Zumtobel Research

Werd Administrative Centre LED Pilot Project. Comparison of two lighting installations in two identical corridors using conventional fluorescent lamp technology and LED technology with optimised lighting management.

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Werd Administrative Centre LED Pilot Project

Werd Administrative Centre

Introduction

The Public Works Department of Zurich City Council conducted a pilot measurement project together with Eteam GmbH and Zumtobel Licht AG: lighting solutions in two comparable corridors were assessed in the Werd Administrative Centre over a period of four months. One corridor remained unmodified: the conventional fluorescent lamps were switched off by presence detectors as soon as there had been no one in the corridor for more than ten minutes. The other corridor was converted to LED luminaires. In addition, the switch-off delay of the presence detectors was reduced down to one minute in several stages. In the case of LEDs, frequent switching or dimming has no adverse effects on lighting comfort and causes no wear. The measured power consumption of the LED solution with optimised presence monitoring was 81% less than that of comparable luminaires fitted with fluorescent lamps.

Abstract

The lighting in two identical corridors in the Werd Administrative Centre was investigated to establish the potential energy savings obtainable using LEDs and optimised presence-based control:

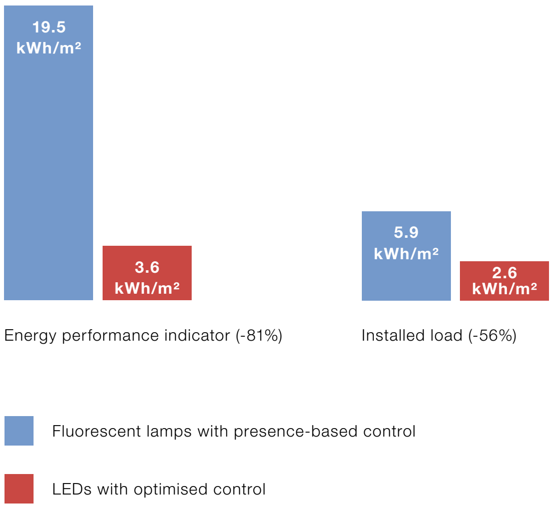
Corridor 1
with fluorescent lamps and presence detectors with
a 10-minute delay interval

Corridor 2
with an LED light line and presence detectors with
variable delay intervals

There was also a requirement to ascertain user acceptance of the system. The illuminance levels and light distributions were identical in both corridors. The system was set up and monitored using Zumtobel's Litenet flexis N2 automation processor. Whereas the lighting and control functions in corridor 1 (8th floor) remained unchanged throughout the entire measurement period (4 months), the delay intervals of the presence detectors of the LED lighting system (7th floor) were reduced in several stages. Because LEDs, unlike fluorescent lamps, are wear-free and start immediately, there is no problem in shortening the delay time in the case of LED luminaires.
In its optimum operating mode (1-minute delay interval with no residual light in off state, measurement period 3), the LED lighting system achieved electricity savings of more than 80% compared with the previous fluorescent lamp technology. Firstly, the installed load dropped from 5.9 W/m² to 2.6 W/m², secondly actual daily operating time fell from 13.2 hours/day in the case of the fluorescent lamp lighting to 5.7 hours/day in the case of the LED lighting. Reducing the delay time from 10 to 5 min (measurement period 2) produced hardly any energy savings and this setting is therefore not recommended. A dimming level of 15% for the unoccupied state was defined in measurement period 4; this was intended to improve user acceptance of abrupt lighting system switching. The energy-saving effect of this residual light setting produced a slight reduction from 81% to 77%, and high levels of user acceptance of the system in this case went hand-in-hand with very good energy savings.

This result illustrates, in exemplary fashion, the fact that LED technology with appropriate lighting control opens up huge scope for savings compared with current standard corridor lighting concepts which are also deemed to be energy-efficient.

Corridor lighting, fluorescent lamps versus LEDs



Nevertheless, good economic efficiency of LED luminaires with optimised lighting control in circulation areas cannot be guaranteed in every case despite extremely large, proven power savings. The extra cost of LEDs needs to be approximately CHF 50 to CHF 100 per downlight or per running metre of batten luminaire in order to achieve an amortisation period of 5 to 8 years.

1 Problem definition

2 Scientific state of the art

Problem definition

The Werd Administrative Centre is Zurich City Council's main administrative centre. This former bank building was renovated and became operational in December 2004. It houses 620 Social Department and Finance Department staff. Renovation made it possible to roughly half the building's energy consumption. The Werd Administrative Centre was awarded a Minergie certificate. The heating energy consumption of an energy-optimised Minergie building is primarily cut by improving its thermal insulation and utilising waste heat in the building. At the same time, the percentage proportion accounted for by electricity consumption can increase in the energy balance if measures are not also taken to improve the efficiency of electrical systems. In buildings such as the Werd Administrative Centre, artificial lighting accounts for a considerable proportion of the power consumed. This posed the question of whether optimised lighting solutions could yield significant potential savings in a situation where highly efficient technologies were already being used.

Scientific state of the art

Practical experience rather than scientific knowledge shows that there is considerable hidden scope to save energy in corridors of administrative buildings. These corridors are simply transit areas or informal shortcuts. If insufficient daylight is available, artificial lighting remains switched on for many hours of the working day as well as early and late in the day. Used in combination with LED technology, presence monitoring provides great opportunities to save energy; daylight-based control offers additional potential in many corridors where there are sufficient quantities of daylight. Frequent switching or dimming has no adverse effect on user convenience or the service life of these innovative light sources. The following study also contains a very good overview of the energy balance of presence monitoring:

The performance of occupancy-based lighting control systems:
A review
X. Guo, DK Tiller, GP Henze and CE Waters
Lighting Research and Technology 2010

http://lrt.sagepub.com/content/42/4/415.full.pdf

3 Research hypotheses

Research hypotheses

It was suspected that innovative LED Slotlight luminaires could make a contribution towards energy savings in corridors without compromising lighting quality even when compared with very efficient luminaires based on fluorescent lamps.
The second hypothesis was that presence monitoring for the luminaires would offer additional energy savings in the Werd high-rise building, but varying the delay times would not necessarily produce corresponding energy savings. The intention was to analyse which luminaire and lighting control system operating mode gave the best energy balance.

4 Research methods

4.1. Measurement methods and installation

Pilot measurement involved the following:

- The electric power supplied to two identical corridors with continuous-row systems was continuously recorded by data loggers over several months. (Storage interval: 1 minute)
- The illuminance levels in both corridors were comparable.
- The lighting in both corridors was controlled by presence detectors.
- The corridor on the 8th floor was equipped with conventional continuous-row systems using fluorescent lamps; this lighting was operated as previously, without any change throughout the entire measurement period.
- The corridor on the 7th floor was equipped with continuous-row LED systems and lighting control was modified several times during the measurement period.

Description of the luminaires

7th floor	Zumtobel SLOTLIGHT LED continuous-row system 1/57 W, 28 m, each 23 W. Maximum operating power for 100 lx: 187 W or 2.6 W/m² of corridor surface area.
8th floor	Zumtobel SLOTLIGHT 1/35 W T16, 19 lamps, 35 W each (+3 W electronic ballast). Maximum operating power for 100 lx: 420 W or 5.9 W/m² of corridor surface area.

An electricity meter that measured only the power consumption of the lighting in the respective corridor was installed on each of the sub-distribution boards on the 7th and 8th floor of the administrative building. The meters each had a data logger that wrote the individual measured values to memory cards. A storage interval of 1 minute was set for measurement purposes. 1,440 individual power values were recorded per day and per corridor, i.e. a total of more than 300,000 measured values. Besides automatic recording, sample readings were taken manually on a random basis.

4.2. Investigation process and overall results

Measurement sequence		A	B	C	D	E
Corridor 1 T16	Entire measurement period	0%	0 s	10 min	0 s	0 %
Corridor 2 LED	1st measurement period	0%	0 s	10 min	0 s	0 %
	2nd measurement period	0%	1 s	5 min	5 s	0 %
	3rd measurement period	0%	1 s	1 min	5 s	0 %
	4th measurement period	15%	1 s	1 min	5 s	0 %

A: Dimming level in corridor, no presence detected

B: Lighting switch-on, presence detected

C: Set delay time – no present detected

D: Lighting switch-off, end of delay time

E: Nights and weekends

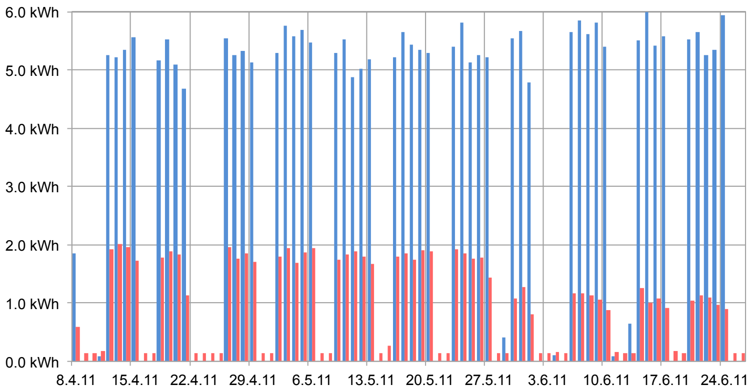
Summary of measurement result	Period 1 10. 4. to 21. 4. 2011		Period 2 22. 4. to 27. 5. 2011		Period 3 28. 5. to 26. 6. 2011		Period 4 18. 7. to 3. 8. 2011	
	T16	LED	T16	LED	T16	LED	T16	LED
Switch-off delay in minutes	10	10	10	5	10	1	10	1
Average operating hours/day	12.6	10	12.8	9.7	13.2	5.7	12.8	6.5
Saving		**-21 %**		**-24 %**		**-57 %**		**-49 %**
Daily electricity consumption kWh	5.3	1.9	5.4	1.8	5.6	1.1	5.4	1.2
Saving		**-65 %**		**-66 %**		**-81 %**		**-77 %**
Daily frequency of switching	4.1	32.8	3.4	29.3	3.9	100.1	4.3	101.5

In the 1st measurement period, the operating hours of the LED lighting system were 21% (2.6 hours/day) lower than those of the conventional lighting. Energy consumption in the case of the LED luminaires was 65% lower. On average the LEDs switched 33 times a day and the T16 luminaires switched 4 times a day.

In the 2nd measurement period, the operating hours of the LED lighting system were 24% (3.1 hours/day) lower than those of the conventional lighting. In the case of the LED luminaires, energy consumption was 66% lower. This means that reducing the switch-off delay from 10 to 5 minutes made hardly any contribution towards saving energy. On average the LED lighting system switched 30 times a day and the T16 luminaires switched 3.4 times a day.

In the 3rd measurement period, the operating hours of the LED lighting system were 57% (7.5 hours/day) lower than those of the conventional T16 lighting. In the case of the LED luminaires, energy consumption was 81% lower. This means that reducing the switch-off delay from 10 to 1 minute made a considerable contribution towards saving energy. On average the LED lighting system switched 100 times a day and the T16 luminaires switched 4 times a day.

The 4th measurement period was the same as the third measurement period except that the LED luminaires were dimmed to approx. 15% rather than being switched off completely during the day. This improved lighting comfort but reduced energy savings. A saving of “only” 77% rather than 81% was obtained; savings during the full-load hours in the 4th measurement period amounted to 5.7 hours rather than 7.5 hours when the lighting was switched off completely. On average the LED lighting system switched 100 times a day and the T16 luminaires switched 4.3 times a day.



Daily energy consumption during the first three measurement periods

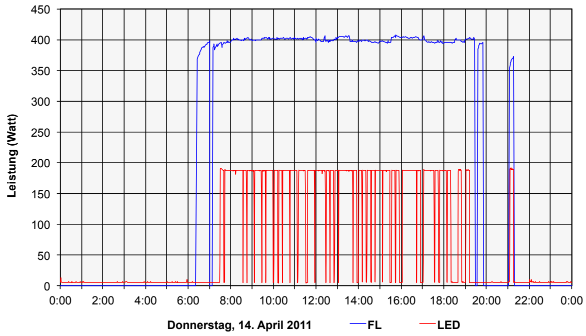
T16
LED

This graph shows the daily energy consumption for both lighting solutions in the corridors during the first three measurement periods. The blue columns represent the conventional lighting system using fluorescent lamps (8th floor); the red columns represent the new lighting system using the continuous-row LED system (7th floor). Thanks to installed load of the LED lighting system which is almost halved, its power consumption in the initial phase with the same control is significantly lower than that of the conventional lighting. Although reducing the delay time from 10 to 5 minutes in the case of the LED lighting system on 22 April produced no additional savings, the reduction obtained by reducing the delay time further to 1 minute in the case of the LED lighting system is clearly apparent.

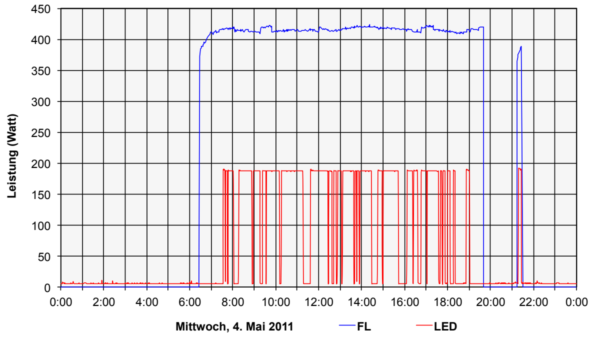
The graph also shows that, because of the power consumed by the actual DALI control system, the LED lighting system has a minimum standby power consumption (6 W for the entire 28 m long batten luminaire) but no power is consumed by the fluorescent lamp lighting system because it is switched off directly by a relay thanks to the presence detectors.

A comparison of four typical days in the four measurement periods is shown below by way of example. As the measurement results revealed, energy efficiency when using presence monitoring in corridors entails frequent switching on and off of the system. This is also illustrated by the four graphs.

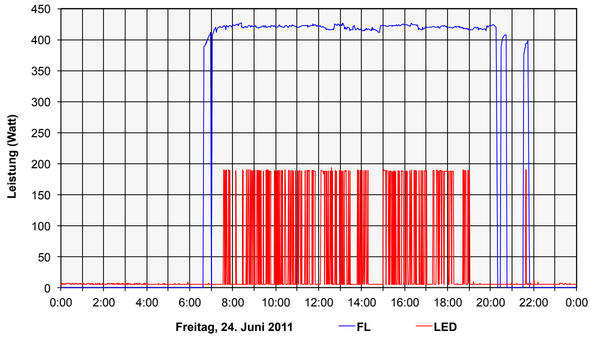
Daily changes in output on a typical work day in **1st measurement period**



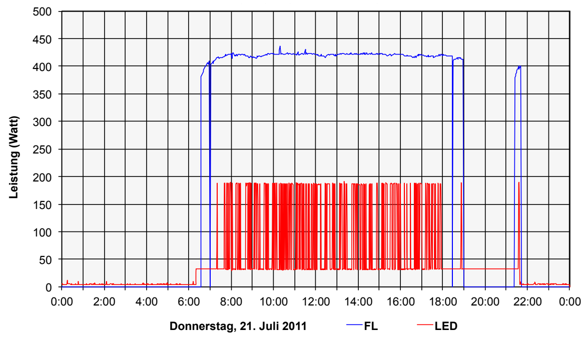
Daily changes in output on a typical work day in **2nd measurement period**



Daily changes in output on a typical work day in **3rd measurement period**



Daily changes in output on a typical work day in **4th measurement period**



Corridor lighting:
Extrapolating the numbers for a full year's operation of the energy-optimised LED lighting system (1-minute delay, no residual light) gives the following comparison figures.

	LEDs	T16 fluorescent lamps
Max. power produced	187 W	420 W
Operating hours	1,463 hours/year	3,343 hours/year
Energy consumption	274 kWh/a	1,404 kWh/a
Energy performance indicator	3.8 kWh/m² = CHF 0.60/m² a	19.5 kWh/m² = CHF 3.10/m² a
SIA 380/4 limit value	19.5 kWh/m²	
SIA 380/4 target value	7.5 kWh/m²	
Minergie requirement	10.5 kWh/m²	

This gives an annual electricity saving of 15.7 kWh/m² or CHF 2.50/m², which is equivalent to CHF 6 per annum per running metre of corridor. Because LED luminaires require no relamping during their entire service life (15 years), experience shows that the amount of the drop in servicing costs is roughly the same as the amount of the energy cost savings. Assuming an additional initial investment of CHF 100 per running meter of LED lighting in a corridor, this easily gives an amortisation period of 8 years for LED lighting.

Lift landing lighting:
At the same time as the corridor lighting, the compact fluorescent lamp downlights were also replaced by LED versions on the 7th floor. The delay time of these lamps which were controlled by presence detectors was left unchanged at the previous value of 10 minutes. Comparing the lift landing with LED lighting to the conventional lighting reveals an electricity saving of 66% over the entire measurement time. As the table shows, the energy performance indicator for the lift landing lighting drops from 16 kWh/m² SIA limit value = 19.5 kWh/m² to 7.2 kWh/m² so that even the strict SIA target value can be achieved with the LED solution.

	LEDs	compact fluorescent lamp
Max. power produced	56 W	125 W
Operating hours	2,765 hours/year	2,765 hours/year
Energy consumption	155 kWh/a	346 kWh/a
Energy performance indicator	7.2 kWh/m² = CHF 1.15/m² a	16 kWh/m² = CHF 2.55/m² a
SIA 380/4 limit value	19.5 kWh/m²	
SIA 380/4 target value	7.5 kWh/m²	
Minergie requirement	10.5 kWh/m²	

The LED downlights on the 16 m² lift landing produce an annual electricity saving of CHF 5.20 per luminaire. Bearing in mind the zero servicing costs, the additional cost of CHF 50 for an LED downlight is amortised within 5 years.

5 Discussion and outlook

The significant energy savings produced by presence monitoring are directly related to frequent switching on and off or dimming of the system. In corridors, LEDs not only have technical advantages over T16 technology, e.g. in terms of system loading due to striking and dimming processes. Lighting comfort is also improved in this application, in particular because LEDs have no perceptible start-up delay. A combination of appropriate light sources and a finely tuned lighting management systems therefore creates innovative, energy-optimised, future-proof lighting solutions that are highly acceptable to users and have short payback periods.

6 Literature

MINERGIE Switzerland
www.minergie.ch

Programme to promote energy-efficient lighting solutions in utility buildings
www.effelux.ch

Deutsche Gesellschaft für nachhaltiges Bauen [German Sustainable Building Council]
www.dgnb.de

Greenbuilding
www.greenbuilding.com

Lighting Research and Technology
http://lrt.sagepub.com

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