LED Indoor Lighting Design Specifications and Savings

The Considerations for Sustainable Indoor Lighting in Buildings

EmiratesGBC Technical Workshop

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Creating An Indoor Lighting Solutions Centers around the Human Asset

Designer's role

Understand	consider task, area, subject and place
Meet requirements	functions, amenity, standards, regulations
Select equipment	conforming to EU legislations and standards, environmental and architectural requirements
Calculate	manual or software aided
Plan	layout, installation, control strategy, use
Cost	supply, installation, use, maintenance

Contractor's role

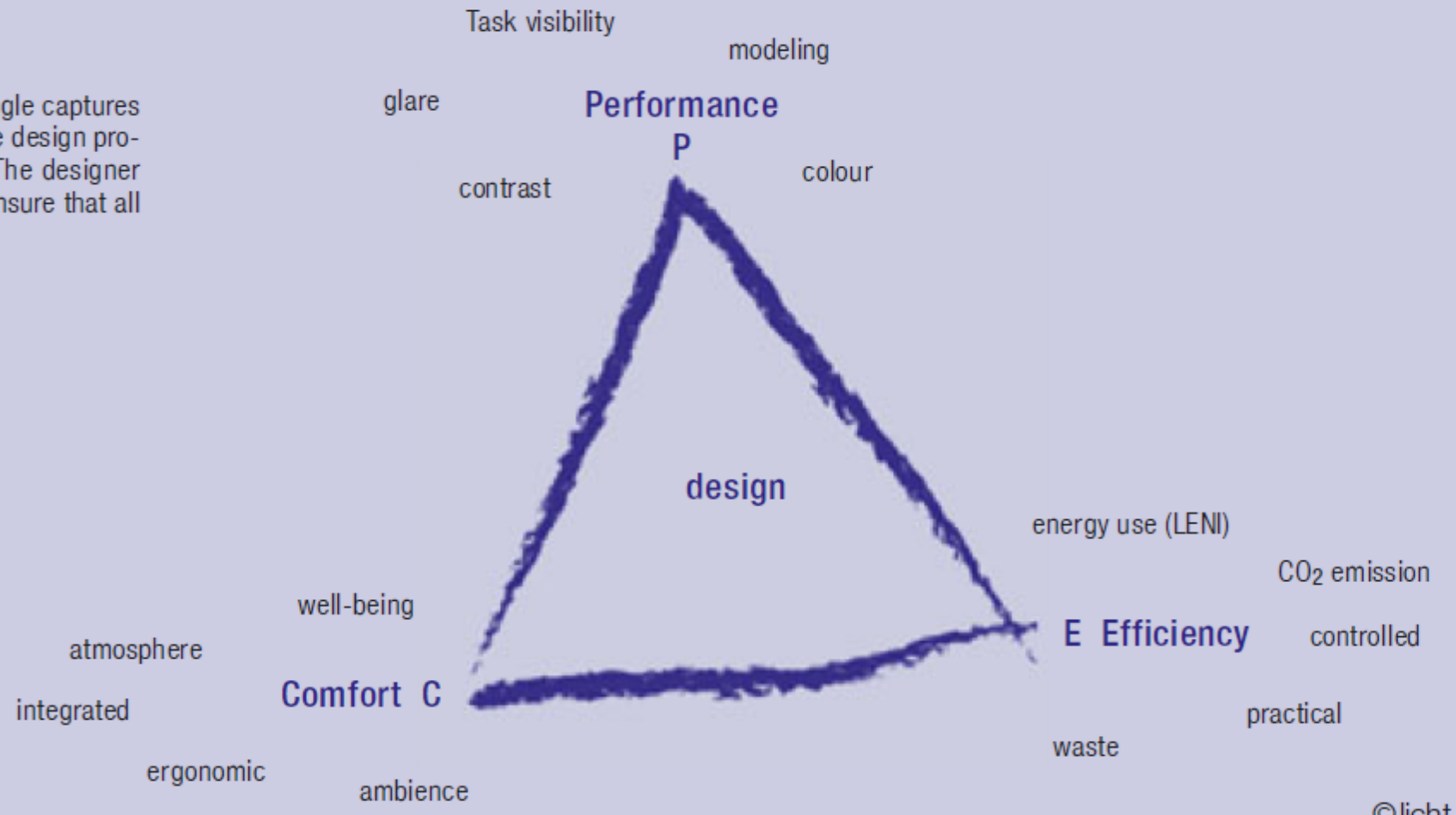
Installing scheme	according to design
Commissioning	set up scheme for hand over
Training	instruct end user on use, operation and maintenance

> Experiencing light quality
> Achieving Convenience
> Reducing costs

Lighting Design Considerations As Captured by Awareness Triangle

Lighting design

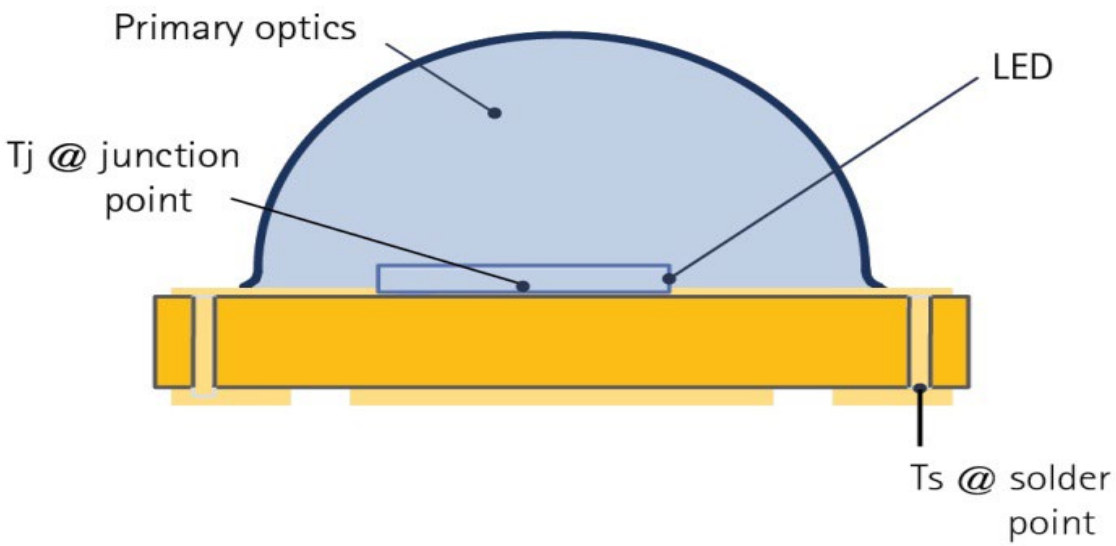
The CELMA Lighting Awareness Triangle captures design considerations. Skilful scheme design provides successful lighting solutions. The designer can make use of the holistic tool to ensure that all influencing factors are considered.



Three E's For Selecting a Sustainable Indoor Energy Efficient LED Luminaire

- **ENERGY :** W/m²
- **ECOLOGY :** Kyoto – reduction CO^2
- **ERGONOMICS :** glare control – ease of installation and maintenance.

Heat Management Of LED Light Source. LED's Depreciate in Lumen Output is a Known Fact



HEAT MANAGEMENT :

- LM-80 and TM-21 (Illuminating Engineering Society in the USA).
- Tj down => LED's don't fade away that quickly !

What Do Some of the LED Chip Manufacturers Say :

Philips: *Proper thermal design is imperative to keep the LED emitter package below its rated operating temperature.*

Cree: *The majority of LED failure mechanisms are temperature dependent. Elevated junction temperatures cause light output reduction and accelerated chip degradation.*

Osram: *In order to achieve reliability and optimal performance a proper thermal management design is absolutely necessary.*

Nichia: *For high power LED applications, the designer must consider how to manage heat, in order to enhance the performance of the LEDs. If heat management is not considered, the lifetime of the LED will be significantly decreased, or the LED will fail.*

- *Source : Michael Stiller - **L**eadership in **E**nergy and **E**nvironmental **D**esign Accredited Professional – IES presentation on LED Lighting : half-baked or ready for prime time.*
- Michael Stiller is currently a faculty member of FIT (Fashion Institute of Technology – State University of New York) in both the interior design department and the school for graduate studies'master degree program in exhibit design.
- LEED : A green building certification program that recognizes best-in-class building strategies and practices. To receive LEED certification, building projects satisfy prerequisites and earn points to achieve different levels of certification. Prerequisites and credits differ for each rating system, and teams choose the best fit for their project.

Maintenance Factor = *LMF x RSMF x LSF x LLMF*

MAINTENANCE FACTOR :

LMF x RSMF x LSF x LLMF

L70B50 (MTTF) :

0,95 x 0,94 x 1 x **0,7**

MF : 0,63

Points For Discussion: Maintenance Factor

MAINTENANCE FACTOR :

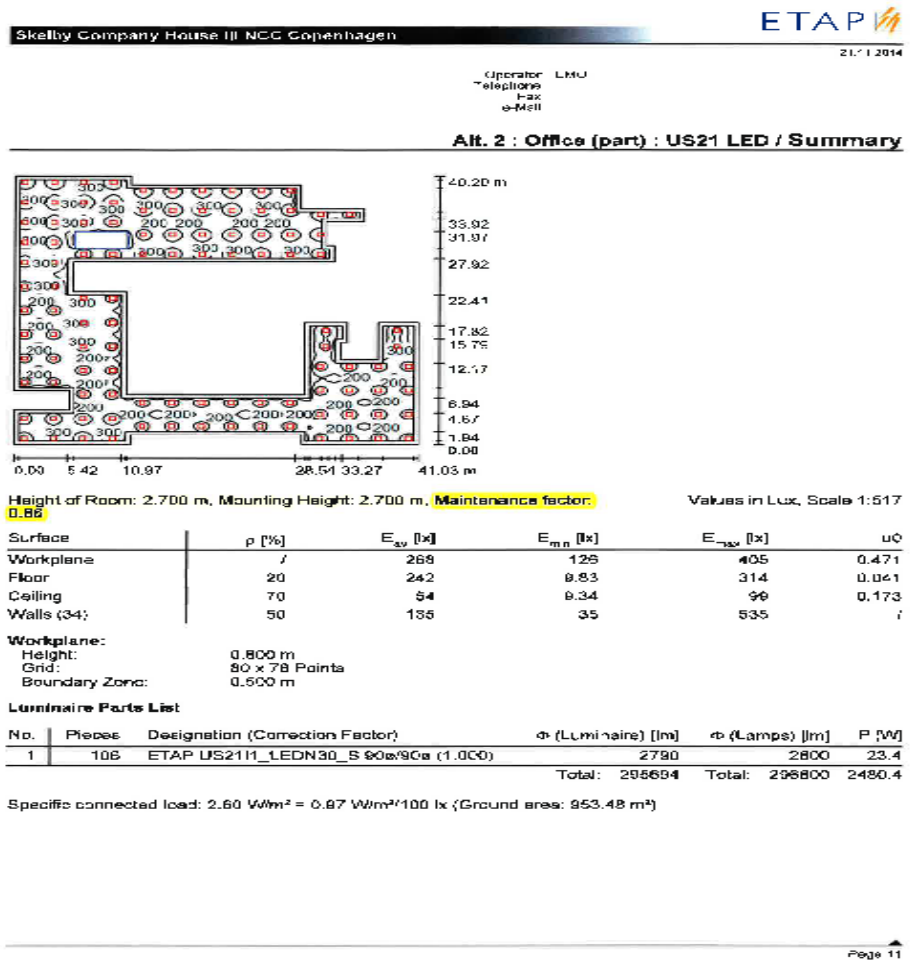
LMF x RSMF x LSF x LLMF

L99B50 (MTTF) :

0,95 x 0,94 x 1 x **0,99**

MF : 0,88

Maintenance Factor Varies for each LED Product



Skelby Company House III NCC Copenhagen — ETAP

Alt. 2 : Office (part) : US21 LED / Summary

Height of Room: 2.700 m, Mounting Height: 2.700 m, Maintenance factor: 0.80 — Values in Lux, Scale 1:517

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	269	126	405	0.471
Floor	20	242	9.83	314	0.041
Ceiling	70	54	9.34	99	0.173
Walls (34)	50	135	35	535	/

Workplane:
Height: 0.800 m
Grid: 80 x 78 Points
Boundary Zone: 0.500 m

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	106	ETAP US21I1_LEDN30_S 90x90 (1.000)	2790	2800	23.4
			Total: 295694	Total: 296800	2480.4

Specific connected load: 2.60 W/m² = 0.97 W/m²/100 lx (Ground area: 953.48 m²)

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MAINTENANCE FACTOR :

- MF varies for each LED product !
- MF expresses the quality of the LED luminaire.

KEY CHALLENGE IN A LED LUMINAIRE:

HOW TO SLOW DOWN LIGHT OUTPUT DEGRADATION IN TIME ?

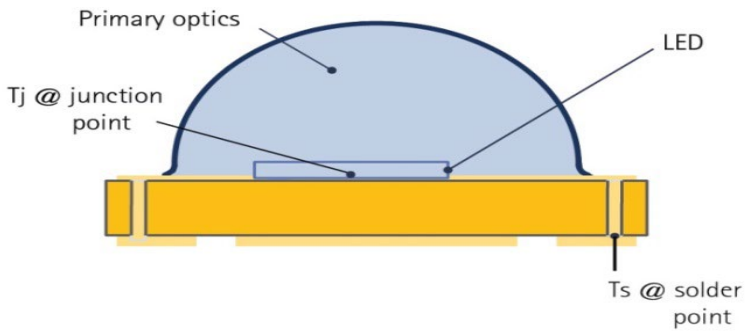
- 35% energy LED converted into light ⇔ 65% converted into heat.

- The higher the Tj, the lower the lumen output and lifetime expectancy.

I.E.S : HOW TO MEASURE AND PREDICT LIGHT OUTPUT RETENTION

IES determined a set of rules to predict lifetime expectancy and degeneration LED's over time :

- LM80: IES approved method for measuring Lumen Maintenance of LED Light sources (≥ 6000h)
- TM21: IES-recommended method for projecting lumen degradation of a LED package, array or module based on data collected according to LM-80



THE MAINTENANCE FACTOR

"is determined by different parameters relating to the ageing of the installation and the rooms"

- **MF= LLMF x LSF x LMF x RSMF**

MF = Maintenance Factor

- LLMF = reduction of luminous flux of the lamp
- LSF = frequency of lamp defects without replacement
- LMF = reduction of the efficiency of the luminaire (due to soiling)
- RSMF = soiling of the room

LSF : LAMP SURVIVAL FACTOR

- Effective failure rate of LED’s during service lifetime : 0,5% => LSF = 1.
- Abrupt failure LED & driver : compensated by other LED chips & spot replacement.
- Impact on MF : 0.

LMF : LUMINAIRE MAINTENANCE FACTOR

- Dust accumulation on luminaire.

- CIE97:2005 : guidelines too strict ⇔ TNO-report.
  - CEN/TC69 : call for tender : accelerated luminaire maintenance factor.

- According to Good Lighting Manufactures og LEDlighting :
  - ***0,95*** for clean office conditions.
  - ***0,89*** for normal industrial environments

- Concern : application of CIE LMF values => unnecessarily high connected load.

RSMF : ROOM SURFACE MAINTENANCE FACTOR

- Space pollution.

- Recommanded values CIE97:2005 :
  - Working environment : Very clean to dirty.
  - Cleaning cycle + reflection factors space.

- Clean office environments – 3 years cleaning cycle - 70/50/20 : ***0,94***

- Normal industrial environments – 3 years cleaning cyle - 50/30/20 : ***0,95***

THE MAINTENANCE FACTOR : WHAT VARIES IS THE LLMF

"is determined by different parameters relating to the ageing of the installation and the rooms"

- **MF= LLMF x LSF x LMF x RSMF**

MF = Maintenance Factor

- LLMF = reduction of luminous flux of *the lamp*

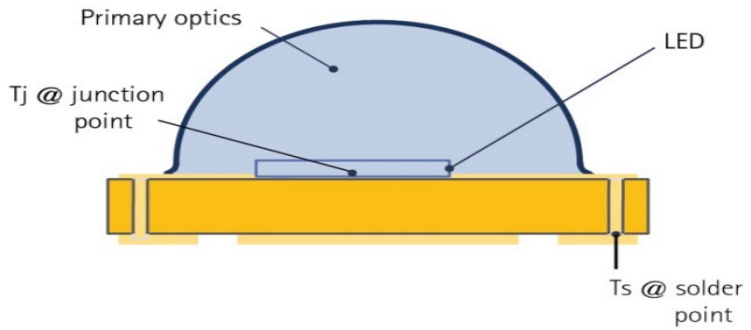
- *LSF = frequency of lamp defects without* replacement
- LMF = reduction of the efficiency of the luminaire (due to soiling)
- RSMF = soiling of the room

LLMF is the only product related variable

I.E.S : HOW TO MEASURE AND PREDICT LIGHT OUTPUT RETENTION

IES determined a set of rules to predict lifetime expectancy and degeneration LED's over time :

- LM80: IES approved method for measuring Lumen Maintenance of LED Light sources (≥ 6000 h – Prescribed standards : A good Manufacturer minimum measurement timespan : **10.000 h**)
- TM21: IES-recommended method for projecting lumen degradation of a LED package, array or module based on data collected according to LM-80 (preditions up to LM80 measurement time x 6 => A good Manufacturer Life Time Prediction is : **60.000 h**)



HOW TO DEFINE LLMF

- Measure at Tsp (solder point).

- Tj is determined according to following equation :

  Tj : Tsp + ({Rth j-sp}) x {Vf } x {Lf})

  - Tsp : temperature solder point
  - Rth j-sp : thermal resistance between the LED junction and the solder point
  - Vf : forward voltage
  - Lf : forward current

HOW TO EXPRESS LLMF

- Luminaires declared as L.. combined with B.. for a given service lifetime :
  - L expresses how many % of the initial lumen output remains
  - B expresses the failure fraction : normally B50 => the declared L-value is valid for 50% of the luminaires (on average)
  - For a given service lifetime : most prevalent : 50.000 hrs.

L70B50 at 50.000 hours therefore means that half of the luminaires will have lost 30% of their initial lumen output after 50.000 operating hours.

PRACTICAL EXAMPLE

L98B50 at 50.000 hrs. : for an office space :

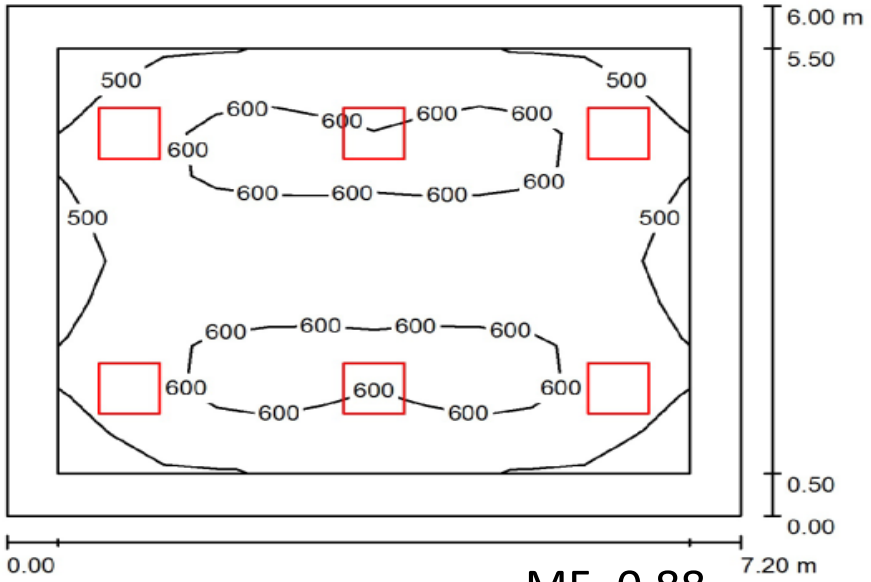
- **LLMF** x LSF x LMF x RSMF **= MF**
- **0,98** x 1 x 0,95 x 0,94 = **0,88**

L70B50 at 50.000 hrs. : for an office space :

- **LLMF** x LSF x LMF x RSMF **= MF**
- **0,7** x 1 x 0,95 x 0,94 = **0,63**

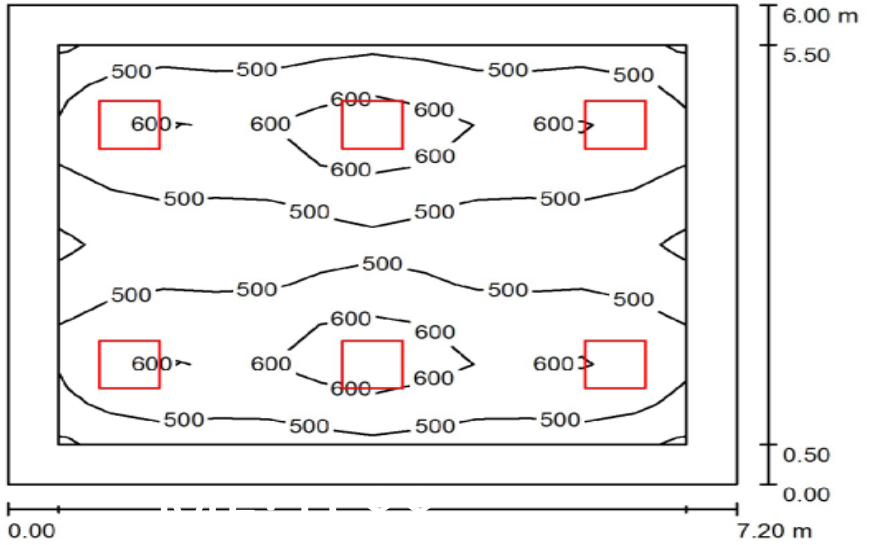
LLMF 98% @ 50KHrs / Poor LLMF70%

0h



MF=0.88

565 lx

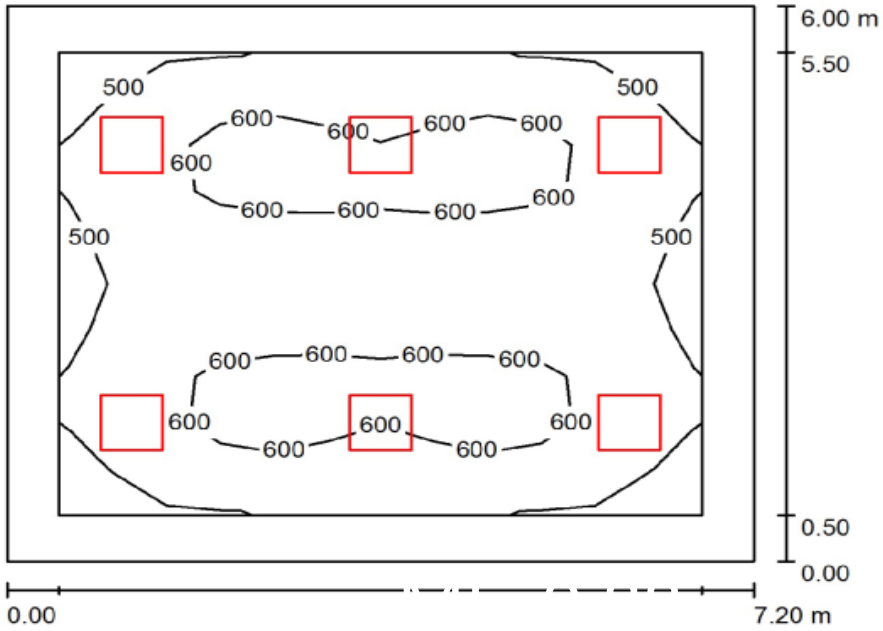


535 lx

MF=0.88

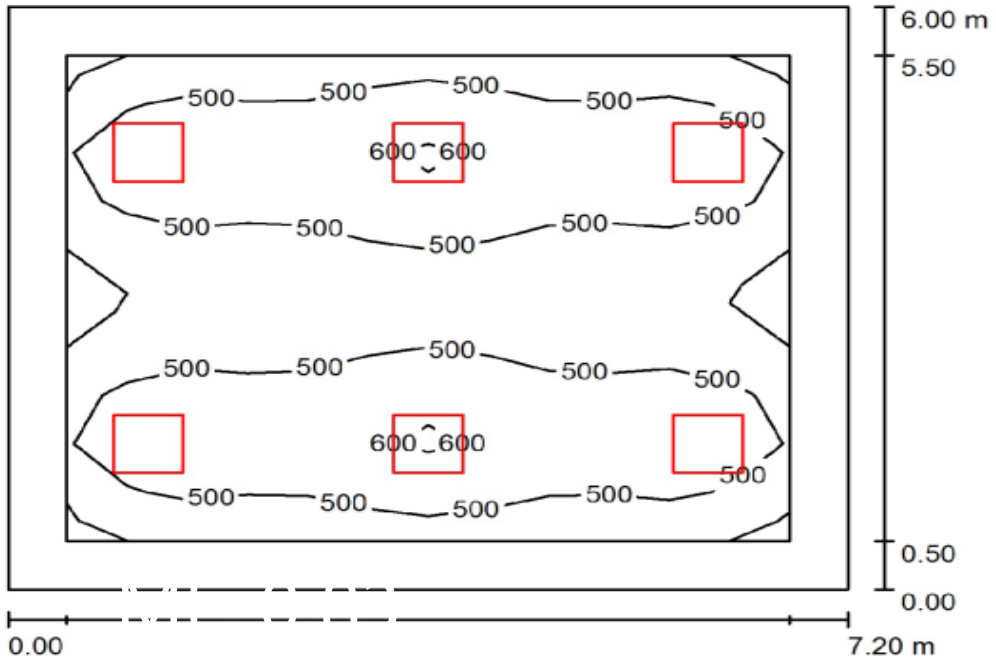
LLMF 98% @ 50KHrs / Poor LLMF70%

10.000h



565 lx

MF=0.88

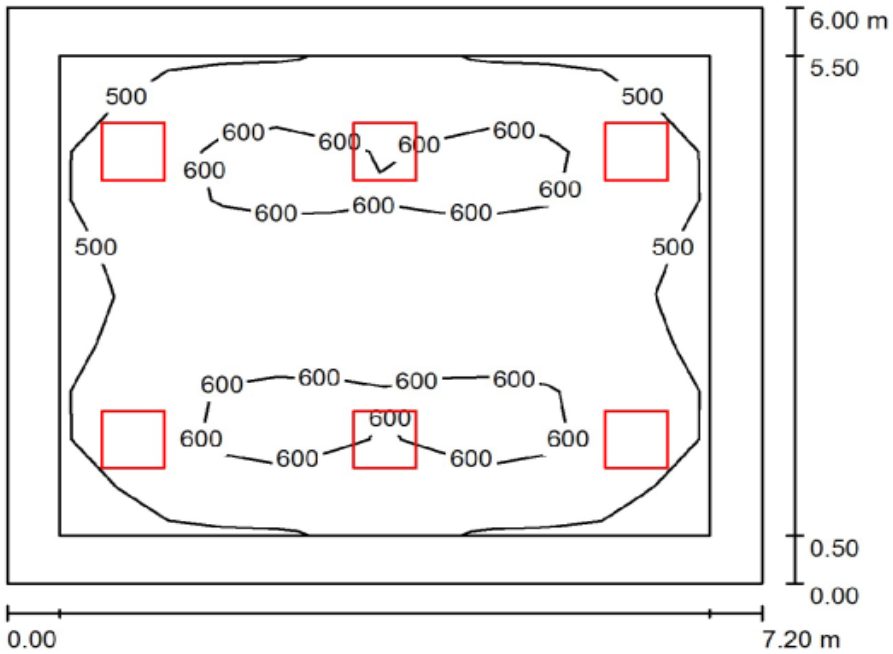


504 lx

MF=0.83

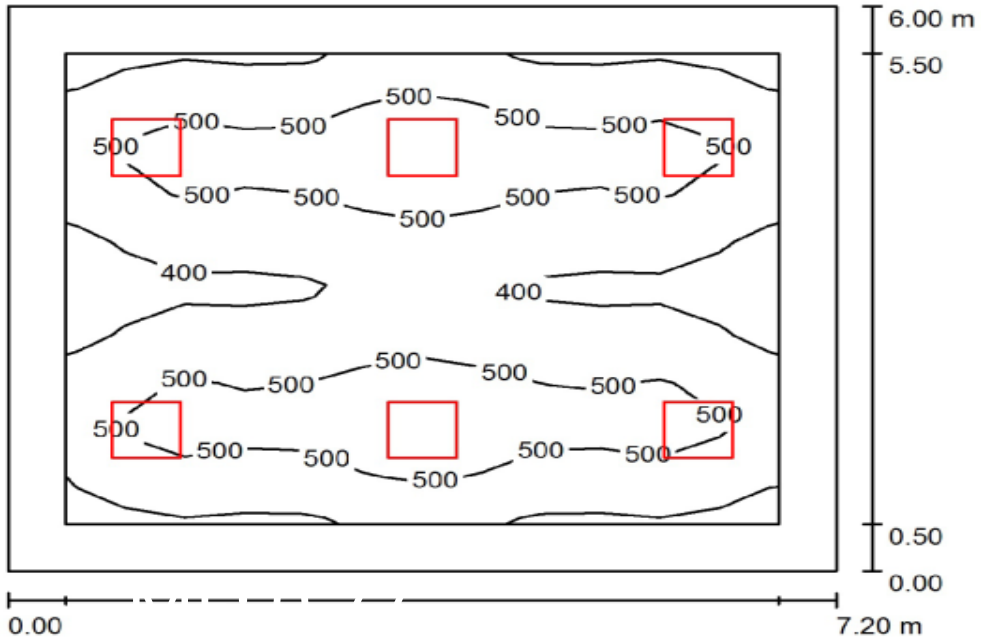
LLMF 98% @ 50KHrs / Poor LLMF70%

20.000h



565 lx

MF=0.88

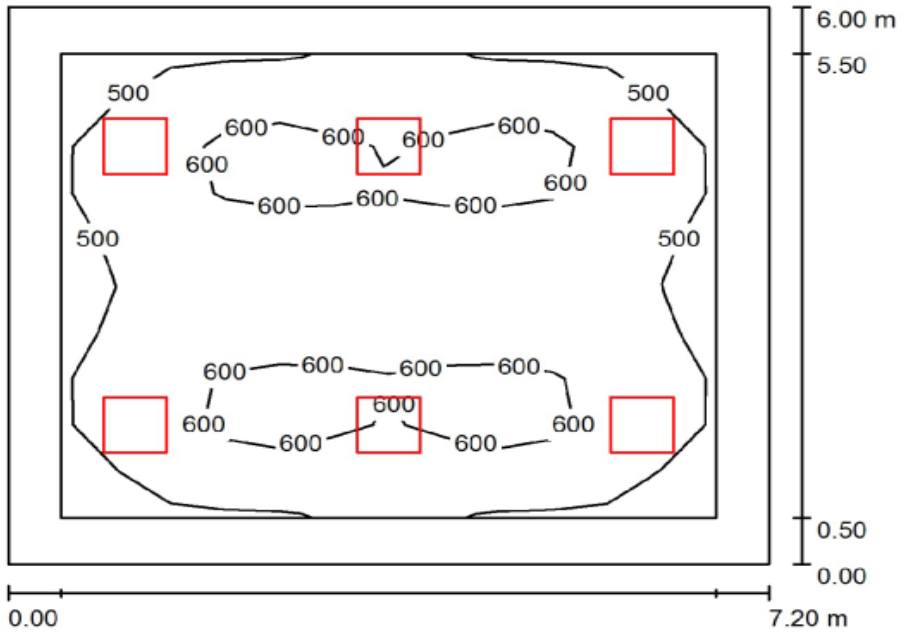


468 lx

MF=0.77

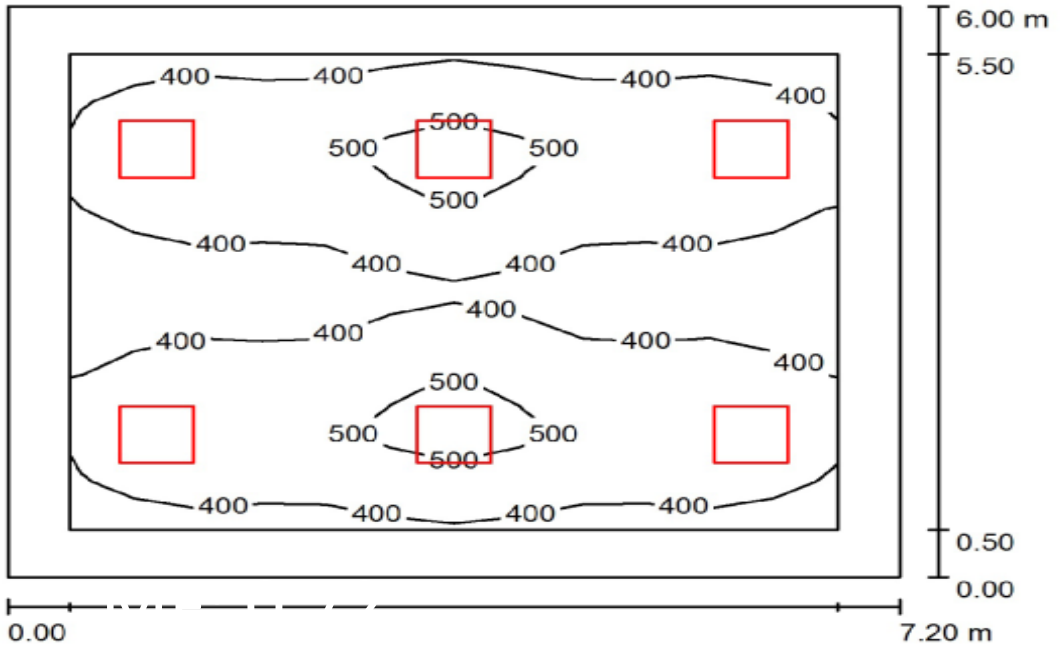
LLMF 98% @ 50KHrs / Poor LLMF70%

30.000h



565 lx

MF=0.88

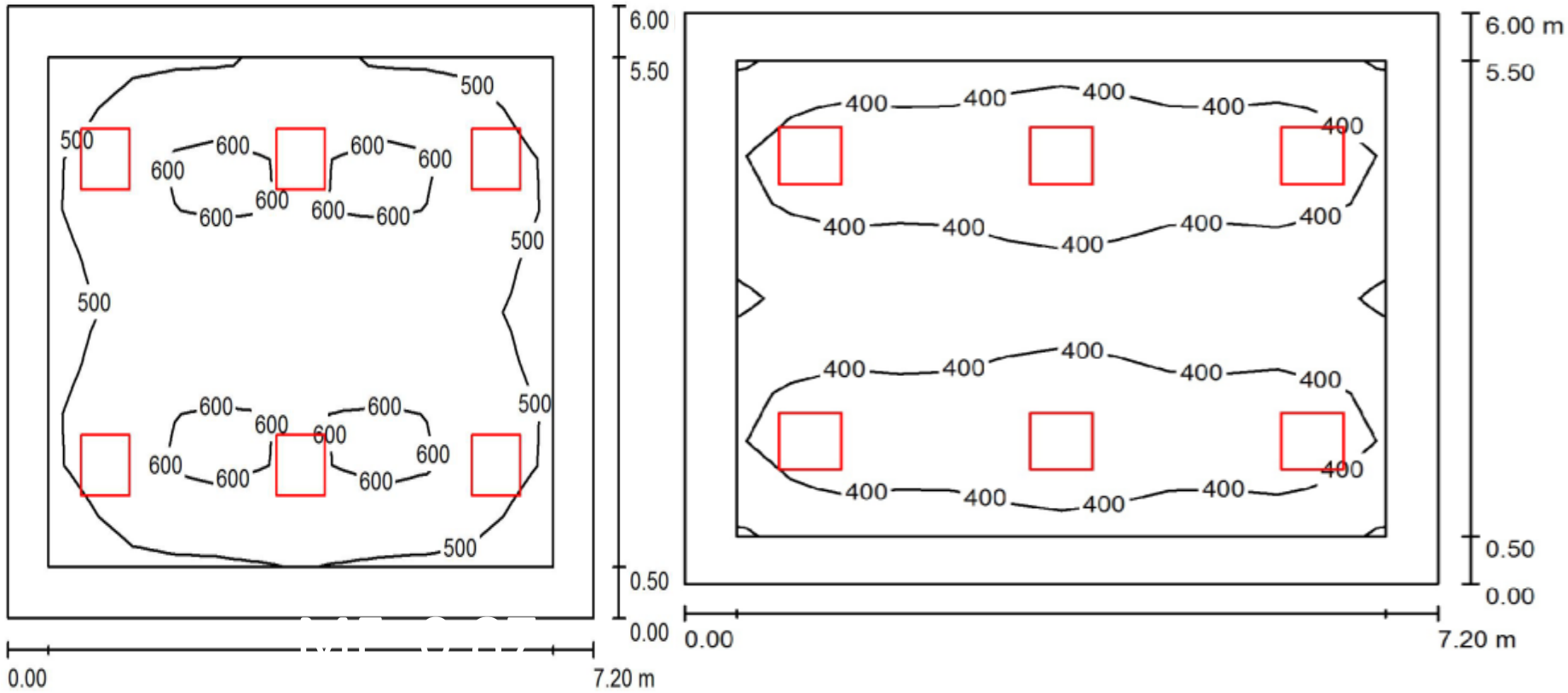


437 lx

MF=0.72

LLMF 98% @ 50KHrs / Poor LLMF70%

40.000h



558 lx

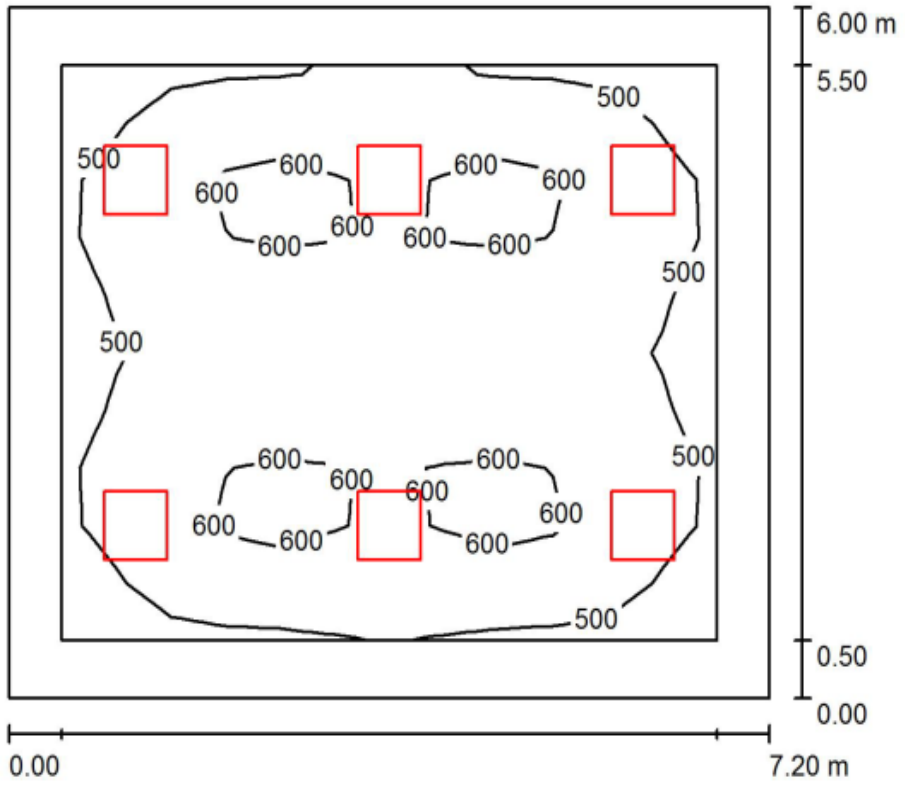
MF=0.87

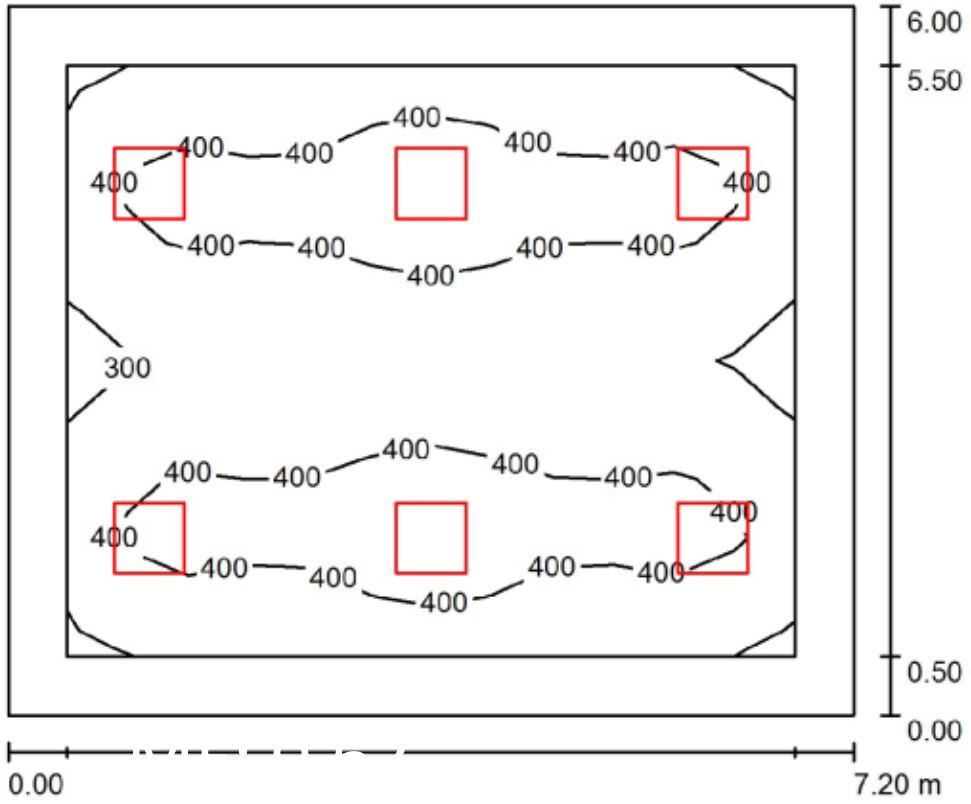
401 lx

MF=0.66

LLMF 98% @ 50KHrs / Poor LLMF70%

50.000h





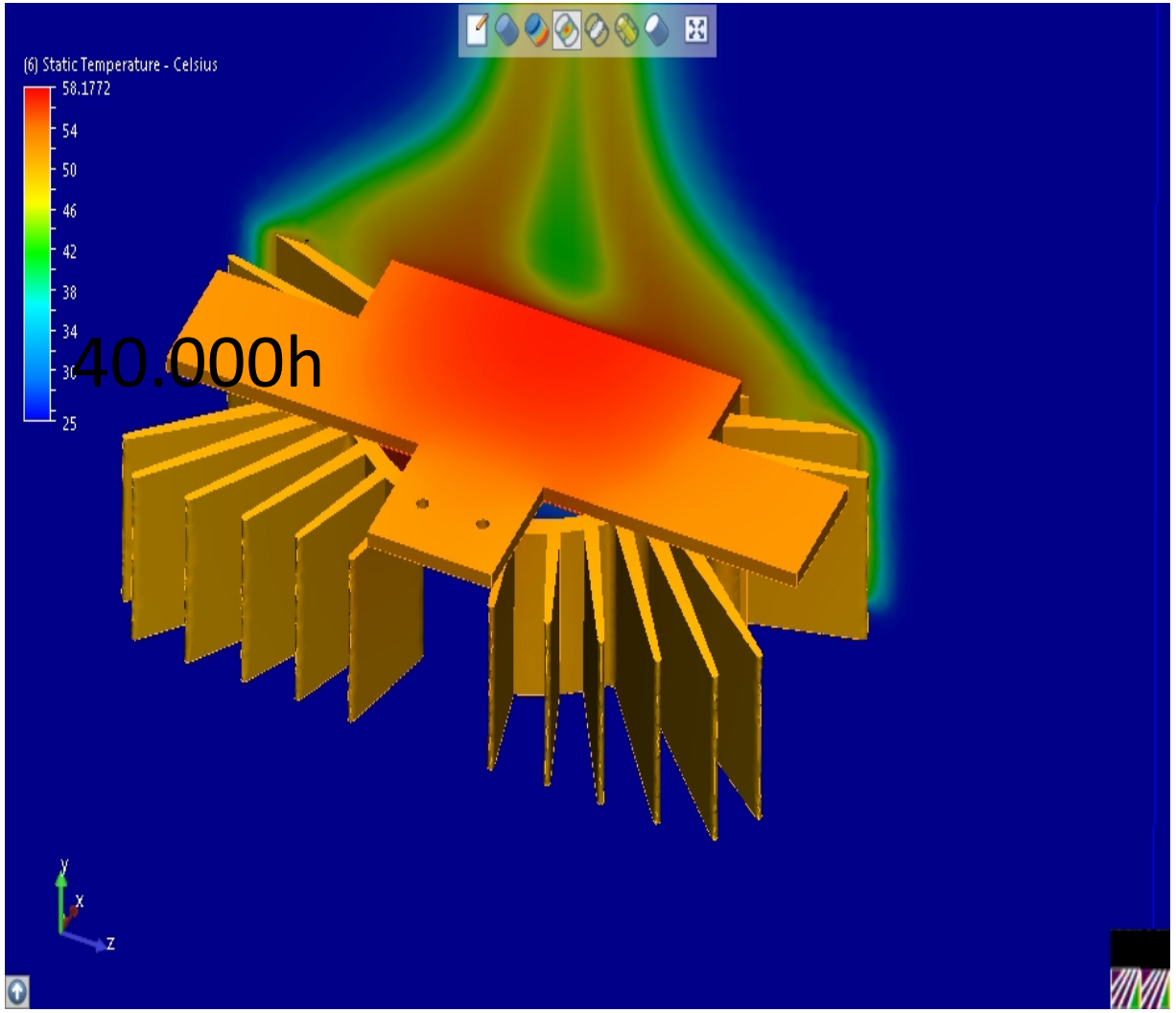
558 lx

MF=0.86

377 lx

MF=0.63

For a Good Energy Efficient LED Luminaire



LUMEN MAINTENANCE :

- L70B50 – L80B50 – ….
- Efficient heat management.

: HOW TO SLOW DOWN LIGHT OUTPUT DEGRADATION IN TIME = HOW TO IMPROVE LLMF ?

- Right balance between output current (in mA) and # LED-chips to obtain the desired lumen output .
- Use of thermal interfaces to improve heat transfer.
- Use of wafer PCB's (reducing the thermal resistance).
- High quality LED-chips : lesser risk of phosphor coating degeneration over time.

OTHER CHALLENGES

- Colour shifting :Colour Binning : < 3 Mc Adam ellips (or SDCM).

- Managing the light distribution : LED & LENS – use of diffusor foils with light beam control. **L97B50 For 50Khrs Service Life Time** Or Dual Lens..etc..
- Aim The Light Beam.
- Control the Glare in Critical Vieing Angle.

To Warranty Light Output : By Producing a Day –one Lighing Calculation & A later Date Lighting Study

Obtain a 5 year product warranty (extension up to 10 years under certain conditions .

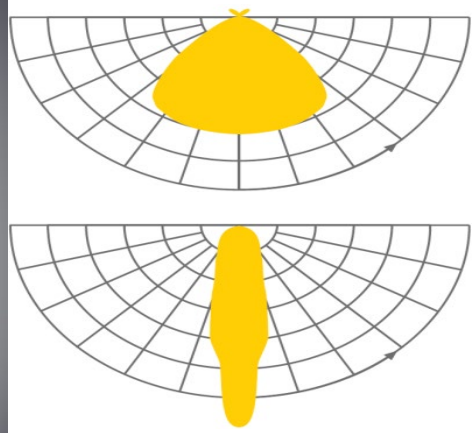
Optics Choices Depending On Applications

LED & LENS

- L97B50 for 50 khrs. service lifetime.

- Colour binning : < 3 SDCM.
- Aim The Light Beam.
- Control the Glare in Critical Viewing Angles

Optic Choices depending On Applications



Industry :

DUAL LENS TECHNOLOGY

- Glare control longitudinally.
- Fresnellens : light distribution control.

LIBERTY'S "RETROFIT PROJECT"

(CASE STUDY)

SUMMARY AT A GLANCE

ZERO BUDGET PROJECT

ENERGY SAVINGS :

3,062,049kwh

WATER SAVINGS:

888,367 liters

REDUCTION OF CO2:

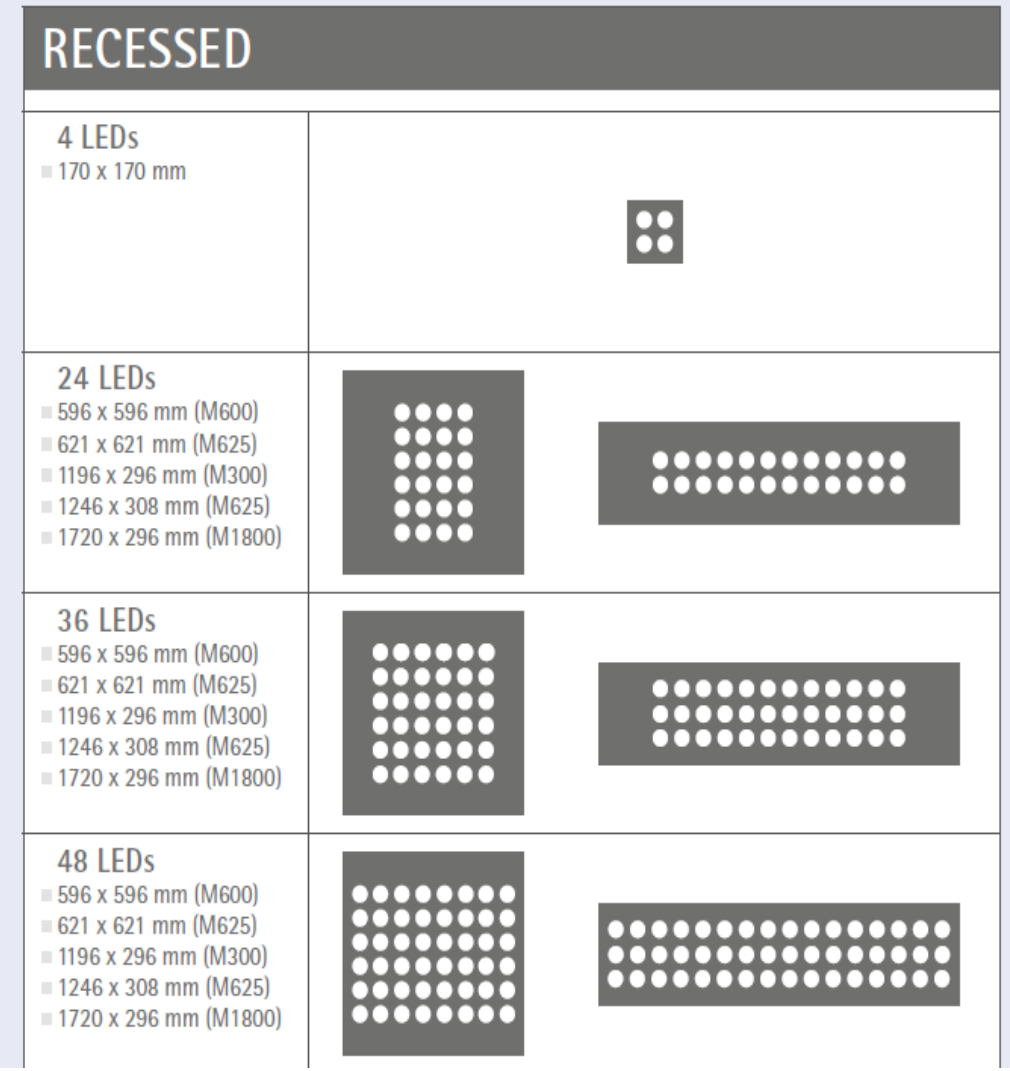
1,550,566 kg

COST SAVINGS

Dh. 1,145,750/-

ROI : 8.3 MONTHS

Same 60 x 60mm LED Luminaire with Different Lumen Outputs

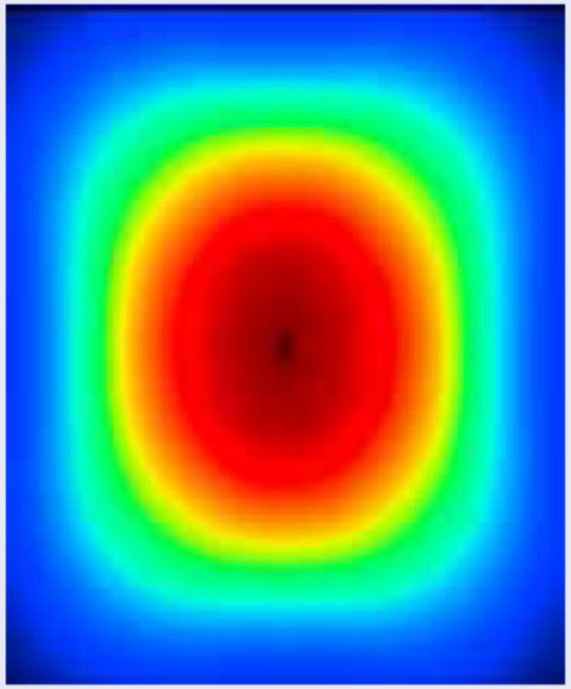


Case Study **Majid Al Futtaim Tower Dubai HQ**

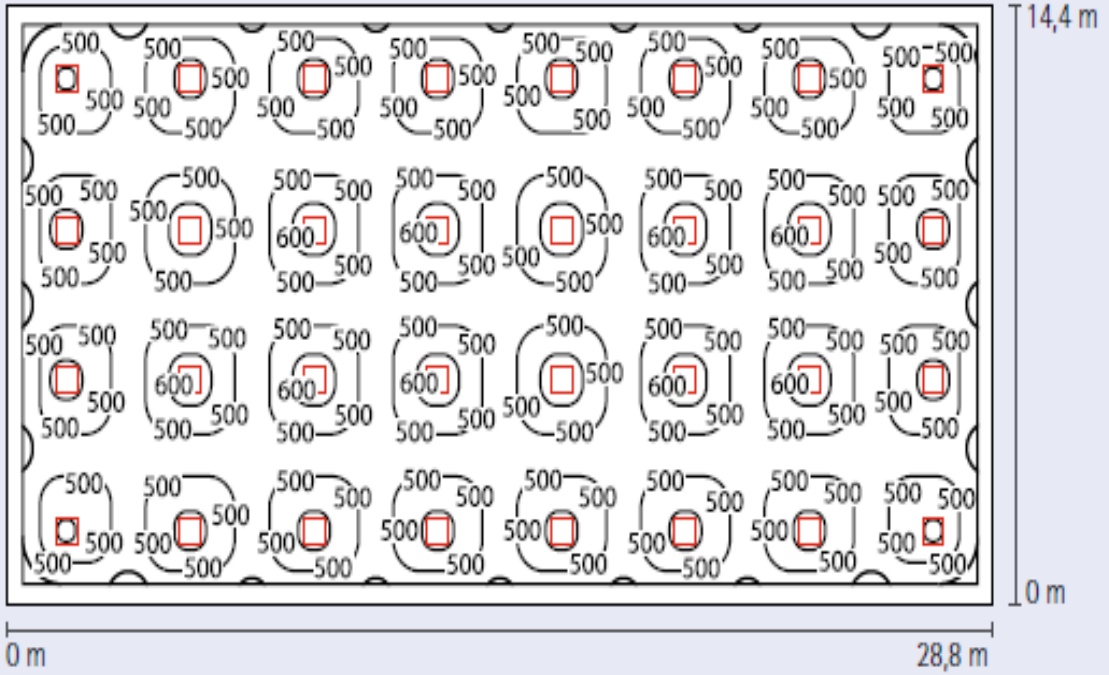
Wide-angle with uplight

In large spaces you can limit the number of luminaires with a wide-angle lens and adjusted lumen package. Suspended luminaires provide 30% uplight as standard: balanced distribution between direct and indirect lighting.

A Large Office with Extreme Wide- angle Lenses Specific Power= 0.75W/M2/100lx



The unique extreme wide-angle lens provides nearly square luminance, which leads to even illumination of the space.



Thanks to the extreme wide-angle lenses you can illuminate your large office spaces with a minimum number of luminaires, using the least possible energy.
Specific power: 0,75 W/m²/100 lx
Maintenance factor: 0,88

Increased 30% Energy Savings with integrated Multi-detector /Daylight Sensor Light On Demand

LEDs have a number of specific properties that make them particularly suitable for use with light control systems. For example, frequent switching has no impact on the service life of LEDs. Furthermore LEDs immediately respond with full luminous flux when switched on, which increases user comfort upon entering the space.

LEDs not only respond fast when switched on, but also after any change in supply, which implies that they dim more smoothly and precisely. Fluorescent lamps react more slowly, especially when they are cold.

R7 and U7 use the updated ELS sensor for daylight control, which is more compact than its predecessor and can be integrated very discreetly into the slim luminaires. At the same time we improved the sensor's performance, which follows the spectral sensitivity curve even more closely, is less temperature-dependent and reacts faster and more accurately. All these improvements result in 30% and more energy savings.

U7 with multidetector EMD.

R7 with daylight-dependent light control ELS.

Case Study Chocolate Factory DIP 2

Specified was 385W LED HIGHBAY

DEWA approved Points.

Ceiling Height : 18/13/10 Meters.

Lighting Levels : 500 Lux in Production Area & 300 Lux in Cold Store-25C & Ware house.

Solution with Linear Glare Free 158W LED Luminaire;IP66; Suitable for ACID Cleaning Driver +70 to -40 C; Narrow & Wide angle Lens; 5.000K; Photo biologically tested; ENEC Approved.

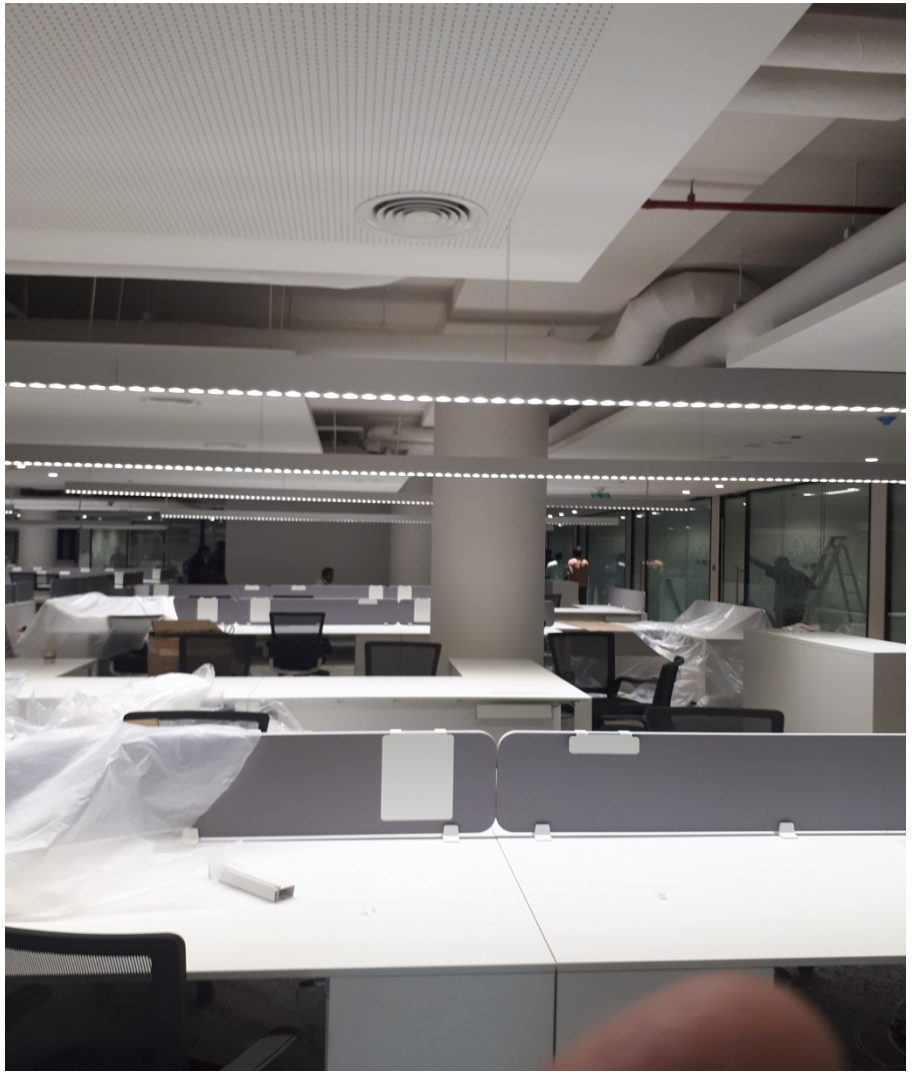
Deciding Factor For Client

TOTAL COST OF OWNERSHIP		
	LED HIGHBAY	LINEAR LED WITH DUAL LENS
CONNECTED LOAD(W)	378	158
OPERATING HOURS PER DAY	24	24
OPERATING DAYS PER YEAR	365	365
BURNING HOURS PER YEAR	8,760	8,760
LOCAL KWH-RATE	AED 0.45	AED 0.45
ANNUAL ENERGY COST PER LUMINAIRE	AED 1,490.08	AED 622.84
ANNUAL ENERGY SAVINGS		AED 867.24
SAVINGS OVER 5YEARS TIME		AED 4,336.20

Ware House with Horizantal & Vertical Illuminance

Case Study MAF Retail Carrefour 5th Floor Office Refurbishment

All Equipped with Microwave Sensors & DIP Switches

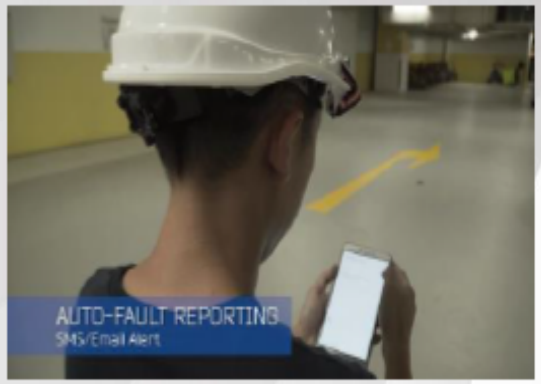


On-demand wireless, Smart lighting system (Benefits)

- On demand Lighting (when and how much as needed)
- Wireless networked sensors (no messy cabling)
- Smart lighting control algorithm (repeatable and reliable)
- Remote configuration, control, monitoring & analytics (convenient, efficient and measurable)

On-demand wireless, Smart lighting system (other features)

- Lightings do not totally switch off (e.g. safety or security reasons)
- Dim level maintain sufficient luminous flux to meet safety & security requirement (user preference or fulfil guidelines)
- Brightness resumes when movement detected
- Fail Safe system (fulfil safety guidelines)
- “Anti Mask” sensors (prevent sabotaging enhance security)
- Trigger CCTV recording (option)



We enumerate the additional Benefits: With a Wireless SMART Lighting System

- Higher Energy Savings than LEDfication.
- Auto Fault Reporting & Monitoring.
- Predictive Maintenance.
- Longer Product Life.
- IoT Enabled.
- Networked Sensors.
- Data Analysis.
- Improved Resource Efficiency.

THANK YOU