8.0 LIGHTING + DAYLIGHTING

Lighting and daylight can play a pivotal role in occupant satisfaction, and also energy savings. Typically, lighting makes up roughly a third of commercial building energy use, making it important to reduce as much as comfortable while preserving function and productivity. The first part of this section describes the lighting criteria and targets.

Reducing lighting energy can also have a secondary benefit by slightly reducing the cooling needs for HVAC systems. The second part of this section describes measures which are primary in lighting energy reduction for the project.

The third part of this section focuses on daylight design, particularly the unique impact of the PV canopy. Daylight can provide a sense of enjoyment in open spaces, functional illumination in working areas, and health benefits such as Vitamin D production in the skin and prevention of sleep disorders. There are also cautionary considerations such as heat associated with sunlight, and discomfort caused by excess brightness.

The fourth part of this section focuses on lighting controls, describing the intended system type and specification strategy in general terms, and including an outline of requirements to achieve many of the lighting energy reduction measures.

8.1 LIGHTING DESIGN

Lighting for the building will be designed according to the following criteria and technology. Target power density values are stated. As the design progresses these values will be updated with actual calculated power density for completed designs solutions.

Room Type	Average Illuminance (fc at 30”)	Fixture / Lamp Type	ASHRAE Baseline Power Density (W/ft^2)	Target Design Power Density (W/ft^2)
Office	25 (all overhead without task lights)	Indirect T5 fluorescent pendants with architectural panel	1.1	0.7
Corridor	10 (reduced to 3 at night)	T5 low-ballast-factor	0.5	0.7
Lobby	10	Direct T5 fluorescent	1.3	1.1
Huddle	30 (switchable to 15)	Direct T5 fluorescent	1.3	0.8
Collaboration	30 (switchable to 10)	LED downlights	1.3	0.9
Conference	30 (dimmable)	Direct T5 fluorescent, plus LED spots in selected rooms	1.3	0.9
Seminar	30 (dimmable)	Direct T5 fluorescent, plus LED spots in selected rooms	1.4	0.9
Cafe	20	Direct T5 fluorescent, plus LED spots	0.9	0.9
Lecture	30 (dimmable)	Direct T5 fluorescent	1.4	1.25
Stair	10 (reduced to 3 at night)	Wall-mounted T5 fluorescent	0.6	0.6

Restroom	5 (overall) 15 (stalls and vanity)	LED cove lighting, LED downlights	0.9	0.8
Storage	10	Industrial T5 fluorescent	0.8	0.5
Elec / IT	40	Industrial T5 fluorescent	1.5	1.2
Mech / Plumb	30	Industrial T5 fluorescent	1.5	0.7

8.1.1 OFFICE ZONE DESIGN

During Design Development, the design included linear suspended fluorescent lighting the space indirectly by reflecting light from a light colored structure above. Since the 50% Construction Documents, the design was revised to maintain a scheme using indirect reflected light, but the linear suspended lighting now falls below 3' wide light colored "reflector" panels, with a light colored structure above. For 100% Construction Documents, it was decided that the overhead lighting power should be increased to provide at least 25fc average without the need for task lights.

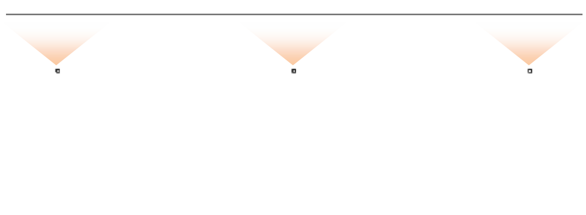

Figure 1 – Design Development Office Zone Lighting Section

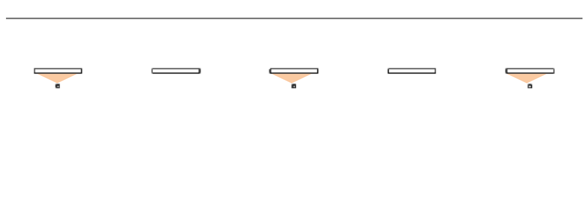

Figure 2 – 50% Construction Document Office Zone Lighting Section (with reflector panels)

The following calculation results from 50% CD demonstrated the design change maintained similar performance. Values are indicated in footcandles at the workplane 30" above finished floor. The average illuminance in a typical area of office zone was evaluated as 18 footcandles (fc) in the DD scenario, and 16fc in the 50% CD scenario. Before accounting for the planned desktop task lighting, both scenario results exceeded the 10fc overall average minimum design criteria (intended to be further supplemented to more than 30fc or close to 50fc at each workstation by desktop task lighting, which was not included in this comparison).

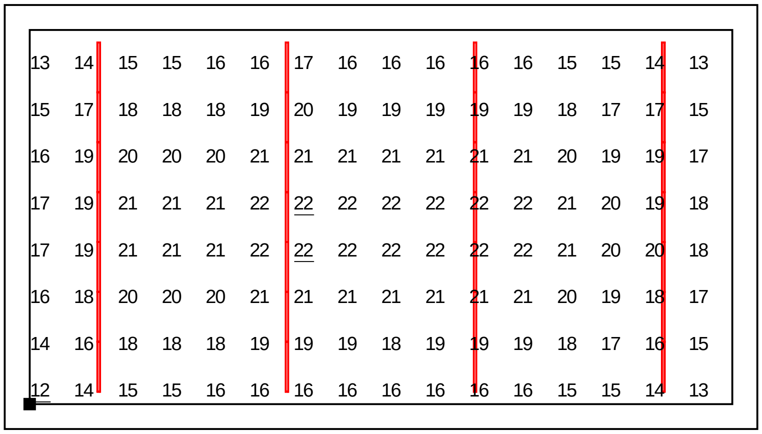

Figure 3 – Design Development Office Zone Lighting Photometric Plan

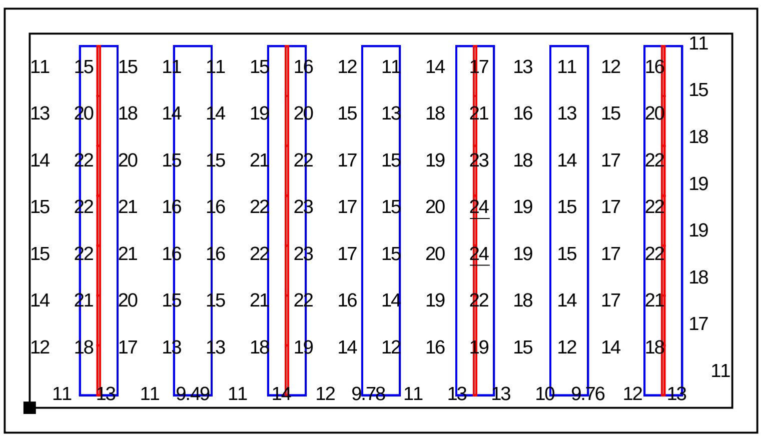

Figure 4 – 50% Construction Document Office Zone Lighting Photometric Plan (with reflector panels)

The intended design conditions represented above each provided less than 30fc from overhead for energy savings (and provided more than 10fc average without task lighting). This approach assumed local task lights to be provided at each workstation – which is the most energy efficient method to achieve greater than 30fc for reading printed text at each desk.

Due to hesitation regarding an average overhead illuminance lower than any known Cornell office facilities, the energy use of overhead lighting for 100% CD was increased to provide greater than 25fc on average across work zones without the need for task lighting at every desk. This provides a higher illuminance from overhead lights across both the desks and the circulation areas between desks. The energy model allotment for this lighting power density did not have to be increased due to the conservative allowance previously assumed for task lighting.

An example photometric plan follows, based on the same 50% CD design with increased energy to accommodate two 28W T5 lamps in the fixture cross-section instead of only one. This could yield an average above 25fc without task lights.

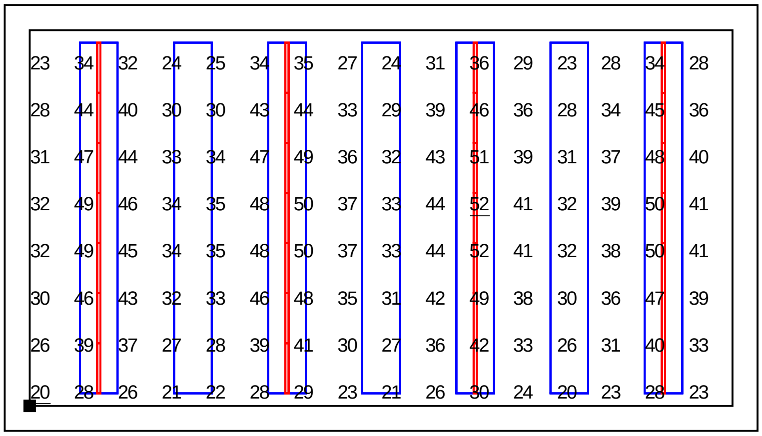

Figure 5 – Example Comparative Photometric Plan, Increased Energy Use, Without Task Lighting Required

8.2 LIGHTING ENERGY STRATEGIES

The following strategies will be included in the design for reduction of lighting power, with an intention of contributing toward minimal total energy use intensity.

8.2.1 TASK LIGHTING

Localized lighting near each work area allows overhead lighting power to be minimized for only circulation and filing. Illumination for detailed tasks can be coordinated exactly where it is needed. The energy impact is:

- Lights close to each task require less power, because less light is cast astray
- Overhead lighting power can be minimized for basic instead of detailed illumination
- Local task lights facilitate fixture by fixture control, so only necessary lights are on each day

If implemented in work areas, 15 footcandles (fc) could be provided from overhead, and supplemented to a total of 50 fc at each desk. This is anticipated to cut lighting power density by 40%, when compared to 50 fc from overhead throughout the work zone.

Based on discussion with Cornell and their existing office spaces and other buildings, an ambient illumination of 15 footcandles throughout may cause concerns for some occupants. It has been decided to illuminate the full open office space to greater than 25fc, with full range dimming for possible adjustments. The resulting energy use with high efficiency fluorescent fixture has remained roughly equal to the conservative allowance previously allotted for task lighting.

8.2.2 JUST RIGHT ILLUMINATION

Design criteria are sometimes overly conservative, padding industry recommendations with higher light levels that require more power, but with little benefit for visibility compared to slightly lower light levels. For occupants ages 25-65, IESNA Handbook, 10th Edition recommends the following illuminance levels:

- 15-30 fc for typical computer work
- 30 fc for reading 8pt font (prolonged)
- 50 fc for reading 6pt font (prolonged)
- Circulation at least 30% of task or adjacent space

Occupants will rarely need to read 6pt type, so typical working spaces will be designed to achieve greater than 25fc at the task areas. No areas requiring 50 fc are currently known or planned for, except for the podium of the lecture hall.

8.2.3 MULTI-LEVEL CONTROLS

Office occupants do not always need the maximum light level that the space is designed for. Many occupants may be satisfied with a lesser lighting scene for common tasks. In huddle, seminar, conference, lecture, and collaboration rooms, a default “ON” action at a wall switch will turn lights on to the 50% output or will turn on only primary zones of lights. Raising lights to the full 100% scene will require an additional switch, touchpad, or button action by the occupant.

8.2.4 DAYLIGHT CONTROLS

Overhead lighting in offices will include automatic dimming according to daylight levels. Those lights and also in public spaces will eventually shut-off when daylight is well above the illuminance target. This is sometimes seen as a distraction to occupants, but distraction is minimized if lights only shut off when daylight alone contributes 50% above or double the electric lighting design target. Switching lights off when possible saves the maximum amount of energy, because fluorescent and LED fixtures typically use at least 10% of their power even if they are dimmed to minimum output (including when minimum output is only 1% or 5%).

Stepped ballasts are less costly than dimming ballasts, and were previously considered as typical ballast type in open office zones, but full range dimming has been agreed based on the new design target of greater than 25fc without task lighting.

8.2.5 LAMP TYPES

Linear fluorescent lighting boasts low initial cost, efficiency bested by a limited number of LED solutions, lamp life exceeding 24,000 hours, and simple cost-effective lamp replacements. For these reasons linear fluorescent lighting will be the standard source for the project. LED will be used for applications not well suited for linear fluorescent such as downlights, small coves, exterior light fixtures, and recessed downlights. In the recent past, these applications would have called for metal halide and compact fluorescent, but the premium cost of

LED in these applications can be offset by improved efficiency and reduced maintenance. Compare metal halide and compact fluorescent lamp life of under 15,000 hours to LED lamp life of over 50,000 hours. Halogen and incandescent will not be used due to their inefficiency and lamp life less than 5,000 hours.

8.2.6 REDUCED NIGHT LIGHTING

Lighting power use will be minimized at night when very few occupants are in the building. For typical corridors, only the code required egress lighting will be kept on between midnight and 5am, to allow any remaining occupants to safely travel the building. This will be done by switch off sections of continuous row fixtures – dimming is not included in corridors due to the cost premium and high number of fixtures.

For open office zones, lighting zones grouped by column bay will turn on by motion sensing at night as they do during the day. However, at night the maximum output will be set to 50% of the daytime maximum to avoid full lighting for few occupants.

8.3 DAYLIGHT AVAILABILITY

The following analysis during Design Development looked at the comparison of daylight at the Tech Plaza depending on the type of PV assemblies used at the building canopy. It was performed during DD to verify intent for the PV canopy design, and although PV geometry has changed, the study and recommendations remain valid at this time.

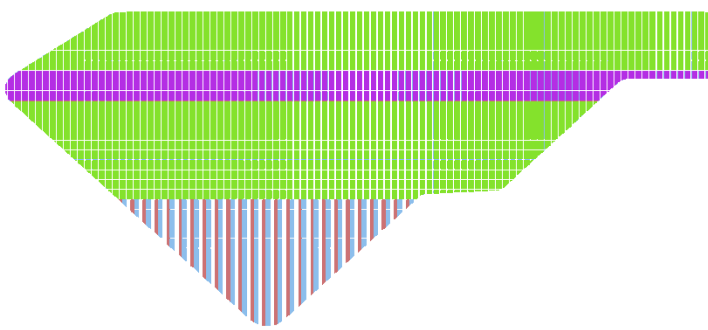

Figure 6 – Previous Photovoltaic Plan, Design Development Study

The PV panels illustrated in green are intended to be high efficiency but fully opaque unitls. The PV panels illustrated in blue and violet are being considered as partially transparent glass embedded panels.

For the following analysis, we assumed the panels in green are fixed as opaque building elements. We tested three scenarios for the possible glass embedded PV:

- Glass embedded PV, 11% average visible transmission after accounting for opaque PV cell areas, glass transmission, and framing
- Opaque high efficiency PV in all locations in lieu of glass embedded
- Theoretical maximum daylight if glass embedded PV were deleted

8.3.1 EXTERIOR TECH PLAZA ILLUMINATION

For the Tech Plaza pedestrian space, plan images show the distribution of Daylight Factor (DF) surrounding the building. Daylight Factor represents the percentage of daylight access at any given point, as a percentage of the daylight available at an unobstructed rooftop location. These plan images are taken cut below the PV canopy, showing the ground level and roof plan daylight levels.

It can be seen that the use of glass embedded PV in selected portions of the canopy provides daylight factors in the range of 35% to 45% in the Tech Plaza under the PV canopy. Changing those glass embedded panels to high efficiency opaque PV gives a negligible decrease in daylight factor to the range of 34% to 42%. If the glass embedded PV over the Tech Plaza was deleted completely, the daylight factor in the zone would only increase to the range of 40% to 45% due to the shadows of the surrounding buildings.

This shows that the PV canopy above the Tech Plaza has a negligible impact on daylight quantity at ground level. The selection of PV panel type between opaque or glass embedded should be made on the basis of visual appearance and efficiency of the canopy itself.

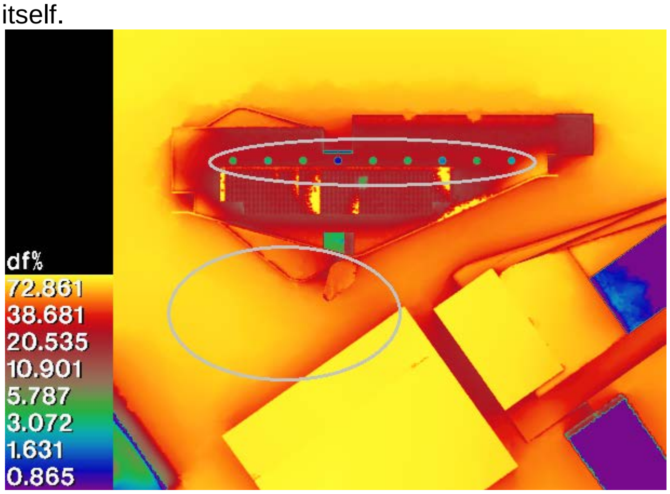

Figure 7 – Daylight Factor Plan, Selected Glass Embedded PV

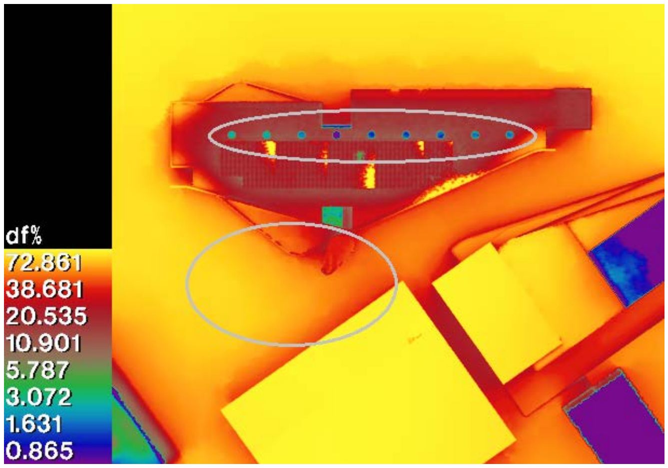

Figure 8 – Daylight Factor Plan, All Opaque PV

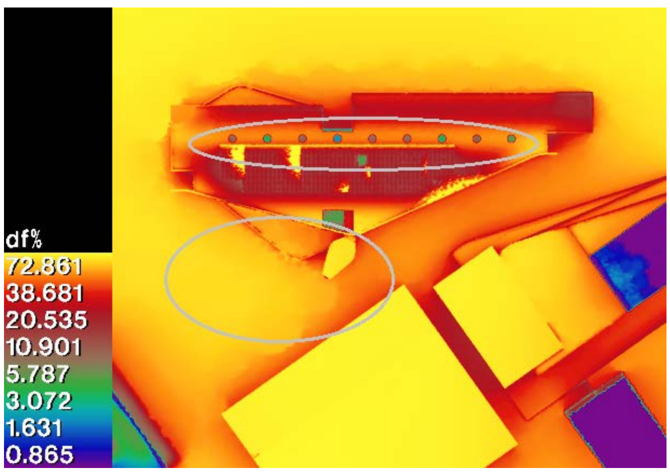

Figure 9 – Daylight Factor Plan, Glass Embedded PV Deleted

The PV type for the panels shown as green in Figure 1, above the central Galleria, impacts the amount of daylight available to the central Galleria skylights. With glass embedded PV in that zone, the daylight factor at the Galleria skylights would be approximately 13%. If those PV panels were changed to fully opaque, the daylight factor at the Galleria skylights would be reduced to approximately 6%. This is compared to if the PV panels above the Galleria skylights were deleted, the daylight factor at those skylights would increase to 32%.

This shows that the PV panel type above the Galleria skylights has a strong impact on the daylight availability through those skylights. It is not recommended to use all opaque PV panels for the zone above the Galleria skylights. If there are any cost issues with using glass embedded PV in that area, it could be considered that efficiency gains of high efficiency opaque panels could be paired with deleting selected panels to preserve or increase daylight access to the Galleria skylights.

8.4 CONTROLS TYPOLOGY

8.4.1 SYSTEM TYPE AND MANUFACTURER COMPETITION

The lighting control for the building is intended to be broken down to a finer grain than HVAC zones. With many individual zones for individual huddle rooms, and rows of desks in open work space, a centralized control topology would create multiple home runs for power circuits and possibly sensor communications. To avoid excess parallel wiring, distributed lighting controls are designed, where branch circuits are run to portions of floor area based on the loads, and split locally into zones with relays and sensors as appropriate. Multiple manufacturers are capable of this system, and are named in the specification, attempting to maintain a performance based specification without manufacturer specific details.

8.4.2 BAS INTERFACE

From talking to Automated Logic and Siemens, the recommended approach for BAS integration is a dedicated control system for lighting (e.g. Lutron, Crestron, Wattstopper, Sensorswitch, Cooper, Encelium), with one or several BAS network gateway(s) for integration. The dedicated lighting control system would likely use its own dedicated low voltage wiring, rather than a converged network. Attempting to merge lighting controls onto a converged network with BAS would limit competition between BAS vendors, some of which have lesser capability and expertise in lighting control. BAS native lighting control devices are likely to be limited depending on manufacturer, while specialty lighting control manufacturers have wider offerings that can suit all special needs, such as occupancy sensor coverage patterns, that may arise.

Without using lighting control on a converged network with BAS, there are still building-wide efficiencies applied. Rather than traditional hardwired contact closure signals from occupancy sensors to BAS, the lighting control system can communicate all occupancy sensor status to BAS via programmable gateway. The gateway can also be read-write to allow BAS to issue lighting commands to control the lights. This can facilitate the BAS utilizing occupancy detection output from the lighting control system, and also avoid duplicate time schedules by using the BAS programming to trigger lighting control actions each day.

8.4.3 SCHEDULING

It has been discussed and agreed that reduced illumination levels will be accepted in common occupied areas outside of normal business hours, including corridors and open work space. This accepts that although the building will be available outside of normal hours, full energy use throughout the building is not warranted for a limited number of occupants remaining.

In corridors, during normal occupancy hours, all lights will be energized to the full design levels. Outside of normal occupancy hours, corridor egress lighting will remain on throughout the night, while at least half of the corridor lights are turned off.

In open work zones, during normal business hours, all lights will be energized based on occupancy and daylight detection, with less than 1000 ft² per occupancy zone. Outside of normal business hours, open work zone lighting will be limited to 50% energy use.

Other spaces such as reception, the central atrium, galleria, etc. which impact visitor experience and the building's image as seen from Manhattan, will be maintained for a longer duration into the night.

Emergency lighting zones on the fourth floor will remain illuminated throughout the night despite occupancy, to maintain a minimal visual aesthetic presence of the fourth floor west façade visible from Manhattan.

Enclosed rooms such as huddle, seminar, and conference rooms will not be schedule dependent, but rely only on occupancy to shut off lighting when left vacant. Manual activation of lighting controls will allow users to select between a portion of, or the full quantity of illumination based on varying uses. Lighting control will rely on AV touchpads for control beyond one basic lighting scene.

8.4.4 DEVICE APPROXIMATION

The following is a previous preliminary approximation of lighting control devices and zone sizes made during Design Development. Refer to current Construction Document electrical lighting plans for actual device layouts, and refer to Construction Document specification 260993 Lighting Control Sequence of Operations for more specific sensor, time schedule, and BAS functionality.

Room Type	Daylight Sensors	Occupancy Sensors	Switch Type	Time Schedule	BACS Integration
Office	One per 1000 ft²	One per 500 ft²	None	Yes	Yes
Corridor	None	One per 40 ft	None	Yes	Yes
Lobby	One per 1000 ft²	One per 1500 ft²	Local at reception	Yes	Yes
Huddle	One per perimeter room	One per room	One four-button per room	No	Yes
Collaboration	None	One per 500 ft²	One four-button per room	Yes	Yes
Conference	One per room	One per 500 ft²	One four-button per room plus dimming sliders	No	Yes
Seminar	One per room	One per 500 ft²	One four-button per room plus dimming sliders	No	Yes
Cafe	One per 1000 ft²	One per 500 ft²	Local at core of building	Yes	Yes
Lecture	One	One per 500 ft²	Four four-buttons per room plus dimming sliders	No	Yes

Stair	One per stair	One per landing	None	Yes	Yes
Restroom	None	One per 500 ft²	None	No	Yes
Storage	None	None	One digital timer per door	No	No
IT	None	None	One digital timer per door	No	No
MEP	None	None	One digital timer per door	No	No

The control zone size in open work areas for 100% CD are approximated in the following graphic.

Figure 10 – Approximate Lighting Control Zone Division of Open Work Spaces

8.5 CODES AND STANDARDS

The following codes and standards will be applied to the project:

- IESNA Handbook, 10th Edition (illuminance criteria)
- New York City Energy Conservation Code, 2011 (lighting energy and controls)
- New York City Building Code, 2008 (egress lighting)
- Cornell University Design Standard 16510, dated 7-17-12