

Review of Energy Technologies and Policy Research

2014 Vol. 1, No. 2, pp. 50-55

ISSN(e): 2313-7983

ISSN(p): 2409-2134

DOI: 10.18488/journal.77/2014.1.2/77.2.50.55

© 2014 Conscientia Beam. All Rights Reserved.



THE ROLE OF LED'S IN MEETING CHINA'S BUILDING CODE REQUIREMENT OF 50% IMPROVED ENERGY EFFICIENCY

Craig Seidelson¹

¹Associate Professor Washington State University, Sr. Visiting Research Fellow University of the West of England

ABSTRACT

China economic development continues to be marred by power shortages, extensive air pollution, and a strained water supply. These problems trace back to China's dependence on coal for power. At present coal consumption levels China stands in the way of maintaining global temperature increase from greenhouse gases below the 2°C target. Amid reports one-third of global energy end use takes place within buildings, China's National Energy Commission (NEC) has responded by requiring new buildings are at least 50% more energy efficient than those built in 2005. This research found LED's reduced overall building power use by approximately 19%. Payback was less than 2 years. In China the legally enforceable, mandatory standard for visual comfort (300 lux) and power density (11 watts/m²) are defined in GB5034-2004. However, since LED's experienced 28% more lumen decay over useful life than fluorescents, the lighting change resulted in savings only if local government officials permitted tasks lighting at reduced intensity.

Keywords: LED lighting, Energy efficiency, China office lighting, China lighting standards.

1. INTRODUCTION

China's Electricity Council (CEC) estimated in 2011 demand for power exceeded supply by 40 million Kwh. Shortages are expected to grow as CEC projects electricity demand by 2020 will be double 2010. Commercial and residential building construction is at the heart of China's need for more power.

Two ways China's National Energy Commission (NEC) is seeking to close the energy gap is by:

- (1) Requiring new buildings to be at least 50% more energy efficient than those built in 2005
- (2) Mandating 40-45% carbon emission cuts per unit of gross domestic product on 2005 levels by 2020 [1].

This paper determines for office space in China, "Is it economical to switch from fluorescent to LED lamps?" "And, if so, to what extent does the change meet NEC energy efficiency targets?"

2. BACKGROUND

The United Nations reports one-third of global energy end use takes place within buildings [2]. China leads the world in building with 6.5 trillion square meters under construction [3].

Coal fired power plants generate 70% of China's electricity. Coal combustion releases carbon dioxide (CO₂), sulfur dioxide, and nitrogen oxides. China is the world's single largest emitter of such "greenhouse gasses" [4]. One result is China's breathable air is strained to the point a Ministry of Environmental Protection report notes only 3 of 74 cities monitored meet minimum standards for air quality [5]. Even if additional coal supplies could be found and burned cleaner, China's coal mining and power generation industries already consume 17% of the nation's water. The United Nations estimates at least 80% of China's coal comes from regions where water supplies are either "stressed" or in "absolute scarcity." [6].

Failing to curb China's growing need for coal has ramifications beyond national black-outs, droughts and air pollution. It has been reported any attempt to maintain global temperature increase from greenhouse gases below 2°C cannot be achieved at China's present coal consumption [7]. Lighting is one key area where the NEC is mandating increases in energy efficiency and reductions in carbon footprint. With China outlawing the sale of incandescent bulbs in 2014, China's building sector is counting on LED lighting to achieve energy efficiency targets.

3. MATERIALS AND METHODS

A 2,500m² Chinese office space in this study was lit by 459 light fixtures. Each fixture consisted of three: 600mm long T8 florescent bulbs, ballasts, starters, and sockets (Figure 1).

Figure-1. Existing Florescent Lighting Fixture



A testing aim was to lower energy cost by lowering power density (watts/m²). The method used was to replace florescent lights with phosphorus coated light emitting diodes (PC-LED's). For the change to be considered successful, 3 deliverables needed to be achieved:

1. Match initial lighting design intensity (300 lux) and color rendering index (CRI) of 80

2. Reduce electricity consumption (and CO₂ equivalents¹) by at least 50%
3. Payback on LED investment less than 18 months

4. RESULTS

Existing T8 florescent bulbs were rated new at 1,025 lumens with a CRI of 80. Each bulb consumed 18 watts and each electric ballast 7 watts. Luminous efficacy (i.e. intensity divided by power) was 41 lumens / watt. With 3 bulbs and 3 ballasts per fixture, all 459 fixtures consumed 34.425 kW (yielding a 13.8 watts/m² power density). Operating 16 hours per day 300 days per year, florescent lights in the office consumed 165,240 kWh.

T8 PC-LED's were selected to fit existing florescent fixtures and sockets. Since LED's did not require starters and ballasts (but needed drivers to convert AC to DC power) fixtures were modified per Figure 2.

Figure-2. Florescent Fixture Modified to Accomodate LED's



LED's were rated 480 mA and, when new, emitted 750 lumens with a CRI of 80. Each LED (including electrical components) required 9 watts of power. Luminous efficacy was 83.3 lumens / watt. LED lighting consumed 12.39 kW (yielding a 5 watts/m² power density). Operating 16 hours per day 300 days per year, LED's consumed 59,486.4 kWh.

Given power savings and the 0.8 rmb / kWh industrial users paid in this part of China, switching to LED's saved approximately 85,000 rmb annually per Equation 1.

¹Equivalence adjusted carbon dioxide emission to also include greenhouse gases such as methane (CH₄) and nitrous oxide (N₂O).

$$(165,240 \text{ kwh} - 59,486 \text{ kwh}) * 0.8 \frac{\text{rmb}}{\text{kwh}} = 84,603 \text{ rmb/yr} \quad (1)$$

After applying a factor specific to how China generates power [8] the office space, per Equation 2, reduced CO₂ equivalents by 110.9 metric ton per year after switching to LED lights.

$$(165,240 \text{ kwh} - 59,486 \text{ kwh}) * 1.049 \text{ kg CO}_2/\text{kwh} = 110,936 \text{ kg CO}_2 \quad (2)$$

With each LED bulb (plus driver) costing 80 rmb, total investment, per Equation 3, was approximately 110,000 rmb.

$$\left(459 \text{ fixtures} * 3 \frac{\text{bulbs}}{\text{fixture}} * 80 \frac{\text{rmb}}{\text{bulb}}\right) = 110,160 \text{ rmb} \quad (3)$$

Equation 4 showed payback converting from fluorescent to LED lights was 16 months.

$$110,160 \text{ rmb investment} / 84,603 \text{ rmb savings per year} \quad (4)$$

5. ANALYSIS

LED conversion (at 83.3 lumens / watt) benefited from a 103% higher luminous efficacy compared to fluorescents. Results were typical (albeit at the high end of expected). For example, US Dept. of Energy findings in 2013 noted most PC-LED efficacies fell between 40 - 80 lumens / watt [9].

One reason LED payback was 2 months shorter than the 18 months needed was because T8 bulbs were selected to operate in existing florescent fixtures and sockets. New LED fixtures and sockets would have cost 60 rmb apiece installed. Without re- using the existing fixtures, LED conversion would have been 2 months longer than the required payback.

Most important to the payback was using the full rated life of LED lights. LED's do not burn out; lumens depreciate and light color emitted shifts over time. For example, a US Dept. of Energy study found while T8 fluorescents are typically 95% of initial intensity at the end of rated life LED's are only 70%. LED bulbs were rated at 40,000 hrs. Since the office space was lit 4,800 hrs per year, LED useful life was an additional 7 years (per Equation 5) after the 1.3 year payback on investment.

$$(40,000 \text{ hrs} / 4,800 \text{ hrs}) - 1.3 \text{ years} = 7.03 \text{ years} \quad (5)$$

In China the legally enforceable, mandatory standard for visual comfort (300 lux) and power density (11 watts/m²) are defined in GB5034-2004. Mandatory in China, however, is relative. It depends on how local Construction Bureau, Worker Safety Bureau, and Power Bureau officials interpret how regulations apply to individual companies in their region.

Management negotiated that when switching to LED's 300 lux was applicable *at time of installation*. This was based on two arguments. One, even after 30% lumen decay over useful LED life, intensity still exceeded OSHA regulations of 215 lux for computer workstations [10]. Two, prior studies found when visual discomfort was not a factor no causal link was found between office lighting and performance [11]. Approval for 300 lux at time of installation was a very important distinction. For example, in a prior work shop lighting study [12] product

inspection and machine operation required a constant 300 lux. When increasing installed LED capacity relative to fluorescents to account for higher lumen decay, fluorescents offered energy savings over LED's.

6. CONCLUSIONS

For the office space studied a conversion from fluorescents to LED's reduced electricity consumption (and CO₂ equivalents) by 64%.

It has been noted in commercial buildings 30% of electricity budget is spent on lighting [19]. LED lighting change, therefore, represented a 19.2% reduction in total building power and CO₂ equivalence. This was less than half the 50% reduction targeted by the NEC.

If existing fluorescent fixtures were re-used payback switching to LED's was 2 months shorter than the 18 months required in this study. If new fixtures were required, payback was 4 months longer.

Savings only occurred if LED's were used to their fully rated life. Since LED's experience 30% intensity loss over useful life, conversion from fluorescents depended on local government permitted reduced intensity task lighting.

This study is one of the very few in the building industry which has taken an energy savings directive from the Chinese government and quantified to what extent energy savings goals can be reached. Clearly, LED's are an important part in improving China's energy efficiency. But, to hit the NEC's target new buildings are at least 50% more energy efficient than those built in 2005 measures beyond LED conversion are needed.

REFERENCES

- [1] J. Qiu, "China gets tough on carbon," *Nature*, vol. 498, pp. 145-146, 2013.
- [2] P. Rode and R. Burdett, "Buildings: Investing in energy and resource efficiency," *United Nations Environmental Programme*, vol. 11, p. 7, 2011.
- [3] National Real Estate Development and Sales in the First Eleven Months of 2013, *National bureau of statistics of China* vol. 1: Beijing Press, 2013.
- [4] J. Olivier, G. Janssens-Maenhout, and J. Peters, "Trends in global CO₂ emissions," Report. PBL Netherlands Environmental Assessment Agency. ISSN# 1831-94242012.
- [5] E. Wong, "In China, breathing becomes a childhood risk," *New York Times*, [Accessed April 23, 2013], p. 1, 2014.
- [6] K. Hamlin, "China coal-fired economy dying of thirst as mines lack water," *Bloomberg News*, [Accessed May 28 2013], p. 9, 2013.
- [7] M. Forsythe, "China's coal dependency threatens efforts to curb warming," *The New York Times*, [Accessed June 1 2014], p. 6, 2014.
- [8] Intergovernmental Panel on Climate Change (Editor), *Climate change 2013 - The physical science basis. March 2014*: Cambridge University Press, 2014.
- [9] US Dept of Energy, "Building technologies program solid state lighting technology fact sheet," *Document # PNNL-SA-94206*, 2013.

- [10] Dept of Consumer and Business Services, "Evaluating your computer workstation," *Oregon OSHA Standards and Technical Resources Publication*. Available: <http://www.cbs.state.or.us/osha/pdf/pubs/1863.pdf> [Accessed April 10 2013].
- [11] P. R. Boyce, J. A. Veitch, G. R. Newsham, C. C. Jones, J. Heerwagen, M. Myer, and C. M. Hunter, "Lighting quality and office work: Two field simulation experiments," *Lighting Research & Technology*, vol. 38, pp. 191-223 2006.
- [12] C. Seidelson, "Lighting factory space in China: Cost of compliance with latest regulations," *International Journal of Innovative Research in Technology & Science*, vol. 1, pp. 66 – 70, 2013.
- [13] D. Nelson, "Energy efficient lighting," *National Institute of Building Science*. Available: <http://www.wbdg.org/resources/efficientlighting.php> [Accessed May 20 2013], 2010.

Views and opinions expressed in this article are the views and opinions of the author(s), Review of Energy Technologies and Policy Research shall not be responsible or answerable for any loss, damage or liability etc. caused in relation to/arising out of the use of the content.