

As of January 14, 2013 the Heschong Mahone Group, Inc. joined TRC Companies, Inc.



TRC is a respected peer in the energy efficiency consulting industry. Together, we strengthened our position at the forefront of this market and bring our clients access to expanded service capabilities and a national footprint. Please enjoy this paper as a representation of what the Heschong Mahone Group brought to the table, as well as what the newly joined TRC team can bring for the future.



## GENZYME, CAMBRIDGE, MA

### Project Highlights

- Advanced daylight-redirecting blinds
- “Open loop” photocontrol system
- Low partitions with desks at right angles to windows

Genzyme is a leading biotechnology company, developing a wide range of medicines and technologies in the field of life sciences. Genzyme employs 10,000 people worldwide. This study describes the daylighting technologies used to provide comfort and energy savings for employees in their Cambridge, MA headquarters building.

Genzyme describes the 350,000 square foot building as “one of the most environmentally responsible office buildings in the United States”. The Genzyme building is LEED platinum certified, and is located on a brownfield site close to an urban center. The building uses a double-skin façade for thermal control, a central atrium for daylight and ventilation, and many other sustainable features.

This case study focuses on the office areas on the tenth floor, a typical floor in this 12-story building. The incoming sunlight and diffuse daylight are controlled by automated window blinds, which both redirect sunlight and preserve view. Thus, these blinds help to reduce solar gain while increasing interior daylight levels, and eliminate the need for fixed solar shading on the outside of the façade.

Cambridge, MA, is a coastal city located at 42° North. Summers are warm with an average daily high temperature of 80°F. Winters are very cold

with an average daily minimum of 25°F. Its maritime climate means that precipitation and cloud cover are frequent and unpredictable, and that the temperature swing between night and day averages only 15°F.

## DAYLIGHTING DESIGN

Most of the employees have immediate access to natural light. Sixty percent of the workstations on the floor surveyed were directly adjacent to windows (either external windows, or windows on to the central atrium). Of the remainder, very few workstations were more than 15' away from a window.

The double-skin façade—a non-structural glass curtain wall—provides a large area of window glazing in all perimeter offices, in most cases running continuously from floor-to-ceiling. The glazing is clear, and the total light transmittance of the façade assembly is around 20%. All exterior windows have advanced daylight-redirecting blinds manufactured by Warema, which have an inverted mirror finish and are shaped to bounce light up at the ceiling. The design intent is to create a consistently comfortable diffuse illuminance at all times of the day and year, while blocking direct glare from the sun.

The blinds are under automatic control but can also be temporarily overridden by occupants. A centralized automatic control closes the blinds in response to sunlight and opens them again when the strength of the sunlight falls below a certain value.

The blinds have perforations along the inner edge to preserve a filtered view outside even when the blinds are fully closed. Interior daylight levels are enhanced by high reflectance walls and ceiling (90% reflectance), and by clear glass interior partitions.

## LIGHTING CONTROLS

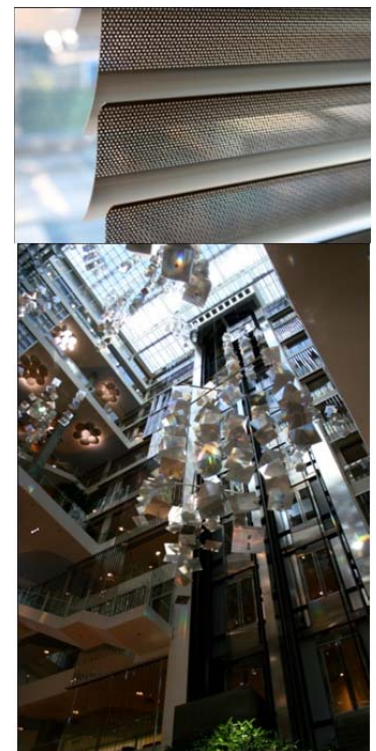
The electric lighting system provides direct/indirect light from a combination of suspended and recessed luminaires, which are positioned directly over workstations to minimize the amount of wasted light. Corridors are separately illuminated.

Occupants have personal up/down dimming control of their own fixtures, and an overhead vacancy sensor switches lights off.

The centralized “open loop” photocontrol system dims luminaires to different levels in response to a single daylight reading from a sensor positioned on the roof of the building. Luminaires are organized into groups that respond uniformly to daylight conditions, to maintain an even appearance across the ceiling.



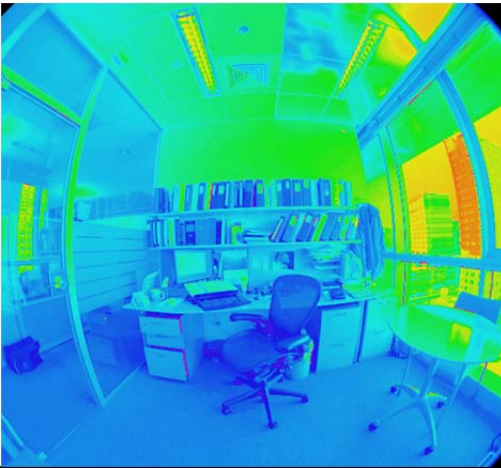
Office areas have daylight-redirecting blinds.



A full-height atrium gives “borrowed” light to the interior of every floor.



## VISUAL ENVIRONMENT



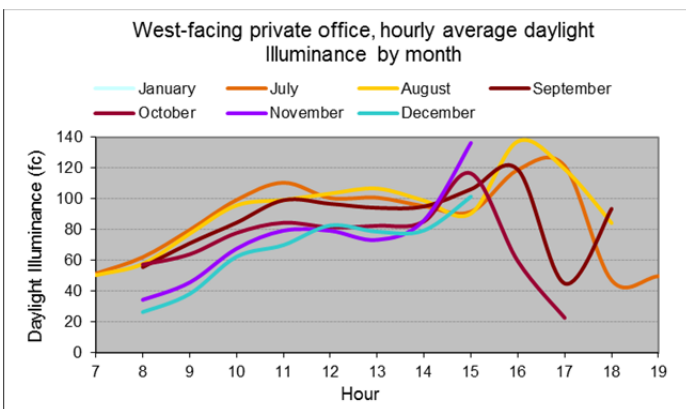
Luminance map showing advanced blinds and reflective metal ceiling panels at top right. Yellow and green areas indicate higher brightness.

Genzyme employees occupy individual offices with glass walls and doors, and interior cubicles with 5'6" high partitions, many of which have translucent panels. These partitions are glazed to encourage daylight transmission, and also give an increased sense of space and longer internal views for visual comfort.

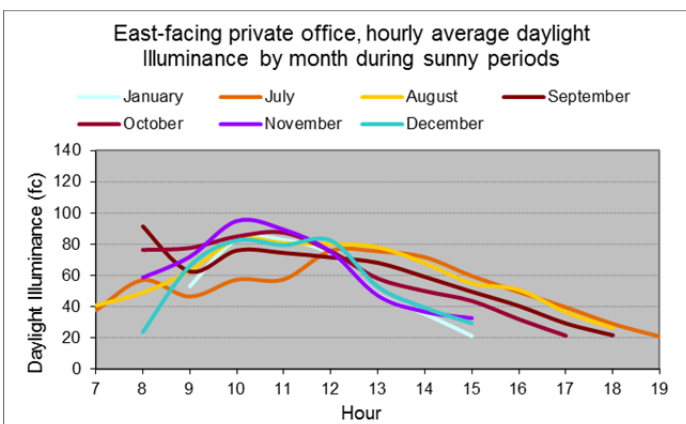
The distribution of daylight within each space is made more uniform by the use of reflective metal ceiling panels that extend four feet back from each window, and bounce the uplight from the blinds into the back of the space.

The open office ambient lighting system provides 25-30 footcandles and the area surveyed had an installed power density of 0.73 W/sf.

## DAYLIGHTING PERFORMANCE



The graphs to the left show weekday illuminances from daylight only, during sunny periods (more than 2,500fc available outside). The colored lines show how the desktop illuminances vary by month. The measurements were taken from ceiling-mounted sensors.



The shape of the graphs shows that the window blinds maintain very consistent interior light levels—illuminances are in the 40-100fc range through most of the day, and do not vary very much from month to month. The two spaces shown in the graphs are on opposite sides of the building and are therefore exposed to sunlight at very different times of day. Nonetheless, their interior illuminances are remarkably similar.

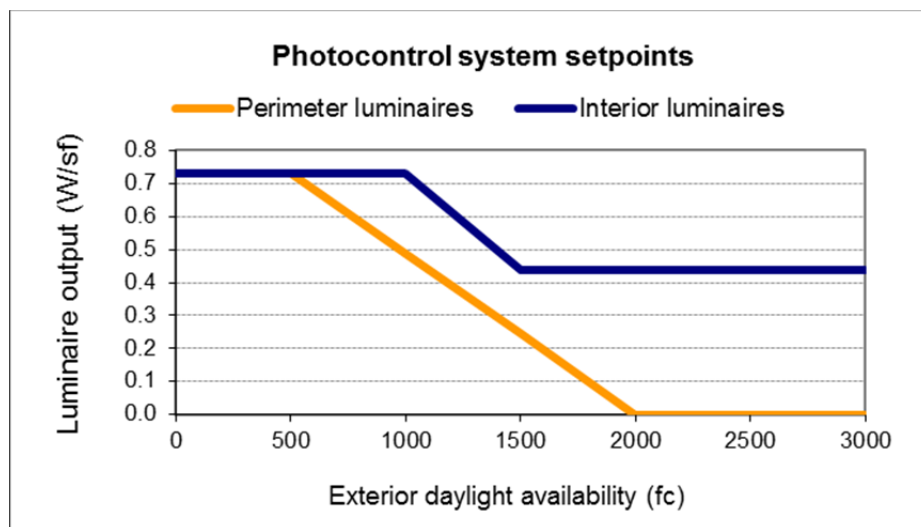
The slightly erratic illuminances in late summer evenings in the west-facing office are likely due to patches of bright reflected sunlight travelling across the ceiling-mounted light sensors as the

sun sets, and may not be indicative of overall space illuminance.

“Daylight autonomy<sup>1</sup>” was calculated for ten locations in the building. Daylight autonomy describes the percentage of the day for which daylighting alone is sufficient to provide task illuminance in a space. For the perimeter offices, daylight autonomy ranges from 55% to 74%, with an average of 60% (although these are *underestimates* due to limitations of the logging equipment). Daylight autonomy for the interior offices is zero, i.e., daylight levels in the interior offices never exceed 30fc. Nevertheless daylight penetration does contribute sufficient light to allow the dimming ballasts to save some energy (as shown in the graph below).

## ENERGY PERFORMANCE

As daylight levels increase, perimeter luminaires dim down sooner than the luminaires in the interior of the space, as shown by the setpoint diagram below.



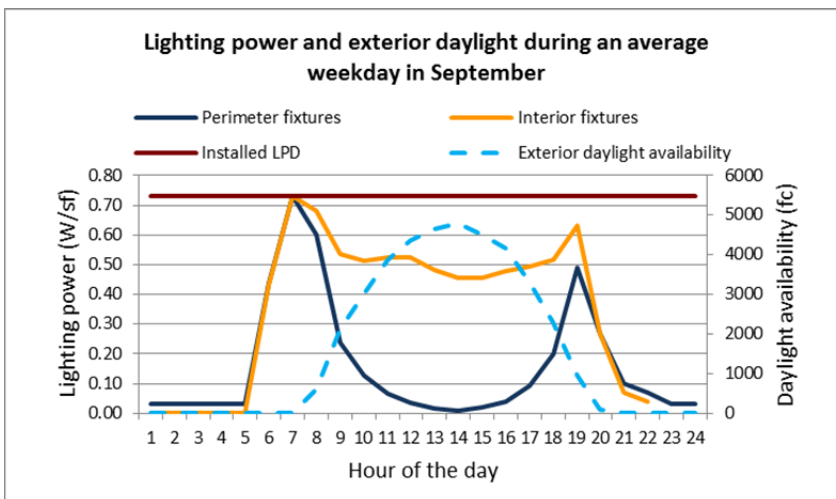
The perimeter luminaires begin to dim down when the exterior illuminance reaches 500fc (a very dim overcast day, or an early morning), and reach zero output when daylight reaches 2,000fc. The interior luminaires do not begin to dim until exterior daylight reaches 1,000fc, and they dim to a minimum level of 60% of full output.

Due to the photocontrol system, the lighting is almost never at full output during the day. The Genzyme building uses 36% less lighting energy than a typical code-compliant building with the same mix of private and open offices.<sup>2</sup>

<sup>1</sup> Figures quoted are “DA300”, i.e., the percentage of the time that daylight levels exceed 300 lux (approximately 30fc) during the period 8:30am to 5:30pm, accounting for daylight savings time.

<sup>2</sup> Assuming 1740 and 3895 hours per year for private and open offices respectively. Source: ADM (2002). *Lighting Controls Effectiveness Assessment, Final Report on Bi-Level Lighting Study*, May 2002, Prepared

	Lighting power density (LPD)	Annual hours of lighting use	Annual lighting energy use (kWh/sf.yr)
Genzyme building	0.73	3935	1.64
Typical ASHRAE/IES 90.1 -compliant building	0.9	2866	2.58
Genzyme building without photocontrols	0.73	3935	2.87



However, a more relevant way to quantify the savings is relative to what this building's energy use *would be* without photocontrols. Due to Genzyme employees' work schedules, the lighting has unusually long hours of use—even with occupancy sensor controls in place. The average luminaire is switched on for almost eleven hours a day. Compared with eleven hours of use per day, the lighting system is saving 44% of the energy that would be used without photocontrols.

## OCCUPANT COMFORT SURVEYS

### Survey Finding

Survey respondents reported no discomfort or annoyance problems from the blinds.

Two online surveys of the building occupants received 32 complete responses. One survey was conducted in the summer and one in the winter to identify whether occupants' satisfaction with the performance of the lighting system differed over the course of the year. For four of the questions, the results are shown relative to a benchmark of high performance daylight buildings from a recent study<sup>3</sup>.

The overall occupant response to the lighting quality was strongly positive (positive responses are towards the left of the chart below).

On average, occupants said that the lighting wasn't "too dim", however their answers were polarized—around half of occupants complained about the dimness of the lighting. A majority of occupants also agreed that there was "too much light in some areas and not enough in others". To preserve confidentiality, we did not know where individual respondents' workspaces were physically located.

Because occupants of perimeter offices have control over their own window blinds, the complaints about "dimness" probably originated from

by ADM Associates Inc. for Hesong Mahone Group under the California Statewide MA&E Program on behalf of Southern California Edison and the California Energy Commission.

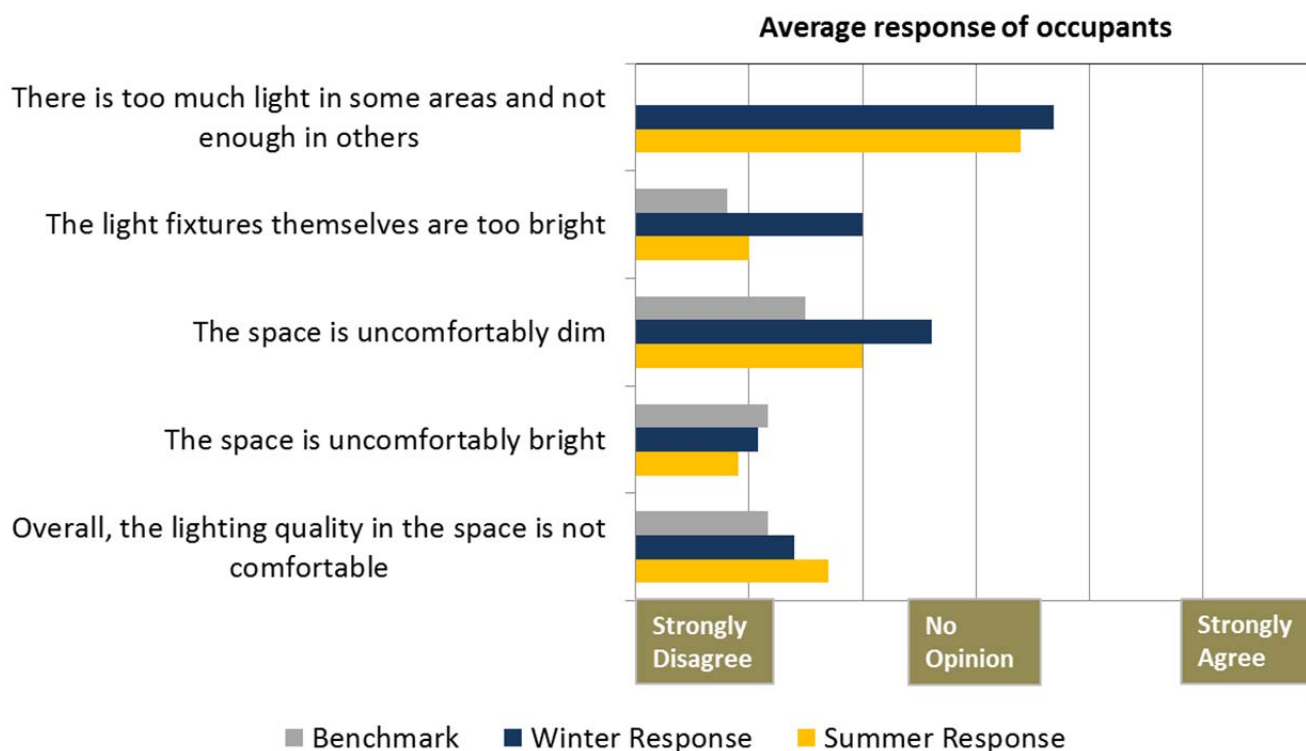
<sup>3</sup> Hesong Mahone Group. 2011. Daylight Metrics Project: Final Report. California Energy Commission, PIER program.

people in the interior of the space. It may be that because the daylight filters through several layers of partition glass before reaching their workspace, it has lost some of its sparkle and quality. Or it may be that interior occupants feel that their spaces are dim *relative* to the brightly-lit perimeter spaces. Or their experience of dimness may be due to office partitions blocking their views out of the building. A potential solution to this and many other lighting problems is to provide improved adjustable task lighting for employees with interior workspaces.

Only one of the respondents to the survey said that they had experienced reflected glare from the window blinds or the reflective panels on the ceiling. And despite the audible noise made by the blinds while adjusting, none of the occupants mentioned any noise disturbance.

The responses to every question were statistically significantly (i.e. different from “no opinion”), except for “The office is uncomfortably dim”. The difference in average response between summer and winter conditions was significant only for “the fixtures themselves are too bright”; this could be a consequence of the blinds reflecting low-angle sun.

An interview was also conducted with the facilities manager. The manager said that the photocontrol system had been working “extremely well for six years, and that the only change he would like to make would be to bring more fixtures under photocontrol.



## LESSONS LEARNED

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The Genzyme daylit building is an ambitious design that has proved successful since it was first occupied in 2005. It uses a centralized, building-wide lighting control system that gives occupants personalized control of their luminaires and blinds, while also making periodic automatic adjustments.

- The advanced blinds are functioning as intended. In perimeter offices they block solar glare yet also maintain IESNA-recommended illuminance levels for most of the day, throughout the year. The blinds maintain a very consistent level of illumination despite large variations in sun angle over the year. Survey respondents reported that their overall lighting quality was good.
- The daylighting system is working successfully. In the office spaces we surveyed, it saves over 35% of electric lighting energy use compared with typical new construction. More importantly it saves almost 45% of electric lighting energy use compared with what *this* building's lighting load would be without photocontrols, due to the long hours of use of the building.
- Almost half the occupants perceived their workspace as being 'too dim'. This could potentially be improved by reducing partition heights to improve views, by using light fixtures with more "glow" or "sparkle", or by adding task lights.
- The photocontrols are performing as designed. Several years after first occupancy, all the photocontrolled lighting circuits are dimming in the same way as they were originally configured. Based on interviews, we have evidence that the maintenance staff understand and make use of the control system.