Building industries and cities
The new smart lighting frontiers
20. May. 2016

Cost models and evidence data for innovation

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Quality – Costs- Energy efficiency – Versatility - Miniaturization

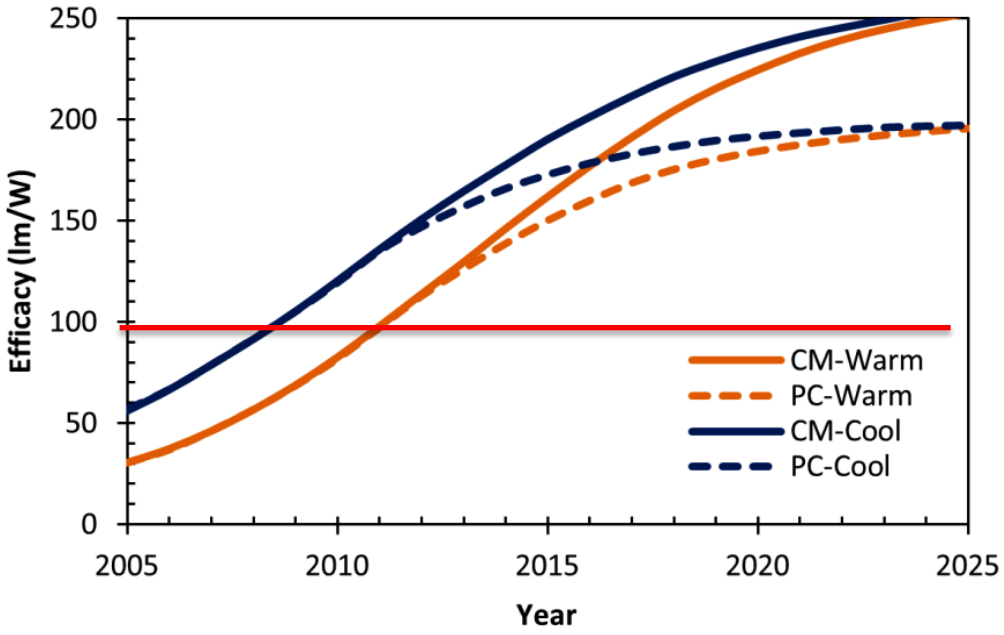
« Solid State Lighting (LEDs) is a disruptive technology which is changing the whole way we will design, install, maintain and finance lighting installations. »

Will bring some facts

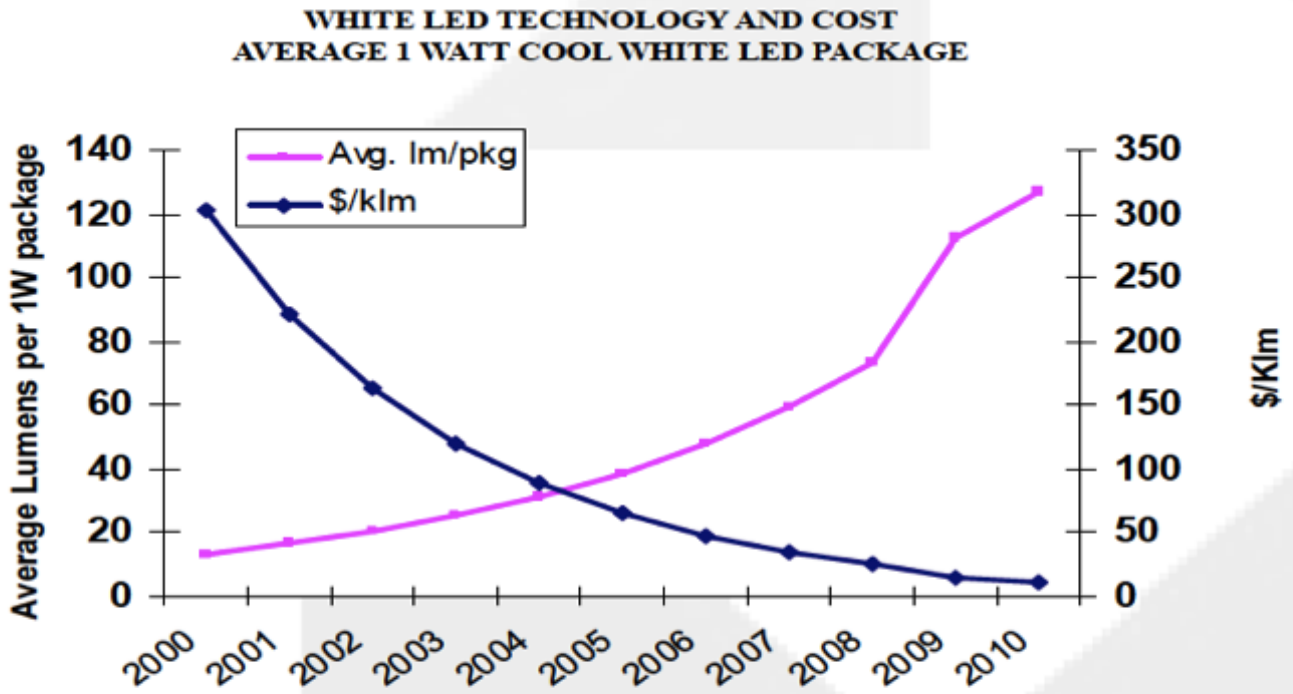
Will show examples of our contribution

New LED based luminaires have an **efficiency 2 to 3 times of** the ones they replace

Cost evolution will reduce **Total Cost of Ownership** by **2 to 5 by 2020**…



Efficiency/Cost



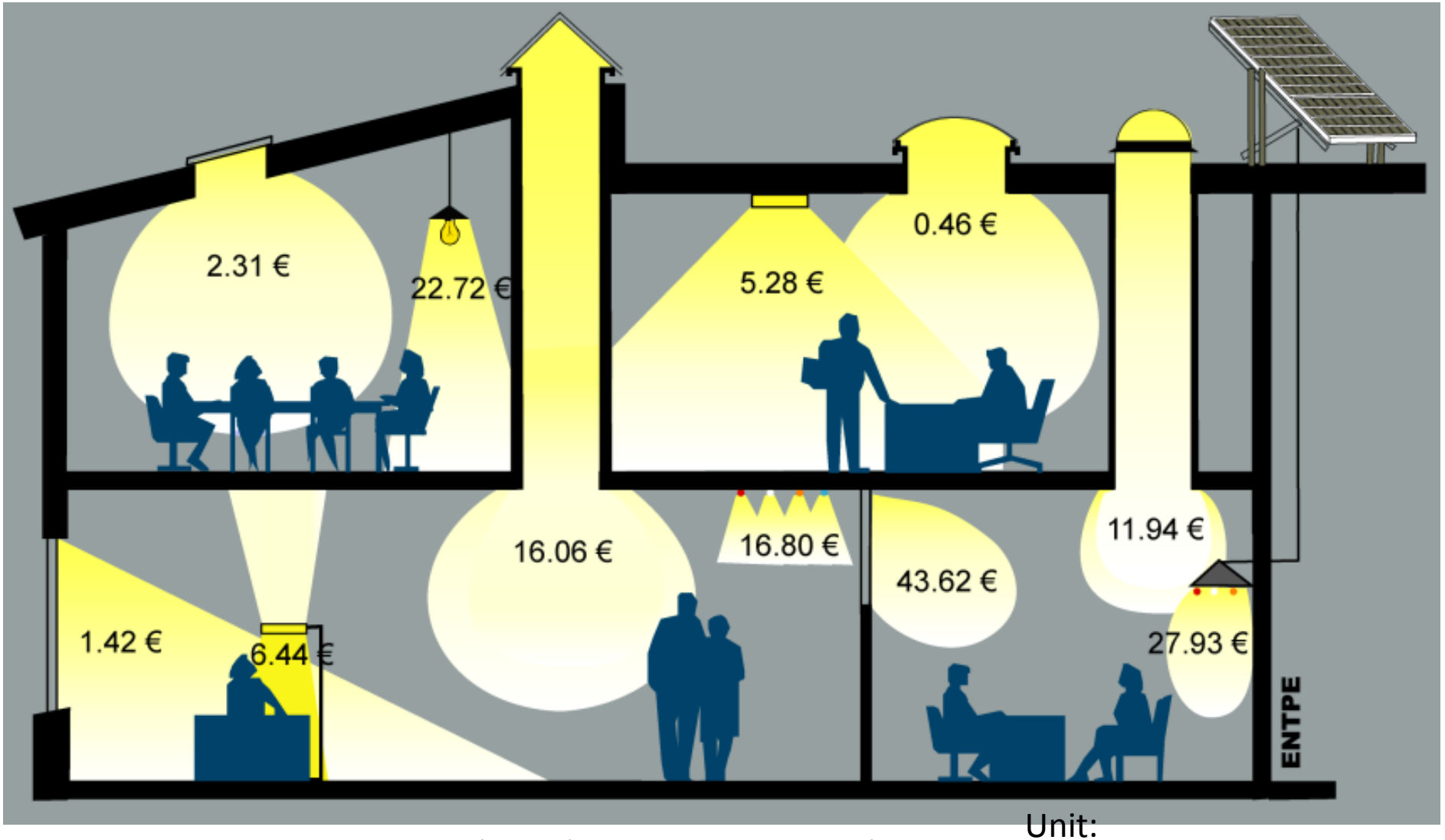
Some trends:

Standards are missing but clusters of companies begin to agree on standard approaches Connected Lighting Alliance , Zhaga…

Some players propose long term supply of lighting (manufacturers, facility managers, utilities, etc.)

Value of general lighting may go down

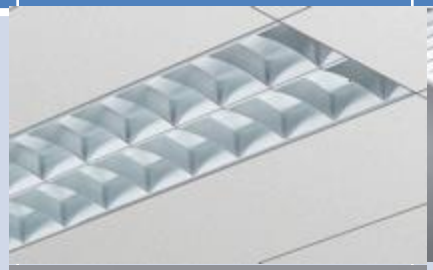
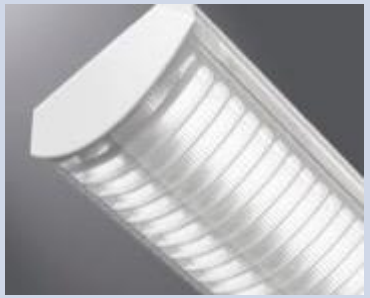
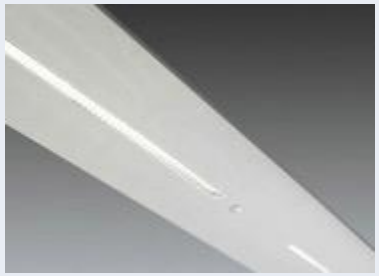
Value moves to visual effects, entertainment, displays, and maintenance contracts.



Source Marc Fontoynont, Light and Engineering Journal, 2008.

Unit:
€/Mlm.hr of useful light

Looking for « low hanging fruits » and best solutions

	Industrial building	Office building	School	Store
Reference installation (15 – 30 yrs)	 	 	 	 
New generation (2014-2015)	 	 	 	 

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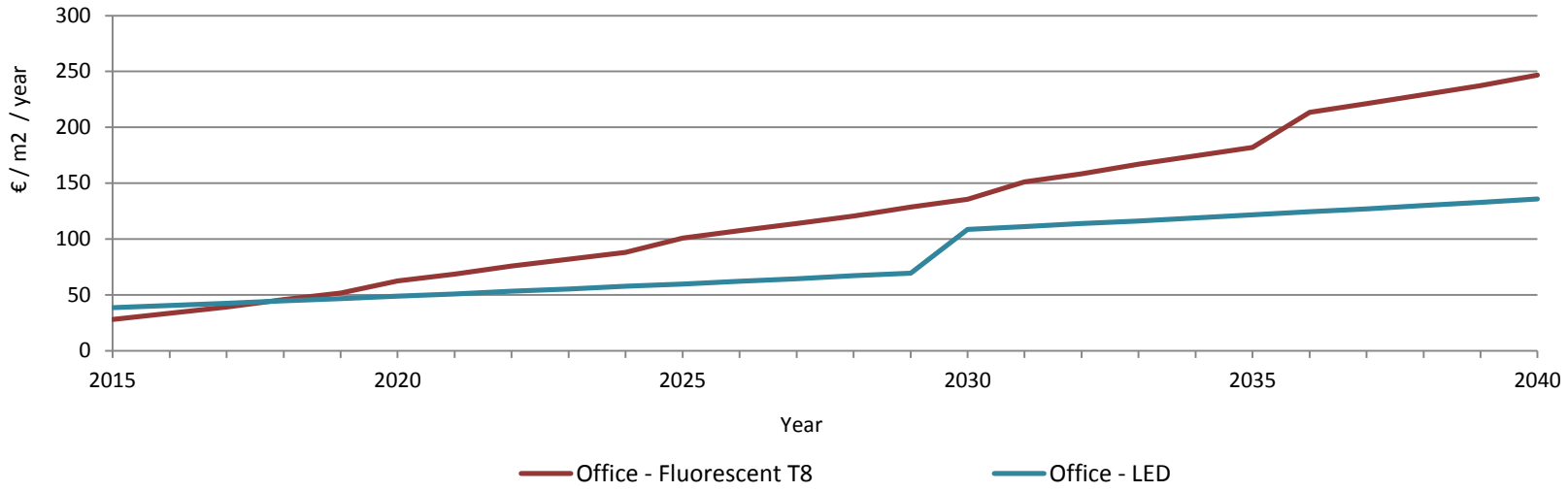
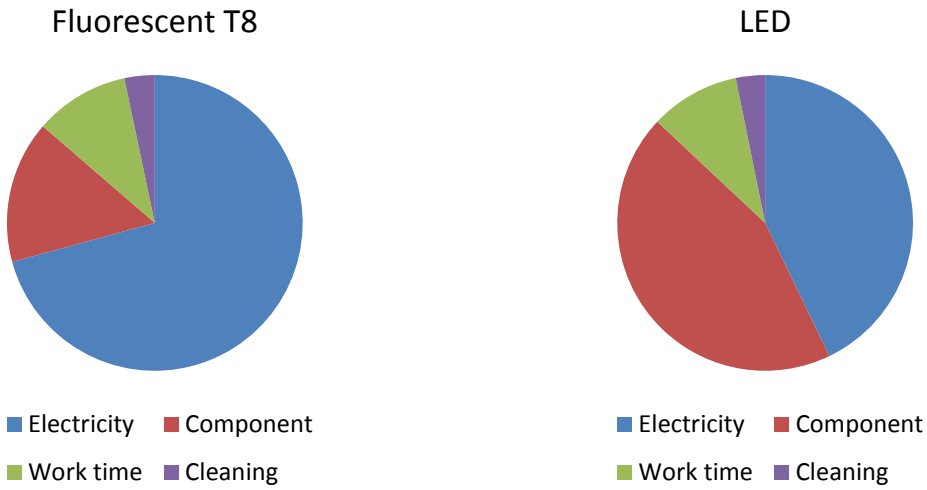
Office building

LCC, Fluorescent T8 and LED



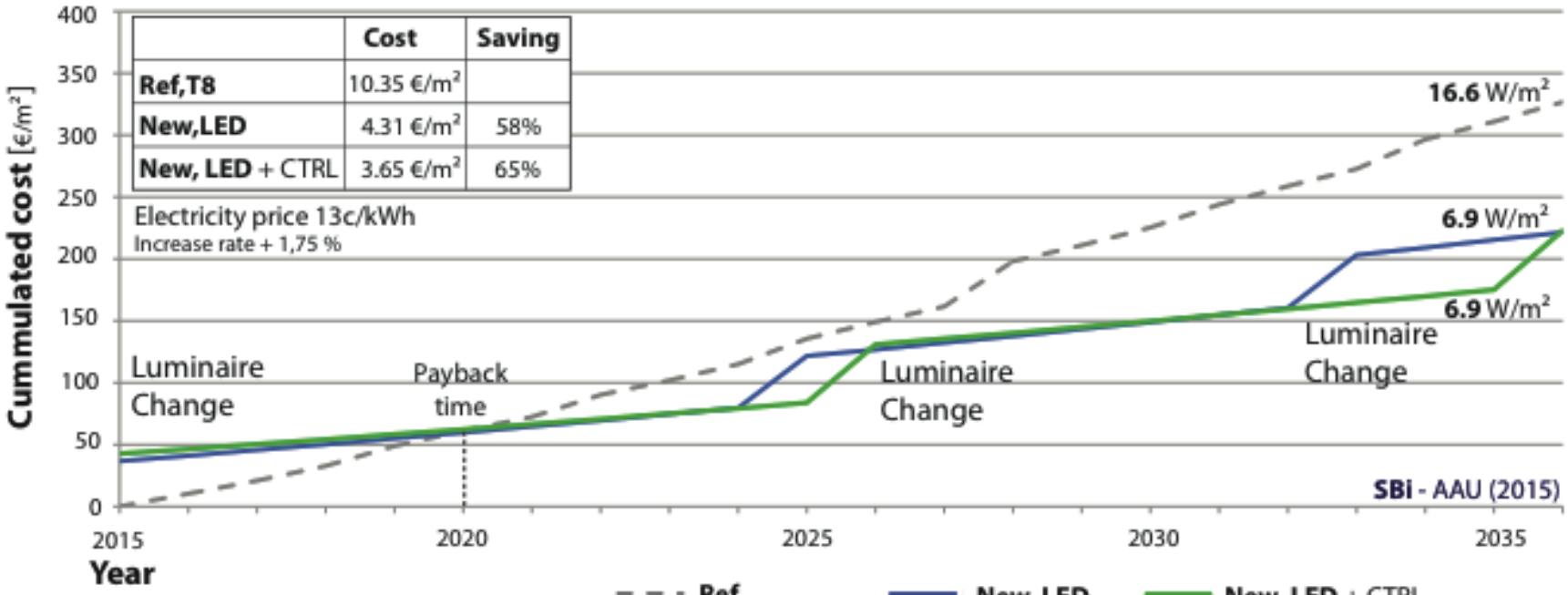
Relative distribution of costs within LCC



Marc Fontoynont 2016, IEA 50

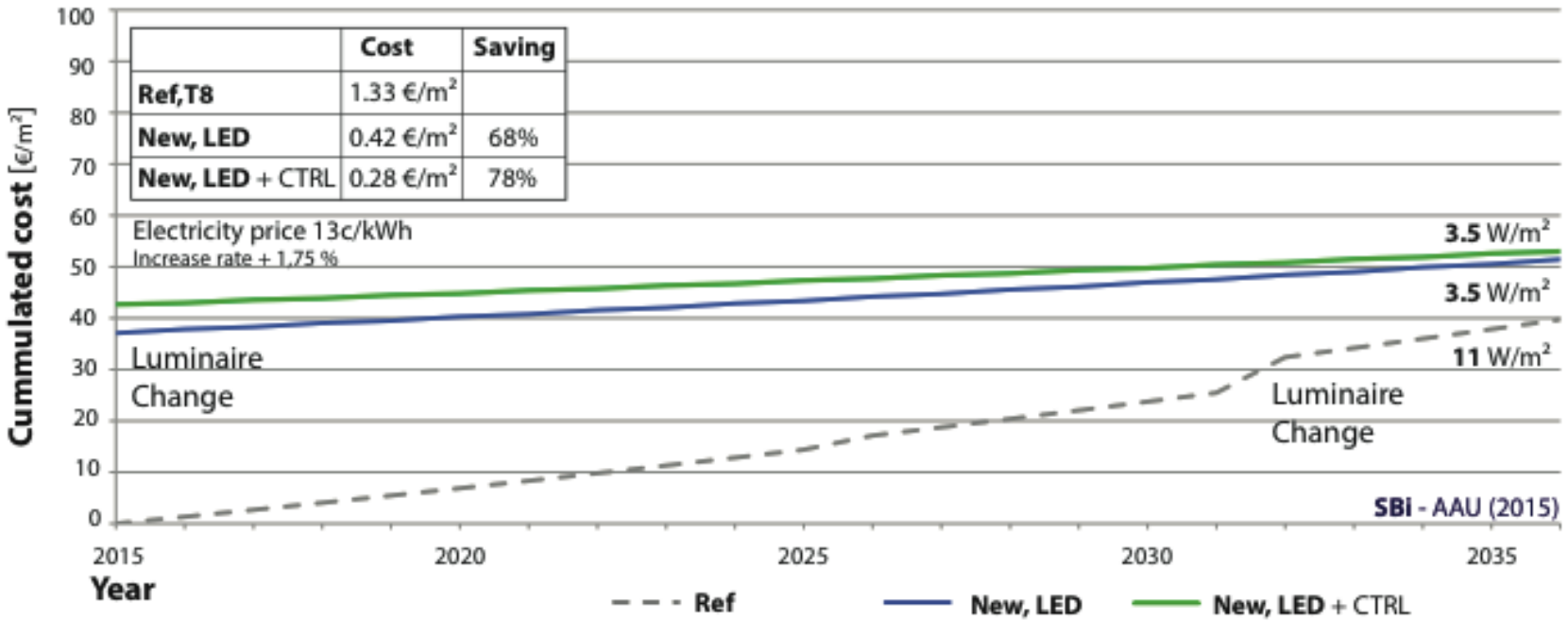
Wholesale Retail

Usage hours: **4801** h/year



Change of luminaire (€/m2)		**36.7** €/m²	**42.7** €/m²
Electrictiy consumption (€/m2) WATTAGE	**10.35** €/m²	**4.31** €/m²	**3.65** €/m²
Usage hours (h/year)	**4801** h/year	**4801** h/year	**4069** h/year

Classroom Usage hours: **932** h/year

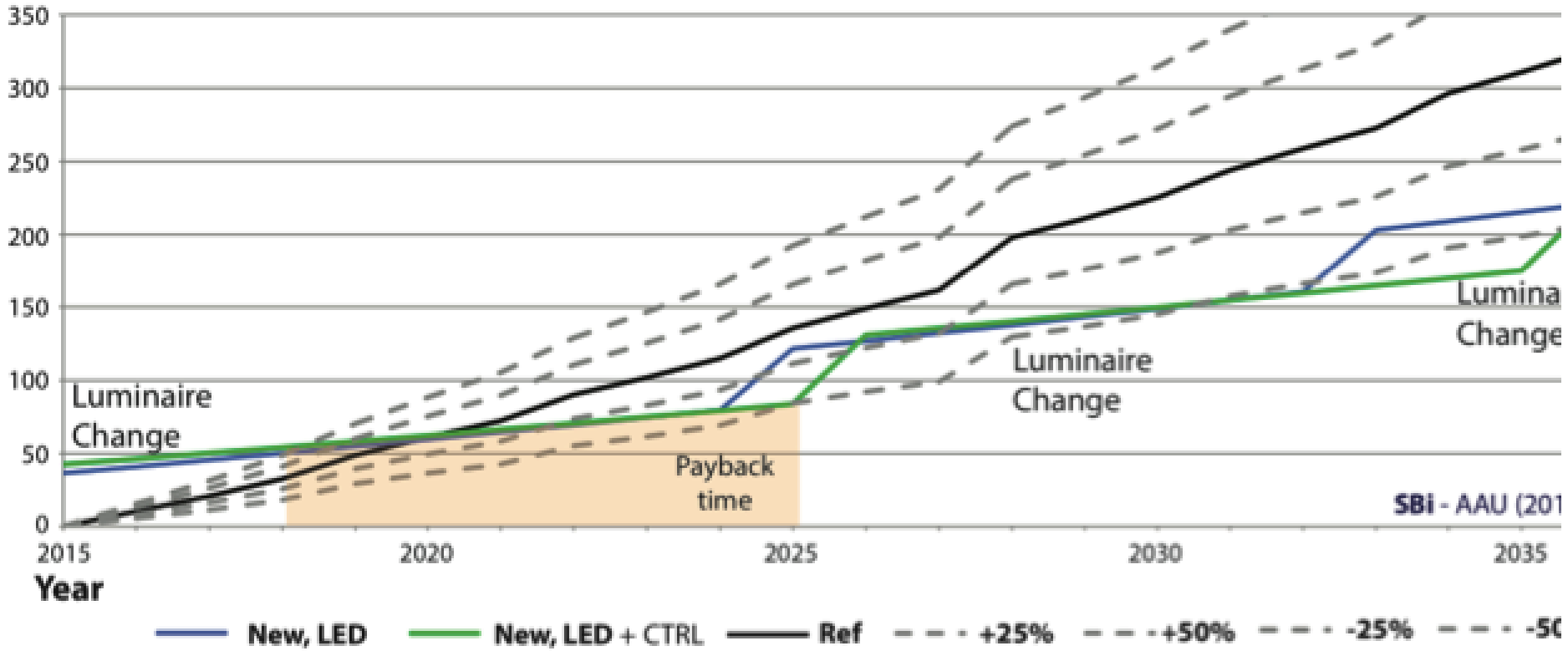


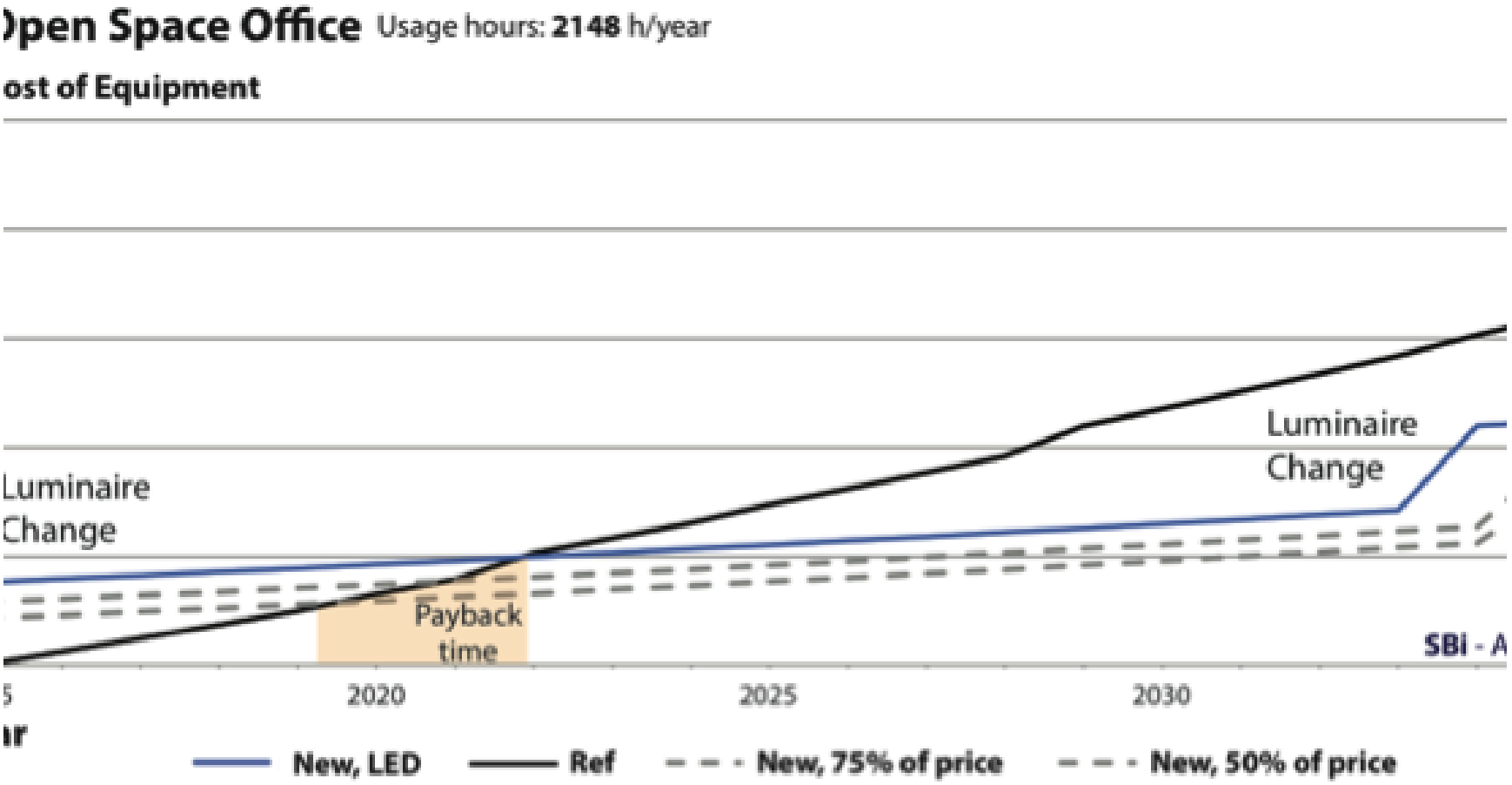
Change of luminaire (€/m2)		**36.7** €/m²	**42.7** €/m²
Electrictiy consumption (€/m2) WATTAGE	**1.33** €/m²	**0.42** €/m²	**0.28** €/m²
Usage hours (h/year)	**932** h/year	**932** h/year	**620** h/year

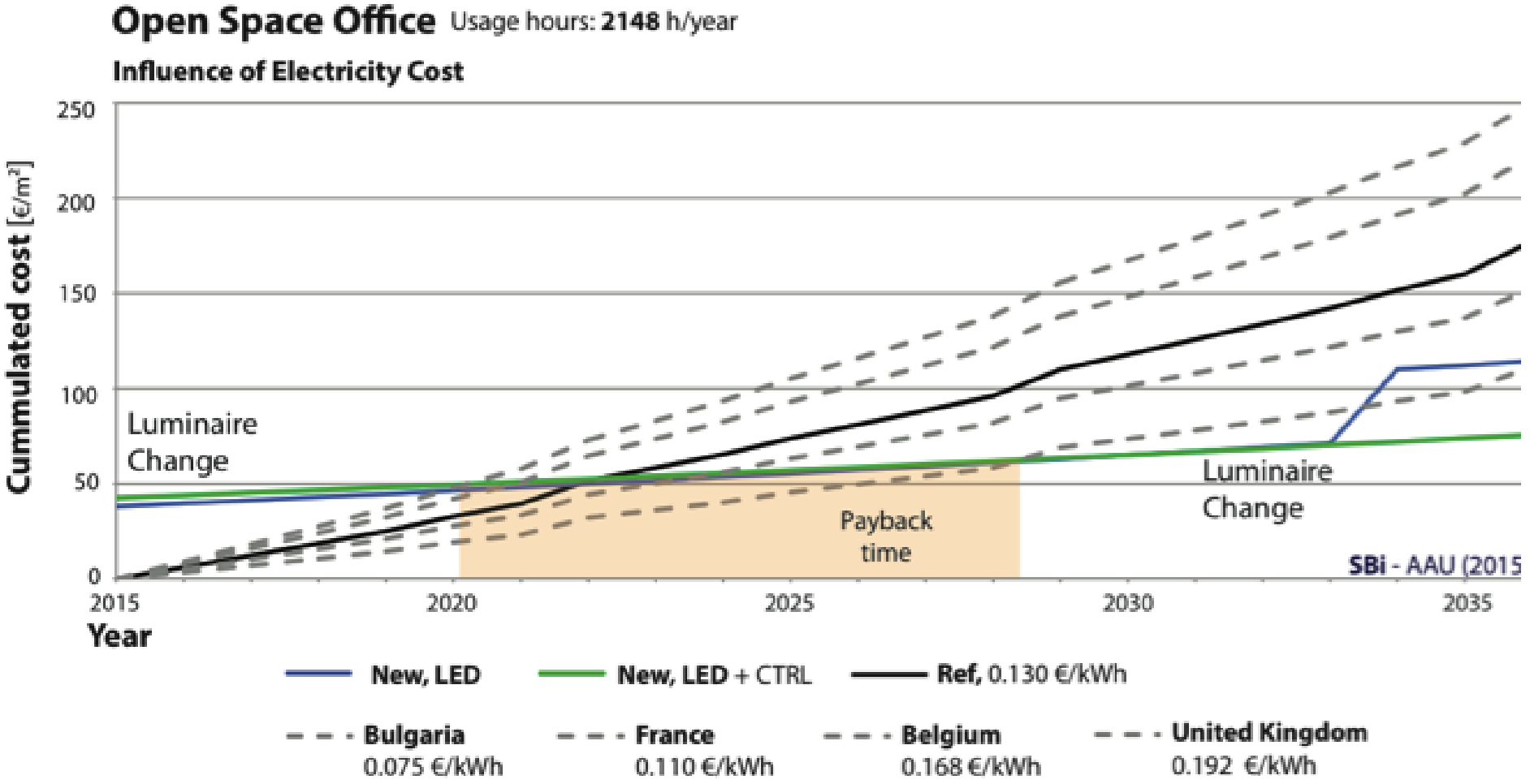
Wholesale Retail

Usage hours: **4801** h/year

Influence of Existing Installed Power

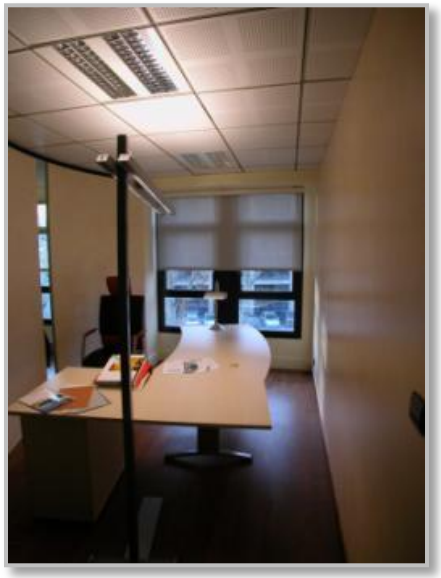


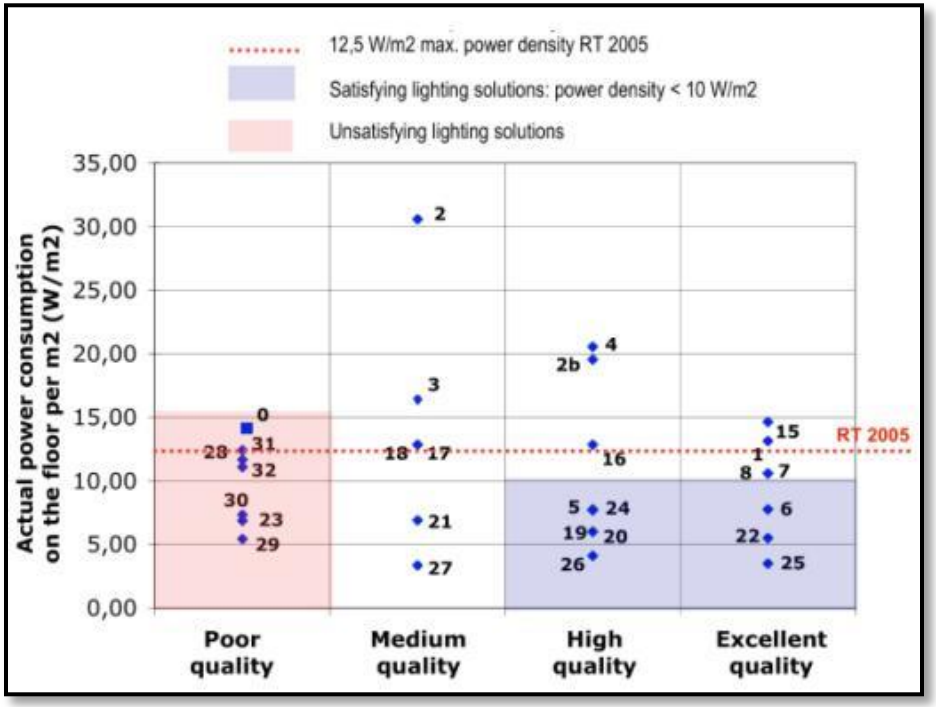

)pen Space Office Usage hours: 2148 h/year
ost of Equipment
Luminaire
Change
Luminaire
Change
Payback
time
SBI - A
5
2020
2025
2030
ır
New, LED
Ref
New, 75% of price
New, 50% of price


Open Space Office Usage hours: 2148 h/year
Influence of Electricity Cost
Cummulated cost [€/m²]
250
200
150
100
50
0
Luminaire Change
Payback time
Luminaire Change
SBi - AAU (2015
2015
2020
2025
2030
2035
Year
New, LED
New, LED + CTRL
Ref, 0.130 €/kWh
Bulgaria 0.075 €/kWh
France 0.110 €/kWh
Belgium 0.168 €/kWh
United Kingdom 0.192 €/kWh

Quality vs Energy Efficiency:

Searching for the Holly Graal





Quality: workplane, glare control, global luminous environment

Source: ADEME PUCA, ENTPE, Ingelux, SONEPAR, 2005 ->

SBI-1. Comparison of calibrated photorealistic images by pairs

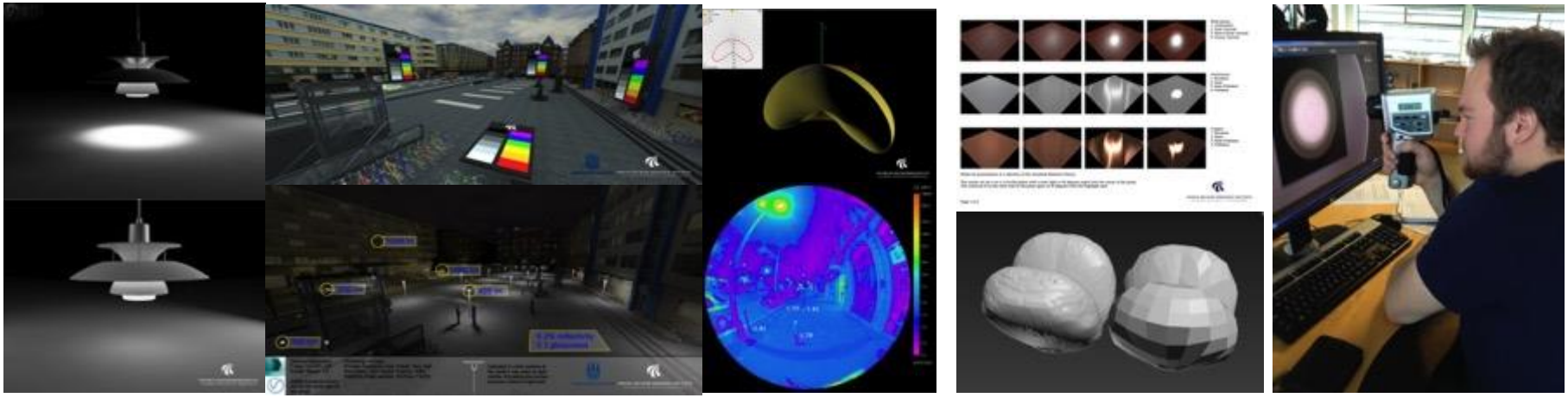
Principle: present calibrated photorealistic images of selected scenes (5 to 15) by pairs, randomly, and ask a question (criterion)

For instance, which one of the two lighting scheme is…

- *More suitable to a given use of the space : work, circulation, orientation?*
- *More comfortable (low glare) ?*
- *More agreeable, elegant???*
- *… and many other possible attributes*

For all processes, multi step calibration procedure by SBI-AAU

Step 1: Light sources: lamps and luminaires, sky conditions (daylighting)
Step 2: Surfaces and glazing photometry
Step 3: Calculation algorithms / convergence / sampling.
Step 4: Verifications Flux / Illuminance/ Luminances / Colour coordinates
Step 5: Calibration of display (screen, video projection, Head Mounted Display)



Accuracy issue is linked to operator more than the software!

Which football team is the best in Germany?

Lest them play all against each other and the one with the highest number of victory wins

(which is ajusted with draws)

Bundesliga
Classement

N°	Équipe	MJ	G	N	P	BP	BC	DB	PTS
1	Bayern	18	16	1	1	48	9	39	**49**
2	Dortmund	18	13	2	3	50	24	26	**41**
3	Hertha BSC	18	10	3	5	26	18	8	**33**
4	Mönchengladbach	18	9	2	7	35	33	2	**29**
5	Leverkusen	18	8	4	6	26	21	5	**28**
6	Schalke	18	8	3	7	24	26	-2	**27**
7	Wolfsbourg	18	7	5	6	28	24	4	**26**
8	Mainz 05	18	7	3	8	23	24	-1	**24**
9	Cologne	18	6	6	6	19	24	-5	**24**
10	Ingolstadt	18	6	5	7	12	18	-6	**23**
11	Hambourg	18	6	4	8	20	25	-5	**22**
12	Darmstadt	18	5	6	7	19	27	-8	**21**
13	Augsbourg	18	5	5	8	21	26	-5	**20**
14	Eintracht	18	5	5	8	24	30	-6	**20**
15	Stuttgart	18	5	3	10	25	38	-13	**18**
16	Werder	18	5	3	10	20	33	-13	**18**
17	Hoffenheim	18	2	8	8	18	26	-8	**14**
18	Hanovre	18	4	2	12	19	31	-12	**14**

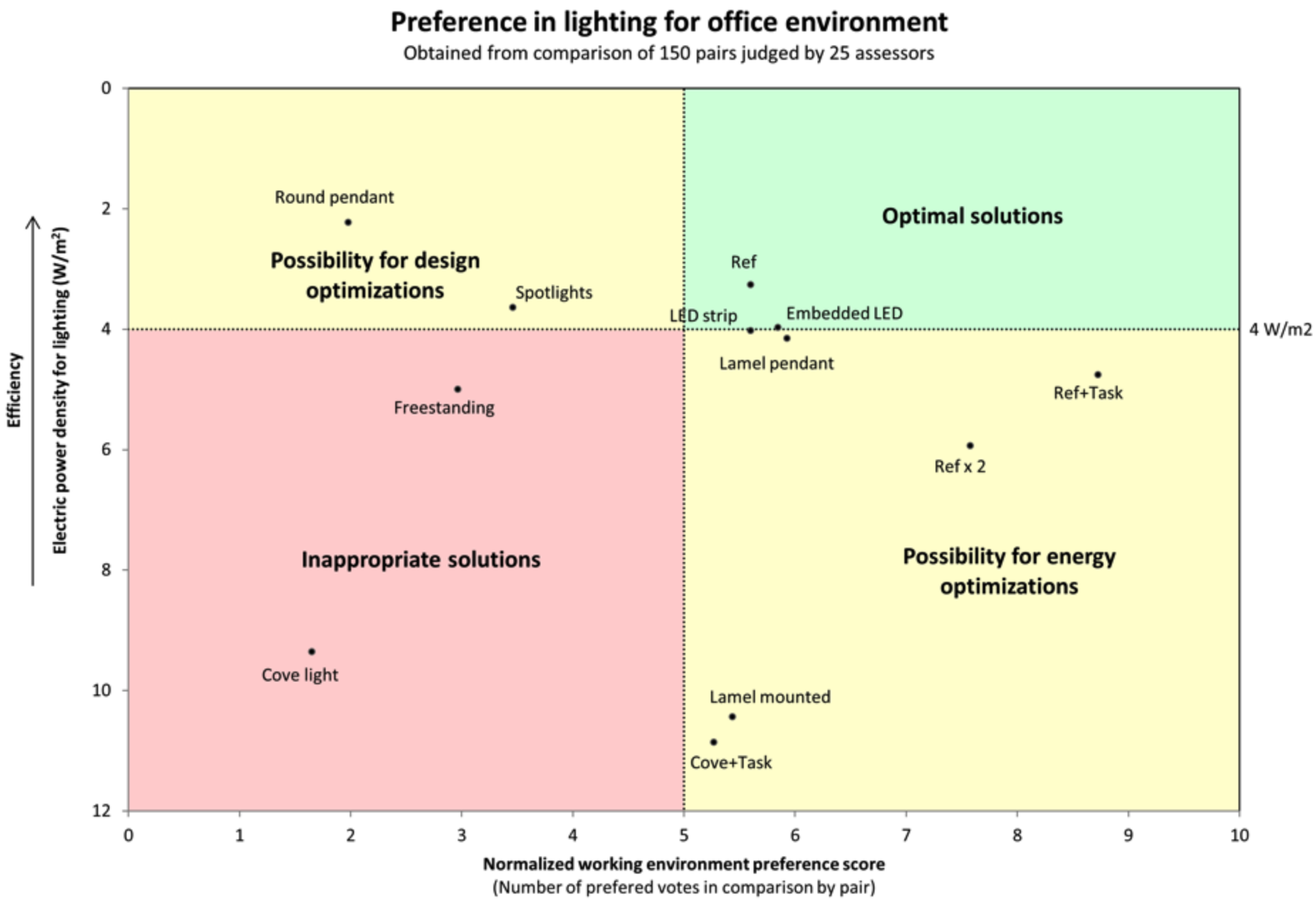

Preference in lighting for office environment
Obtained from comparison of 150 pairs judged by 25 assessors
Efficiency
Electric power density for lighting (W/m²)
0
2
4
6
8
10
12
Round pendant
Possibility for design optimizations
Spotlights
Optimal solutions
Ref
LED strip
Embedded LED
Lamel pendant
4 W/m2
Freestanding
Ref+Task
Ref x 2
Inappropriate solutions
Possibility for energy optimizations
Cove light
Lamel mounted
Cove+Task
0
1
2
3
4
5
6
7
8
9
10
Normalized working environment preference score
(Number of prefered votes in comparison by pair)

Figure 13 Office iteration 2 scheme 1

Figure 14 Office iteration 2 scheme 2

Figure 15 Office iteration 2 scheme 3

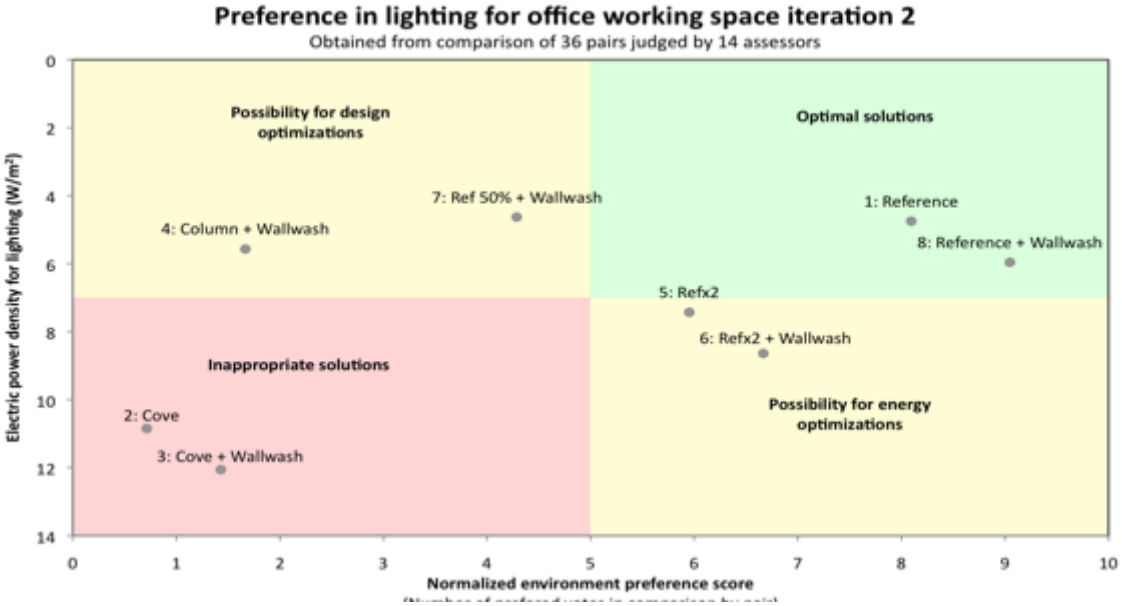
Figure 16 Office iteration 2 scheme 4

Figure 17 Office iteration 2 scheme 5

Figure 18 Office iteration 2 scheme 6

Figure 19 Office iteration 2 scheme 7

Figure 20 Office iteration 2 scheme 8



Point of view 1: from lying patient

Figure 24 Hospital room, patient POV scheme 1

Figure 25 Hospital room, patient POV scheme 2

Figure 26 Hospital room, patient POV scheme 3

Figure 27 Hospital room, patient POV scheme 4

Figure 28 Hospital room, patient POV scheme 5

Figure 29 Hospital room, patient POV scheme 6

Figure 30 Hospital room, patient POV scheme 7

Figure 31 Hospital room, patient POV scheme 8

Point of view 2: from standing visitor

Figure 32 Hospital room, visitor POV scheme 1

Figure 33 Hospital room, visitor POV scheme 2

Figure 34 Hospital room, visitor POV scheme 3

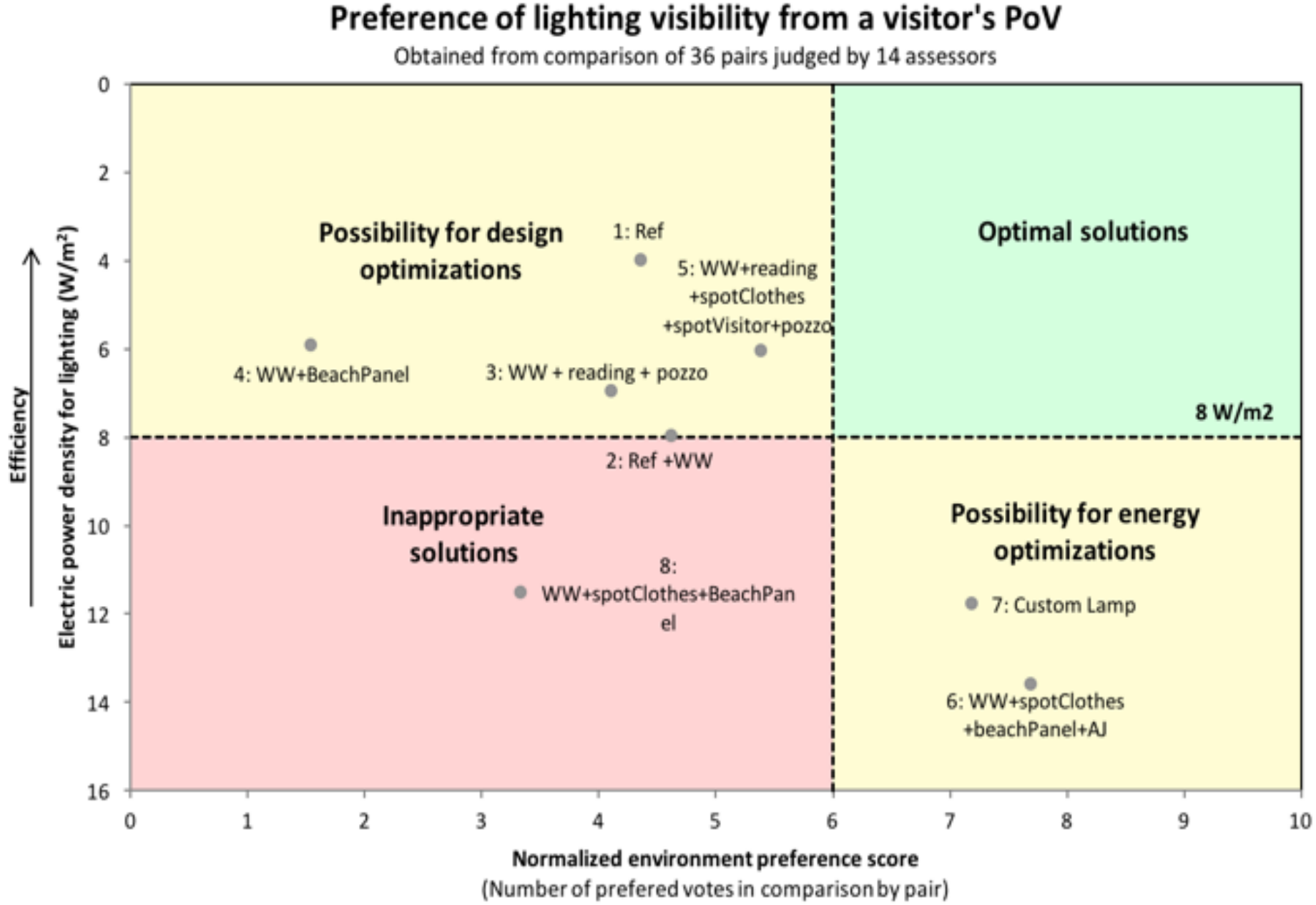
Figure 35 Hospital room, visitor POV scheme 4

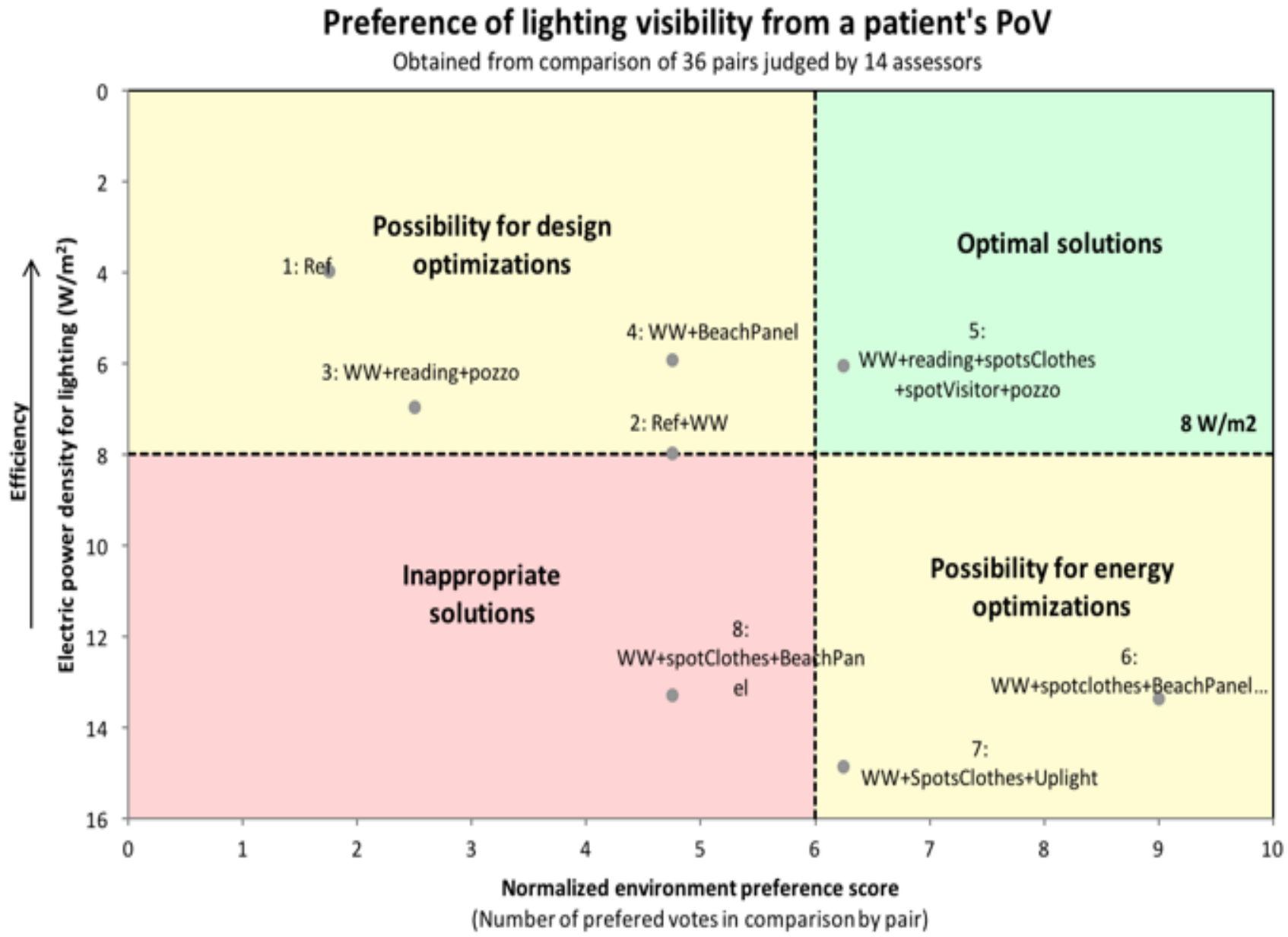
Figure 36 Hospital room, visitor POV scheme 5

Figure 37 Hospital room, visitor POV scheme 6

Figure 38 Hospital room, visitor POV scheme 7

Figure 39 Hospital room, visitor POV scheme 8


Preference of lighting visibility from a visitor's PoV
Obtained from comparison of 36 pairs judged by 14 assessors
Possibility for design optimizations
Optimal solutions
Inappropriate solutions
Possibility for energy optimizations
1: Ref
5: WW+reading +spotClothes +spotVisitor+pozzo
4: WW+BeachPanel
3: WW + reading + pozzo
2: Ref +WW
8 W/m2
8: WW+spotClothes+BeachPanel
7: Custom Lamp
6: WW+spotClothes +beachPanel+AJ
Efficiency
Electric power density for lighting (W/m²)
0
2
4
6
8
10
12
14
16
0
1
2
3
4
5
6
7
8
9
10
Normalized environment preference score
(Number of prefered votes in comparison by pair)


Preference of lighting visibility from a patient's PoV
Obtained from comparison of 36 pairs judged by 14 assessors
Efficiency
Electric power density for lighting (W/m²)
Possibility for design optimizations
Optimal solutions
Inappropriate solutions
Possibility for energy optimizations
1: Ref
2: Ref+WW
3: WW+reading+pozzo
4: WW+BeachPanel
5: WW+reading+spotsClothes +spotVisitor+pozzo
8 W/m2
6: WW+spotclothes+BeachPanel...
7: WW+SpotsClothes+Uplight
8: WW+spotClothes+BeachPanel
0
2
4
6
8
10
12
14
16
0
1
2
3
4
5
6
7
8
9
10
Normalized environment preference score
(Number of prefered votes in comparison by pair)

Results (1) :

Added value of a task lamp above a work place, or pendants above a meeting room

Added value of thin wall washers, or lines created by cove lighting, or accentuation of architectural features, to increase the perception of space (make it more interesting, more spacious)

Role of illuminance of faces of occupants, suggesting that sufficient light is provided on face, and that contrast is obtained with a darker background

The importance of deliberate lighting was stressed, with light focussing on specific functions (reading, vision of people, circulation, etc.)

Results (2)

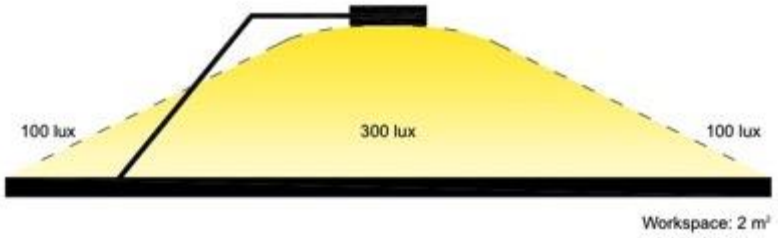
Added value of a task lamp above a work place, or pendants above a meeting room

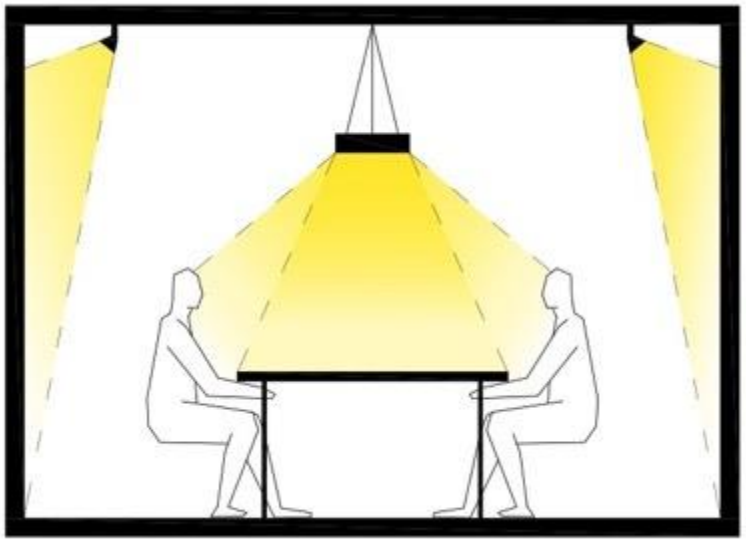
Added value of thin wall washers, or lines created by cove lighting, or accentuation of architectural features, to increase the perception of space (make it more interesting, more spacious)

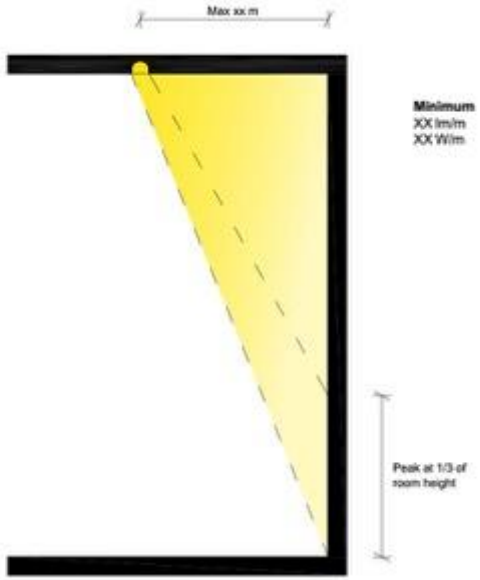
Role of illuminance of faces of occupants, suggesting that sufficient light is provided on face, and that contrast is obtained with a darker background

The importance of deliberate lighting was stressed, with light focussing on specific functions (reading, vision of people, circulation, etc.)

Some examples of results: luminaires to design.







Ceiling integrated LEDs

Indoor luminaires for large volumes, inspired by outdoor luminaires.

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Specifications for AAU processes:

- Present luminous schemes (stimuli) to individuals or groups of observers, **rate lighting schemes with respect to a criterion …**
- Imaging systems **appropriate** to the proposed test.
- **Portable**, to be easily used by groups of stakeholders..

Screen

Low Power video

High Power video

Head mounted display

Conclusion

Solving problem **together**:
Client/manager/architect/engineer/Lighting professional

Collective exploration, collection validation.

Long term approach (costs, operation, etc.)

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