

Harvest daylight and reap rewards

Abstract

The concept of daylight harvesting (also called daylighting) is simple. During the day when natural light is streaming in through windows and skylights, you don't need to use as much artificial light. You can either adjust lighting levels manually, or you can use an automated system that detects daylight levels (using photosensors), and automatically dims or brightens electric lights as required.

Making more use of natural light helps you to consume less energy, which reduces both your energy costs and carbon footprint. Lights that are dimmed or turned off typically emit less heat, which helps to reduce air conditioning costs. Dimming can also extend the life of a lamp, helping to further reduce costs (and landfill). And studies show that people prefer natural to electric light, so you also help to make your building occupants happier.

This paper looks at the benefits that daylight harvesting can provide, and how those benefits can be further enhanced by removing the wires.

Automating daylight harvesting

A number of automated daylight harvesting solutions are available, consisting of dimmable luminaires (or lamps within luminaires), photosensors, and lighting control software.

The sensors have a photoelectric "eye" that measures the illumination in a specified zone. They transmit this information to lighting control software, which is programmed with acceptable threshold levels. If the illumination levels fall outside those thresholds, the software sends commands to dim or brighten the luminaires as required.

It is possible to implement pseudo-daylight harvesting that uses timers to dim and brighten luminaires at the same time every day, but this is a less satisfactory solution. Timers are not able to take into account things like whether the sky is clear or overcast, or whether people have closed the window coverings to reduce heat and glare, so often result in inappropriate levels of illumination.



Obtaining the best results

Daylight harvesting can return maximum benefits in buildings that are occupied primarily during daylight hours, such as office buildings, schools and other government buildings.

Levels of natural light vary throughout a building affected by things like orientation, proximity to windows or skylights, and the colors of walls, ceilings and furnishings. To achieve the best results, you need a solution that is flexible enough to allow luminaires to be dimmed in different "zones" at different times and rates, and to different levels.

For example, you might select to enable daylight harvesting only for the first three or four banks of ballasts next to windows. The bank immediately next to the window, which receives the greatest amount of natural light, would be dimmed by the greatest amount. If required, dimming levels could gradually reduce as you move away from the window and the amount of natural light decreases.

Continuous and stepped dimming

The goal for successful daylight harvesting is to adjust electric light levels gradually enough that building occupants don't notice the change.

This means that using stepped dimming, where light levels typically change from 100% to 50% in a single step, is not ideal for buildings such as offices or schools where occupants perform stationary tasks. Instead, you will achieve better results with

continuous dimming, where fixture light output can be gradually dimmed over the full range, from 100% to 10% (or even less).

Stepped dimming is more suitable for areas where occupants spend less time and do not perform stationary tasks, such as corridors and parking garages. In these areas, you can combine occupancy sensors and photosensors to achieve greater savings (dimming lights further when the area is unoccupied).

The finishing touches

For the best results, you may also decide to update the interior design of a building to make greater use of colors that reflect light (rather than absorb it). Dark interior finishes can compromise an otherwise great daylight harvesting design.

In office buildings, it is also ideal if you are able to orient desks so that occupants are sitting at 90 degrees from the window. This helps to reduce extreme contrast and glare, which are two of the most common factors that lead to window coverings being closed. You can also use window coverings that cut the glare while still letting natural light through.



Increased productivity

While reducing costs and emissions might be the primary driver behind introducing daylight harvesting, there is an added positive benefit on the productivity and well-being of the building's occupants.

In the [ASHRAE GreenGuide](#), the American Society of Heating, Refrigerating and Air-Conditioning cites studies that show just how much of a difference this can make:

- In the retail sector, greater use of natural daylight resulted in a 40% improvement in sales.
- Increasing natural daylight in schools resulted in a 20% improvement in math scores and a 26% improvement in reading scores.

Staff salaries and benefits often account for 80–90% of a company's costs. An increase of just 1% in productivity—measured by production rate, production quality, or absenteeism—can provide savings to a facility that exceed its entire energy bill (according to the "[Building Momentum: National Trends for High-Performance Green Buildings](#)" report by the US Green Building Council).

Removing the wires

Many traditional building and lighting control systems are fully wired, with all lights, sensors and switches hard-wired to a central controller (or to a gateway that facilitates communication between the lighting network and lighting control software). Because of the cost of the wiring, and the complexity of covering a large area, these often operate as a number of self-contained systems (for example, one per room or floor).

Newer lighting systems take advantage of wireless mesh networking, which allows the lights, sensors, switches and the central controller to communicate with each other without the need for wires. Removing those wires provides more flexibility in terms of where switches and sensors can be placed, and also makes it more affordable to include additional sensors in your network (allowing you to obtain more granular information about occupancy and illumination levels).

Wireless mesh also supports more flexible and easier control of larger systems with more devices. It allows you to run your lighting control solution as a single system that covers an entire building (or multiple buildings), as well as room by room (or floor by floor) deployments. This approach provides a system-wide view of operations, current power usage, savings, and more.

Wireless retrofits

Not only is wireless a good choice for new buildings, it is also ideal for retrofits and redesigns.

Retrofits provide the potential for huge cost and energy savings. More than 75% of the estimated five million commercial, industrial and institutional buildings in the US were built at least 20 years ago. Because of their age, many were grandfathered in when stricter energy-use requirements were introduced in the last decade. Updating the lighting in these buildings to include scheduling, daylight harvesting and occupancy controls is an affordable and intelligent way to deliver energy efficiency and improved system performance, and to help bring these buildings into the 21st century.

Existing wired dimmable ballasts and luminaires can often be incorporated into the new lighting system by fitting them with "wireless adapters" that allow them to wirelessly communicate with the rest of the mesh network. Removing the need to run control wiring from every fixture, control and sensor back to the central controller not only saves time and money, it can also help to minimize disruption in buildings that are occupied during the retrofit.

Once the wireless lighting system is installed, control zones and lighting behavior can be changed by simply reconfiguring the lighting software. Sensors and controls are also much easier to add and relocate when they don't have wires.

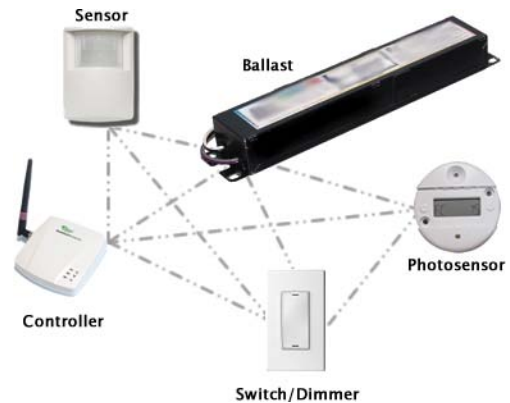
How wireless mesh networks work

This type of network consists of a mesh of interconnected devices (e.g. luminaires, switches, controllers). Each device contains a small radio transmitter that it uses for communication. These transmitters can be either built in to the device or can be fitted externally.

In a wireless mesh network, each device is typically connected through at least two pathways, and can relay messages for its neighbors.

Data is passed through the wireless network from device to device using the most reliable communication links and most efficient path until the destination is reached. Two-way communication also helps to increase reliability, by allowing devices

to acknowledge receipt of data and to require retransmission of data not received.



The mesh network is self-healing, in that if any disruption occurs within the network (such as a device failing or being removed), data is automatically re-routed. The built-in redundancy of having multiple pathways available helps to make the mesh network both robust and reliable.

Mesh networks are also highly scalable, in that you can extend the network simply by adding more devices. The network's self-configuring capabilities identify when a device is added: working out what type of device it is, where its neighbors are, and what the best path is through the network. Weak signals and dead zones can also be eliminated simply by adding more devices to the network.

You can find out more about the benefits of mesh networks in Daintree's white paper: [What's so good about mesh networks?](#)

Regulations and initiatives

Lighting upgrades are extremely cost-effective, generally providing an ROI in two to five years (with savings in both operations and maintenance costs).

This is sweetened further by the incentives many governments are offering to promote green building and retrofits, and to stimulate the building industry after the recent economic downturn.

In the US, refer to the DOE's Database of State Incentives for Renewables & Efficiency (DSIRE) at <http://www.dsireusa.org/> for details about available incentives.

Some utilities also provide credits for lighting control solutions that support demand side load-shedding. A lighting control solution can be configured to automatically react to demand response events from utilities, and adjust lighting to pre-set acceptable levels to take advantage of cost savings.

Regulations and codes

Governments around the world are introducing regulations and initiatives aimed at making buildings greener and more sustainable. These include lighting control and scheduling standards and codes for both new buildings and retrofits (such as Title 24, IESNA and ASHRAE).

Codes are being updated regularly to become more stringent, and all are advocating the use of some form of automated lighting control that includes scheduling and occupancy control (for automatic shutoff of building lighting) and daylight harvesting. While these are still guidelines and recommendations in many places, they are gradually making their way into mandatory building requirements.

Find out more about these codes:

- Building energy codes program (including status of state energy codes): www.energycodes.gov
- California Energy Commission (CED) Title 24: www.energy.ca.gov/title24
- Illuminating Engineering Society of North America (IESNA): www.iesna.org
- American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE): www.ashrae.org

Certification

Lighting control systems need to be certified to qualify for many of the available government incentives.

One of the leading certifications is LEED (Leadership in Energy and Environmental Design). Within the US, LEED is the nationally accepted benchmark for the design, construction and operation of high performance green buildings.

You can find out more at www.usgbc.org/leed.

Wireless pros and cons

Mesh networks provide many benefits for lighting control, and removing the wires provides even more including increased flexibility and reduced installation costs. But no single solution is perfect for everyone. Below is a summary of both the pros and cons of wireless mesh lighting control:

- **Cost:** Installation costs are greatly reduced without the need to run control wires from each device back to the central controller. However, wireless sensors and controls are sometimes more expensive than their wired counterparts, so some of the money you save on wiring may go back into purchasing the wireless devices.
- **Security:** Both wired and wireless solutions provide effective security. Most wireless lighting technologies use 128-bit Advanced Encryption Standard (AES) security for communications. This security is robust enough that, in June 2003, the US Government announced that AES may be used to protect classified information.
- **Scalability:** Wireless mesh solutions support more devices over greater distances than wired ones, which makes wireless ideal for multi-office and multi-floor installations. The nature of mesh networks means that simply adding new devices can extend the communication coverage of the network. And the wireless nature of the controls allows you to place them in areas that were previously difficult or costly to access.
- **Reliability:** Both wired and wireless networks use mature technologies that offer great robustness and reliability. There is the potential of radio interference and data loss with some wireless technologies that share the same radio frequency (such as Wi-Fi® and ZigBee®). Fortunately, this problem is easily avoided for your lighting solution by selecting channels within the radio frequency that are not commonly used by other wireless devices. You can further protect yourself by selecting a wireless mesh technology like ZigBee, which can automatically switch to a new channel if it detects interference on the current channel.

- **Flexibility:** This is one of the biggest benefits of wireless. Devices can be installed where they will provide maximum benefit instead of where it is easiest to run wires. Devices are also grouped into "zones" using addressing and software rather than hard wiring, which allows changes to be made at any time through simple software reconfiguration (no costly or disruptive rewiring required).
- **Complexity:** Wireless allows you to avoid the complexity of connecting wires from hundreds (or thousands) of devices back to a controller, but that comes at a price. It can be more difficult to locate a device when you don't have wires to follow. The good news is that tools are available to help you locate and identify devices during installation and commissioning, and for the ongoing operation, monitoring and maintenance of the system.

Summary

Cost and energy savings, increased flexibility, and higher productivity are major design considerations for modern lighting systems. A wireless daylight harvesting and lighting control solution provides all this and more.

Removing the wires from the lighting controls provides additional benefits, including greater flexibility in where controls can be placed, significant savings in installation (by avoiding the expense and disruption of wiring), and the ability to control and monitor large lighting installations as a single system.

You not only save money on the installation and usage costs, but can also take advantage of the tax incentives offered by many governments to encourage greener buildings and retrofits. And making more use of available daylight can help you to meet new building codes and regulations and achieve LEED certification.

Natural daylight is the most affordable, best quality, and most environmentally friendly light that you can provide to your building occupants. So let the sun shine in!

About Daintree Networks

Based in Mountain View, California, Daintree Networks is a clean technology company that provides wireless control solutions for commercial buildings. Daintree has a strong background in wireless sensor and control mesh networking, with extensive knowledge and experience gained through its industry-standard design verification and operational support tool, the Sensor Network Analyzer (SNA). In addition to wireless embedded expertise, Daintree has put together a team of seasoned professionals from the lighting, telecommunications and networking worlds. Daintree's expertise and knowledge is now being focused on the development of cost-effective building automation systems. These provide benefits including reduced energy consumption, costs and carbon footprint, compliance with new "green" building regulations, and cost savings available through government rebates and the ability to take advantage of demand response programs.

Daintree's Wireless Lighting Control Solution (WLCS) allows lighting manufacturers to speed their time to market, and enables them to deliver powerful, comprehensive, flexible, and reliable wireless lighting control systems for commercial buildings. For more information, visit www.daintree.net or email sales@daintree.net