

Case Study: Tenant Energy Performance Optimization

Li & Fung USA, Empire State Building



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The core mission of the Center for Market Innovation (CMI) is to expand the impact of NRDC by creating market conditions that will redirect capital flows toward sustainable uses. We believe that engaging mainstream capital is a critical component in achieving our common goals. We do so by engaging with the business community to articulate and implement sustainable value propositions, with a current focus on energy efficiency, water management, and regenerative agriculture. A collaborative approach between building owners and occupants is essential to optimizing the performance of commercial office buildings, and tenant demand will be a critical factor in driving the market toward optimizing commercial building performance. CMI has established a High Performance Tenant Demonstration Project (the "Project") aimed at accelerating demand for high performance tenant spaces in the commercial office market by demonstrating their economic benefits. The Project aims to promote the compounding effect of owner/tenant collaboration, as tenants who value high performance spaces choose to locate or remain in buildings with highly efficient central systems and transparent energy management practices. As a result, building owners investing in central system energy efficiency improvements will not only garner operating savings, but will also gain competitive advantage in attracting and retaining these high value tenants. Visit us at www.marketinnovation.org and follow us on Twitter @NRDC_CMI.

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EXECUTIVE SUMMARY

Li & Fung USA (LFUSA), a global consumer goods company, has committed to design and construct a high performance tenant space in the Empire State Building to reduce energy demand, increase efficiency, and improve indoor environmental quality. The tenant project is the first in a series of case studies by the Natural Resources Defense Council's (NRDC) Center for Market Innovation (CMI) aimed at demonstrating the energy and cost savings impact of high performance tenant design.

The first phase of LFUSA's high performance build-out encompassed three floors and is projected to yield a **28 percent annual electricity savings** compared to an American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) 90.1-2007 code-compliant design (minimum energy performance required by law), resulting in nearly \$38,000 in annual electricity cost savings for these three floors. Over the 15-year lease term, the performance measures are projected to return **\$566,495 in energy savings** (\$392,000 present value using a 5 percent discount rate).¹ The incremental implementation cost of the energy performance measures (EPM) package is 134,000 (\$0.98/ft²) over a code-compliant design budget, including energy modeling soft costs and net New York State Energy Research and Development Authority (NYSERDA) incentives, resulting in a **simple payback period of 3.5 years**. The net present value of the projected full lease term energy savings, after recouping the tenant's up-front incremental cost, is \$258,000, constituting a **192 percent return on the tenant's initial investment** in the energy performance package and a **27 percent internal rate of return**.

If the suggested package of performance measures is implemented on the remaining six floors that LFUSA has yet to build out under its lease at the building, the company can capture 31 percent in energy savings on those floors, yielding a combined savings across all floors of **\$1.8 million over the 15-year lease term**.

The package of energy performance measures for the three floors of Phase 1 is projected to reduce electricity consumption by nearly 3.3 million kilowatt-hours (kWh) over the lease term, which will avoid approximately 1,660 metric tons of carbon dioxide (CO₂) emissions,² roughly equal to taking 346 cars off of the road for one year.³

OVERVIEW OF PACKAGE OF ENERGY PERFORMANCE MEASURES.

EPMs are technologies and systems that aim to reduce energy use through efficiency and conservation. Working closely with the building owner and CMI, LFUSA evaluated an integrated, multi-component package of energy performance measures, which were then incorporated into the space design to achieve substantial, cost-effective energy savings, and corresponding carbon emissions reductions (see table 1). The project team determined six target energy performance measures to include in the initial stage of analysis including lighting, mechanical, and plug load measures.

Table 1: Overview of Proposed Energy Performance Measures (EPMs)

I. Daylight Harvesting Lighting Controls: Utilize luminaires with built-in photosensors and controls to dim lights when ambient daylighting lights the space.
II. High Efficiency Lighting: Utilize high efficiency luminaires and install occupancy sensors.
III. Optimized HVAC Units: Right-sized, high efficiency, variable air volume (VAV) units.
IV. Demand Control Ventilation (CO₂ Sensors): Use CO ₂ sensors to control outdoor air damper.
V. Low Velocity Air Handlers: Reduce the fan power requirement through use of lower face velocity air handlers (larger footprint or additional unit).
VI. Plug Load Management: Circuit plug loads to a single master shutoff switch that is turned off outside of business hours.

Figure 1: Project Information and Projected Performance

Building Information		
Building Information	Tenant Name	Li & Fung USA (LFUSA)
	Building Owner	Empire State Realty Trust
	Location	350 5 th Avenue, Midtown Manhattan
	Building Size	2.7 million square feet (102 Floors)
	Principal Use	Class A Office with Street-Level Retail
	Construction Type	Pre- WWII Skyscraper
	U.S. EPA ENERGY STAR® Rating	90
	USGBC® LEED® Certification	Gold
	Energy Retrofit Completion Date	2011
	LFUSA Lease Term	15 Years
Phase 1 Build-Out (3 Floors)		
Phase 1 Build-Out (3 Floors)	Square Footage	137,400 sq. ft.
	Modeled Energy Reduction	28%
	Total Electricity Savings over Lease Term	3.3 GWh
	<i>Incremental Implementation Cost (w/o incentives)</i>	\$164,370
	<i>State Incentives (net of review and filing costs)</i>	\$36,940
	<i>Energy Modeling Soft Cost</i>	\$6,600
	Adjusted Incremental Implementation Cost	\$134,030 (\$0.98/ft ²)
	Total Electricity Cost Savings over Lease Term	\$566,495
	Present Value of Electricity Cost Savings over Lease Term (5% discount rate) ^a	\$392,002
	Net Present Value of Project Investment	\$257,972
	Return on Investment (ROI) over Lease Term	192%
	Internal Rate of Return	27%
	Payback Period	3.5 years
Projected Total Build-Out (9 Floors)		
Projected Total Build-Out (9 Floors)	Square Footage	412,200 sq. ft.
	Modeled Energy Reduction	31%
	Total Electricity Savings over Lease Term	10,519,320 kWh
	<i>Incremental Implementation Cost (w/o incentives)</i>	\$511,110
	<i>State Incentives (net of review and filing costs)</i>	\$124,876
	<i>Energy Modeling Soft Cost</i>	\$19,800
	Adjusted Incremental Implementation Cost	\$406,034 (\$0.99/ft ²)
	Total Electricity Cost Savings over Lease Term	\$1,813,733
	Present Value of Electricity Cost Savings over Lease Term (5% discount rate) ^b	\$1,255,062
	Net Present Value of Project Investment	\$849,028
	Return on Investment (ROI) over Lease Term	209%
	Internal Rate of Return	29%
	Payback Period	3.4 years

^a Assuming zero escalation in electricity prices over the lease term, and a 5 percent administrative fee per the terms of tenant's lease.

^b Ibid.

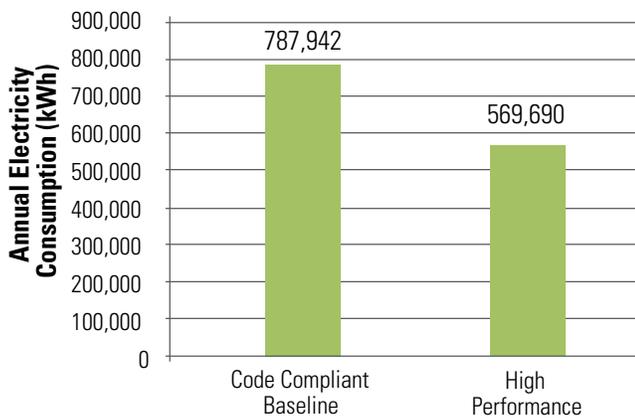
The project team streamlined coordination among the architect, engineer, energy modeler, and general contractor to facilitate the design planning process. Early on, the team engaged an energy modeling consultant to build an iterative eQUEST energy model for the leased premises, which incorporated the proposed EPM package, and reviewed results for energy reduction potential against a baseline code-compliant design (based upon ASHRAE 90.1-2007 standards).⁴

PACKAGE SELECTION. Due to the long lead time of custom heating, ventilation, and air conditioning (HVAC) units, the project team was not able to pursue one of the target measures—low velocity air handling units (AHUs)—for the first phase of the project because the tenant had purchased the standard units before a final decision could be made. The results described below are inclusive of the five implemented measures listed in table 1. However, the package recommendation for the build-out of future floors incorporates the low-velocity AHU measure, leading to higher projected savings on the future floors.

ENERGY REDUCTION. The implemented package of energy performance measures is projected to reduce electricity consumption by 28 percent (218,252 kWh annually) across the three floors (see figure 2).

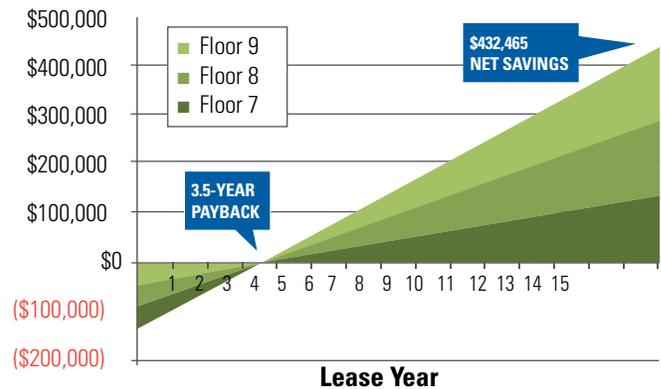
VALUE ANALYSIS. The incremental cost to implement the package of measures is an additional \$164,370 (\$1.20/ft²) in construction costs over a code-compliant design budget and \$6,600 (\$0.05/ft²) in energy modeling soft costs. This up-front cost was reduced by the capture of NYSERDA incentives totaling \$36,940 (\$0.27/ft²), net of filing fees and consulting review costs, yielding an adjusted incremental cost of \$134,030 (\$0.98/ft²).

Figure 2: Projected Annual Energy Consumption of Code-Compliant Space and High Performance Space



LFUSA's three high performance floors are projected to consume 27.7 percent less electricity than a code compliant space due to the implementation of a package of EPMs.

Figure 3: Modeled Electricity Cost Savings for Floors 7, 8, and 9 over the 15-year Lease Term



The incremental first cost of implementation (\$134,030) is paid back within 3.5 years, and the \$566,495 of electricity cost savings over the lease term nets a projected savings of \$432,465.

Using the energy modeling outputs and the incremental costing information, accounting for energy modeling soft cost and net incentives received, the CMI team 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 value analysis process enabled the team to package the energy performance measures to meet the three-to-five-year simple payback threshold desired by the tenant and prescribed by the lease.

The incremental first cost of implementation is paid back within 3.5 years, and the \$566,495 of electricity cost savings over the lease term nets a projected savings of \$432,465 over the 15-year lease term (see figure 3).

FUTURE OPPORTUNITIES. After the completion of construction on floors 7, 8, and 9, LFUSA will have six floors remaining to build out.⁵ Assuming that the future floors have a floor plan similar to the Phase 1 design, LFUSA has the opportunity to reduce energy consumption by 31 percent (7.2 million kWh) and realize a projected \$1.8 million in additional electricity cost savings over the 15-year lease term by implementing the full package of recommended EPMs. The projected energy savings for future floors is greater than the savings projected for the Phase 1 floors because the recommended package of EPMs includes incorporation of low-velocity air handling units, which were not implemented in Phase 1. The estimated incremental implementation cost of the EPM package for the future floors is \$272,000 (\$0.99/ft²), including construction and energy modeling costs, and assuming the tenant will capture net NYSERDA incentives of \$14,656 (\$0.32/ft²) per floor.

INTRODUCTION

The core mission of NRDC's Center for Market Innovation (CMI) is to help solve critical environmental issues by creating market conditions that will redirect capital flows toward sustainable uses. We believe that engaging mainstream capital is a critical component in achieving our common environmental goals. We do so by engaging with the business community to articulate and implement sustainable value propositions, with a current focus on energy efficiency, water management, and regenerative agriculture.

CMI believes that a collaborative approach between building owners and occupants is essential to optimizing the performance of commercial office buildings, and that tenants will play a critical role in driving the overall demand for commercial building retrofits. In order to accelerate this tenant demand, CMI has launched its High Performance Tenant Demonstration Project (the "Project") to quantify, document, and publish the economic benefits that result from the build-out of high performance tenant workspaces.

The Project aims to compound the impact of owner/tenant collaboration, as tenants who value high performance spaces choose to locate or remain in buildings with highly efficient central systems and transparent energy-management practices. Building owners investing in energy efficiency improvements garner operating savings and gain competitive advantage in attracting and retaining high value tenants.

This case study is part of a series of case studies through which CMI is highlighting the compelling business case for

high performance build-outs of tenant spaces and energy efficient retrofits of central building systems. By publishing this series of case studies and a companion high performance build-out process guide, CMI intends to provide transparency and a replicable blueprint that will help scale the high performance tenant build-out market. The case studies demonstrate the value that can be achieved by direct energy savings in these spaces.

The CMI team engaged with LFUSA during the design phase to guide the energy modeling process and provide a value analysis of potential EPMS. This study documents the process and energy saving projections from the package of EPMS that LFUSA decided to implement in the first phase of the build-out (three floors) as well as recommendations and projections for future floor build-outs. The CMI team will perform measurement and verification of the Phase 1 occupied space and document the results, updating this case study accordingly with actual energy usage data.

PROJECT BACKGROUND

TENANT

Li & Fung USA (a subsidiary of Li & Fung Limited)

Li & Fung Limited is a Hong Kong-headquartered multinational group widely recognized as an international leader in consumer goods design, development, sourcing, and distribution. The company specializes in supply chain management of high-volume, time-sensitive goods for leading retailers and brands worldwide via an extensive global network.

Sustainability is an integral part of Li & Fung's corporate identity, as the company not only strives to improve efficiency within its own facilities and operations, but also to promote sustainability efforts amongst its suppliers and business partners, and throughout its global supply chain.⁶

BUILDING OWNER

Empire State Building Company, LLC (Empire State Realty Trust)

Under the direction of Anthony E. Malkin, Empire State Realty Trust (originally Wien & Malkin), together with its operating units and partnerships owns approximately 11 million square feet of office property in the Greater New York area, 1.9 million square feet of retail space, 1.4 million square feet of warehouse/distribution space, and 2,700 multi-family units in 15 states.

Empire State Realty Trust has long been committed to promoting sustainability throughout its portfolio. The company has been on the forefront in implementing innovative energy efficiency retrofits of existing buildings, the leading example of which is the Empire State Building in midtown Manhattan

PROJECT SCOPE

LFUSA recently leased floors 3 thru 11 in the Empire State Building (the "leased premises"). The first phase of LFUSA's tenant build-out covered floors 7 thru 9, and the final analysis presented herein includes only those Phase 1 floors (see table 2). Floors 7 thru 9 are comprised primarily of open office space with several conference and work rooms and some space designated as showroom. The remaining portion of the leased premises yet to be built-out are floors 3, 4, 5, 6, 10, and 11, and are referred to as "future floors."

LEED® RATING

The LFUSA team with the assistance of its LEED consultant, CodeGreen, applied for and was awarded a Platinum rating under the U.S. Green Building Council's LEED for Interior Design and Construction for floors 8 and 9. LFUSA was awarded innovation credit for the measurement and verification plan described in this case study, which reconciles actual energy performance with projected. LFUSA is also applying for LEED certification of the 7th floor, but are awaiting results.

Tenant	Each Floor	Total
Rentable Square Footage (RSF)	43,909	395,181 (9 floors)
Gross Square Footage (GSF)	45,800	412,200 (9 floors)
Gross Square Footage in Phase 1 (floors 7, 8, 9)*	45,800	137,400 (3 floors)

*The analyses included in this study use gross square footage.

Figure 4: Project Milestone Timeline

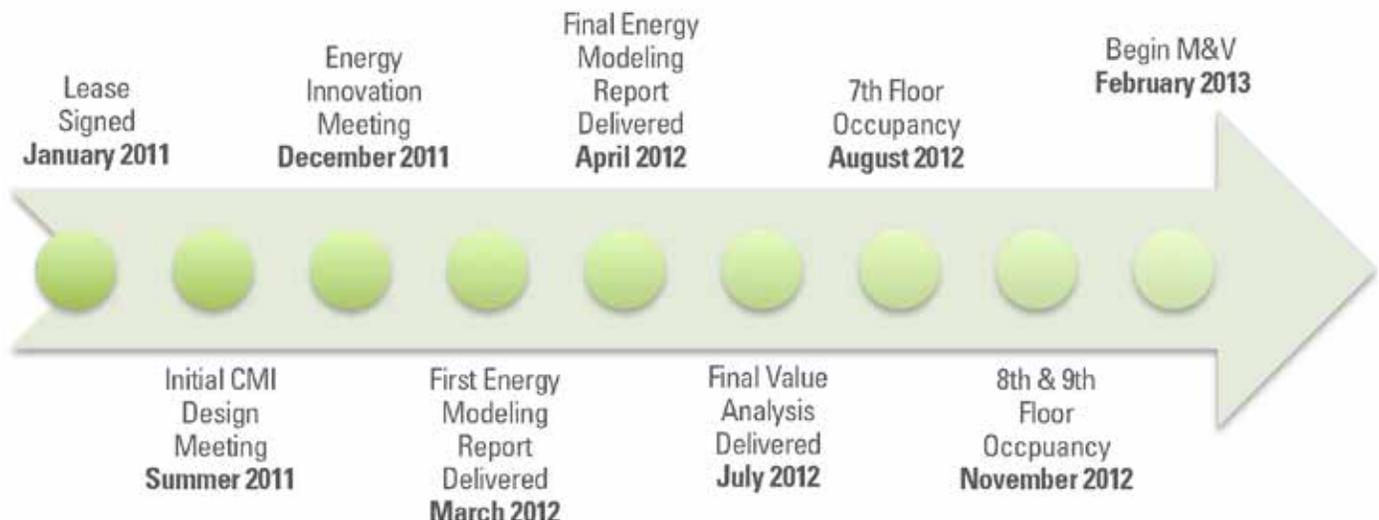


Figure 5: Lease Cycle Energy Optimization Process



Project Process. CMI has developed a 10-step Lease Cycle Energy Optimization Process to guide tenants through the leasing, design, modeling, analysis, execution, and measurement and verification stages of the high performance build-out process (see figure 5).⁷ The general progression is outlined here, followed by a more detailed account of each step as it occurred in the LFUSA case.

1. SELECTING AN OFFICE SPACE

In January 2011, LFUSA leased nine floors in the Empire State Building, the largest leasing transaction in the building's 80-year history. Motivated by the company's sustainability policy, LFUSA had considered several options when selecting office space for its expansion in New York, including space in newly constructed buildings. However, the company was drawn to the Empire State Building because of the ownership's commitment to retrofit and build out the Empire State Building as a leading example of making a landmark building sustainable and reducing their carbon footprint.



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The building owner's commitment to energy efficiency positions the Empire State Building at the forefront of the sustainable building retrofit movement. Coupled with a major building overhaul to achieve Class A office space, the building has been able to attract quality tenants. In 2010, the Empire State Building undertook a major energy efficiency retrofit, as part of a much larger renovation of the entire building. The retrofit, which included performance measures that enhanced the efficiency and comfort of tenant spaces, such as the upgrade of inefficient windows and the insulation of radiators to stabilize heating, is expected to reduce the building's energy consumption by 38 percent, and save the building owner \$4.4 million annually through reduced

energy expense.⁸ The building management also added new provisions to the building's standard lease language that require tenants to incorporate certain high performance energy strategies into their respective build-outs provided that those measures meet certain economic criteria. (For more on the Empire State Building retrofit, see "Spotlight: Empire State Building Retrofit" on page 22).

As LFUSA signed its lease and began its design process, the Empire States Building's ownership recommended that the tenant partner with CMI as part of the High Performance Tenant Demonstration Project. Through this dynamic relationship, CMI has helped LFUSA analyze the potential performance of its space and select a package of energy

performance measures that would maximize potential cost effective energy savings, thereby reducing the tenant's operating costs and minimizing environmental impact. Furthermore, reducing LFUSA's ongoing energy consumption will contribute to the Empire States Building's aggressive whole building energy reduction goals, which rely substantially on tenant performance. As described throughout this case study, owner-tenant collaboration and goal alignment is critical to the success of high performance build-outs.

LEASE TYPE AND TERM. LFUSA signed a 15-year lease for nine full floors. In accordance with the Empire State

Building's standard leasing policy, LFUSA's electricity consumption in the leased premises is submetered and the tenant pays for electricity based upon its actual submetered electrical usage. Furthermore, to help the Empire States Building reach its energy efficiency goals, all tenants are required per the lease to incorporate a prescribed set of energy performance measures into their respective build-outs, provided that those measures have a payback period under five years. The value analysis performed for this project justified the economic benefit of the required measures and also spurred the implementation of non-lease-required measures.

2. SELECTING A PROJECT TEAM

A well-qualified and integrated project team can streamline the tenant energy optimization process greatly. When LFUSA assembled its project team, it sought contractors and consultants with experience in sustainable design. In addition, the project was managed by Gardiner & Theobald, the tenant's representative with experience working with the CMI team and energy optimization process.

Table 3: LFUSA Build-Out Team

Tenant Project Representative	Gardiner & Theobald
Architect	DPM Architecture, PC
General Contractor	Benchmark Builders, Inc.
LEED/Incentive Consultant	CodeGreen Solutions
Lighting Designer	Lighting Workshop
MEP Engineer	AMA Consulting Engineers, PC

3. SETTING ENERGY PERFORMANCE GOALS AND DEVELOPING MENU OF MEASURES

PROJECT KICKOFF. The LFUSA sustainability team, design team, Empire State Building representatives, and CMI team held an initial meeting in the summer of 2011 to engage all stakeholders in the energy efficiency planning process. In order to help the project partners better understand the implications of participating in the High Performance Tenant Demonstration Project, the CMI team reviewed stakeholder roles, process, and general project expectations during the life of project development, measurement and verification, and case study documentation. This meeting addressed questions and concerns, and promoted collaboration, communication, and transparency during the process.

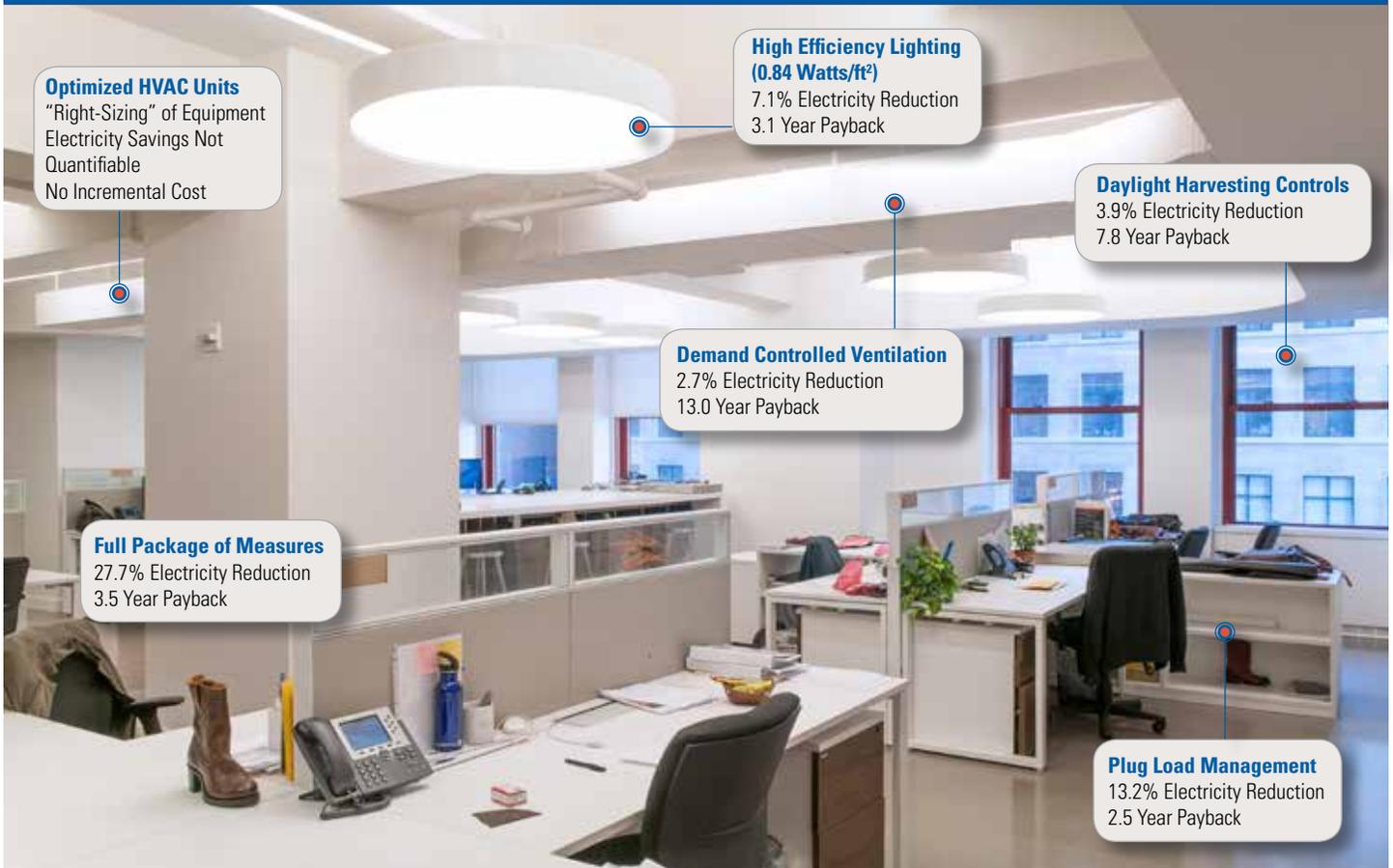
At the kickoff meeting, the team also began to gather the information that would be necessary to guide the tenant optimization process and inform the energy model and value analysis including: construction and occupancy schedule, initial set of design drawings, applicable lease provisions, base building record drawings and design criteria, tenant design drawings and criteria, current design features, and code comparisons including feedback and analysis from MEP

engineering, lighting, and LEED/sustainability consultants. In addition, the building owners provided the Empire State Building energy model that had been developed during the earlier base building retrofit, and which can be an amenity for tenants as it can reduce the cost of new energy modeling for the tenant's leased premises.

ENERGY INNOVATION MEETING. After the initial meeting and data collection period, in December 2011 the project team held an energy innovation meeting. The team began an integrated analysis process to identify opportunities for energy efficiency and determine which measures would be beneficial for LFUSA to incorporate into its tenant space build-out based upon incremental cost and projected energy savings considerations. The project team initially considered 14 unique energy performance measures (see appendix a for the full list of measures), and identified six target measures. The six selected measures were prioritized by the tenant and building owner based on lease requirements, initial cost estimates, feasibility within the existing space, and tenant preference.

4. MODELING PROJECTED ENERGY PERFORMANCE

Figure 6: LFUSA Tenant Space with Implemented Energy Performance Measures



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ENERGY MODELING. After the energy innovation meeting and review of the proposed design drawings, CMI worked with consultants to develop an energy model for the three Phase 1 floors, using eQUEST modeling software. CMI engaged Integral Group to develop the energy model, as well as Quest Energy to peer review the model. Both consultants were involved in the Empire State Building base building retrofit energy modeling process and are familiar with the building's energy improvements.

Based on initial design drawings provided by the architect, the spaces were modeled to a baseline of ASHRAE 90.1-2007 code-compliant energy performance. The team's selected package of six proposed EPMS addressing lighting, mechanical, and plug load reduction measures, were modeled individually to see independent effects and iteratively to understand the combined effects on energy performance. The six EPMS and the energy performance projections for each are as follows:

I. Daylight Harvesting Controls. Daylight harvesting utilizes an automatic system that recognizes when

a space has adequate illumination by natural light penetrating through exterior windows and dims lighting in response. Occupants are able to turn the lights back on if desired using a manual override switch, although typically natural daylight is not only more energy efficient but also preferred by occupants.

Because of the building's position, the Empire State Building windows provide adequate access to daylight on most floors, although the low ceilings can limit the penetration of sunlight into spaces closer to the core. One of the challenges faced in the LFUSA space was that the tenant design included showroom space on several floors, which requires consistent lighting and so cannot utilize dimming. Although this feature posed a programmatic constraint on daylighting in certain areas, the measure could be implemented in non-showroom locations to provide an opportunity for energy savings. Consequently, the architect designed for daylight sensors on 9 to 23 percent of the installed lighting power, dependent on the floor. The energy model showed a

projected energy savings of roughly 30,000 kWh per year for this measure, a 3.9 percent reduction from the baseline lighting performance.

II. Reduced Interior Lighting Power Density. Decreasing the average lighting power density in a building is often one of the most cost effective means of reducing annual energy use. Lighting power can be reduced in several different ways while still maintaining full functionality, aesthetics, and illumination, including: 1) determining the most accurate lighting power needed for each space and designing to that minimum requirement; 2) selecting the most efficient fixtures with high lumen to watt ratios (efficacy); and 3) maximizing use of automatic controls such as occupancy sensors and timers.

The proposed design for the LFUSA space made extensive use of high efficiency lighting sources, including the latest light-emitting diode (LED) options, in addition to installing high efficiency T8 and T5 fluorescent fixtures.⁹

The average watts per square foot designed for the floors were 20 to 25 percent more efficient than the code compliant lighting baseline of 1.1 W/ft² (see table 4). Modeling indicated that the high efficiency lighting design would yield over 55,000 kWh of energy savings per year across the three floors, a 7.1 percent energy reduction from the baseline.

Table 4: Typical Lighting Power Density Designed for LFUSA Tenant Space & Comparison to Baseline

Floor	Average W/sf ² installed	Reduction vs. ASHRAE 90.1-2007
Floor 7	0.88	20%
Floor 8	0.82	25%
Floor 9	0.83	25%

III. Optimized HVAC Units. With heating and cooling supplied by the base building plant, the primary HVAC equipment power usage by the tenant is fan energy.¹⁰

The air handling units (AHUs) specified in LFUSA's original design drawings were more efficient than code-compliant units. ASHRAE 90.1-2007 sets a baseline system fan power efficiency of 1.07 watts per cubic feet per minute of airflow (W/CFM), while the AHUs proposed for floors 7 thru 9 have an average efficiency of 1.03 W/CFM (see table 5).

In addition to having a slightly more efficient fan system, optimized AHUs use a variable air volume (VAV) system, which holds the supply air temperature constant while adjusting the air flow rate to respond to heat gains or losses in the thermal zone. The energy model indicated that the units were projected to consume slightly more energy (approximately 1500 kWh/year, a 0.30 percent increase over baseline) across all three floors. The reason

Table 5: Designed Mechanical Schedule

Unit #	Airflow (CFM)	Motor kW	W/CFM
7-1	7,500	8.0	1.07
7-2	8,000	8.0	1.00
7-3	10,000	9.8	0.98
7-4	10,000	9.8	0.98
8-1	4,400	4.3	0.97
8-2	6,500	6.7	1.03
8-3	7,000	7.4	1.05
8-4	7,000	7.4	1.05
8-5	8,000	8.4	1.05
9-1	5,500	5.2	0.95
9-2	7,200	7.4	1.02
9-3	7,600	8.2	1.08
9-4	7,600	8.2	1.08
9-5	8,000	8.4	1.05

for this unexpected result is that the ASHRAE 90.1-2007 standard allows for a greater level of operational variance of the units than the energy model does. More specifically, the operational design of the proposed AHUs (as modeled) called for them to maintain space conditions 100 percent of the time during operating hours, even on peak days. Code compliance, on the other hand, allows for variation in unit operation, allowing them to underperform and space conditions to fall below 100 percent on peak cooling days in the modeled scenario. So because of the increased energy demand that results from consistent cooling, the proposed optimized units are projected to consume slightly more electricity throughout the year due to consistent maintenance of space conditions despite their increased fan power efficiency. The actual energy use and operational schedule of the mechanical units will be carefully monitored during the measurement and verification period.

IV. Demand Controlled Ventilation (DCV). Conditioning outdoor air is one of the most significant loads on the HVAC system in any building; it is also a significant contributor to the air quality within a space. Inadequate outside air can result in unpleasant and “stuffy” spaces, but bringing in too much outside air wastes energy as the system must work harder to condition the air. An efficient way to optimize these competing demands is to install CO₂ sensors in the space that actively monitor the air quality. The system senses when CO₂ levels rise within the space due to occupancy, and, in response, bring in outside air only when needed.

The energy model showed that implementing DCV would reduce tenant energy consumption by 2.7 percent compared to the baseline model. DCV has a more substantial effect on energy reduction when modeled iteratively with other load-reducing EPMS (see “Combined Effects” section on page 12).

V. Low Velocity Air Handlers. A significant portion of the electricity consumed by an HVAC system is fan power used to push air through the filters and coils on the face of an AHU. Spreading the fan coils and filters across a larger surface area allows air to pass more evenly and efficiently at a lower velocity from the supply ducts through the face of the AHU, while still maintaining a high level of filtration. The increased face area allows the unit to operate with lower fan speed, thus reducing the amount of energy consumed to run the fan.

In addition to the energy savings, there are typically maintenance cost savings as filters can be changed less frequently than in typical models. Furthermore, larger AHUs have the added benefit of reducing the noise generated by fans as they run at a lower speed.

A lower face velocity can be achieved one of two ways: 1) upsizing the AHU to a higher CFM unit and operating it at a lower fan speed, or 2) purchasing a custom model with the right-sized CFM motor but a larger face area, which will be enclosed in a larger casing.

The energy model assumed a 50 percent reduction in fan power would be needed to achieve desirable efficiency results. Cutting the air handler velocity in half would require a unit with slightly larger height and width than the code-compliant units (see table 6). Despite the potential energy savings of approximately 30,000 kWh/year (3.9 percent) associated with low velocity AHUs, LFUSA was unable to implement the measure on floors 7 thru 9 because they had pre-purchased the long lead time HVAC units early in the design process, before any recommendations based on the low-velocity AHU measure could be analyzed. So, while the measure could not be implemented in the initial construction phase on floors 7 thru 9, it is recommended as a measure for the build-out of future floors and is included in the value analysis of those floors.

Table 6: Air-Handling Unit Dimensions for Code-Compliant and Low-Velocity Units Proposed for LFUSA

Air Handler Efficiency	Dimensions
Code-compliant	84" L x 60" W x 54" H
50% lower AHU fan power	85" L x 66" W x 72" H

VI. Plug Load Management. In a typical office building, computers, office equipment, electronics, appliances, and other plug loads account for as much as 10 to 15 percent of whole- building electricity consumption, and an even greater percentage of energy use within tenant spaces.¹¹ Many devices continue to draw power, albeit at a reduced rate, even when they are in standby or off modes. One method to minimize these phantom loads is to install an active control that can shut off power to specified outlets when the space is unoccupied.

LFUSA had previously implemented a plug load management solution in another office space that used a manual master switch on each floor to control power to a series of outlets, which could be turned off after hours. Typical plug loads on this circuit include printers, desk lamps, computer monitors, shredders, and other miscellaneous office equipment. One of the drawbacks to a manual master switch as opposed to an automated method of plug load management, such as occupancy sensors or specialized power strips, is that it relies on a behavioral element, requiring someone to actually turn the switch off at night. If the switch is not turned off, there will be no energy savings.

The energy model assumed that implementing active plug controls would cut nighttime plug power usage by 50 percent. This measure contributed to the greatest energy savings of all the EPMs in the model, showing the potential for a 13.2 percent reduction from baseline energy consumption if implemented correctly.

PASSIVE OPTICAL NETWORK SYSTEM. As a separate feature of its build out, LFUSA decided to install a passive optical network (PON) system in the Intermediate Distribution Frame (IDF) rooms on floors 8 and 9. This fiber optic networking technology eliminates the need for powered routers, thus drastically reducing plug load. Energy savings are achieved directly from the lower plug loads and indirectly from the reduced need for cooling, as traditionally powered routers create substantial waste heat that requires supplemental cooling to maintain space temperature and equipment performance. The PON system allowed for the elimination of four 800 CFM fan coil cooling units from the four server rooms on the 8th and 9th floors.

Installation of the PON system was an elective measure, which LFUSA independently decided to implement to support the IT system rather than from an energy savings motivation. However, because the PON system dramatically reduces waste heat in the server rooms, the Project Team



MDF room on floor 7 with traditional Cat 6 cable system (left) and IDF room on floor 8 with passive optical network (PON) system (right). Note that the fiber optic cables of the PON system dramatically reduce the amount of cable required as compared to the more traditional Cat 6 cable system.

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decided to build this measure into one iteration of the energy model to review its effect on the projected energy performance of the space. The model estimated that inclusion of the PON system achieves an additional 3.4 percent energy savings over the adjusted baseline, which included the server rooms (see figure 6).

While the PON system has energy saving implications, installation of the system was a technology-driven decision, and as the system can be very expensive, it cannot necessarily stand alone as a cost-effective energy performance measure. Therefore, the PON system is not accounted for in the value analysis performed by CMI. In order to most effectively analyze the cost savings implications of the package of EPMS without conflating the results due to the presence of the PON system, the value analysis excludes the server rooms and PON system from the results.

ENERGY MODELING RESULTS. The energy model analyzed how the proposed EPMS would affect energy performance in the tenant space compared to a minimally code-compliant baseline design consistent with ASHRAE 90.1-2007 standards. As discussed previously, LFUSA was not able to incorporate low-velocity AHUs into the build-out of floors 7 thru 9 because the HVAC units were purchased early in the design process due to a long lead time. However, the purchased units were consistent with the recommended “optimized HVAC unit” measure.

The energy model projected that implementation of the package of the remaining five EPMS—including daylight harvesting, high efficiency lighting design, optimized

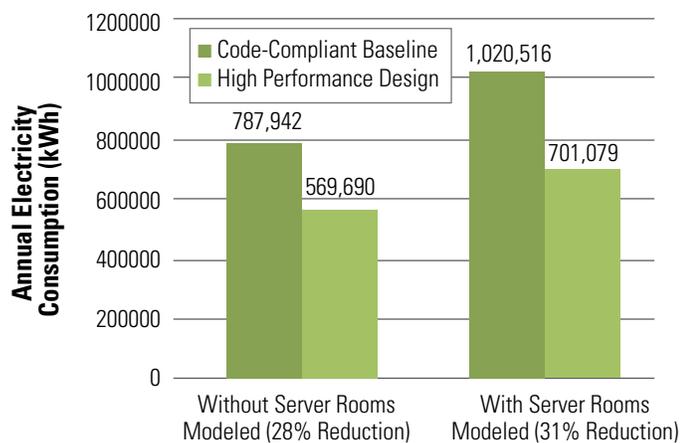
HVAC units, demand controlled ventilation, and plug load management—would lead to a 28 percent reduction in electricity consumption across the three Phase 1 floors. In a separate run of the model that included the server and IDF rooms in the baseline and incorporated the energy saving benefits of the PON system, the reduction increased to 31 percent from the code-compliant baseline (see figure 7).

COMBINED EFFECTS. It is important to note that, due to interaction among the EPMS, the combined package of energy performance measures differs in energy savings from the sum of all of the individual measures. One notable interaction is between the two lighting measures. When daylight dimming is implemented, the lights, no matter how efficient, use less power over the course of a day due to reduced demand. Because natural daylight is supplanting some of the demand for lighting, high efficiency lights have less opportunity to confer savings. Additionally, the cooling load is decreased slightly because less waste heat is generated by the lights, so higher efficiency HVAC units operate for slightly reduced periods, resulting in fewer energy savings than the HVAC measure could confer alone.

The combined effect is particularly significant in the demand controlled ventilation measure, which when combined with the other implemented EPMS, provides more than twice the savings than if implemented independently. In the baseline case, the load demand is higher due to the waste heat of less efficient lighting and greater plug load. As the lighting efficiency is improved and plug load decreased, the modeled load requirements are less and the airflow demand declines accordingly. Because the LFUSA floors have some showroom floorspace, which is designated as high-occupancy space by ASHRAE 90.1-2007 (similar to a conference room or retail space), the reduced load demand allows ventilation demand to become the primary driver of airflow instead of cooling. With a highly responsive DCV system, the space can have lower minimum airflow set points, because the system can respond quickly to changes in occupancy. The reduced fan power demand from lower set points yields energy savings, which are especially pronounced in LFUSA’s Phase 1 space due to the prevalence of high-occupancy space.

As a result of implementing the EPMS as a comprehensive package to maximize positive effect among the measures, the energy model showed that the EPM package would result in a 28 percent reduction in energy consumption, rather than a 26 percent reduction when measures were considered individually. This is important to note for accurate analysis of economic viability, and also supports the implementation of an entire EPM package, rather than individual measures.

Figure 7: Modeled Electricity Consumption of Baseline Design and High Performance Design as Implemented, with and without the Inclusion of the Server Rooms and PON System in the Energy Model



5. REVIEWING INCREMENTAL COSTING AND AVAILABLE INCENTIVES

INCREMENTAL COSTING. The general contractor provided two sets of cost estimates for the material and labor costs that LFUSA would incur when implementing different design scenarios: 1) ASHRAE 90.1-2007 code-compliant design; and 2) high performance design showing the additional cost of each individual EPM. It is critical to isolate the incremental cost of each measure independently so that paybacks may be analyzed individually. Aggregating incremental costs by subcontractor trade does not allow for granular analysis. The contractor provided estimates that the package of five measures for the Phase 1 floors would cost the tenant an additional \$164,370, approximately \$1.20/ft².

SUBMETER COSTS. LFUSA installed on each floor submeters that are capable of independently monitoring electricity used by HVAC, lighting, plug load, and information technology (IT) equipment. The tenant monitors and analyzes detailed energy use at other office locations, and in the Empire State Building space, invested approximately \$50,000 per floor for the ongoing energy management instrumentation, which connects with the existing tenant energy management network portal provided by the building owner. Across the industry, the expense of submeter installation can range, with a starting cost round \$5,000.¹² These costs are not included in the value analysis performed by CMI as there are no direct energy savings associated with submeters. Rather, the submeters are a tool to measure and verify energy use and aid in ongoing energy management to prevent energy waste during occupancy.

SOFT COSTS. As part of the High Performance Tenant Demonstration Project, some of the soft costs associated with LFUSA's high performance build-out were funded by CMI as part of a grant to study the tenant energy optimization process and inform the market. Many of the work items in the tenant space energy optimization process can be incorporated into the standard design process without any additional cost. For example, incremental cost estimates can typically be provided by the general contractor at no additional cost if incorporated into the design as alternates, as was the case for LFUSA's incremental costing. Similarly, the energy modeling engineer will typically include rough incremental cost estimates and calculate the simple payback period, potentially eliminating the need for additional consultants. For the three floors included in LFUSA's Phase 1, energy modeling costs were \$6,600. This cost can vary depending on the complexity of the space design and whether building and/or tenant energy model already exist. In many cases, a base building energy model can be an amenity for tenants considering a high performance design, as the model will have already incorporated many design

elements, such as the building envelope and mechanical systems.

For the LFUSA space, however, the existing base building model was overly complex given the depth of analysis for the retrofit that the modeling engineer elected to design the LFUSA model anew. Going forward, designing future floors using the tenant-specific energy model built for Phase 1 will help LFUSA reduce future energy modeling costs, although CMI did not estimate any such savings in our analysis.

The goal is to integrate the value analysis steps into the standard build-out process, the financial analysis process that CMI provided in this project can be easily incorporated in the energy modeling or engineering consultant scope with minimal if any additional cost for the tenant's future build-outs. With the toolkit that we have assembled, templates for value analysis can greatly reduce the amount of time needed to analyze measures. Additional templates for the energy modeling request for proposal (RFP), energy modeling results reporting, and incremental costing will help streamline the project management process and reduce the amount of time required to oversee consultants and contractors.¹³ Going forward, as all of these practices become commonplace and further integrated into the standard design process, we expect soft costs to continue dropping.

INCENTIVES. NYSERDA offers incentive programs for energy efficiency upgrades, which LFUSA was able to utilize. CodeGreen, the LEED consultant engaged by LFUSA, prepared the pre-qualified incentive submittals for all three Phase 1 floors. Pre-qualified incentives are fixed incentives offered on a dollar-per-unit basis for a prescribed set of measures. LFUSA's received pre-qualified incentives valued at \$15,430 for the 7th floor, \$14,003 for the 8th floor and \$15,967 for the 9th floor—a total of \$45,400, or \$0.33/ft². The cost for CodeGreen to prepare, review, and submit the incentive filings for the three floors was \$8,460, leading to a net NYSERDA incentive capture of \$36,940 (\$0.27/ft²). The incentives reduced the simple payback period for the EPM package of the Phase 1 build-out by 1 year (see table 7), improving the economic feasibility of the project.

NYSERDA also offers performance-based incentives through their Existing Facilities and New Construction Programs that are often better suited for multiple-measure upgrade packages. As LFUSA designs its future floors, there will be an opportunity for early and coordinated effort between incentive analysis and energy modeling efforts so that LFUSA can apply for the New Construction incentive path, which is based on energy modeling and projected energy performance, to potentially receive more substantial incentives toward the implementation of its EPM package.

Table 7: Payback Analysis Including NYSERDA Incentives

Including Incentives	Floor 7	Floor 8	Floor 9	Floors 7, 8, 9
Electricity Use Reduction	28.9%	26.3%	27.9%	27.7%
15-yr Electricity Cost Savings	\$193,712	\$181,503	\$191,280	\$566,495
Net NYSERDA Incentives	\$12,610	\$11,183	\$13,147	\$36,940
Energy Modeling Soft Costs	(\$2,200)	(\$2,200)	(\$2,200)	(\$6,600)
Adjusted Incremental First Cost	(\$44,380)	(\$45,807)	(\$43,843)	(\$134,030)
<i>Incremental First Cost /ft²</i>	<i>\$0.97</i>	<i>\$1.00</i>	<i>\$0.96</i>	<i>\$0.98</i>
Payback (w/ Incentives)	3.4 yrs	3.8 yrs	3.4 yrs	3.5 yrs
Without Incentives	Floor 7	Floor 8	Floor 9	Floors 7,8,9
Incremental First Cost (incl. modeling soft costs)	(\$56,990)	(\$56,990)	(\$56,990)	(\$170,970)
<i>Incremental First Cost /ft²</i>	<i>\$1.24</i>	<i>\$1.24</i>	<i>\$1.24</i>	<i>\$1.24</i>
Payback	4.4 yrs	4.7 yrs	4.5 yrs	4.5 yrs

Note: Incremental costing was not provided by the contractor for the PON system, therefore energy savings due to PON are not included in the payback analyses.



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FEDERAL TAX DEDUCTION. An additional incentive opportunity may exist in utilizing Section 179D of the Internal Revenue Code, a tax deduction created by the 2005 Energy Policy Act, which allows a building owner or major tenant to deduct from its current taxable income the cost of installed energy efficiency improvements (up to a cap set forth in the tax code) that would typically be recovered through depreciation over the useful life of the improvements. §179D deductions require an energy model, and the amount of the available deduction is based on the level of projected energy reduction over an ASHRAE 90.1-2001 code-compliant baseline, which will require an additional run of the energy model against the different baseline. LFUSA did not pursue any §179D deductions.

6. PERFORM VALUE ANALYSIS

Table 8. Simple Payback Analysis for EPMS on Floors 7, 8, and 9

The projected energy cost savings for each implemented measure, the incremental first cost above code-compliant installations, and the simple payback period

FLOORS 7, 8, 9 Energy Performance Measures	Annual Electricity Reduction (kWh/yr)	Percentage of Electricity Use Reduction from Baseline	Annual Electricity Cost Savings	Incremental First Cost	Simple Payback
Daylight Harvesting Controls	30,968	3.9%	\$5,359	(\$41,850)	7.8 yrs
High Efficiency Lighting	55,746	7.1%	\$9,646	(\$30,000)	3.1 yrs
Right Sized HVAC Units	0	0%	\$0	\$0	N/A
Demand Control Ventilation (CO ₂ Sensors)	21,147	2.7%	\$3,659	(\$47,520)	13.0 yrs
Plug Load Management	103,713	13.2%	\$17,946	(\$45,000)	2.5 yrs
Combined EPM Package (without incentives or energy modeling costs)	218,252	27.7%	\$37,766	(\$164,370)	4.4 yrs
Net NYSEERDA Incentives	--	--	--	\$36,940	
Energy Modeling Soft Costs	--	--	--	(\$6,600)	
Combined EPM Package (with Incentives and energy modeling costs)	218,252	27.7%	\$37,776	(\$134,030)	3.5 yrs

Note: The energy savings above are evaluated independently for each measure, and also as the "Combined EPM Package" to evaluate the implemented EPM package as a whole, which accounts for the interactive effects of measures.

METHOD. The goal of value analysis is to consider the costs and benefits of implementing the proposed package of energy performance measures to determine if the initial investment is recovered in a reasonable amount of time and makes financial sense for the tenant. The CMI team performed a value analysis for LFUSA's proposed EPMS to determine the economic case for implementation. We pulled the projected energy savings from the energy modeling report and translated them into electricity cost savings, which were discounted over the 15-year lease term to determine the present value of the energy savings. Then we looked at the incremental first cost provided by the general contractor, which is the cost difference of implementing the EPMS compared to a simply code-compliant installation, soft costs of energy modeling, and net incentives. Using the projected savings and initial costs, the CMI team determined the simple payback and economic returns of the EPMS over the term of LFUSA's lease at the Empire State Building (see table 8).

The value analysis projected that by implementing the efficiency package, and thereby reducing energy consumption by 28 percent, the EPMS would save nearly \$38,000 in annual electricity costs across the three floors compared to the baseline code compliant design. The projected payback period of the implemented package of measures of 4.4 years was reduced to 3.5 years by capturing available NYSEERDA incentives (see table 9).

Value analysis showed that over the term of LFUSA's 15-year lease, implementation of the EPM package on floors 7 thru 9 translates into a projected cost savings of \$566,495,

the present value of which (using a 5 percent discount rate) is \$392,002. Accounting for the initial cost, the net present value of the project investment is \$257,972, a 192 percent return on investment (ROI) over the 15-year lease term, or a 27 percent internal rate of return.

Table 9: Lease Cycle Cost Analysis for Floors 7, 8, and 9

Lease Year	Cash Flow from EPMS	Cumulative Balance	Present Value of Electricity Savings
0	(\$134,030)	(\$134,030)	(\$134,030)
1	\$37,766	(\$96,264)	\$35,968
2	\$37,766	(\$58,497)	\$34,255
3	\$37,766	(\$20,731)	\$32,624
Payback 3.5 years			
4	\$37,766	\$17,035	\$31,070
5	\$37,766	\$54,802	\$29,591
6	\$37,766	\$92,568	\$28,128
7	\$37,766	\$130,334	\$26,840
8	\$37,766	\$168,101	\$25,562
9	\$37,766	\$205,867	\$24,245
10	\$37,766	\$243,633	\$23,185
11	\$37,766	\$281,400	\$22,081
12	\$37,766	\$319,166	\$21,030
13	\$37,766	\$356,932	\$20,028
14	\$37,766	\$394,699	\$19,075
15	\$37,766	\$432,465	\$18,166

7. REVIEWING BUDGET AND SELECTING MEASURES

DECISION-MAKING PROCESS. The CMI team was integrated into the energy design process, and worked in tandem with the tenant's project team throughout the evaluation process to provide the energy modeling, energy use quantification, costing coordination, and final value analysis of the energy measures considered for the project. As the project schedule was on a fast track, and due to mechanical pre-purchase schedules, the low-velocity air handler measure, which provided a strong payback, could not be incorporated on the first phase of floors, yet is being considered for the build-out of future floors. CMI's value analysis data supported the incorporation of the Empire State Building's lease-required energy measures, and by presenting the economic benefits to Li & Fung's executive management, the process encouraged implementation of additional energy management strategies, including a plug load master switch and end use sub-metering.

FUTURE FLOORS. Based on the projections for Phase 1 of construction on floors 7 thru 9, if LFUSA were to implement the full recommended package of EPMS, including the low-velocity AHU measure, on the six remaining floors, they have the opportunity to capture nearly \$1.25 million in additional projected electricity savings over the 15-year lease term with a 29 percent internal rate of return.

For future floors, initiating an energy model early in the design process to apply for customized performance-based incentives through a NYSERDA-approved technical advisor may enhance the incentive amount available for the build-out (estimated to range from \$0.30-\$1.00/ft²), which will contribute to even shorter payback periods and greater return on investment. The projections in table 10 assume LFUSA will spend \$2,200 per floor on energy modeling and capture net NYSERDA incentives of \$14,650 per floor (\$0.32/ft²), resulting in an incremental first cost of \$272,000 (\$0.99/ft²). There is additional opportunity to reduce first costs associated with implementation of EPMS by capturing

Table 10: Potential Electricity Cost Savings due to EPM Package Implementation across Future LFUSA Floor Build-Outs

LFUSA Tenant Space	EPM Package	15-Yr Electricity Cost Savings
Floors 7, 8, 9	As Implemented	\$566,495
6 Future Floors	As Recommended	\$1,247,238
9 Total Floors	See above	\$1,8137,33

\$179D tax incentives; however the CMI team did not analyze LFUSA's potential deduction due to the lack of availability of tax information.

THE FUTURE OF ASHRAE 90.1 AND CHANGING

BASELINES. The energy model baseline for the LFUSA build-out was created following ASHRAE 90.1-2007 requirements, which is one of the current compliance options in the State of New York Energy Conservation Construction Code (ECCC). However, a new revision of this ASHRAE guideline has been released and is expected to be adopted in the next version of the NY State ECCC, although the timeline is uncertain. ASHRAE 90.1-2010 is an aggressive effort to increase building efficiency across the board. As part of this effort, it mandates several of the performance measures that LFUSA voluntarily adopted. Just as the project's value analysis and modeling process identified many cost-effective energy performance measures to incorporate into LFUSA's build-out design, ASHRAE has recognized the benefits and adopted many of the same measures into its 2010 requirements.

Regardless of the baseline, LFUSA has built an efficient and cost-effective space. The ASHRAE 90.1-2010 baseline space is not as efficient but is closing in on the high level of efficiency demonstrated in the LFUSA space. (See appendix B for a full summary of how ASHRAE 90.1-2010 updates related to energy efficiency will affect the LFUSA package of EPMS).

Table 11: Summary of Proposed Changes to ASHRAE Baseline as Related to LFUSA Package of EPMS

Energy Efficiency Measure	ASHRAE 90.1-2007 Baseline Space	ASHRAE 90.1-2010 Baseline Space
Daylight Harvesting Controls	No requirements	Required in perimeter spaces; Section 9.4.1.4
High Efficiency Lighting Design	Baseline W/ ft ² defined for office, restrooms, storage, retail, conference and corridors	W/ft ² decreased for some LFUSA space types; but LFUSA efficiency still exceeds baseline
Optimized HVAC Units	Maximum fan power allowance set	No changes from 2007
Demand Controlled Ventilation	Required for conference rooms	Required for all high occupant density spaces
Lower Velocity Air Handlers Option	Maximum fan power allowance set	No changes from 2007
Plug Load Management—Controlled Outlets	No requirements	Required for 50% of outlets; LFUSA exceeds by controlling more than 50% of outlets; Section 8.4.2

8. BUILDING OUT THE SPACE

Benchmark Builders, Inc. was selected as the general contractor for the construction of the LFUSA space. The company has extensive background in constructing commercial interior spaces seeking LEED certification and is familiar with all of the required reporting, facilitating a smooth construction process.

One unforeseen issue that arose during construction was the need to coordinate installation of the end-use submeters

with the base building system. Given that the tenant space is already submetered by floor, there was an issue tying the panel level submeters into the tenant energy management system so that the tenant could monitor plug load, HVAC, and lighting electricity independently. As a consequence, the start of measurement and verification is delayed until the upgraded system is in place.

9. DEVELOPING POST-OCCUPANCY PLAN

BACKGROUND. Measurement and verification (M&V) planning and implementation assures optimal energy performance over the lifetime of a space by comparing the actual monitored performance of its systems to predicted, calculated, and historical values. Measuring the actual energy use of the facility verifies that the design was implemented as intended, that the energy model assumptions match the actual operating schedules and loads, and that the tenant is realizing optimal energy performance.

SUBMETERING. As part of the build-out design, and consistent with Empire State Building sustainability policy, submeters were installed to measure the tenant electricity usage by floor. LFUSA was interested in the benefits of detailed energy use information for ongoing energy management, so installed distinct panels dedicated to separately measure end uses, such as lighting, HVAC, plug loads, and IT equipment. Segregating electrical panels by load is a good practice in electrical design in order to facilitate submetering. The end-use data collected by the submeters will be transmitted to the tenant energy management system and used to calibrate the energy model simulation. Once calibrated, the energy model is incorporated into the M&V process to ensure that the installed systems and EPMS are operating as intended. Periodic monitoring of end-use energy loads and comparison with the calibrated energy model allows the tenant to identify and correct anomalies, and ensure operations are on track to meet energy goals.

DATA COLLECTION. Monthly energy end-use consumption and one-hour interval data trends for a minimum of a two-week period during each of the cooling and heating seasons will be collected and used to calibrate the energy model for the as-built tenant case and the baseline case. Both the ASHRAE 90.1-2007 baseline and the as-built model will receive identical schedule and load updates based upon the actual, observed use to ensure that an accurate

savings differential can be determined. Slight changes to the occupancy schedule, plug load density, and lighting schedule are expected as actual space operations often differ from the design assumptions.

LFUSA will provide the metered data in electronic format to the energy modeler, who will then perform the model calibration and reporting. Monthly kWh consumption will be monitored throughout the year, and hourly consumption data will be analyzed twice per year for two-week periods to provide a high level of resolution and verification.

MODEL CALIBRATION. The goal of calibration is to tweak the energy model to achieve an accuracy level within 10 percent of actual energy consumption when accounting for weather, occupancy, and end-use energy loads as detailed below:

- **Weather Data:** The pre-construction energy model relies upon historical weather data capturing trends in long-term weather patterns and representing a “typical” weather data set for the representative climate zone. During the post-occupancy model calibration, actual weather data will be used to assure accurate calibration of heating and cooling loads, and to determine efficiencies and capacities of energy-using equipment.
- **Occupancy Profile of Tenant Space:** The occupancy profile of the tenant’s premises is the schedule that the space is occupied and systems are operating, which significantly affects the annual energy consumption. In the pre-construction energy model, reasonable estimates are made for the occupancy profile based upon design and programming documents provided by the tenant. During the M&V period, data will be taken directly from the tenant energy management system logs of building equipment (i.e. lights and fans) during the two trended periods, to develop an accurate occupancy use profile for the model calibration.

- **Lighting Energy:** To verify lighting end-use, all the meter data from the lighting panels will be collected to determine power consumption (kWh). The collected data will establish typical daily, weekday, and weekend lighting profiles (kWh vs. hour), which will be used to adjust lighting schedule in the energy model. Peak lighting demand will be used to determine and verify total installed lighting wattage and total lighting power density.
- **HVAC (Fan) Energy:** The HVAC panel meter data will be collected and assessed to determine actual fan schedules and HVAC power usage.
- **Plug and Miscellaneous Loads:** The data from the meter monitoring the plug load panel will verify the effectiveness of the plug load management measure. In order to achieve projected energy savings, it is especially important to monitor the effectiveness of the plug load management measure. LFUSA's installation of a master shutoff to eliminate waste energy from unused equipment at night relies heavily on human behavior, and as one of the most significant contributors to projected energy savings, ensuring the plug load is being shut off regularly is critical to the success of this EPM.

The final M&V report will include a detailed account of the methodology of data collection and calibration as well as final energy modeling results, re-run to demonstrate performance under actual conditions. The report will include the adjusted baseline energy consumption as well as the actual energy savings achieved in the high performance space for use in CMI's post-occupancy performance analysis.



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10. COMMUNICATE RESULTS

The purpose of this case study is to explain the process undertaken for the LFUSA Phase 1 high performance tenant build-out and convey the projected energy and economic benefits. A follow-up report will be published when the M&V process is complete and actual results can be evaluated.

The CMI team identified the following lessons learned during this project:

OWNER/TENANT COLLABORATION. This case study demonstrated that the alignment of landlord and tenant goals can be mutually beneficial. The Empire State Building retrofit and commitment to energy performance was one of LFUSA's primary reasons for selecting the space in the Empire State Building. The completed base building measures, such as upgraded windows and radiator insulation, increase tenant comfort. Additionally, the ESB's building automation system (BMS) ties into the tenant energy management system to enhance the tenant's ability to monitor and manage ongoing energy usage in the tenant space.

LEASE STRUCTURE. The Empire State Building's standard lease provisions incentivize energy efficiency and demand reduction. First and foremost, the tenant's space is separately submetered and the tenant pays for electricity based on actual electricity consumption in its space, allowing the tenant to realize direct savings from the EPMS it elects to implement. The lease also requires tenant to incorporate various EPMS in its build-out provided that those EPMS are projected to have acceptable payback periods (3 to 5 years, depending on the measure). Finally, the lease form requires the tenant's design team to meet with the Empire State Building team for an energy workshop, and to work toward the most energy efficient execution of the tenant's installation program without compromising design intent or space performance. These lease provisions require the tenant to consider efficiency in its design process, but also ensure that the tenant is able to

realize direct savings from the implemented EPMS, making such measures economically viable.

EARLY INVOLVEMENT. It is critical to have all of the players involved in the early stages of the design process. In order for the value analysis process to be impactful, the energy model must be run early in the design process so that EPM packages can be analyzed for their energy savings and economic performance to inform the decision-making process. In the LFUSA case, we found that one proposed EPM with proven financial benefit could not be implemented due to pre-purchase of long lead-time HVAC equipment. Had the energy model and value analysis been performed earlier, perhaps this measure could have been incorporated to improve the overall package.

INCENTIVES. Similarly, early engagement in the incentive seeking process is critical. Because NYSERDA was not engaged at the earliest stages of the energy modeling process, LFUSA was not able submit for the custom performance-based incentives, which are typically greater than the pre-qualified incentives they ultimately achieved. Additionally, coordinating the LEED filing with the energy modeling process can allow the tenant to utilize the analysis process for multiple purposes.

COMMITMENT AT THE TOP. LFUSA is committed to sustainability throughout its organization. When it was time to decide on EPMS that were outside of the lease requirements, the decision to include plug load management came from the executive level. It is important to have commitment to energy performance at the highest levels of an organization translate the vision of a potential high performance workplace into execution.

APPENDIX A

List of Energy Performance Measures Considered:

Open Office Layout

Locating Offices in Interior Space/Around Core

Daylighting

Lighting Layout

Lighting Controls

High Efficiency Lighting

Plug Load Management

Demand Controlled Ventilation

Optimized HVAC Units

Low-Velocity HVAC Units

Occupancy Sensors for VAVs

Optimal Zoning

HVAC Controls and Optimized Sequence of Operations

Tenant Energy Management Dashboard

APPENDIX B

Summary of Impact of Changing Baseline from ASHRAE 90.1-2007 to ASHRAE 90.1-2010				
Energy Efficiency Measure	ASHRAE 90.1-2007 Baseline Space	ASHRAE 90.1-2010 Baseline Space	Summary of Effect of Change on LFUSA Design	Projected Impact on LFUSA Savings Projections
Daylight Harvesting Controls	No requirements	Required in perimeter spaces; Section 9.4.1.4	ASHRAE-90.1 2010 considers daylighting control as baseline in many of the spaces LFUSA implemented it. Under 2010, perimeter spaces near windows (within one ceiling height of the window) that are over 250 ft ² total require automatic daylighting controls of the type LFUSA installed. Some savings over the 2010 baseline would still be seen since LFUSA implemented daylighting control in some offices smaller than 250 ft ² and to greater than a 8.5 foot depth in some spaces. There is also an exemption based on the height of adjacent structures that one façade may be qualified to take. However, to a great extent daylighting controls as implemented by LFUSA will be baseline in the 2010 version.	<i>Savings decrease versus baseline of 65-90%</i>
High Efficiency Lighting Design	Baseline W/sf defined for office, restrooms, storage, retail, conference and corridors	W/sf decreased for some LFUSA space types; but LFUSA efficiency still exceeds baseline	ASHRAE-90.1 2010 continues the systematic lowering of lighting power density considered baseline. The LFUSA spaces achieved an average lighting power density of from 0.82 – 0.88 W/ ft ² across the entire floor plate. In 2007, the whole building baseline allowance for office space was 1.0 W/ ft ² . The 2010 revision has lowered this 10% to 0.90 W/sf, which is still greater than the 0.82 – 0.88 W/sf achieved by LFUSA. The LFUSA space shows better savings versus the baseline under a more detailed space by space approach since it has more than the typical amount of conference room space and some retail space; however, there is a similar reduction in baseline lighting power allowance occurring in those areas. Savings from more efficient lighting are still present compared to the 2010 baseline, but they are expected to be reduced by approximately 10 percentage points. The exemptions for display case lighting remain intact.	<i>Savings decrease versus baseline of 30-40%</i>
Optimized HVAC Units	Maximum fan power allowance set	No changes from 2007	No relevant changes.	<i>No savings versus baseline change</i>
Demand Controlled Ventilation	Required for conference rooms	Required for all high occupant density spaces	ASHRAE-90.1 2010 expands the requirement for demand controlled ventilation beyond conference rooms to all space with an occupant density greater than 1 person for every 25 square feet. The LFUSA space does not have significant spaces of this density, so the implementation of demand controlled ventilation for the entire space continues to be a savings over baseline.	<i>No savings versus baseline change</i>
Lower Velocity Air Handlers Option	Maximum fan power allowance set	No changes from 2007	No relevant changes.	<i>No savings versus baseline change</i>

SPOTLIGHT: EMPIRE STATE BUILDING RETROFIT

One of the strongest drivers in LFUSA's selection of space in the Empire State Building was the recent retrofit and repositioning of the building as a leader in energy efficiency. A 102-floor skyscraper built between 1930 and 1931, the Empire State Building was once the world's tallest building. At a height of 1,472 feet (449 meters), the Empire State Building has approximately 2.8 million square feet of leasable office space with a range of large to small tenants, drawn by the building's prestige, skyline views, and convenient Manhattan location.

In 2008, building owner Empire State Realty Trust committed to establishing the Empire State Building as one of the most energy-efficient buildings in New York City, and the world's most environmentally conscious office tower built before World War II. Looking to reposition the building and showcase the benefits and economic viability of whole-building retrofits, Anthony Malkin, president of Empire State Realty Trust, undertook an extensive capital improvement project, which included a comprehensive energy efficiency retrofit. The efficiency measures changed the way nearly \$107 million of the capital improvement budget was spent, with a net incremental cost of \$13.2 million.¹⁴ The project team's goal was to implement the most cost-effective and impactful package of energy performance measures and to create a replicable model for future full-building retrofits in the process.

Energy Savings Target. The resulting package of energy performance measures was projected to reduce energy consumption by 38 percent and reduce Empire State Building's carbon emissions by a minimum of 105,000 metric tons of CO₂ over the next 15 years both by implementing base building measures and maximizing tenant participation.

Project Measures and Costs. Empire State Building's package of efficiency measures aimed to improve performance in the core building infrastructure, common spaces, and tenant suites. The retrofit package focused on eight energy performance measures, which had an incremental cost of approximately \$13.2 million, which is net of the avoided cost replacing the chiller plant, a planned upgrade that was no longer needed due to lower load requirements resulting from the implementation of the eight EPMs. The table below lists the energy performance measures implemented and details the project costs and projected annual energy savings of \$4.4 million upon project completion, with a payback under five years.

By renovating its central systems, the Empire State Building made it easier for tenants to realize savings as spaces are leased and built out. In order to achieve its energy savings target, which depended significantly on participation at the tenant level, the Empire State Building instituted lease language that requires tenants to implement specific energy performance measures provided that the value analysis demonstrates that

Building Information	
Location	350 5th Avenue, New York City (Midtown Manhattan)
Construction Type	Historic skyscraper, pre-WW II
Square Footage	2.8M square feet
Usage	Office space and street-level retail

Empire State Building Retrofit Team	
Program Manager	Jones Lang LaSalle
Energy Service Company	Johnson Controls, Inc.
Design Partner and Peer Reviewer	Rocky Mountain Institute
Facilitator	Clinton Climate Initiative

they have an acceptable payback period. The innovative lease provisions have ensured that the effect of the base building upgrades would be maximized across the tenant spaces, which account for the bulk of the energy consumption in the building.

Whole-Building Energy Model. During the retrofit process, the Empire State Building retrofit team built a whole-building energy model for all 102 floors. Although the model was fairly standard from floor-to-floor, as spaces were all treated as unoccupied, the energy model allowed the Empire State Building team to target the most cost-effective and impactful measures while optimizing interplay between measures. Upon each lease signing, Empire State Building makes the energy model available to tenants to inform their design process and reduce upfront energy modeling costs. Although the energy model must be customized for each space design, the existence of the base building model saves time and money as the tenant begins the modeling process because the engineers do not have to create a model from scratch.

Preliminary Results. In the first year since the retrofit project was completed, the Empire State Building has realized \$2.4 million in energy savings, 5 percent more than projected for the first year.¹⁵ As tenant occupancy increases further, avoided electricity costs will also increase, and results are expected to be on par with or greater than expected. Because of the retrofit, the Empire State Building has repositioned itself as a major player in the New York City office market, something it had not been in decades. The fresh focus on energy efficiency and sustainability has helped to attract bigger and strong credit tenants looking for a Manhattan flagship and a high performance office space. The alignment of tenant and landlord goals, along with a support structure put in place by the building owner, has allowed sustainability efforts to flourish at Empire State Building, as has been demonstrated in the Li & Fung case.

Endnotes

- 1 Assuming zero escalation in electricity prices over the lease term, and a 5 percent administrative fee per the terms of tenant's lease.
- 2 Calculation based on eGRID2012 Version 1.0 Year 2009 GHG Output Emission Rates for the NYCW Subregion (1,119.25 lb CO₂e/MWh), available at http://epa.gov/cleanenergy/documents/egridzips/eGRID2012V1_0_year09_GHGOutputrates.pdf
- 3 Calculation based on EPA Greenhouse Gas Equivalencies Calculator (May 2011), available at <http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results>
- 4 The energy model was built using DOE-2 eQuest software, which is a free and open source platform.
- 5 Floors 3, 4, 5, 6, 10, and 11.
- 6 For more on Li & Fung's sustainability policies, see their website, available at <http://www.lifung.com/eng/csr/csr1.php>
- 7 See Energy Performance Optimization Guide, NRDC Center for Market Innovation. November, 2012, available at <http://www.nrdc.org/business/cgi/files/optimization-guide.pdf>
- 8 From "A landmark sustainability program for the Empire State Building." Prepared by Jones Lang LaSalle, Clinton Climate Initiative, Rocky Mountain Institute, and Johnson Controls, available at http://www.esbnyc.com/documents/sustainability/ESB_White_Paper_061809.pdf
- 9 T8 and T5 are different sizes of commercial fluorescent lamps. The T8 has a 1" diameter and the T5 has a 5/8" diameter, and both are more efficient than typical older fluorescent lamps. T12 bulbs were eliminated from the market in 2012 by U.S. Department of Energy's 2009 rulemaking.
- 10 The primary metric used to measure fan system efficiency is the watts of power (W) used for each cubic foot per minute (CFM) of air delivered (W/CFM).
- 11 Charles Copeland, "Improving Energy Performance of NYC's Existing Office Buildings," ASHRAE Journal, August 2012; From "Managing Plug Loads" presentation; Climate Leaders Web Conference (February 11, 2009). Prepared by Jessica Rivas, E Source, available at http://www.epa.gov/climateleadership/documents/events/11feb_plugloads.pdf
- 12 Current work on wireless metering technology bears the potential to substantially reduce the cost of submetering over the next few years.
- 13 See CMI website for links to templates, available at <http://www.nrdc.org/business/cgi/guide.asp>
- 14 Calculation based on EPA Greenhouse Gas Equivalencies Calculator (May 2011), available at <http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results>
- 15 From Empire State Building's Energy Performance Contract: 2011 Annual Savings Report (February 2012), Prepared by Jones Lang LaSalle and Johnson Controls, available at http://www.esbnyc.com/documents/sustainability/ESB_2011_Annual_Savings_Report.pdf

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