Books/Book chapters   School of Electrical and Electronic Engineering

2011

Lighting Controls and Their Associated Problems: an Investigation Into Why Lighting Controls Fail in Buildings

Bernard Doyle
Dublin Institute of Technology

Kevin Kelly
Technological University Dublin, kevin.kelly@tudublin.ie

Follow this and additional works at: https://arrow.tudublin.ie/engschelebk

1 Introduction

Figure 1-a Building A - Public Office

1.1 Basis for Studies

This project began as a post occupancy evaluation of an existing lighting control system in an office space to determine the installed financial savings and CO_2 emission reduction. Three buildings had been chosen as case studies. It was intended to compare the actual consumption of energy and greenhouse gas emissions due to lighting with automated controls to previous manually switched systems or simulated systems. However, during the initial stages of data acquisition it became apparent that a large number of developments had significant problems with such.

The research question then evolved to a much bigger research question, i.e. why were the controls disconnected and what were the factors governing success or failure of these systems? It became apparent that disconnection of these systems was not untypical and although considerable research has been conducted into a comparison of control types, little research was available for the reasons for failure of systems within Ireland. Documented evidence of failed systems is also a rarity. Galasiu et al.(2007) highlights the lack of availability of information for long term performance studies of daylight control systems. However, the use of lighting control systems is becoming more relevant as energy consumption, energy costs and greenhouse emissions are pushed to the agenda forefront.

This research attempts to address the issues that result in the disconnection of lighting controls systems in day to day use within buildings. The research questions will investigate why controls were disconnected from the

public office and the shopping centre, and why they were successful in the school.

1.2 Why install lighting controls?

Recent decline in the energy growth is merely a sign of a slowdown in the global economy. In the long term energy consumption is still on the increase. The commercial and public services sector final energy consumption experienced an increase of 6.9% and was recorded as 1.807 Mtoe(Sustainable Energy Ireland., 2009b). It can be seen in Figure 1-b Final Consumption of Electricity by Sector that the commercial and public services sector accounted for approximately 30% of the electricity consumed in 2006.
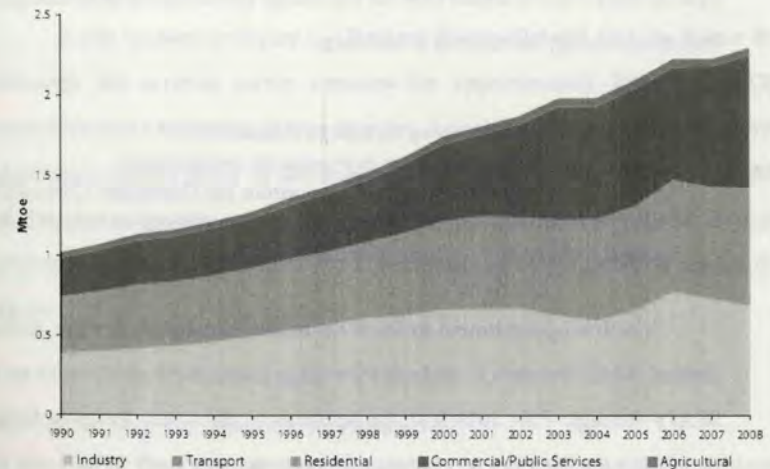

Figure 1-b Final Consumption of Electricity by Sector
(Sustainable Energy Ireland., 2009a)

The real impact of these figures is what that means to the end user. Rising consumption and energy costs are increasingly applying pressure to businesses. As people start to see an increase in their energy costs, both direct and indirect, i.e. carbon taxation; factors such as lighting controls systems are going to become more prominent. It is therefore imperative that these systems operate according to requirements and aid financial gains rather than losses, through the correct integration and avoiding problematic disconnections.

According to MK Electrics(2008) up to 40% of a building's total energy consumption is due to lighting. Energy consumption and carbon emissions are quickly becoming areas of major global concern and through EU Directives and local policy, reductions are being sought in each sector, where appropriate. Items such as the Directive 2002/91/EC on the energy performance of buildings actively encourage energy reductions in buildings.

EU Energy Performance of Buildings Directive
The objective of this Directive is to promote the improvement
of the energy performance of buildings within the (European) Community,
taking into account outdoor climatic and local conditions, as well as indoor
climate requirements and cost-effectiveness. (2002)

The Irish government in the form of the Sustainable Energy Authority of Ireland, SEAI, attempts to address the energy issues through schemes such as the SEAI's Strategic Plan 2010-2015. In response to the Kyoto Protocol Ireland had supported the 20% cut in greenhouse gas emissions from 1990 levels by 2020. However, it is feared that these targets may not be achieved.
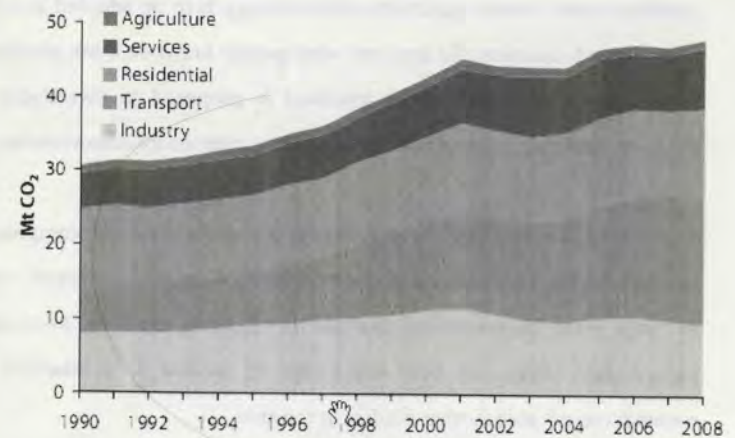
Figure 1-c Primary Energy Related CO$_2$ by Sector
(Sustainable Energy Ireland., 2009b)

It can be seen in Figure 1-c Primary Energy Related CO$_2$ by Sector that although the services sector accounts for approximately 18% of the CO$_2$ emissions that a reduction of consumption, through better controls, could have a significant positive effect on this number. As lighting can account for up to 30% of the electricity consumed by an Irish business premises(ESB, 2010) daylight controls systems have become more prominent in recent times to reduce this figure.

1.3 How will the research be conducted?

Due to the change in research question, any previous methods envisaged where no longer relevant, i.e. there is no quantitative data if the controls have been disconnected. The reasons for disconnection can only be established by discussions with those involved during the design stages and times when

problems arise. A new qualitative methodology is to be adapted to address the new research question. To find out what people know or think you have to ask them. Interviewing the parties involved is proposed to investigate how the supplier, designer and end user feel about the reasons for disconnection.

This data will then be scrutinised for similarities and compared to past research findings for reasons of disconnection. As minimal research with regard to long term performance analysis of lighting controls systems, by an independent party, has been conducted in Ireland it is intended that this research can act aide further studies in the area.

Three different building types will be investigated as to why the installed lighting controls succeeded or failed. The buildings are a public office building, a shopping centre and a primary school. The buildings are located throughout southern Ireland.

2 Literature Review

2.1 Introduction

Energy consumption and greenhouse emissions are problems on a global scale; however, increasing energy costs are the key drivers forcing business and developers to consider means of possible savings. It has been recognised that artificial lighting may not always be required at full output as had come to be standard practise.

Figure 2-a Building A - Office with Significant Natural Light

A number of studies relevant to daylighting control systems have been carried out in the past. Roisin et al.(2008) conducted experimentation on the possible savings of the different types of lighting controls and at different locations. This data was found to be somewhat in contrast to that expected from manufacturer specifications. Location, orientation and daylight

availability are highlighted and could well be the reason for the differences in energy consumption.

A case study on the lighting controls installed in the New York Times Building further questions the expected savings but with an optimistic view. Savings of up to 72%(Lutron, 2009) were recorded through the installation of a Lutron control system. In contrast, further research has highlighted total disconnection of daylight controls in some instances due to day to day operating problems.

2.2 Projected Savings

Manufacturer specifications and promotional documents often offer best case results, ranging from 60% to over 80%. Thorn lighting offer potential energy savings of 70%. Although this data may be accurate in some developments it can prove misleading in others. In past works Roisin et al.(2008) have recorded and simulated measurements from similar systems throughout a range of sites in Europe and emphasize that the orientation and availability of daylight should be an integral part of the feasibility of such systems. Results returned indicated minor increases in savings when simulations were carried out with south facing rooms. The range of results returned were between 45% and 63% savings from that of a reference system. These results were dependant on the variables of location, orientation and availability of daylight to the interior in question.

These figures can be offset against the New York Times Building,

where the Lutron system was installed. Refer to Figure 2-b NYT Headquarter Lighting Power Consumption.

Winter 2008-2009	**0.37 W/sq. ft.**
Fall 2008	**0.37 W/sq. ft.**
Summer 2008	**0.33 W/sq. ft.**
Spring 2008	**0.38 W/sq. ft.**

The seasonal data reflects yearly lighting energy savings of 72 percent.

Figure 2-b NYT Headquarter Lighting Power Consumption

(Lutron, 2009)

1 ft² = 0.092903 m², which means that 0.37 W/ft² equates to approximately 3.98W/m². Glenn Hughes was the acting energy consultant during the design process of the development. Initial estimations were 1.28 W/ft² equates to approximately 13.78W/m² electrical consumption for lighting. ASHRAE 90.1-1999, USA state that a typical value for office spaces is 14 W/m². Hughes has claimed (Lutron, 2009) that this figure turned out to be 70% less at 0.38 Watts per square foot. The result being yearly lighting energy savings of 72%. It must be noted however that these savings were published through the lighting control manufacturer, Lutron and not an independent assessor.

In depth analysis was also carried out prior to the installation of the lighting controls in the New York Times Building. Models were constructed and analysed over a range of months to establish the correct system and

settings required. This may not always be an option for developers or designers and will be addresses in this research.

2.3 Comfort V's Energy Savings

Roisin et al.(2008) comments that extra savings could be made in a manually switched office if the occupants refuse to turn lighting on, even if 500lux is not achieved on the workplane. 500lux is the CIBSE recommended level for offices but Roisin et al. also comments about the problems of not achieving this recommendation, i.e.

- Comfort
- Profitability
- Eyestrain

Generally the recommended lux level is applied to the entire area at the workplane height(CIBSE et al., 2003), with an exclusion area about the perimeter. Hunt(1979) highlights that in an office environment *"Usually either all or none of the lighting was in use—it was rare for only part of the lighting to be on"*.

Recent recommendations suggest that localised task lighting may lead to a solution to this problem. Required lux level for occupant comfort could be achieved by allowing occupants to decide if task lighting is required.

2.3.1 Revision of CIBSE Lighting Guides

CIBSE Lighting Guide 7 specifically targets office spaces. Most values

recommended are based on maintained illuminance of the working plane. CIBSE Lighting Guide 7 recommends that

For the ceiling not to appear dark, the average illuminance on the ceiling, from both the direct and reflected components, should be at least 30% of the average horizontal illuminance across the working plane.

It also states

To achieve a good luminance balance in a space, the average wall illuminance above the working plane, from both the direct and reflected components, should be at least 50% of the average horizontal illuminance on the working plane.

In practice these factors increase the number of luminaires required and in turn impede the localised task lighting argument. Artificial lighting is required throughout the premises to achieve the recommended lighting levels at workplane height, whilst maintaining the recommended wall to workplane and ceiling to workplane ratios; as stipulated in CIBSE Lighting Guide 7.

It is felt that if workplane to ceiling and workplane to wall ratios were reduced, lower lighting levels could be maintained for occupant comfort, whilst localised task lighting would allow the user to set the desired lighting levels where required, i.e. on the workplane in use.

2.4 Daylight Harvesting

One of the drawbacks to the growth of daylighting harvesting systems is the lack of long term assessment performance studies. It has been stated that much research has been carried out in the area of lighting controls. Roisin et al.(2008) research was based mainly in offices. Galasiu et al.(2007) highlights the lack of availability of information for long term performance studies. The research conducted by Galasiu was also mainly conducted in an open plan office. It was felt that the greatest amount of collected data available was from documentation on the studies of the Weidt Group 2004-2005 Dimming Study.

DiLouie(2006) has produced a number of books and published articles in the area of lighting controls and regularly cites the studies of the Weidt Group. The Weidt Group 2004-2005 dimming study was a survey submitted to 4,317 industrial participants with a 6.7% response. The responses were reduced to eight number buildings that allowed for a range across their "success/failure spectrum". Eijadi and Vaidya, of the Wiedt Group, recommend that the following steps need to be taken in the design of daylight harvesting projects:

1. *Conduct a daylight simulation and use these plans when designing the lighting system and its controls.*
2. *Prepare plans that document daylight zones, and establish independent control zones that work optimally with these patterns.*
3. *Locate the photosensor on the reflected ceiling plans and interior elevations.*
4. *Identify light fixtures that are controlled by individual sensors or controllers.*
5. *Write a daylighting controls narrative.*
6. *Require the contractor to submit shop drawings based on design documents and control narrative for review.*

7. *Include the requirement for calibration of controls in the specifications, and require calibration logs to be submitted by the contractor.*

8. *Provision building operator training by the controls manufacturer* (DiLouie, 2006)