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SmartLighting

A Quick And Low Cost Solution To

Save 80% of Energy

In Open-Plan Office Lighting

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In Open-Plan Office Lighting

Executive Summary

The Open-Plan Office (aka "Open Office") layout is widely adopted in many office buildings worldwide. Yet, the nature of open offices does not relate well to energy saving practices and lighting control solutions available today. As such, even current Building Energy Codes such as the ASHRAE 90.1, IECC and California Title 24 that are endorsed and enforced by various local governments, are unable to adequately address the colossal lighting energy wastage in today's modern big, open office buildings.

This paper enumerates the problems associated with open office lighting control, and proposes a technological solution to solve these problems.

The solution involves converting the ubiquitous fluorescent lighting used in almost all existing open-plan offices into dimmable LED lighting, and taking advantage of the energy-saving dimmability with a smart lighting controller integrated into each luminaire. The converted smart LED light is able to automatically dim the light gently and smoothly :

- in areas which remain unoccupied longer than a specified period of time
- and proportionately according to amount of daylight coming through windows and skylights

The proposed solution aims to achieve the following benefits:

a) Significantly reduce electricity bills by automatically and intelligently minimizing lighting energy wastage in sections of existing open-plan offices which are unoccupied or where and when daylight is available to supplement work area lighting needs

b) Granular lighting management at individual luminaire level without causing discomfort or annoyance to other occupants who share the same open office.

c) Improve occupants' comfort by automatically maintaining a consistent brightness level for each occupied space.

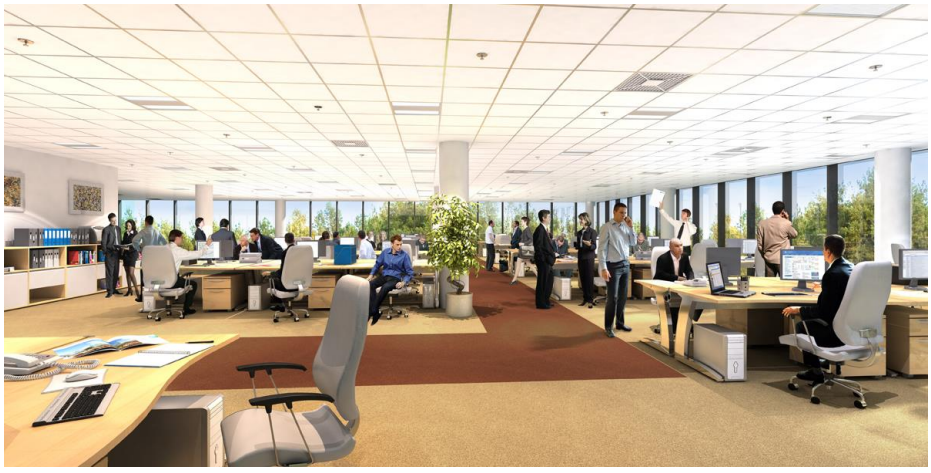
This paper also reviews (in Section VI) how the proposed luminaire-level controlled, smart LED lighting can be implemented using a newly available, low-cost LED conversion kit with an attached smart lighting controller. Such a conversion kit can convert any 1 to 4-tube fluorescent fixture within 10 minutes.

Since no alteration of mains circuit or above-ceiling rewiring is required, the proposed energy saving solution can thus be quickly implemented in any open plan office with almost no disruption to the day-to-day operation. Best of all, the quick fix will achieve more than 80% energy saving instantly.

Contents

I. Problem : Lighting Energy Wastage in Open Offices

Electric energy used for lighting up work spaces is a major component of energy usage in modern offices. To reduce energy wastage in homes and offices, energy codes such as the ASHRAE 90.1, IECC and California Title 24 have been adopted and enforced by various local governments. These energy codes define the lighting power limits and control strategies for all types of **enclosed** spaces in a building. However, even the most effective energy saving strategies defined in these energy codes are often not applicable to large, open-plan offices commonly found in government and large corporations.

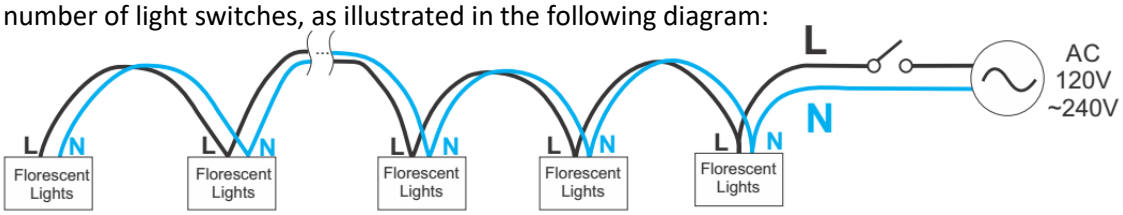


An open-plan office (aka "open office") is defined as a large area of work space without floor-to-ceiling height partitions. Such large spaces are mostly populated by work desks and / or modular cubicles. The open office layout offers much flexibility which justify its continued popularity.

However, from an energy efficiency perspective, the way lighting is installed and managed in open offices represents a colossal wastage of electric energy.

II. Traditional Open Office Lighting Plan

Open offices come in many sizes. The larger ones occupy several thousand square feet space. The majority are still lit with an array of fluorescent troffer lights or banks of suspended fluorescent fixtures, all typically wired in parallel to one switch, or in large groups to a small number of light switches, as illustrated in the following diagram:



It is not uncommon therefore, to have to turn a switch that turns on lighting for the **entire** office or half the office even if it were occupied by just a single employee.

III. Why Traditional Open Office Lighting Plan Wastes Energy

Generally, in an open office, all the lights are turned ON **before the first worker arrives**, and all the lights are only turned OFF **after the last person leaves** . Such a simple lighting arrangement may have worked well in the past, when most workers enter and leave their office at more or less fixed times of the day (e.g. 9am to 5pm). However, this is no longer the case in recent times, due to work culture changes :

a) Flexible hours. Some workers may work into the night because they start late, others may work on weekends.
b) Mobile work force. A number of workers may work remotely from home on some days, others may be at client sites or on the road certain days of the week, leaving their work stations unoccupied during these periods.
c) Flexible workspace assignment. More workers today are not assigned fixed work stations, but will take whatever space not already occupied, to do their work.
d) Daylit sections. Large open offices often mean sections of the area are in proximity to daylight from windows and occasionally, skylight covers. These areas are often unnecessarily overlit.

The above changes in work culture mean that space usage and correspondingly, light and energy usage, is highly inefficient and presents enormous opportunity for wastage reduction.

IV. Why Aren't Open Offices Wired into Multiple Sections?

There a re several reasons why a large open office is seldom divided into many smaller lighting sections that can be switched ON or OFF independently :

a) Too many light switches, more complicated wiring, high wiring cost during installation..

b) Workers will not remember which switch controls which lights; no incentive to turn lights off when leaving (someone else will do it).

c) Without subtle graduated transitions, lights turning ON and OFF in individual sections in a shared office will likely distract/annoy co-workers in neighboring sections

d) Fluorescent lighting does not offer economical daylight harvesting options to take advantage of separate day-lit sections.

For the reasons above, modern building energy codes such as the ASHRAE 90.1-2013 continue to permit an open office area as large as 10,000 ft^2 in a large building to be controlled as a single zone, albeit with some requirement for automatic-OFF after office hours. Consequently, many existing office buildings also continue to use fluorescent lighting fixtures, without any advanced control strategies. This is unfortunate as there are real opportunities to vastly reduce lighting energy consumption with new, advanced lighting control solution proposed in the next section.

V. Solution To Reduce Energy Wastage in Open Offices

There are many solutions that can be considered with today's technology. They vary in concept, complexity, planning effort, equipment cost, installation cost, dependency on ongoing vendor support. An acceptable solution must address all the above and as such, to date, only the companies with significant budgets or/and a mission towards zero-net energy commitment have invested in eliminating wastage that highlighted in this paper.

To appeal to industry more widely, the solution proposed in this paper is predicated on the following objectives :

1. Adopts lighting technology with
    a. substantially higher efficacy than existing florescent lights
    b. dimmability that is proportional to energy usage and that is easily controlled
2. Applies energy-saving controls to as small an operating unit as possible
3. Practical for implementation in existing offices and for standard light fixtures
4. Costs less both for equipment and installation than solutions available today (no above ceiling rewiring – no worry about hazardous materials evaluation such as asbestos)
5. Minimal planning and implementation disruption to user location than with solutions today (quick onsite installation process is important)

In this paper, several solutions were considered and compared :

IMPROVEMENTS & BENEFITS	A New LED Type A Tubes (non-dimmable, manual ON/OFF Only)	B New LED Panels Local Zone Sensors and Central Control	C New LED Panels Independent Local Zone Sensors & Controllers	D Retrofit LED conversion Independent Luminaire-integrated sensor and
Energy Savings	35% - 40%	75% - 85%	75% - 85%	75% - 90%
Hardware Cost	Low	High	Low-Medium	Low
Installation Complexity and Cost	Low	High	Low-Medium	Low
ASHRAE Code Compliance	No compliance to controls requirement	Yes	Yes	Yes
Network Monitoring and Reporting	n.a.	Yes	Yes	n.a.
Incentive Program Qualification	n.a.	Yes	Yes	Yes
ROI (1 for quickest)	2	3	2	1

From the above table, the solution that makes the most sense for majority of open offices would be D, where monitoring and reporting (and scheduling) are secondary in consideration of total cost add. Otherwise, Solution C would be a viable next alternative. Solution B is too expensive for most businesses and due to overhead time and costs involved in both planning and implementation, is challenging for existing building environments. Solution A is tempting in terms of cost and simplicity, but leaves much on the table in terms of energy savings and falls short in terms of ROI; also, where/when not exempted from code compliance, Solution A also falls short due to lack of intelligent controls.

Along the lines of D, the solution recommended is outlined as follows**:**

1) **Configurability**. The luminaire level lighting controller on each retrofitted fixture must allow user to adjust to the optimal working brightness for its lighting area. This prevents over-lighting (especially when the luminaire is new) that will lead to wasted energy. Offline configurability would also facilitate installation expediency onsite.

2) **Daylight Harvesting and proportional controls**. When the lighting zone receives daylight from windows or skylight, it gradually dims the luminaire to a low light level to save unnecessary wasted energy

3) **Smart vacancy/occupancy controls** (embedded sensor/controller). When there is no occupant in the lighting zone for more than 15 to 30 minutes, the luminaire will very gradually and smoothly dim down to a low light level that is not noticeable to the neighboring occupants (typically around 25 to 50% of full brightness) to save energy. As soon as an occupant is detected, the luminaire will again slowly and smoothly brighten up to the preset working brightness.

4) **Comfortable light level transitions**. To prevent the dimming actions of the lighting controller from causing annoyance to other occupants who are still in their own lighting zones in an open office, the lighting controller must dim and brighten the light very smoothly and gradually, making the changes unnoticeable by other occupants.

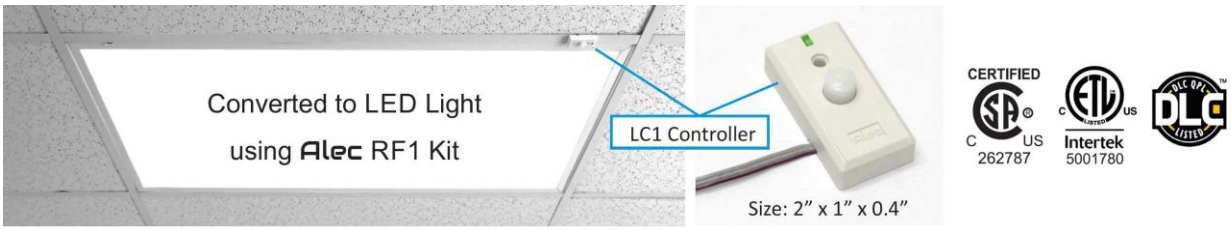
5) **Quick conversion Installation, no/low disruption to operation.** A one-for-one fixture conversion process with no above-ceiling installation work would greatly reduce disruption to existing operations.

6) **Low Equipment, Overall Cost, High ROI.** A well-packaged solution hardware kit need not be expensive. Low complexity resulting in low installation cost, as well as not having a need to dispose of bulky existing fixtures simply translates into the very low overall cost and the highest Return-on-Investment.

7) **Scheduling solution**. The mains circuit power to the open office can still be controlled by a time-clock as per stipulated by the energy codes. The individual luminaire lighting controllers simply further reduce the power consumption of the open office by an additional 30 ~ 50% compared to uncontrolled fully lighted spaces. Coupled with the higher efficacy of LED lighting, a smart retrofit as described in this article can readily save 75% to 90% of the lighting energy currently consumed by fluorescent lighting in open offices.

VI. Implementing The Proposed Solution Using Alec Smart LED Conversion Kit

The solution described above was reviewed with an available off-the-shelf type conversion kit from ALEC SmartLighting, a division of Triangle Research International Inc. , a Canadian company with deep roots in industrial automation and control. ALEC SmartLighting has developed a uniquely suitable lighting controller that works with their high efficacy fluorescent-to-LED retrofit kit. The result is the **ALEC Smart LED Conversion kit** (ALEC-SLC). The ALEC-SLC is extremely competitively priced, takes less than 10 minutes per fixture conversion, and even allows some flexibility for specific sensor placement. Due to the percentage of time the LED lights spend in low voltage DIM mode with smart control, their lamp life-span is substantially extended beyond L70 ratings.



A converted 2' x 4' Smart LED Light from an existing fluorescent fixture

VII. About Triangle Research International, Inc./ Alec SmartLighting

Triangle Research International (TRi), founded in 1993, is an embedded programmable logic controller (PLC) specialist. Thousands of its PLC products have been used in applications that run 24/7 in harsh industrial environment for more than 25 years.

In 2016, TRi started to leverage its deep industrial automation expertise to develop a new line of purpose-built PLCs, dedicated to intelligent lighting control. The resulting **Alec SmartLighting controller** solutions help customers meet new and exacting energy-saving building codes that are increasing demanded by many jurisdictions around the world.

Alec SmartLighting lighting control system has been selected by the Federal Government of Canada under its Build In Canada Innovation Program (BCIP) for pilot installations in multiple government's facilities in 2019.

For more details about **Alec SLC,** please visit: http://www.aleccontrol.com/SLC

Email: info@aleccontrol.com Tel: 1-877-874-7527 (BC, Canada)

VIII. Appendix: Comparison of T12, T8, TLED vs Alec Smart LED Conversion Kit

Application: **Open Plan Office:** **60 hrs/Week** = 3120 hrs / year. Lights dim after vacancy time-out.

Currently Installed Fixture Type: 4-Tube Fluorescent Lamps

Local Electricity Rate - Please enter your local rate (include all taxes and fees) $0.20 /kWh

1. Technology Comparison (Assume Ballast Factor = 1.0. **T8-LED (17W)** power adjusted to ballast factor = 22W)

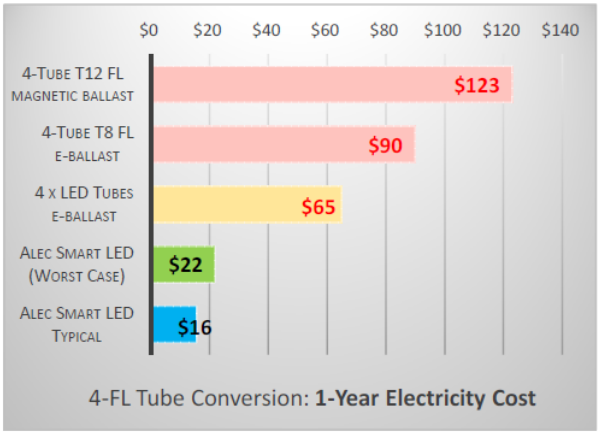
	T12 FL-40W magnetic ballast	T8 FL-32W e-ballast	T8-LED Tube-17W e-ballast factored	Alec Smart LED Conversion (SLC) Model SLC-24F40WDXXK
Lamp Power : 4-Tube FL	40Wx4 = 160W	32Wx4 = 128W	22W x 4 = 88W	1 to 40W[1]
Automatic Dimming	No	No	No	**YES** (0-100%)
Tube life	15000 hrs	25000 hrs	50000 hrs (L70)	> 50000 hrs
Ballast life	50000 hrs	20000 hrs	20000 hrs	n/a

[1] *The maximum power limit can be set by the software app*

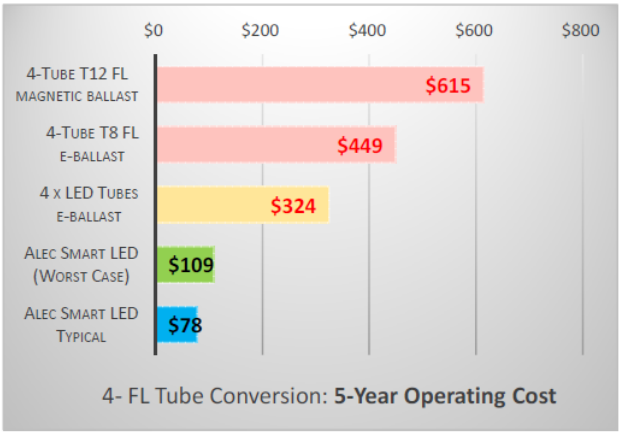
2. Energy Evaluation:

	4-Tube T12 FL magnetic ballast	4-Tube T8 FL e-ballast	4 x LED Tubes e-ballast	Alec Smart LED (Worst Case)	Alec Smart LED Typical
Operating Conditons					
Annual Operating Hours	3120	3120	3120	3120	3120
Ballast Factor	1.00	1.00	1.00	-	-
Ballast power lost[2]	37W	16W	16W	-	-
Maximum power (occupied)	160W	128W	88W	40W	40W
Minimum power (vacant or with daylight)	160W	128W	88W	20W	10W
% of time the light @ Full Brightness	100%	100%	100%	75%	50%
Average power	197W	144W	104W	**35.0W**	**25.0W**
1-year Operating cost					
Total Energy (kWh)	615 kWh	449 kWh	324 kWh	109 kWh	78 kWh
Electricity Cost @rate: $0.20/kWh	$123	$90	$65	$22	$16
5-year Operating cost					
Electricity Cost	$615	$449	$324	$109	$78
No. of ballast replaced	0	0	0	0	0
No. of tubes replaced	0	0	0	0	0
Near end of life after 5 years	No	No	No	**No**	**No**
Ballast replacement (parts+labour)	$0	$0	$0	$0	$0
Tube replacement (parts+labour)	$0	$0	$0	0	0
Total 5-year Operating Costs	$615	$449	$324	**$109**	**$78**

[2] *https://www.ehow.com/info_12210865_much-wattage-ballast-lose.html*



4-FL Tube Conversion: **1-Year Electricity Cost**



4- FL Tube Conversion: **5-Year Operating Cost**