

## Electrical Power Options for Linear Replacement Lamps

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There are more than 6 billion fluorescent sockets in the world, and the cost and efficiency of LEDs have improved to the point that it is now economically sensible to replace those tubes--and their accompanying ballasts--with an LED-based lighting solution.

The installed base of fluorescent tubes and ballasts awaiting replacement is far from uniform. Older T12 fluorescent tubes generally use magnetic ballasts, while the newer and narrower T8 tubes use electronic ballasts. In turn, there are several types of electronic ballasts, including instant start, rapid start, program start, and dimming ballasts. Instant start ballasts are the least expensive, but their higher voltage operation dramatically shortens the life of the lamp with frequent power cycling. They also use alternative wiring in the lamp-holder sockets of the fixtures that short (“shunt”) the two pins together. The other ballast types use the heaters connected to the pins and require non-shunted sockets.



There are three basic power options for replacing fluorescent tubes with an LED solution, and they each come with trade-offs.

One option is to simply use the existing ballast. While this option is the easiest to install, it can lead to problems of incompatibility, low efficiency, increased maintenance and additional cost. In order to use the existing ballast (which provides alternating current) to power an LED lamp (which requires direct current), special rectifying circuitry must be included within the lamp. In the case of a rapid start and program start ballasts, additional circuitry in the lamp may also be needed to handle the heater circuit. To date, universal circuitry to enable a single version of a lamp that works with all ballast types appears to have eluded lamp manufacturers, and it may well not be cost-effective. Unfortunately, multiple types of ballasts can often be found in a single location (even in the same fixture!), and the specific type of ballast in a fixture is generally not identifiable until the electrician is standing on a ladder, attempting an installation.

In addition to the necessary circuitry required in a lamp to enable it to run on an existing ballast, there are additional costs--such as higher rated flame retardant and insulating materials--associated with designing a ballast-driven lamp for Class 1 (high voltage) versus Class 2 (low voltage) certification. Finally, placing a new LED lamp in a fixture with an existing ballast of uncertain age, efficiency and ballast factor may lead to increased maintenance costs and disappointing results for this hybrid configuration.

A second option for replacing fluorescent tubes with an LED-based solution is to bypass or remove the existing ballast and incorporate a driver within the lamp itself. Again, there are trade-offs. Thermally, LEDs and driver components work better and last longer when kept cool. Placing the driver inside a tube, alongside the LEDs, has heat implications for both the driver and the LEDs. In addition, rather than sharing an external power source across multiple lamps, a solution requiring a separate driver for each lamp may be both less efficient and more costly. Space constraints may also lead to limited filtering, causing annoying light flicker at 120Hz. Moreover, due to the limitation of the existing bi-pin connectors to the fixture, implementing dimming or daylight harvest controls with an internal driver configuration is generally not feasible.

For safety reasons, certification rules generally require both high voltage connections to be at the same end of the lamp. This requirement means that lamps with internal drivers will likely not work in fixtures with shunted lamp holders--that is, in fixtures where instant start ballasts were previously used. Again, this incompatibility is usually discovered only at the time of installation.

The third option for replacing fluorescent tubes with LED lamps is to replace the existing ballast with an external driver. While this option adds some additional installation time (although no more than a ballast replacement itself), when all factors are considered, we believe this solution to be optimal. With respect to the overall efficiency of the solution, a power supply specifically designed to regulate the DC current for a particular LED lamp can be made more efficient than any hit-or-miss hybrid configuration. As a result, it provides the most energy savings and robust operation.

With an external driver configuration, it is practical to operate the lamp at low voltage and allow direct lamp connection to both shunted and non-shunted sockets. Depending on the application requirements, it is also practical to add controls such as 0-10v dimming, occupancy sensing, demand response and daylight harvesting for comfort and additional energy savings.

In conclusion, as lighting technology has developed, so too has the variety and sophistication of delivering the electrical power to the light. While it is possible to mix and match some technologies, there are tradeoffs in efficiency, cost, quality, safety and capability. The best solutions tend to be those specifically-designed for the type of lamp and its intended use.

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