giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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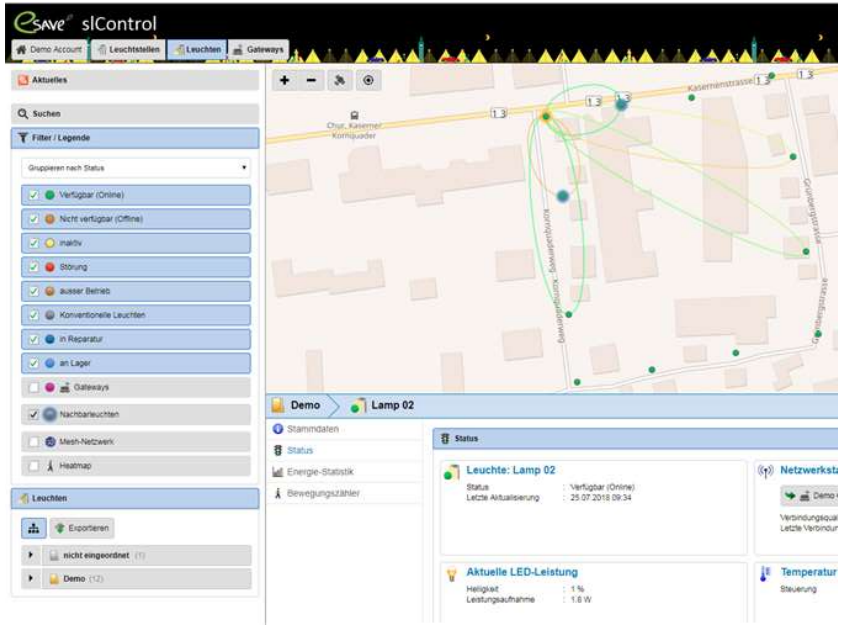


DYNAMIC STREETLIGHT

Samuel Fiedelak, Prof. S. Völker | 20.07.2021

Das Vorhaben „DymPro – Dynamische Anpassung der Berliner Straßenbeleuchtung“ (Projektlaufzeit: 10/2019 bis 11/2022) wird im Berliner Programm für Nachhaltige Entwicklung (BENE) gefördert aus Mitteln des Europäischen Fonds für Regionale Entwicklung und des Landes Berlin (Förderkennzeichen 1257-B5-O)

Lichttechnik

BERLIN Senatsverwaltung für Umwelt, Verkehr und Klimaschutz

EUROPÄISCHE UNION
Europäischer Fonds für regionale Entwicklung

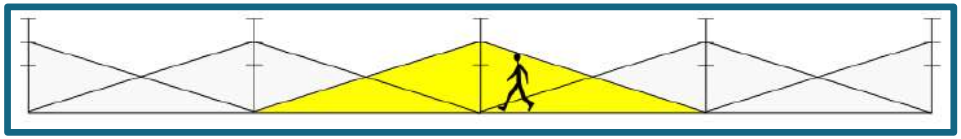
AGENDA

1. What is dynamic Streetlight?
2. Light Management Systems
3. Research & Projects

1.1 Term – Dynamic Street Lighting

Dynamic Street Lighting is adaptive lighting,…

*i.e. it is provided where and when it is needed, depending on various variable conditions, … reduces light pollution, energy consumption; … recognizes different human and social needs… .” **



* Prof. Dipl.-Ing. Axel Stockmar:
DYNAMIC LIGHT—TOWARDS DYNAMIC, INTELLIGENT AND ENERGY EFFICIENT URBAN LIGHTING. HANDBOOK ABOUT INTERPRETATION OF EN 13201 AND ROOM FOR IMPLEMENTATION OF DYNAMIC LIGHTING.
Interreg Dynamic Light. Online verfügbar unter www.interreg-central.eu/Content.Node/Dynamic-Light.html , zuletzt geprüft am 05.10.2020.

1.2 STANDARDS – DIN EN 13201-1

- Where Parameter are known
  > simple timebased control system
  (e.g. residential areas)

- For complex areas should be used a sensorbased realtime control system
  (also considers construction work, accidents & weather coditions)

- maximum 3 different light levels may be realized

Tabelle 5 — Hauptverkehrsstraßen innerorts ≥ 50 km/h für M-Klassen

Auswahlparameter	Optionen/Auswahlmöglichkeit	Wichtungswert V_W	Gewählte Wichtungswerte	
Anzahl Fahrstreifen je Richtung[a]	> 1	1		
	1	0		
Trennung der Richtungsfahr-bahnen	nein	1		
	ja	0		
		Zwischenwert		
Variable Parameter für die adaptive Beleuchtung	Optionen/Auswahlmöglichkeit	Wichtungswert V_W	Zeitpunkt t_0	t_1
Verkehrs-aufkommen	normal	0		
	gering	−1		
Typische Geschwindigkeit	normal	0		
	reduziert auf ≤ 30 km/h	-1		
Verkehrsart / Zusammensetzung	gemischt, hoher Anteil nicht motorisiert	2		
	gemischt	1		
	nur motorisierter Verkehr	0		
Leuchtdichte der Umgebung	hoch	1		
	mittel	0		
	gering	−1		
Parkende Fahrzeuge	zulässig	1		
	nicht zulässig	0		
Erhöhte Anforderungen	vorhanden	1		
	nicht vorhanden	0		
		Summe der Wichtungswerte V_{ws}		
		Beleuchtungsklasse $M = 6 - V_{WS}$		

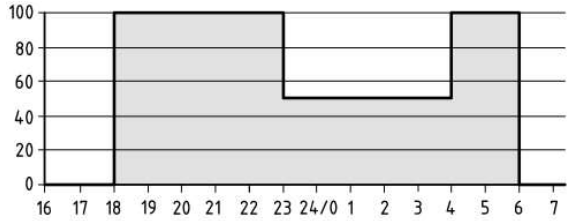
Die zu verschiedenen Zeiten realisierten Beleuchtungsklassen dürfen sich um nicht mehr als drei Stufen der Beleuchtungsklassen verändern.

[a] Für den fließenden Verkehr.

1.3 Concepts

Streetlight-Concepts

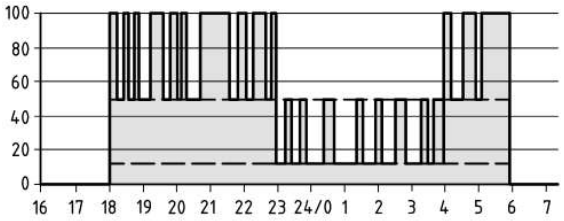
Changing lighting classes



© DIN EN 13201 - 5

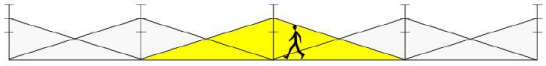
- Survey of the traffic volume and lowering of the Lighting level at times of low usage.

Short-term local adjustment



© DIN EN 13201 - 5

- Realization of a low basic lighting level, which is only raised running along when a road user is detected.



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1.4 Current status in ZA

mineral resources & energy
Department:
Mineral Resources and Energy
REPUBLIC OF SOUTH AFRICA

High Mast and Street Lighting Specification
Point 4.10
Telemanagement requirements

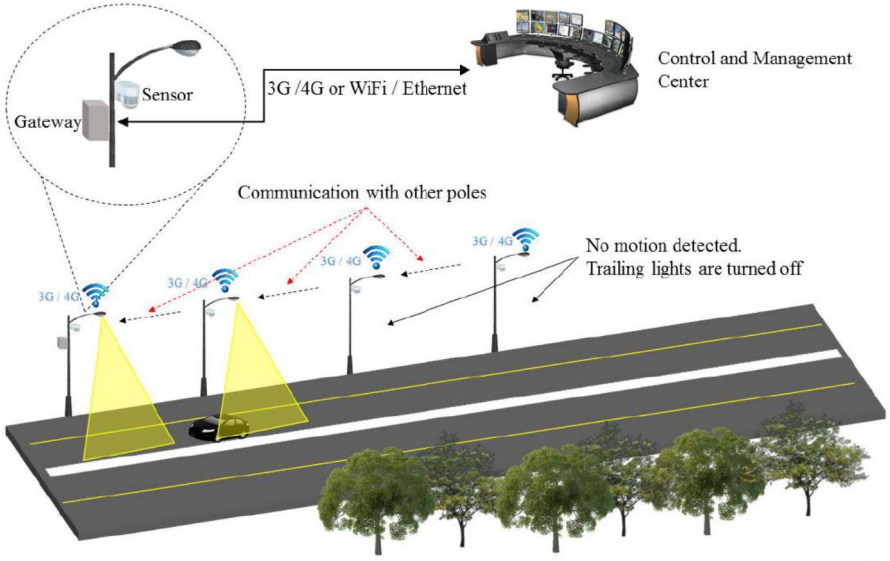
- Ready for dynamic Streetlight

Product Type	Telemanagment Readiness	Year Applicable
Dimmable LED Luminaire	Shall incorporate a 7-Pin ANSI C136.41 twist-lock receptacle (7-Pin NEMA socket) that is to be used with an ANSI C136.10 compliant photocell or ANSI C136.41 compliant telemanagement device with IP65 rating or higher. All terminals shall be wired into the luminaire control gear to allow control by photocell or communication between the electronic driver and the telemanagement device and system. An ANSI C136.10 compliant shorting cap with IP65 rating or higher shall be supplied and attached to the 7-Pin ANSI C136.41 twist-lock receptacle. The shorting cap shall allow the luminaire to operate normally without control. Electronic information and data about the luminaire and electronic driver shall be contained on the electronic driver. This shall enable the telemanagement device to transmit and receive information about the luminaire to/from the telemanagement system to the electronic driver.	≥ 2024
Dimmable LED Luminaire	The minimum information and data provided shall be: 1. Driver product name, manufacturer, serial number, part ordering number; 2. Luminaire product name, manufacturer, serial number, part ordering number; 3. Brochures, certificates and technical datasheet of driver and luminaire; and 4. GPS Location.	≥ 2024

7-Pin NEMA socket is interchangeable with Zhaga socket

Lichttechnik

2.1 Light Management Systems



(*)

(*)Gharaibeh, Ammar; Salahuddin, Mohammad A.; Hussini, Sayed Jahed; Khreishah, Abdallah; Khalil, Issa; Guizani, Mohsen; Al-Fuqaha, Ala (2017):
Smart Cities: A Survey on Data Management, Security, and Enabling Technologies.
In: *IEEE Commun. Surv. Tutorials* 19 (4), S. 2456–2501. DOI: 10.1109/COMST.2017.2736886.

1. Standalone solution
   (no internet connection, local programmable)

2. Smart Light Management
   (internet connection, online management platform, maintenance management)

3. Smart City Management
   (service solution with e.g. WiFi, park guidance system, Irrigation management, traffic guidance system)

2.3 Example for Energy-Savings – Chur (CH)

- 4100 luminaires in Chur, in 2020 about 2000 LED-luminaires
- Implementation of “short-term local adjustment” with integrated PIR-Sensors
- 2014 vs 2020: 1.927.059 kWh/a less power supply -> 285.233 CHF/a less power costs

https://ibc-chur.ch/story/cleveres-chur/ © IBC

3 Research & Projects - Main Questions

- Where do we need Light?
- How much light is needed?
- What are appropriate dimming?

3.1 Where do we need Light?

- Road
- Sidewalk
- Bicycle path
- Facade/Surrounding

Effective Road areas, SteFFi, ©TU

3.2 How much Light is needed?

	obstacle		Pedestrian total				Pedestrian face		vertical surfaces	House Facades		
	visibility	safety of vision	horicontal illuminance				vertical illuminance	semi-cylindrical illuminance	vertical illuminance	vertical illuminance		luminance
	STV	P_0	$E_{h,min}$ [lx]	E_{min} [lx]	U_0	f_{TI} [%]	$E_{v,min}$ [lx]	$E_{SC,min}$ [lx]	E_v [lx]	E_v [lx] before sleep period	E_v [lx] during sleep period	L_b [cd/m²]
	min	min	min	min	min	max	min	min	min	max	max	max
Access Road	3,2	0,9	10,0	2,0	0,7	25,0	3,0	2,0	5,0	10,0	2,0	2,0
Sidewalk	2,2	0,9	7,5	1,5	0,7	25,0	2,5	1,5	0,5			
Bicycle path		0,9	5,0	1,0	0,7	30,0	1,5	1,0				

Sandy Buschmann, SteFFi, ©TU

- Are the light levels appropriate?
- Can we save more Energy but keep the safety?

3.2 Project Heiningen- How much light is needed?

Task:

- Dynamic Light for Heiningen

Partners:

- Light Planer - studioDL
- Local energy supplier – NetzeBW
- Schredér

Aim:

- Dynamic Streetlighting – How much light is needed?
- New Controlmethods (TomTom, Bluetooth, Wlan)

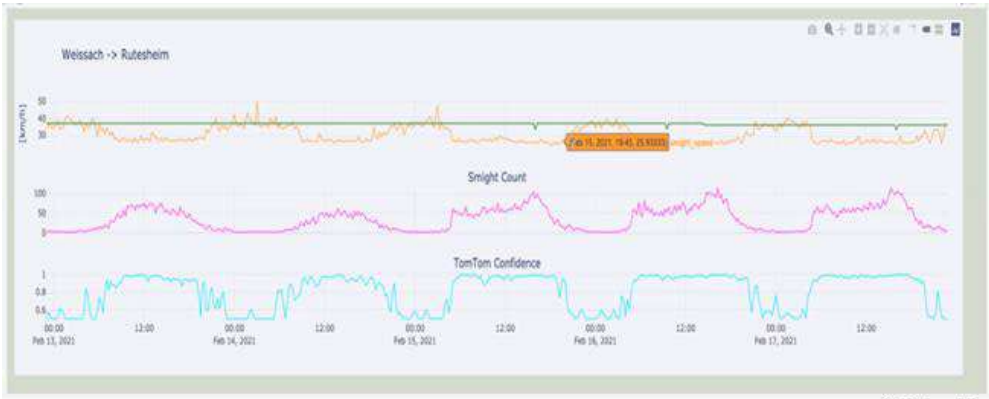
3.2 Project Heiningen- Done

Done:

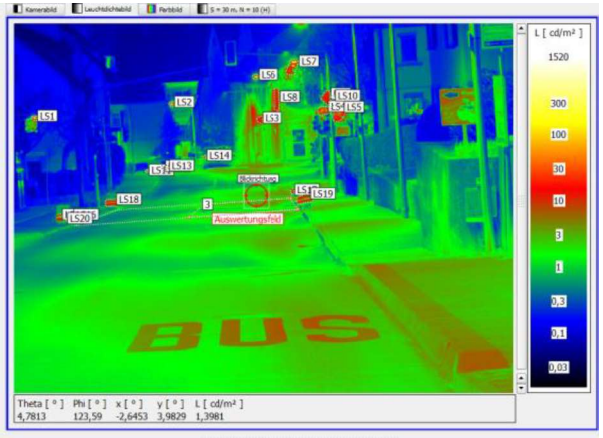
- Collected test data
- Luminance Measurement
- Dimmcurve ECG

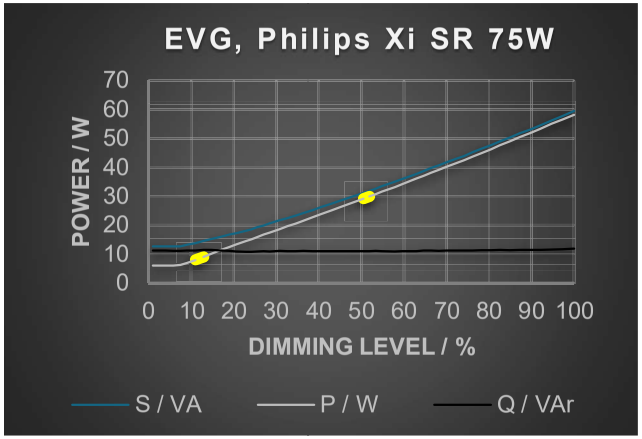
First Finding:

➢ 2 Light Levels above Standard



© Schredér





Lighting Class	L [cd/m²]	Dimming level [%]
M2	1,5	100
M3	1	68,5
M4	0,75	51,4
M5	0,5	34,2
M6	0,3	20,5
P6	0,15 (~2lx)	10

3.2 Project Bad Hersfeld

Task:

- Dynamic Light
- Tunable White
- Light for residential roads

https://badhersfeld.urbanpulse.de/#!/tiles/

Partners:

- Urban Institute – [ui!]
- City Bad Hersfeld
- Schredér

Aim:

- Dynamic Streetlighting – How much light is needed on residential roads?
- User Acceptance

3.2 Research – How much Light is needed?

Survey 1:

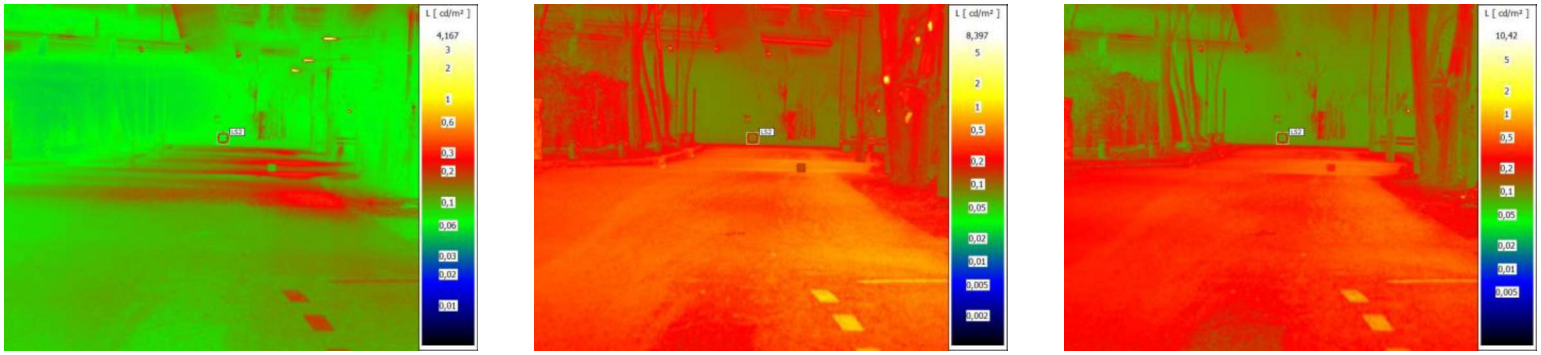
- Pedestrians in Heiningen and Bad Hersfeld
- According to Fotios et al.

The lighting on this street is:	Bad	1	2	3	4	5	6	Good
	Bright	1	2	3	4	5	6	Dark
	Not glaring	1	2	3	4	5	6	Glaring
	Unevenly spread (patchy)	1	2	3	4	5	6	Evenly spread (uniform)
Overall, how satisfied are you with the lighting on this street?	Very dissatisfied	1	2	3	4	5	6	Very satisfied

Fotios et al. (*)

Survey 2:

- Local Luminance-Measurements with obstacles
- Survey on Visibility Level at the TU Berlin



© TU Berlin, www.led-laufsteg.de

(*)Fotios, S.; Monteiro, A. Liachenko; Uttley, J. (2019): Evaluation of pedestrian reassurance gained by higher illuminances in residential streets using the day–dark approach. In: *Lighting Research & Technology* 51 (4), S. 557–575. DOI: 10.1177/1477153518775464.

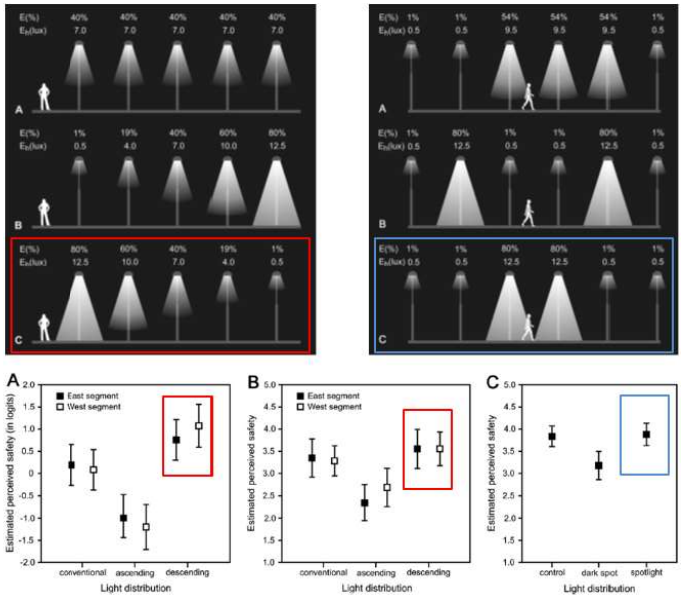
3.3 Question 2 – Appropriate Dimming Times

Current Status:

- Dimming Schemes known from Haans and De Kort – brightest light at user, light decreasing in front of the user
- each manufacturer uses different hysteresis curves

What`s needed?

- High dimming time
- Hold time
- Run-on time
- Basic lighting level

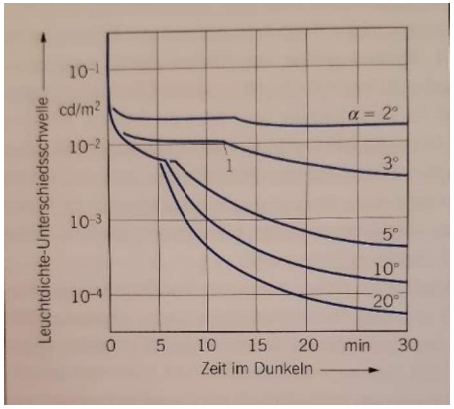


Study design and results of Haans and De Kort on adaptive lighting (Haans & De Kort, 2012; Kretzer, 2021)

3.2. Survey - Appropriate Dimming Times

To consider:

- Dark adaptation curve
- User speed
- User Acceptance
- Ambient luminance



Dark adaptation curve for object sizes α, 1 = Kohlrausch-Kink (Baer, 2020)

Survey:

Location:

- LED-Laufsteg

Systems:

- eSave
- Signify (Interact)

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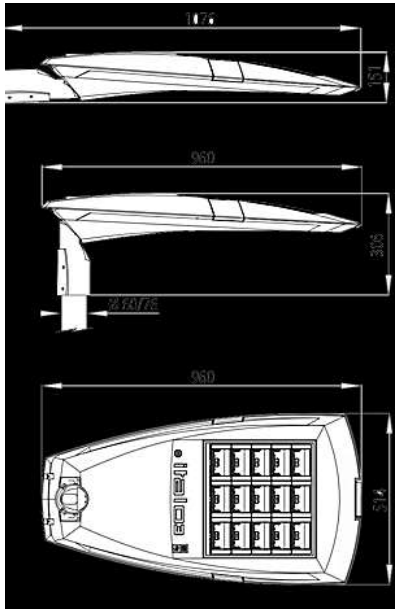
4.0 Technical Development

Standard Luminaire



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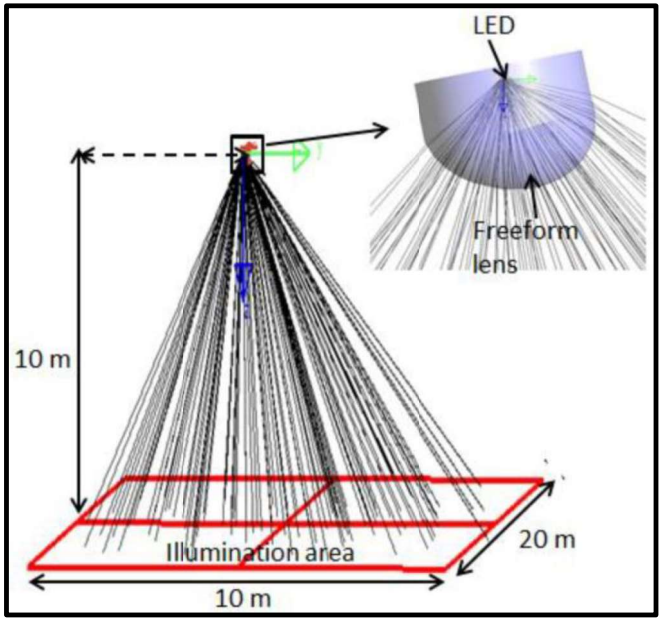
➢ Simulation With LightTools



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➢ 3D Lens Printing

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Thank you!

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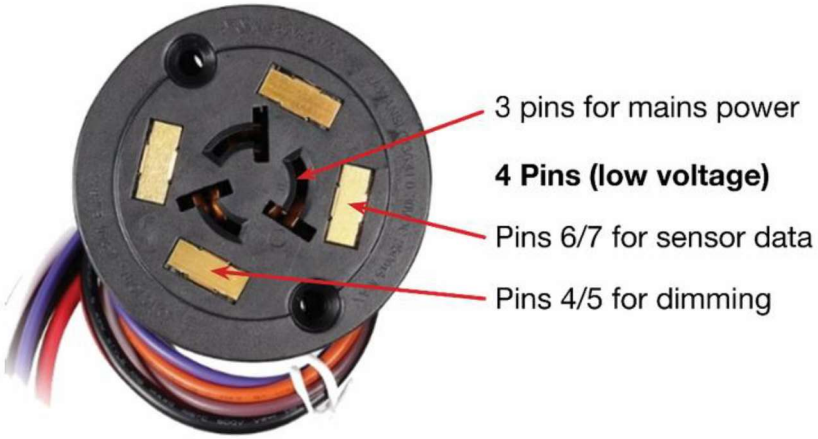
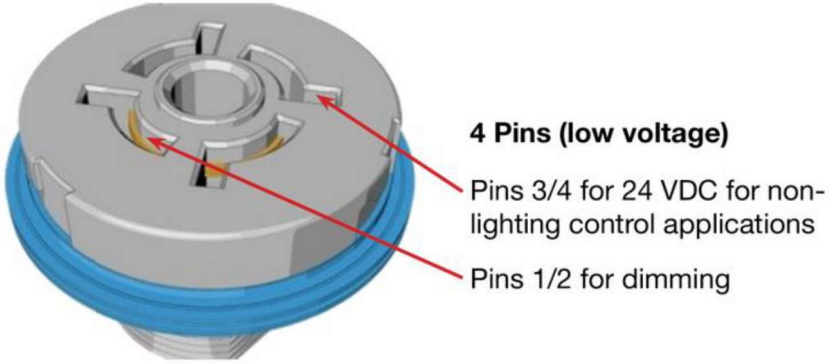
2.2 NEMA VS. ZHAGA





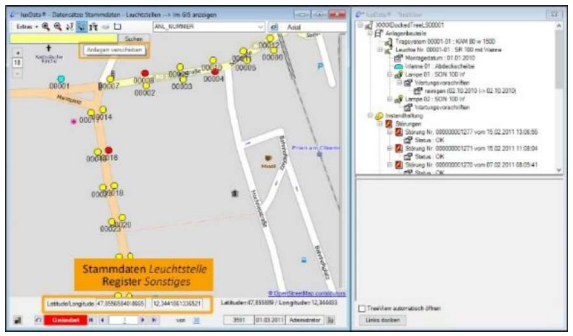
ANSI C136.41
PROS:
1.Millions of LED luminaires have been deployed with this feature.
2.Sensors can be added to any streetlight in the field with limited changes to luminaire wiring.
3.Many applications for connected cities (monitoring for traffic, air quality, dynamic lighting) can be deployed, adding flexibility of use, including those with higher power requirements.
CONS:
1. Can be aesthetically unappealing to some, with the devices on top of a luminaire.

Zhaga Book 18
PROS:
1.In some cases, lower cost of ownership as the controllers are powered by the LED drivers in the luminaires.
2.Provides signaling and power for low-powered sensors.
3.Some lower-profile controllers may improve aesthetics.
CONS:
1.Added complexity for connected city sensor use cases with higher-power requirements.
2.May include higher upfront cost equipment reliant on DALI wiring schemes.

https://www.nema.org/news-trends/ei/view/two-devices-one-goal-socket-choice-is-critical-for-lighting-controls

Current status in Berlin

- Luminaire data are stored In "LuxData“
- GIS data for location
- Platform retrievable and linkable (FisBroker, Alkis, Störung24)
- Switching via radio signal - 129kHz
- no cooperation with traffic control center
- Problems: SmartMetering necessary, no animal detection



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