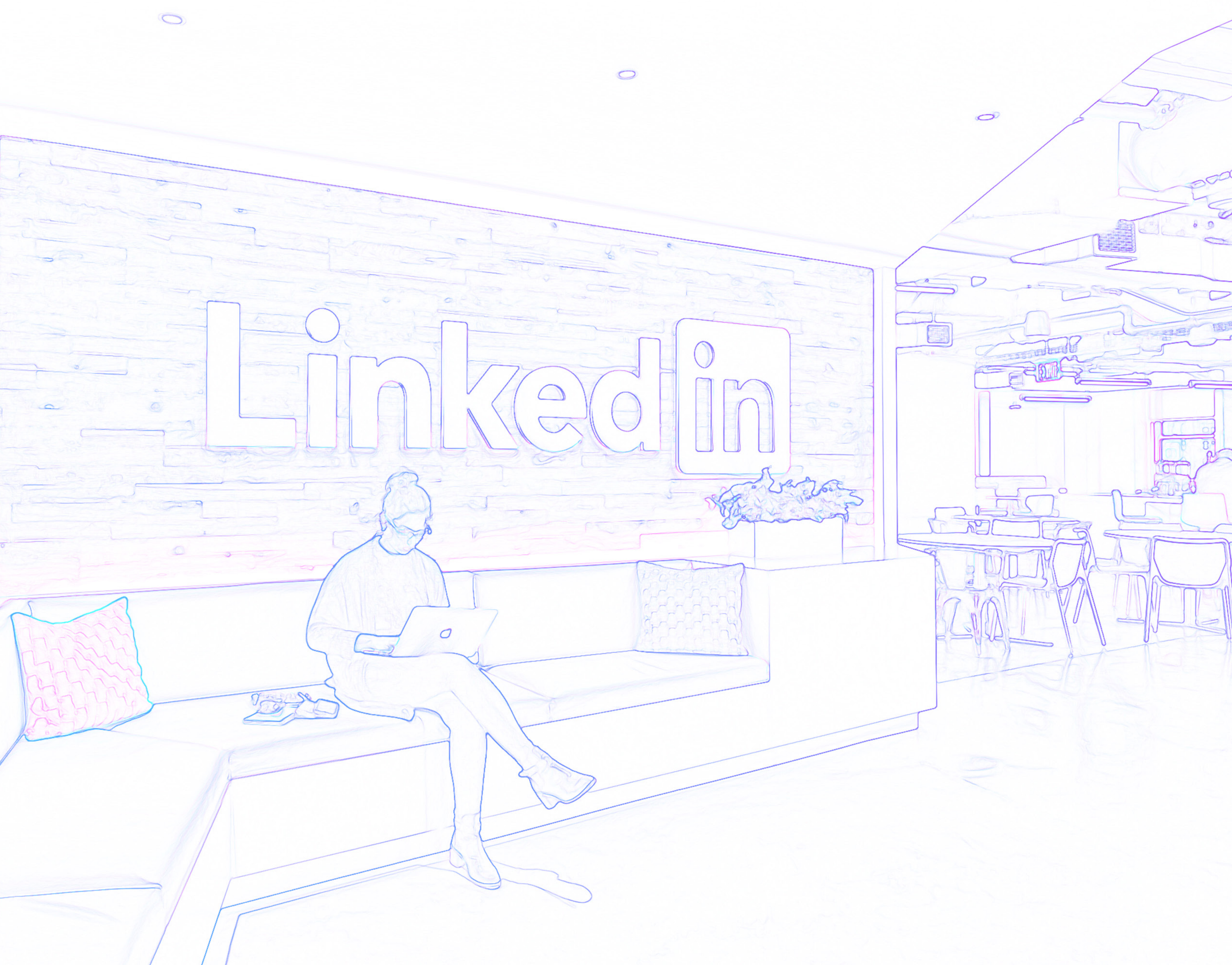
Urban Land Institute

ULI Tenant Energy Optimization Program

Case Study:
LinkedIn Corp.



Executive Summary: LinkedIn's Story

In 2011, LinkedIn Corp.—the world's largest online professional network with over 300 million members in over 200 countries and territories—decided to lease office space in the Empire State Building. It now occupies multiple floors in the building, including the nearly 36,000-square-foot Floor 22.

When LinkedIn signed its initial lease, the 2.8 million square-foot Empire State Building was in the midst of a major retrofit and repositioning, which transformed it into a Class-A, high-performance building located in the heart of Midtown Manhattan at Fifth Avenue and West 34th Street.

When it was time to design and construct its new space, LinkedIn had three goals: efficiently designed space to support its growing sales team; flexible space that would quickly allow the company to repurpose the space for other teams, such as sales support, research & development, and corporate support; and space that is engaging to its employees and reflective of the local norms and culture.

Enter 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 in tandem with landlord Empire State Realty Trust (ESRT) and a team of experts, LinkedIn evaluated an integrated package of energy performance measures (EPMs)[1] for Floor 22. 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 LinkedIn's 10-year lease, the project is estimated to provide energy costs savings of more than $153,000, a 23% return on LinkedIn's investment[2], and a 10.1% internal rate of return (IRR)[3]. The projected payback: 6.4 years.

LinkedIn'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[4] 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%[5], 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. Assuming zero escalation in electricity prices over the lease term and a 5% administrative fee per the terms of tenant's lease.
3. 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)
4. The guides can be accessed at tenantenergy.uli.org.
5. 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: LinkedIn Project Information and Projected Performance

Building Information				
Tenant Name	LinkedIn Corp.			
Building Owner	Empire State Realty Trust			
Location	350 Fifth Avenue, Midtown Manhattan			
Building Size	2.8 million square feet (102 floors)			
Principal Use	Class-A office with street-level retail			
Construction Type	Pre-World War II skyscraper			
U.S. EPA ENERGY STAR® Rating	90			
Energy Retrofit Completion Date	2011			
LinkedIn Lease Term	10 years			
Floor 22 Buildout	**Projected Design**		**M&V Calibration**	
Square Footage	35,665 square feet		35,665 square feet	
Modeled Energy Reduction	34.2%		31.3%[6]	
Annual Electricity Reduction	172,230 kWh	4.6 kWh/SF	92,840 kWh	2.5 kWh/SF
Total Electricity Savings over Lease Term	1.7 GWh	46.3 kWh/SF	0.9 GWh	25.0 kWh/SF
Incremental Implementation Cost: ***Energy Modeling Soft Cost:*** ***State Incentives:***	$113,590 *$9,000* *$24,680*	$3.05/SF *$0.24/SF* *$0.66/SF*	$113,590 *$9,000* *$24,680*	$3.05/SF *$0.24/SF* *$0.66/SF*
Adjusted Incremental Implementation Cost	$97,910	$2.63/SF	$97,910	$2.63/SF
Total Electricity Costs Savings over Lease Term	$284,195	$7.64/SF	$153,000	$4.11/SF
Electricity Cost Savings over Lease Term(Present Value)	$224,432	$6.04/SF	$120,826	$3.25/SF
Net Present Value of Project Investment	$126,523	$3.40/SF	$22,917	$0.62/SF
Return on Investment over Lease Term	129%		23%	
Internal Rate of Return	30.6%		10.1%	
Payback Period (with Incentives)	3.4 years		6.4 years	

6. 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 LinkedIn Chose the Empire State Building

In 2013, LinkedIn spokeswoman Blair Decembrele told CNBC that the professional networking website chose to locate its New York office inside the Empire State Building not only because of the structure's cultural prestige, but also because the space is well-positioned for a resurgence in New York's technology sector.

"As the city of New York continues to reinvent itself as a hub for some of today's fastest-growing technology companies, the Empire State Building was a natural fit for our New York office," she told the news website.[7]

But another strong driver that persuaded many of the Empire State Building's tenants to take space in the property was owner Empire State Realty Trust's (ESRT) commitment to establishing the 2.8 million-square-foot Empire State Building as one of the most energy-efficient buildings in New York City. By choosing to locate in this building, LinkedIn immediately improved its energy performance compared to a typical New York building.

A Collaborative Effort

When LinkedIn signed its lease with the Empire State Building, the lease language required the tenant implement specific EPMs that demonstrate an acceptable payback period. To compound the tenant savings opportunity, the Empire State Building lease requires LinkedIn's tenant improvement installation to include certain lighting, plug, and cooling EPMs that produce a five-year (or shorter) payback period.

ESRT began introducing this language in lease documents back in 2008 in order to reach its energy savings target, realizing that tenant participation is critical in achieving that. In fact, actions taken by tenants in the building would ultimately account for more than one-quarter of the anticipated energy reduction from the initiative. For one, LinkedIn's electricity consumption is sub-metered, and the tenant pays for electricity based upon its actual sub-metered electrical usage. The innovative provisions ensure that the impact of the base building upgrades would be maximized across the tenant spaces, which account for the bulk of the building's energy consumption.

The Empire State Building retrofit team also built a whole-building energy model for all 102 floors; upon each lease signing, ESRT makes this model available to tenants to refer to in the design process. Although a new energy model must be customized for each space design, the base-building model saves time and money—engineers can better understand the building's design and energy improvements therefore reducing upfront energy modeling costs and enabling more accurate projections. By packaging the analysis to include current and future floor designs, further upfront soft costs for energy modeling savings were realized.

7. http://www.cnbc.com/2013/10/02/empire-state-building-goes-public-here-are-its-tenants.html

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 ESRT and LinkedIn is a great example of this partnership.

A 2014 survey[8] 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.

The Project's Key Stakeholders

The Tenant: LinkedIn

LinkedIn Corp. (NYSE: LNKD) is the world's largest online professional network with over 300 million members in over 200 countries and territories. Founded in 2002, the website officially launched in 2003 and is now available in 24 languages. The company is publicly held and has a diversified business model with revenues coming from talent solutions, marketing solutions, and premium subscription products.

Headquartered in Mountain View, Calif., LinkedIn also has U.S. offices in New York, Chicago, Los Angeles, Omaha, San Francisco, Sunnyvale and Washington D.C., as well as various international offices.

In Q3 2015, its total revenue grew 33% year-over-year to $780 million.[a]

The Building Owner: Empire State Realty Trust

Empire State Realty Trust, Inc. (NYSE: ESRT), a leading real estate investment trust (REIT), owns, manages, operates, acquires, and repositions office and retail properties in Manhattan and the greater New York metropolitan area, including the Empire State Building, the world's most famous building. ESRT is a leader in energy efficiency in the built environment.

a. https://press.linkedin.com/about-linkedin

8. 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.

LinkedIn Integrates the Tenant Energy Optimization Process

LinkedIn's space on Floor 22 consists of office space, meeting and conference rooms, recreational space, a kitchen and pantry, and a small data center intermediate distribution frame (IDF) room.

Floor 22 at a Glance

Space Type:	Floor 22
Whole-Floor Project Area	35,665 SF
Office	32.9%
Conference	10.6%
Corridor	10.4%
Mechanical/Electrical	12.0%
Other	8.5%
Storage	9.4%
Unconditioned	13.8%
Restroom	2.4%

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

Selecting the Buildout Team

The LinkedIn Buildout Team

Company	Role
Joel Wood	Project Manager
M Moser Associates	Architect
ICON Interiors	General Contractor
AKF Group	Engineer
Wendy Fok	Energy Project Director
Quest Energy	Energy Consultant and Modeler
Integral Group	Energy Consultant
Empire State Realty Trust	Landlord
JLL	Owner's Representative

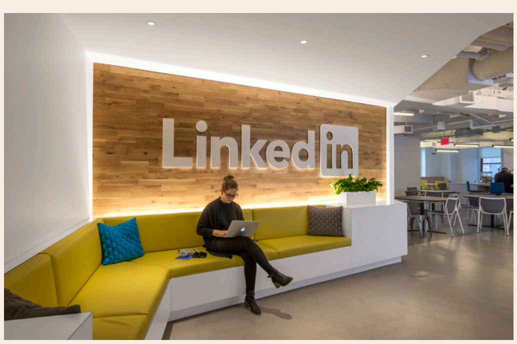
Those leading the LinkedIn project team, including the energy modeler, had already been involved in the Empire State Building retrofit and were experienced in the process.

Setting Energy Performance Goals and Developing a Menu of Measures

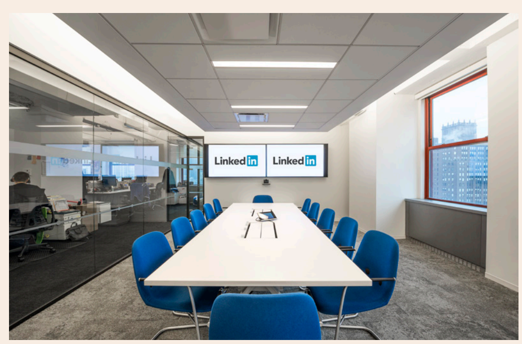
The process was kicked off with an energy design workshop in October 2013, which brought together the design and construction team that would be involved in LinkedIn's build out. These groups worked in tandem to make sure all energy reduction strategies conformed to the goals and intent of LinkedIn's design. Among the factors it wanted to consider:

1. The office should have the look and feel of tech space, with a distinctly New York feel;
2. The space should be highly flexible and could be quickly reconfigured at a low cost;
3. The space should be interesting in design, essentially a space that people want to come work in; and
4. It should have open space, but with lots of options for different types of collaboration spaces, such as closed conference, phone meetings, small meeting rooms, and open break rooms.

With LinkedIn's objectives in mind, the project team put together tenant space parameters, which formed the basis for the project's energy performance goals. The accompanying Menu of Measures summarizes the energy efficiency measures that were discussed at the energy design workshop:



Spaces are bright and open, with light-reflecting fixtures and bright surfaces. Photo by Timothy Schenck.



Conference rooms include energy-efficient equipment and allow daylight into open office areas through windows and glass walls. Photo by Timothy Schenck.

Menu of Measures

Demand-Controlled Ventilation with Optimized VAV Box Minimums: The amount of outside air needed to maintain space comfort is roughly proportional to the number of people in the space. Controls can accurately measure how many people are in the space by continuous measurement of the amount of carbon dioxide in the air. This allows for outside air volumes to be reduced when there are few people in the space, reducing the heating and costs. The active control of outside air also allows for the minimum airflow to spaces to be reduced, saving fan power. Modern electronically actuated VAV boxes are capable of stable control at significantly lower airflow rates than their default setting. Utilizing lower airflow settings reduces fan power and, when coupled with demand controlled ventilation, maintains space ventilation.

Lighting Occupancy Controls: Occupancy control of lights is required by code in private offices and conference rooms. Savings are increased by expanding it to cover open office spaces as well. To ensure savings are realized, verification that the occupancy sensors are properly adjusted must be done as part of project commissioning.

Low Lighting W/SF: Low ambient lighting power by design (0.8 W/SF is commonly achieved, with 0.5 W/SF possible) is a feasible goal. Wide deployment of mature LED lighting systems has brought efficient lighting into the high-end design market, offering efficiency and design flexibility.

Daylighting Dimming and Harvesting Controls: Automatic lighting controls offer an excellent opportunity to reduce power use. There are a number of options on the market that dim lights when windows are providing comfortable levels of illumination, reducing both power use and cooling load while also giving a pleasant work space. Maximizing the interior ceiling height at the perimeter and use of interior glazing on perimeter conference room and office partitions are key design features. An open-ceiling approach makes the most of the limited floor-to-floor height at the Empire State Building. Daylight penetration can be extended through the use of lighter-colored surfaces, interior light shelves, and high ceiling heights.

Plug Load Management: The consumption of power by plug loads when they are not actively in use can be significant in a modern office space. Controls that automatically switch off receptacles when the space is unoccupied are becoming more common and are a baseline technology in the ASHRAE 90.1-2010 standard. There are several approaches to reducing this power cost by switching off outlets, including manually switched outlets and occupancy sensor based outlet switching, as well as using the WattStopper Isolé[9] (post construction) and Modlet[10] controlled outlet and monitor. Any outlet control approach must include a mix of non-controlled outlets to provide always-on outlet for occupants, typically clearly identified by a different color outlet socket. The use of dual-technology occupancy sensors (acoustic and IR) is recommended for automatically controlled outlets in large open areas to minimize the risk of nuisance switching. Done properly, computers should never be accidentally switched off by the plug load management system.

HVAC Occupancy Control of Conference Rooms: With demand-controlled ventilation and occupancy-based lighting controls commonly used for conference rooms, it is often feasible to control the HVAC to coincide with occupancy. The VAV box supplying a conference room can be set to fully closed, not merely minimum position, when the CO_2 sensor and lighting occupancy sensor indicates the space is unoccupied.

Low-Face Velocity Air Handlers: A significant portion of the HVAC fan power is used to push air through the filters and coils in the air handler unit. This pressure drop could be reduced by using a larger air handler unit—a coordination challenge that may ultimately cost some floor area, but a feasible option that is not hampered by the strict floor-to- floor height limits. Larger air handler units also reduce the noise generated by the fans, provide future expansion flexibility, and can reduce the maintenance requirements slightly (longer filter change intervals, lower RPM fan). Typically, the fan power reduction also allows for a downsizing of the fan motor and drive, recouping some of the initial cost of a larger unit casing immediately.

Chilled Water Data Center Cooling Unit: The building chilled water system is the most efficient source of cooling at this site. Specifying computer room air conditioners that are able to use it directly is a more efficient approach than using ones that have a stand-alone compressor always in operation. The elimination of humidification in the data center is also a best practice that significantly reduces energy use and maintenance costs. Humidification in data centers is a legacy of the punch card and tape-drive era, but in modern computer rooms can be more of a reliability liability by injecting a pressurized water supply directly into the data center envelope.

Sub-Metering and Power Monitoring: Sub-monitoring of power to break down power use by lighting, plug power or HVAC power, respectively, can be done very economically provided good practice is followed and separate panels are used for each load type. The addition of this sub-metering allows the tenant to monitor where their energy is going—a pre-requisite for optimizing and effectively managing their consumption.

9. http://www.wattstopper.com/resources/sustainability/plug-loads/isole.aspx#.VbxxQflViko
10. https://mymodlet.com/Account/Login?ReturnUrl=%2f

Best Practices Data Center Set Points: Modern data center equipment operates well over a wide range of conditions. Over-controlling computer rooms is at best a waste of energy and at worst reduces reliability. ASHRAE has developed guidelines for data center space control that define a wide temperature band, up to 80°F, as recommended practice for the highest-tier-level data centers. Adoption of these recommendations of the most appropriate tier level is recommended to provide the best current standard of care. Humidity control is another key area to consider adopting best practices in the design stage. Humidification of data centers was initially done to ensure smooth operation of punch card feeders. More recently, there were concerns that some magnetic tape drive media was sensitive to humidity. But in a modern computer room, the need for humidification should be assessed with a critical eye. Humidification is not an accepted method of controlling electrostatic discharge and the introduction of the pressurized water lines and fill valves that are part of humidifiers is a significant reliability (and cost and energy) concern. Elimination of humidification should be considered with a clean sheet mentality, based on an assessment of the rooms intended use and equipment, and not grandfathered in as a traditional aspect of datacenter systems.

Heat Recovery from IT Room: Configure the computer room to allow air to be cascaded from the computer room out to the general office space towards the perimeter in the winter. Using this method, heat can be supplied to perimeter zones in winter. If hot IT room air is introduced into the main system return air stream, it will also reduce the outside air preheat load when it is mixed with ventilation air intake. Heat recovery is best implemented in combination with a hot aisle enclosure. Hot aisle enclosures can be site fabricated, typically using flexible plastic curtains or panels, or purchased as a freestanding enclosure structure. They serve to collect hot air exhaust from the computer racks so it can be directly returned to the computer room air conditioning units without causing potentially damaging recirculation and hot spots. Collecting the hot air also has efficiency benefits and would allow for effective harvest of heat from the IT rooms.

Modeling the Projected Energy Performance

During design development, a predictive energy model[11] was created using eQuest software, which modeled energy consumption and EPM results for LinkedIn's space on Floor 22.
The model was later calibrated using metered data gathered during tenant occupation.[12]

Assumptions Present in the Modeling

- Operable windows will be open a negligible amount of time.
- The cooling set point in the spaces is 72°F, with a 2°F setback to 74°F. The heating set point is 68°F with a 2°F setback to 66°F.
- The number of people on the floor is estimated as 187 GSF (including storage and corridors, but excluding unconditioned core) per person, based on 140 peak employees.
- On a typical day, approximately 85% of the maximum occupancy will be present and working on the floor. Lower occupancy is typically due to offsite meeting, absences, and travel. For example, Floor 22 is estimated as having maximum design occupancy of 140 people but a typical day maximum occupancy of 119 people.
- The space begins occupancy at 9 a.m., with a few people coming in at 8 a.m. and ends occupancy at 6 p.m., with a few people staying until 7 p.m.
- Most lights are turned on at 8 a.m. and off at 6 p.m.
- On a typical day, 95% of the installed lighting is turned on (ignoring daylight harvesting controls but including occupancy sensors).
- On a typical day, 40% of the installed equipment is turned on (without controls).

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 LinkedIn'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.

11. There are three baselines shown in the energy model: the as-built baseline of the Empire State Building; an ASHRAE 90.1-2007 baseline, which has been used for the majority of the savings calculations; and an ASHRAE 90.1-2010 baseline.
12. See Appendix A for detailed analysis.

Flexible open office space and meeting rooms include advanced lighting controls that provide energy use and occupancy monitoring. Photo by Timothy Schenck.

A variety of modern collaboration spaces provide dynamic and comfortable workspaces. Photo by Timothy Schenck.

Recommended EPM[13]	Target Area	Incremental First Cost
High-Efficiency Lighting	Lighting	$1,000
Advanced Lighting Controls	Lighting	$80,090
No Humidification in Data Center	Data Center	$2,000
Temperature Set Point in Data Center	Data Center	$0
Chilled Water Economization of Data Center	Data Center	$15,000
Optimized VAV Air Handler Units	HVAC	$0
Demand-Controlled Ventilation	HVAC	$12,500
Low Velocity Air Handler Units	HVAC	$31,420
Noise Trap Elimination	HVAC	$0
ALTERNATE TO ABOVE: Advanced Lighting Controls	Lighting	$0
ENERGY STAR® Equipment	Plug Loads	$0
Switched Outlet Control	Plug Loads	$14,000
Computer Shut-Off Software	Plug Loads	$2,100
Occupancy Sensor Plug Strips	Plug Loads	$7,000
ALTERNATE TO ABOVE: Controlled Outlets	Plug Loads	$10,500
Master Shutoff Switch	Plug Loads	$7,800

13. For a more detailed analysis, see LinkedIn's Space: The 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 LinkedIn and prescribed by ESRT's lease.

As part of the modeling process, the partners 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.

LinkedIn's Space: The Preliminary Value Analysis

EPM ID	EPM Description	Electricity Reduction (kWh/yr)	Percent Electricity Reduction	Annual Electricity Savings	Incremental First cost	Costing Assumptions	Simple Payback	10-year Cost Savings
1a	High-Efficiency Lighting (0.85 W/SF)	14,646	2.9%	$2,486	($1,000)	$10 premium for high-efficiency lamps for 100 lamps	0.4 yrs	$24,860
1b	Advanced Lighting Controls	27,091	5.4%	$4,599	($80,090)	Enlighted includes task tuning, day-light harvesting, and occupancy controls; JLL costing	17.4 yrs	$45,985
1c	ENERGY STAR® Equipment	20,233	4.1%	$3,434	$0	No incremental cost	Immediate	$34,344
1d	No Humidification in Data Center	35,198	7.1%	$5,975	$2,000	Avoided cost	Immediate	$59,746
1e	Temperature Set Point in Data Center	3,296	0.7%	$559	$0	No incremental cost	Immediate	$5,595
1f	Chilled Water Economization of Data Center	18,033	3.6%	$3,061	($15,000)	One economizer coil	4.9 years	$30,611
1g	Optimized VAV Air Handler Units	16,628	3.3%	$2,822	$0	No incremental cost because "rightsizing" equipment per load expectations	Immediate	$28,224
1h	Demand-Controlled Ventilation	553	0.1%	$94	($12,500)	JLL costing	N/A	$938
1i	Noise Trap Elimination	1,279	0.3%	$217	$0	No incremental cost	Immediate	$2,171
2a	1i Alternate: Advanced Lighting Controls, Increased Use	16,025	3.2%	$2,720	$0	Enlighted, Increased Use; No additional first cost. JLL costing.	Immediate	$27,201
3a	Switched-Outlet Control	6,824	1.4%	$1,158	($14,000)	Additional circuitry and panels	12.1 yrs	$11,583
3b	Computer Shutoff Software	16,344	3.3%	$2,774	($2,100)	Computer software $15 per work station for 1st year (140 computers) $2/comp for remaining lease years	0.8 yrs	$27,743
3c	Occupancy Sensor Plug Strips	26,976	5.4%	$4,579	($7,000)	$50 per work station for 140 work stations	1.5 yrs	$45,790
4a	3c Alternate: Controlled Outlets	19,847	4.0%	$3,369	($10,500)	$75 per work-station for 140 work stations	3.1 yrs	$33,689
5a	Master Shutoff Switch	3,249	0.7%	$551	($7,800)	One Switch in each of three game rooms	14.1 yrs	$5,514
5b	Low-Velocity Air Handler Units	5,774	1.2%	$980	($31,420)	Increase in size of air handler units	32.0 yrs	$9,801
Total	**All EPMs (No Alternates)**	196,123	39.3%	$33,291	($168,910)		5.1 yrs	$332,906

Comparing LinkedIn's EPM Packages

Energy Performance Measures by Package	Least Energy Reduction	Moderate Energy Reduction	Significant Energy Reduction
High-Efficiency Lighting (0.85 W/SF)	+	+	+
Advanced Lighting Controls	+	+	+
ENERGY STAR® Equipment	+	+	+
No Humidification in Data Center	+	+	+
Temperature Set Point in Data Center	+	+	+
Chilled Water Economization of Data Center	+	+	+
Optimized VAV Air Handler Units	+	+	+
Demand-Controlled Ventilation	+	+	+
Noise Trap Elimination	+	+	+
Alternate - Advanced Lighting Controls, Increased Use			
Switched Outlet Control		+	+
Computer Shutoff Software		+	+
Occupancy Sensor Plug Strips		+	+
Alternate - Controlled Outlets			
Master Shutoff Switch (in Game Rooms)			+
Low-Velocity Air Handler Units			+

Reviewing the Budget and Selecting the EPMs

Energy modeling and costing analysis determined the following eight EPMs would offer the best value for LinkedIn.

1. **High-Efficiency Lighting:** Use of high-efficiency light luminaires as well as use of occupancy sensors and a high level of controllability will contribute to reduced lighting energy consumption. Overall, the whole floor is 0.85W/SF installed.
2. **Advance Lighting (Daylight Harvesting, Occupancy Sensors)**: Utilize luminaries with built in photosensors and controls to dim the luminaires when ambient daylighting lights the space for a 15-foot perimeter. Passive infrared occupancy sensors detect motion and reduce or shut off lights when spaces are unoccupied.
3. **No Humidification in IDF:** The unit serving the data center will have no installed humidifier or humidity controls.
4. **Increase Temperature Set Point in IDF:** The unit serving the data center will maintain 74°F.
5. **Optimized Air Handlers (As-Designed HVAC):** Use VAV air handling units tied into the existing central plant. The existing central plant was modeled for both the ASHRAE and proposed models.
6. **Demand-Controlled Ventilation:** Reduce OA levels by monitoring carbon dioxide levels; allow VAV boxes to go down to 20%.
7. **Plug Load Management (ENERGY STAR® Equipment):** Install ENERGY STAR® office equipment.
8. **Plug Load Management (Occupancy Sensor Plug Strips):** Install controlled plug outlets powered off and on by occupancy sensors.

Building the Space

All EPMs were implemented on schedule and within the anticipated timeframe.

Developing a Post-Occupancy Plan: The Measurement & Verification Process

As one of the final phases of the process, measurement and verification (M&V) has been performed for LinkedIn.

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 LinkedIn project, M&V was vital in demonstrating that the energy value analysis achieved the level of value promised.

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, or a piece of equipment was incorrectly programmed or not operated as intended, or a product did not perform to its specifications. Naturally, LinkedIn 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.

The first monitoring period of LinkedIn's space took place between the dates of April 12 and April 29, 2015. Integral Group collected actual tenant energy consumption data and calibrated the existing energy model to correspond to observed usage.

Results show that the original, un-calibrated energy model overestimated energy consumption by about 40%. This is largely due to overestimation of IT equipment load and associated power required to cool the IDF space. Lighting and plug load power densities were accurately modeled and required only mild alterations to schedule diversity and operating hours.

Total savings, represented as a percentage of baseline, remain consistent between the original model and calibrated model, with total savings realized by the implemented package increasing slightly from 29.3% to 31.3%. Individual EPM savings and total electric consumption are adjusted, however, based on the modifications to the energy model. A comparison summary of input parameters, total tenant energy consumption, and energy savings by EPM can be found in Appendix A.

LinkedIn's Initial Energy Model versus the Calibrated Model after the M&V Process

	Uncalibrated Model	Calibrated Model
Occupancy Hours (weekday)	8 a.m.–7 p.m.	6 a.m.–6 p.m.
Peak Office Plug Load Power Design – (W/SF)	2.175	2.175
Peak Office Plug Load Power Actual – with Diversity (W/SF)	0.85	0.90
Peak Lighting Power (W/SF)	0.85	0.85
Minimum Lighting Power (W/SF)	0.04	0.09
Minimum Lighting Power (W/SF)	0.5	0.2
HVAC fan schedule hours	6 a.m.–8 p.m.	6 a.m.–6 p.m.
Peak IT Power kW*	25	2
Total Tenant Electricity Consumption — 90.1 2007 Baseline (kWh)	503,089	296,306
Total Tenant Electricity Consumption — Implemented Package (kWh)	330,859	203,465

* Note: Starred values are not called out by ASHRAE baseline, and represents significant changes to baseline energy consumption

Lighting

Total connected lighting power was accurately modeled and taken from design electrical drawings. Overnight lighting was slightly underestimated by the original model. Such an underestimation is typically a result of emergency lighting circuits remaining on at all times, not specifically called out in preliminary lighting drawings. Data gathered from the installed Enlighted lighting system allowed for specific breakout of total installed lighting power and savings attributed to daylight harvesting sensors, occupancy sensors, and task dimming.

- **The Enlighted System:** The final lighting plans issued for construction indicate a High-Efficiency and very controllable lighting design has been developed, using an Enlighted system[14]. The extensive use of LEDs and dimmable luminaires can provide a very high-efficiency lighting system when combined with daylight harvesting controls in all perimeter office spaces and effective occupancy sensors and scheduling controls. Occupancy sensors are included per the lighting design and exceed the requirements of ASHRAE, which state that occupancy sensors must be installed in conference/meeting rooms, and employee lunch and break rooms. This measure reduces installed lighting power from the ASHRAE baseline of 1.0-1.1 W/SF to the designed 0.85 W/SF (excluding core spaces).

  The use of daylighting sensors and photocells on the perimeter spaces can reduce lighting requirements when there is sufficient natural light. The original energy model has assumed daylight sensors will be located in all perimeter spaces per the drawings and controlling the lights to a depth of approximately 15 feet from the exterior walls. The Enlighted system allows for advanced lighting design, reducing maximum turned on lighting load significantly and leaving less room for savings via daylight sensors. The diversity schedule has been adjusted in the calibrated model to include savings from the advanced Enlighted system, which includes dimming control and occupancy sensors.

HVAC

The most significant changes to the calibrated model were to the air handling unit (AHU) fan schedule. The baseline computer-room air conditioning (CRAC) unit power serving the intermediate distribution frame (IDF) room has also been significantly decreased due to lower than expected IT load, causing negative savings for optimized air handlers. Reduction in savings after calibration for EPMs associated with the IDF room is due to the reduced baseline consumption of the IDF CRAC unit, as a result of the reduced internal equipment.

- **Air Handler Fan Power:** Metered data revealed that air handler fans ran parallel to floor occupancy, approximately 6 a.m. to 6 p.m. The original model assumed fan operation from 6 a.m. to 8 p.m. Minimum allowable fan speed was increased from 30% to 40% in the calibrated model, reflecting minimum observed values during the metering period. The "All-Hands AC" is shown by metering to run continually, 24 hours per day, and the schedule was modified accordingly.
- **Optimized Air Handlers (As-Designed HVAC):** The existing mechanical equipment at the Empire State Building is water-cooled constant volume fan coils, and the ASHRAE 2007 air distribution is auto-sized variable air volume (VAV) air handlers tied into the existing Empire State Building central plant. By sizing the VAV units appropriately for the proposed tenant loads and specifying equipment with fan power below ASHRAE allowances, energy savings are achieved through reduced fan energy. AHU size and fan power were taken directly from design documents, and this measure represents actual installed HVAC on Floor 22. Main AHU fans show a reduction from ASHRAE baseline in this measure; however, negative energy savings are shown due an apparent oversizing of the IDF room CRAC unit. The ASHRAE baseline model auto-sizes the CRAC unit to match installed IT load. Metering revealed much lower than expected IT load, causing the baseline IDF fan energy to be very low. EPM 1g, however, manually sizes the unit based on installed unit. According to metered load, it appears that the CRAC is oversized,

14. http://www.enlightedinc.com/

resulting in unnecessarily high fan energy. Tenants often overestimate IT load and IDF room requirements to allow for future intended growth. Unit size should be verified, as original model sizing may be based on preliminary design documents.

Plug Loads/Equipment

Equipment power was initially modeled accurately with plug load density varying from 0.2 W/SF to 12 W/SF based on space type, as taken from electrical power plans. Plug load diversity schedules were adjusted slightly based on actual observed profile, particularly for weekend hours.

- **Installing ENERGY STAR® Equipment:** Use of ENERGY STAR-rated office equipment leads to a reduced plug load for the office, conference room, and pantry spaces. This measure assumes that the plug-in equipment in the conference and office areas will be per the specified ENERGY STAR equipment. The baseline standard efficiency equipment is assumed to be 15% higher in energy consumption than the selected ENERGY STAR equipment.
- **Occupancy Sensor Strips:** Typically, plug loads are reduced at night but not to zero. Many plug loads continue to draw power, at a reduced rate, when they are in sleep or off mode. One approach to minimizing these phantom loads is to provide some number of outlets with active control that turns off power completely when the space is unoccupied. This analysis assumes that plug-in equipment will be reduced by 15% during occupied hours and 25% during unoccupied hours.

Energy efficiency and thermal comfort are optimized throughout the space by utilizing demand control ventilation and variable air volume air handling equipment. Photo by Timothy Schenck.

LinkedIn's Sustainability Initiatives and Their Impacts on Employees

LinkedIn's cultural values of integrity, collaboration, and transformation create an imperative for the firm to measurably reduce the environmental impact of its business. As part of that effort, LinkedIn pledges to:

- Make measurable and sustained progress toward its ultimate goal of powering its operations with 100% renewable energy;
- Locate, design, and operate its workplaces and data centers with very high sustainability standards to reduce employee commutes, energy, waste, and water use; and
- Increase education for its employees to practice sustainable approaches to transportation, energy, food, waste, and water use.

The company also strives to optimize its digital platform's energy efficiency and to increase the use of clean energy so members can freely collaborate with minimal impact. It provides world-class, earth-friendly workplaces and make responsible procurement decisions to reduce the impacts within its supply chain and engages and inspires its employees, members, and suppliers to participate in this journey. It also has a Sustainability Team to deliver this vision by setting clear and actionable goals, tracking performance against these goals, and providing transparency regarding the company's progress.

Kitchen and pantry areas include ENERGY STAR equipment and opportunities for employee engagement. Photo by Timothy Schenck.

Further Recommendations

The project team has determined that LinkedIn has the opportunity to reduce energy consumption even further during occupancy by implementing additional energy performance measures: occupancy sensor power strips and computer shutoff software. Plug load accounts for over 60% of the total estimated energy use, and controls which can be implemented after construction can increase the total projected energy savings.

To optimize energy performance in future tenant space, additional lighting efficiencies of 0.7W/SF, game room equipment controls, and low-velocity air handling equipment can reduce energy use by 41%.

Ongoing energy management systems will help ensure energy use is well managed. End-use sub-metering (lighting, plug, IT room, and HVAC loads) would provide feedback for ongoing commissioning and maintenance of the systems and assist in maintaining energy savings consistent over the life of the investment. LinkedIn electricity sub-meters and the base building tenant energy management system provide data to measure and verify detailed energy consumption. To further understand energy consumption and trends by end use, temporary data logging instrumentation was installed as part of the final phase of the process.

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

Original Model Results: Tenant Electricity

	Description	Total Tenant Electricity					Tenant Electricity Reduction	
#	**Name**	**Total kWh**	**Lighting kWh**	**Equipment kWh**	**HVAC kWh**	**IT (Inc. CRACs) kWh**	**vs. Empire State Building Base-line (B-1)**	**vs. ASHRAE -2007 Baseline (B-2)**
B-1	ESB Upgrades - Baseline	529,623	74,284	146,362	67,998	240,978	n/a	n/a
B-2	ASHRAE 90.1-2007 Baseline	503,089	74,284	146,362	28,421	254,022	5.0%	0.0%
B-3	ASHRAE 90.1-2010 Baseline	486,013	62,071	146,362	23,867	253,713	8.2%	3.4%
1f, 1g, 1h	As-Designed HVAC (Economization, Optimized VAV, DCV)	460,722	74,284	146,362	25,054	215,022	13.0%	8.4%
1a	High-Efficiency Lighting (0.85 W/SF)	427,919	43,736	146,362	22,977	214,844	19.2%	14.9%
1b.1	Advanced Lighting Controls Task Tuning (and Occupancy)	423,223	39,362	146,362	22,672	214,828	20.1%	15.9%
1b.2	Advanced Lighting Controls Daylight Harvesting	415,932	32,585	146,362	22,163	214,822	21.5%	17.3%
1c	ENERGY STAR® Equipment	396,053	32,585	127,811	20,863	214,794	25.2%	21.3%
1d	No Humidity in Data Center	357,533	32,585	127,811	20,869	176,268	32.5%	28.9%
1e	Temperature Set Point in Data Center	357,763	32,585	127,811	21,099	176,268	32.4%	28.9%
3c	Occupancy Sensor Plug Strips							
	Incremental Savings vs Previous Run						**Percentage Savings**	
B-1	ESB Upgrades - Baseline	n/a	0	0	3,438	40	-	-
B-2	ASHRAE 90.1-2007 Baseline	n/a	n/a	n/a	n/a	n/a	-	n/a
B-3	ASHRAE 90.1-2010 Baseline	43,609	12,214	0	4,554	308	8.2%	8.7%
1f, 1g, 1h	As-Designed HVAC (Economization, Optimized VAV, DCV)	42,367	-12,214	0	-1,187	38,691	7.9%	8.4%
1a	High-Efficiency Lighting (0.85 W/SF)	32,804	30,549	0	2,077	178	6.2%	6.5%
1b.1	Advanced Lighting Controls Task Tuning (and Occupancy)	4,696	4,374	0	305	17	0.9%	0.9%
1b.2	Advanced Lighting Controls Daylight Harvesting	7,291	6,777	0	509	6	1.4%	1.4%
1c	ENERGY STAR® Equipment	19,878	0	18,551	1,300	28	3.7%	4.0%
1d	No Humidity in Data Center	38,520	0	0	-5	38,526	7.2%	7.7%
1e	Temperature Set Point in Data Center	-230	0	0	-230	0	0.0%	0.0%
3c	Occupancy Sensor Plug Strips	26,904	0	25,335	1,569	0	5.0%	5.3%

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

Calibrated Model Results: Tenant Electricity, Actual Final Package

	Description	Total Tenant Electricity					Tenant Electricity Reduction	
#	**Name**	**Total kWh**	**Lighting kWh**	**Equipment kWh**	**HVAC kWh**	**IT (Inc. CRACs) kWh**	vs. Empire State Building Baseline (B-1)	vs. ASHRAE -2007 Baseline (B-2)
B-1	ESB Upgrades - Baseline	335,844	86,601	149,356	79,058	20,828	n/a	n/a
B-2	ASHRAE 90.1-2007 Baseline	296,306	86,601	149,356	38,375	21,972	11.8%	0.0%
B-3	ASHRAE 90.1-2010 Baseline	283,278	76,081	149,356	36,218	21,623	15.7%	4.4%
1f, 1g, 1h	As-Designed HVAC (Economization, Optimized VAV, DCV)	304,301	86,601	149,356	32,593	35,750	9.4%	-2.7%
1a	High-Efficiency Lighting (0.85 W/SF)	266,133	50,768	149,356	30,501	35,507	20.8%	10.2%
1b.1	Advanced Lighting Controls Task Tuning (and Occupancy)	257,054	42,035	149,356	30,184	35,480	23.5%	13.2%
1b.2	Advanced Lighting Controls Daylight Harvesting	255,664	40,759	149,356	30,071	35,478	23.9%	13.7%
1c	ENERGY STAR® Equipment	235,497	40,759	130,426	28,865	35,447	29.9%	20.5%
1d	No Humidity in Data Center	228,840	40,759	130,426	29,139	28,516	31.9%	22.8%
1e	Temperature Set Point in Data Center	229,080	40,759	130,426	29,379	28,516	31.8%	22.7%
3c	Occupancy Sensor Plug Strips	203,465	40,759	106,174	28,016	28,516	39.4%	31.3%
	Incremental Savings vs Previous Run						**Percentage Savings**	
B-1	ESB Upgrades - Baseline	0	0	0	0	0	0.0%	-
B-2	ASHRAE 90.1-2007 Baseline	39,538	0	0	40,683	-1,144	11.8%	11.8%
B-3	ASHRAE 90.1-2010 Baseline	52,566	10,520	0	42,840	-794	15.7%	15.7%
1f, 1g, 1h	As-Designed HVAC (Economization, Optimized VAV, DCV)	-21,022	-10,520	0	3,626	-14,128	-2.4%	-2.4%
1a	High-Efficiency Lighting (0.85 W/SF)	38,168	35,833	0	2,092	243	11.4%	11.4%
1b.1	Advanced Lighting Controls Task Tuning (and Occupancy)	9,078	8,734	0	317	28	2.7%	2.7%
1b.2	Advanced Lighting Controls Daylight Harvesting	1,390	1,276	0	112	2	0.4%	0.4%
1c	ENERGY STAR® Equipment	20,167	0	18,930	1,206	31	6.0%	6.0%
1d	No Humidity in Data Center	6,657	0	0	-273	6,930	2.0%	2.0%
1e	Temperature Set Point in Data Center	-241	0	0	-241	0	-0.1%	-0.1%
3c	Occupancy Sensor Plug Strips	25,615	0	24,252	1,363	0	7.6%	7.6%

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

EPM Description		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
B-1	ESB Upgrades - Baseline	n/a	n/a	n/a	n/a	n/a	n/a
B-2	ASHRAE 90.1-2007 Baseline	29,379	n/a	n/a	39,531	11.8%	$6,523
B-3	ASHRAE 90.1-2010 Baseline	13,559	2.6%	$2,237	13,039	3.9%	$2,151
1a	As-Designed Lighting (0.85 W/SF)	1,105	0.2%	$182	26,472	7.9%	$4,368
1b.3	Advanced Lighting Controls	27,065	5.1%	$4,466	10,392	3.1%	$1,715
1c	ENERGY STAR® Equipment	20,224	3.8%	$3,337	20,504	6.1%	$3,383
1d	No Humidity in Data Center	33,546	6.4%	$5,535	2,939	0.9%	$485
1e	Temperature Set Point in Data Center	3,727	0.7%	$615	845	0.3%	$139
1f	Economization (Chilled Water) of Data Center	18,048	3.4%	$2,978	1,387	0.4%	$229
1g	Optimized VAV AHU	16,630	3.2%	$2,744	-8,571	-2.6%	($1,414)
1h	Demand-Controlled Ventilation	554	0.1%	$91	232	0.1%	$38
1i	Noise Trap Elimination in AHU**	1,276	0.2%	$211	1,503	0.4%	$248
3a	Switched Outlet Control**	6,824	1.4%	$1,126	6,837	2.3%	$1,128
3b	Computer Shutoff Software**	16,341	3.3%	$2,696	12,256	4.1%	$2,022
3c	Occupancy Sensor Plug Strips	26,971	5.4%	$4,450	6,406	2.2%	$1,057
4a	Plug Load Shutoff Controls (in Game Rooms) **	-7,127	-1.4%	($1,176)	10,265	3.5%	$1,694
5a	Master Shutoff Switch**	10,375	2.1%	$1,712	6,884	2.3%	$1,136
5c	Low-Velocity AHUs**	5,762	1.2%	$951	8,079	2.7%	$1,333

Notes: Electric rate of $0.165/kWh assumed
**Measure Not Implemented

Energy Model Output by Measure: Updated to Actual Package

EPM Description		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**
B-2	ASHRAE 90.1-2007 Baseline	3,478	0.7%	$574	39,538	11.8%	$6,524
B-3	ASHRAE 90.1-2010 Baseline	43,609	8.2%	$7,196	52,566	15.7%	$8,673
1f, 1g, 1h	As-Designed HVAC (Economization, Optimized VAV, DCV)	42,367	7.9%	$6,991	-7,995	-2.4%	($1,319)
1a	High-Efficiency Lighting (0.85 W/SF)	32,804	6.2%	$5,413	38,168	11.4%	$6,298
1b.1	Advanced Lighting Controls Task Tuning (and Occupancy)	4,696	0.9%	$775	9,078	2.7%	$1,498
1b.2	Advanced Lighting Controls Daylight Harvesting	7,291	1.4%	$1,203	1,390	0.4%	$229
1c	ENERGY STAR® Equipment	19,878	3.7%	$3,280	20,167	6.0%	$3,328
1d	No Humidity in Data Center	38,520	7.2%	$6,356	6,657	2.0%	$1,098
1e	Temperature Set Point in Data Center	-230	0.0%	($38)	-241	-0.1%	($40)
3c	Occupancy Sensor Plug Strips	26,904	5.0%	$4,439	25,615	7.6%	$4,227
	Total Implemented Package	172,230	34.2%	$28,418	92,840	31.3%	$15,319

Notes: Electric rate of $0.165/kWh assumed
Total Package and % Savings reported versus ASHRAE 90.1 2007 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

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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**.