

Park illumination of Hofgarten using DIALux Evo

Ebru Avci

6th of January, 2019

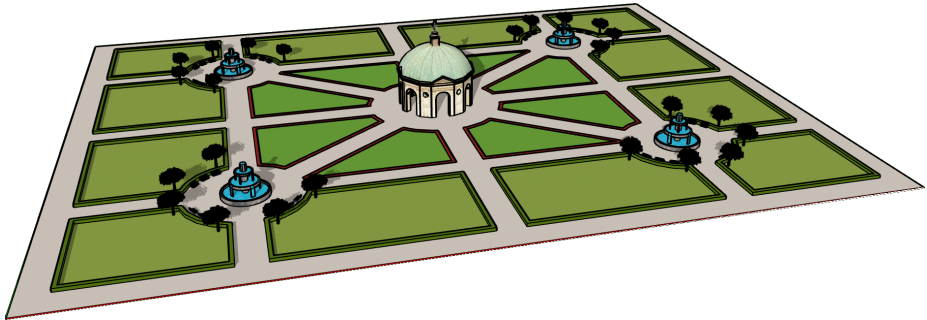
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- Design in DIALux
- DIALux model calculation results
- Annual energy consumption of the park

CAD model of the park

Sketchup 3D model of the Hofgarten

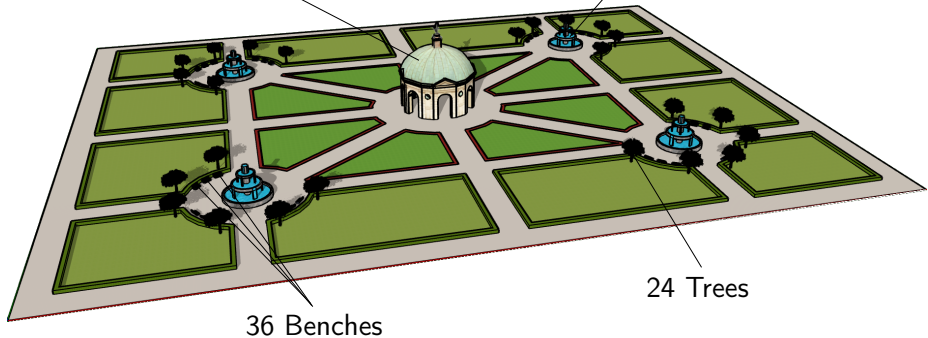


CAD model of the park

Sketchup 3D model of the Hofgarten

1 Monument (Dianatempel)

4 Fountains

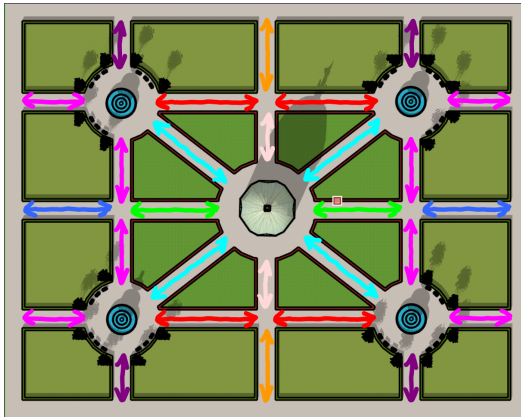


24 Trees

36 Benches

CAD model of the park

Path measurements of the Hofgarten



Path length:

12.29m

14.33m

17.29m

20.00m

24.33m

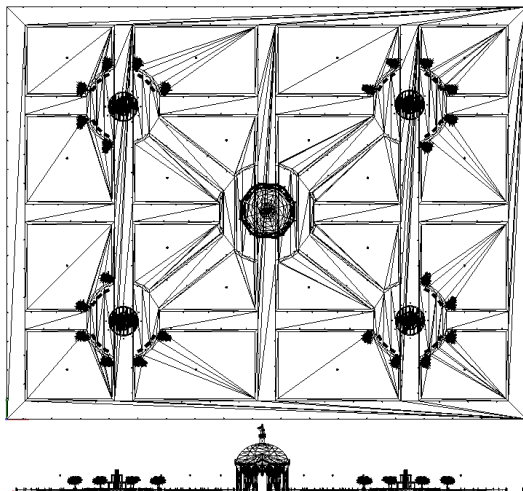
25.00m

26.43m

27.29m

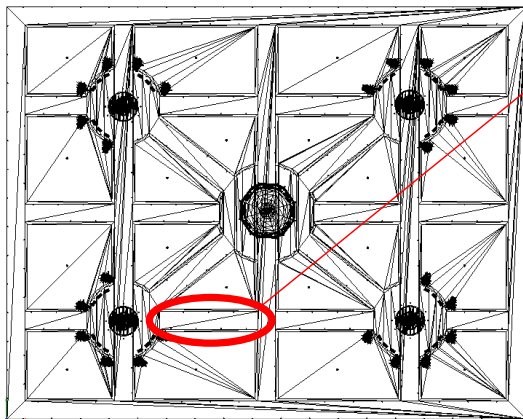
Design in DIALux

Overview of the entire park design



Design in DIALux

Overview of the entire park design

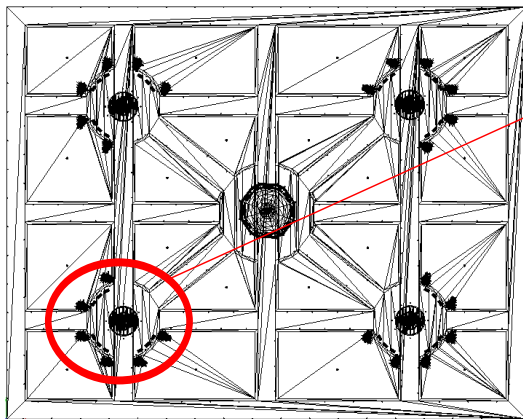


● Path illumination design



Design in DIALux

Overview of the entire park design

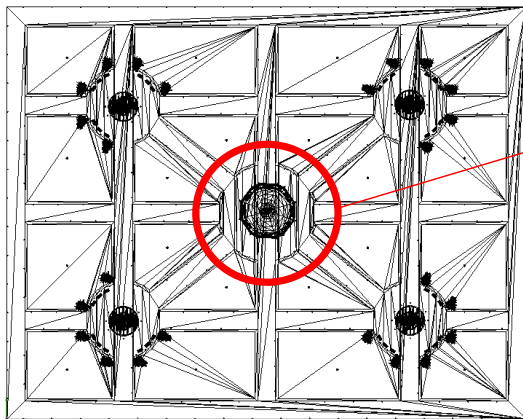


- Path illumination design
- Fountain area design



Design in DIALux

Overview of the entire park design

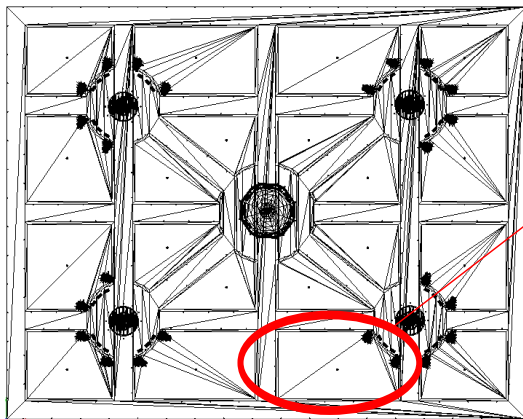


- Path illumination design
- Fountain area design
- Monument area design



Design in DIALux

Overview of the entire park design



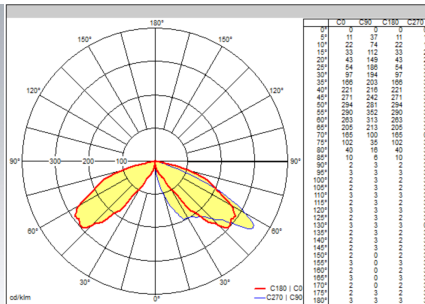
- Path illumination design
- Fountain area design
- Monument area design
- Center grass area design



Design in DIALux

Path illumination design

Choosing the path lamps (Thorn: URBA BOLLARD 4L105 740 CL1):



Key specifications (Data sheet):

$$P_i = 16W$$

$$\Phi_i = 826lm$$

$$h = 0.9m \text{ (Installation height)}$$



Design in DIALux

Path illumination design

Depreciation and Utilization factor (D.F. and U.F.):

Design in DIALux

Path illumination design

Depreciation and Utilization factor (D.F. and U.F.):

- The D.F. can assumed to be 80% for average cleaned lighting.

Design in DIALux

Path illumination design

Depreciation and Utilization factor (D.F. and U.F.):

- The D.F. can assumed to be 80% for average cleaned lighting.
- The U.F. can be gotten from the table below. For outdoor lighting and a room index of 4.44 (for an orange path, see p.4), we get 91%.

REFLECTANCE											
Ceiling	0.8	0.8	0.8	0.7	0.7	0.7	0.5	0.5	0.5	0	
Walls	0.7	0.5	0.3	0.7	0.5	0.3	0.7	0.5	0.3	0	
Working plane	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0	
ROOM INDEX	UTILIZATION FACTORS (PERCENT) $k(RI) \times BCR = 5$										
$k = 0.60$	69	60	54	69	60	54	68	59	54	49	
0.80	79	70	64	78	70	64	77	69	64	58	
1.00	87	79	73	86	78	73	84	79	72	67	
1.25	93	85	80	92	85	80	90	83	79	73	
1.50	97	90	85	96	89	85	93	88	83	77	
2.00	102	96	92	101	95	91	98	93	89	83	
2.50	105	100	95	103	98	94	100	96	92	85	
3.00	108	103	99	106	101	98	102	98	95	88	
4.00	110	106	103	108	105	102	104	101	99	91	
5.00	112	108	106	110	107	104	106	103	101	92	
ROOM INDEX	UF (total)										Direct
According to DIN EN 13032-2 2004											
Suspended											
SHRNM = 1.25											

Design in DIALux

Path illumination design

Number of lamps N at an area for an average illuminance of $\bar{E}=30\text{lx}$:



Design in DIALux

Path illumination design

Number of lamps N at an area for an average illuminance of $\bar{E}=30\text{lx}$:



Number of lamps by the “lumen method”
(exemplary for a path of $20\text{m} \times 5\text{m}$):

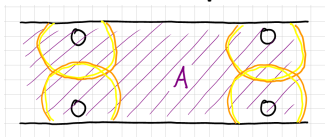
$$N = \frac{\bar{E} \cdot A}{\text{D.F.} \cdot \text{U.F.} \cdot \Phi_i} = \frac{30 \text{ lx} \cdot 100 \text{ m}^2}{0.8 \cdot 0.91 \cdot 826 \text{ lm}} = 4.99$$

$$\Rightarrow N = 5$$

Design in DIALux

Path illumination design

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$$\Rightarrow N = 5$$

Odd number of lamps (here: $N = 5$)
enables a staggered arrangement:

$$\bar{E} = \frac{N \cdot \text{D.F.} \cdot \text{U.F.} \cdot \Phi_i}{A} = \frac{5 \cdot 0.8 \cdot 0.91 \cdot 826 \text{ lm}}{100 \text{ m}^2} = 30.1 \text{ lx}$$

Design in DIALux

Path illumination design

Number of lamps N at an area for an average illuminance of $\bar{E}=30\text{lx}$:



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Number of lamps for the
different path categories:

$$12.29\text{m} \rightarrow N = 3$$

$$14.33\text{m} \rightarrow N = 3$$

$$17.29\text{m} \rightarrow N = 5$$

$$20.00\text{m} \rightarrow N = 5$$

$$24.33\text{m} \rightarrow N = 7$$

$$25.00\text{m} \rightarrow N = 7$$

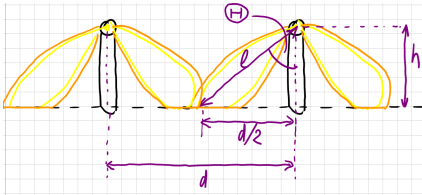
$$26.43\text{m} \rightarrow N = 7$$

$$27.29\text{m} \rightarrow N = 7$$

Design in DIALux

Path illumination design

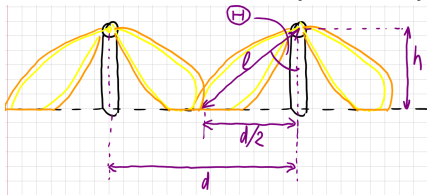
Distance d inbetween path lamps (here: 2 lamps considered):



Design in DIALux

Path illumination design

Distance d inbetween path lamps (here: 2 lamps considered):



Distance by “lambert’s cosine law” and the “inverse square law of illumination”:

$$l = \frac{h}{\cos(\Theta)} \quad ; \quad d = 2 \cdot h \cdot \tan(\Theta)$$

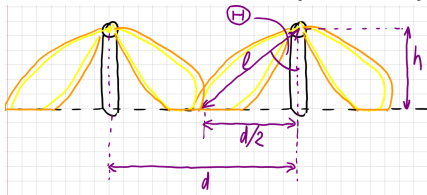
$$E_i = \frac{I_i}{l^2} = \frac{I_i}{h^2} \cdot \cos^2(\Theta)$$

$$E_1(\Theta) = E_2(90^\circ - \Theta)$$

Design in DIALux

Path illumination design

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$$E_i = \frac{I_i}{l^2} = \frac{I_i}{h^2} \cdot \cos^2(\Theta)$$

$$E_1(\Theta) = E_2(90^\circ - \Theta)$$

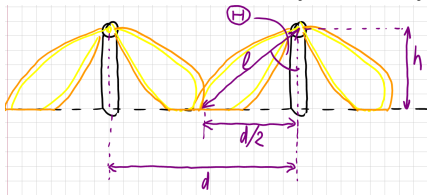
Θ [°]	I_i [cd/klm]	E_1 [lx]	E_2 [lx]	ΣE [lx]	d [m]
0	0	0	0	0	0
5	11	11	0	11	0.16
10	22	22	1	23	0.32
15	33	31	7	38	0.48
20	43	39	20	59	0.66
25	54	45	37	82	0.84
30	97	74	67	141	1.04
35	166	114	97	211	1.26
40	221	132	124	256	1.51
45	271	138	138	276	1.80
50	294	124	132	256	2.15
55	290	97	114	211	2.57
60	263	67	74	141	3.12
65	205	37	45	82	3.86
70	165	20	39	59	4.95
75	102	7	31	38	6.72
80	40	1	22	23	10.21
85	10	0	11	11	20.57
90	2	0	0	0	—

Luminous flux I_i gained from the Table on p.6

Design in DIALux

Path illumination design

Distance d inbetween path lamps (here: 2 lamps considered):



Distance by “lambert’s cosine law” and the “inverse square law of illumination”:

$$l = \frac{h}{\cos(\Theta)} \quad ; \quad d = 2 \cdot h \cdot \tan(\Theta)$$

$$E_i = \frac{I_i}{l^2} = \frac{I_i}{h^2} \cdot \cos^2(\Theta)$$

$$E_1(\Theta) = E_2(90^\circ - \Theta)$$

Distance chosen to be $d = 7m$

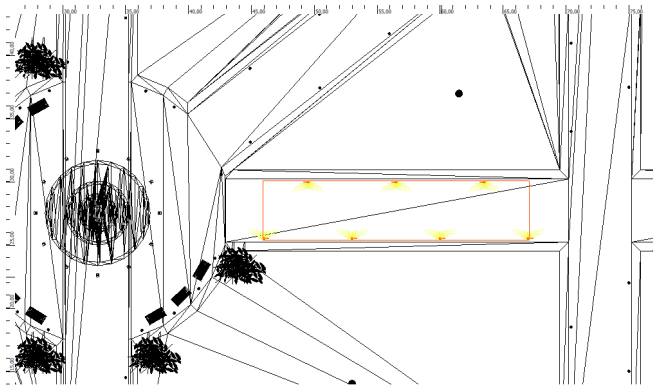
Θ [°]	I_i [cd/klm]	E_1 [lx]	E_2 [lx]	ΣE [lx]	d [m]
0	0	0	0	0	0
5	11	11	0	11	0.16
10	22	22	1	23	0.32
15	33	31	7	38	0.48
20	43	39	20	59	0.66
25	54	45	37	82	0.84
30	97	74	67	141	1.04
35	166	114	97	211	1.26
40	221	132	124	256	1.51
45	271	138	138	276	1.80
50	294	124	132	256	2.15
55	290	97	114	211	2.57
60	263	67	74	141	3.12
65	205	37	45	82	3.86
70	165	20	39	59	4.95
75	102	7	31	38	6.72
80	40	1	22	23	10.21
85	10	0	11	11	20.57
90	2	0	0	0	—

Luminous flux I_i gained from the Table on p.6

Design in DIALux

Path illumination design

Path illumination applying a staggered arrangement:

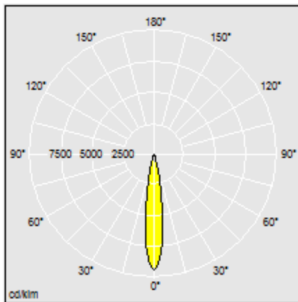


Exemplary design for a path of $27.29\text{m} \times 5\text{m}$.

Design in DIALux

Fountain area design

Choosing the ornamental lamps (Thorn: QBA LED 8L100 830):



Key specifications (Data sheet):

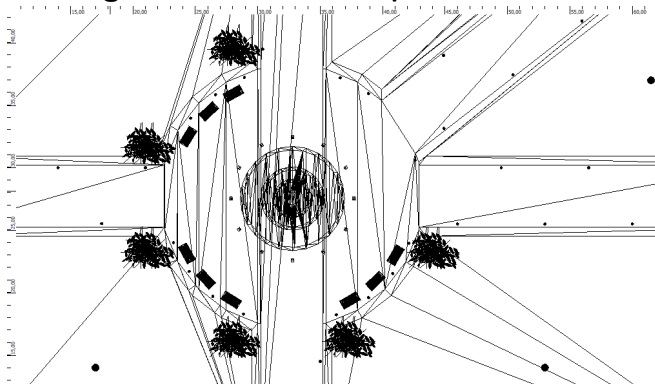
$$P_i = 28W$$

$$\Phi_i = 1802lm$$

Design in DIALux

Fountain area design

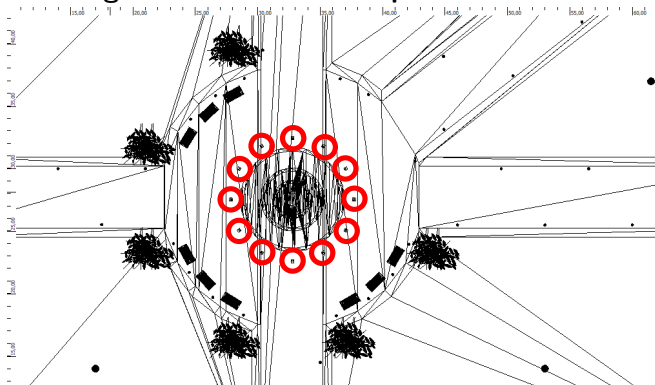
Choosing the ornamental lamps:



Design in DIALux

Fountain area design

Choosing the ornamental lamps:

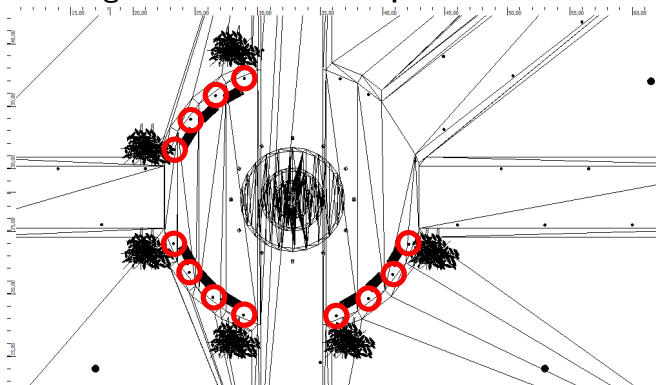


- Ornamental illumination of the fountains

Design in DIALux

Fountain area design

Choosing the ornamental lamps:

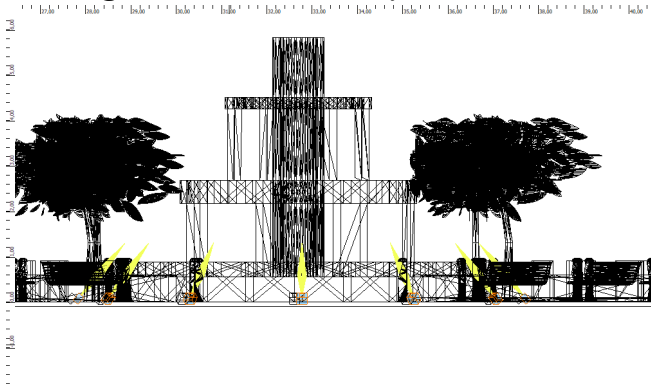


- Ornamental illumination of the fountains
- Illumination of the areas around the benches

Design in DIALux

Fountain area design

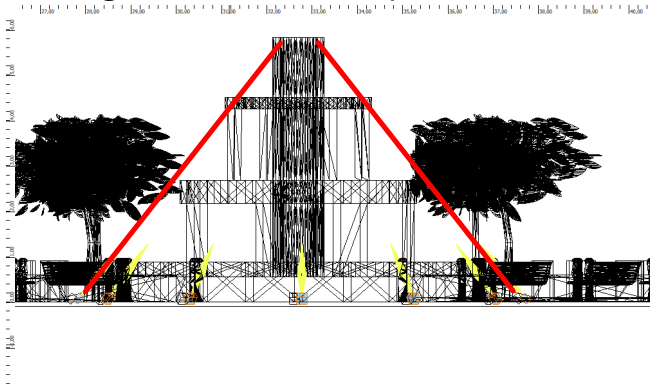
Choosing the ornamental lamps:



Design in DIALux

Fountain area design

Choosing the ornamental lamps:

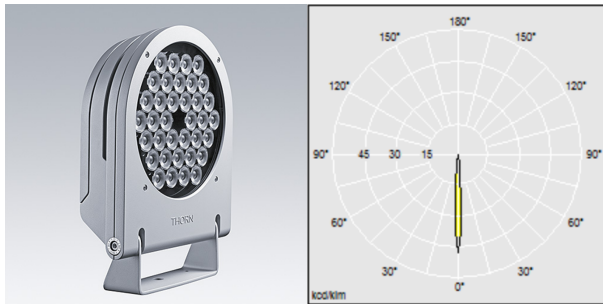


- Radiation angle chosen to illuminate every fountain layer without causing glare

Design in DIALux

Monument area design

Choosing the ornamental lamps (Thorn: CONT2 L 36L105 757 R/S 8°):



Key specifications (Data sheet):

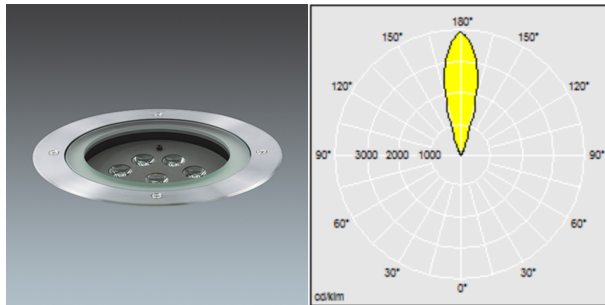
$$P_i = 119W$$

$$\Phi_i = 11674lm$$

Design in DIALux

Monument area design

Choosing the ornamental lamps (Thorn: EFACT R2 9L90 ACC 28D 840 RS SF):



Key specifications (Data sheet):

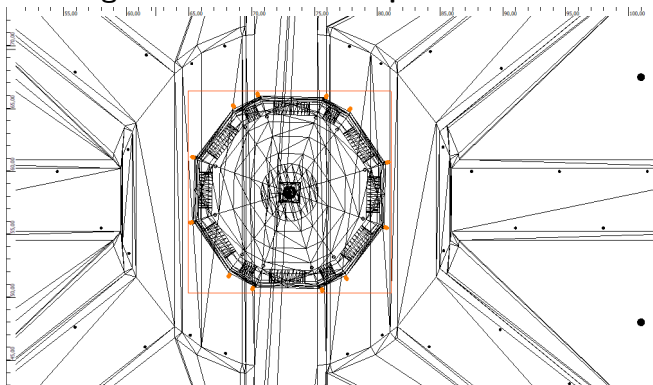
$$P_i = 27.3W$$

$$\Phi_i = 1630lm$$

Design in DIALux

Monument area design

Choosing the ornamental lamps:

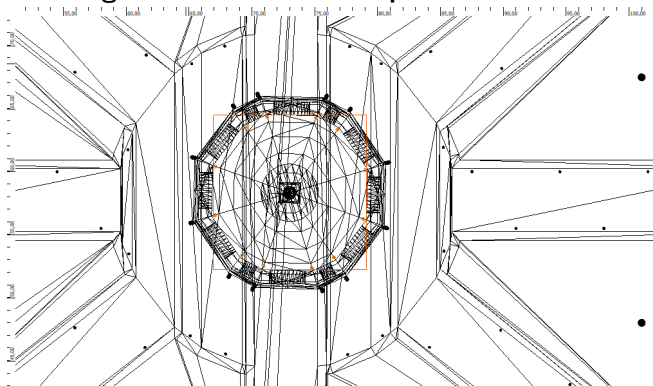


- External ornamental illumination of the monument (Dianatempel)

Design in DIALux

Monument area design

Choosing the ornamental lamps:

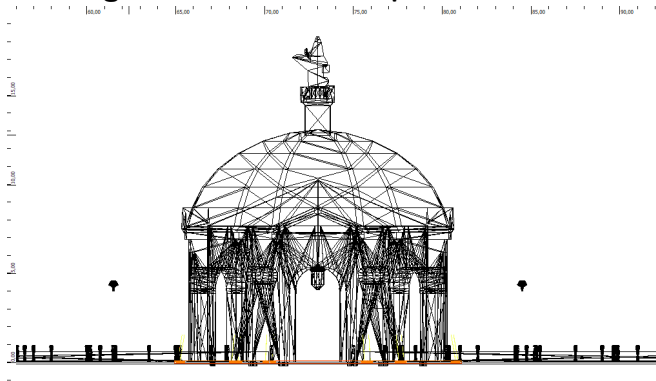


- External ornamental illumination of the monument (Dianatempel)
- Internal ornamental illumination of the monument (Dianatempel)

Design in DIALux

Monument area design

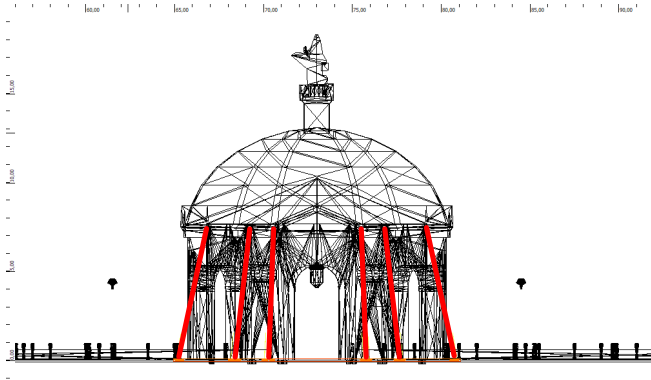
Choosing the ornamental lamps:



Design in DIALux

Monument area design

Choosing the ornamental lamps:

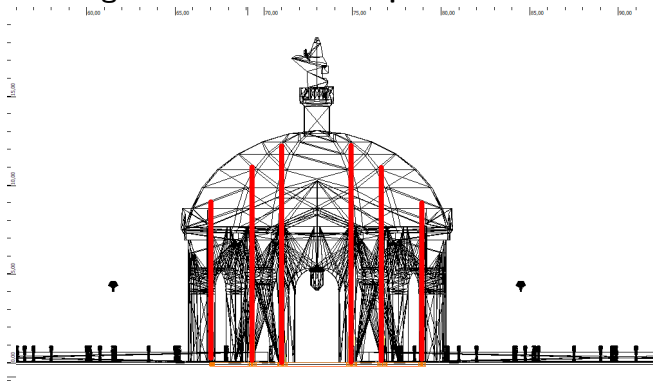


- External illumination chosen to obtain optimal visibility of the monument

Design in DIALux

Monument area design

Choosing the ornamental lamps:

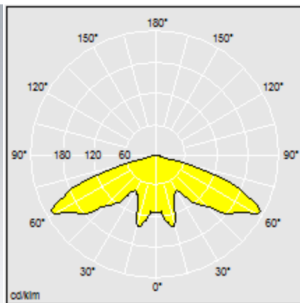


- External illumination chosen to obtain optimal visibility of the monument
- Homogeneous interior illumination of the monument

Design in DIALux

Center grass area design

Choosing the ornamental lamps
(Thorn: PLURIO OR 100W HIT 240V PM CL1 ECL D76/L):



Key specifications (Data sheet):

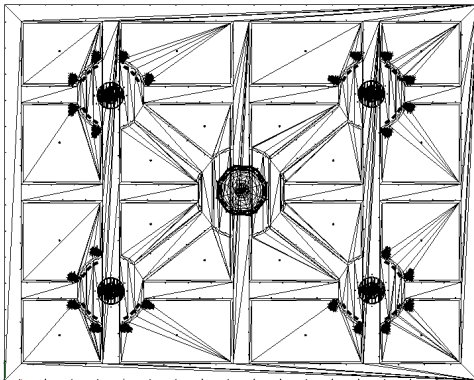
$$P_i = 117W$$

$$\Phi_i = 6301lm$$

Design in DIALux

Center grass area design

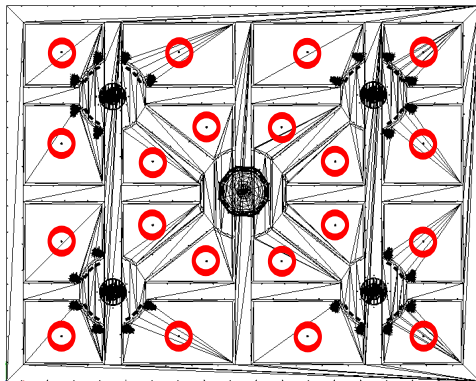
Choosing the ornamental lamps:



Design in DIALux

Center grass area design

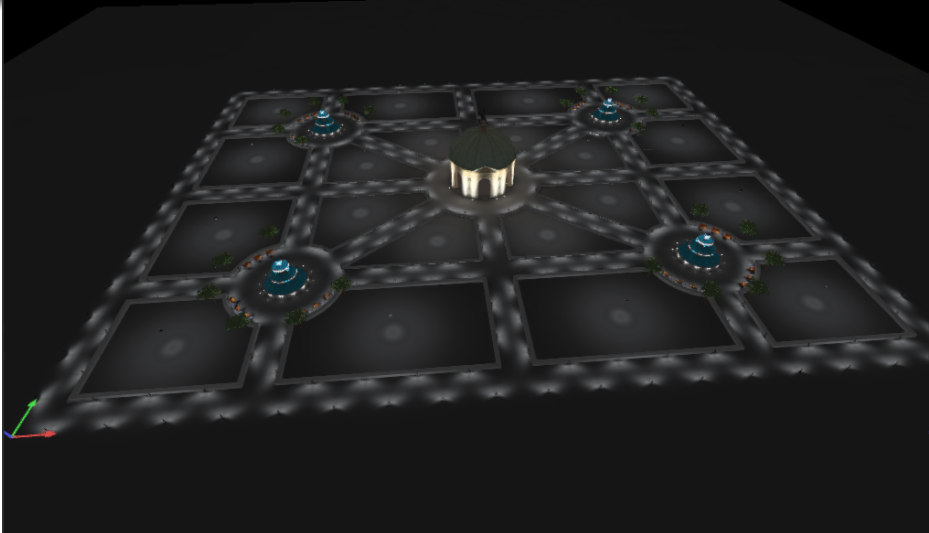
Choosing the ornamental lamps:



- Additional illumination for the grass areas chosen to increase the sense of security

DIALux model calculation results

Overview of the entire park



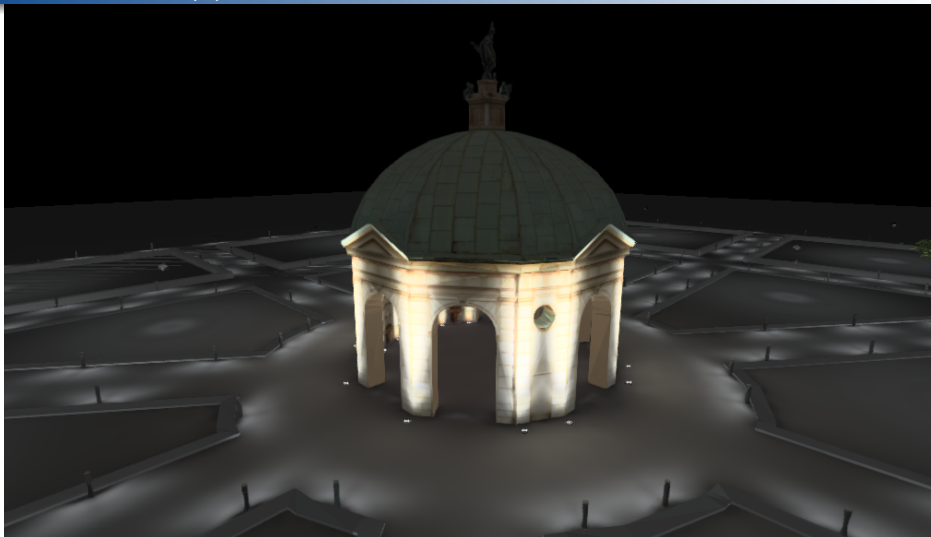
DIALux model calculation results

Fountain area



DIALux model calculation results

Monument area (A)



DIALux model calculation results

Monument area (B)





Annual energy consumption of the park

Assuming a permanent operation of the illuminants at obscureness:

Annual energy consumption of the park

Assuming a permanent operation of the illuminants at obscureness:

Location: Munich

adh = 4383h (annual daylight hours)

ah = $365d \times 24h/d = 8760h$ (annual hours)

aoh: annual obscureness hours

Annual energy consumption of the park

Assuming a permanent operation of the illuminants at obscureness:

Location: Munich

adh = 4383h (annual daylight hours)

ah = $365\text{d} \times 24\text{h/d} = 8760\text{h}$ (annual hours)

aoh: annual obscureness hours

Total power consumption:

$$\sum P = 336 \cdot 16\text{ W} + 48 \cdot 28\text{ W} \\ + 12 \cdot (119\text{ W} + 27.3\text{ W}) + 20 \cdot 117\text{ W} = 10.82\text{ kW}$$

Annual energy consumption of the park

Assuming a permanent operation of the illuminants at obscureness:

Location: Munich

adh = 4383h (annual daylight hours)

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aoh: annual obscureness hours

Total power consumption:

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Annual energy consumption:

$$W_{anh} = \sum P \cdot aoh = \sum P \cdot (ah - adh) \\ = 10.82 \text{ kW} \cdot (8\,760 \text{ h} - 4\,383 \text{ h}) \\ = 47\,340 \text{ kWh}$$

End

Further details can be obtained from the DIALux file!