Extending The Benefits Of Remote Centralized LED Drivers From Indoor Horticulture To Commercial And Industrial Lighting

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Removing the power supply or driver from the LED light fixture in indoor farming offers reductions in both capital (CapEx) and operating (OpEx) expenditures. Locating the driver at a remote location away from the growing area also reduces unwanted heat to the plants. This use of a remote centralized driver is now common practice in indoor horticulture and is part of the Design Lights Consortium (DLC) specifications. DLC specifications call out allowable architectures with merit and specifications that will assist with utility rebate programs.

The remote centralized driver approach can also be used for new or retrofitted commercial and industrial buildings where it will lower CapEx and OpEx costs and provide a much more reliable lighting system. This article begins by discussing the use of remote centralized drivers in indoor horticulture. After reviewing the lighting, energy and power requirements in this application, we explore how remote centralized drivers not only remove heat from the growing area, but also simplify installation of the lighting systems, save energy and improve system reliability and uptime. Some of the benefits of remote centralized drivers, such as improved surge protection and power factor correction, may come as a surprise.

In the next section of the article, we examine how the advantages of remote centralized drivers are also relevant in commercial and industrial lighting systems such as those used in box stores and factories, and other indoor and outdoor lighting applications. Finally, a case study is presented illustrating the benefits of remote centralized drivers in a commercial building's lighting system. In this and other examples, use of Advanced Energy's Artesyn series drivers helps to quantify the performance gains.

The Horticulture Story

Indoor horticulture, or controlled environment agriculture (CEA), is growing in importance as our society's attitudes adapt and change. Consumers are aware of the benefits of consuming fresh, locally grown food, which include improved food security and reduced impact of transport on the environment. Additionally, the growing season is extended as the environment is controlled and yields are improved.

However, these benefits come at a cost. Providing the artificial environment requires significant electrical energy—primarily to provide HVAC and lighting, which, as Fig. 1 shows, together account for 94% of energy usage.

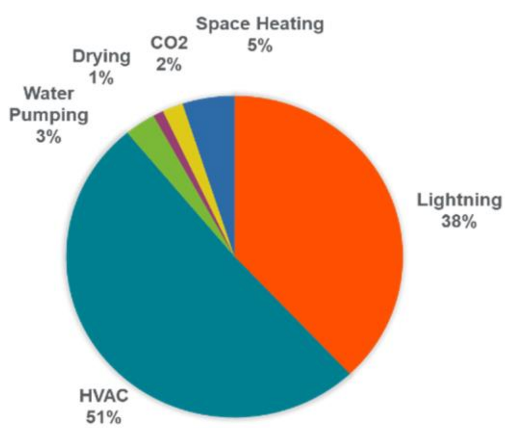


Fig. 1. Energy usage in a standard indoor growing facility.[1]

As indoor horticulture is increasingly adopted, the energy consumed will grow significantly unless changes can be made to the components used, the power architecture, and the source(s) of energy. However, the situation is not unprecedented. The data center industry faced the same challenges and substantially improved through technical changes and energy standards.

Within CEA, the trajectory of the power curve can be improved by several steps: moving from HPS (high pressure sodium) lighting to LED, introducing dimming, changing the power architecture, and adopting renewable energy sources (Fig. 2).

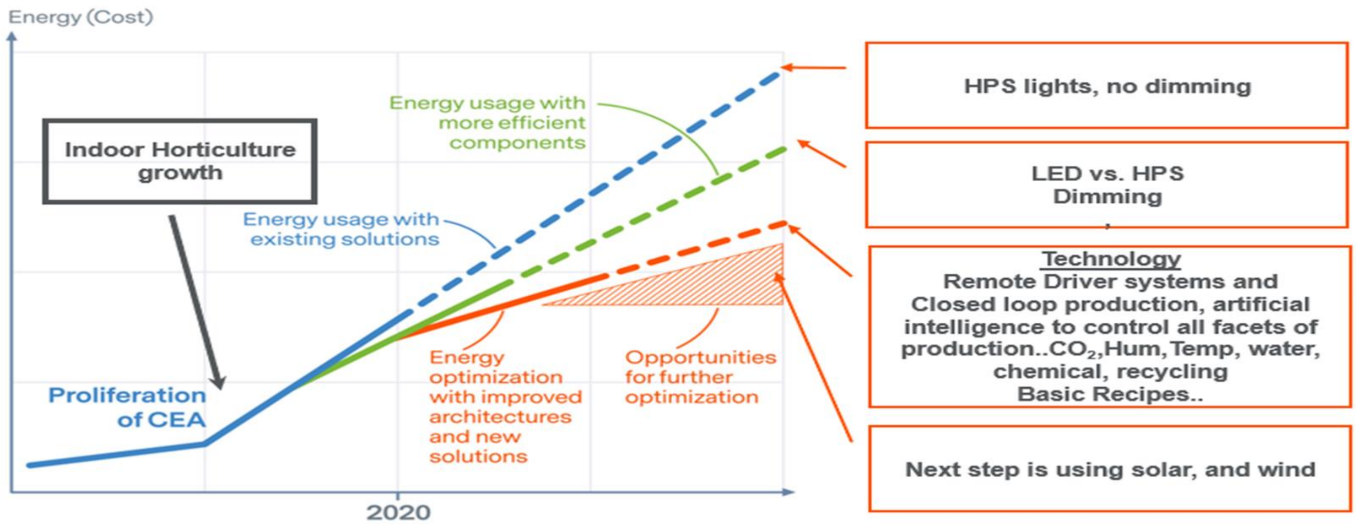


Fig. 2. Bending the energy usage curve with technology.[1]

The move from HPS lights to LEDs is happening rapidly and use of LEDs has grown approximately five-fold in the past six years as users recognize their benefits. LEDs are more efficient, delivering more light per watt consumed and lifetime is at least four times that of HPS. What's more, LED lights have a much greater dimming range, allowing more controllability in CEA applications. Even at end of life, LEDs are preferred as they contain no mercury, eliminating the need for special handling and recycling.

A traditional light fixture includes a driver with an ac input voltage cable. The ac is converted to a dc voltage to power the LEDs, requiring another cable, while a third cable is used to control or dim the lights. Fig. 3 shows a traditional light setup with local drivers and how a light fixture is simplified with one cable vs. three cables.

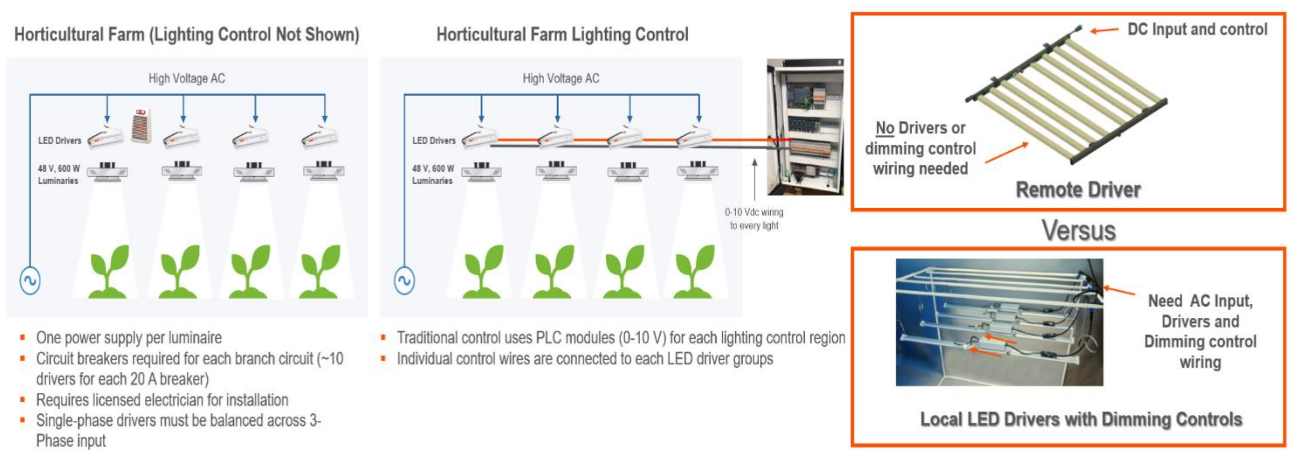


Fig. 3. Traditional LED light with three sets of cables and a heat-producing driver.

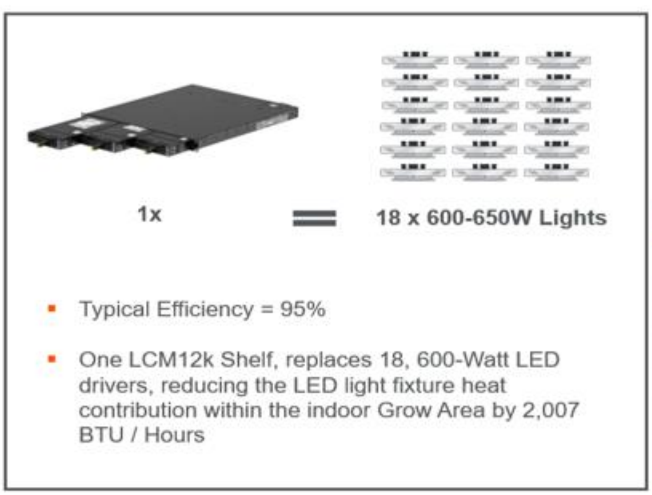
The drivers produce heat based on their efficiency, typically 90% to 95%. For a 1000-W drive, at 95% efficiency, the heat would be 50 W for each light. That quickly adds up when you consider that a facility may have 1000 lights, adding 50,000 W of heat into the growing area—a heat dissipation that would require a 15-ton ac unit to remove. Indeed, heat from the light fixtures is among growers' top complaints.

Removing the driver from the light fixture makes the installation straightforward and lowers the CapEx cost by 20% to 50% for a medium to large facility. Fig. 4 shows the remote centralized driver architecture.

There are two main reasons for lower CapEx; the first is the reduction in the number of cables to the lights from three to one. The second is the reduction in ac circuit breakers; one 12-kW shelf can power many lights, as shown in Fig. 5.

If using 600-W lights, there would be one ac connection to the 12-kW shelf versus 18 ac connections to individual lights. For 300-W lights, there would be 39 ac connections vs. one ac connection, making for a large part of the CapEx savings. An additional positive effect is a lower risk of surge failure; instead of the surge going to 39 300-W drivers, it will go to only one 12,000-W driver with a much-more-robust input circuit. This is especially important considering that about 75% of light fixture failures are due to a driver issue.

Fig. 4. Use of the remote centralized driver in indoor farming removes drivers from the grow areas.



POWER LOSSES

- 650W x 0.05 = 32.5W /driver
- 30W x 18 drivers = 585W
- 2,007 BTU / Hour
- Added Heat Within Grow Area

	12 kW self
Light Size (watts)	Lights per Shelf
300	39
500	24
600	18
650	18
750	15
800	15
1000	12

Fig. 5. With a remote centralized driver powering LED grow lights, one driver can replace 18 or more drivers, removing heat from the grow area.

The primary reason for using remote centralized drivers was to get the heat out of the growing area by removing the local drivers. With the remote driver, lights are now controlled by a high-voltage dc source, typically 250 V dc, running a constant current. Lights are controlled by varying the current at a given time, following a given schedule. Fig. 6 shows a typical remote centralized solution with a 4000-W remote power driver and 12,000-W shelf hardware.

Fig. 6. Centralized driver lighting approach. The driver only needs one cable vs. three the traditional way.

The current to the lights can be managed with an external analog 0 V to 10 V or Modbus digital control. With digital control comes monitoring and feedback functions that ensure the lighting system works properly.

Monitoring points include input and output voltages, current, power, fan speed, internal driver temperatures, and other parameters. Minor and major limits can be set for many parameters and a notification sent if the limit is reached. The minor may be an email/text while a major may also automatically take an action.

An example would be if something is blocking the driver's fans. The temperature will increase, and a minor warning will be sent. If nothing is done, the temperature will increase further, and a major alert will be sent. Simultaneously, the driver will shut down to protect it from a destructive failure since a major limit is reached.

Such rapid notification allows for a fast "Meantime to Repair." Fig. 7 outlines the timing in regular operation.

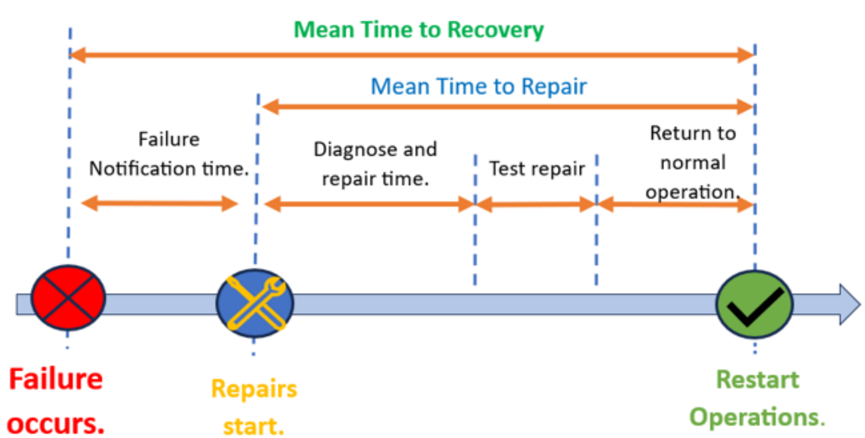


Fig. 7. Typical mean time to recovery.

When plants mature, it isn't easy to see non-functional light in a grow room. Using digital control to monitor the set limits for light voltage and current and sending an email/text allows a fast response to light failures, with failure notification within three to five minutes.

Time to repair using the product GUI to determine if the driver has failed could take 10 minutes and as drivers are hot-plug swappable there is no need to shut the system down for replacement (Fig. 8). The system will test and recover itself and an operator should check that the lights are doing what is expected, for about five minutes. Everything should return to normal when the testing phase is done. The total time to find and fix a problem is, therefore, approximately 15 to 30 minutes.

Fig. 8. The LCM12K driver system holds 3 x 4000-W drivers. Drivers are hot-plug swappable—pull one out, plug one in.

With the traditional approach, someone would need to notice a light is out, then possibly climb up and replace the light fixture. A light could be out for hours or even days before someone sees it and installs a new fixture.

Replacing fixtures is also a waste, since approximately 75% of failures are for drivers and not LEDs as shown by a study done by the DOE (Fig. 9). Of this we can assume that 52% plus 7% are due to driver and control. The remainder of failures are due to the significant stresses added when mounting a heavy driver onto the light fixture. Some drivers weigh as much as 9 lbs—much more than the actual LED lights. We can assume 50% of the package failures are due to the driver.

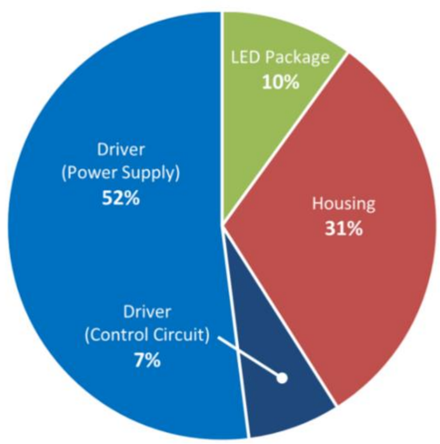


Fig. 9. Typical LED light fixture components.[2]

To summarize, there are many benefits to using remote centralized power in indoor horticulture applications, including

- Removal of heat sources from the grow area.
- Digital control; no dimming wires are needed.
- Feedback on the health of the lights and driver.
- Fast "meantime to repair"—easy hot swap of driver (75% of the time, the driver fails).
- Lower utility cost due to higher power factor, which leads to lower OpEx.
- Reduced installation cost including 3:1 reduction in circuit breakers, which means lower CapEx.
- 4:1 lower shipping cost for the same power.

Additional OpEx savings can be achieved by using drivers with a higher power factor (PF) because, for utility cost, PF makes a more significant impact than even efficiency. The efficiency of Advanced Energy's LCM4000 driver, for example, is 95.5%, but it is the PF of 0.99 that makes the bigger impact.

The power factor for the remote centralized architecture is 0.2 to 0.5 better than traditional drivers, depending on load. At 100% load, the difference of 0.99 vs. 0.97 would be 5% utilities savings; at 60%, the difference is 0.99 vs. 0.94, and the savings would be 9%. The lower CapEx and the utility savings provide a quick ROI (return on investment). Fig. 10 shows that a remote system power factor always saves money over a local driver, no matter what the load.

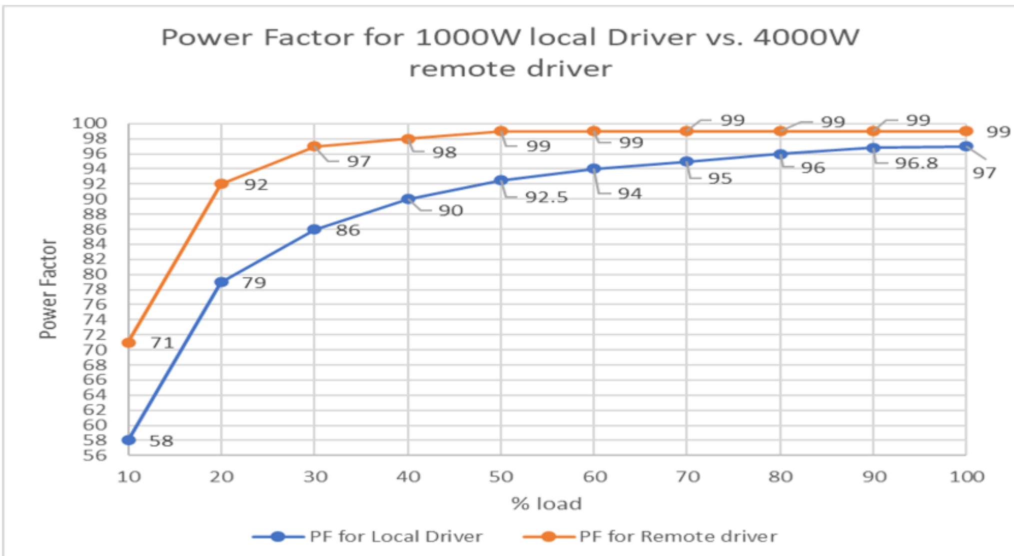


Fig. 10. A remote driver provides a high power factor of >0.99 at typical operating points, easily outperforming a local driver.

The horticultural industry is already following the data center hyperscale solution and is bending the energy usage curve to minimize energy consumption and lower CapEx and OpEx. It's time now for commercial and industrial buildings to do the same as they evolve to LED lighting solutions.

The Commercial And Industrial Story

Fig. 11 shows how LED lighting is growing as a solution for new buildings and retrofits.

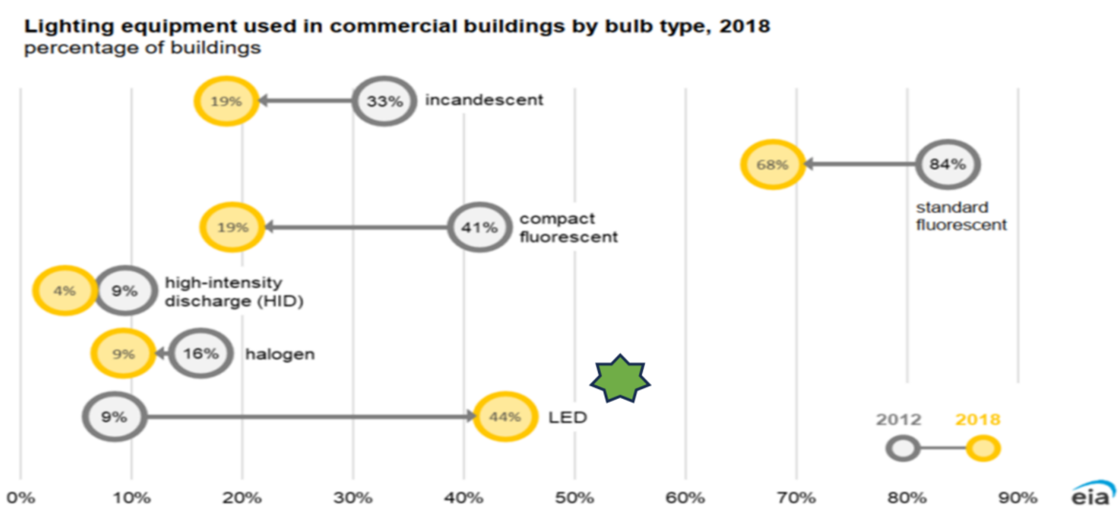


Fig. 11. Among the different lamp types used in commercial buildings, LED lights are the only one whose usage has been growing in recent years.[3]

Indeed, moving to a centralized remote driver is even more critical for large industries as the repair costs are much higher than in horticulture, especially for lights located at much greater heights when unions and special lifts may have to become involved. The number of lights deployed is also often more than needed in horticulture because of the larger spaces involved.

In Fig. 12, which depicts examples of commercial and industrial light applications, we see that when the driver is part of the light (image on the top right), the weight added is 1 to 9 lbs per light; the driver also produces extra heat that calls for more tons of HVAC than the centralized remote driver. If there is a human factor vs. a plant factor, the area's temperature will need to be lower, which calls for even more HVAC. And as 75% of the failures derive from drivers it is better not to put them up there in the first place and have power in a central location making maintenance and replacement much simpler.

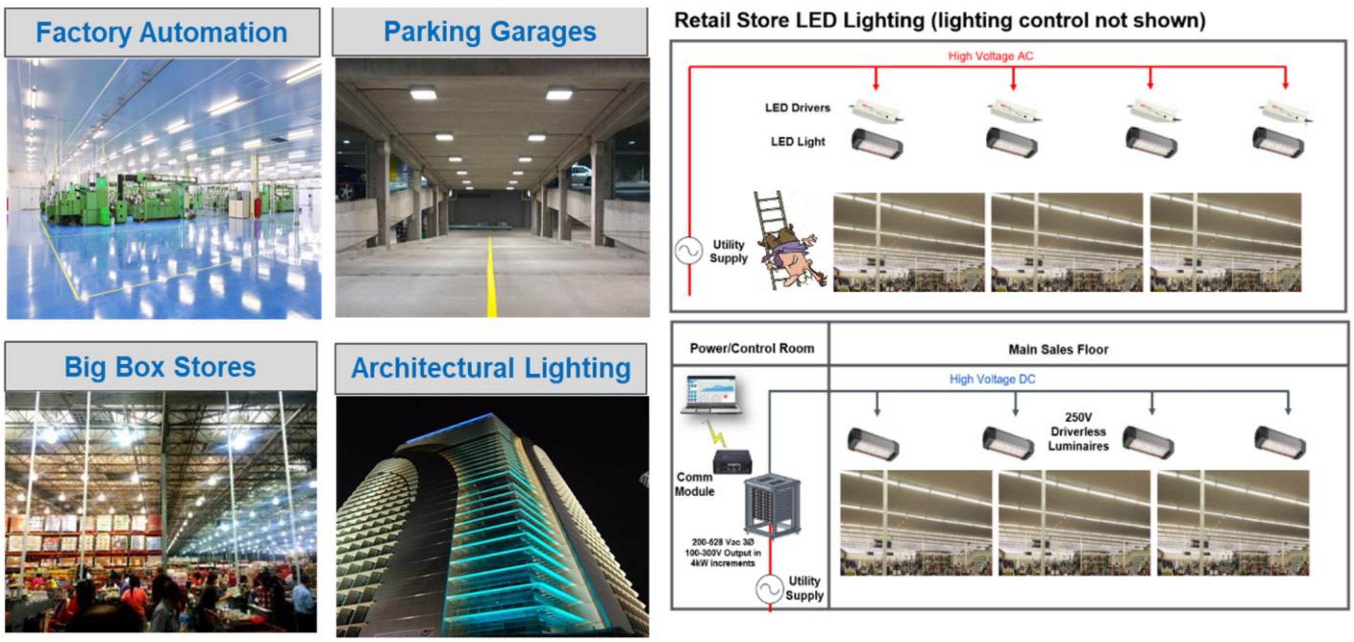


Fig. 12. LED light fixtures can be in difficult-to-reach locations. For the most part, removing the local driver will eliminate the need to replace fixtures as it's usually the driver that fails or which causes the fixture to fail.

For OpEx savings, monitoring and feedback features become valuable. Fig. 13 shows various sensors used to control the environment for indoor farming growing areas. Fig. 14 shows the sensors for the entire facility.

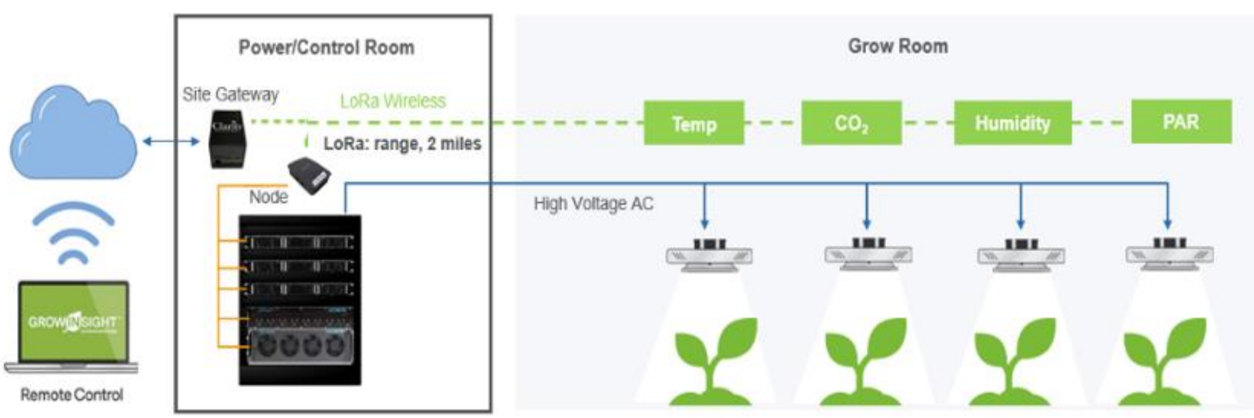


Fig. 13. Horticulture environmental monitoring can be implemented using wireless sensors. Some of these sensors can also be used to monitor buildings.

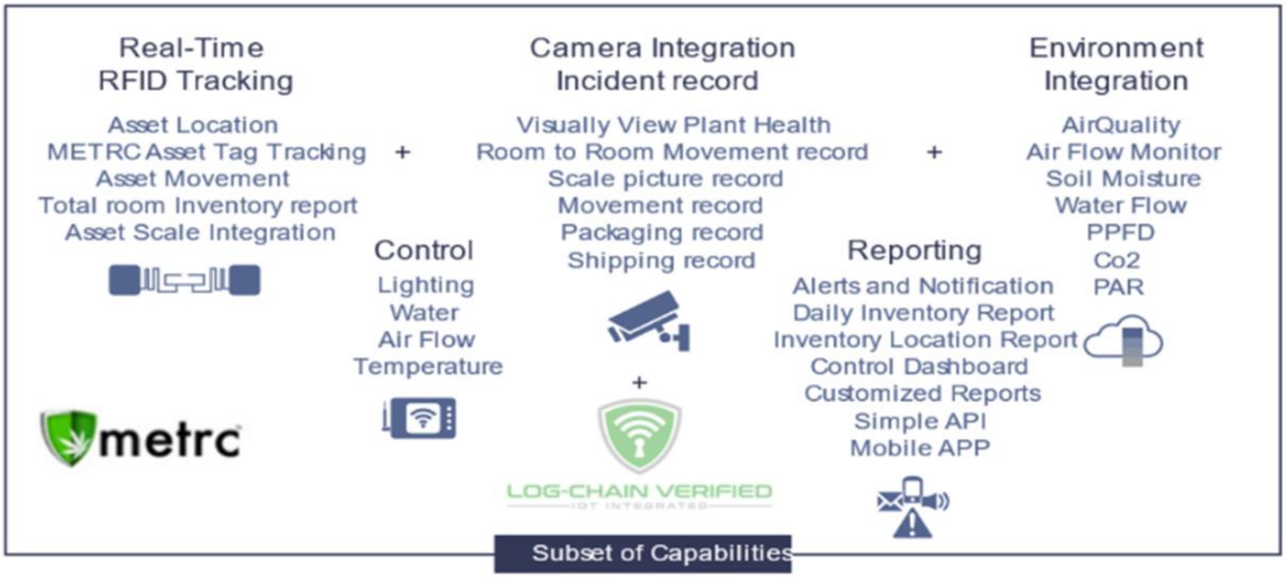


Fig. 14. Facility sensors and monitoring. Many of these sensors help in reducing facility operating costs.[4]

Many of the same sensors can be used for industrial and commercial buildings. Motion sensors are essential; turning off lights when unnecessary saves additional energy and lowers OpEx. Moreover, by collecting real-time data, building management systems can adjust heating, cooling, lighting, and ventilation based on actual usage. This prevents unnecessary energy consumption and lowers utility bills. To reduce CapEx, sensors can use LoRa wireless communication to reduce wiring and allow for sensor positioning as needed.

As in horticulture, power factor and efficiency come into play to reduce OpEx in commercial installations, but the difference is more extreme for building lights as they are lower in power (in the 20-W to 100-W range, versus horticulture lights of 300 W to 1000 W). As we have observed, there are also many more lights for commercial buildings due to the higher square footage.

The problem with the lower wattage lights and drivers is that the efficiency is typically 90%, and the power factor is 0.95 at best. With remote power at an efficiency of 95% and a power factor of 0.99, a 10% utility savings can easily be realized.

Fig. 15 shows where the energy is used with 10% for lighting, 32% for heating and 9% for cooling. A total of 51%, therefore, can be reduced using remote centralized drivers.

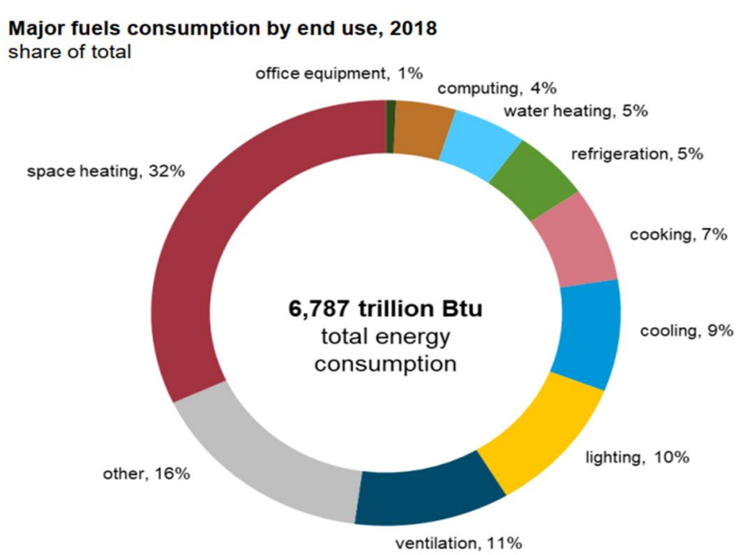


Fig. 15. Using remote centralized drivers for industrial and commercial lighting, cost savings can be had for lighting, heating, and cooling.[3]

Moving the drivers from the workspace removes the extra heat so lowering the cooling needed, while heating cost can also be reduced by allowing heat from the remote driver's area to be exhausted either outside or back to the work area when necessary (Fig. 16). The lighting cost will also be reduced because of the difference in efficiency and power factor.

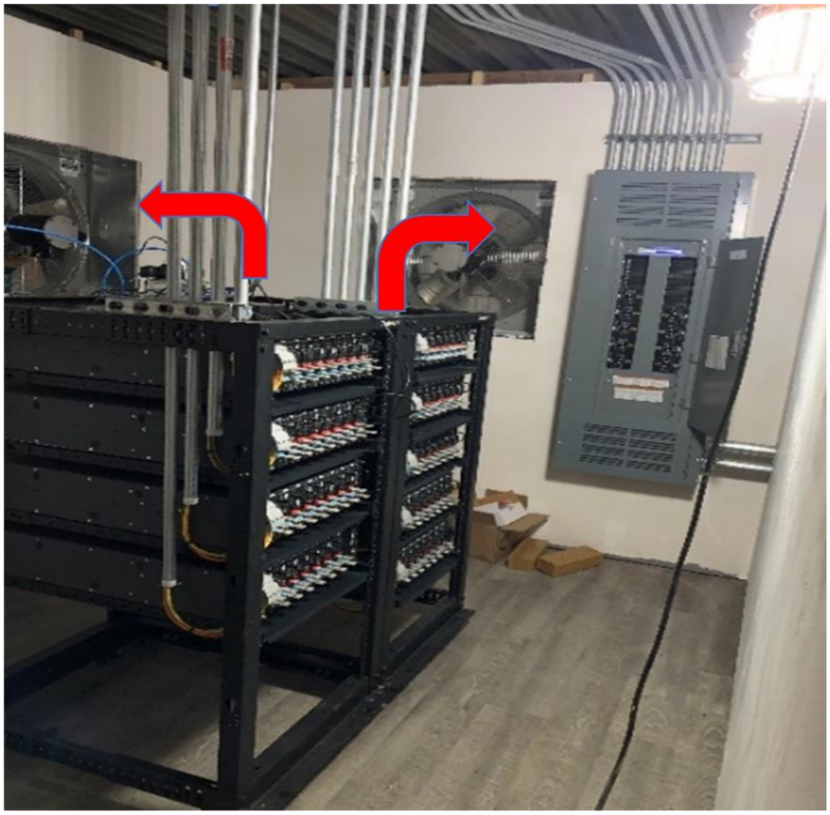


Fig. 16. Remote drive heat can be exhausted outside the facility or back into the workspace.

A Case Study

Advanced Energy is working on a commercial building using 32-V, 90-W lights with eight lights in series, giving a working voltage of 8 x 32 V = 256 Vdc; this keeps the wire size small. With one driver, it is possible to power four sets of lights or 32 individual lights. A single shelf has three drivers and can, therefore, power 96 lights.

Fig. 17 shows a block diagram in which eight lights are grouped to get a working voltage of 256 Vdc, keeping the wire size small and lowering the cost of CapEx. The architecture simplifies the installation with one ac input connection vs. 96 ac connections. Ten circuit breakers would be needed at ten lights per circuit breaker vs. one with a remote power shelf. The weight of 96 drivers is also removed from the structure, as is the heat generated.

Another benefit is that the remote driver can be connected to emergency backup power; when ac power is lost, the lights can be dimmed to 20% to slowly discharge the batteries. With thousands of lights, the hot swap features would allow a swift and safe replacement if a driver were to fail. With most failures being due to the driver, this becomes a significant benefit.

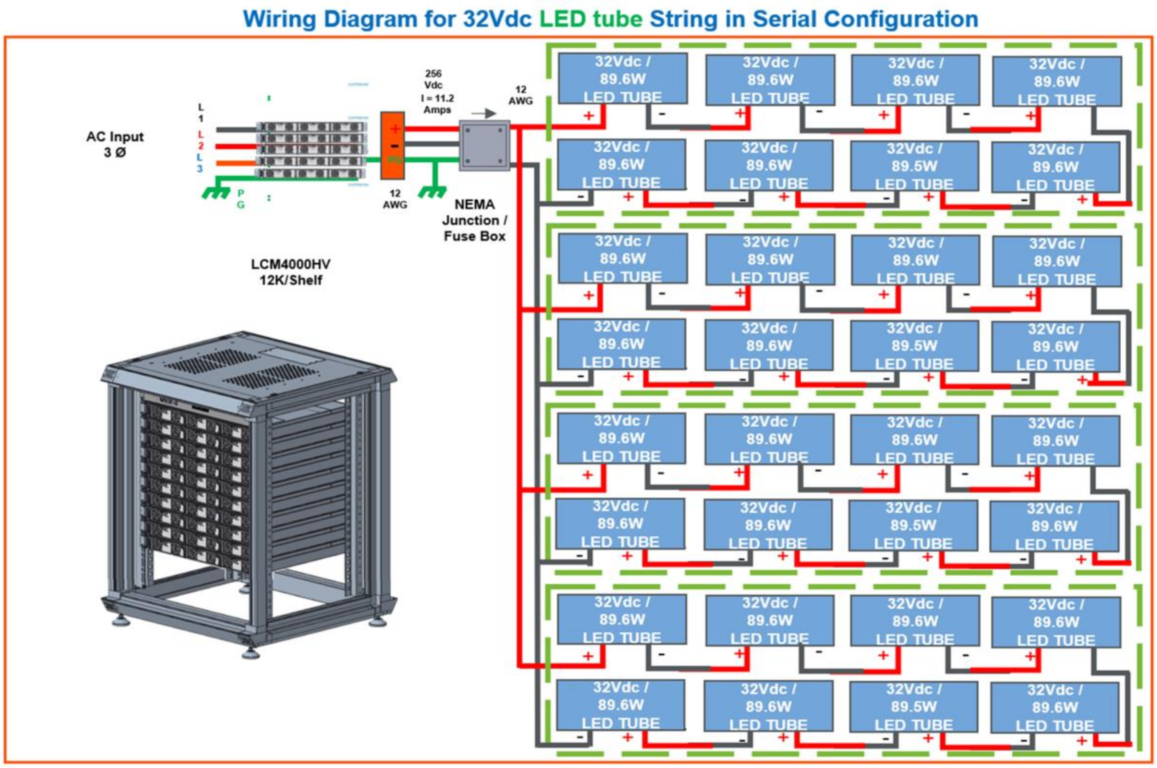


Fig. 17. Factory lighting using remote power. One driver powers four sets of eight lights as pictured here. With three drivers on a single shelf, 96 lights can be powered resulting in an ac input reduction of 96:1 and a circuit breaker reduction of 10:1.

We can summarize commercial and industrial LED light problems and solutions using remote centralized drivers as follows:

- A single-phase driver per light fixture is the weakest reliability link.
  Solution: A remote centralized driver is a three-phase system that will balance the phases.

- Complex wiring and phase balance with three-phase facility power.
  Solution: The remote centralized driver is three-phase and will use 4 to 10 times fewer circuit breakers for more straightforward wiring and installation.

- Added weight per light fixture with LED driver (retrofit might require ceiling reinforcement).
  Solution: Drivers add 1 to 9 lbs of weight per light. Remote centralized driver architectures remove all the local drivers and move the power to a remote location, eliminating the extra weight on the structure.

- Added heat per light fixture in the ceiling, needing more HVAC.
  Solution: With the drivers removed from the lights, the extra heat produced by the power loss in the drivers is eliminated.

- Repair/replacement of driver must be done in the ceiling on a ladder or using a lift and a highly paid repair specialist, possibly disrupting store hours.
  Solution: Remote centralized drivers are an intelligent, hot-plug solution. If any issue arises, an email/text is sent, and if the failure occurs, a driver can be replaced in minutes vs. hours or days.

Conclusion

Centralized power for horticulture and building LED lighting share similarities due to their focus on efficient and distributed energy management. Centralized power systems for horticulture and LED lighting are designed to minimize energy waste by ensuring that the right amount of light is delivered precisely where needed, reducing light spills and unnecessary energy consumption. With so many benefits, usage will continue to increase as the commercial and industrial sectors become aware of the benefits. They will then “bend” their energy curve just as data centers have done.

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About The Author

Frank Cirolia is a field application engineer at Advanced Energy. He has over 40 years of experience in the power supply industry, working for companies such as Lockheed, Unipower, ABB, and Delta. Frank has worked closely with growers and horticultural integrators in the U.S. and Canada, as they adopt, LED lighting and move to a centralized driver approach.