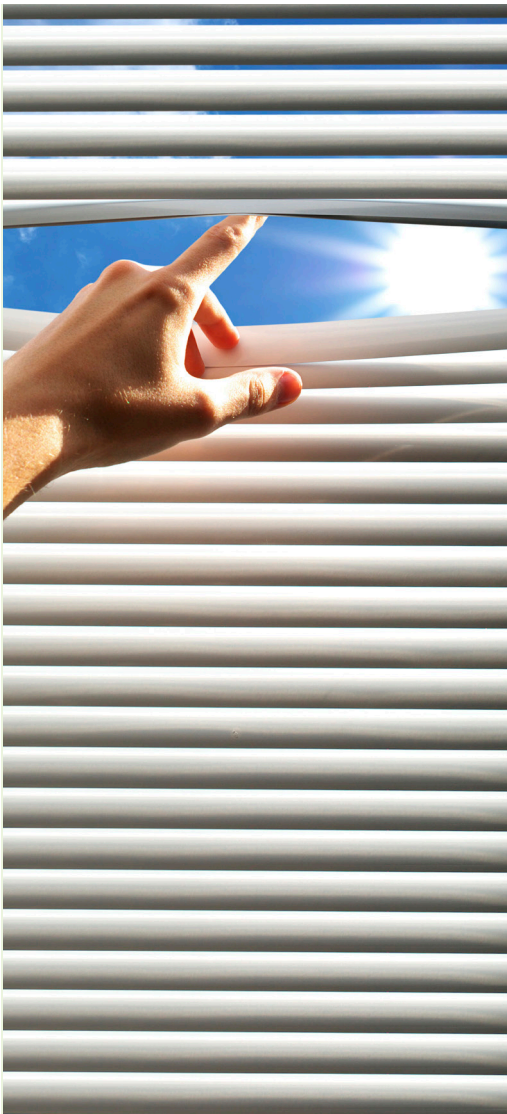




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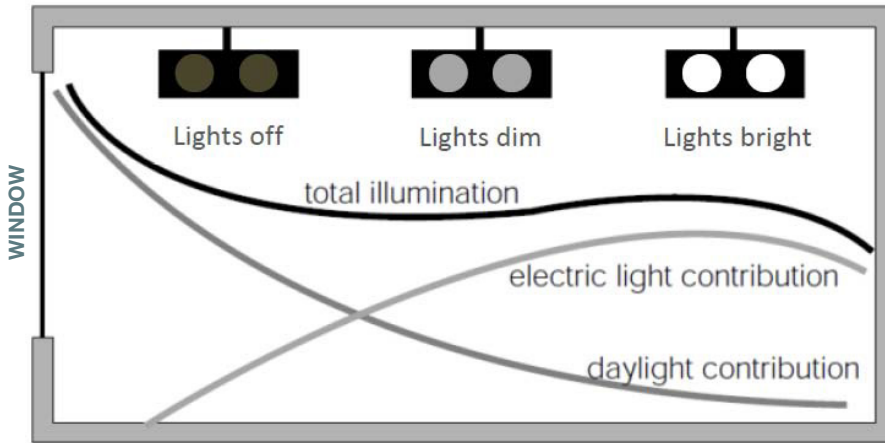
# INTEGRATED DAYLIGHTING SYSTEMS



## Daylight Harvesting Saves Energy by Balancing Natural and Electric Light

Office space electric lights are too often left on during the day, even in areas fully illuminated by sunlight. In fact, at 26%, electric lighting accounts for the largest percentage of all electricity used in U.S. commercial office buildings.<sup>1</sup> Daylight harvesting, the use of natural light to offset electric light in perimeter workspaces, offers the opportunity to reduce lighting consumption significantly. Energy savings are estimated to be between 20% and 60%,<sup>2</sup> assuming that daylight harvesting is only one component of an integrated lighting control system. To evaluate the incremental savings from daylight harvesting, GSA's GPG program commissioned Lawrence Berkeley National Laboratory (LBNL) to assess the performance of daylight harvesting at five federal building sites. Findings from LBNL's assessment included an average annual energy savings of 27% and simple payback as low as four years. Workspace design, interior floor plan, and occupant education and buy-in proved critical for the efficient use of natural light.

# INTRODUCTION



Interaction between natural light and electric light at various distances from a window.

*“By relying on timers and occupancy control at Cottage Way, we’d already dropped our EUI way below the national average. By adding daylight harvesting to the mix, we saved an additional 39%.”*

—Mark Levi  
Energy Program Manager  
GSA, PBS, Pacific Rim Region

## PERFORMANCE SPECIFICATIONS

Lighting Energy Use

### MEASURED AVERAGE

EUI Before	<b>2.9</b>
EUI with Daylighting	<b>2.1</b>

### U.S. COMMERCIAL BUILDINGS

EUI	<b>4.5<sup>3</sup></b>
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## What is This Technology?

### IDS SYNCs LIGHTING CONTROL STRATEGIES TO SAVE ENERGY

Daylight harvesting requires the use of an Integrated Daylighting System (IDS). IDS measures prevailing natural light against predetermined lighting setpoints, and signals electronic dimming ballasts to minimize electric light output accordingly. Photosensors are calibrated by exposing them to minimum and maximum light levels, enabling sensors to provide accurate signals to ballasts in order to maintain a programmed light level. In well-calibrated systems, electric light supplements natural light only as needed, reducing the use of electric light without compromising the comfort and effectiveness of lighting in the workplace. Systems with lower predetermined lighting setpoints have less room for savings from daylight harvesting because energy use is already minimized.

## What We Did

### M&V EVALUATION OF DAYLIGHT HARVESTING CAPTURES CONDITIONS IN A WIDE VARIETY OF GSA WORKSPACES

Researchers from LBNL assessed current GSA deployment of daylight harvesting to determine whether energy and cost savings justify expanded deployment. LBNL vetted 92 Federal office buildings with active daylighting projects, selecting 13 representative sites to establish baseline study conditions and five of the 13 for long-term measurement and verification (M&V). The five sites captured a diverse group of agencies, occupancy patterns, work styles, and baseline energy usage. For a period of between six weeks and five months, researchers collected data to assess light conditions, energy savings, and cost effectiveness.

# FINDINGS



**SIGNIFICANT ENERGY SAVINGS** The five long-term study sites averaged annual energy savings of 0.84 kWh/ft<sup>2</sup> or 27%. Average energy use intensity (EUI) was reduced from 2.9 kWh/ft<sup>2</sup> (already considerably below the U.S. average of 4.5 kWh/ft<sup>2</sup>)<sup>3</sup> to 2.1 kWh/ft<sup>2</sup>. Average lighting power density (LPD) was reduced from 1.6 W/ft<sup>2</sup> to 0.77 W/ft<sup>2</sup>.



**PAYBACK VARIES WITH OCCUPANCY** Payback ranged from 4.3 to 17.6 years, with three of the five long-term sites realizing simple payback of less than 6 years. One of the remaining two sites, the Ronald Dellums Federal Building had very low predetermined light levels and therefore little room for additional savings from daylight harvesting. Both Dellums and Hammond would have had more attractive payback if they had been occupied a larger percentage of the time—greater use resulting in greater savings. As a rule of thumb, daylight harvesting becomes cost-effective at an installed cost of \$1.40/ft<sup>2</sup>, with a utility rate equal to the national average of \$0.10/kWh, assuming dimming ballasts are already in place.



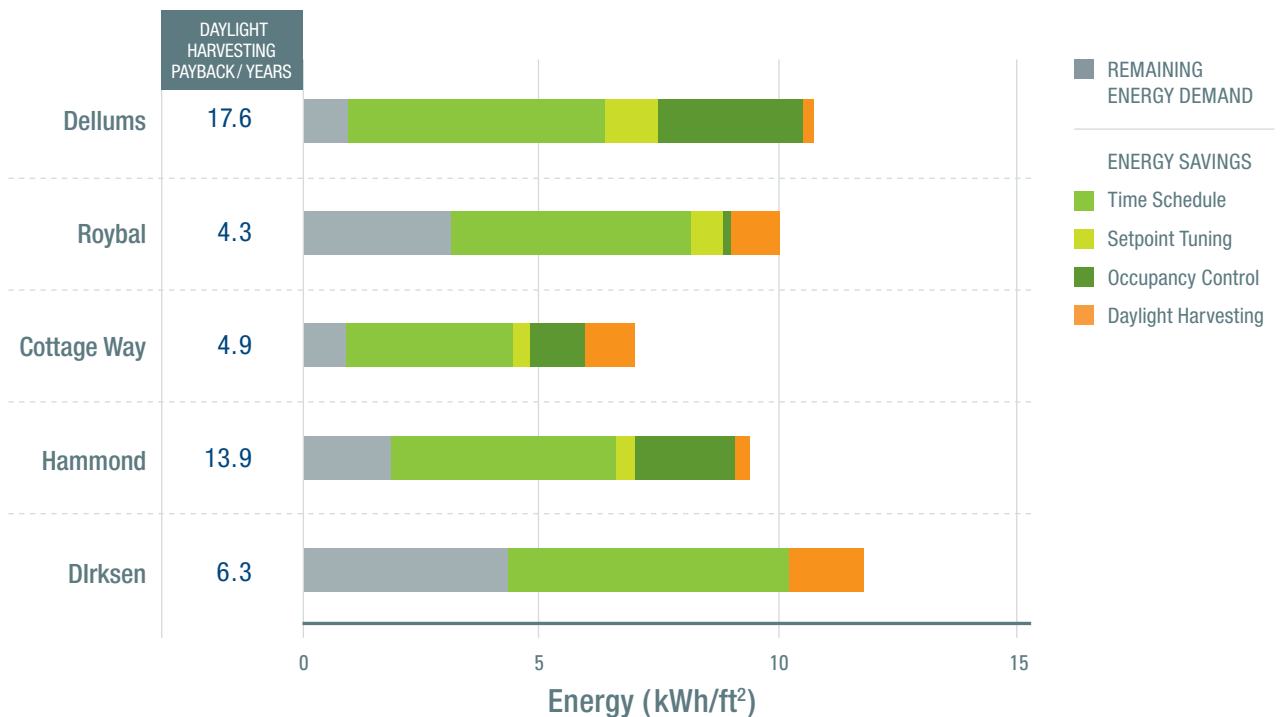
**BEHAVIOR AND DESIGN CAN IMPEDE USE OF NATURAL LIGHT** Eight of the 13 baseline sites could meet necessary light levels with daylight alone during bright conditions. However, window blinds were partly or fully closed in 9 of the 10 private office sites studied, and systems and furnishings further impacted the use of natural light in shared perimeter workspaces.



**DEPLOY WHERE EXISTING LIGHTING USE IS HIGH** Target daylighting to new building construction and retrofit projects with existing LPD greater than 1.1 W/ft<sup>2</sup> and EUI greater than 3.3 kWh/ft<sup>2</sup>.

## Lighting Energy Savings Control Strategies

Increased savings from Occupancy Control leaves little room for savings from Daylight Harvesting



# CONCLUSIONS

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These Findings are based on the report, “Integrated Daylighting Systems,” which is available from the GPG program website, [www.gsa.gov/gpg](http://www.gsa.gov/gpg)

For more information, contact GSA's GPG program [gpg@gsa.gov](mailto:gpg@gsa.gov)



## Footnotes

<sup>1</sup>U.S. Energy Information Administration (EIA), available at <http://www.eia.gov/emeu/cbecs/cbecs2003>

<sup>2</sup>Williams, A., Atkinson, B., Garbesi, K., Page, E., & Rubinstein, F. (2012). Lighting Controls in Commercial Buildings. Leukos, 161-180.

<sup>3</sup>Rubinstein, Francis M. Advanced Lighting Controls and Services: A Snapshot of Where We Are. s.l. :Prepared for Advanced Energy 2012 Conference, 2012.

## What We Concluded

### DAYLIGHT HARVESTING IS APPLICABLE NATIONWIDE

Daylight harvesting can save energy throughout the GSA portfolio. Buildings that combine high lighting energy use (LPD > 1.1 W/ft<sup>2</sup> and EUI > 3.3 kWh/ft<sup>2</sup>) with unobstructed sky views, limited seasonal daylight variation, high visible transmittance and a window-to-wall ratio > 50% will be most cost-effective and should be given highest priority. Daylight harvesting will be most productive in perimeter areas, where perimeter depth is no more than two times the maximum window height. Moreover, cost-effectiveness increases where individual photosensors control multiple lighting fixtures, minimizing associated materials and labor costs. Additional cost reductions should be realized as the market for advanced lighting continues to grow and contractors gain experience with the installation and commissioning of IDS.

**NOTE:** This study focused on fluorescent-lamp-based lighting and lighting controls (florescent lighting was the preferred technology at the time of the assessment). Conclusions may not apply to daylight harvesting with LED-based systems, as LED performance characteristics are very different in terms of dimming range, efficiency and cost-effectiveness.

## Best Practices

### OPTIMAL CONDITIONS FOR DAYLIGHT HARVESTING

- Program lighting to either turn off or dim to a minimum, when natural light is sufficient. The former saves more energy, the latter results in longer lamp life. Alternatively, lighting can be dimmed to the lowest level for a predetermined period of time and then turned off.
- Daylight harvesting is appropriate for all building perimeters but west-facing orientations with unobstructed façades are most conducive to energy savings.
- Furnishings, wall surfaces, and cubicle partitions should be light in color; partitions should be installed perpendicular to the window, and, if opaque, should be at most three feet tall.
- Third-party installation and commissioning expertise should be engaged whenever possible, as synced daylight harvesting control is complex, requiring familiarity with IDS.
- Provide occupant education, training, and manual operations alternatives to maximize occupants' use of daylight harvesting as an alternative to electric light.

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*Reference above to any specific commercial product, process or service does not constitute or imply its endorsement, recommendation or favoring by the United States Government or any agency thereof.*