Species protection through environmentally friendly lighting

Birte Saathoff, Prof. Stephan Völker | 20.07.2021

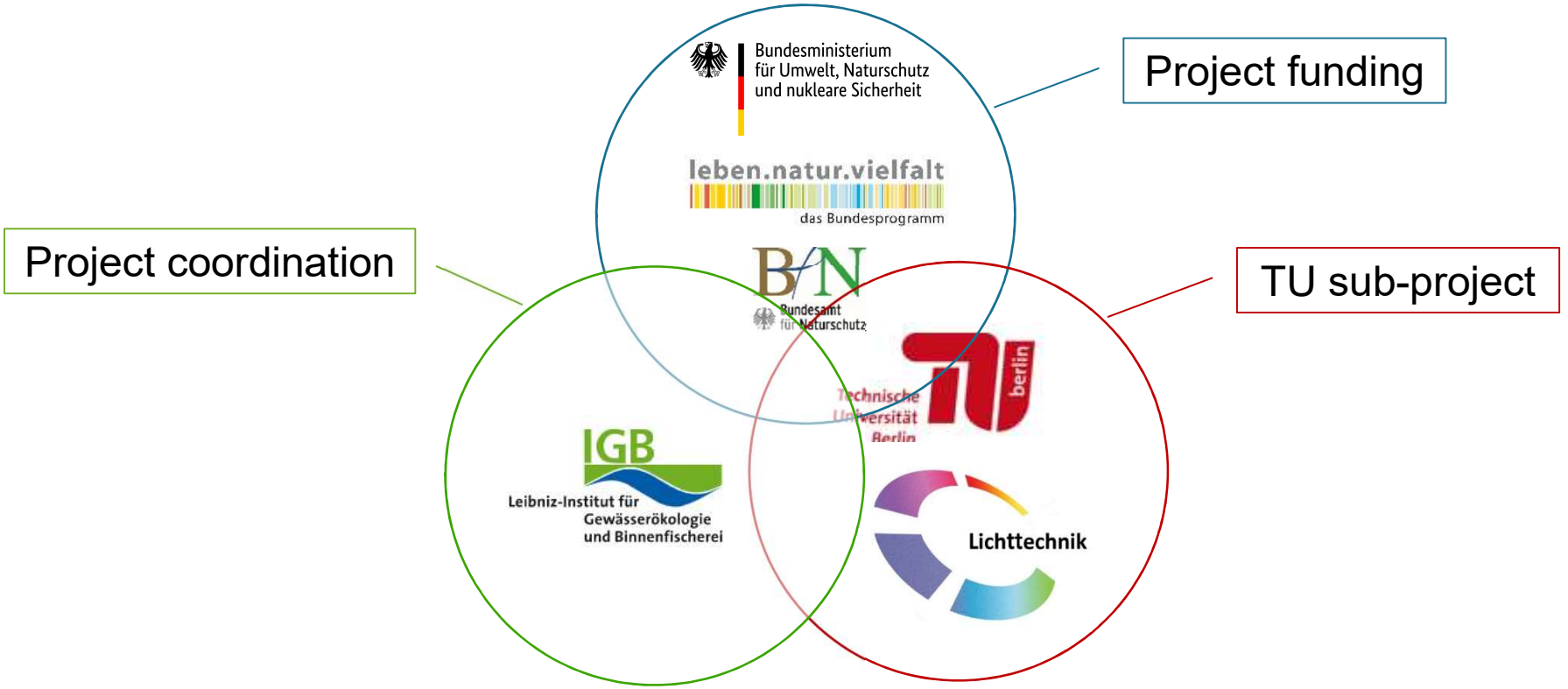
Image source: Rainer Stock / Loss of the Night Network 2016

Agenda

- Short introduction
- Motivation
- Requirements
- Research Condition and Method
- Conclusion

Project AuBe

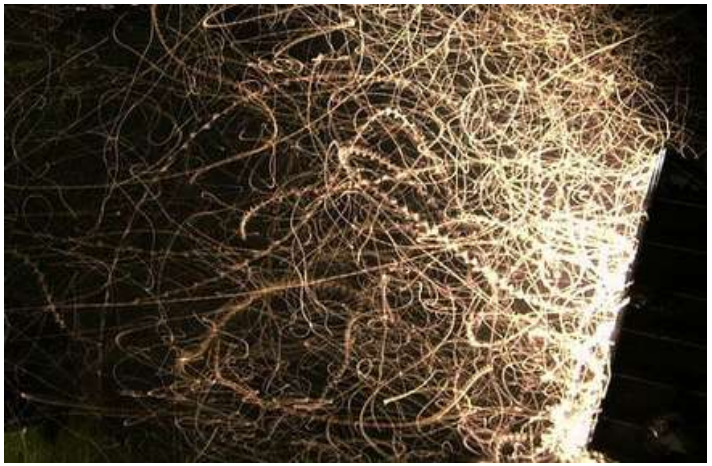
Protection of species through environmentally friendly lighting



Motivation

Obtrusive light and light pollution has a big impact on our environment and the whole ecosystem.

© Wikimedia View_of_the_summer_sunset_from_Sunset_Beach,_Cape_Town.jpg



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→ Artifical light among other factors causes:

- Insect decline
- Fragmentation of their habitats
- Imbalance of our ecosystem

Motivation

Attract attention and reach the public:

There are **NO** ecological benefits of artificial light at night

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Motivation

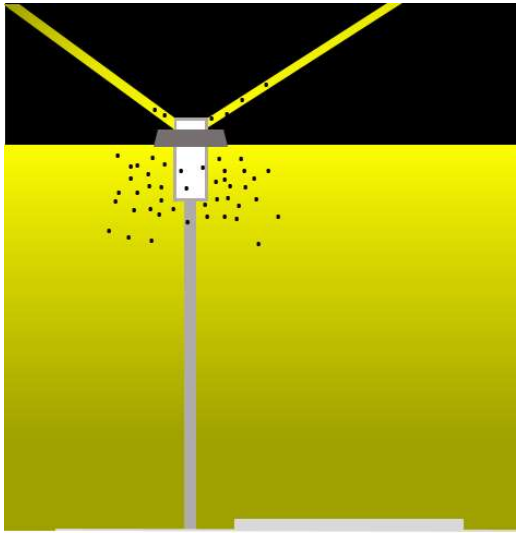
- Many animals are nocturnal
  - 28% of vertebrates (31% primates)
  - 64% of invertebrates [1]

- 2/3 of crops and 80% of wild plants are pollinated by insects

[2]

Motivation & aim of the project

Developing an optimized luminous intensity distribution for street luminaire considering street safety **AND** ecological aspects



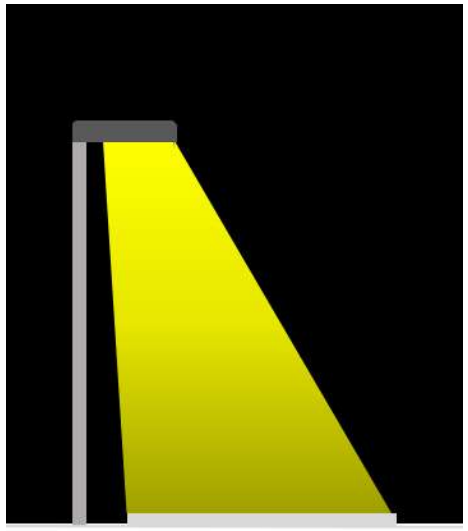
Common Design in Parks/Green Areas in Germany

Minimization of the attraction radius of insects

Reduction of the barrier effect of flying insects

Optimal illumination of the assessment area

Considering road safety according to the requirements of DIN standards

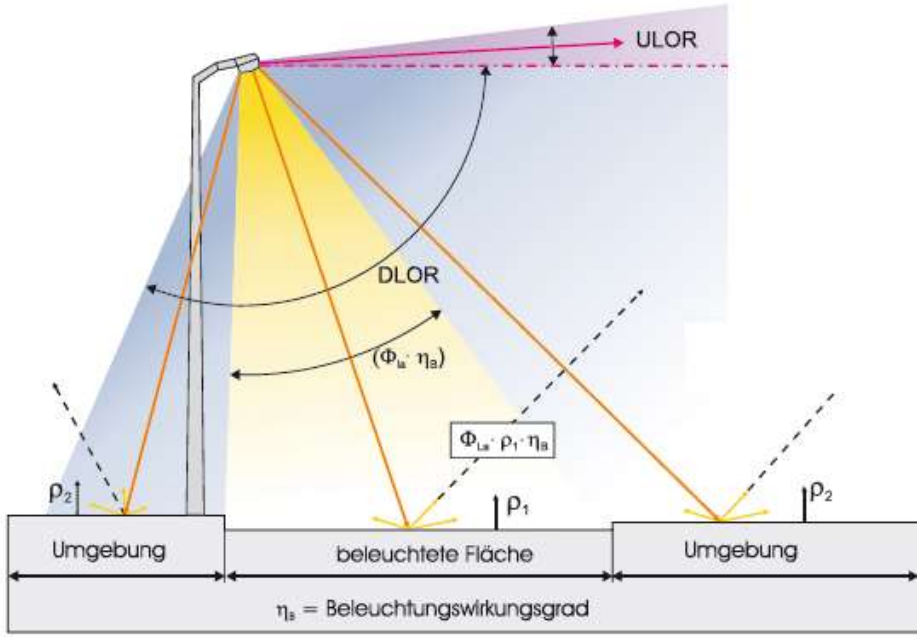


New Optimized Design

Requirements

Ecological

- As little light as possible!



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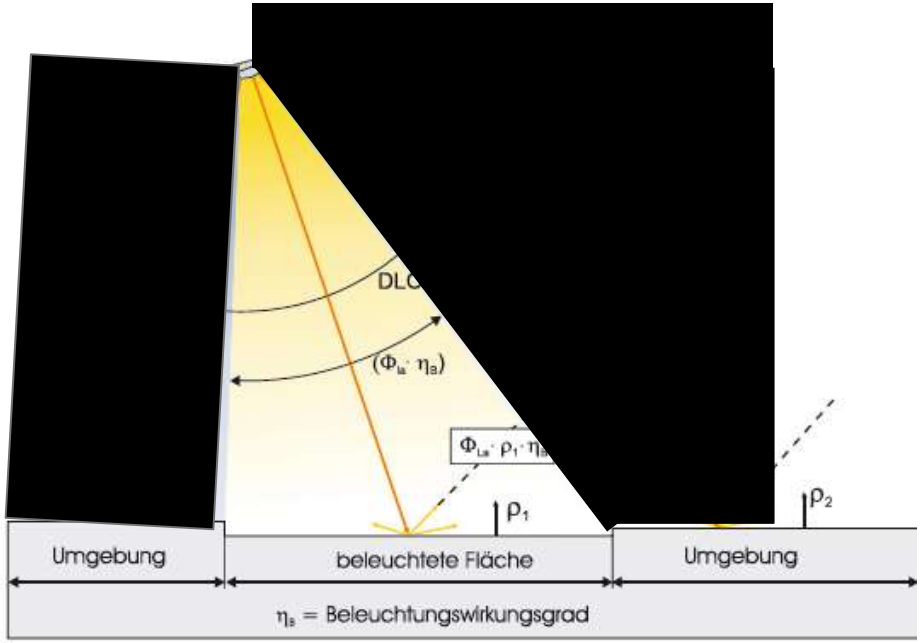
Requirements

Ecological

- As little light as possible!
  - → No upwards sky brightening (ULOR = 0)
  - → Minimum luminous flux into adjacent areas / facades / Narrow light distributions
  - → CCT: max. 3000 K

→ Luminaire shouldn't be "visible" for insects

→ Optimal Reduction of Light Pollution



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Requirements

For Traffic and Pedestrian Safety?

Tabelle 1 — M-Beleuchtungsklassen

Klasse	Fahrbahnleuchtdichte bei trockener bzw. nasser Straßenoberfläche				Physiologische Blendung	Beleuchtung der Umgebung
	trockene Zustände			nass	trockene Zustände	trockene Zustände
	$\bar{L}$ [Minimaler Wartungswert] cd·m^{2} N1	U_o [Mindestwert]	U_l [a] [Mindestwert]	U_{ow} [b] [Mindestwert]	f_{TI} [c] [Höchstwert] %	R_{EI} [d] [Mindestwert]
M1	2,00	0,40	0,70	0,15	10	0,35
M2	1,50	0,40	0,70	0,15	10	0,35
M3	1,00	0,40	0,60	0,15	15	0,30
M4	0,75	0,40	0,60	0,15	15	0,30
M5	0,50	0,35	0,40	0,15	15	0,30
M6	0,30	0,35	0,40	0,15	20	0,30

Requirements

For Traffic and Pedestrian Safety?

Tabelle 2 — C-Beleuchtungsklassen, basierend auf der Fahrbahnbeleuchtungsstärke

Klasse	Horizontale Beleuchtungsstärke	
	$\bar{E}$ [minimaler Wartungswert] lx	U_o [Mindestwert]
C0	50	0,40
C1	30	0,40
C2	20,0	0,40
C3	15,0	0,40
C4	10,0	0,40
C5	7,50	0,40

Requirements

For Traffic and Pedestrian Safety?

Tabelle 3 — P-Beleuchtungsklassen[N2)]

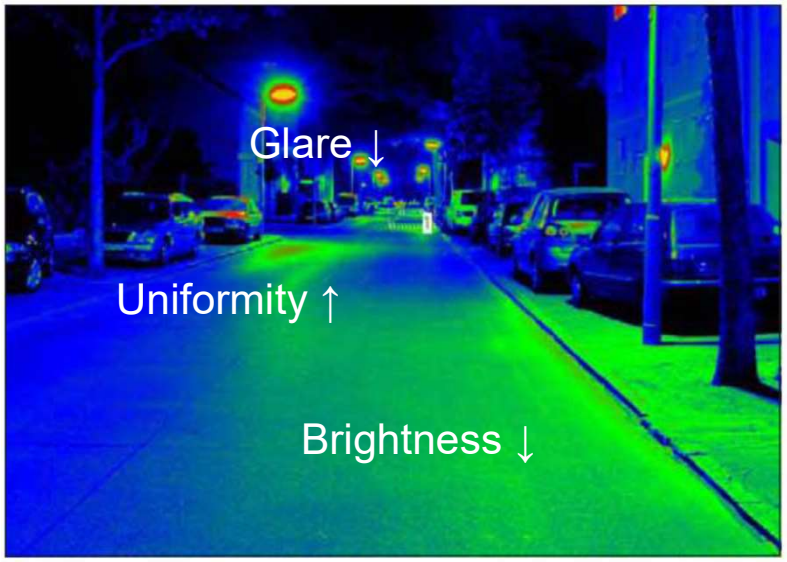
Klasse	Horizontale Beleuchtungsstärke		Zusätzliche Anforderungen falls Gesichtserkennung erforderlich ist	
	$\bar{E}$ [a] [minimaler Wartungswert] lx	E_{min} [Wartungswert] lx	$E_{v,min}$ [Wartungswert] lx	$E_{sc,min}$ [Wartungswert] lx
P1	15,0	3,00	5,0	5,0[N2]
P2	10,0	2,00	3,0	2,0
P3	7,50	1,50	2,5	1,5
P4	5,00	1,00	1,5	1,0
P5	3,00	0,60	1,0	0,6
P6	2,00	0,40	0,6	0,2[N2]
P7	unbestimmte Anforderung	unbestimmte Anforderung		

[a] Um Gleichmäßigkeit sicherzustellen, darf der tatsächliche Wert des Wartungswertes der mittleren Beleuchtungsstärke das 1,5-fache des für die Klasse vorgesehenen Mindestwertes $\bar{E}$ nicht überschreiten.

Requirements

For Traffic and Pedestrian Safety

- Overall uniformity U_o ↑
- Visibility level VL ↑
- Glare ↓
- Vertical illumination for face recognition $E_{sc,min}$
- Perception of safety, edge illumination ratio EIR



Research Condition and Method

4 Project Areas / Municipalities all over Germany

- (future) Star Park Regions
- Exposure to water / aquatic insects
- Parks or traffic-calmed streets (mostly P4)

- New light installations are planned

Image: Open street map

Research Condition and Method

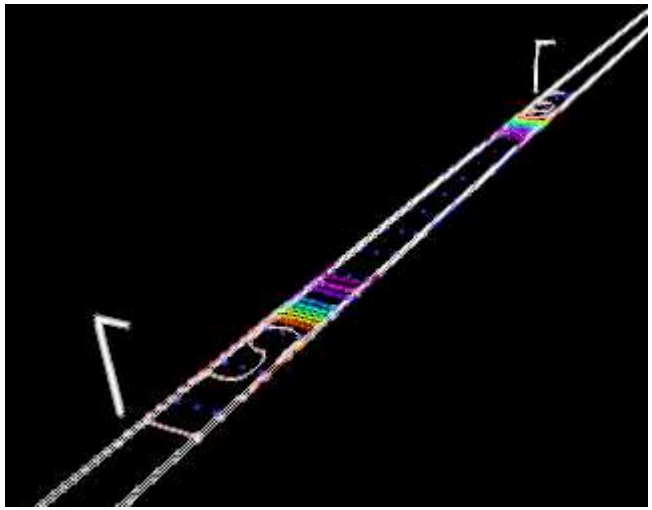
4 Project Areas / Municipalities all over Germany

- Different current street ligthing (HPS & Mercury vapour lamps)
- Different Pole distance / Pole height Ratio

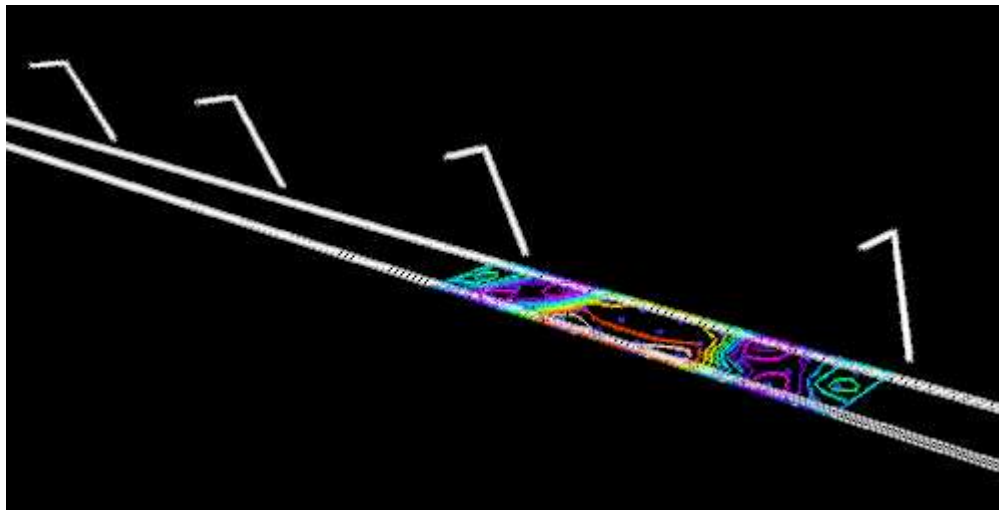
Project area	Street width	Pole		
		Height (h)	Distance (d)	Ratio d/h
Krakow am See	2.7 m	3.44 m	25 m	7.3
Neuglobsow	4.0 m	3.30 m	30 m	9.1
Gülpe	5.4 m	4.40 m	30 m	4.8
Fulda	2.8 m	4.33 m	50 m	11.6

Research Condition and Method

For Traffic and Pedestrian Safety



Large pole distance: bad uniformity



Small pole distance: good uniformity

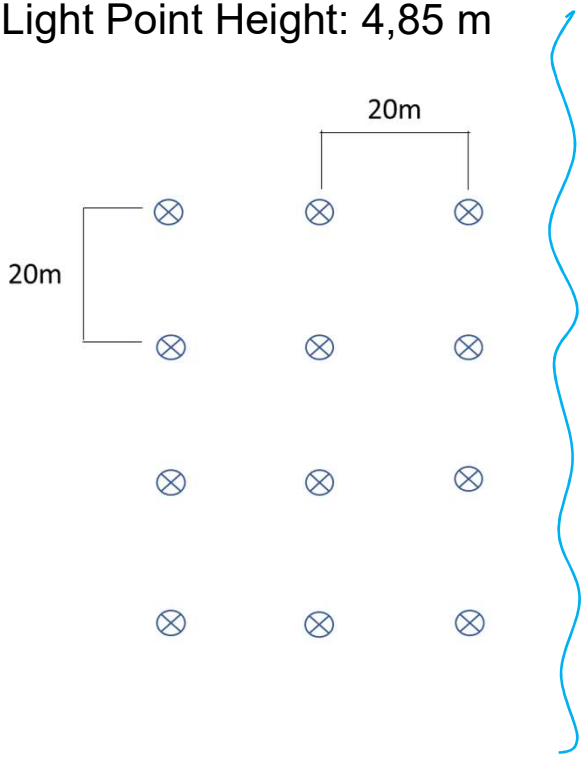
→ Ideal Pole height / Pole distance ratio : 1/4

Result: not just the luminaire but also the geometries are relevant for a good ecological and traffic safety lighting

Research Condition and Method

Experimental Field

Light Point Height: 4,85 m



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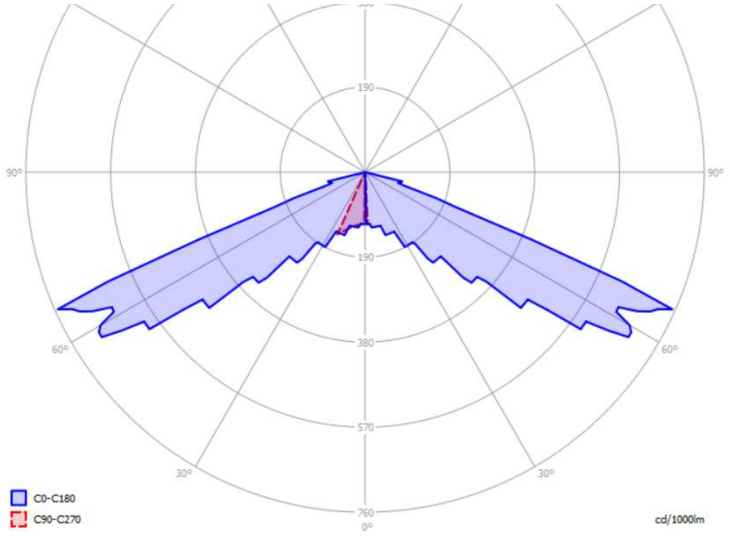
Pole height / Pole distance ratio : 1/4

Research Condition and Method

Light Distribution Curve Simulation / Experimental Field

- Street width 2,5 m



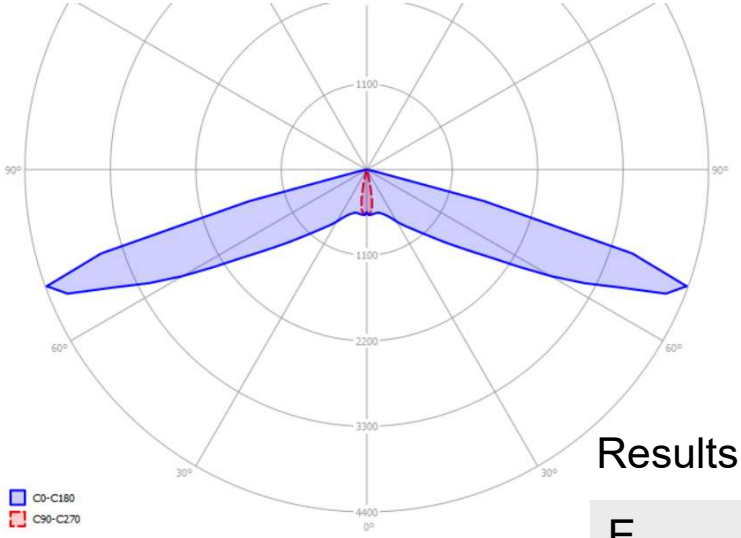
Results: Lighting Class P4

E_{ave}	5,01 lx	✓
E_{min}	4,94 lx	✓
U_O	0,99	✓
TI	4,00	✓

Research Condition and Method

Light Distribution Curve from Manufacturer / Experimental Field

- Street width 2,5 m



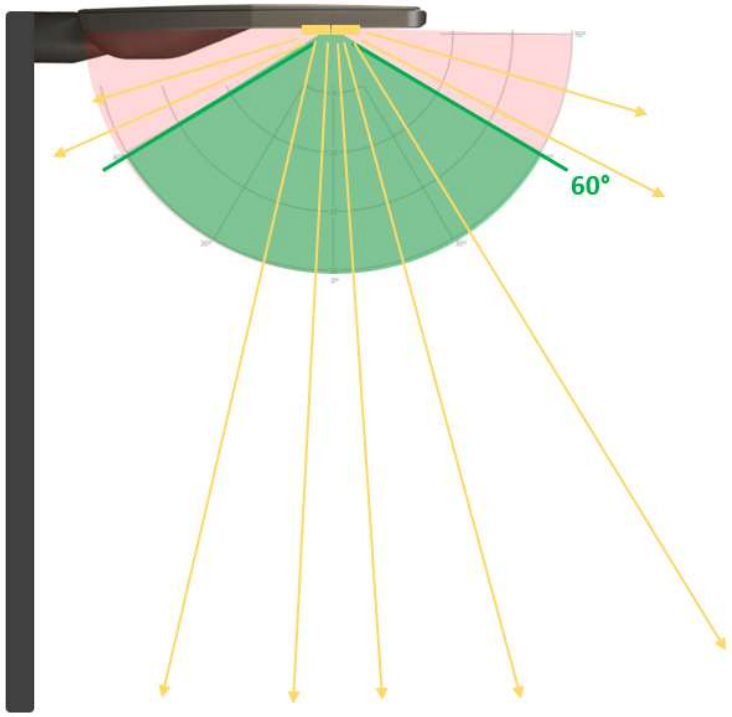
Results: Lighting Class P4

E_{ave}	5,23 lx	✓
E_{min}	4,1 lx	✓
U_O	0,78	✓
TI	28	✗

Research Condition and Method

Light Distribution Curve from Manufacturer / Experimental Field

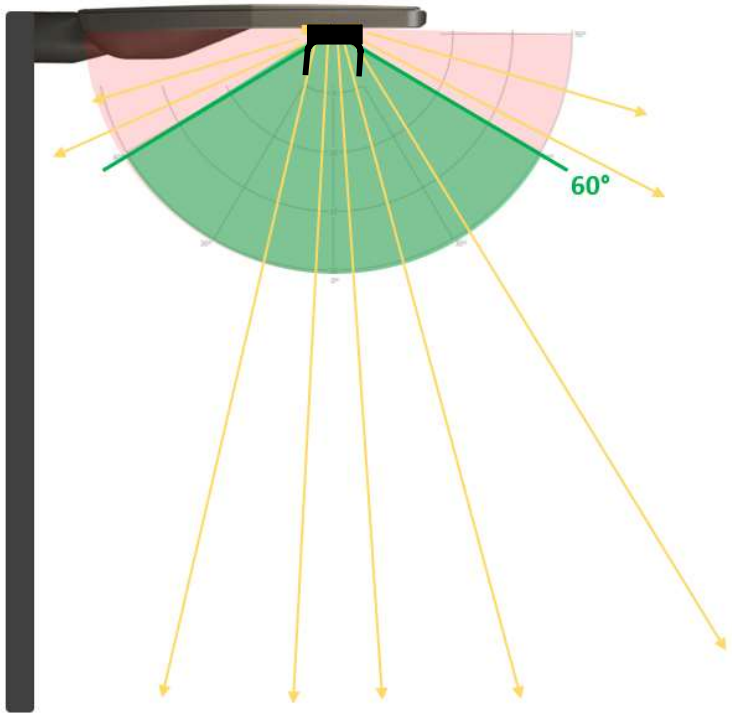
- Street width 2,5 m



Research Condition and Method

Light Distribution Curve from Manufacturer / Experimental Field

- Street width 2,5 m



Conclusion – next steps

- For the project:
  - Design of a perfect environmentally friendly luminare
    - Using a cover for glare protection
      - Adaptable for `every` luminare ?
    - Simulation in LightTools of new optics/ lenses
  - Analysis of the prototype on the experimental field

Conclusion

- In general:
  - Analysis of the current situation (traffic / safety / ecological exposure …)
  - Static insectfriendly light: precise lighting design before installation
  - Minimizing the luminous flux → Energy saving
  - The technically and ecologically set requirements serve as orientation for new Municipalities / Luminaire manufacturer / Lighting designers
  - Alternatives: Dynamic Street Lighting

Thank you!

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Sources

Project homepage: https://www.tatort-strassenbeleuchtung.de/

[1] Schroer, S., Huggins, B., Böttcher, M. & Hölker, F. (2019) Leitfaden zur Neugestaltung und Umrüstung von Außenbeleuchtungsanlagen – Anforderungen an eine nachhaltige Außenbeleuchtung. - BfN-Skripten 543.

[2] https://www.welt.de/wissenschaft/plus232343029/Krise-der-Artenvielfalt-Warum-Insekten-und-andere-Tiere-weltweit-sterben.html?notify=success_subscription#Comments