RETROFITTING DAYLIGHT CONTROLS
IN NYC OFFICE BUILDINGS

DECEMBER 2012

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ENERGY
EFFICIENCY
EDUCATION

The very large commercial office market of New York City is on the brink of upheaval. Recent legislation and more stringent codes are forcing a long ignored but critical energy user, office lighting, to center stage. As the lighting of the world's financial center is replaced and retuned to meet current codes, it is critical that we do not miss an additional and significant opportunity: the deployment of advanced daylighting controls across our office landscape.

Our analysis indicates that at least 114 million square feet of New York City office space can easily accommodate the retrofit of comprehensive, advanced daylighting controls and that these retrofits could result in electric peak demand reduction of as much as 160 megawatts, and 340

gigawatt hours (GWh) of electricity savings. We estimate this would result in financial savings of over $70 million annually for New York City building owners and tenants.

This report advocates for advanced daylighting systems to become a standard feature of New York City office spaces. We describe the potential energy and financial benefits, outline the challenges faced and the steps required to surmount them.

PHOTO: Michel Denancé

NEW YORK TIMES CAFETERIA
Properly managed daylighting provides the highest quality indoor environment

PHOTO: SimonPix (Flickr)

The density of New York City office space, with a relatively small group controlling a large majority of that space, combined with a regulatory mandate to retrofit the lighting in that space, creates a unique opportunity to transform the market for optimal lighting control packages. The scale of the New York City opportunity, with all large, non-residential buildings required to retrofit their lighting by 2025, is an opportunity to drive substantial demand of dimmable ballasts and improved controls.

Introduction

Lighting New York City's office buildings consumes a tremendous amount of energy — more than any other electrical end use — accounting for nearly one third of Con Edison's commercial sector electricity delivery.[1]

In late 2009 New York City passed a suite of laws called the "Greener, Greater Buildings Plan," as part of a host of measures intended to reduce energy demand and greenhouse gas emissions. One of these laws created a New York City Energy Conservation Construction Code (Local Law 1 of 2011) – eliminating a previous loophole that exempted lighting upgrades (and other work) from meeting current standards. Another key law, the Lighting & Submetering law (Local Law 88 of 2009), requires large non-residential buildings to upgrade their lighting systems by 2025 to meet the current NYC Energy Conservation Construction Code in place at the time of the upgrade.

The lighting upgrade requirement is estimated to affect 1.25 Billion SF of space and represents a singular opportunity to drive substantial energy savings, including peak demand reductions. The lighting industry has seen unprecedented innovations over the last 25 years, including multiple new technologies and a far more nuanced understanding of the appropriate types and amount of lighting for different uses. Due to the previous code exemptions noted above, New York City's building stock has not fully benefited from these improvements. Significant reductions in the typical connected lighting load are available, and better controls are cutting the number of hours that electric lights are turned on and reducing the energy that lights consume when they are in use.

The current energy code improves lighting requirements significantly relative to previous iterations. Requirements include reductions in connected load, controls for specific spaces and zones, as well as occupancy/vacancy sensors and other auto-shutoffs. The vast majority of projects will endeavor to reach code compliance and, although it is not the specific subject of this study, a significant education effort will be required to ensure that the real estate community in general, and the design and construction community in particular, are able to rise to this new challenge.

NYC COMMERCIAL BUILDING ELECTRICITY USAGE

26% Interior Lighting
6% Exterior Lighting
17% Cooling
15% Ventilation
8% Office Equipment
3% Space Heating
25% Other

SOURCE:
Con Edison 2010 Energy Efficiency Potential Study (see endnote 1)

Project teams that intend to integrate daylighting with lighting systems are faced with a wide variety of strategies, systems and technologies: from “on/off” or “stepped” daylight responsive controls that turn fixtures (or lamps within fixtures) completely off when sufficient daylight is available, to fully dimmable, fully automated, daylight responsive lighting integrated with perimeter systems such as shades, blinds or other sun control devices. This study focuses on the benefits, opportunities and challenges of implementing strategies at the more advanced end of this spectrum.

Daylighting is an important component of a comprehensive lighting controls package. Energy savings from daylighting are only realized if controls make it easy and acceptable to turn down or dim the electric lighting in the space. Additionally, the interaction of the lighting with window shades and blinds, and with the colors of interior finishes, has the potential to negatively impact occupant satisfaction if not managed properly. Daylighting in buildings can save significant electricity, including reducing peak demand, while also enhancing occupant satisfaction in the building.

Exposure to daylight and access to views are associated with important health benefits, and studies indicate that interior space with good daylighting enhances the comfort, well-being and productivity of the occupants. Measuring the direct causal impact of daylight on occupant health and productivity has proven elusive, but strong correlations are evident. Because the cost of employees heavily outweighs all other business expenses, even mild increases in productivity (through impacts like reduced absenteeism) can have positive financial impacts that dwarf the typical ROI considerations of energy conservation measures. Given the difficulty in quantifying these potential benefits and the present lack of consensus around occupant health and productivity benefits, this study focuses almost solely on the energy savings benefits of daylighting systems.

New York City buildings are very well situated to capitalize on the benefits of daylight. Many of the City’s older office buildings were designed to utilize daylight, as they were built in electric lighting’s infancy. Block sizes and orientation have generally resulted in pre-war building floor plates in which daylight reaches a good portion of the floor area – in fact, New York City’s first comprehensive zoning ordinance was enacted in 1916 in part to preserve access to daylight. Apparently, the 1916 zoning changes were accepted by building owners in part because they understood that daylit offices could command higher rent.

The City’s recently adopted lighting upgrade law will drive massive retrofits of antiquated (mostly non code compliant) lighting systems throughout larger office buildings, dramatically reducing lighting energy use. This wave of forth-coming lighting retrofits in New York City is a unique opportunity to maximize potential energy savings and the quality of our indoor environments.

New York City's Office Market

New York City has a unique concentration of office buildings—the biggest office market in the United States by a significant margin.

A 2002 report found that New York City "… is far and away the largest single concentration of office activity in the nation. New York City by itself has approximately ten percent of the entire stock of offices in the United States; a remarkable statistic as the city accounts for just 2.8% of the national population and employment."[2]

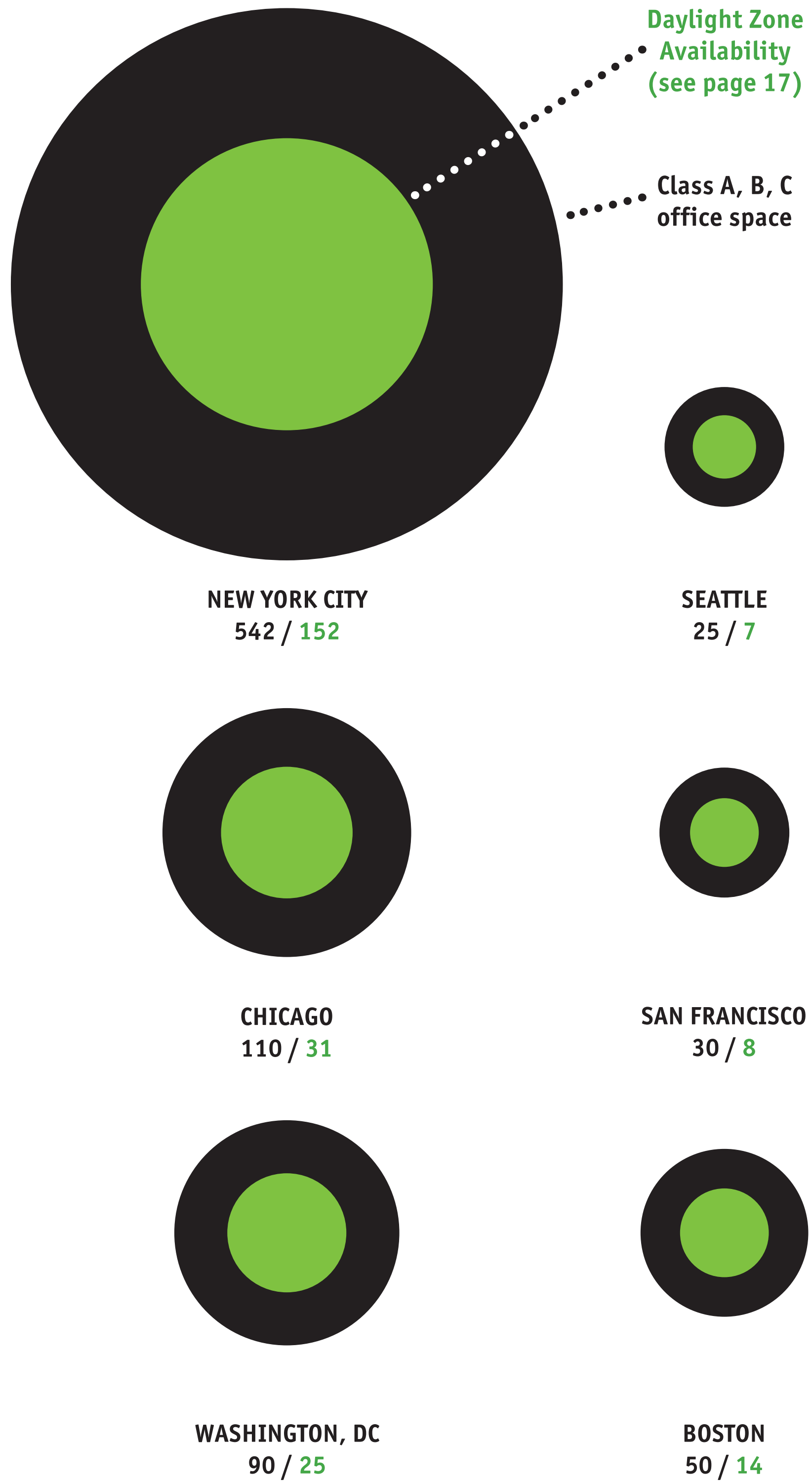
The same report went on to state, "Manhattan is far and away the largest single market in the nation (and in the world), with about twice the inventory of the next largest areas–Washington, DC, Chicago and Los Angeles… Lower Manhattan, taken by itself, represents an office inventory equal to such metro areas as Boston, Dallas and Atlanta."

Another way to view the size of the New York City office market relative to other cities is comparing the amount of office space in city Central Business Districts, as shown to the right.

New York State includes 708 million square feet of office space within buildings larger than 50,000 square feet. A 2010 review of the New York City office market[3] found that 76%, or 542 million square feet, of this office space is located in New York City, with 69%, or roughly 500 million square feet, in Manhattan alone.

Not only is the New York City office market enormous, decision making for these buildings is concentrated among a relatively small number of owners, man-

OFFICE SPACE IN MAJOR U.S. CENTRAL BUSINESS DISTRICTS[4] (MILLION SQ. FT)



SOURCE:
Data for office markets outside of NYC from U.S. Office Market Report, March 2012, prepared by Falcon Real Estate Investment Management, Ltd.

agers and tenants. The 15 largest self-managing building owners control 33% of commercial real estate in Manhattan, and the 15 largest third-party managers are responsible for almost all of the remaining office space in Manhattan. The forty largest commercial office tenants in New York City occupy 67 million square feet. While education is still required to ensure that other stakeholders (architects, engineers, lighting designers, contractors, etc.) can deliver efficient systems, these 30 firms have a unique ability to drive change in New York City office space.[5]

44% of our current office building stock was constructed prior to 1950, a period in which buildings were typically reliant on daylight and natural ventilation and therefore included numerous features to enable this, including:

- Narrow floor plates, light wells and courtyards
- Windows in nearly every space, including storage and toilet rooms
- Transom windows and interior glazing to communicate daylight into internal hallways

Nearly half the office buildings impacted by New York City's lighting retrofit legislation typically include basic physical features that are highly receptive to the application of sophisticated daylighting systems.

Another third of New York City office buildings were constructed between 1950 and 1980 an era defined by:

- Inexpensive energy
- The onset of widely available air conditioning systems
- Lighting standards that assumed high illuminance values would improve occupant comfort
- A widespread belief in sealed office environments intentionally disconnected from the natural environment

These factors resulted in designs that largely ignore access to daylight and provide only rudimentary lighting controls (whole floor switching inaccessible to the occupants, for instance, was the norm.)

The scale of New York City's office market, and the onset of legislation requiring broad retrofits of lighting, present an unprecedented opportunity to drive market transformation of lighting control systems. Upgrading the electric lighting systems in large New York City buildings is already attracting the attention of lighting equipment manufacturers, who see this as a key opportunity to demonstrate the quick payback of investments in efficient lighting and to support broader building efficiency goals and peak demand targets.

NYC LARGE OFFICE BUILDINGS (GREATER THAN 50,000 SQUARE FEET)

	Million sq. ft	# of buildings	Average Size (K sf)	Class of space (million sf) A	B	C
Downtown	104	444	243.5	73	27	4
Midtown	293	1,531	199.5	208	63	22
Midtown South	84	1,203	82.8	14	46	25
Uptown	8	332	38.7	2	4	3
Manhattan Total	489	3,510	564.5	297	140	54
Other Boroughs	53					
NYC Total	542					

SOURCE:
Commercial Real Estate Market Report, prepared for the New York State Energy Research & Development Authority by HR&A Advisors. Summer 2010.

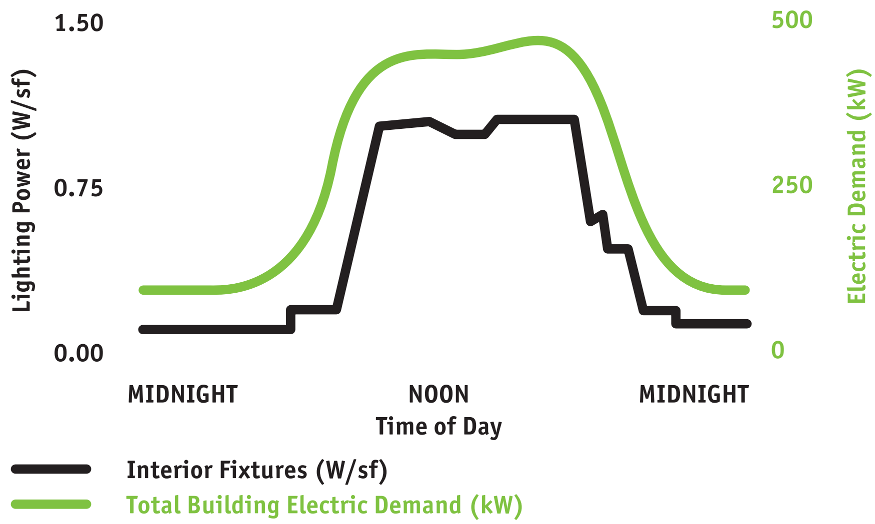
Energy Savings Potential

Interior lighting energy accounts for 26% of New York City office building electricity use.[6]

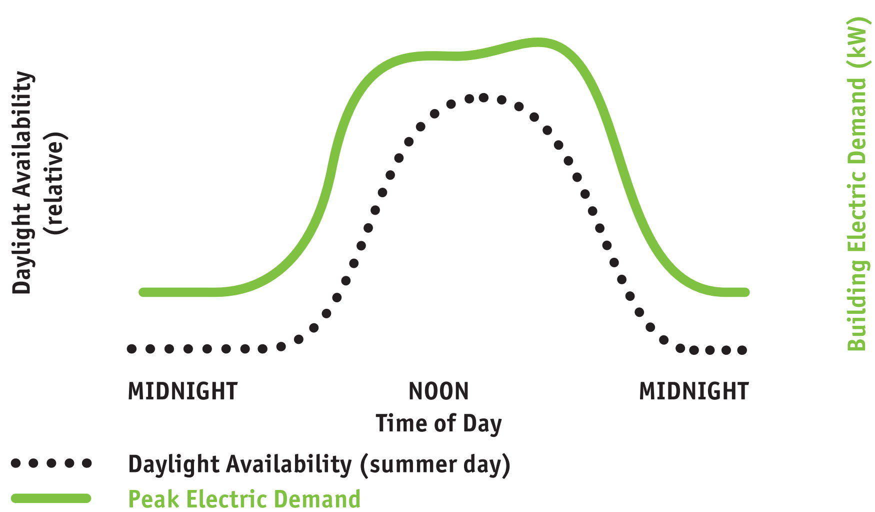
Electricity for larger buildings is billed for two quantities: the amount of electricity consumed ("energy" used, measured in kilowatt-hours, or kWh), and the "peak" demand (expressed as kilowatts, or kW) set in any given billing period. For most customers, "peak demand" is the highest amount of kW used during any 30 minute period in a given month, and for a large number of NYC office customers the highest demand set in any month is carried as the per kW charge for the full year. This "ratchet" mechanism gives customers strong incentive to keep their electric load relatively flat and consistently low throughout the year. As such, "peak demand" is perhaps the single most important determinant of a building's electricity charges. Energy providers charge for peak demand levels because they are required by regulatory mandate to be able to supply that amount any time a customer may use it; as a result peak capacity is a major cost driver of current utility rates. Peak periods are when all available generating equipment needs to run, including the oldest, least efficient, and dirtiest power plants feeding the grid, so reducing peak load has significant environmental benefits.

Daylight is most available at the time of day when demand for electricity is highest, and when the electricity is most expensive; in NYC this is a summer afternoon, when the warmest hours of the day occur, occupants and equipment have been shedding heat most of the day, and therefore air conditioning demand is highest. And daylight is most available in summer, the season with highest peak electricity use. Daylight design has strong potential to not just reduce overall energy use, but to substantially reduce demand during peak periods. With this in mind, daylighting should be a priority of both the consumers and providers of electricity.

COINCIDENCE OF LIGHTING & BUILDING PEAK DEMAND



DAYLIGHT AVAILABILITY RELATIVE TO PEAK DEMAND



GLNY analysis

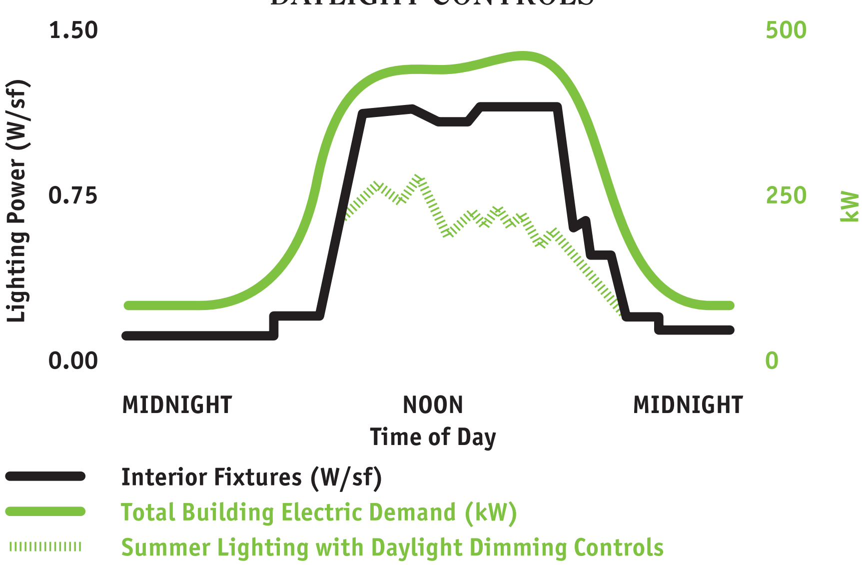
Reducing lighting use can also reduce the need for air-conditioning if solar gain is managed carefully at windows. Even the most efficient lighting sources contribute to "internal gains" because even efficient lamps convert only a fraction of the electricity into useful light, with the remainder emitted as heat. In many office buildings, internal gains are the primary driver of air conditioning needs for significant portions of the year. These internal gains include heat from lighting, but also body heat from occupants, and heat from equipment like computers and printers. In many cases these internal loads are great enough that the office building will require cooling even in winter. Cutting internal gains from electric lighting use can have significant impacts on energy use, with the most dramatic financial impact obviously occurring during peak periods.

It is also true that many design teams simply assume that more daylight is better, and that floor to ceiling glazing represents an ideal condition for daylighting. In fact, floor to ceiling glass is typically the product of brokers, owners and design teams conflating views with daylighting and, if unmanaged, floor to ceiling glass provides far too much daylight for typical office tasks. In most cases excess and/or unshielded glazing leads to occupants drawing blinds or shades which, once deployed, are rarely retracted. Excessive glazing with poor optical properties and without proper shading also typically leads to excessive solar heat gain. All of which is to say that the ratio of glazing to opaque exterior wall, the choice of glazing, the availability and use of shading, and the position of the glazing relative to the interior work surfaces, must be carefully balanced.

Lighting energy savings in office buildings typically result from:

- Reducing the "connected lighting load"
- Reducing the hours that lights are in use; and,
- Providing only the lighting output actually needed for a given task (typically through dimming)

IMPACT OF ADVANCED DAYLIGHT CONTROLS



GLNY analysis

The connected lighting load in a building is the sum total wattage of all light fixtures in the building, including the lamps and any ballasts needed to regulate power to the lamps. The connected load effectively measures the total electricity used for lighting if the building has every light on, and at full illuminance (i.e., not dimmed.) According to Con Edison estimates, the average connected lighting load (often referred to as "lighting power density") in large New York City office buildings is 1.8 watts per square foot.[7] Actual connected lighting loads vary significantly for each building, but at 1.8 w/SF, an office floor plate of 30,000 square feet would be equivalent to 540 100-watt incandescent lights burning on that floor.

Newer designs, with more efficient lamps, ballasts and fixtures, can reduce the connected load significantly and controls, when appropriately specified and operated, can reduce actual lighting energy use even further. The New York Times Company occupies over 600,000 sf in their new headquarters building, completed in 2007 (see sidebar). The Times office space was designed with a connected lighting load of 1.28 watts per square foot.[8] With advanced lighting and daylighting controls in place, the Times operates their offices at an average lighting load of just 0.396 watts per square foot, one-third their "connected load" and one-quarter the estimated average connected load for New York City buildings. The Times building uses a floor design that brings views and daylight to most occupants. While the building includes floor to ceiling glass, it specified:

1) a state of the art glazing system to reduce cooling
2) external fixed shading to provide a first defense against direct sun
3) interior automated motorized shades for glare control.

The current New York City energy code caps the connected load for new office building lighting at 1.0 watt per square foot. There are many examples of advanced daylighting controls further reducing the energy use of lighting systems, essentially by turning off or dimming lights when there is sufficient daylight.

The same Con Edison report noted above estimates that in a typical New York City office the connected load is on for 2,800 hours per year, about 54 hours per week- a significantly higher figure than would be expected if offices took advantage of available daylight.

THE NEW YORK TIMES BUILDING Completed in 2007, the Times headquarters is a 1.5 million square foot office tower located at 620 Eighth Avenue designed with several innovative energy features, including a dynamic shading system and state of the art dimmable lighting system intended to maximize the harvesting of daylight. The building is saving over $600,000 per year on their lighting according to a case study prepared by the controls manufacturer (see endnote 8).

PHOTO: Purple X (Flickr)

Simple, code-compliant systems include occupancy/vacancy sensors in enclosed spaces, which turn lights off when those rooms are unoccupied. These sensors and more active use of switching by occupants can cut total operating hours significantly. Lighting operating hours can be further reduced in open plan office areas using time-clock scheduling closely optimized to actual work hours, coupled with occupancy sensors. However, going beyond code compliant controls to state of the art dimmable daylight control systems provides the most savings by enabling the tuning of light levels to meet occupant needs as well as daylight savings, and provides the potential for additional health and productivity benefits.

The required electric lighting levels determined by code and industry standards in commercial office workspaces assume there is no daylight entering the space. This results in most lighting systems being designed to satisfy the worst case condition, night time. Without controls these spaces are significantly overlit at any time that daylight is available –which is the vast majority of a building's operating hours. Daylight dimming control systems monitor the daylight within a space and automatically adjust the output of the electric lights, maintaining the desired overall light level while saving a significant amount of electric energy.

Advanced daylighting controls (like those found at the Times building) are not explicitly called for in the current code. The current code, however, does require lighting fixtures in the daylight zone to be separately controlled, by a switch or other means. (The daylight zone is defined as the area extending 15' into a space from a window and extending 2' either side of the window.) Although future versions of the code will likely require "automatic" daylighting controls (ASHRAE/IESNA Std. 90.1 & future NYS codes), the current code requirements do not capture the energy savings and demand reduction potential of daylight. Capturing these savings should be a priority for policy makers interested in cost-effective energy efficiency, for energy providers who will need to meet future energy demands, and should be a priority of building owners who will compete with buildings constructed under future codes that require more responsive lighting controls.

Lighting controls of dimmable luminaires can turn lights off completely when enough daylight is available, and can also lower the operating watts per square foot when appropriate.

In addition to tuning electric lighting relative to available daylight, dimming controls can also provide another excellent benefit to occupants: tuning the electric lighting to the activity in the space. In a typical office, design illuminance levels are set at a high uniform level for all spaces, regardless of use, which means there is an intrinsic and significant amount of wasted energy to be captured. At The New York Times building, the "tunability" of the dimming system allows light levels to be set for the specific activity or task being performed in a given space at a given time (projected presentations, meetings, computer work, reading, etc.) Light level tuning in the Times offices has significantly optimized the lighting, providing the highest quality office environment and reducing lighting energy use for substantial energy and economic savings.

A lighting retrofit project recently completed on two floors of the Time Warner Center (see sidebar) is taking advantage of this light level tuning capability. By installing continuously dimming ballasts in all overhead fluorescent fixtures, the project pared back its average 24-hour lighting load from 0.55 w/sf to about 0.20 w/sf and created the ability to "tune" light levels to a given activity, such as at the New York Times Building. The lighting retrofit was completed in mid-October, and has recorded lighting energy savings of 55%. With continued tuning of the new sensors and controls and longer daylight hours over the Spring and Summer, the 70,000 sf space is expected to cut lighting energy use by 65% annually – and peak lighting electric demand from 70 kilowatts to 30 kilowatts, or 0.43 w/sf. The project's savings – estimated to pay back the project cost in about 4.3 years after a Con Edison rebate – are particularly notable considering the building is less than 10 years old, and the replaced lighting was considered state of the art at the time of its installation.

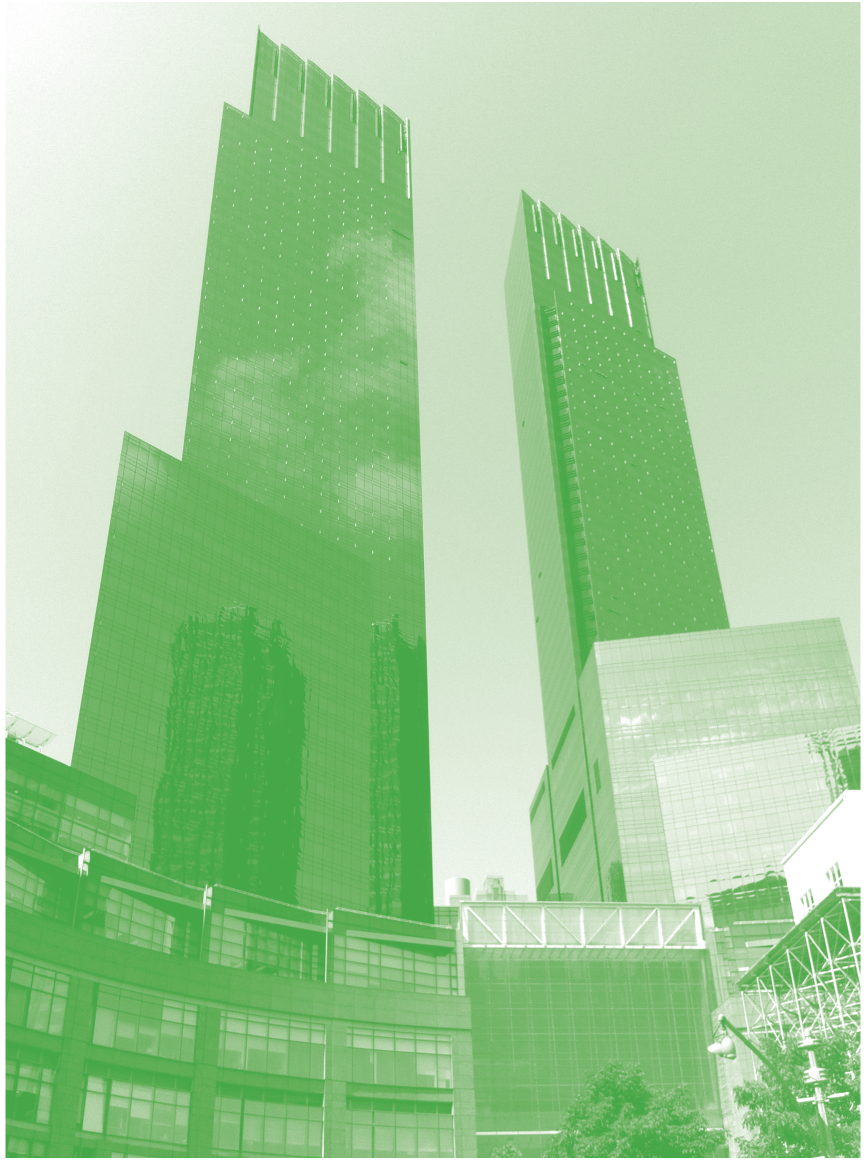


PHOTO: GLNY

TIME WARNER CENTER RETROFIT
Related Companies, developer of the Time Warner Center that was completed in 2004, decided to retrofit their two floors in the building with state of the art lighting controls in 2012. The system includes some new LED lighting, occupancy sensors throughout the space, daylight sensors in perimeter offices, and continuously dimming digitally addressable ballasts in overhead fluorescent fixtures that are controlled wirelessly.

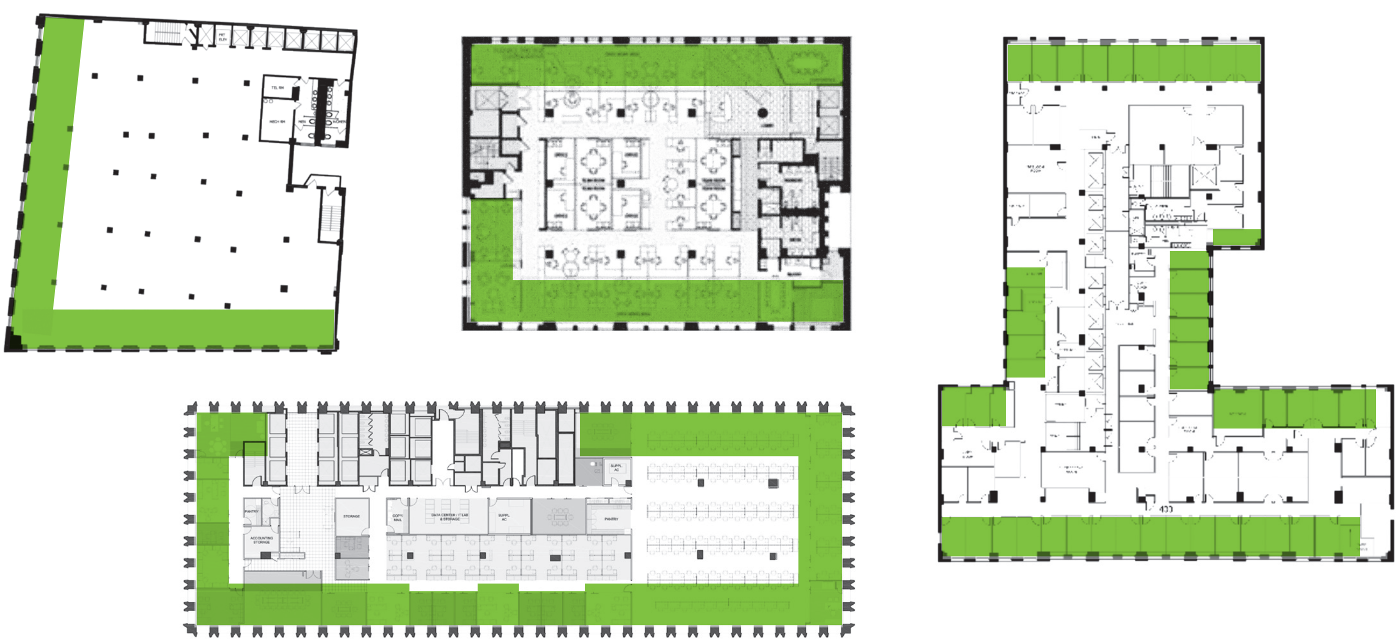
Technical Potential

To estimate the energy use and peak demand reduction potential that would result from the retrofitting of advanced daylighting controls in New York City office buildings a simple model has been developed. The model uses the office building floor area estimates described above, along with information about current lighting energy use from studies prepared for Con Edison (see model output in Appendix).

Approximately twenty New York City office buildings – a representative sample including typical size, vintage and building envelope/glazing styles – were analyzed to understand typical floor plan layouts and daylight availability in the building stock. Each building in the data set is larger than 50,000 square feet, and is therefore among the pool of buildings that will be required by recent legislation to upgrade their lighting to current code by 2025. From this analysis, the “daylight zone area” (DZA) was established: the area where electric lighting could be significantly reduced or turned off. The DZA includes spaces within 15 feet of the building perimeter where there is an exterior wall with windows. This zone is reduced to the depth of any private offices that might be along the exterior walls. The DZA for four example buildings is shown at below.

After studying the floor plates of these typical buildings, the average DZA for all of the buildings was found to be roughly 28% of the whole building floor area. This fraction, when multiplied by the 542 million sf of large office space in all five

DAYLIGHT ZONE AREAS
FOR EXAMPLE BUILDINGS



GLNY analysis

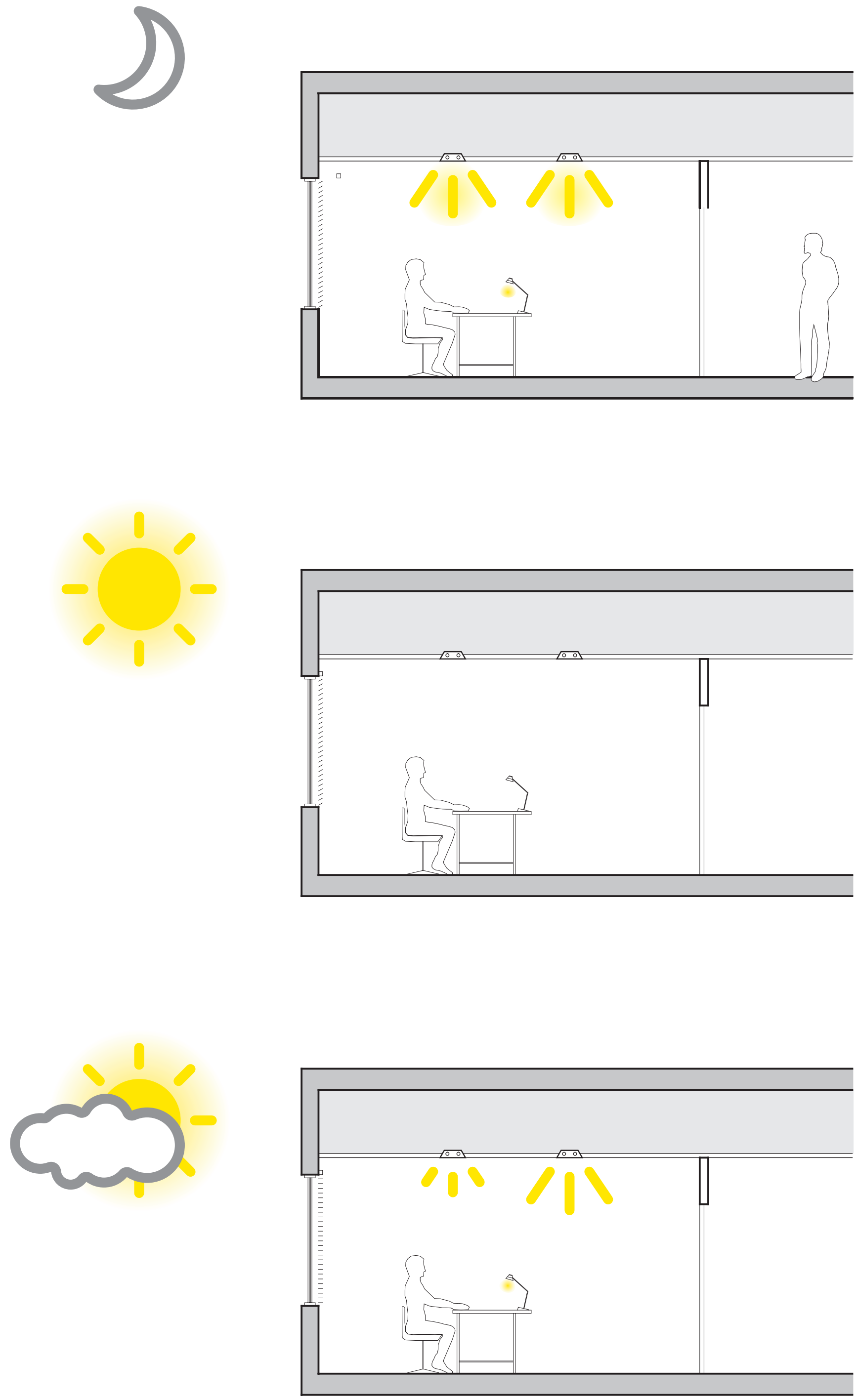
boroughs, results in potential floor area for daylighting controls of about 152 million sf.

This potential floor area was further reduced because there are other factors that will limit the daylight availability in some offices. Filters were developed such as physical factors, including façade factors (window to wall area ratio, transmittance of glass), and weather factors like sun availability. Certain occupancy filters were also assumed, including space use, occupancy type, and configuration of interiors (perimeter offices); each of which would reduce the available space for daylighting retrofits. These adjustments conservatively reduce the potential space by another 25%, bringing the total floor area where daylighting controls might be deployed down to 114 million sf.

While many studies have shown that electric lighting can be completely turned off at the perimeter for extensive periods of the day, for this analysis it was assumed that some electric lighting would remain on in the DZA, though at a reduced lighting power density of 0.4 watts per sf during peak load periods (relative to the current assumed average of 1.81 w/sf). Our analysis also assumes that the electric lighting load varies throughout the year, with more lighting required (and therefore more electricity drawn) in winter than summer, as well as throughout each day, with more lighting required in mornings and late afternoons.

These measures result in a reduction of lighting energy use from the current average of 5.1 kWh/sf/year to 2.1 kWh/sf/year.

The resulting energy savings from reducing the lighting power density from 1.81 to 0.4 w/sf, and the annual electricity consumption from 5.1 to 2.1 kWh/sf/year,



DAYLIGHT CONTROLS
Occupants preset a desired light level for their workspace. Sensors control dimmable lights to maintain an even light level, adjusting the amount of electric light relative to the available daylight. Task lamps can supplement local workspace light, individually tuning the light required for specific tasks.

over the 114 million sf of daylight available floor area, results in potential savings of 160 MW of electric demand, and 340 gigawatt hours (GWh) of electricity savings. This demand reduction is equivalent to the electric demand of about 16 Empire State Buildings, while 340 GWh is more than the electricity consumption of all of the private office space in Albany's Central Business District.[9]

Using the average electricity charge for New York City commercial buildings, this electricity reduction is equal to over $70 million in annual savings for New York City owners and tenants.

As noted earlier, reductions in lighting energy use also result in lower internal loads and reduced demand for air conditioning, resulting in further energy savings and peak demand reduction.

Economic Potential

While the technical potential for energy and cost savings for daylighting controls is large, tapping them immediately is challenging due to significant cost barriers and the lack of widespread experience with the use of these systems.

Dimmable ballasts and advanced lighting controls remain expensive relative to simple, code compliant systems, and the labor costs of retrofitting these systems is relatively high, resulting in a longer return on investment than most projects are willing or able to consider.

Currently, it is estimated that a comprehensive advanced daylighting controls retrofit has a payback in the range of 5 to 10 years – a longer cost recovery period than most owners or tenants will find acceptable. However, given the scale of lighting retrofits that will be taking place in the coming decade, it is realistic to expect both equipment and labor costs will decline. Additionally, digital controls and wireless systems (where sensors, controls and fixtures communicate without the need for expensive installation of control wiring) are reducing overall installation costs significantly. A well-designed incentive program could ensure these systems are cost-effective almost immediately.

While a number of demonstration projects are getting underway in late 2012 and early 2013, it is unlikely that any large-scale retrofit initiative could be launched prior to 2014. A targeted effort to retrofit advanced daylight controls in 3% of New York City office space annually for three years, and 5% of office space annually for the next three years, would result in 24 MW of demand reduction by 2020, with resulting annual energy savings of 82 GWh, worth about $16 million in reduced electric bills to customers at 2011 average commercial rates.

Collaboration with Others

The opportunities in New York City are not happening in a vacuum. Much is currently underway around the country to address barriers to adoption of advanced daylighting systems.

The California Energy Commission's Public Interest Energy Research program, along with significant support from California utilities, has organized the Daylight Forum, and funded substantial work on Daylight Metrics and potential energy reductions. The California Energy Commission has also supported a much more comprehensive analysis of Office Daylighting Retrofit Potential in California[10] (the findings of which are consistent with this analysis). A great deal of "emerging technology" demonstration work is currently taking place in California, addressing the feasibility of a variety of daylight optimized blinds and task/ambient lighting systems. There is an opportunity for New York City to leverage what is being done in California to maximum benefit given the enormous scale of lighting retrofits expected in New York City in the coming decade.

At the Federal level, the U.S. Department of Energy continues to support development of new tools for design of daylighted spaces (e.g., COMFEN, Tips for Daylighting), partnerships with companies to develop improved glazing, shading and daylighting solutions, and documentation of daylighting use in high performance commercial buildings, and is exploring new programs to encourage improved sensors and controls. The General Services Administration (GSA) is evaluating lighting controls and daylighting installations throughout their nationwide building stock as part of their Green Proving Ground program.

Elsewhere, the New Buildings Institute, in partnership with the Integrated Design Lab (based in Seattle, WA), based on a successful initiative underway in California has created the Daylight Pattern Guide, an online resource hosted by the advancedbuildings.net website.

There is also a growing recognition that some of the expected savings from daylighting projects have not materialized, and as a result many market actors are interested in collaborating to showcase what is working. A new, multi-utility initiative is getting underway through the Consortium for Energy Efficiency which will allow NYC's efforts to complement other related activities around the U.S.

Additionally, there is a growing industry focused on "demand response" programs that offer large incentives to reduce energy consumption at periods of peak demand. These demand response providers can take advantage of the "load shedding" capabilities of dimmable ballasts and would no doubt support the efforts advocated for in this report.

Summary

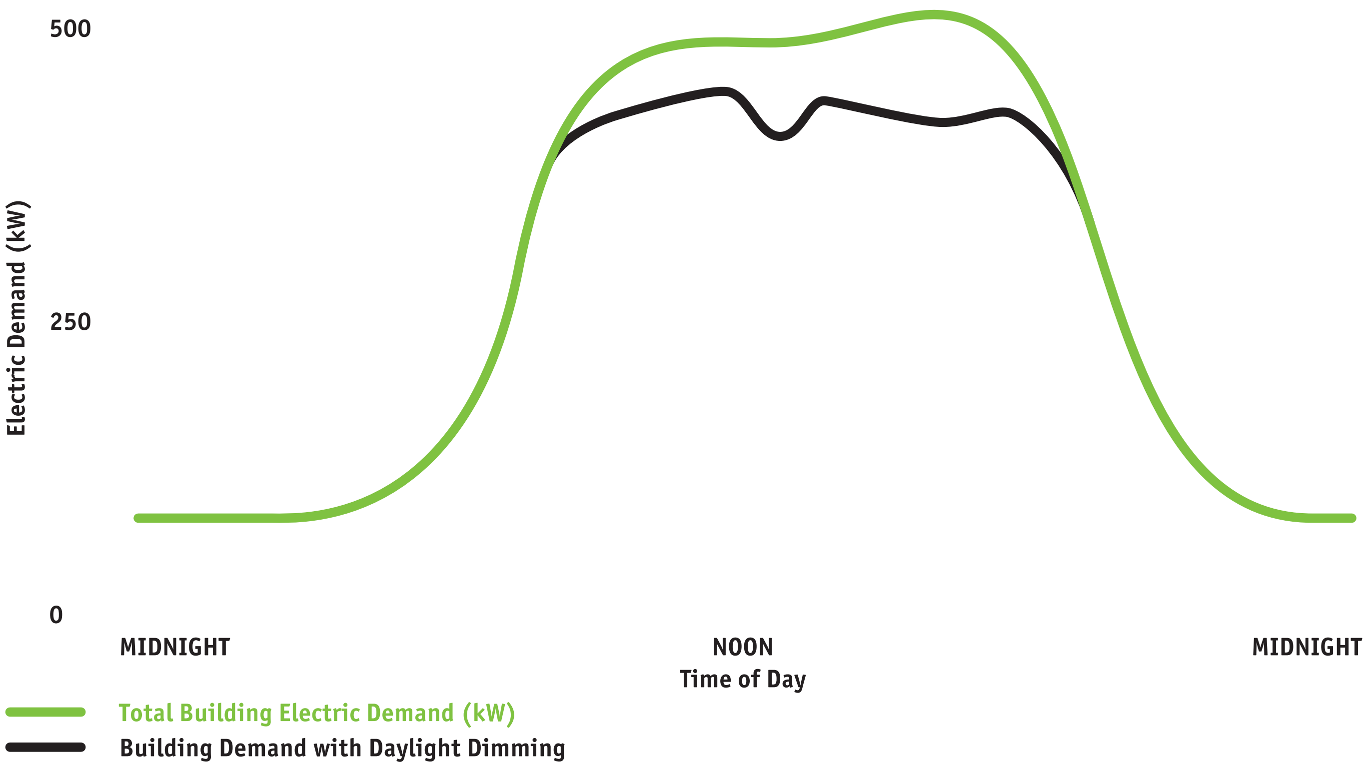
The density of NYC office space in a compact geographical area, with a relatively small group of owners, managers and tenants controlling a large portion of that space, combined with a regulatory mandate to retrofit the lighting in that space, creates a unique opportunity to guide and transform the market for optimal lighting control packages.

While there are a range of technologies that can reduce lighting energy use, advanced daylighting systems are an important and unique tool toward maximizing energy savings, with a host of important collateral benefits: peak demand reduction, lower utility bills (from both reduced energy use and reductions in peak demand charges), effective integration in demand response initiatives, and improved occupant health and satisfaction.

The scale of the New York City opportunity, with all large, non-residential buildings required to retrofit their lighting by 2025 (only 13 years at the writing of this report), is an opportunity to drive massive sales of dimmable ballasts and improved controls. The advent of wireless technology is another significant potential benefit to the controls retrofit market. Wireless technology allows a much lower cost installation and implementation of daylight sensors and controls, augmenting the capability of existing systems without requiring a complete redesign or total system replacement, and avoiding the separate controls wiring typically required.

A creative procurement competition and/or incentive program could transform the ballast and wireless markets, ensuring costs are competitive with traditional systems.

ELECTRIC ENERGY
(MEASUREMENT & BILLING)



DEMAND CHARGES

Heavy users of electricity pay for the assurance of energy being available, whether or not they are using that capacity at all times. This “demand charge” is determined by the “peak demand” during each monthly billing period. Typically, all the energy consumed by that user is billed at the peak demand rate to defray the infrastructure and maintenance costs associated with providing energy at peak moments. As a result, small reductions in peak demand can significantly decrease the cost of energy over the entire billing period.

Daylighting controls can significantly reduce peak demand, and the associated charges, since the periods of peak demand often coincide with maximum daylight availability.

PHOTO: GLNY

Implementing daylighting systems is not easy, and can be expensive. Interactions with interior shading must be considered. Occupants and building operators need to understand the intended operation of the systems and how to keep them functioning properly.

Many existing advanced daylighting systems are not working as intended, or have been disabled, and often these systems are not delivering expected savings. A robust program of analysis is needed to determine the critical elements of successful projects.

31 CHAMBERS ST.,
NEW YORK, NY
Many historic buildings were designed to take advantage of day light.

Complicated Systems

The potential energy savings from daylight controls has been recognized for a long time, but there are limited success stories that demonstrate significant realized savings. In the late 1970s, the US Department of Energy's Energy Efficient Lighting Program set out to demonstrate the energy savings and cost-effectiveness of advanced daylight controls; large potential savings were found. However, many of the barriers identified over 30 years ago remain today, and little of the potential savings has yet to be harvested.

Unfortunately, doing daylighting right is not easy. There are interactions with interior shades and blinds to consider- often deployed to prevent screen glare or reflected glare from neighboring glass buildings. In many cases, there is too much natural light available, so shades and blinds must be adjusted regularly throughout the day – a major challenge when these adjustments affect multiple workers in open office areas and blinds are likely to be drawn down at the first hint of glare and never raised again.

Integrating the controls for electric lighting with information about available light levels in the space can also be challenging. While designers often know how to do this well, educating the occupants in the building about the systems rarely occurs, and often control systems are quickly bypassed because they are perceived as challenging to use, or not providing the quality of light that occupants desire.

While it is easy to measure light levels provided by electric lighting, the quality of daylight in a space is harder to quantify. A great deal of work has been done in recent years attempting to develop "daylight metrics"– indicators of performance about the use of daylight and occupant satisfaction, but there are not yet widely accepted, simple to use metrics for this purpose. And all daylight is not created equal. The uniform blue skylight of the clear northern sky is relatively easy to accommodate and control, while direct sunlight (especially the low angled sun of morning and late afternoon/summer evening) can be very challenging in terms of both visual and thermal comfort.

For advanced daylighting systems to work optimally, some integration with shading systems is almost always required. Furthermore, optimal lighting design requires coordination with interior design and finishes. The color of carpets, walls and furnishings, the height and transparency of interior partitions, and other attributes, can dramatically affect the resulting light levels and the ability of daylight to adequately serve the space. Unfortunately, in most cases these interior finish decisions are made with little regard for their impact on the lighting systems, whether the project intends to utilize daylight or not.

Proper commissioning of advanced daylighting systems is also critical, as is continued maintenance and training. Building operators and occupants (if they will need to interface with the system) need to understand the intended operation of the systems and building managers need to know how to keep them functioning properly. Because these systems are not commonplace, in most cases the fairly extensive training and guidance required does not occur.

After publishing a feature story earlier this year on "Doing Daylighting Right, " Environmental Building News published a very informative piece: "More Heat Than Light: Six Wrong Ways to Daylight a Building".[11] The six "wrong ways" identified were:

- Overglaze it
- Ignore orientation
- Emphasize views and call it daylighting anyway
- Skip the automated controls (or skimp on commissioning)
- Bump up the contrast, and
- Keep occupants out of the loop

At least some of these problems seem to be common among a number of recent NYC daylight retrofit projects. Unfortunately, many existing projects with advanced daylighting systems are not working as intended, or have been disabled. In our research for this report, discussions with a wide variety of practitioners had a common theme: well-intentioned daylighting systems that are not delivering expected savings. The most commonly cited reasons for these failures are "value-engineering" cost cutting measures, including last minute reductions in the number of daylight sensors.

Surprisingly, several of these poorly functioning examples are projects that have been the subject of widely disseminated daylighting system case studies, and which include occupants that seem relatively motivated to get the systems working properly. As a result, designs that are not functioning properly are being hailed as exemplars without acknowledgement of occupancy phase issues. The problems encountered may or may not be the result of design phase decision making, but it is clear there is a need for more forensic investigation of why these projects are not operating and delivering anticipated savings. Not enough information is currently known about why some projects are not working as expected. However, researchers and experienced industry leaders are confident that these challenges can be overcome through carefully organized analysis and training.

Expensive Components

Daylight controls usually supplement simpler, lower cost lighting controls, such as occupancy/vacancy sensors, and more flexible circuiting and switching which allow certain spaces to shut off lights, or reduce levels. These lower cost lighting controls, when applied to more efficient, lower overall wattage lighting systems, provide a significant majority of available energy efficiency savings.

Daylighting controls supplement these lower cost systems, but if considered independently and added after the other systems are in place they have long payback periods. A key challenge remains the dimmable ballast used in fluorescent systems – these are still low volume, high cost elements in the lighting industry.

To avoid the higher costs of dimmable ballasts, many projects around the country have installed either "on/off" or "stepped" daylighting systems that switch fixtures or individual lamps fully on or off in response to available daylight. This may work in certain public spaces (hallways, lobbies, etc.) but our research indicates it is generally not acceptable to users in active work spaces. Surveys have repeatedly found that most building occupants are dissatisfied with the lighting when it goes on and off regularly while they are in the space. Without the continuously dimming ballasts offered in advanced daylighting systems it is very likely that the controls will be disabled. To ensure long term functionality, dimming control is a necessary component of a daylighting system.

Dimmable ballasts are a significant portion of the cost of an advanced daylighting system, but are required to enable many of the capabilities of the systems mentioned in this study, including participation in demand response programs, and tuning light levels in response to specific activities. These capabilities are critical to capture all potential savings from lighting efficiency.

Designing and operating daylighting controls correctly requires skill, attention and diligent follow up. Even well-designed projects are often subjected to "value-engineering" cost cutting that impairs the functionality of the system. Case studies of daylighting-enabled office buildings with extensive monitoring in the occupancy phase are needed to demonstrate actual energy and cost savings. These studies should especially focus on delivering energy savings, peak demand reductions and occupant satisfaction.

Dimmable ballasts and daylight sensors are expensive today because they have never been engineered as high volume, low cost systems. Historically, sophisticated dimmable systems were installed as low volume solutions in spaces where budgets were not critical drivers, (e.g., executive conference rooms).

Making dimmable ballasts the default solution for virtually all office lighting would almost certainly drive innovation and competition among manufacturers in response to new market opportunities. Discussions with suppliers suggest that dimmable ballasts could be manufactured in large volume at a $5 premium rather than the $20–60 per ballast cost often quoted today. Likewise, improved sensors and wireless communications will further reduce the networking and communications costs involved in making these systems work effectively. A major incentive program in New York City has the potential to drive costs down substantially, due to both the volume of potential work in this region and because the New York City design, real estate and lighting communities impact work all over the world.

PHOTO: Matt Haughey

Green Light New York proposes a comprehensive, six-year implementation plan with the following primary elements: proof of concept projects; financial incentives; training and outreach; and, deployment, evaluation and reporting. At the end of this carefully incentivized deployment period it is estimated that dimmable ballasts and related controls will be competitive enough with standard systems they can be mandated by code to deliver significant demand response potential and energy use savings.

NEW YORK TIMES NEWSROOM
Maximizing daylight can significantly reduce energy consumption while improving the quality of spaces

Proof of Concept

There is a strong need for well documented demonstration projects that provide the "proof of concept" for advanced daylighting systems.

These projects should focus on reducing additional construction costs and increasing long term benefits, measured energy reductions, and energy cost savings, including an emphasis on peak demand reductions and assessing occupant response. There are many green building case studies that list daylight controls among their features, but very little evidence has been gathered about how these systems are working, or what kind of energy or cost savings are resulting (if any). Proof of concept demonstration projects will not be constructed on an accelerated timeline without targeted incentives designed specifically to produce them. These demonstration projects will contribute to broader national efforts to determine the lighting contribution to building energy use.

Green Light New York will advocate for funding to construct, monitor, analyze and publicize advanced daylighting demonstration projects to illustrate the value of daylight harvesting to the design, construction, real estate ownership and energy policy regulation communities. These demonstration projects will be specially designed to monitor pre- and post-retrofit energy use, pre- and post-retrofit peak demand, and will involve the collection of detailed construction cost and energy cost savings figures. The case studies will include projects from the three major construction eras outlined above (Pre-1950, 1950–1980, 1980–present) each with different façade types (masonry vs. curtainwall envelope, varied % of glazing), and each of the interior layouts described above. The performance of these demonstration projects will then be extrapolated to the broader New York City, as outlined above, to estimate the potential energy use, peak demand and cost savings available. These projects will not only provide data and feedback to support the next phases of the program, but will generate interest throughout the industry and build confidence in the systems being analyzed.

Green Light New York has identified several major New York City real estate firms that are interested in participating in the proof of concept pilot project described here.

Financial Incentives

Currently, costs are high for well-designed daylight systems with dimmable ballasts, but daylight delivers electricity savings at the peak times when it is most valuable.

The scale of the NYC retrofit opportunity, along with the potential for peak demand reduction, should be an opportunity for specialized incentive programs from NYSERDA and/or Con Edison. A bulk procurement commitment by a few leading New York City building ownership firms, along the lines of earlier "Golden Carrot" procurement programs which drove technology commercialization for efficient refrigerators on a large scale, can dramatically reduce system costs, and would likely prove to be very cost-effective from the perspective of regulatory review.

Training

Effectively capturing the potential for daylight harvesting will require a focused effort to reach and train the dispersed decision-makers and end-users of the New York City office lighting sector.

Although New York City commercial real estate is ultimately controlled by a small group of actors who affect tens of millions of square feet of space, there are still several different constituents who require education on daylight design and controls. This disparate group includes architects, lighting designers, engineers, and interior designers; building owners, managers, and operators; as well as contractors, installers, and electricians. Although training needs to start with the groups that will design, install, own and operate the systems, outreach efforts should also focus on the end-users and occupants will be critical to the successful adoption and operation of daylighting controls.

Controls training is quickly becoming a focus by many New York City groups. The New York City Chapter of the Illuminating Engineering Society, convenes an annual conference, “Control This!”, which includes manufacturers exhibiting their systems, as well as educational seminars. This event draws mostly from the lighting design community. NYSERDA is working with the City of New York and the IBEW to develop more robust control trainings, including adoption of the National Advanced Lighting Controls Training Program (NALCTP). This critical training – based on a successful initiative already operating in California – will be focused on installers, contractors and electricians. Green Light New York currently delivers a suite of lighting efficiency trainings targeting the design community (architects, interior designers, lighting designers, and engineers) as well as real estate owners and operators.

It should be noted that there are many approaches to successful daylighting, and no individual system that will be acceptable in every circumstance. The authors have observed small offices with ample daylight, manual blinds, and simple on/off light switches providing very effective daylit environments. The occupants of these offices manually “tune” the blinds and light-levels, and the electric lights remain off during daylight hours. The success of this system requires an engaged and educated occupant – further indication of the need for a broad educational program around the fundamental benefits of daylight harvesting. The other end of the spectrum includes fully automated, dimmable, and integrated systems, more suitable for large open-plan offices such as the New York Times building, with little or no input required of the occupant, except the occasional ability to override the raising or lowering of the blinds. Both low-tech and high-tech examples are delivering significant energy savings, while also creating wonderful, productive, daylit work environments. Each is appropriate for a different set of occupants in a particular setting.

One of the challenges in realizing the efficiency potential of effective daylight design is the need to advance the knowledge and skills of the diverse group of decision-makers and end-users required. However, there are many training efforts underway and in the pipeline to address this need.

Given this challenge and the education necessitated by the onset of lighting retrofit legislation in New York City, significant resources should be dedicated to educating this diverse group on the design, construction and operation of daylighting systems. This training should include both good practice systems with stepped lighting or simple switching as well as advanced daylighting with fully automated, dimmable systems.

A Phased Approach

As outlined above, there exists a singular opportunity to drive progressive daylighting retrofits across a massive swath of office space.

The potential for energy savings represented by the lighting retrofit law and the new city energy code, in a city whose robust concentration of designers, engineers, real estate firms and property managers have global reach, is a once in a generation opportunity. The danger is that the building community will merely meet the minimum requirements of current code, rather than using this moment to greatly enhance building performance. If it is not taken advantage of, New York City tenants and building owners will not benefit from huge financial and energy savings and New York City itself will have missed an obvious opportunity to further reduce it's carbon footprint.

A major contributor to the success of the dimmable lighting and automated shading systems at The New York Times building was a carefully managed demonstration program. Through the support of a public/private partnership, a 5,000 square foot offsite mockup of a portion of a typical floor plate was constructed and utilized as a test bed and research facility. Test results from this mockup were used to develop clear, achievable, and cost-effective performance specifications for the critical lighting and shading systems. Manufacturers responded aggressively to that challenge, in part because of the large procurement opportunity in that single high-profile project. New York City now has a chance to expand this model and capture a vastly larger market with local, regional and global impact.

To ensure the potential energy and financial savings outlined in this report are captured requires a well-supported plan. Change of the magnitude proposed here will not occur without the active engagement and financial support of both public and private organizations. Based on the research conducted to support this report, Green Light New York recommends a plan that will systematically address the technical and business obstacles that have stymied capturing these savings potentials for decades, but builds on the self interest of an enlightened marketplace. The plan recognizes that these changes can best be made in stages so that continuous feedback can reinforce both the message and the recommendations of the program. The multiphase plan also recognizes that there are leaders and laggards in markets and that not all owners will move at the same pace. Green Light New York suggests the following multi-phased effort to ensure long-term, cost-effective deployment of advanced daylighting systems across the majority of New York City office space by 2025:

- PHASE 1: Two years (2013–14) of strategically-selected, very well-monitored demonstration projects to document challenges and solutions and finalize Phase 2 and 3;

- PHASE 2: Two years (2015–16) of carefully subsidized, performance-based deployment (at least 3 million square feet) of advanced daylighting systems, with vendors agreeing to cost and performance targets to receive incentive funds (similar to successful "bulk procurement" or PV deployment programs);
- PHASE 3: Two years (2017–18) of enhanced deployment across at least 12 million square feet with lower cost targets and other well-defined success metrics (e.g., 500 trained installers and New York City trained designers).

At the end of this carefully incentivized deployment period it is estimated that dimmable ballasts and related controls will be competitive enough with standard systems they can be mandated by code to deliver significant demand response and reduction potential.

The implementation of the New York City lighting retrofit laws presents an unprecedented opportunity to trigger a major shift toward advanced daylight controls as the standard system within office buildings. Not pursuing daylight savings simultaneously with other lighting system upgrades would be a lost opportunity of enormous scale.

The amount of high end office floor space that will have its lighting modernized in the coming decade brings an opportunity for transformation of how electric lighting is controlled in offices. The successful deployment of advanced daylight controls will reduce energy use, reduce peak demand, provide financial savings, and significantly impact climate change.

The opportunity, however, is complicated and presents several challenges. This report has quantified the potential savings, and recommends a series of actions that can ensure that New York City harvests the great potential of daylighting.

END NOTES

1
The reference forecast presented in Con Edison's Energy Efficiency Potential Study shows interior lighting consuming 26%, and exterior lighting 6%, of the company's 2007 commercial electricity consumption (Energy Efficiency Potential Study for Consolidated Edison Company of New York, Inc.; Volume 2: Electric Potential Report, Global Energy Partners, LLC, Walnut Creek, March 2010).

2
The New York Regional and Downtown Office Market: History and Prospects after 9/11. Report prepared for the Civic Alliance, August 9, 2002, by Hugh F. Kelly.

3
Commercial Real Estate Market Report, prepared for the New York State Energy Research & Development Authority by HR&A Advisors. Summer 2010.

4
Data for office markets outside of NEW YORK CITY from U.S. Office Market Report, March 2012, prepared by Falcon Real Estate Investment Management, Ltd.

5
HR&A Advisors Analysis, in the report cited above.

6
Energy Efficiency Potential Study for Consolidated Edison of New York, Inc., as described in Note 1. Additional information provided by Con Edison specific to large office buildings confirmed the same 26% of total use for interior lighting.

7
Lighting data in Appendix F to the Con Edison Energy Efficiency Potential Study, per the previous note.

8
The energy savings from the lighting controls at the NY Times Building are reported in a case study prepared by Lutron, the manufacturer of the control system, which is available at http://New York City.lutron.com/CaseStudyPDF/The%20New%20York%20Times%20Building_English.pdf

9
The Empire State Building peak electric demand for 2011 was 9,952 kW, per the building's Energy Performance Contract: 2011 Annual Savings Report dated February 2012, available at www.esbnyc.com. Albany's Central Business District inventory of private office space is 5.6 million square feet, per CBRE/Albany's Fourth Quarter 2011 Albany Office Market View; at the ConEd average total electricity office use of approximately 20 kWh/s.f, the total electricity use is well less than 340 GWh.

10
Office Daylighting Potential (Task 3 of the PIER Daylighting Plus Research Program). Prepared by Heschong Mahone Group, Inc., for the California Energy Commission, 2011.

11
Doing Daylighting Right, Feature Story in Environmental Building News, March 2012 issue. Full article only accessible with subscription, but the "Six Wrong Ways to Daylight a Building" is available to all at http://www2.buildinggreen.com/blogs/more-heat-light-six-wrong-ways-daylight-building

TECHNICAL POTENTIAL ASSESMENT

Manhattan Large Building Office Building Stock per HR&A Advisors analysis of CoStar data, 2010; buildings over 50k sf; more details about current stock shown in “NYC Office Market sheet”	**542 million sq ft**
Estimated fraction of Office Building Floor Area with “Daylight Availability” Based on sampling of floor plans/plates of 20 representative office buildings, and site investigation of actual daylight availability	**28%**
Potential Floor Area where daylighting controls can reduce electric lighting “Daylight Zone Area”, or DZA	**151.8 million sq ft**
Current Electric Lighting in these offices	
Installed lighting power density **Average lighting energy consumption/year** from ConEd “Energy Efficiency Potential Study”, prepared by Global Energy Partners, March 2010; specific numbers for “Large Office” segment per Appendix G, which assumes current lighting on full load all operating hours—approx 2,800 hrs/yr	**1.81 w/sf** **5.1 kWh/sf/yr**
Likely lighting power density in daylit spaces post-controls retrofit Assumes some facades still need at least partial lights on, but at reduced light output levels; dimmable ballasts means variable power density	**0.4 w/sf** **2.1 kWh/sf/yr**
Post-retrofit electric lighting savings in daylit spaces The power density reduction is not across all operating ours; assumes variable power density due to dimming ballasts	**1.41 w/sf** **3 kWh/sf/yr**
Filters Physical Factors: window/wall ratio, glass transmittance, sun availability, ext. obstructions Occupancy/Use Factors: space use/configuration, including perimeter offices; shades	**Reduce potential space** **25%**
Actual Floor Area likely to include dalight controls	**113.8 million sf**
Long-term Technical Electric Lighting Potential Reduction	**160.5 MW**
Total Savings, not including reduced air-conditioning load	**341.5 GWh/yr**
Achievable Potential	
3% of building stock per year for first 3 years (2014–2016)	**14 MW by 2016**
5% of building stock per year for next 3 years (2017–2020)	**24 MW by 2020**
Two thirds of remainder of stock over next 10 years	**108 MW by 2030**

ABOUT THIS REPORT

CO-AUTHORS
Adam Hinge
Sustainable Energy Partnerships
Yetsuh Frank
Green Light New York, Inc.
Richard Yancey
Green Light New York, Inc.

REPORT SPONSOR
Natural Resources Defense Council

NRDC
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STEERING COMMITTEE
Ashok Gupta
Program Director, Air & Energy
Natural Resources Defense Council
Laurie Kerr
Senior Policy Advisor on Buildings and Energy, City of New York, Mayor's Office of Long-Term Planning & Sustainability

ADVISORY GROUP
Mark Ambrosone
Vice President - Architecture & Design, Vornado Realty Trust
Candace Damon
Vice Chairman, HR&A Advisors, Inc.
Elizabeth Donoff
Editor, Architectural Lighting Magazine
Jonathan Flaherty
Director of Sustainability, Tishman Speyer
Chris Garvin
Senior Associate, Cook+Fox Architects
Russell Leslie
Associate Director, Lighting Research Center
Hayden McKay
Principal, Daylighting and Sustainable Design Studio, HLB Lighting Design
Chris Meek
Daylighting Specialist, Integrated Design Lab, Seattle, WA
Michael Mehl, Director
Director, Lighting Design, Jaros, Baum & Bolles Consulting Engineers
Jean Savitsky
Practice Lead, Energy and Sustainability Projects, Jones Lang LaSalle
Stephen Selkowitz
Lawrence Berkeley National Lab
Byron Stigge
Founder, Level Infrastructure
Marsha Walton, PhD
Senior Project Manager, Energy Efficiency & Research Exploration, NYSERDA

Design by Other Means

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greenlightny.org

Green Light New York, Inc., is an independent, non-profit organization that is creating an energy efficiency resource center for education and innovation in New York City. Initially focused on lighting, the GLNY center will be a venue to see the best practices, view displays, experience new technology, take a class, receive assistance, test ideas through mock-ups and models, as well as provide a forum for progressive discourse.

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The Building Energy Exchange is a project of Green Light New York

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