Comparison of Dimmable Electromagnetic and Electronic Ballast Systems—An Assessment on Energy Efficiency and Lifetime

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Abstract—There is a common misconception that energy saving is always equivalent to environmental protection. Compared with electromagnetic ballasts, electronic ballasts have a much shorter lifetime and are not recyclable. This prompts new concerns about their environmental impacts due to the accumulation of a huge amount of toxic and/or nonbiodegradable electronic waste components and materials. In this paper, the combined use of a central dimming system with low-loss electromagnetic ballasts is compared with electronic ballasts. Experimental results have confirmed that the use of a central dimming system for large electromagnetic-ballast-driven lighting systems can be as energy efficient as electronic ballasts. Considering the long lifetime (>30 years) of electromagnetic ballasts and the recyclability of their magnetic chokes, this paper shows that such combined technology can provide an improved environmentally friendly and energy-saving solution for large-scale electric-lighting systems, particularly for lighting systems in large public areas. Due to the elimination of many electronic ballasts, this proposed technology has the potential of drastically reducing a huge amount of electronic waste. With the positive results obtained in this paper, it is hoped that international regulatory organizations would reconsider their current policies and promote lighting technology that is both environmentally friendly and energy saving.

Index Terms—Central dimming systems, dimmable electromagnetic ballasts, electronic ballasts, energy-saving issues, environmental.

I. INTRODUCTION

Environmental protection involves two essential factors, namely protection of the atmosphere (reduction of greenhouse gases), and protection of soil and water (reduction of waste and pollutants). These two factors must go hand in hand. Energy saving is a means to reduce greenhouse gas emission. However, the energy-saving technology is not necessarily environmentally friendly (green) unless the amount of waste and pollutants generated in the process is insignificant. Nuclear power generation has zero gas emission but is generally not considered as “green” simply because of the nuclear waste problem. Understanding this point is very important in lighting research, because not all energy-saving methods in lighting technology are green.

Like all electric discharge lamps, each fluorescent lamp requires a ballast to ignite the discharge and to properly control the discharge current. For optimal operation and long lamp life, it is important that the ballast provides adequate open circuit voltage, quick glow-to-arc transition, and low current crest in normal operation [1]. The choice of the ballast can be either electromagnetic or electronic. Both electromagnetic and electronic ballasts have their own advantages and disadvantages. The conventional electromagnetic ballast (which is sometimes simply called magnetic ballast) is operated at 50- or 60-Hz mains power frequency. It consists of a magnetic choke, a starter, and a power factor correction capacitor. The structure of the ballast system is simple, robust, and reliable. It can be used even under hostile working environments and has a very long service life. That is why electromagnetic ballasts have been around for over 60 years. However, the “conventional” magnetic ballast has its own shortcomings, i.e., poor power regulation ability and high power loss caused by the iron and copper losses in the magnetic choke.

Electronic ballasts have been promoted as replacements for electromagnetic ballasts for the last decade. Some governments even changed their regulations to encourage the use of electronic ballasts. The authors believe that many arguments such as energy saving and environmental impacts that favor electronic ballasts need further justifications. It is usually thought that electronic ballasts are more energy efficient (typically claimed to be 10%–15%) than electromagnetic ballasts. However, such claim needs to be reviewed, particularly with the availability of low-loss electromagnetic ballasts and a new central dimming system for electromagnetic ballasts. Very few research projects have compared these two ballast technologies.

There is a common misconception that energy saving is equivalent to environmental protection. In addition to the energy-saving issue, the environmental issue is another important factor for consideration [2], [3]. The lifetime of electronic ballasts, which is mainly limited by the lifetime of the electrolytic capacitors, is relatively short (which is typically one to five years depending on quality and price) when compared with that of electromagnetic ballasts (which is typically...
Fig. 1. Projected lifetimes of electrolytic capacitors.

![Projected lifetime of Electrolytic Capacitors](image)

**Fig. 2.** Lifetime graph of a low-loss magnetic ballast (courtesy of Tridonic ATCO Ltd.).

30–50 years). Fig. 1 shows the projected lifetimes of the four common types of electrolytic capacitors with rated lifetimes of 10,000 h at 105 °C, 8,000 h at 105 °C, 5,000 h at 105 °C, and 2,000 h at 85 °C. The lifetimes of electrolytic capacitors are halved if the temperature increases every 10 °C and are doubled if the temperature decreases every 10 °C. For tubular fluorescent lamps, the ballasts are usually housed above the lamp fixture, which is warmed by the heat generated from the fluorescent lamps. The typical lamp fixture temperature is about 40 °C to 45 °C, and the measured temperature of the electrolytic capacitors in several commercial electronic ballasts is 87 °C on average. Assuming a 24-h daily operation, Fig. 1 projects that the electronic ballasts for tubular fluorescent lamps (typically operating at 87 °C) can last from a few months to a few years. For electronic ballasts housed inside compact fluorescent lamps, the operating temperature is often higher (typically over 100 °C) because the compact lamps are often placed in a confined area without ventilation. The typical lifetime of compact fluorescent lamps ranges from a few months to less than two years. On the contrary, modern low-loss magnetic ballasts have lifetime in excess of 30 years, as shown in Fig. 2 [4]. Even at the end of their service, the magnetic chokes of electromagnetic ballasts are still recyclable. Therefore, the relatively short lifetime of electronic ballasts has prompted new concerns on the environmental impacts of frequently disposed electronic ballasts because of the quick accumulation of a huge amount of toxic and nonbiodegradable waste materials over a short period of time. As the difference of energy efficiency between electronic ballasts and low-loss electromagnetic ballasts at full-power operation is diminishing [5], it is imperative to ask whether it is worthwhile to use electronic ballasts to save a small amount of energy for a few years and yet let them become pollutants for many hundreds of years. This question is particularly relevant for large public lighting systems such as road lighting, lighting systems in multistorey car parks, etc., because the flickering-free feature of electronic ballasts is irrelevant in those applications.

In this paper, we present an energy efficiency comparison of the electromagnetic and electronic ballast systems under both full power and dimming conditions. In particular, we focus on a large-scale lighting network and evaluate the use of a new central dimming system that can turn “nondimmable” electromagnetic ballasts into “dimmable” ones. With a comprehensive investigation, this paper shows that the use of this new central dimming system together with “low-loss” electromagnetic ballasts offers a highly competitive solution in terms of initial costs, real energy saving, energy efficiency, high reliability, low management costs, and environmental friendliness. These advantages can particularly be highlighted in large-scale lighting applications where the dimming function is beneficial (such as multistorey car parks, hallways, and corridors in commercial, residential, and industrial buildings, public parks, and gardens). The proposed technology is both energy saving and environmentally friendly.

### II. Brief Review of Ballast Technology

In this section, the advantages and disadvantages of electromagnetic and electronic ballasts are addressed. Then the features of the combined use of a central dimming system and the electromagnetic ballasts are described.

#### A. Electromagnetic Ballast Technology

The advantages and disadvantages of electromagnetic ballasts can be summarized as follows.

- **Advantages:**
  1) low cost;
  2) long lifetime (> 30 years at 105 °C);
  3) highly robust and reliable;
  4) suitable for extreme weather conditions such as high humidity, wide temperature variation, and lightning;
  5) environmentally friendly (magnetic chokes are recyclable);
  6) self-recovery feature (when the ac mains voltage recovers after a disturbance);
  7) very low maintenance costs;
  8) proven record of over 50 years.

- **Disadvantages:**
  1) not dimmable (in the past);
  2) not energy saving (in the past);
  3) flickering effect.

It can be seen that the conventional electromagnetic ballast is a mature technology with many years of proven record. The flickering effect is only an issue in office or factories...
where motor drives are used. For large-scale lighting networks used for general illumination in multistorey car parks, public corridors, and staircases in large buildings, the flickering effect is not a serious issue. Under severe lightning, the voltage in the power lines may be disturbed, and discharge lamps may occasionally turn off. The self-recovery feature here means that while the lamp may turn off after a voltage disturbance, it will be turned on (recovered) after the ac mains voltage recovers to normal condition.

### B. Electronic Ballast Technology

The advantages and disadvantages of electronic ballasts can be summarized as follows.

#### Advantages:
1. dimmable (only applicable for expensive products that are not commercially competitive in public lighting systems);
2. energy saving;
3. no flickering effect.

#### Disadvantages:
1. relatively expensive;
2. short lifetime (typically one to five years);
3. relatively poor immunity against extreme weather conditions such as high humidity, wide temperature variation, and lightning;
4. not environmentally friendly (toxic and/or nonbiodegradable electronic waste that is not recyclable);
5. no self-recovery feature;
6. high maintenance and repair costs.

Electronic ballasts do not have the self-recovery feature because even if the fuses of the electronic ballasts blow (or some other electronic fault occurs), the lamp will not be automatically turned on again after the ac mains voltage recovers.

### C. Central Dimming System for Electromagnetic Ballasts

The central dimming technology includes autotransformers and power electronic systems. Recently, many power control methods have been investigated for improving the power quality and power flow control [12]–[17], [19], [20]. Such methods provide new insights into power control in lighting systems. The central dimming system under investigation in this paper is an ac–ac power electronic system that can provide a variable ac voltage at the mains frequency for a network of electromagnetic-ballast-driven lighting systems, as shown in Fig. 3. Essentially, it is a patented low-loss power controller [6] that inserts an auxiliary voltage \( V_a \) into the power system so as to vary the output voltage \( V_o \) smoothly for dimming the magnetic-ballast-driven lighting system. To ensure system availability, it has a bypass switch \( S \) that will be closed when the dimming system experiences abnormal situation. In order to minimize the power loss in the central dimming system, the power controller only controls part of the total reactive power so that the real power can flow directly from the mains to the lighting system. The dimming level can be set by using a dc reference signal. Through a pulsewidth modulation controller and a synchronization circuit, a power inverter can generate a sinusoidal auxiliary voltage \( V_a \) so that the input mains voltage \( V_s \) can be adjusted to a smoothly controlled output sinusoidal voltage output \( V_o \) for powering a lighting network. Fig. 4 shows the power flow diagram of the patented technology. This novel concept of central dimming can be more energy efficient than traditional electronic ballasts that have to handle both real and reactive power. In order to preserve the lifetime of the lamps, the lamps are always turned on at full rated voltage. The central dimming system is activated after the warm-up time of the lamps (typically 10 min for fluorescent lamps). It is also programmed to change power from one level to another smoothly over a short duration of typically 10 min. This central dimming system can turn “nondimmable” electromagnetic-ballast-driven lighting systems into “dimmable” ones without major rewiring of individual lighting fixtures. Therefore, it retains most of the advantages of both electromagnetic and electronic ballasts for large lighting networks as follows.

#### Advantageous features:
1. low cost;
2. long ballast lifetime (> 30 years at 105 °C);
3. highly robust and reliable;
4. suitable for extreme weather conditions such as high humidity, wide temperature variation, and lightning;
5. environmentally friendly (magnetic chokes are recyclable, and the electronic waste per lamp is greatly reduced);
6. very low maintenance costs;
7. self-recovery or fail-safe feature (i.e., when the central dimming system fails, it can withdraw itself from the network by closing the bypass switch \( S \) in Fig. 4 so that existing lighting system can still function normally at full power);
8. dimmable;
9. energy saving under dimming conditions.

### III. Experimental Setup and Evaluation

Experiments have been set up to evaluate and compare the dimmable electronic and electromagnetic ballasts in a lighting network. 36W T8 Philips fluorescent lamps are used in the

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**Fig. 3.** Schematic of the central dimming system for magnetic-ballast-driven lighting system.
tests. For the dimmable electronic ballast, a Philips HF-R 136 is used as the typical electronic ballast for evaluation. With a voltage control signal from 1 to 10 V, this dimmable electronic ballast can be controlled for different dimming levels. The central dimming system employed for test in this paper is an e.Energy T&K Indoor Lighting Interface Module (ILIM) system, which is a three-phase system and is rated at 220–240 V and 10 A per phase. At its full capacity, each ILIM system can control at least one hundred 36W T8 fluorescent lamps. Two types of electromagnetic ballasts are tested. One is a standard-type MARBLE MT2040, and the other is a Tridonic low-loss-type ATCO LLEC36/40-06. According to the application guide to lamp control gear of Philips [7], “when operated on conventional gear, all ‘TL’ lamps can be dimmed without great problems down to approximately 50% light output."

Fig. 5(a) shows the measured input voltage $V_s$, output voltage $V_o$, and load current $I_o$ of an ILIM system before activating the ILIM system. The load current waveform is typical for nonlinear discharge lamps. The corresponding measurements after activating the ILIM system with output voltage regulated to 200 V are shown in Fig. 5(b). It can be observed that both input and output voltages are sinusoidal, and the load current is reduced. These measured waveforms show the voltage regulation functions of the central dimming system.

As the focus of this paper is to evaluate the energy efficiency for a large lighting network in a public area such as multistorey car park, corridors, and hallway of large buildings, the dimming range is limited from 100% to 65% of full power. This power range roughly corresponds to the dimming range from 100% to 50% of luminous flux. A loss comparison is made on a per-lamp basis. For the central dimming system, twenty-five 36W T8 ballast–lamp sets are used in the laboratory test. The power loss in the central dimming system is therefore divided by 25 in order to get the per-lamp power loss of the dimming system. Thus, for the central dimming system, the power loss per lamp includes the total input power loss, system loss (dimmer loss/lamp + ballast loss), and lamp power loss. For the electronic ballast, each Philips HF-R 136 controls one 36W T8 lamp. Therefore, its dimmer loss has been included in its ballast loss, i.e., the system loss for the electronic ballast system is the same as its ballast loss.

A. Ballast Losses at Full Power and Dimming Conditions

Before comparison is made on the total system losses of the electronic and electromagnetic ballasts, it is useful to understand and evaluate their power losses of the different types of ballasts under both full power and dimming conditions. It is also important to use the same reference for comparison. As the high-frequency operation of the electronic ballast can generate a higher efficacy (i.e., in lumen/watts), the luminous flux (lux) is used as a common reference for comparison. The luminous flux is measured with a spectro-photo-colorimeter and an integrating sphere, as shown in Fig. 6.

Fig. 7 shows the ballast loss of: 1) a dimmable electronic; 2) a standard electromagnetic; and 3) a low-loss electromagnetic ballast. The dimming of the electronic ballast was achieved by varying the 1–10-V dimming control voltage. For the two electromagnetic ballasts, the ac voltage was initially varied by a variac. It should be noted that the power loss in the variac is not considered in the comparison in Fig. 7.

Four important observations can be made in Fig. 7.

1) The statement that the “electronic ballast is 10%–15% more energy efficient than electromagnetic ballast” is only correct at the full-power operating point when compared with the standard electromagnetic ballast. This statement is no longer true for low-loss electromagnetic ballasts, particularly under dimming conditions.

2) The power loss of the dimmable electronic ballast increases as the lamp is dimmed. This trend is due to the use of frequency control in the dimming process of the electronic ballast [8], [9]. In the conventional dimmable electronic ballast, the operating frequency is set at about 40 kHz for full-power operation. The inverter frequency will be increased so as to increase the impedance of the resonant inductor ($\omega L$) in the ballast in order to reduce the lamp current (i.e., to dim the lamp). As the inverter dc link voltage is fairly constant, increasing the operating frequency will increase the switching loss in the power electronic devices and the core losses in the magnetic components in the ballast. Therefore, the power loss of the dimmable electronic ballast increases as the lamp is dimmed, as shown in Fig. 7.
3) The power losses in the two types of electromagnetic ballasts decrease as the lamps are dimmed. As the ac voltage applied to the electromagnetic ballasts are reduced as a dimming means, the magnetic core losses and conducting winding loss decrease. This trend is in great contrast with that of the conventional dimmable electronic ballast.

4) Under most of the dimming ranges, the power loss of a low-loss electromagnetic ballast is less than that of a dimmable electronic ballast. In other words, the electromagnetic ballast can be more energy efficient than the dimmable electronic ballast under dimming operation.

Of course, the power loss of the central dimming system has not been considered yet in the comparison in Fig. 7.

of the ILIM system before activating the dimming function (with $V_o = 220$ V).

Fig. 6. Spectro-photo-colorimeter with an integrating sphere.

Nevertheless, the results in Fig. 7 highlight the two different power loss characteristics of the electronic and electromagnetic ballasts under dimming operation.

B. Comparison on System Loss per Lamp

With the understanding of the power loss characteristics of different ballasts, we now consider the total system loss on a per-lamp basis. For the dimmable electronic ballast, the ballast loss is the system power loss per lamp because each electronic ballast controls one lamp only. For the central dimming system, 25 lamps are used in this setup. Therefore, the system loss per lamp is equal to the sum of each electromagnetic ballast loss and the central dimming system loss per lamp. The power loss of each electromagnetic ballast can be individually measured. The power loss of the central dimming system per lamp is calculated by dividing the total loss of the central dimming system by the number of ballast–lamp sets.

Fig. 8 shows the variations of the system power loss per lamp over the dimming range. It can be confirmed that, for the same luminous flux, the central dimming system with
electromagnetic ballasts (or called dimmable electromagnetic ballast system hereafter) has less system loss per lamp than the dimmable electronic ballast over most of the dimming ranges (from 90% of the relative flux and below) in this paper.

C. Comparison of Total Power Consumption per Ballast–Lamp Set

The total power consumptions per ballast–lamp set of the three sets of equipment have been measured and plotted in Fig. 9. It can be confirmed that, for the same luminous flux, the dimmable electromagnetic ballast system uses less power than the dimmable electronic ballast from about 84% of the luminous flux and below.

It is interesting to note that the crossover points in Fig. 8 (90%) and Fig. 9 (84%) are not the same. The reason is that for the same luminous flux, the fluorescent lamp operated at high frequency consumes less power than at low frequency. The same 36W T8 lamp was used in the tests for light measurements, and Fig. 10 shows the lamp power variations under the control of three ballasts in this paper. It can be seen that the same lamp driven by two electromagnetic ballasts that operate at the mains frequency virtually consumes the same power for a given luminous output, but it consumes slightly less power when driven by the high-frequency electronic ballast.

For large lighting networks, the results in Fig. 9 clearly point out that the dimmable electromagnetic ballast system can be as good as a dimmable electronic one in terms of energy saving. However, the use of dimmable electromagnetic ballasts has the following advantages over that of dimmable electronic ballasts.

1) There is no need to replace existing electromagnetic ballasts if the dimming function is needed. Therefore, no replacement cost is involved in turning a nondimmable system into a dimmable one if the central dimming technology is adopted.
2) There will be a great reduction in electronic waste per lamp as one central dimming unit has the capacity (10 A per phase for three phases) to handle at least one hundred 36W T8 ballast–lamp sets.
3) Most of the advantages of electromagnetic ballasts can be retained, which results in highly reliable, low maintenance, environmentally friendly, and energy-saving lighting systems.
4) As the ballast chokes can be recycled at the end of their services, waste disposal costs can be minimized.

IV. DIMMABLE VOLTAGE RANGE FOR ENSURING LONG LIFETIME OF FLUORESCENT LAMPS

One important issue on the dimmable electromagnetic ballast system is the effect of voltage on the lifetime of the fluorescent lamp. The filament temperature and the filament voltage drop must be monitored to make sure that thermionic emission can take place without sputtering of the filament materials. The lifetime of a fluorescent lamp is mainly determined by the lifetime of its cathode. When a lamp is working under a dimming condition, the discharge current is lower than its rated value. The amount of heat generated in the electrode by the discharge current decreases as the discharge current decreases.
If the cathode is not sufficiently hot, it may not generate enough thermionic emission current to the discharge column. To sustain the discharge current in the lamp, the cathode has to generate both thermionic emission and field emission current. Therefore, the cathode has to suffer a high cathode voltage drop and a high sputtering rate. The emitting material on the cathode will be worn out by the cathode material sputtering, and the life of the lamp will be ended soon. The way to reduce the cathode voltage drop is to introduce a cathode heating voltage source to supply extra power to the cathode. The cathode heating voltage source can reduce the cathode material sputtering, but it also increases the power loss in the ballast system. It is important to find out the lower limit range for the input voltage at which the cathode voltage drop will not exceed the critical range so that the lifetime of the cathode can be protected without an extra cathode heating system.

The critical value of the cathode voltage drop should typically be lower than 17 V over the entire half cycle [1], [18]. If the cathode voltage is higher than that value, the incoming mercury ions should bombard the cathode surface and make the surface material sputtering, which results in a reduced lifetime. The cathode voltage drop is measured by the improved “hammer method,” which is a capacitive probe method. The hammer method is a technique for measuring the cathode fall voltage by using an external conducting band circumferentially connected around the lamp near the electrode [11]. This capacitive coupling technique measures the voltage profile from the external band to the input lead connected to the hot-spot side of the emission-mix-containing electrode. The value and the shape of the cathode voltage drop can be determined by analyzing the anode oscillations that are evident in the potential drop that appears between the capacitive probe and the electrode [10]. The cathode fall voltage measured in this intrusive fashion approximately gives the same value as would an internal Langmuir probe inserted in the discharge adjacent to the emission-mix-containing electrode. The basic measurement setup is shown in Fig. 11. Measurements have been taken for the fluorescent lamps driven by both low-loss and standard electromagnetic ballasts. The typical waveforms of the cathode voltage drop for lamps at rated power driven by the two types of ballasts are shown in Figs. 12 and 13.

According to [1] and [10], the peak value of the anode voltage drop is 10.4 V. Therefore, the absolute zero point of the cathode voltage drop can be determined according to the lowest point of the anode voltage drop (−10.4 V), as shown in Figs. 12 and 13. Table I shows the total measurement results of the peak cathode voltage drop for different driven ballasts. The results show that the lamp driven by a low-loss magnetic ballast has a lower peak cathode voltage drop at the same input voltage value. The standard magnetic ballast consumes more power loss than the low-loss magnetic ballast. Therefore, under the same input voltage, its lamp voltage is lower.
Fig. 14. Light spectrum of the fluorescent lamp driven by the low-loss magnetic ballast at rated power (39.9 W). Rendering Index Ra = 74.2, and Flux = 1933.8 lm.

Fig. 15. Light spectrum of the fluorescent lamp driven by the low-loss magnetic ballast at reduced power (25.2 W). Rendering Index Ra = 74.8, and Flux = 1352.6 lm.

The results in Table I also show that the critical input voltage value for the lamp driven by a low-loss magnetic ballast is about 180 V. At that value, the cathode voltage drop is 16.5 V. For the lamp driven by a standard magnetic ballast, the critical input voltage is 190 V at which the cathode voltage drop is 16.5 V. These results show that the central dimming system can be used within the certain voltage range to dim these electromagnetic ballast–lamp sets and save energy without adversely affecting the lifetime of fluorescent lamps. In this case, the voltage range is from 220 to 180 V, and the dimming range is from 100% to 67% for a low-loss magnetic ballast and 100% to 73% for a standard magnetic ballast.

V. LIGHT SPECTRAL VARIATION UNDER DIMMING

Figs. 14 and 15 show the typical spectral distributions for fluorescent lamps under rated power (39.9 W) and reduced power (25.2 W), respectively. The output flux of the lamp has been reduced during the dimming state. However, the spectral distribution remains the same. Measurements show that Rendering Index Ra = 74.2 and Flux = 1933.8 lm when the lamp power is 39.9 W, and Rendering Index Ra = 74.8 and Flux = 1352.6 lm when the lamp power is 25.2 W. The rendering index basically remains unchanged at reduced power operation. It is well known that the response of the human eye to the spectrum changes with the luminance level. Under normal daylight conditions, the peak of the human eye sensitivity curve lies at 555 nm. While under moonlight condition, the peak response of the human eye is at 507 nm. The lighting conditions of roadway and public area (such as car park) are between daylight and moonlight. Therefore, the sensitive spectrum should be between 555 and 507 nm. It is obvious that the dimming condition does not change the spectral distribution. That means that under lower light level, the spectrum can still match the sensitivity of the human eyes.

VI. DISCUSSION

The central dimming system is a power electronic circuit that also uses electrolytic capacitors. It can be installed in the meter room. Without tight restriction in compactness of the electronic ballast products, it could be designed to maximize the lifetime of the electrolytic capacitors due to the lower operating temperature. Compared with electronic ballasts that can typically control one to two lamps, one central dimming unit can typically control over 100 fluorescent lamps. Hence, the amount of electronic waste generated with this dimmable magnetic ballast technology can be drastically reduced. Since recycling facilities for fluorescent lamps are already available, and the metallic materials of the magnetic ballasts can be recycled, the dimming magnetic ballast system is more sustainable than the electronic ballast technology.

It should be pointed out from a practical point of view that most of the electronic ballasts in the market are nondimmable. Dimmable electronic ballasts are usually three to four times more expensive than nondimmable electronic ballasts. They also need extra control wiring and so are not commonly used in large lighting systems in public areas such as multistorey car parks, corridors, and stairs of tall buildings. The use of nondimmable electronic ballasts could deprive the users’ opportunity of using lighting energy according to their needs. Fig. 16 graphically illustrates this issue. Although replacing the low-quality high-loss magnetic ballasts with electronic ones can save some energy at the full-power operating point, using high-quality low-loss magnetic ballasts can narrow the gap of this energy consumption at this single full-power operating point. With a dimming magnetic ballast system, the users can dim the lighting system according to their needs (i.e., peak and off-peak periods). From our experience over the last two years, the lighting system in a multistorey car park can be dimmed by 20%–30% between midnight and 5 A.M. without affecting safety and security.
VII. Conclusion

In this paper, a central dimmable electromagnetic ballast system has been compared with a dimmable electronic ballast system. It is found that the central dimming system can turn “nondimmable” electromagnetic ballasts into dimmable ones. This means that the highly reliable electromagnetic ballasts can be as energy efficient as (and in some dimming range, more energy efficient than) dimmable electronic ballasts. This key finding leads to new considerations in choosing appropriate energy-saving and environmentally friendly technology for large lighting systems used in public areas such as car parks, hallways, corridors, and staircases of large buildings. Electronic ballasts have a relatively short lifetime of typically five years, while the chokes of electromagnetic ballasts need little maintenance and are recyclable even after their long lifetime (> 30 years). Is it justifiable to use electronic ballasts (without much gain in energy saving when compared with the dimmable electromagnetic ballast system) in large public lighting systems for only a few years and then dispose them as electronic waste (that becomes pollutants for many hundreds of years)? The results in this paper clearly indicate that it is both environmentally friendly and energy saving to use a central dimmable electromagnetic ballast system for large lighting systems. For countries that have just changed their regulations to encourage electromagnetic ballast system (in large public lighting systems) in large public lighting systems used in public areas such as car parks, hallways, corridors, and staircases of large buildings. Electronic ballasts have a relatively short lifetime of typically five years, while the chokes of electromagnetic ballasts need little maintenance and are recyclable even after their long lifetime (> 30 years). Is it justifiable to use electronic ballasts (without much gain in energy saving when compared with the dimmable electromagnetic ballast system) in large public lighting systems for only a few years and then dispose them as electronic waste (that becomes pollutants for many hundreds of years)? The results in this paper clearly indicate that it is both environmentally friendly and energy saving to use a central dimmable electromagnetic ballast system for large lighting systems. For countries that have just changed their regulations to encourage the use of electronic ballasts, it is time to reconsider their recommendations. Otherwise, lots of nonbiodegradable electronic waste will be quickly accumulated, which will eventually lead to a long-term environmental disaster.

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References


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