Smart City Street Lighting System Quality and Control Issues to Increase Energy Efficiency and Safety

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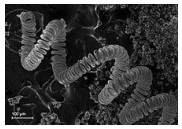
VISION ZERO FOR SUSTAINABLE ROAD SAFETY IN THE BALTIC SEA REGION 2-3 DECEMBER 2020, RIGA

1862
RTU
ENERĢĒTIKAS UN ELEKTROTEHNIKAS FAKULTĀTE

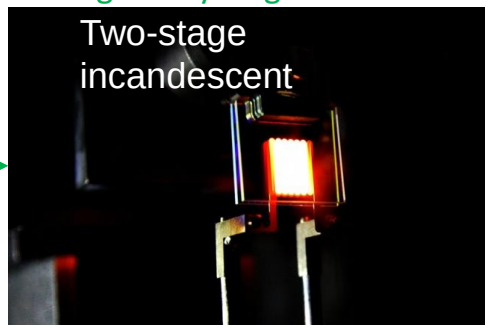
Street lighting – Quo Vadis?



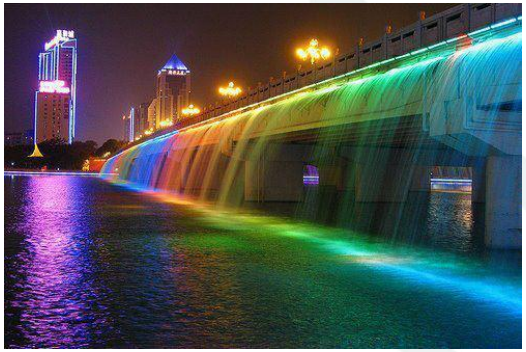
2007/2012.

Dimmed to 4W, working form year 1901

“light recycling”

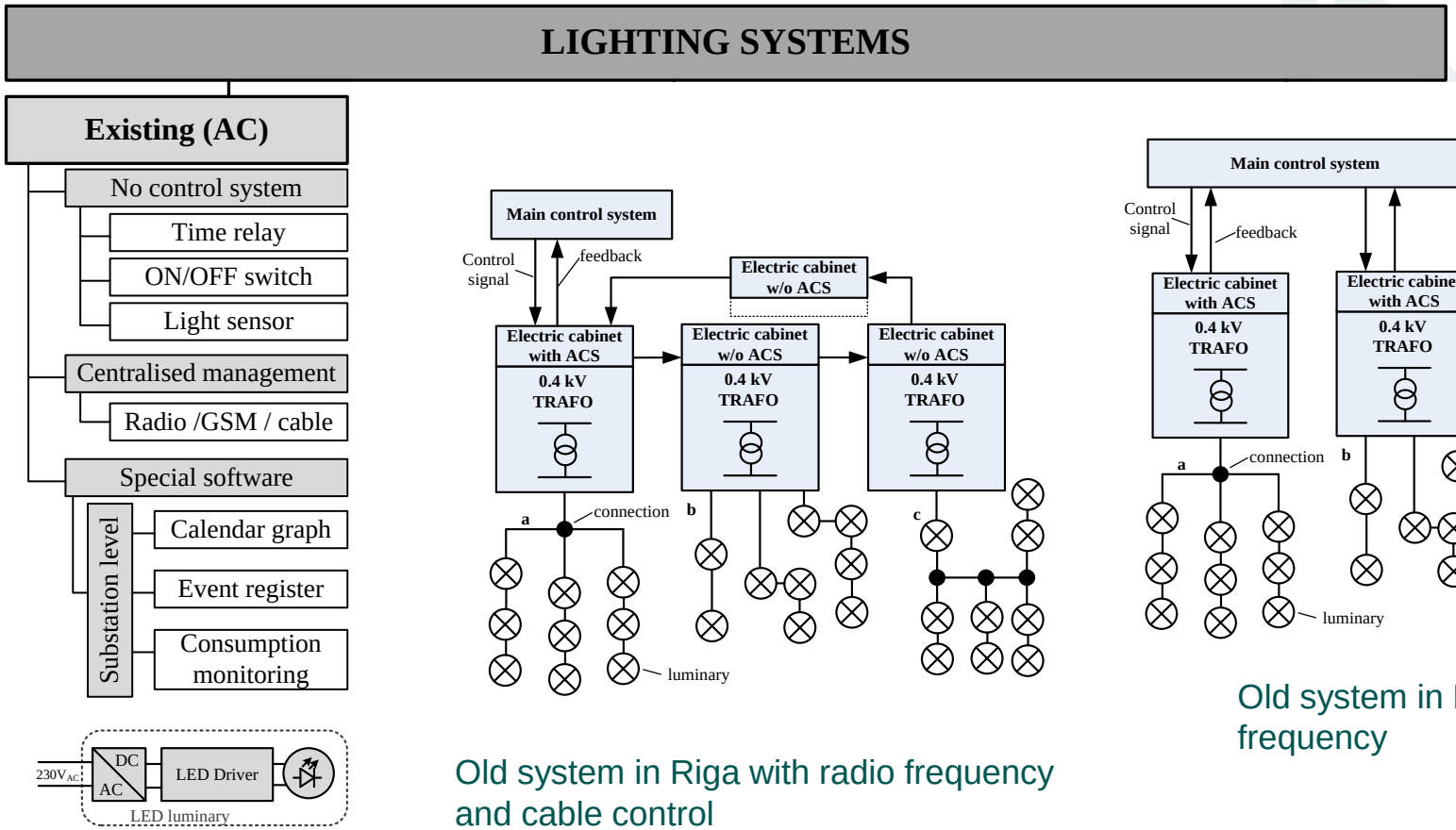


MIT and Purdue University
11.01.2016. [n=6,6% no *40%*] (LED ir 5-20%)



LED and Incandescence can be dimmed at 100% range

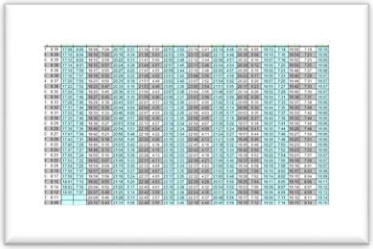
City Light Calendar Graph



Old system in Riga with radio frequency and cable control

Old system in Riga with radio frequency

Regulation: ON/OF by Calendar Graph

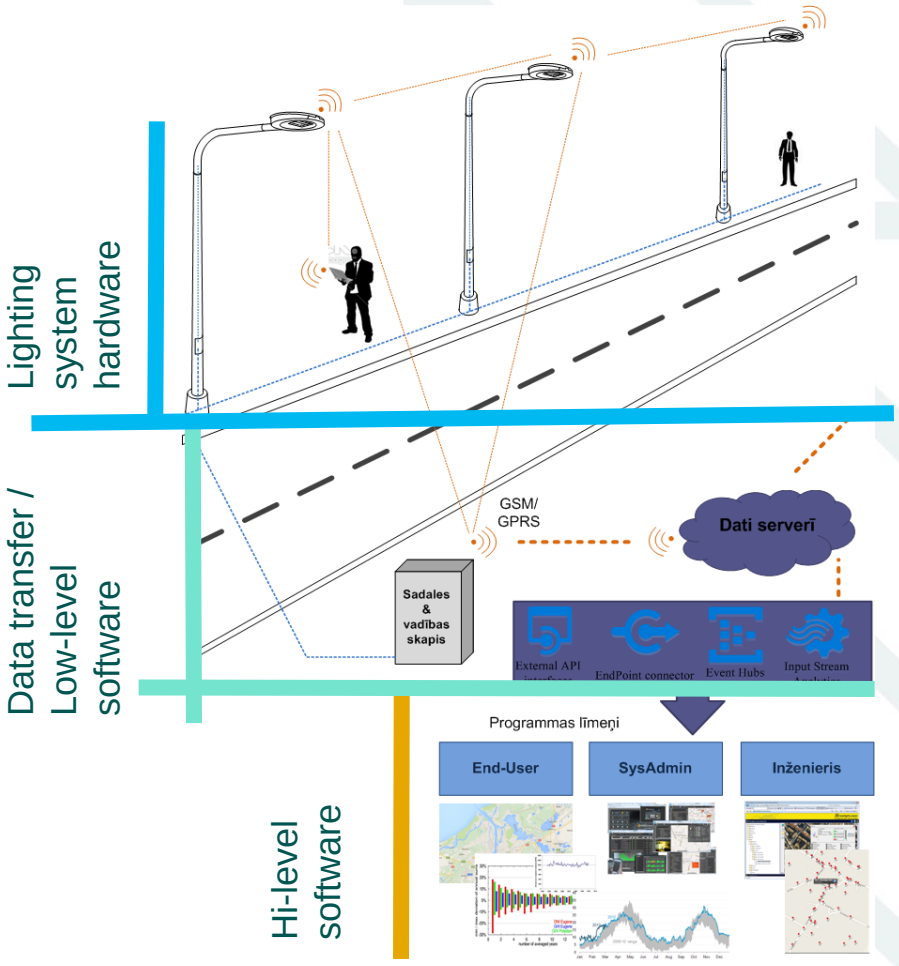


New control system levels

Hardware / Parameters / engineer / «Node»

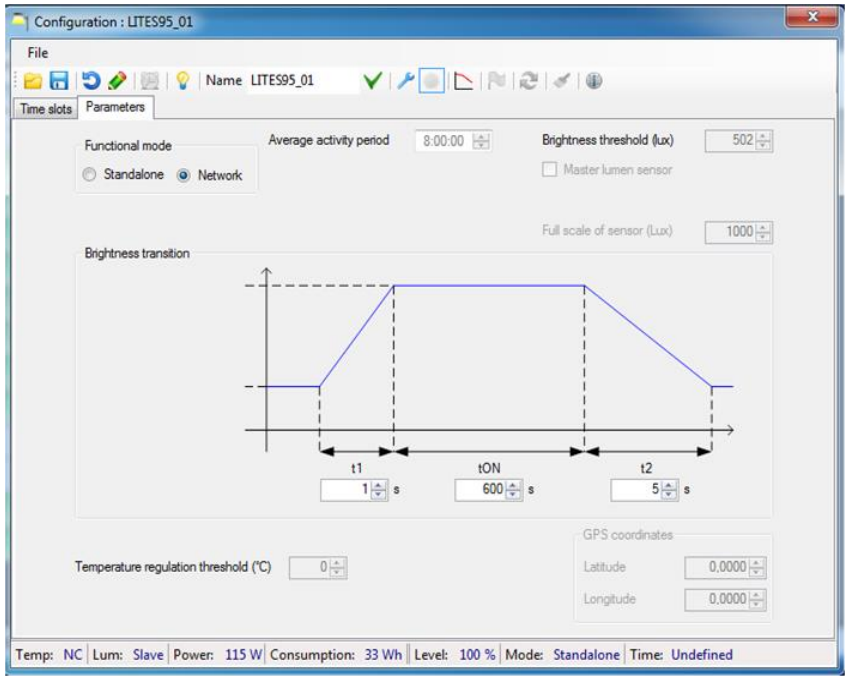
Communication / data input / «Segment controler»

Data processing Alerts /Analytics / user levels/ «Software»

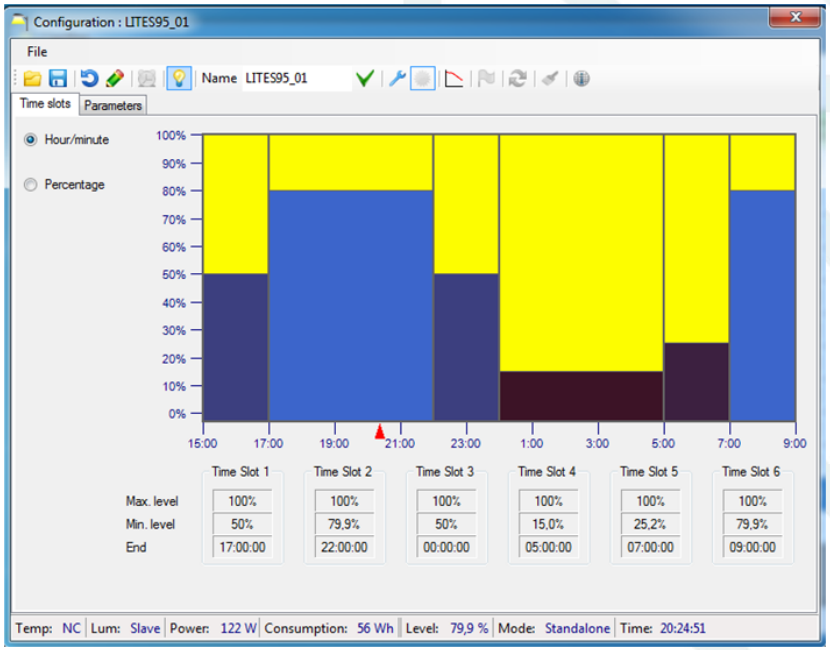


Sample of control of a «node»

Each luminary or each street profile



Ramp – up and ramp down, to reduce glare

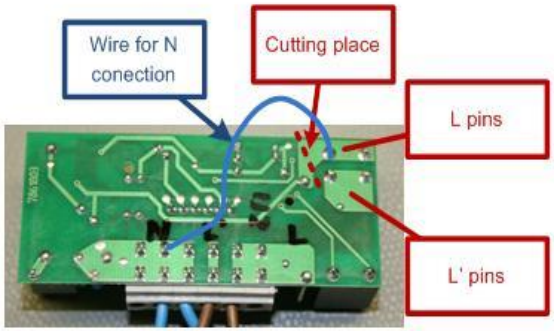


Lighting time zones and min/max level config

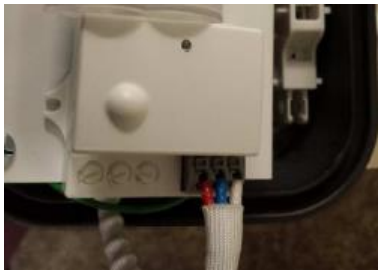
Smart lighting sensor types

PYR and microwave

Steinel IS3180PF Sensor



230VAC



MICAS AUTOLIGHTxs @ 5,8GHz (Aveiro)

230VAC

And comination of them….

Bosch TriTech® DS720i

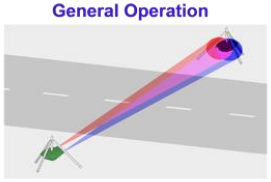
9-15VDC

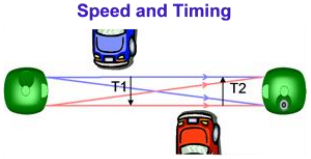
And many more….

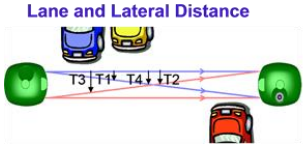
Traffic sensor types

Movement detector →	Video	Termal imaging	Radar (microwaves)	Infrared	Acoustic	Magnetic	Inductive loop

detects the change in the Earth's magnetic field

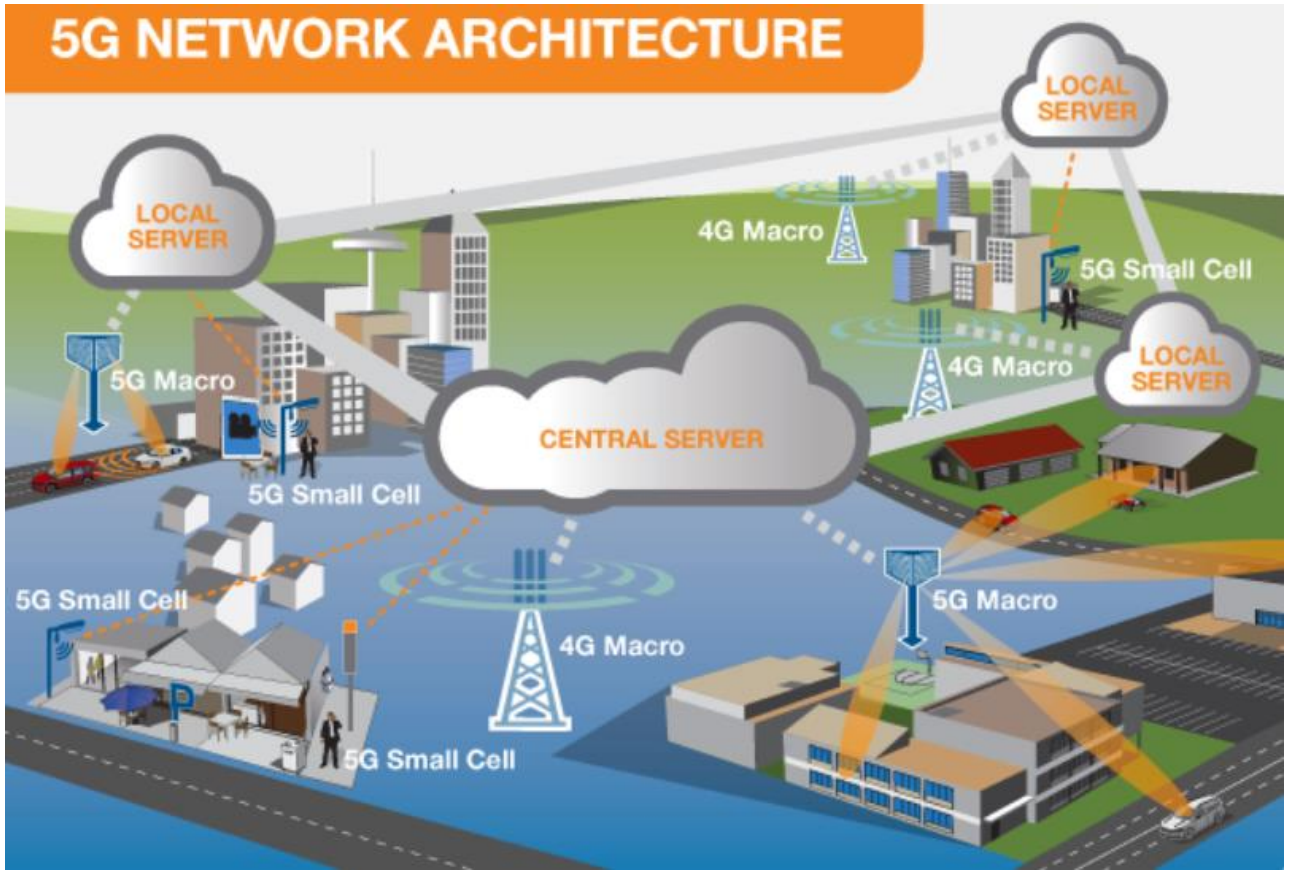






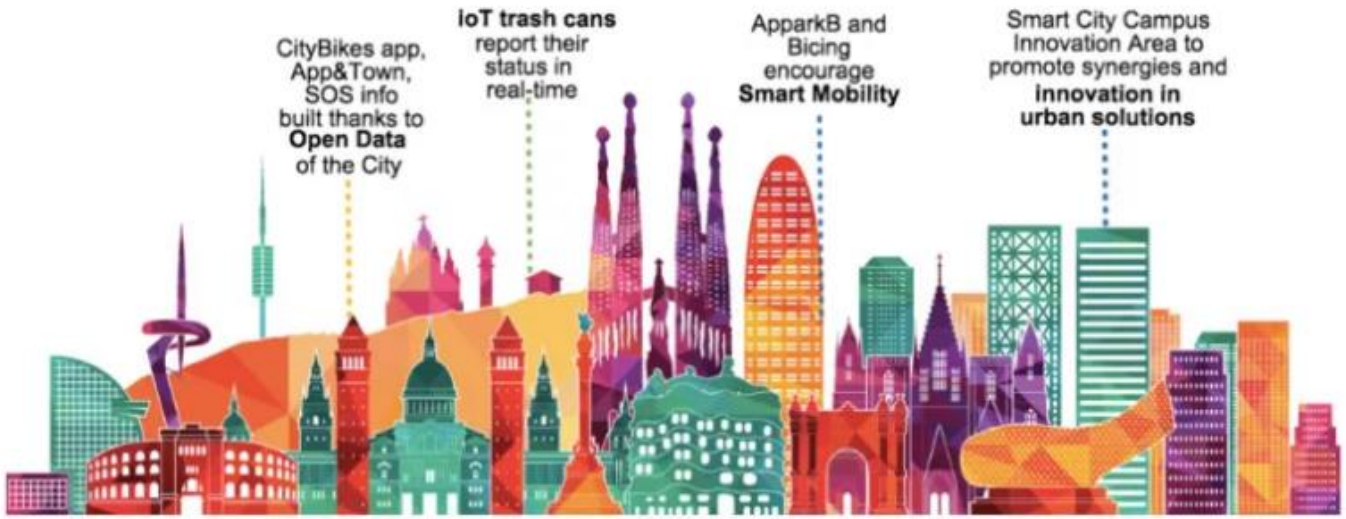
Result: Valuable traffic data can be obtained

IoT & 5G tech upcoming…



As well as:
Low Power Wide Area (LPWA) networks such as Sigfox, LoRa, NB-IoT and RPMA

Barselona – smart city



SMART CITY SERIES: THE BARCELONA EXPERIENCE

ZIGURAT GLOBAL INSTITUTE OF TECHNOLOGY × 7 FEBRUARY, 2019

Smart traffic control,parking lot control, ligthing control system. It is planned to save 42.5 million euros in water and generating 36.5 million euros in a year thanks to smart car parks.

Source: https://www.e-zigurat.com/blog/en/smart-city-barcelona-experience/

Amsterdam

The Amsterdam Smart City platform has been created to promote a user-friendly, rational city. The open data-based platform makes it possible to connect local businesses, municipalities and citizens.

Smartphone app for citizens to …

On your bike at night in the Port of Amsterdam area? Adjust the street lighting with the app on…

Ecube Labs

Data driven smart waste management solutions

Smart Parking - Citibrain

A PARKING TICKET THAT NEVER EXPIRES

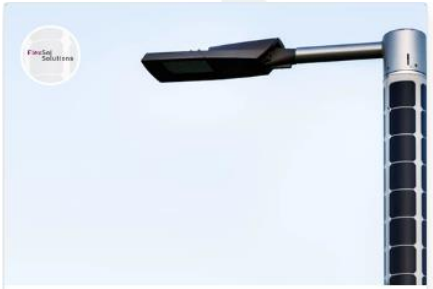
Lightinus - Smart Solar Street Lig…

LIGHTINUS is state-of-the-art smart street light powered by renewable energy.

https://amsterdamsmartcity.com/products

Odaddy Smart Bench

undefined

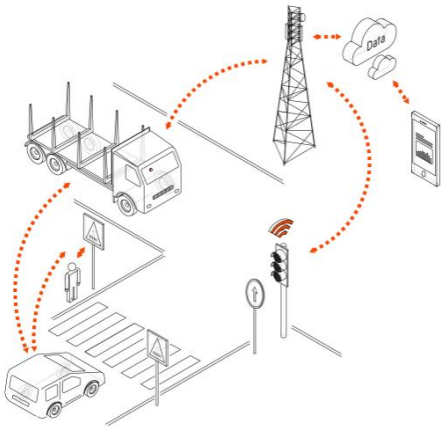


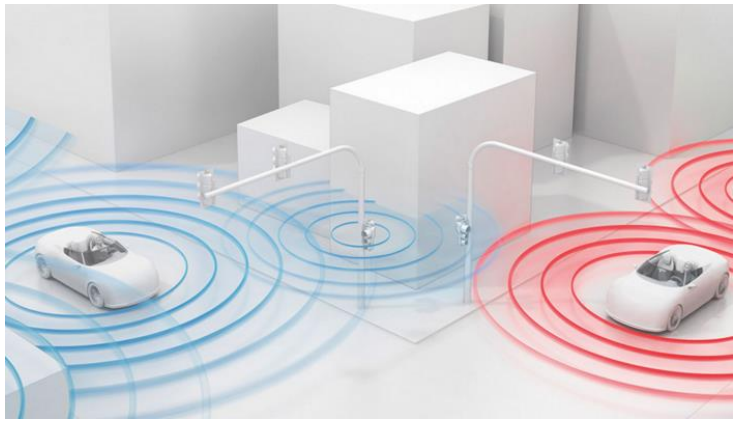
Soluxio: solar light post

The fully autonomous solar powered street light

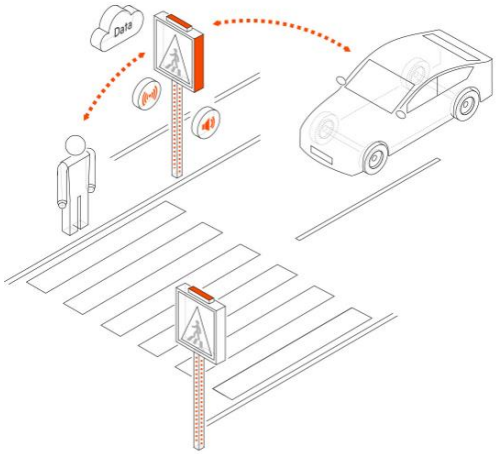
LMT inovation projects

5G connected and automated mobility



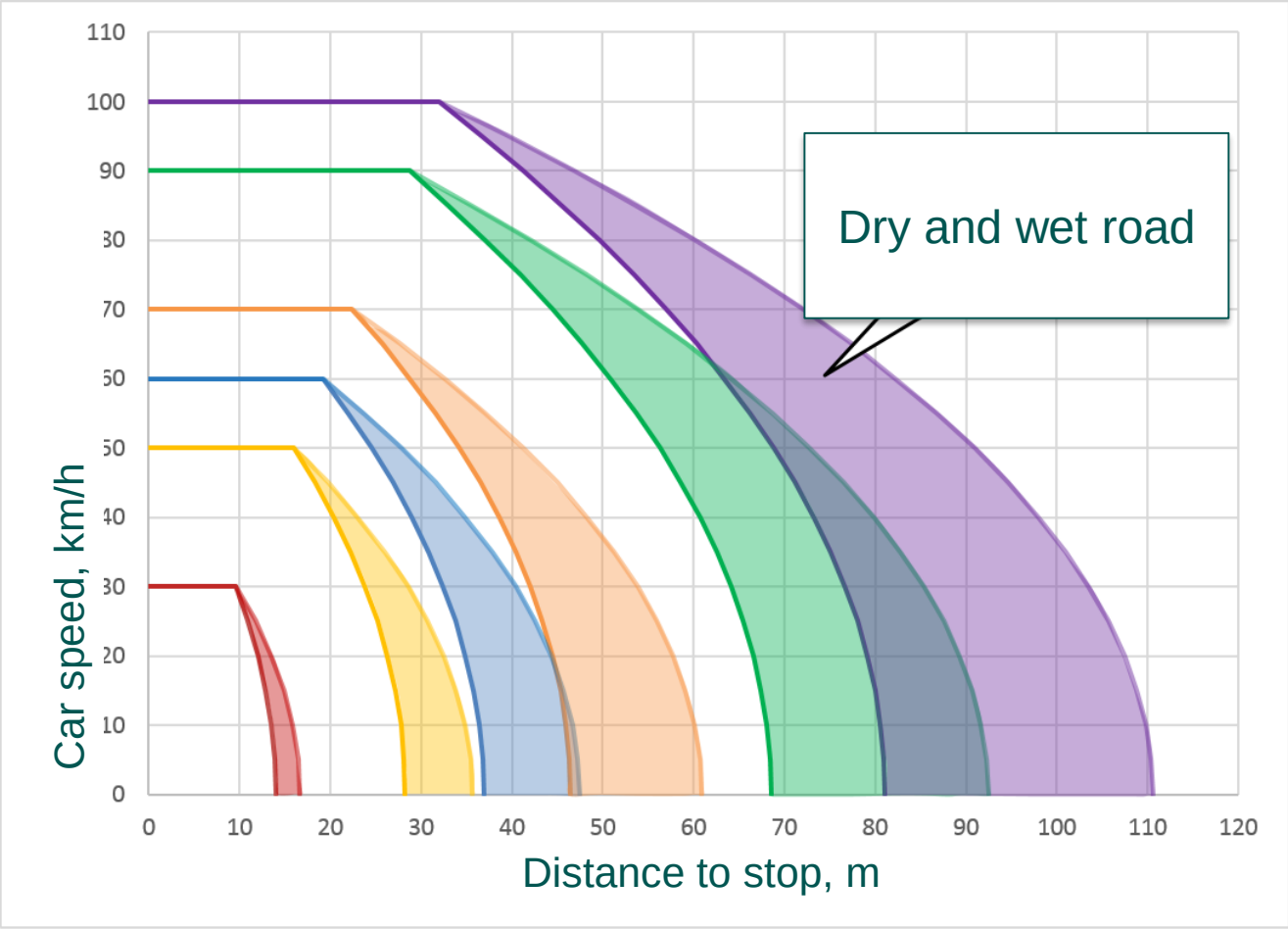


Smart Pedestrian Crosswalk



https://innovations.lmt.lv/en/projects

Speed vs distance to stop



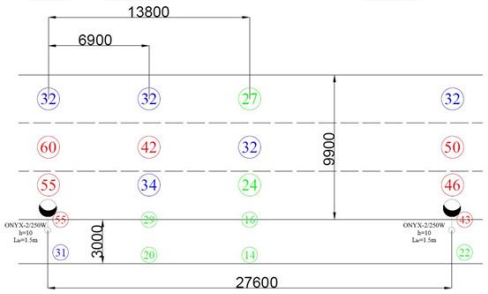
+ Extra savings if wet (or snowy) road detected (new sensor needed)
+ Radar sensor can detect speed (can trigger police to monitor unsafe places)

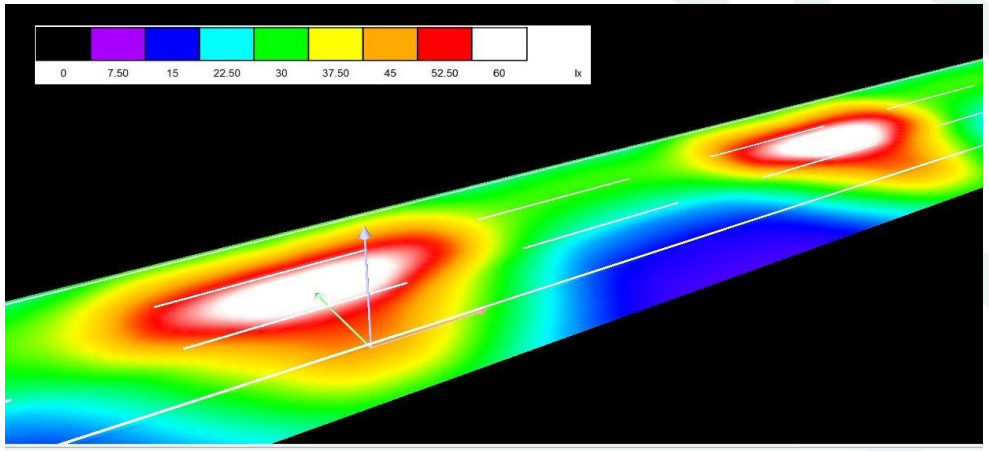
Dienvidu bridge case

Dienvidu bridge

EN13201 part 1
CEN/TR 13201-1:2015

Existing: ME2 class

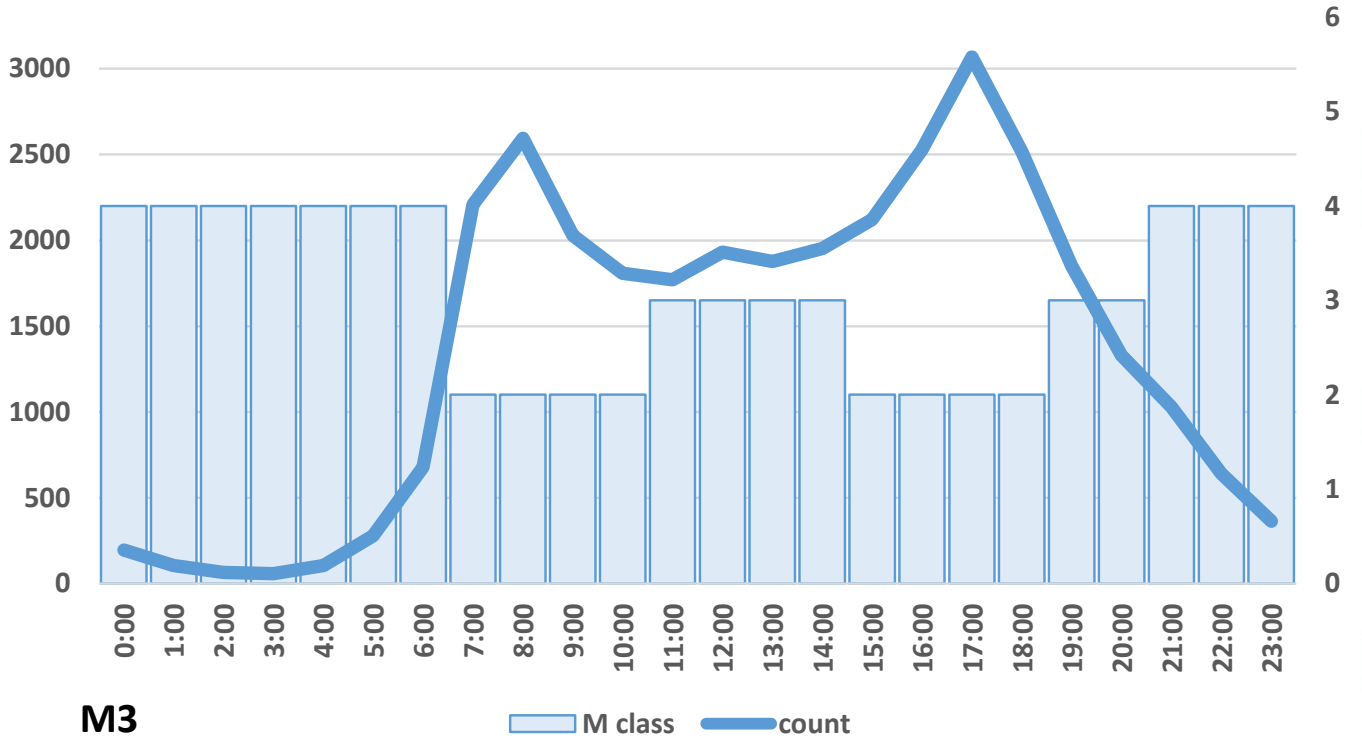


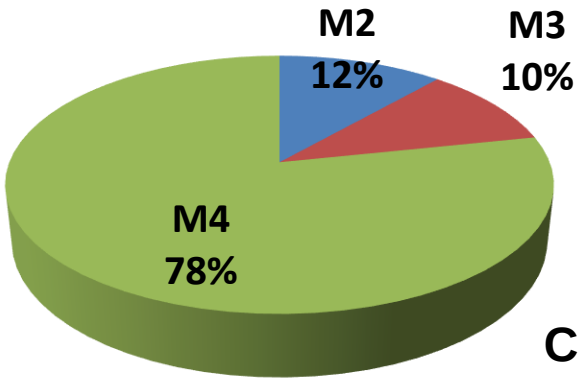


Values	L_{av}[cd/m²]	U0	UI	TI[%]	SR
Calculated	2.21	0.57	0.74	10	0.52
Required	≥ 1.50	≥ 0.40	≥ 0.70	≤ 10	≥ 0.50
	✓	✓	✓	✓	✓

Schreder ONYX2 (reflector #1419) 250W HPS

Real traffic intensity vs ME clases





Class based on real traffic intensity data

SAVAS data analysis results

- M2 class – 454 hours (11.5%) from total lighting hours
- M3 class – 401,5 hours (10.2%) from total lighting hours
- M4 class – 3093 hours (78.3%) from total lighting hours

According to existing street class selection method – in time values **88.5%** cases a higher class is chosen as needed in reality.

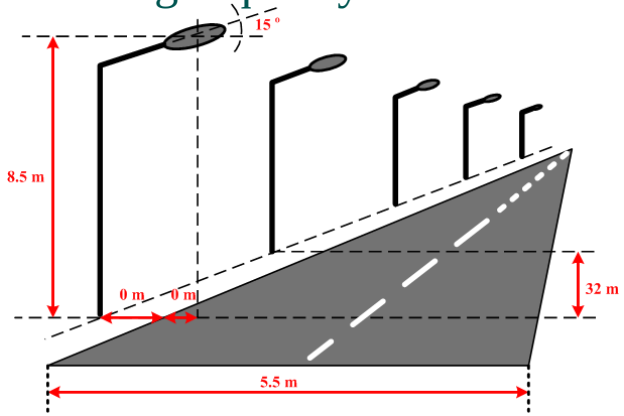
- With equivalent LED luminary (Schreder Ampera Maxi)

	154W	117W	117W	Yearly consumption	
M2 burning hours (h)	3948.5167			608.0715718	kWh
M2,M3,M4 burning hours (h)	453.9167	401.4833	3093.117	478.7713718	kWh
	M2,M3,M4/M2=		0.78736		
Potential yearly saving:			**21.26**	**%**	

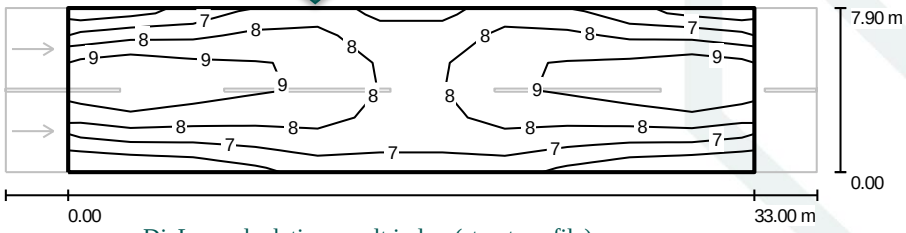
As a result – cheap traffic detection sensors needed

Street profile measurements

Main Light quality standard is: **EN13201 part 1 LVS CEN/TR 13201-1:2015**



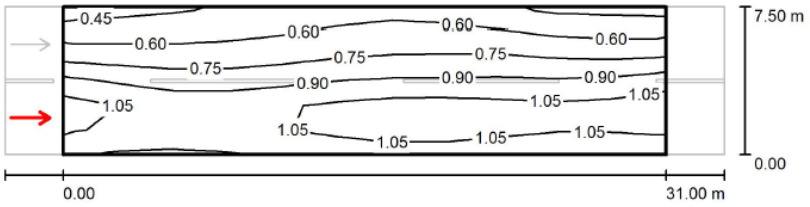
Values	L_{av} [cd/m²]	U_0	U_l	TI [%]	SR
class ME1	≥2,0	≥0,4	≥0,7	≤10	≥0,5
class ME2	≥1,5	≥0,4	≥0,7	≤10	≥0,5
class ME3a	≥1,0	≥0,4	≥0,7	≤15	≥0,5
Class ME3b	≥1,0	≥0,4	≥0,6	≤15	≥0,5
class ME3c	≥1,0	≥0,4	≥0,5	≤15	≥0,5
class ME4a	≥0,75	≥0,4	≥0,6	≤15	≥0,5
class ME4b	≥0,75	≥0,4	≥0,5	≤15	≥0,5
class ME5	≥ 0.50	≥ 0.35	≥ 0.40	≤ 15	≥ 0.50
class ME6	≥0,3	≥0,35	≥0,4	≤15	–



DiaLux calculation result in lux (street profile)

LS-100 Luminance Meter

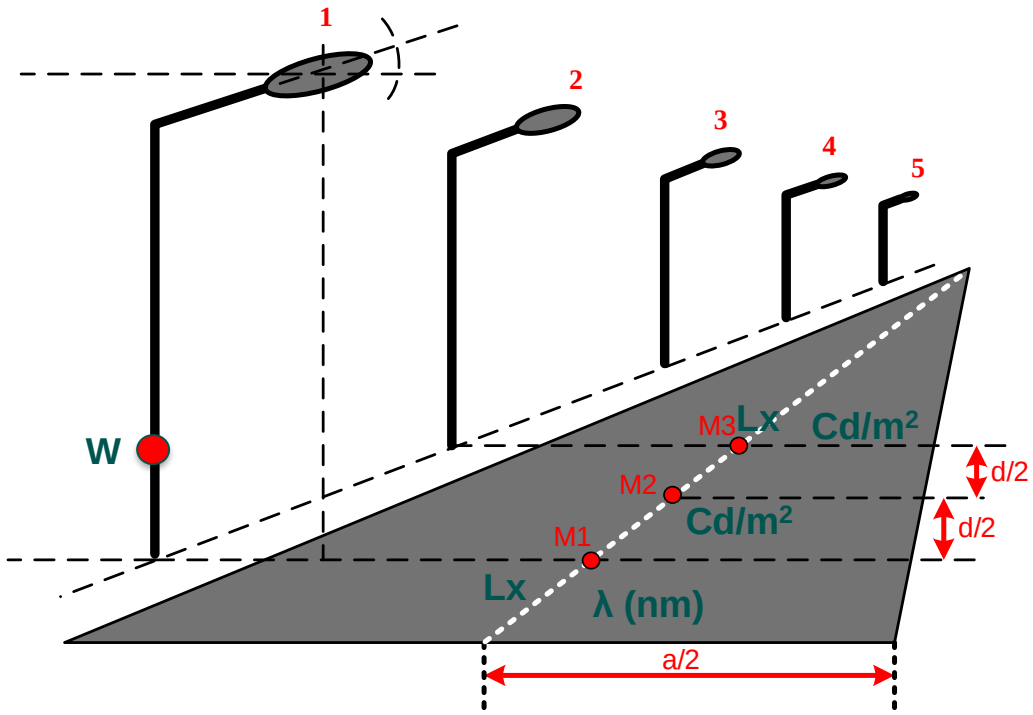
Hagner EC1 (0.1-200'000 lux)



Values in Candela/m², Scale 1 : 265

Large city case study

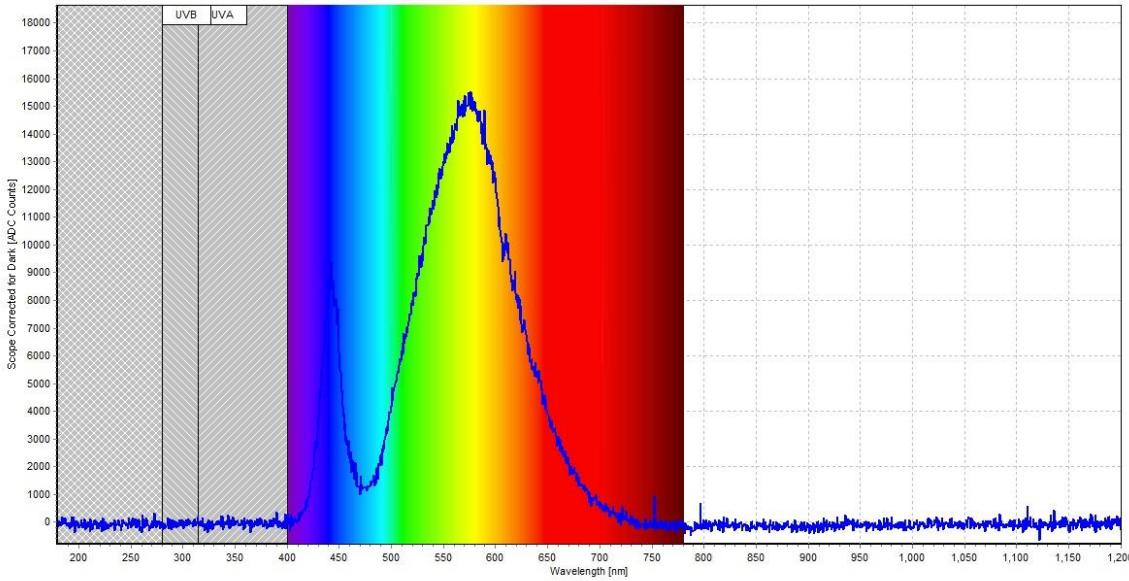
- Smart LED luminaries were installed in three city regions: one is **central** (higher traffic) and two are in sub-urban areas (lower traffic)
- Overall more than 1300 ligting poles were measured (Lux, Ra)
- More than 100 luminaries measured at dimmed regimes (P,W, Lux, Candela)



Measurement equipment

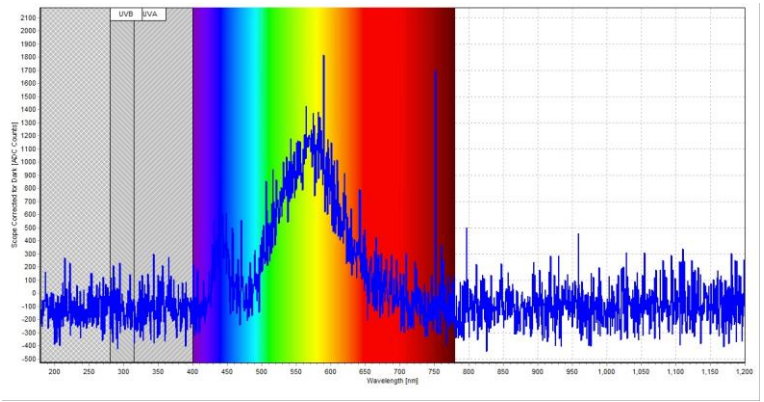
Color, x,y,z values, spectrum, etc parameters are detected by spectrometer.

AvaSpec-2048-USB2-UA

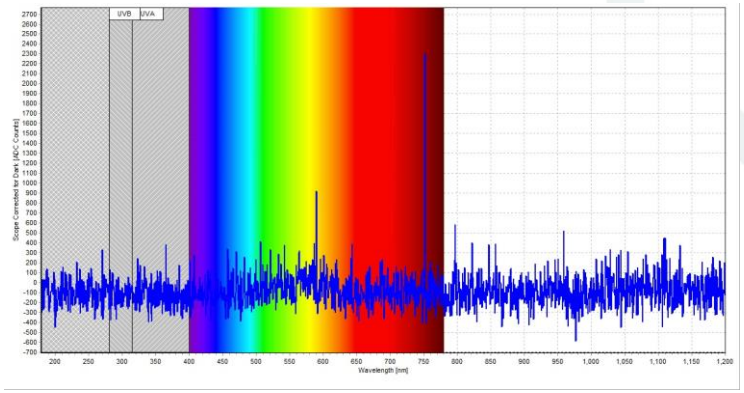


CRI (Ra) values: 51 -78

With noise: Indirect

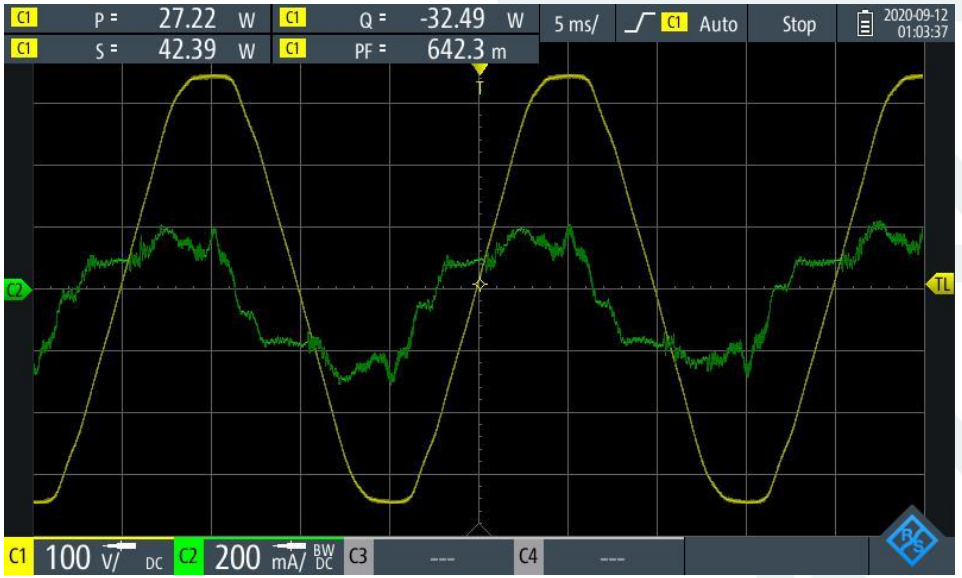


leaves



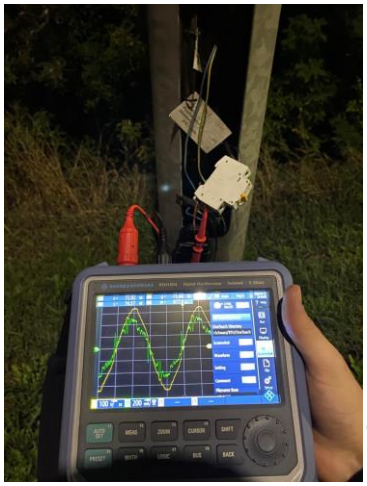
Dimming measurements

Rohde & Schwarz RTH1004



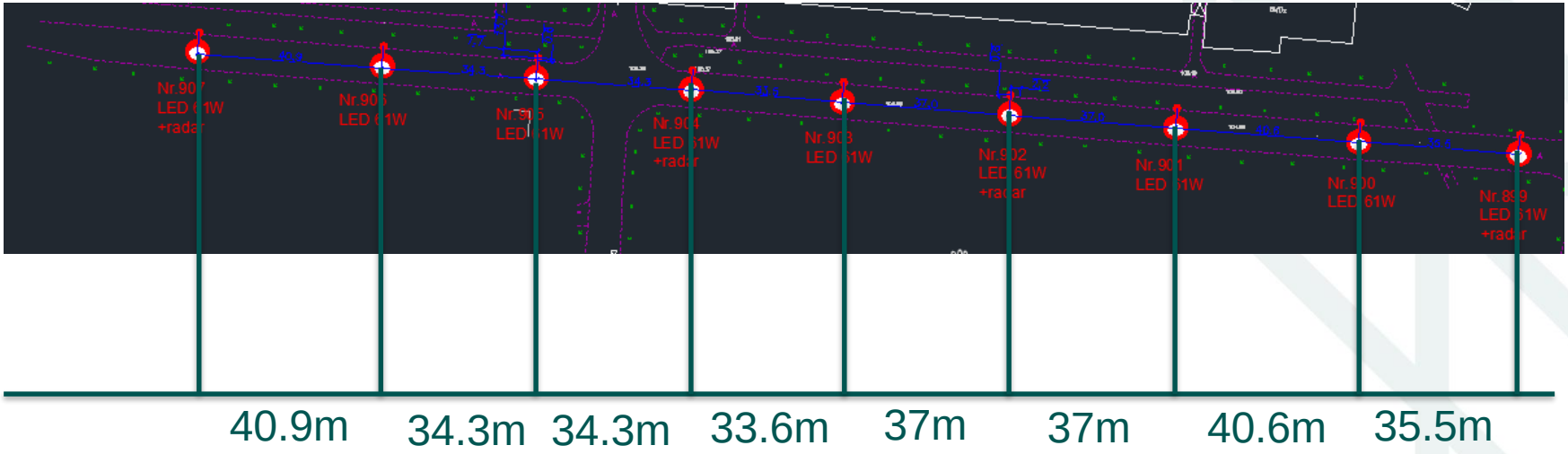
40%

ON - site



100%

Street profile for Dialux



For Dialux calculations are 2 options:

1) Calculate for each different pole distance
2) Calculate for average distance values and use only one simulation to evaluate

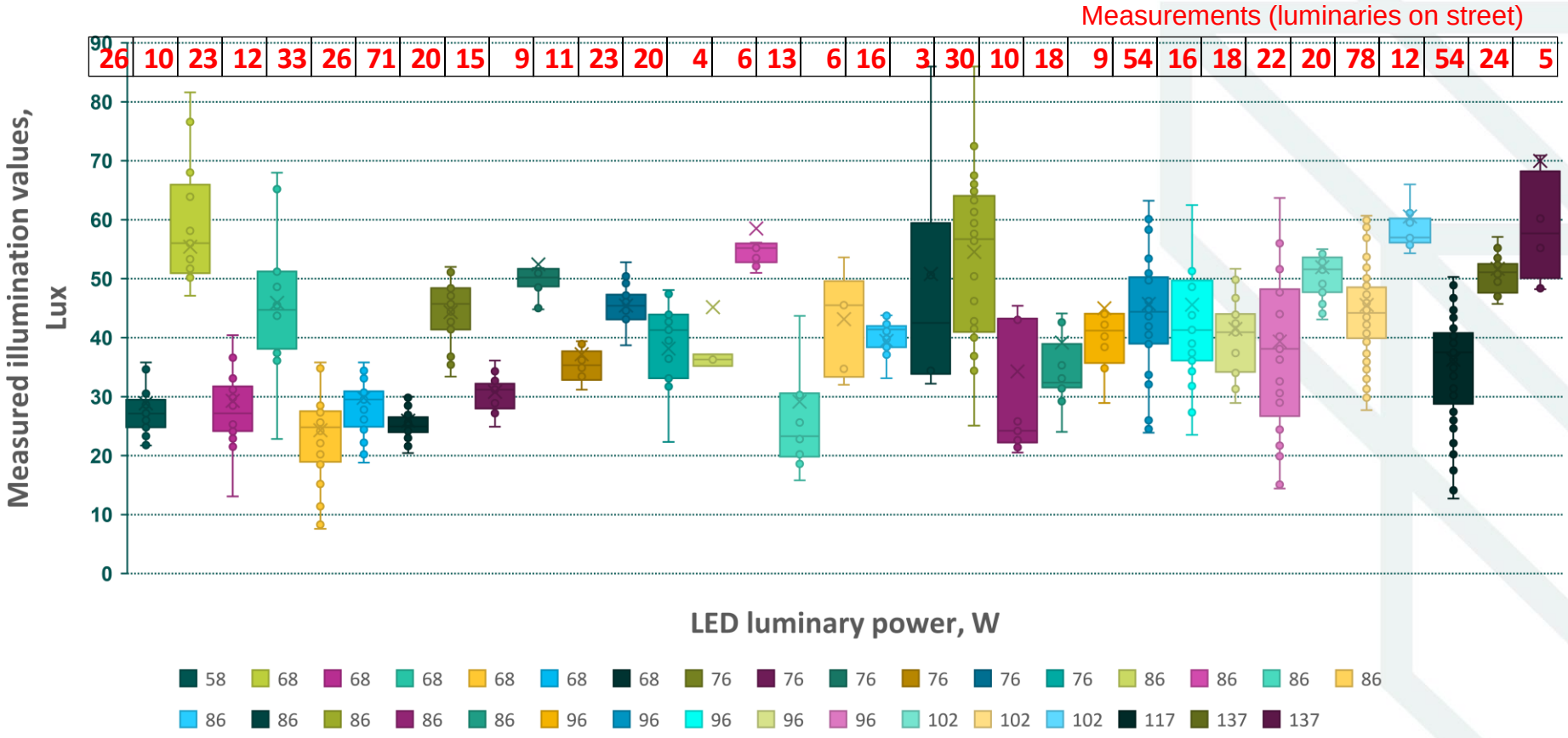
Lav=(L1+L2+L3+L4+L5+L6+L7+L8)/n=293.2/8=**36.65m**

Averaged profile used for Dialux calculations

Grid: 11 x 6 Points
Observer Position: (-60.000 m, 1.875 m, 1.500 m)
tarmac: R3, q0: 0.070

	L_{av} [cd/m²]	U0	UI	TI [%]
Calculated values:	0.85	0.53	0.86	8
Required values according to class ME4a:	≥ 0.75	≥ 0.40	≥ 0.60	≤ 15
Fulfilled/Not fulfilled:	✓	✓	✓	✓

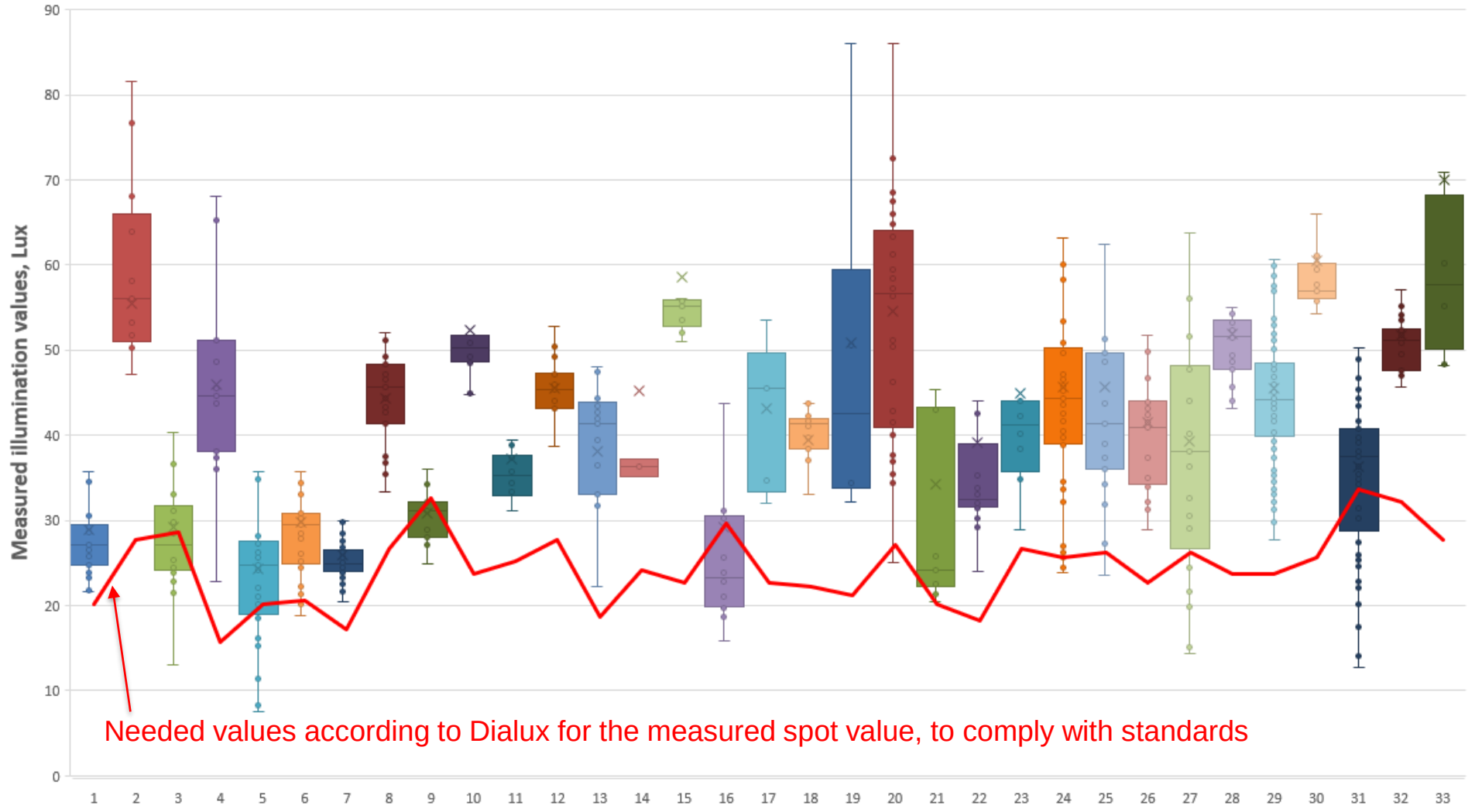
717 measurements - luxmeter



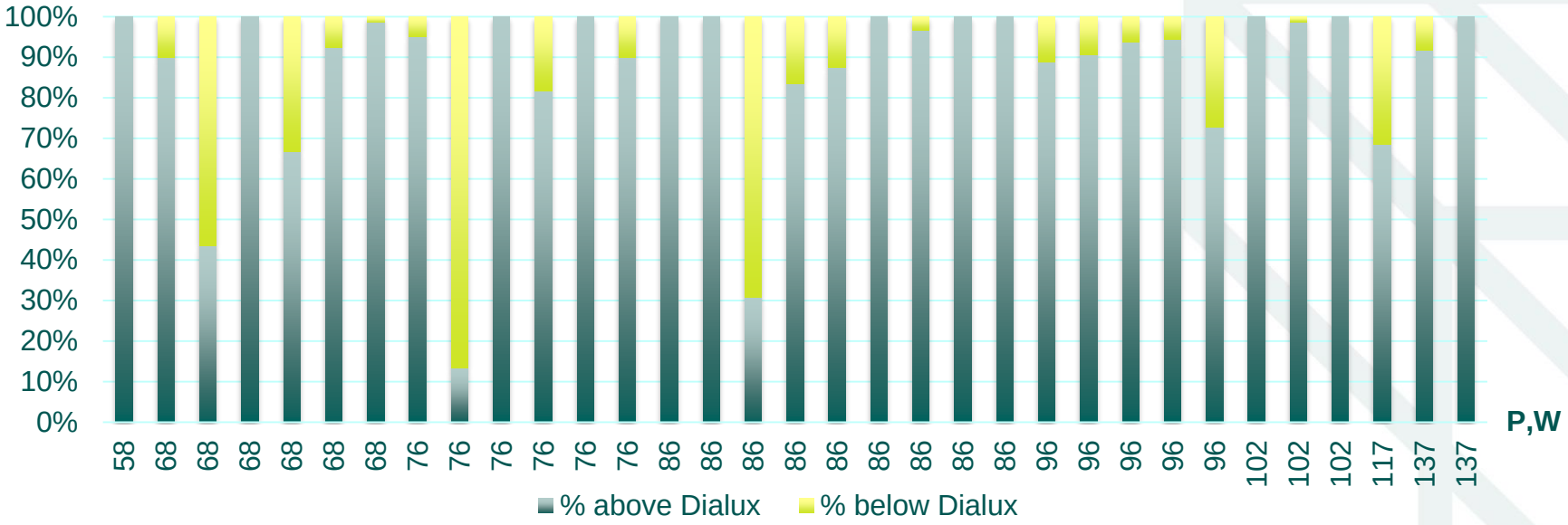
MIN	22	3	13	23	2	19	17	12	21	45	24	33	3	31	51	16	4	2	32	25	21	24	19	21	24	17	14	29	17	44	8	7	48
AVG	28	54	28	44	23	28	25	43	30	50	34	44	36	35	54	25	36	37	39	54	29	37	39	45	42	38	37	49	45	57	35	48	57
MAX	39	82	40	65	45	41	35	52	36	57	39	54	48	37	56	44	54	44	51	99	45	66	62	95	71	52	64	55	74	66	50	57	71

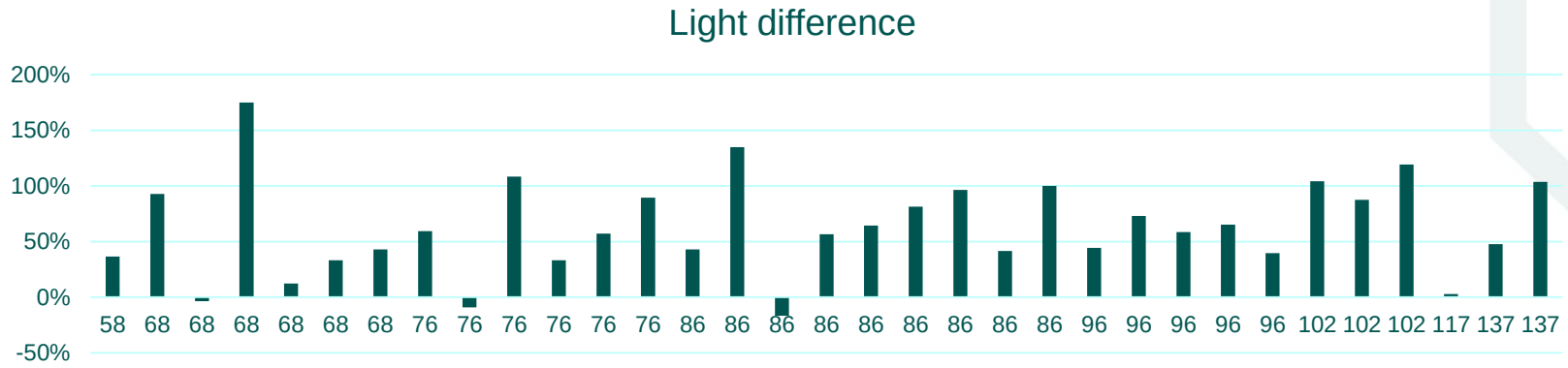
There are some quite many points above average & outside the median. Dialux?

Comparison with DiaLux4.13



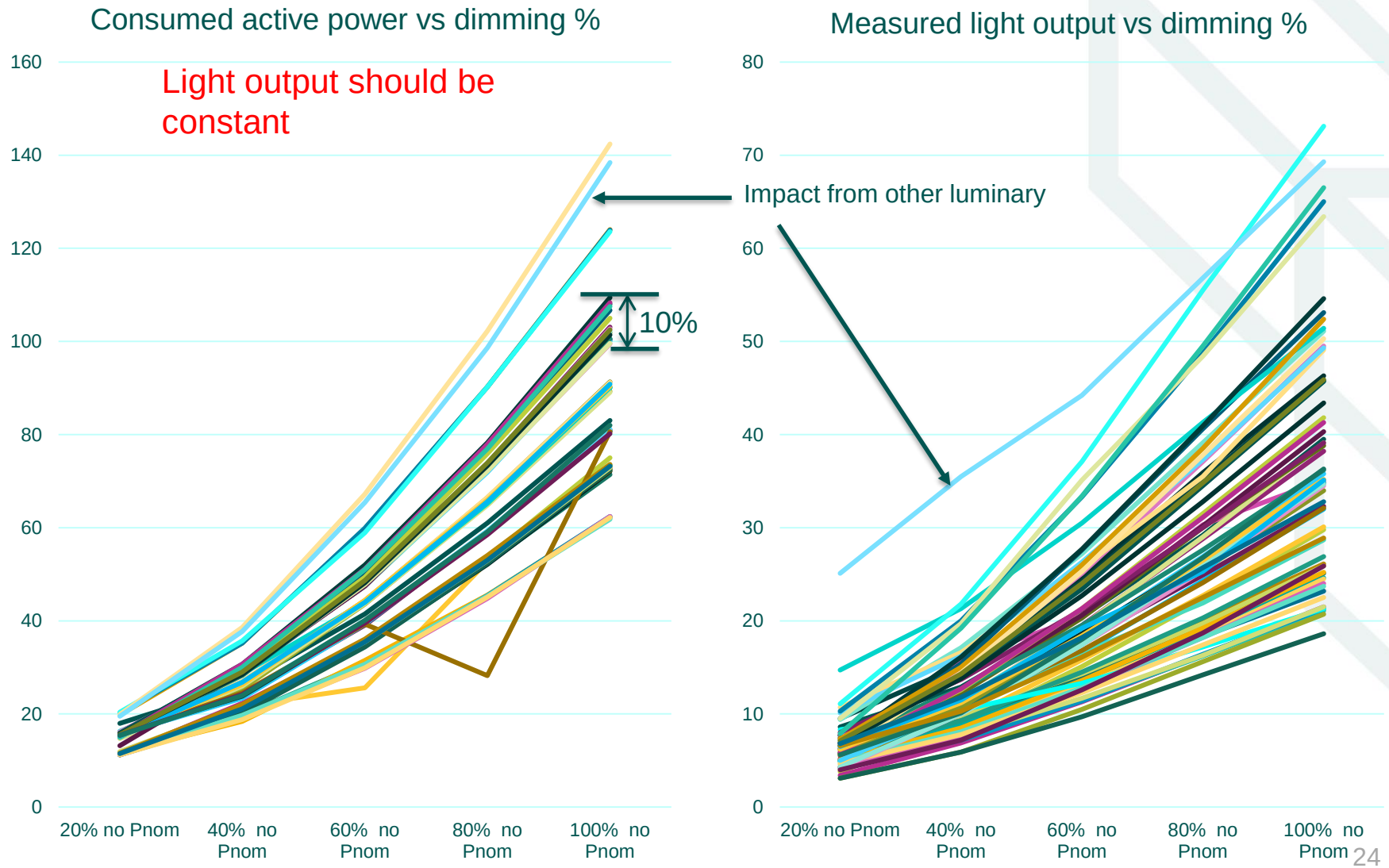
Comparison with DiaLux4.13



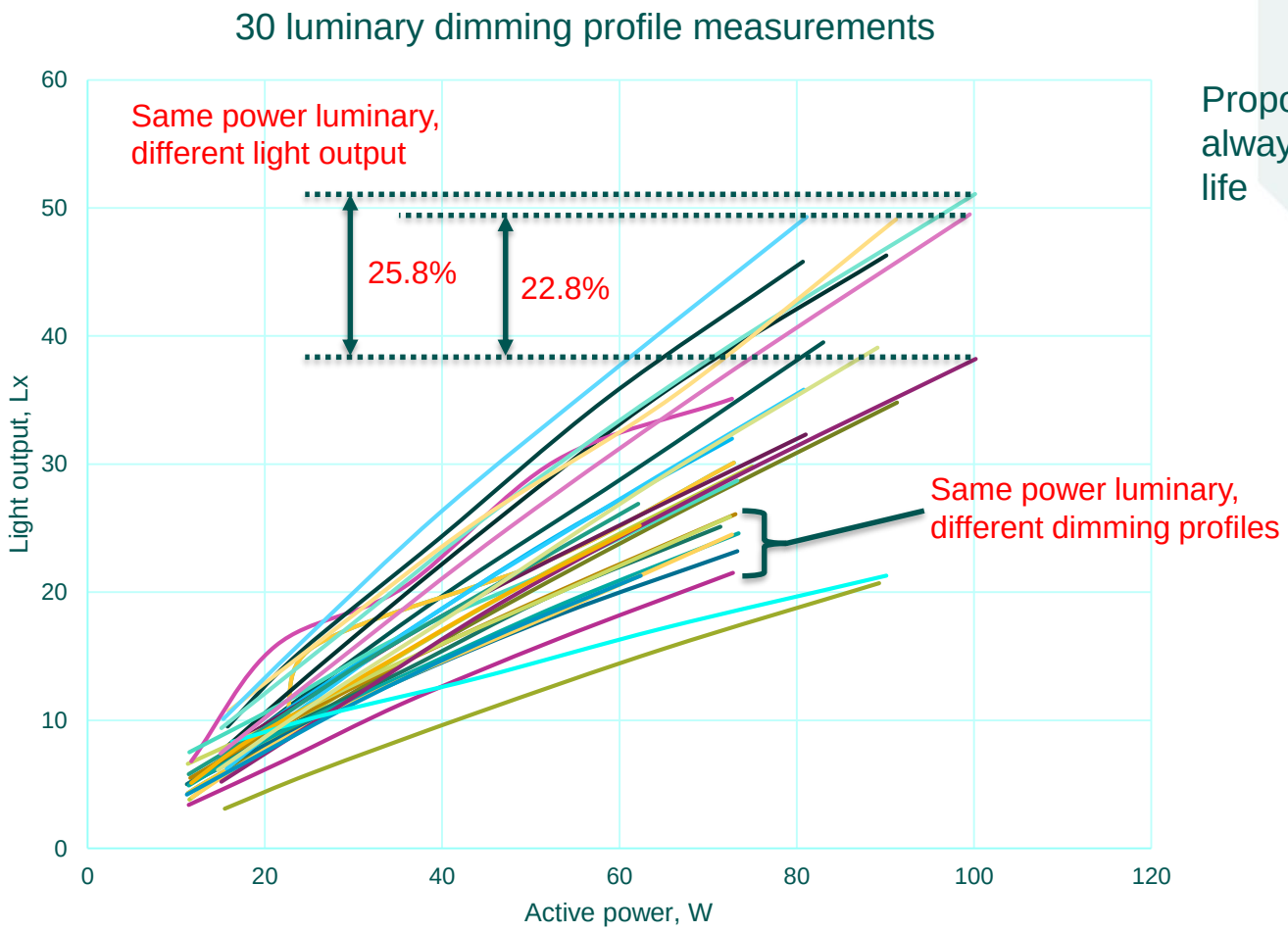


Light decrease potential (by AVG measured values to reach Dialux spot value), %
In average potential is **63%**

Dimming issues



InSitu - dimming isues



Proportional, but not always linear in real life

Conclusions

- Measurements after installation should be mandatory
- Extra energy savings OR increased safety can be reached
- More light than needed (in early years) → extra savings & no investment
- New simulation/calculation tool is needed for smart lighting systems (street profile(CAD file data) / dimming / spot measurements at nominal power)
- LED luminary design should have extra power/light output ability, above nominal (needed for safety in specific street profile spots / LLF adjustment during lifetime)
- LED ballast and control node regulation for «dimming profile» could be improved

Thank you for your attention

More details are planned to publish in special issue of:
The Baltic Journal of Road and Bridge Engineering

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NATIONAL DEVELOPMENT PLAN 2020

EUROPEAN UNION
European Regional Development Fund

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