Energy Efficiency Lighting System in South Africa for bigEE

Authors
Xianming Ye
CNES University of Pretoria
Approved by
SANEDI

06/2017

Table of contents

Abbreviations and Acronyms

ABBREVIATION/ACRONYM	DESCRIPTION
EE	Energy Efficiency
POET	Performance, Operation, Equipment and Technology
LED	Light-Emitting Diode
HID	High-Intensity Discharge
lm	Lumen
SANS	South African National Standards
CELMA	Federation of National Manufacturers Associations for luminaires and electrotechnical components for luminaires in the European Union (CELMA)
BAT	Best Available Technology

This document provides guidance on the state of the art efficient heating, ventilation and air conditioning (HVAC) systems and Energy Efficiency (EE) improvements to existing HVAC systems.

1 Introduction

Information on HVAC systems is provided in terms of the performance, operation, equipment and technology (POET) framework. When possible, the information is classified in to groups of South Africa best available technologies and practices and International best available technologies and practices. The feasibility of using energy efficiency technologies outlined in this report shall be evaluated based on the incremental investment costs incurred to achieve energy and energy cost saving. An easy and quick decision making indicator is the payback period. A maximum payback period should be fixed for each energy efficiency technology or optimal component design. The energy efficiency technology or optimal component design will be recommended if its payback period does not exceed the maximum payback period.

2 Lighting system technology

2.1 Energy efficiency lighting retrofitting

A. Best available practice (IEA, 2006):
   - Indoor lamp retrofitting: Replace inefficient lamp such as incandescent lamp, T8 Linear fluorescent lamp with energy efficient lighting such as Compact fluorescent lamp, LED lamp and T5 linear fluorescent lamp.
   - Outdoor lamp retrofitting: Replace Mercury-vapor lamps and Metal halide lamps with High-pressure sodium lamps. Replace inefficient HPS lamps with new energy efficiency HPS lamps. Use solar driven lighting system if it is possible.
   - Electronic ballast: Replace the magnetic and hybrid ballast with high efficiency electronic ballast.
   - Luminaire reflector: Old and degraded luminaires that cannot be rectified by cleaning alone are generally excellent reflector retrofit candidates.

2.2 Recommendation

Best available practice shall be used subject to financial feasibility and technical suitability in plant and mining area.

2.3 Automatic lighting control system up-grading

A. Best available practice (IEA, 2006): Upgrade manual lighting control system with automatic lighting control system such as centralized lighting control system.
   - Indoor lighting control: Centralized controls are also known as building automation systems, and if their primary function is energy management they are known as building energy management systems (BEMS). BEMS, systems could incorporate a range of energy-management functions beyond just lighting, or they could be dedicated lighting controls. Such systems can be programmed to control lighting throughout the day, depending on building-use patterns and daylight availability.
   - Outdoor lighting control: Photosensor, motion sensor and timer can be applied to outdoor lighting system.

2.3.1 Recommendation

Best available practice shall be used.

3 Lighting system specifications and maintenance

3.1 Lamp efficacy/efficiency

A. Best available practice (IEA, 2006; Narendran, 2009; USDOE, 2017):
   - Linear fluorescent lamp: 65-105 lm/W;
   - Compact fluorescent lamp: 25-60 lm/W;
   - Metal halide lamp: 47-105 lm/W;
   - Ceramic metal halide lamp: 67-104 lm/W;
   - High-pressure sodium lamp: 70-120 lm/W;
   - Low-pressure sodium lamp: 120-200 lm/W;
   - LED lamp: 10-120 lm/W.

B. International Standard:
   - Class A, A+ and A++. EU Regulation (EU, 2012)
   - Energy Star Certified lamp.

C. National Standard-SANS 475 (SANS, 2017b): Class A.

3.1.1 Recommendation

International Standard and National Standard shall be applied due to reduced energy consumption. The above lamps can be applied in different circumstances. In any case, the lamp with highest efficacy/efficiency should be considered subject to financial feasibility and technical suitability in plant and mining area.

3.2Lamp lifetime

A. Best available practice (IEA, 2006; Narendran, 2009; USDOE, 2017):
   - Linear fluorescent lamp: 20,000-30,000 hours;
   - Compact fluorescent lamp: 6000-10,000 hours;
   - Metal halide lamp: 6000-20,000 hours;
   - Ceramic metal halide lamp: 6000-15,000 hours;
   - High-pressure sodium lamp: 5000-30,000 hours;
   - Low-pressure sodium lamp: 10,000-16,000 hours;
   - LED lamp: 35,000-50,000.

B. International Standard: Energy Star Certified lamp.

C. National Standard-SANS 475 (SANS, 2017): Class A.

3.2.1 Recommendation

Best available practice and National Standard shall be used due to a sustained energy performance. The suitable energy efficient lamp with longest lifetime shall be considered subject to financial feasibility.

3.3Lamp nominal power

A. Best available practice (Philips, 2017; OSRAM, 2017):
   - Linear fluorescent lamp: 4-80W;
   - Compact fluorescent lamp: 5-145W;
   - Metal halide lamp (HID): 70-2081W;
   - Ceramic metal halide lamp (HID): 20-401W;
   - High-pressure sodium lamp (HID): 50-1001W;
   - Low-pressure sodium lamp: 18-180W;
   - LED lamp: 1-75W.

3.3.1 Recommendation

Best available practice to be considered depending on the market availability.

3.4Ballast/Driver efficiency

A. International Standard-CELMA (CELMA, 2009):
   - Ballast for fluorescent lamp: Energy Efficiency Index in Class A2, A2BAT and A1BAT,
   - Ballast for HID lamp: Energy Efficiency Index in Class A1 and A2.

3.4.1 Recommendation

International Standard for high-energy efficiency.

3.5Light fixture and luminaires efficiency

A. International Standard: Class A, A+, and A++. EU Regulation (EU, 2012)
B. National Standard-SANS 475 (SANS, 2017): Class A.

3.5.1 Recommendation

International Standard and National Standard for high energy efficiency: The fixture and luminaires in the same class with highest efficiency (lm/W) shall be considered.

3.6Application of luminaires

A. Best available practice:
   - Highbay Luminaires: For mounting heights of 10 meters and higher above the working level, Highbay Luminaires shall be used. Highbay luminaires shall not be of the open ventilated type. The reflector shall be of the"Alglas" finished multi-faceted type chemically polished aluminum. Luminaires to be equipped with E40 lamp holders. Only 940 Watt (141000 lumen) Xenon Sodium elliptical lamps shall be used. Note: The 360 Watt (475,00 lumen) unit shall only be provided in cases where the 940 Watt unit is impractical due to glare factor problems. Control gear shall be mounted within one metre of the luminaires.
   - Lowbay Luminaires: For mounting height between 5 meters to 10 meters above working level, Lowbay Luminaires shall be used. Lowbay luminaires shall not be of the open ventilated type. The reflector shall be of the "Alglas" finished multi-faceted type chemically polished aluminum. The luminaires is to be complete with integral control gear. Only 220 Watt (29,500 lumen) /360 Watt (47,500 lumen) Xenon Sodium elliptical lamps shall be used.
   - Well Glass Luminaires: The luminaire shall consist of a cylindrical, electrostatic epoxy coated, cast aluminum upper housing and a high thermal shock-resistant borosilicate glass diffuser secured to the housing by means of a slotted ring, which is fastened with three stainless steel screws. This luminaire is to comply with an IP66 enclosure. Only 110 Watt (11,000 lumen/220 Watt (26,500 lumen) Xenon Sodium elliptical lamps and suitable control gear shall be used.

- Luminaires: The luminaires consist of an electrostatic epoxy coated cast aluminum upper housing and a borosilicate glass diffuser. This luminaire is to comply with an IP66 enclosure. Only 75 Watt (6,500 lumen) Xenon Sodium elliptical lamps and suitable control gear shall be used.
- Fluorescent Fittings: Fluorescent fittings shall conform to SANS 1119 and shall be equipped with switch start ballasts and electronic starters. Where possible, lamp holders shall be of the telescopic type. Lamps shall conform to the SANS colour designation No. 2, and of the 26 mm "Power saving" type.
- Fittings used in dusty conditions and hydraulic rooms shall comply with an IP66 enclosure. Explosion proof fittings shall be applied in battery rooms.
- The following standard fittings shall be used:
  I. 1,500 mm length; (single or double tube)
  II. 1,200 mm length only where 1,500 mm length cannot be used;
  III. 600 mm length, single type with galvanised fittings complete with hinged protective guards shall only be used in cable tunnels.
- Floodlights: Floodlights shall be of the totally enclosed type. Access to the lamp shall be possible without disturbing the focus and direction adjustment. Only 400 Watt (50,000 lumen)/940 Watt (1,48,000 lumen) Xenon Sodium tubular lamps and suitable control gear shall be used except where special applications require halogen due to light spectrum required. This luminaire is to comply with an IP66 enclosure.
- Streetlights: Streetlights shall be of the totally enclosed type and comply with IP55 and shall be complete with 135 Watt "Sox" lamp and tapped control gear

3.6.1 Recommendation

N/A.

3.7 Control gear

A. Best available practice:
   - Automatic switching: High bay and outside lighting systems shall be provided with automatic switching (Daylight switch control). This shall be arranged to switch the lights off during daytime when natural light is sufficient and to switch on the lights whenever the level of natural light falls below a predetermined value. Provision shall be made for a manual (lockable) override of the automatic switching system.
   - Remote Control Gear: Control gear for gas discharge fittings shall be matched with the lamps. The control gear shall contain power factor correction capacitors and shall be mounted in weatherproof boxes suitable for remote mounting.

3.7.1 Recommendation

N/A.

3.8Lighting masts

A. Best available practice:
   - Street lighting: 9-meter poles shall be used.
   - Area lighting: High mast lighting with masts between 15 meters and 40 meters high are normally used for this purpose.

3.8.1 Recommendation

N/A.

3.9Illumination level requirement

A. Best available practice:

Generic Area	Standard	Source of Standard
Outside Areas		
Conveyor Head ,Tail Take-up and loading points	100 Lux	OHSAct **(**Power stations**)**
Conveyor Walkway's	50 Lux	OHSAct **(**Power stations**)**
Conveyors	10 Lux	OHSAct (Outside area's)
Storage	5 Lux	OHSAct (Outside area's)
Roads: rail and road crossings	20 Lux	SANS 10389-1
Parking (Mining, high Risk)	20 Lux	SANS 10389-1
Parking (Other)	5 Lux	SANS 10389-1
Walkways and Staircases	20 Lux	OHSAct (Outside area's)
Inside Areas		
Plant Entrances	100 Lux	OHSAct
General working areas	75 Lux	OHSAct (Coal and Ash handling)
Workshops : Rough Work	150 Lux	OHSAct (Various types of workshops)
Workshops : Medium Work	200 Lux	OHSAct (Various types of workshops)
Workshops : Fine Work	500 Lux	OHSAct (Various types of workshops)
Control rooms	200 Lux	OHSAct
Warehouses	100 Lux	OHSAct
Offices	300 Lux	OHSAct

Ablutions	100 Lux	OHSAct
Switch rooms/MCC	200 Lux	OHSAct

All illumination levels, glare indexes and eliminating the hazard of stroboscopic effects on rotating machinery, shall comply with SANS 1119; 1277; 1278; 1279 1464 and the OHS Act section EW-2 through 14. Recommended and calculated illumination levels and glare indexes shall be stated on the drawings.

3.9.1 Recommendation

N/A.

3.10 Illumination level degradation/maintenance factor

A. Best available practice: 10% to 15% depreciation is noticed compared to initial lumen output over the 1,000 hour life of an incandescent lamp. Current high quality fluorescent lamps using rare earth phosphors will lose only 5-10% of initial lumens at 20,000 hours of operation. Compact fluorescent lamps (CFLs) experience higher lumen depreciation compared to linear sources, but higher quality models generally lose no more than 20% of initial lumens over their 10,000 hour life. HPS will lose no more than 20% of initial lumens over their 5,000 hour life.

3.10.1Recommendation

Best available practice shall be used. The illumination level degradation will affect the lighting installation number during the lighting design processing. More illumination level depreciation, more lightings are needed. The illumination level degradation is also called as maintenance factor which is determined by four factors: lamp lumen depreciation, lamp burnout, luminaire dirt depreciation and room surface reflectance maintenance. The lower frequency of maintenance schedule will increase the illumination level degradation significantly. Within the financial feasibility the illumination level degradation should be as low as possible.

3.11 Illumination level design

A. Best available practice: For office building, many researchers propose to give occupants a restricted range of illuminances to choose from. This range is chosen so that the expected preferred illuminance will be less than the standard level, meaning they will be satisfied with their environment despite an illuminance less than standard level, and energy consumption will be reduced (Dubois and Blomsterberg, 2011).

3.11.1 Recommendation

Best available practice shall be used for office building. The appropriate illumination levels for coal mine have a significant impact on energy consumption of lighting system. The lighting designer should design and calculate the correct illumination level for specific areas.

3.12 Maintenance type

A. Best available practice: Preventive maintenance/ Optimal maintenance (Ye et al., 2015).

3.12.1Recommendation

Best available practice for sustainable energy saving. The maintenance activities of lighting include group relamping, luminaries cleaning and burnout lamp replacing. Since the maintenance schedule also affect the installed lighting number, the proper maintenance schedule should be designed before the lighting installation.

4 Lighting system operation

4.1Allowable operating region

A. Best available practice (IEA, 2006): lighting system should be designed to match the peak time lighting load.

4.1.1 Recommendation

Best available practice shall be used for high energy efficiency.

4.2Control philosophy

A. Best available practice (IEA, 2006): The lighting automatic control system should be used to match the dynamic lighting load.
   - Occupancy sensors/motion sensors can be used to prevent illumination from being delivered to unoccupied spaces.
   - Photosensors automatically adjust electric-lighting levels in response to the detected illuminance level to maintain a pre-set level. They can be used to either turn a lamp on/off or to dim it in response to variations in daylight availability.
   - Timers switch lights on and off at pre-set times. Normally they can be manually overridden when necessary.

4.2.1 Recommendation

Best available practice for more energy saving. The dimming control with photosensors can only applied to the lamp or luminaires with dimming function. If it is applied to the lamp or luminaires without dimming function, it will affect the lighting system lifetime significantly.

5 Lighting system Performance

5.1 Energy consumption

A. National Standard: Table 12 in SANS 204 (SANS, 2017a)

5.1.1 Recommendation

In the SANS 204, only the maximum energy consumption of lighting system in buildings is indicated. An energy consumption baseline in kWh/m^2 for indoor and outdoor lighting shall be determined. The lower the energy consumption, the higher the lighting system energy] performance is.

6 References

- CELMA (2009). *CELMA Guide for the application of the Commission Regulation (EC) No. 245/2009 on "Tertiary lighting sector products"*. Federation of National Manufacturers Associations for Luminaires and Electrotechnical Components for Luminaires in the European Union (CELMA).
- Dubois, M. and Blomsterberg, Å. (2011). Energy saving potential and strategies for electric lighting in future North European, low energy office buildings: A literature review. *Energy and Buildings*, 43(10), pp.2572-2582.
- EU(2012) European Union, Commission Delegated Regulation (EU) No 874/2012 of 12 July 2012 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labeling of electrical lamps and luminaires Text with EEA relevance, 26/09/2012.
- IEA (2006). *Light's Labour's Lost: Policies for Energy Efficiency Lighting*. [online] OECD/IEA, p.Paris. Available at: https://www.iea.org/publications/freepublications/publication/light2006.pdf [Accessed 28 Jun. 2017].
- Narendran, N. (2009). Overview of Recent Technology Trends in Energy-Efficient Lighting.
- OSRAM (2017). *Homepage of the international OSRAM website | Light is OSRAM*. [online] Osram.com. Available at: http://www.osram.com [Accessed 28 Jun. 2017].
- Philips (2017). *Philips Lighting - LED & Conventional lighting solutions*. [online] Lighting.philips.com. Available at: http://www.lighting.philips.com [Accessed 28 Jun. 2017].
- SANS (2017). Building Regulations South Africa - An Introduction. [online] Sans10400.co.za. Available at: http://sans10400.co.za/ [Accessed 28 Jun. 2017].
- SANS (2017). SANS 475: Luminaires for interior lighting, streetlighting and floodlighting - Performance requirements. Pretoria: South African Bureau of Standards.
- USDOE (2017). *Technology Fact Sheets | Department of Energy*. [online] Energy.gov. Available at: https://energy.gov/eere/ssl/technology-fact-sheets [Accessed 28 Jun. 2017].

- Ye, X., Xia, X., Zhang, L. and Zhu, B. (2015). Optimal maintenance planning for sustainable energy efficiency lighting retrofit projects by a control system approach. *Control Engineering Practice*, 37, pp.1-10.

bigEE

Your guide to energy efficiency in buildings.

bigee.net

bigEE is an international initiative of research institutes for technical and policy advice and public agencies in the field of energy and climate, co-ordinated by the Wuppertal Institute (Germany). It is developing the international web-based knowledge platform bigee.net for energy efficiency in buildings, building-related technologies, and appliances in the world's main climatic zones.

The bigee.net platform informs users about energy efficiency options and savings potentials, net benefits and how policy can support achieving those savings. Targeted information is paired with recommendations and examples of good practice.

Co-ordinated by

Wuppertal Institut

Partners to date

中城深科 CSUSIBR · top10.cn · teri · ENERGY IS LIFE CONSERVE IT · sonedi · cscp

Supported by:

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

Dr. Stefan Thomas • bigee@**wupperinst.org**

Wuppertal Institute for Climate, Environment and Energy • Doeppersberg 19 • 42103 Wuppertal • Germany • Phone: +49 (0)202 2492-129