



GUIDANCE ABOUT ENERGY EFFECTIVE LIGHTING

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- 1 Read Chapter 3 in the Federal Lighting Guide to learn more about Energy Effective Design and Specification.
- 2 The Energy Effective Lighting Checklist provides a one-page list of the most important things to do in your relighting projects.
- 3 For greater detail that is application-specific, review the Energy Effective Lighting Recommendations for Offices and Warehouses, found in Appendix 2 of the Federal Lighting Guide.
- 4 Use lighting design professionals for unusual or challenging relighting projects.
- 5 Perform a pre- and post-occupancy survey to quantify the satisfaction of Federal workers. For standardized survey tools, contact Carol.Jones@pnl.gov.
- 6 Contact FEMP to obtain technical support for challenging or unusual applications.

circadian rhythm: a self-sustained biological rhythm which in an organism's natural environment normally has a period of approximately 24 hours.

luminaire: a light fixture; a complete lighting unit consisting of a lamp or lamps and ballast(s) (when applicable) together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply.

visual acuity: a measure of the ability to distinguish fine details.

Benefits of Energy Effective Lighting

Energy Effective Lighting accomplishes the dual objectives of being efficient while meeting the needs of the space occupants. The U.S. Department of Energy Federal Energy Management Program is committed to saving energy and improving workspaces for Federal workers at the same time.

When one considers the cost of labor in the workplace compared to the cost of electricity, it becomes immediately apparent that it is important to consider lighting impacts on the Federal workforce. In offices alone, the total Federal lighting energy use represents energy costs of about \$170 million per year, while Federal office worker employee costs represent about \$70 billion per year, or over 400 times more.¹ Potential productivity improvements are possible *if* the relighting is an improvement to the quality of the lighted environment. Considering this within the context of the Federal energy savings goals, it means that additional benefits should arise out of the implementation of the presidential executive orders. This provides significant incentive for efficiency projects that include relighting. In addition to the environmental and cost benefits of energy savings, it becomes possible to improve the workplace for Federal workers, resulting in increased satisfaction and performance.

Proven Opportunities

The theory behind improving productivity with quality lighting is based on the fact that lighting has a direct and powerful impact on the occupants of buildings. From a conceptual perspective, it is easy to understand that lighting affects us in many ways, both physically and psychologically. However, many energy managers struggle to separate the anecdotal stories about such benefits from reliable and proven opportunities. This flyer provides specific information from actual research studies, with simple guidance on steps to take in your project work.

Research on Lighting and Productivity

Decades of lighting research have focused on the relationships between task visibility, glare, comfort, and performance on visual tasks. Only recently have the attributes of light that influence satisfaction, emotional functioning, and performance on a broad array of cognitive and creative tasks been studied. In addition to the studies discussed below, exciting new research is now under way in the Federal and private sectors.

“The more we come to understand about lighting the more we appreciate it’s importance. Lighting projects present a significant opportunity for us to add value to our facilities and improve the workplace.”

James Woods, Energy Conservation Officer
U.S. Department of Commerce

“At the Department of State we’ve learned from experience that our employees feel strongly about having good lighting, and that lighting can help our people accomplish their missions. Energy and cost savings along with improved environments give us the best of both worlds.”

Richard Tim Arthurs, Energy Policy and Conservation Officer
Office of Facilities Management Services, U.S. State Department

BENEFICIAL ASPECTS OF LIGHTING

Room Surface Brightness

The overall brightness of a room is greatly influenced by the luminance of vertical surfaces, including walls as well as cubicle partitions. In general, people prefer well-lighted walls to dark ones, so long as the wall is not so bright that it becomes a secondary glare source. Although worker satisfaction is valuable in its own right, there is some preliminary indication that satisfaction and improved moods (positive emotional functioning) also may impact task performance and motivation.²

- Numerous studies have shown that satisfaction is higher in spaces with vertical surface lighting — such as that from wall washers and wall sconces, or ceiling light that spills over onto the walls.^{3,4,5}

- Dissatisfaction with dark walls may result from perceptions of gloominess. Researchers suggest that gloom is psychologically undesirable because it is associated with reduced peripheral vision and thus serves as a primitive warning system that visual acuity is being compromised.⁶
- Wall washers and sconces also add a sense of visual interest that is associated with increased ratings of lighting quality.⁷
- Another mitigating factor is the nature of the task: people prefer lower wall brightness for computer tasks and higher brightness for reading or writing. Similar results were found in a study of workstation lighting.⁸

REFERENCES

Personal Control

It has long been known that individuals vary enormously in preferred lighting. Yet there has been little effort to develop lighting technologies and systems that allow for individual control, in part because building managers believe that personal control will lead to increased energy consumption. With greater personal control over lighting at the workstation, individuals can choose light levels consistent with their general preferences and can vary light to fit their specific tasks.

- A recent study at the National Research Council Canada shows that the ability to control lighting has positive impacts on workers' mood and satisfaction, and also leads to high ratings of lighting quality.⁹ The Canadian study also found that the lighting choices were well within current energy code limits for office lighting.
- A laboratory study at Rensselaer Polytechnic Institute's Lighting Research Center found that subjects who had dimmable ceiling light adjusted it throughout the experimental conditions as tasks changed.¹⁰ Further, subjects who had the controllable lighting were more satisfied with the lighting, felt more comfortable in the room, rated the tasks as less difficult, and rated the lighting quality as higher than subjects who did not have control. Importantly, having the control system produced a 35% to 42% decrease in electrical consumption.

Overhead and Reflected Glare

Glare from ceiling lights can be a problem if it produces reflections on the computer screen that interfere with task visibility. In addition, new research indicates that bright luminaires located overhead can create visual discomfort.

- A significant problem in many offices is the reflection of luminaires in visual display terminal (VDT) screens.¹¹ Lensed fixtures are more problematic than most other fixture types. A new study shows that reflected glare from bright luminaires in the ceiling plane is reduced significantly if the highest-quality VDT screens are used.¹²
- An experimental workshop was held by the joint committees of two professional lighting associations* to study the phenomenon of overhead glare. The results obtained demonstrate that a significant number of people do experience discomfort from a high-luminance luminaire overhead, even when the fixtures are at the edge of the field of view or just outside the field of view.¹³

* The workshops were held by the Illuminating Engineering Society's Quality of the Visual Environment Committee and the International Association of Lighting Designers Metrics of Quality Committee.

Other Lighting Aspects

In addition to the categories listed above, numerous other aspects of lighting are being studied. The impacts are profound, ranging from visual fatigue to important physical and psychological health effects.

- There is an indication from a number of researchers that headaches are reduced when electronic ballasts are used rather than magnetic.¹⁴
- An extensive review of lighting and health¹⁵ shows that bright light affects circadian rhythms and seasonal depression. However, the lighting levels necessary to positively influence physiology and well being are much higher than lighting in typical office settings. Thus, interior light is not expected to influence circadian systems. An exception is shift work where bright light is being used to reduce fatigue, increase alertness, and improve cognitive functioning in night workers.
- It is widely understood that most people prefer daylighting and often desire access to a view in most types of work settings.¹⁶ A recent study found that improved student performance is positively associated with more daylight in schools. There is reason to believe that benefits from daylighting can be translated to other building types and human activities.¹⁷
- Lamps that are high to very high in color temperature (5,000k to 7,500k) provide improved visual acuity compared to lower-color temperature lamps (typically 3500k) at the same light level. High-color temperature lamps are rich in the blue portion of the color spectrum and have a noticeably "cool" appearance. For applications where it is appropriate to use lamps with this color appearance, one can produce similar visual performance with fewer measured footcandles and less energy consumption.¹⁸
- Although numerous claims have been made about the benefits of "full-spectrum" light, there is no convincing evidence at the present time about differential health benefits associated with spectral characteristics.¹⁹

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⁴ Collins, B., Fisher, W.S., Gillette, G.L., and Marans, R.W. 1990. Second level post occupancy evaluation analysis. *Journal of the Illuminating Engineering Society*, Summer: 21-44.

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TECHNICAL QUESTIONS?

Send email to Carol.Jones@pnl.gov