657	106,432	4.1%
T-3	High-Efficiency Lighting - Bi-Level Dimming Controls	7,626	227,757	254,657	105,591	2.6%
T-4	High-Efficiency Lighting - Dimmable Switching Controls	3,833	224,281	254,657	105,273	1.3%
T-5	Plug Load Management - ENERGY STAR® Equipment	3,918	220,820	258,164	105,312	1.4%
T-6	Plug Load Management - OS Power Strips	2,698	220,820	257,033	105,223	0.9%
T-7	Plug Load Management - Kill Switch Controls	2,859	220,820	257,163	105,254	1.0%
T-8	Plug Load Management - Quads	1,956	220,820	256,412	105,102	0.7%
T-9	HVAC - VFDs on AHUs	86,378	220,820	254,657	191,280	29.8%
X-1	**All measures combined**	**129,138**	**252,942**	**261,803**	**194,772**	**44.5%**

Original Model Results: Tenant Electricity, Floor 31

	Description	Total Tenant Electricity				% Savings
EPM ID	**Name (EPMs in Gray Were Not Implemented)**	**Total kWh**	**Lighting kWh**	**Equipment kWh**	**HVAC kWh**	**vs B-1**
BL	ASHRAE 90.1-2007 Baseline	331,943	51,476	137,039	143,428	N/A
B-1	HVAC - As-built AHUs (Pre-built BL)	446,492	51,476	137,039	257,977	N/A
T-1	High-Efficiency Lighting - Lighting Power Density to 0.84 W/SF	436,415	43,287	137,039	256,089	2.3%
T-2	*High-Efficiency Lighting - Daylight Harvesting*	*428,832*	*36,620*	*137,039*	*255,174*	*4.0%*
T-3	*High-Efficiency Lighting - Bi-Level Dimming Controls*	*440,555*	*46,329*	*137,039*	*257,187*	*1.3%*
T-4	*High-Efficiency Lighting - Dimmable Switching Controls*	*443,550*	*48,908*	*137,039*	*257,603*	*0.7%*
T-5	Plug Load Management - ENERGY STAR® Equipment	433,202	51,476	124,441	257,285	3.0%
T-6	*Plug Load Management - OS Power Strips*	*436,688*	*51,476*	*128,565*	*256,647*	*2.2%*
T-7	*Plug Load Management - Kill Switch Controls*	*436,957*	*51,476*	*128,791*	*256,689*	*2.1%*
T-8	*Plug Load Management - Quads*	*437,683*	*51,476*	*129,630*	*256,577*	*2.0%*
T-9	HVAC - VFDs on AHUs	346,484	51,476	137,039	157,969	22.4%
X-1	**All measures combined**	**323,542**	**43,287**	**124,441**	**155,815**	**27.5%**
	Savings by Measure (all runs based on B-1)					
BL	ASHRAE 90.1-2007 Baseline	N/A	N/A	N/A	N/A	N/A
B-1	HVAC - As-Built AHUs (Pre-Built BL)	N/A	N/A	N/A	N/A	N/A
T-1	High-Efficiency Lighting - Lighting Power Density to 0.84 W/SF	10,078	403,206	309,453	190,403	2.3%
T-2	*High-Efficiency Lighting - Daylight Harvesting*	*17,660*	*409,873*	*309,453*	*191,319*	*4.0%*
T-3	*High-Efficiency Lighting - Bi-Level Dimming Controls*	*5,937*	*400,164*	*309,453*	*189,305*	*1.3%*
T-4	*High-Efficiency Lighting - Dimmable Switching Controls*	*2,943*	*397,585*	*309,453*	*188,889*	*0.7%*
T-5	Plug Load Management - ENERGY STAR® Equipment	13,290	395,016	322,052	189,207	3.0%
T-6	*Plug Load Management - OS Power Strips*	*9,804*	*395,016*	*317,928*	*189,845*	*2.2%*
T-7	*Plug Load Management - Kill Switch Controls*	*9,536*	*395,016*	*317,701*	*189,803*	*2.1%*
T-8	*Plug Load Management - Quads*	*8,809*	*395,016*	*316,863*	*189,915*	*2.0%*
T-9	HVAC - VFDs on AHUs	100,008	395,016	309,453	288,523	22.4%
X-1	**All measures combined**	**122,950**	**403,206**	**322,052**	**290,677**	**27.5%**

Calibrated Model Results: Tenant Electricity, Floor 31

	Description	Total Tenant Electricity				% Savings
EPM ID	**Name (EPMs in Gray Were Not Implemented)**	**Total kWh**	**Lighting kWh**	**Equipment kWh**	**HVAC kWh**	**vs B-1**
BL	ASHRAE 90.1-2007 Baseline	185,703	66,143	24,556	95,004	N/A
B-1	HVAC - As-Built AHUs (Pre-Built BL)	274,731	66,143	24,556	184,032	N/A
T-1	High-Efficiency Lighting - Lighting Power Density to 0.84 W/SF	261,932	55,259	24,556	182,117	4.7%
T-2	*High-Efficiency Lighting - Daylight Harvesting*	*251,446*	*46,392*	*24,556*	*180,498*	*8.5%*
T-3	*High-Efficiency Lighting - Bi-Level Dimming Controls*	*267,162*	*59,603*	*24,556*	*183,003*	*2.8%*
T-4	*High-Efficiency Lighting - Dimmable Switching Controls*	*271,003*	*62,880*	*24,556*	*183,567*	*1.4%*
T-5	Plug Load Management - ENERGY STAR® Equipment	270,955	66,143	21,205	183,607	1.4%
T-6	*Plug Load Management - OS Power Strips*	*272,687*	*66,143*	*22,723*	*183,821*	*0.7%*
T-7	*Plug Load Management - Kill Switch Controls*	*273,610*	*66,143*	*23,627*	*183,840*	*0.4%*
T-8	*Plug Load Management - Quads*	*271,408*	*66,143*	*21,534*	*183,730*	*1.2%*
T-9	HVAC - VFDs on AHUs	205,808	66,143	24,556	115,108	25.1%
X-1	**Implemented Package (EEM B-1, T-1, T-5, T-9)**	**189,929**	**55,218**	**21,205**	**113,507**	**30.9%**
	Savings by Measure (all runs based on B-1)					
BL	ASHRAE 90.1-2007 Baseline	N/A	N/A	N/A	N/A	N/A
B-1	HVAC - As-Built AHUs (Pre-Built BL)	N/A	N/A	N/A	N/A	N/A
T-1	High-Efficiency Lighting - Lighting Power Density to 0.84 W/SF	12,799	219,472	250,175	92,614	4.7%
T-2	*High-Efficiency Lighting - Daylight Harvesting*	*23,285*	*228,339*	*250,175*	*94,233*	*8.5%*
T-3	*High-Efficiency Lighting - Bi-Level Dimming Controls*	*7,569*	*215,128*	*250,175*	*91,728*	*2.8%*
T-4	*High-Efficiency Lighting - Dimmable Switching Controls*	*3,728*	*211,851*	*250,175*	*91,164*	*1.4%*
T-5	Plug Load Management - ENERGY STAR® Equipment	3,776	208,588	253,526	91,125	1.4%
T-6	*Plug Load Management - OS Power Strips*	*2,044*	*208,588*	*252,008*	*90,911*	*0.7%*
T-7	*Plug Load Management - Kill Switch Controls*	*1,121*	*208,588*	*251,104*	*90,891*	*0.4%*
T-8	*Plug Load Management - Quads*	*3,323*	*208,588*	*253,197*	*91,001*	*1.2%*
T-9	HVAC - VFDs on AHUs	68,923	208,588	250,175	159,623	25.1%
X-1	**Implemented Package (EEM B-1, T-1, T-5, T-9)**	**84,802**	**219,514**	**253,526**	**161,225**	**30.9%**

Appendix B: Floor 28 Energy Model Output by Measure (Original and Calibrated)

		Uncalibrated Baseline vs Proposed Savings			Calibrated Baseline vs Proposed Savings		
EPM Description		**Annual Tenant Electricity Savings (kWh)**	**Percent Savings**	**Annual Cost Savings**	**Annual Tenant Electricity Savings (kWh)**	**Percent Savings**	**Annual Cost Savings**
BL	ASHRAE 90.1-2007 Baseline	N/A	N/A	N/A	N/A	N/A	N/A
B-1	HVAC - As-Built AHUs (Pre-Built BL)	N/A	N/A	N/A	N/A	N/A	N/A
T-1	High-Efficiency Lighting - Lighting Power Density to 0.84 W/SF	11,231	2.6%	$1,853	14,310	4.9%	$2,361
T-2	High-Efficiency Lighting - Daylight Harvesting	9,887	2.3%	$1,631	11,771	4.1%	$1,942
T-3	High-Efficiency Lighting - Bi-Level Dimming Controls	5,781	1.3%	$954	7,626	2.6%	$1,258
T-4	High-Efficiency Lighting - Dimmable Switching Controls	2,891	0.7%	$477	3,833	1.3%	$632
T-5	Plug Load Management - ENERGY STAR® Equipment	16,550	3.8%	$2,731	3,918	1.4%	$646
T-6	Plug Load Management - OS Power Strips	10,916	2.5%	$1,801	2,698	0.9%	$445
T-7	Plug Load Management - Kill Switch Controls	10,633	2.5%	$1,754	2,859	1.0%	$472
T-8	Plug Load Management - Quads	9,655	2.2%	$1,593	1,956	0.7%	$323
T-9	HVAC - VFDs on AHUs	113,042	26.2%	$18,652	86,378	29.8%	$14,252
X-1	**All Measures Combined (Implemented Package)**	**170,055**	**39.4%**	**$28,059**	**129,138**	**44.5%**	**$21,308**

Notes: *Electric rate of $0.165/kWh assumed*
Total savings reported versus pre-built baseline (B-1)

Floor 31 Energy Model Output by Measure (Original and Calibrated)

EPM Description (EPMs in Gray Were Not Implemented)		Uncalibrated Baseline vs Proposed Savings			Calibrated Baseline vs Proposed Savings		
		Annual Tenant Electricity Savings (kWh)	Percent Savings	Annual Cost Savings	Annual Tenant Electricity Savings (kWh)	Percent Savings	Annual Cost Savings
BL	ASHRAE 90.1-2007 Baseline	N/A	N/A	N/A	N/A	N/A	N/A
B-1	HVAC - As-Built AHUs (Pre-Built BL)	N/A	N/A	N/A	N/A	N/A	N/A
T-1	High-Efficiency Lighting - Lighting Power Density to 0.84 W/SF	10,078	2.3%	1,663	12,799	4.7%	2,112
T-2	*High-Efficiency Lighting - Daylight Harvesting*	*17,660*	*4.0%*	*2,914*	*23,285*	*8.5%*	*3,842*
T-3	*High-Efficiency Lighting - Bi-Level Dimming Controls*	*5,937*	*1.3%*	*980*	*7,569*	*2.8%*	*1,249*
T-4	*High-Efficiency Lighting - Dimmable Switching Controls*	*2,943*	*0.7%*	*486*	*3,728*	*1.4%*	*615*
T-5	Plug Load Management - ENERGY STAR® Equipment	13,290	3.0%	2,193	3,776	1.4%	623
T-6	*Plug Load Management - OS Power Strips*	*9,804*	*2.2%*	*1,618*	*2,044*	*0.7%*	*337*
T-7	*Plug Load Management - Kill Switch Controls*	*9,536*	*2.1%*	*1,573*	*1,121*	*0.4%*	*185*
T-8	*Plug Load Management - Quads*	*8,809*	*2.0%*	*1,454*	*3,323*	*1.2%*	*548*
T-9	HVAC - VFDs on AHUs	100,008	22.4%	16,501	68,923	25.1%	11,372
X-1	**Implemented Package (EEM T-1, T-5, T-9)**	**122,950**	**27.5%**	**20,287**	**84,802**	**30.9%**	**13,992**

Notes: *Electric rate of $0.165/kWh assumed*
Total savings reported versus pre-built baseline (B-1)

About the Urban Land Institute

The mission of the Urban Land Institute is to provide leadership in the responsible use of land and in creating and sustaining thriving communities worldwide. Established in 1936, the Institute today has more than 39,000 members worldwide representing the entire spectrum of the land use and development disciplines. ULI relies heavily on the experience of its members. It is through member involvement and information resources that ULI has been able to set standards of excellence in development practice. The Institute has long been recognized as one of the world's most respected and widely quoted sources of objective information on urban planning, growth, and development.

About the Center for Sustainability

The ULI Center for Sustainability is dedicated to creating healthy, resilient, and high-performance communities around the world. Through the work of ULI's Greenprint Center for Building Performance, the ULI Urban Resilience Program, and other initiatives, the Center advances knowledge and catalyzes adoption of transformative market practices and policies that lead to improved energy performance and portfolio resilience while reducing risks caused by a changing climate.

Acknowledgments

Case Study Participants

The foundation of ULI's Tenant Energy Optimization Program is a ten-step process that, when implemented in ten pilot fit-out projects, yielded impressive energy and cost savings. Pilot projects applying this process were carried out in tenant spaces occupied by Bloomberg L.P., Coty Inc., Cushman & Wakefield, Estée Lauder Companies, Global Brands Group, LinkedIn, New York State Energy Research and Development Authority (NYSERDA), Reed Smith LLP, Shutterstock, and TPG Architecture. Case studies documenting their experiences were written to inform tenants, building owners, real estate brokers, project managers, architects, engineers, contractors, and energy consultants.

Project Director

ULI's Tenant Energy Optimization Program builds on the energy efficiency retrofit project conducted at the Empire State Building under the direction of Wendy Fok, principal of OpDesigned LLC. From 2011 to 2016, Fok led the development of a portfolio of tenant buildouts to create a financial and design template to incorporate energy efficiency in tenant spaces. Fok has been a key contributor to the standards set forth in the Energy Efficiency Improvement Act of 2015 (S. 535), which created the national Tenant Star framework. A registered architect, she received her degree from the University of Texas at Austin with real estate executive education from Harvard Business School.

Funders

Funding to develop the program was generously provided by the Goldman Sachs Center for Environmental Markets, John and Amy Griffin, the Helmsley Charitable Trust, the Natural Resources Defense Council, the Malkin Fund, the SL 2012 Fund, the Ripple Foundation, the Robertson Foundation, and the Rockefeller Foundation.

For More Information

Interested in implementing the process?
ULI provides tools such as technical resource guides, how-to documents, case studies, and other training materials. These materials can be found at: **tenantenergy.ULI.org**.