



NMF

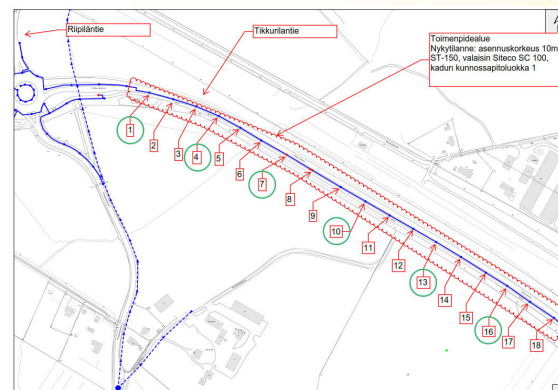
Maintenance factor measurements in Finland

25.11.2019

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Ledivalaisimien alenemakerroinmittaukset

- The project started in January 2017
- The aim of the work is to study the MF-values for different LED luminaires
- In the project, 18 luminaires (6 different manufacturers, 3 luminaires/manufacturers) were installed on a street in August 2017
- The project duration is 6 years
- Measurements will be performed every 2 years
- Before installation all 18 luminaires were measured at Aalto University
 - Measurement results are used as reference values during the project
- The measurement results were also used for quality control of the LED luminaires
- In September 2019 six luminaires (6 manufacturers, 1 luminaire / manufacturer) were taken down and measured at Aalto University as dirty and clean

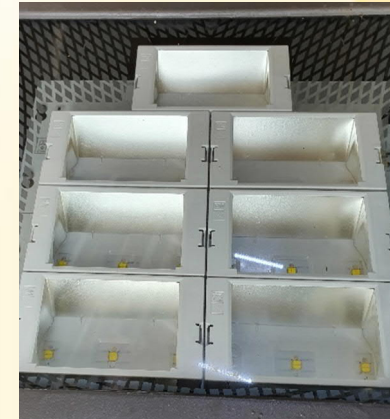
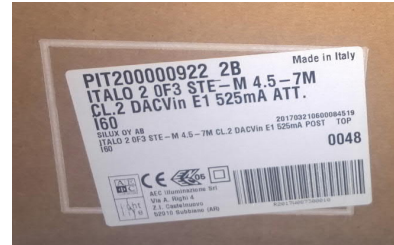


Maintenance factor measurements

- The topics under study are:
 - Luminous flux factor (effects of lenses, reflectors and different materials)
 - Luminaire maintenance factor (effects of flat glass and flat glass with integrated lenses)
 - Changes in the photometry of the luminaires due to dirtiness and aging of lenses and reflectors
 - Changes in correlated colour temperature and colour rendering index due to aging
 - Quality control of the LED luminaires on the market (comparison between info provided by manufacturers and measurement results)
- Measured quantities are (as dirty and clean):
 - Photometric properties
 - Input power
 - Circuit power factor
 - Luminaire luminous flux
 - Luminous efficacy
 - Correlated colour temperature
 - Colour rendering index

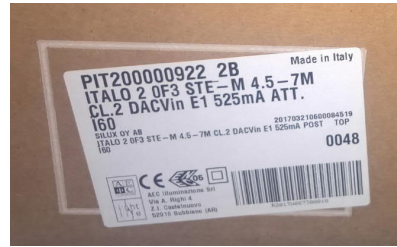


AEC Italo 2



	Reference results	Luminaire 1, dirty	Result	Luminaire 1, clean	Result
Input power (W)	129,8	130,1	+0,2 %	130,1	+ 0,2 %
Circuit power factor	0,985	0,977	OK	0,977	OK
Luminaire luminous flux (lm)	15 850	15 290	- 3,5 %	15 500	- 2,2 %
Luminous efficacy (lm/W)	122,1	117,5	- 3,9 %	119,1	- 2,5 %
CCT (K)	4 029	4 053	OK	4 055	OK
CRI R _a	80	73	?	72	?

AEC Italo 2

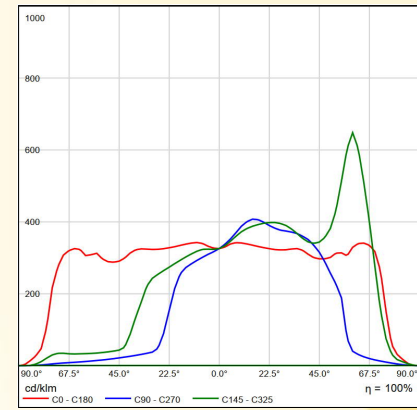
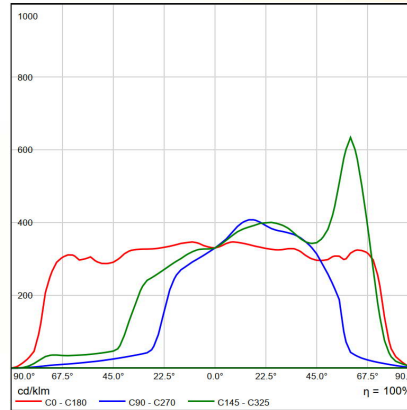
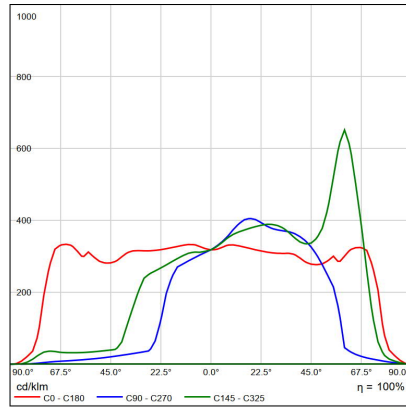
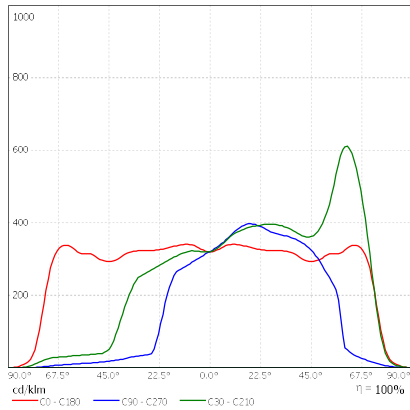


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Luminaire 1, reference

Dirty

Clean





AEC Italo 2

Roadway 1 (M4)

Lm [cd/m ²] ≥ 1.00	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30
✓ 1.09	✓ 0.51	✓ 0.66	✓ 11	✓ 0.76

Roadway 1 (M4)

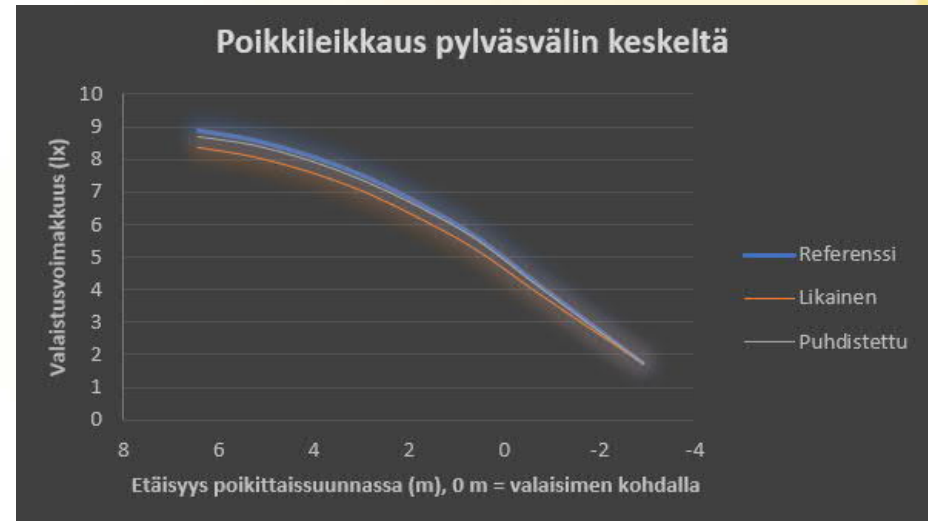
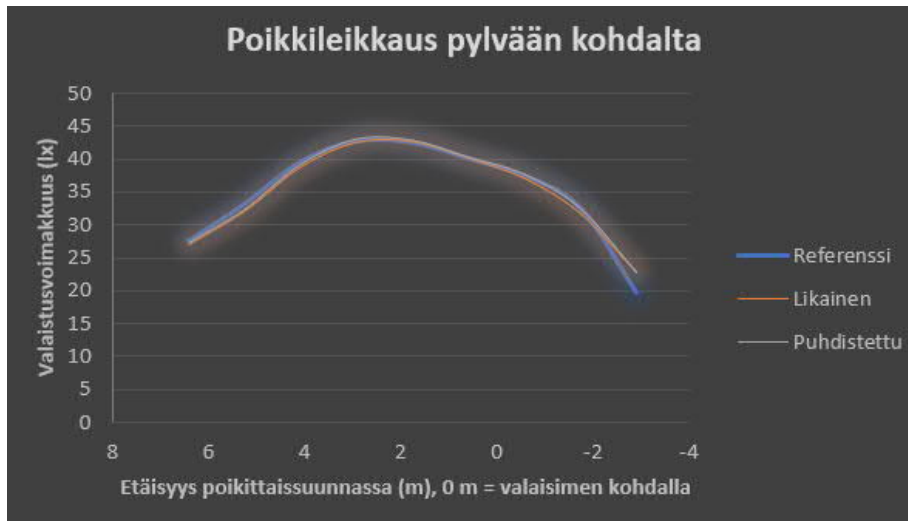
Lm [cd/m ²] ≥ 0.75	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30
✓ 1.06	✓ 0.53	✓ 0.65	✓ 10	✓ 0.76

Roadway 1 (M4)

Lm [cd/m ²] ≥ 0.75	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30
✓ 1.09	✓ 0.52	✓ 0.66	✓ 11	✓ 0.76



Illuminance values in between the column spacing and at the column, transverse direction



LiCon-AT

Carriageway 0-7 m and pedestrianway 0 - -3.5

Easy LED Pro Wave 150



	Reference results	Luminaire 3, dirty	Result	Luminaire 3, clean	Result
Input power (W)	148,9	148,4	- 0,3 %	148,4	- 0,3 %
Circuit power factor	0,973	0,962	OK	0,962	OK
Luminaire luminous flux (lm)	19 030	16 880	- 11,3 %	18 910	- 0,6 %
Luminous efficacy (lm/W)	127,8	113,8	- 11,0 %	127,4	- 0,3 %
CCT (K)	4 320	4 243	OK	4 301	OK
CRI R _a	72	71	OK	72	OK

Easy LED Pro Wave 150

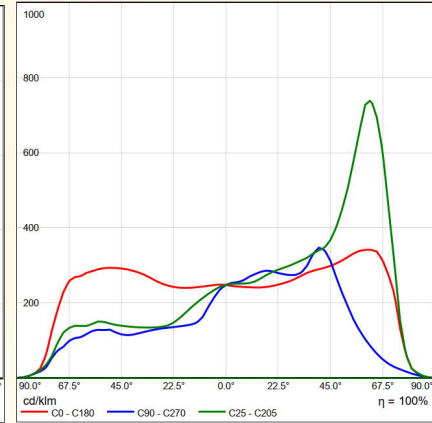
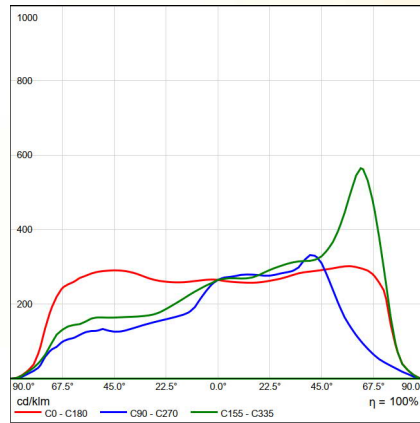
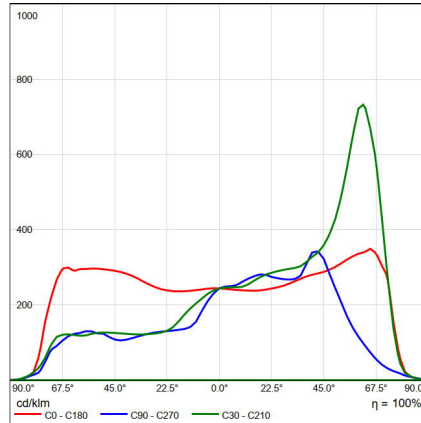
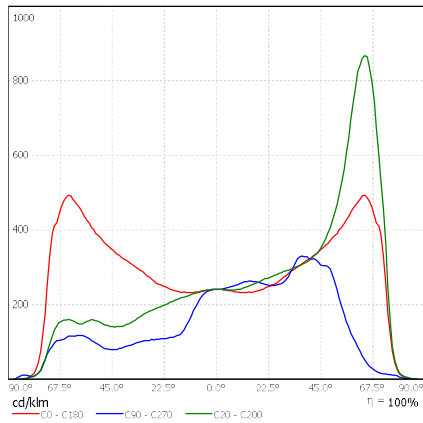


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Luminaire 3, reference

Dirty

Clean





Easy LED Pro Wave 150

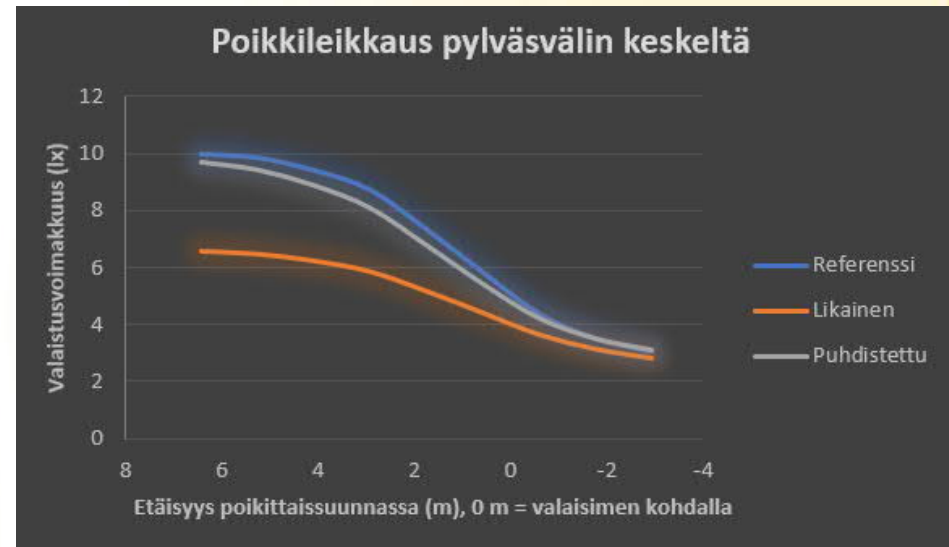
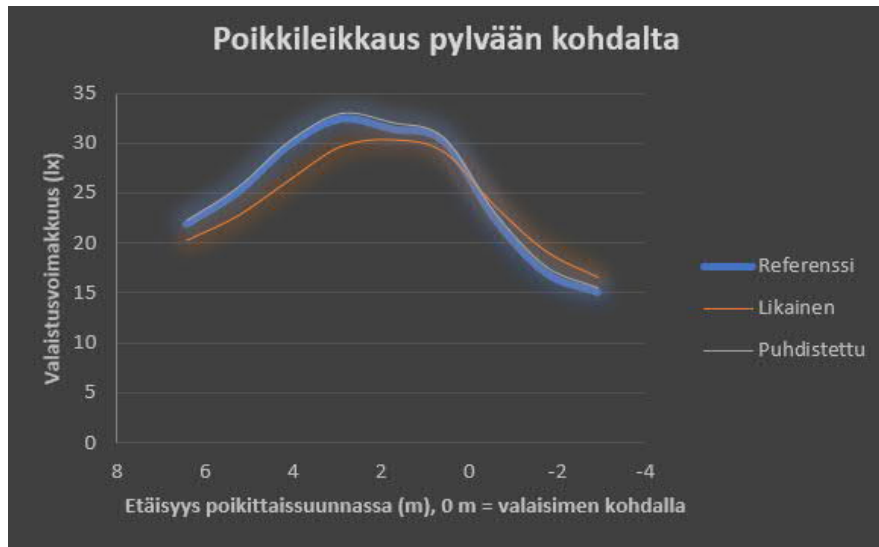


Roadway 1 (M4)				
Lm [cd/m ²] ≥ 1.00	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30
✓ 1.17	✓ 0.55	✓ 0.62	✓ 12	✓ 0.87

Roadway 1 (M4)				
Lm [cd/m ²] ≥ 0.75	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30
✓ 0.97	✓ 0.57	✓ 0.60	✓ 9	✓ 0.83

Roadway 1 (M4)				
Lm [cd/m ²] ≥ 0.75	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30
✓ 1.13	✓ 0.56	✓ 0.60	✓ 10	✓ 0.87

Illuminance values in between the column spacing and at the column, transverse direction



Carriageway 0-7 m and pedestrianway 0 - -3.5

Greenled Sirius M 110M



	Reference results	Luminaire 1, dirty	Result	Luminaire 1, clean	Result
Input power (W)	96,8	97,4	+ 0,6 %	97,2	+ 0,4 %
Circuit power factor	0,992	0,986	OK	0,986	OK
Luminaire luminous flux (lm)	11 332	10 880	- 4,0 %	11 020	- 2,8 %
Luminous efficacy (lm/W)	117,0	111,7	- 4,5 %	113,4	- 3,1 %
CCT (K)	4 070	4 032	OK	4 037	OK
CRI R _a	72	77	?	77	?

Greenled Sirius M 110M

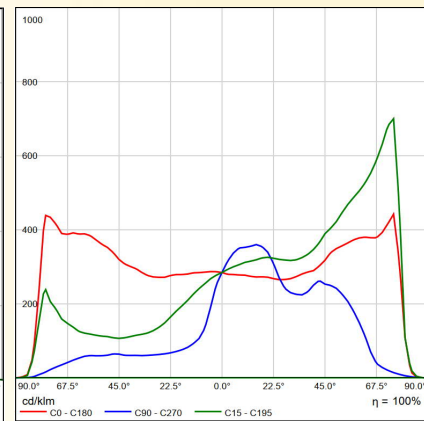
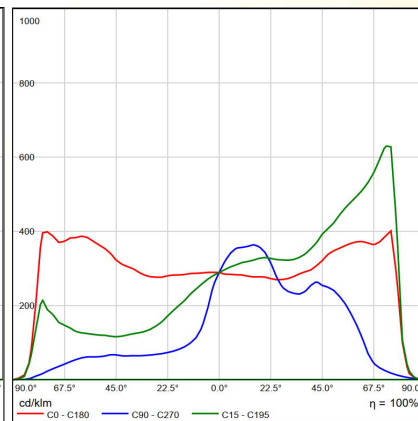
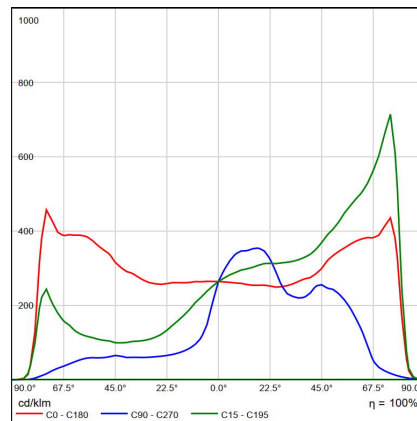
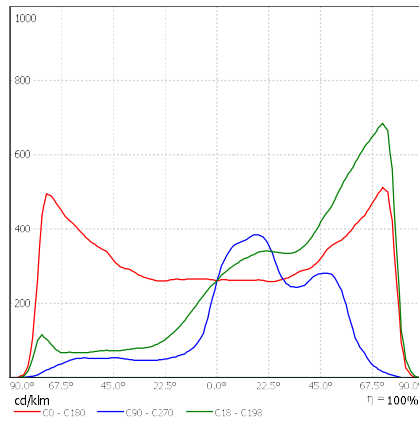


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Luminaire 1, reference

Dirty

Clean



Greenled Sirius M 110M



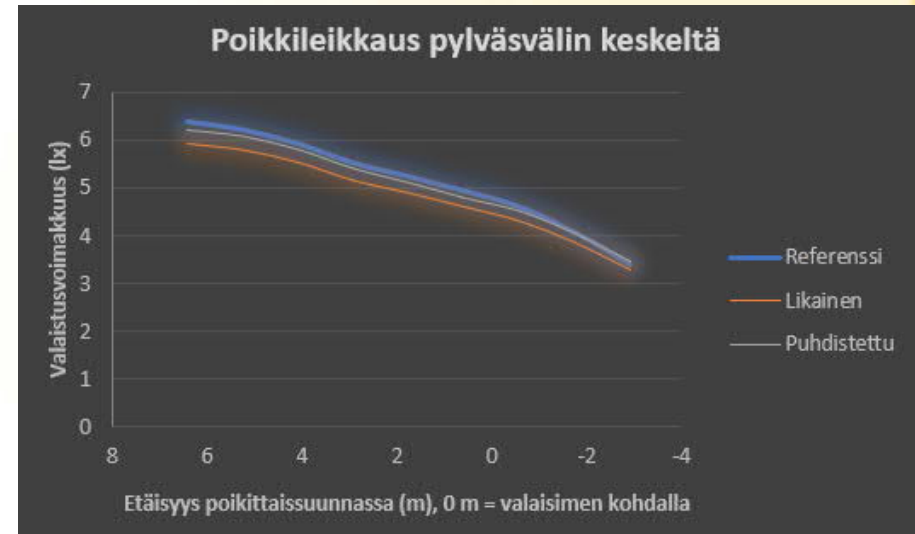
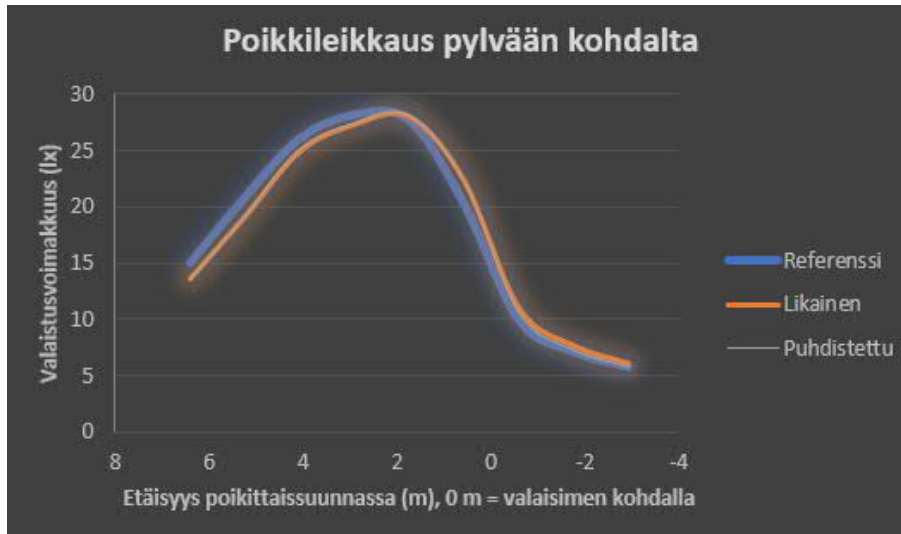
Roadway 1 (M4)				
Lm [cd/m ²] ≥ 1.00	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30
✗ 0.93	✓ 0.57	✓ 0.79	✓ 12	✓ 0.68

Roadway 1 (M4)				
Lm [cd/m ²] ≥ 0.75	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30
✓ 0.89	✓ 0.54	✓ 0.75	✓ 11	✓ 0.68

Roadway 1 (M4)				
Lm [cd/m ²] ≥ 0.75	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30
✓ 0.93	✓ 0.54	✓ 0.76	✓ 11	✓ 0.68



Illuminance values in between the column spacing and at the column, transverse direction



Philips Iridium gen3 Large



	Reference results	Luminaire 1, dirty	Result	Luminaire 1, clean	Result
Input power (W)	105,2	104,8	- 0,4 %	104,9	- 0,3 %
Circuit power factor	0,977	0,968	OK	0,968	OK
Luminaire luminous flux (lm)	15 360	13 390	- 12,8 %	14 810	- 3,6 %
Luminous efficacy (lm/W)	146,0	127,8	- 12,5 %	141,2	- 3,3 %
CCT (K)	3 949	3 915	OK	3 961	OK
CRI R _a	73	73	OK	73	OK

Philips Iridium gen3 Large

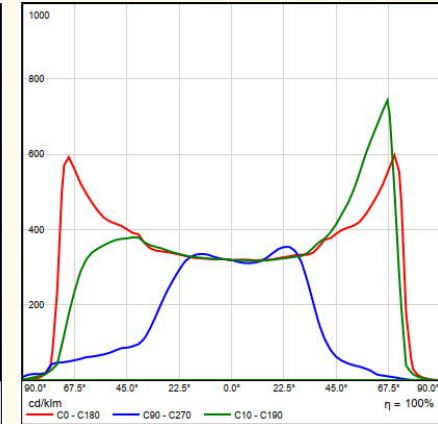
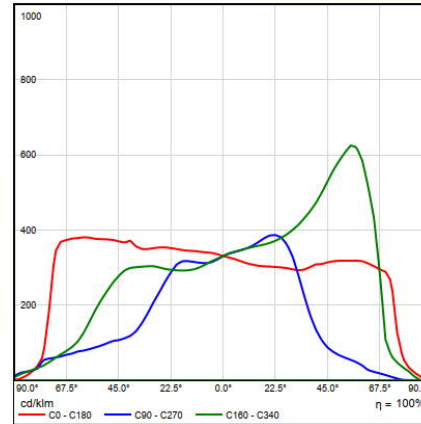
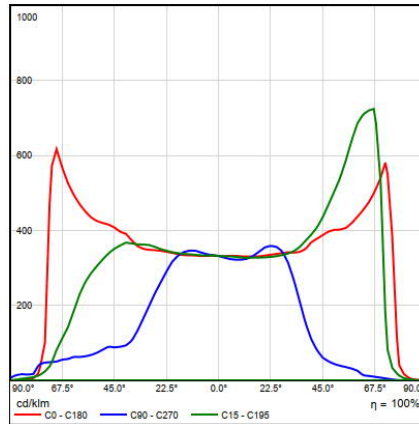
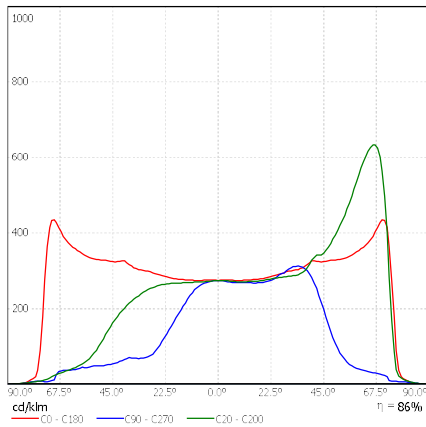


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Luminaire 1, reference

Dirty

Clean



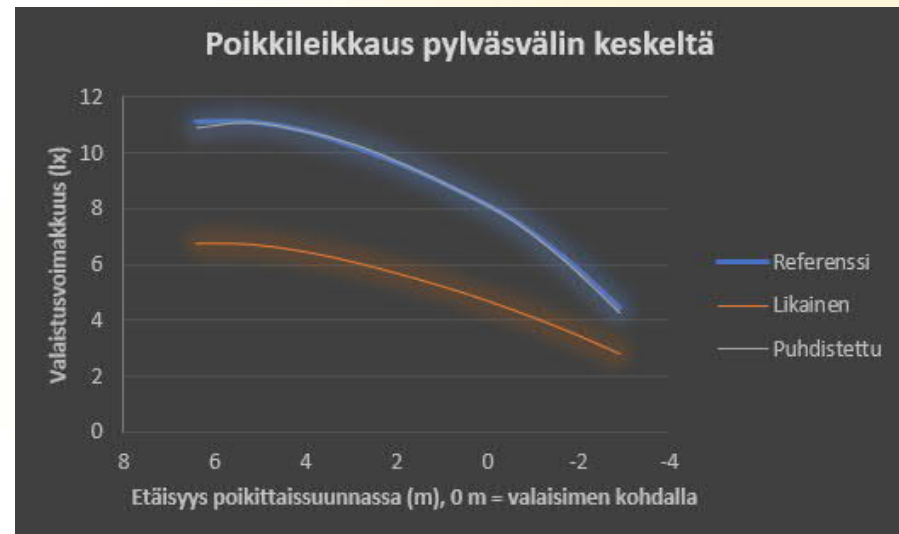
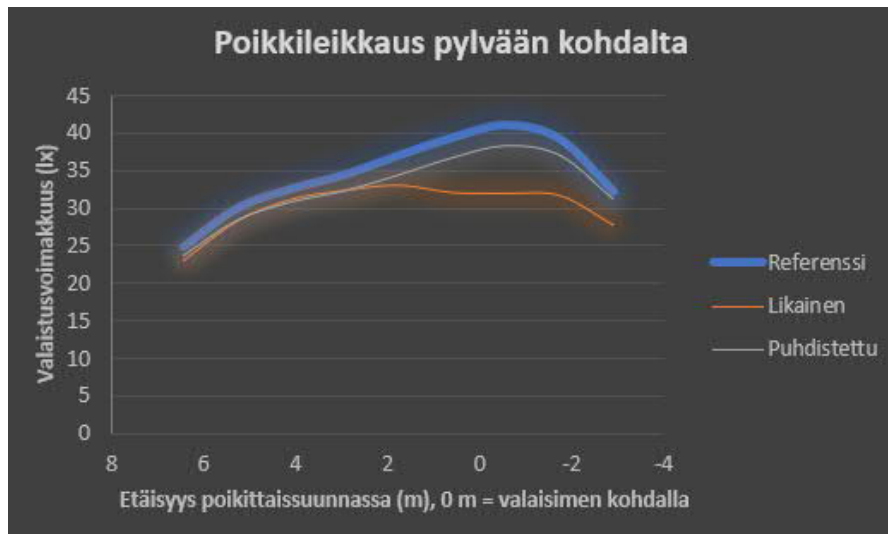
Philips Iridium gen3 Large



Roadway 1 (M4)					
Lm [cd/m ²] ≥ 1.00	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30	
✓ 1.28	✓ 0.44	✗ 0.44	✓ 15	✓ 0.47	
Roadway 1 (M4)					
Lm [cd/m ²] ≥ 0.75	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30	
✓ 0.99	✓ 0.50	✗ 0.57	✓ 11	✓ 0.46	
Roadway 1 (M4)					
Lm [cd/m ²] ≥ 0.75	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30	
✓ 1.25	✓ 0.45	✗ 0.53	✓ 15	✓ 0.47	



Illuminance values in between the column spacing and at the column, transverse direction



Carriageway 0-7 m and pedestrianway 0 - -3.5

Philips Luma 1



	Reference results	Luminaire 1, dirty	Result	Luminaire 1, clean	Result
Input power (W)	112,6	112,7	+ 0,1 %	112,7	+ 0,1 %
Circuit power factor	0,979	0,972	OK	0,972	OK
Luminaire luminous flux (lm)	15 000	14 190	- 5,4 %	14 770	- 1,5 %
Luminous efficacy (lm/W)	133,2	125,9	- 5,5 %	131,1	- 1,6 %
CCT (K)	4 141	4 161	OK	4 179	OK
CRI R _a	72	72	OK	72	OK

Philips Luma 1

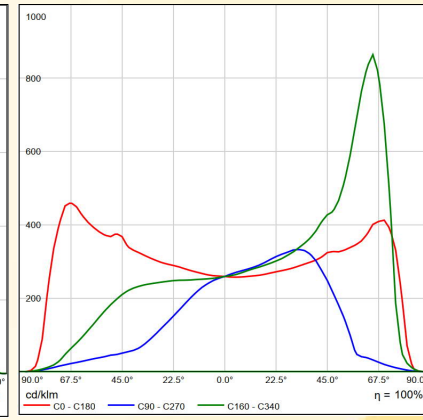
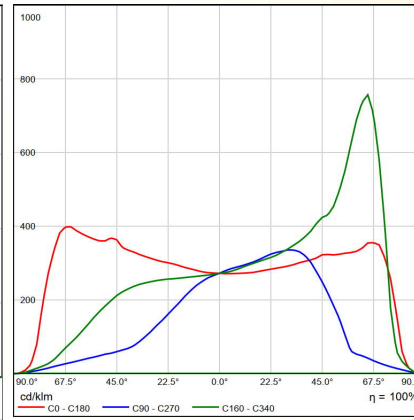
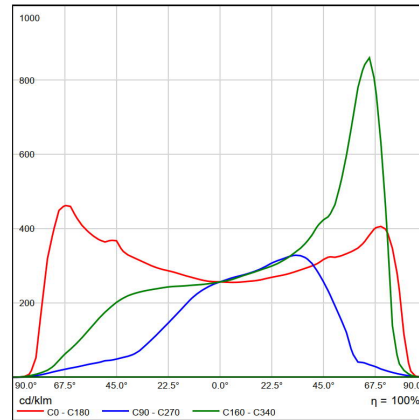
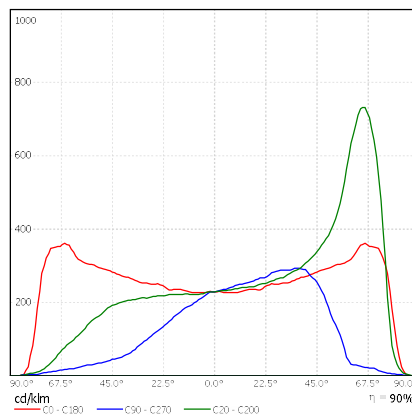


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Luminaire 1, reference

Dirty

Clean



Philips Luma 1



Roadway 1 (M4)

Lm [cd/m ²] ≥ 1.00	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30
✓ 1.18	✓ 0.60	✓ 0.70	✓ 12	✓ 0.89

Roadway 1 (M4)

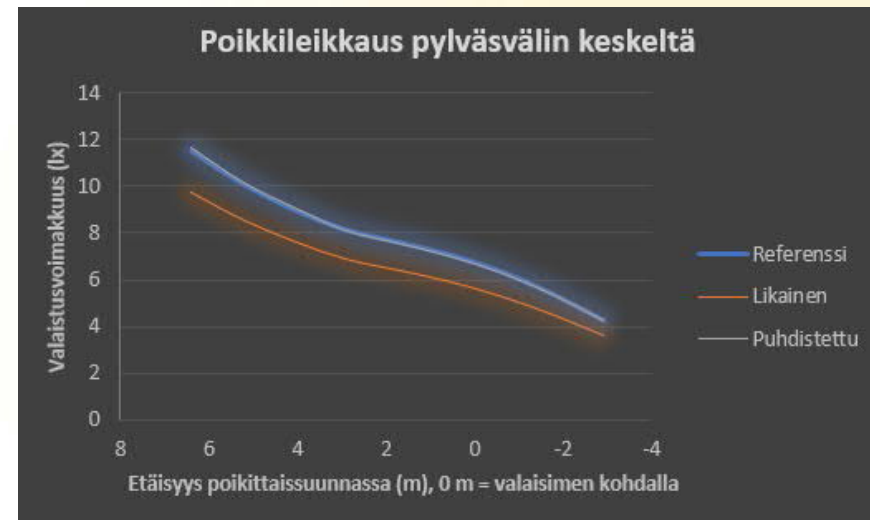
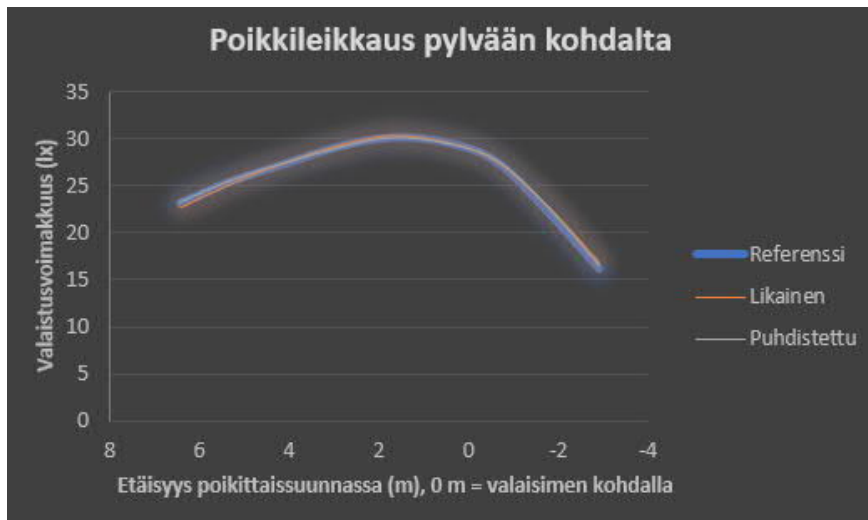
Lm [cd/m ²] ≥ 0.75	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30
✓ 1.06	✓ 0.62	✓ 0.69	✓ 11	✓ 0.84

Roadway 1 (M4)

Lm [cd/m ²] ≥ 0.75	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30
✓ 1.19	✓ 0.62	✓ 0.72	✓ 12	✓ 0.86

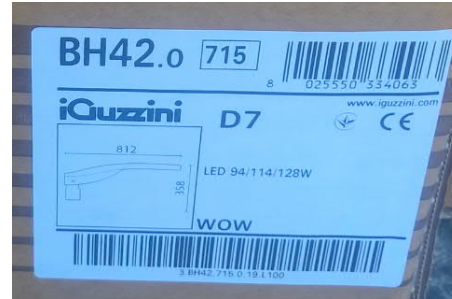


Illuminance values in between the column spacing and at the column, transverse direction



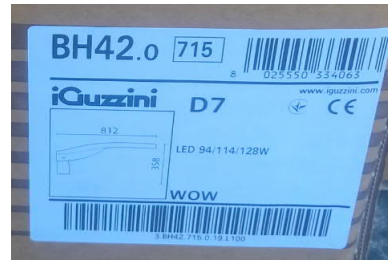
Carriageway 0-7 m and pedestrianway 0 - -3.5

iGuzzini Wow BH42



	Reference results	Luminaire 1, dirty	Result	Luminaire 1, clean	Result
Input power (W)	120,8	120,1	- 0,6 %	120,2	- 0,5 %
Circuit power factor	0,994	0,991	OK	0,992	OK
Luminaire luminous flux (lm)	14 660	13 900	- 5,2 %	14 150	- 3,5 %
Luminous efficacy (lm/W)	121,4	115,7	- 4,7 %	117,7	- 3,0 %
CCT (K)	3 941	3 966	OK	3 982	OK
CRI R _a	73	73	OK	73	OK

iGuzzini Wow BH42

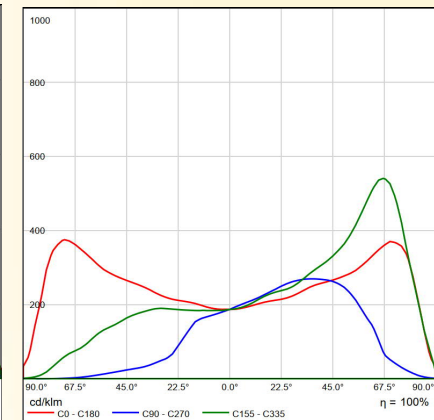
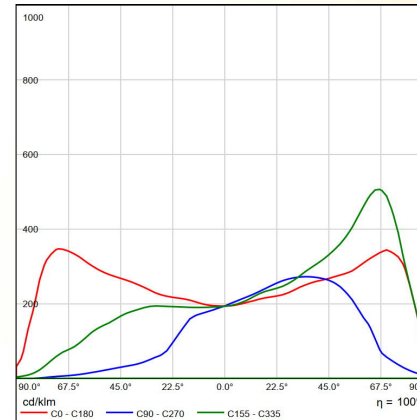
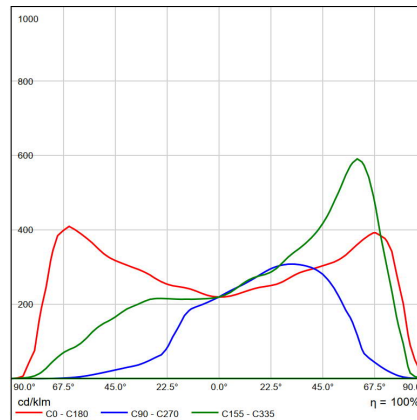
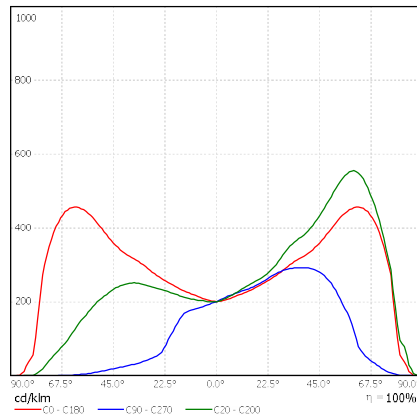


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Luminaire 1, reference

Dirty

Clean



iGuzzini Wow BH42



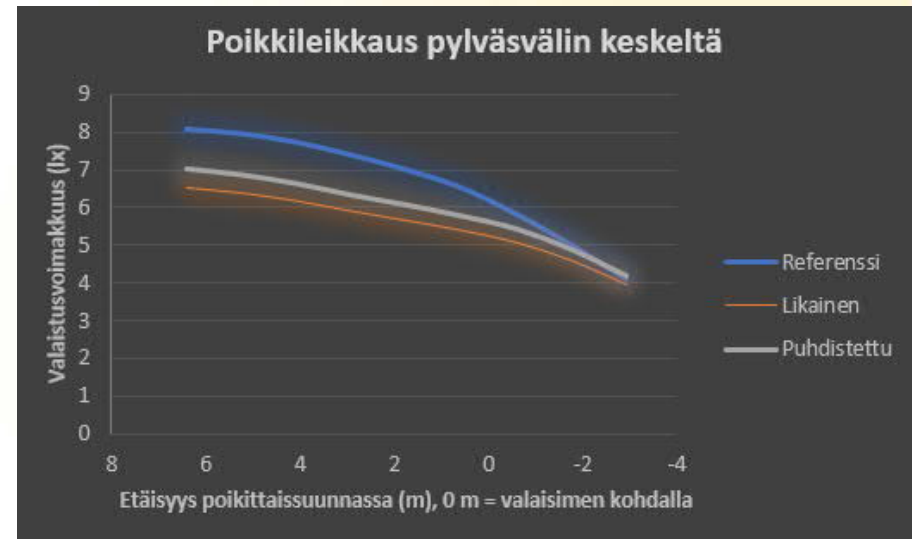
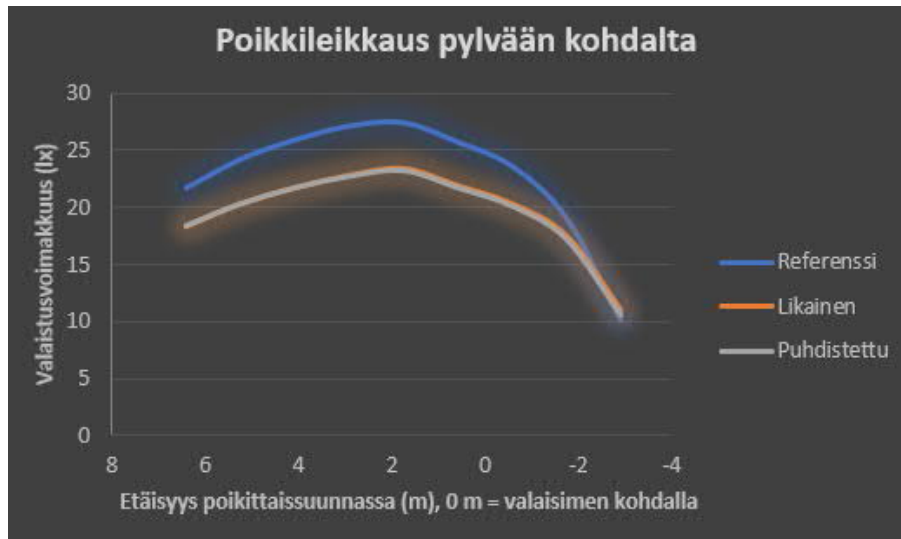
Roadway 1 (M4)					
Lm [cd/m²] ≥ 1.00	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30	
✓ 1.05	✓ 0.54	✓ 0.66	✓ 12	✓ 0.79	

Roadway 1 (M4)					
Lm [cd/m²] ≥ 0.75	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30	
✓ 1.01	✓ 0.52	✓ 0.78	✗ 22	✓ 0.81	

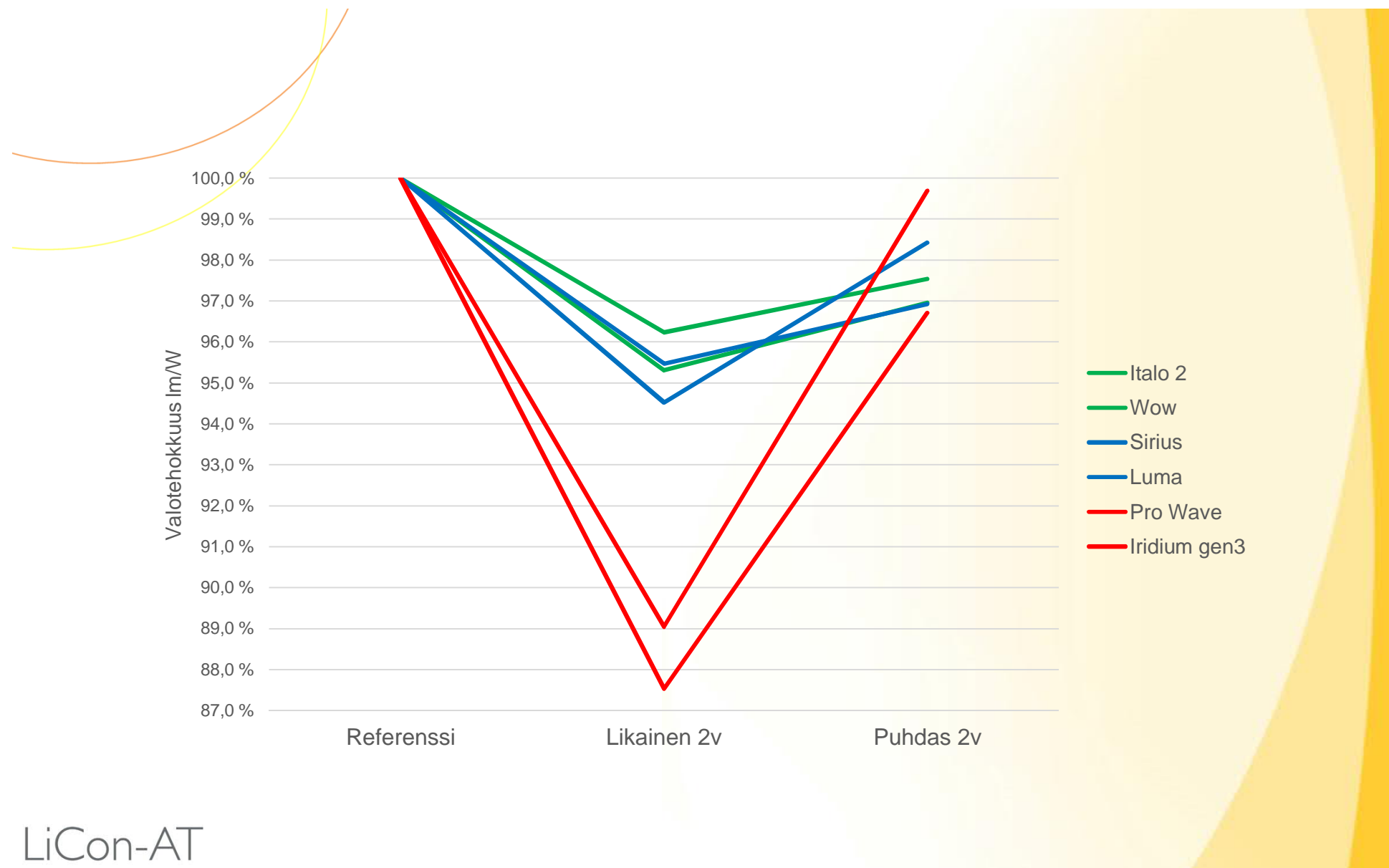
Roadway 1 (M4)					
Lm [cd/m²] ≥ 0.75	Uo ≥ 0.40	UI ≥ 0.60	TI [%] ≤ 15	EIR ≥ 0.30	
✓ 1.07	✓ 0.53	✓ 0.80	✗ 23	✓ 0.82	



Illuminance values in between the column spacing and at the column, transverse direction



Carriageway 0-7 m and pedestrianway 0 - -3.5



LiCon-AT

Summary 2019

- After 2 years the luminaire maintenance factor of luminaires with flat glass is **0,979**
- After 2 years the luminaire maintenance factor of luminaires with flat glass lens modules is **0,899**
- There was no significant difference between luminaires with reflectors and flat glass compared to luminaires with lenses and flat glass
- After 2 years the luminous flux factor of luminaires is **0,977**
- After 2 years the maintenance factor of luminaires with flat glass is **0,956**
- After 2 years the luminaire maintenance factor of luminaires with flat glass lens modules is **0,883**
- Average luminance and threshold increment values decrease when the luminaire becomes dirty

