Optimization of Atrium Skylight Baffles

14th International Radiance Workshop August 2015

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pjCarew Consulting

passive + low energy design

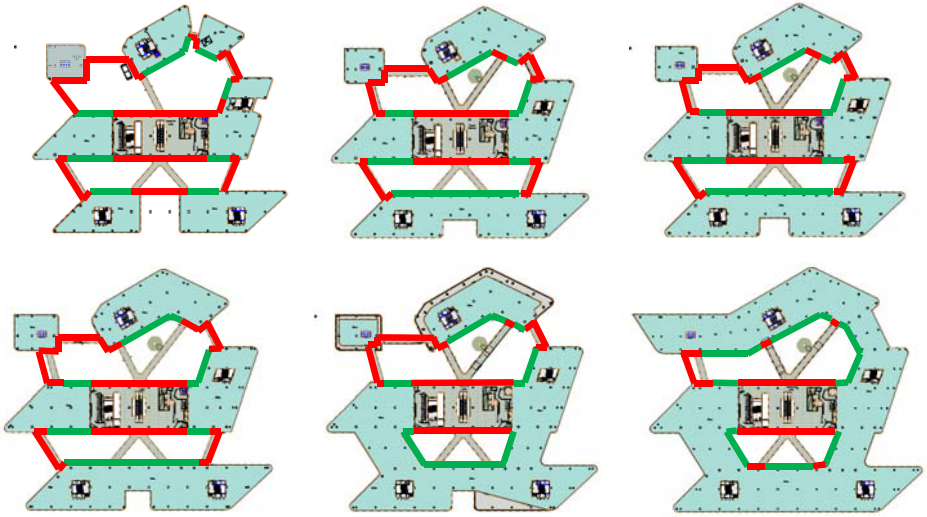
CONTEXT

Office Design - Atria
Process Overview
Shading Design
HVAC Peak Capacity
Daylight conditions
Result

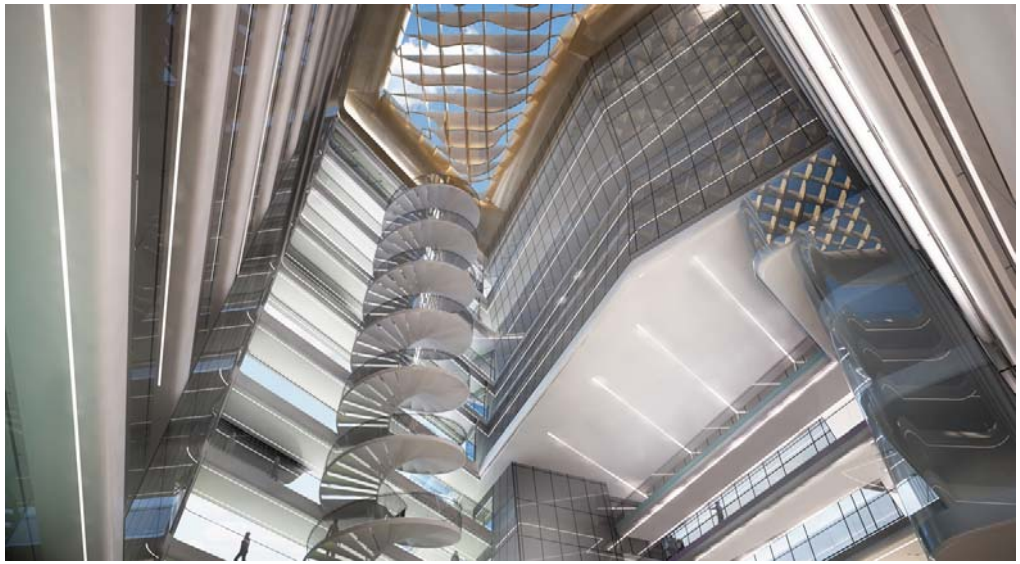
DESIGN OFFICE ATRIA

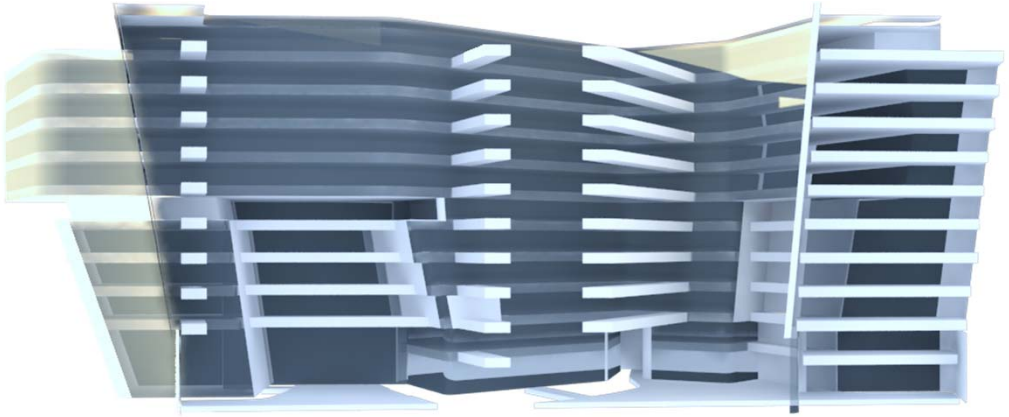
Office building

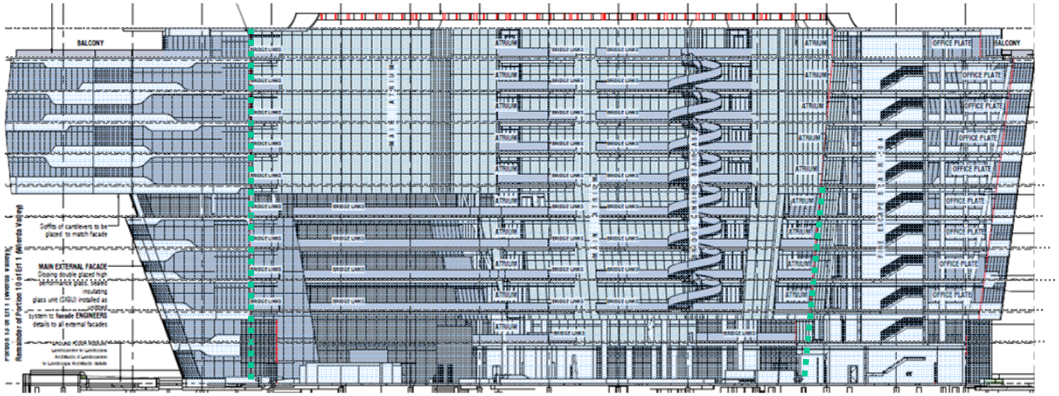
- 67,000m2
- 11 floors
- 2 atria
- >17m floor depths
- temperate climate 1,700m altitude
- Johannesburg, South Africa



ATRIA







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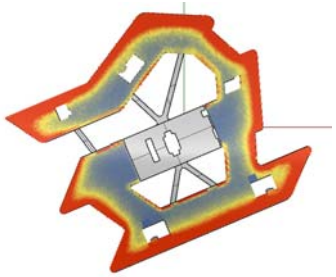
Design

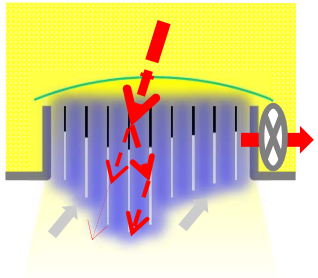
- Complement building design
- No blinds in atrium

Daylighting

- Glare
- “Useful” Daylight



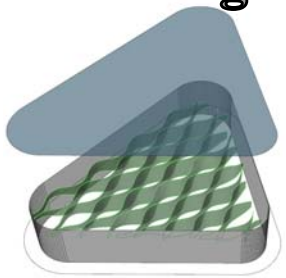
HVAC Peak capacities



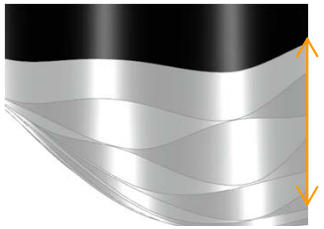
PROCESS OVERVIEW

PROCESS OVERVIEW

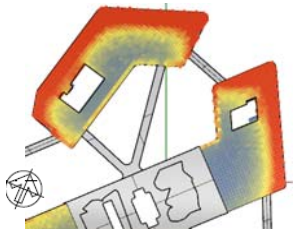
Glazing



Shading geometry (glare)



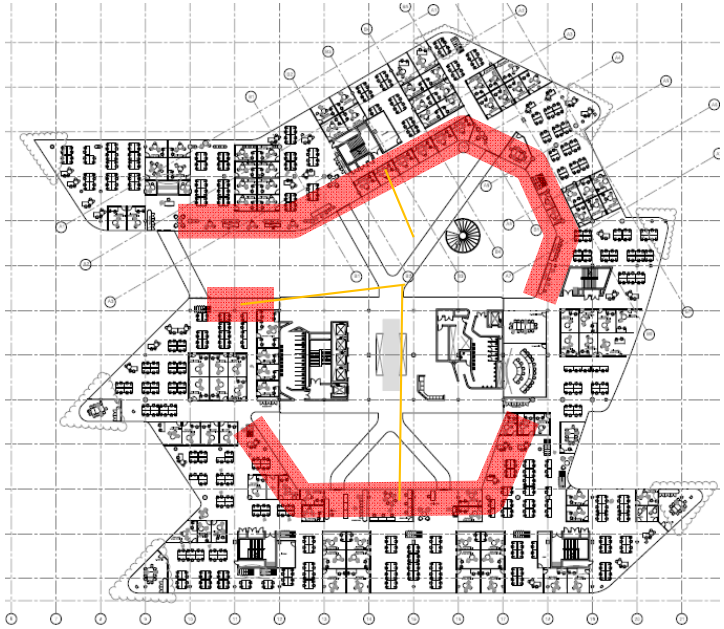
Optimize for heat (HVAC peak capacities)

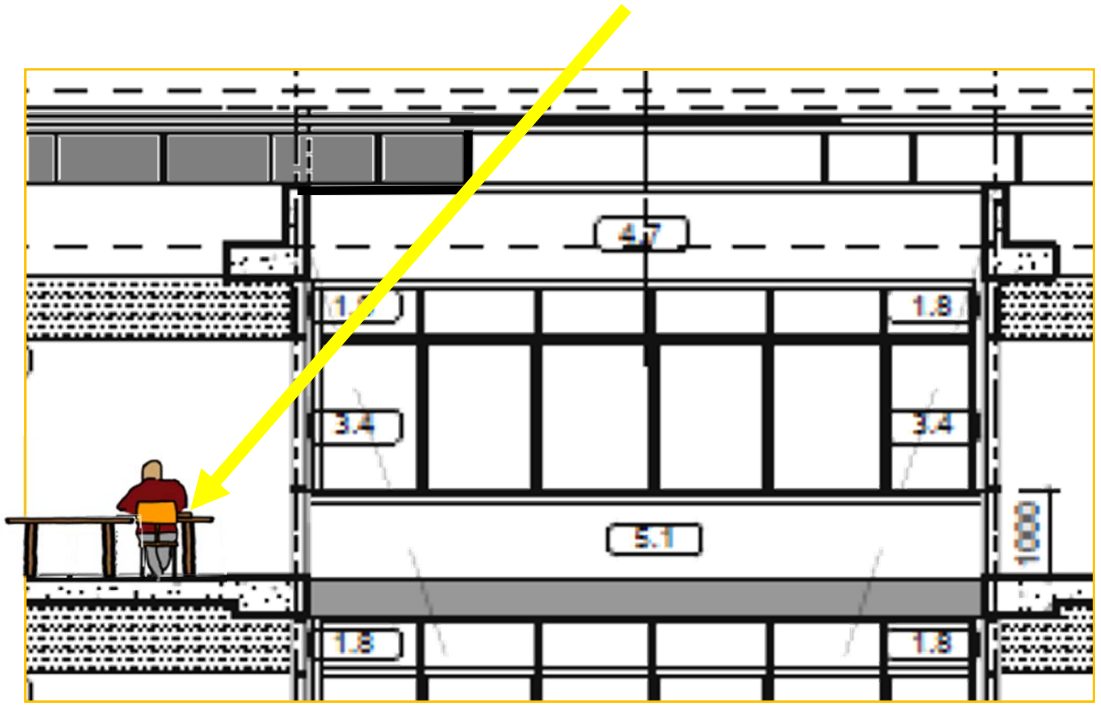


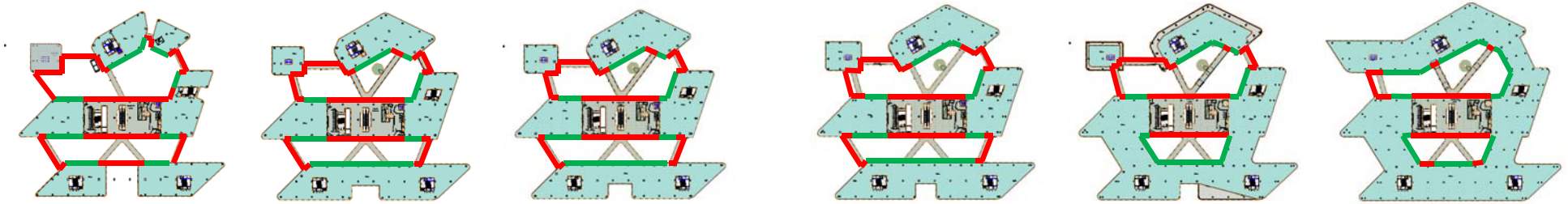
Daylight conditions (UDI)

SHADING DESIGN

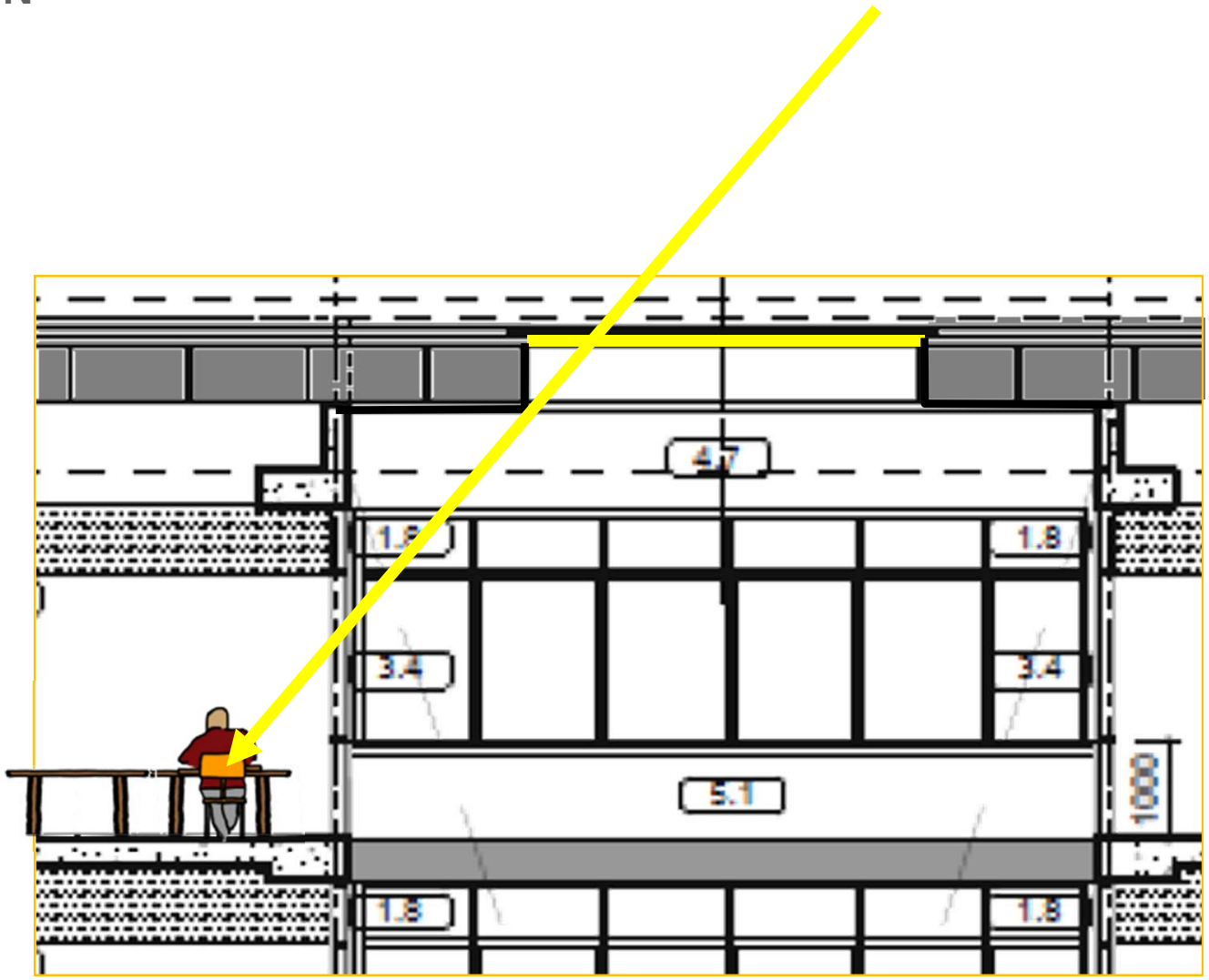
DAYLIGHT CONDITIONS







SHADING DESIGN



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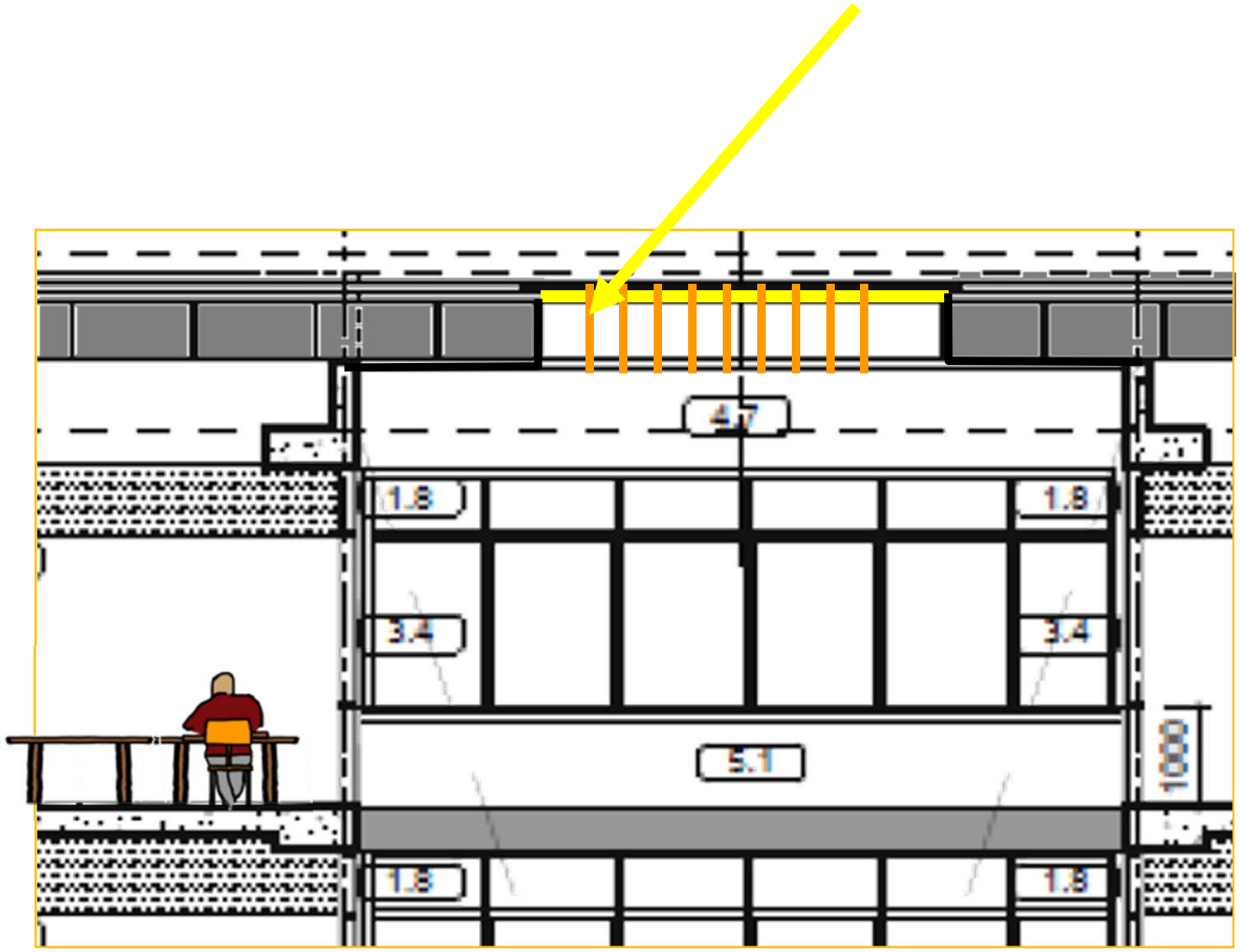
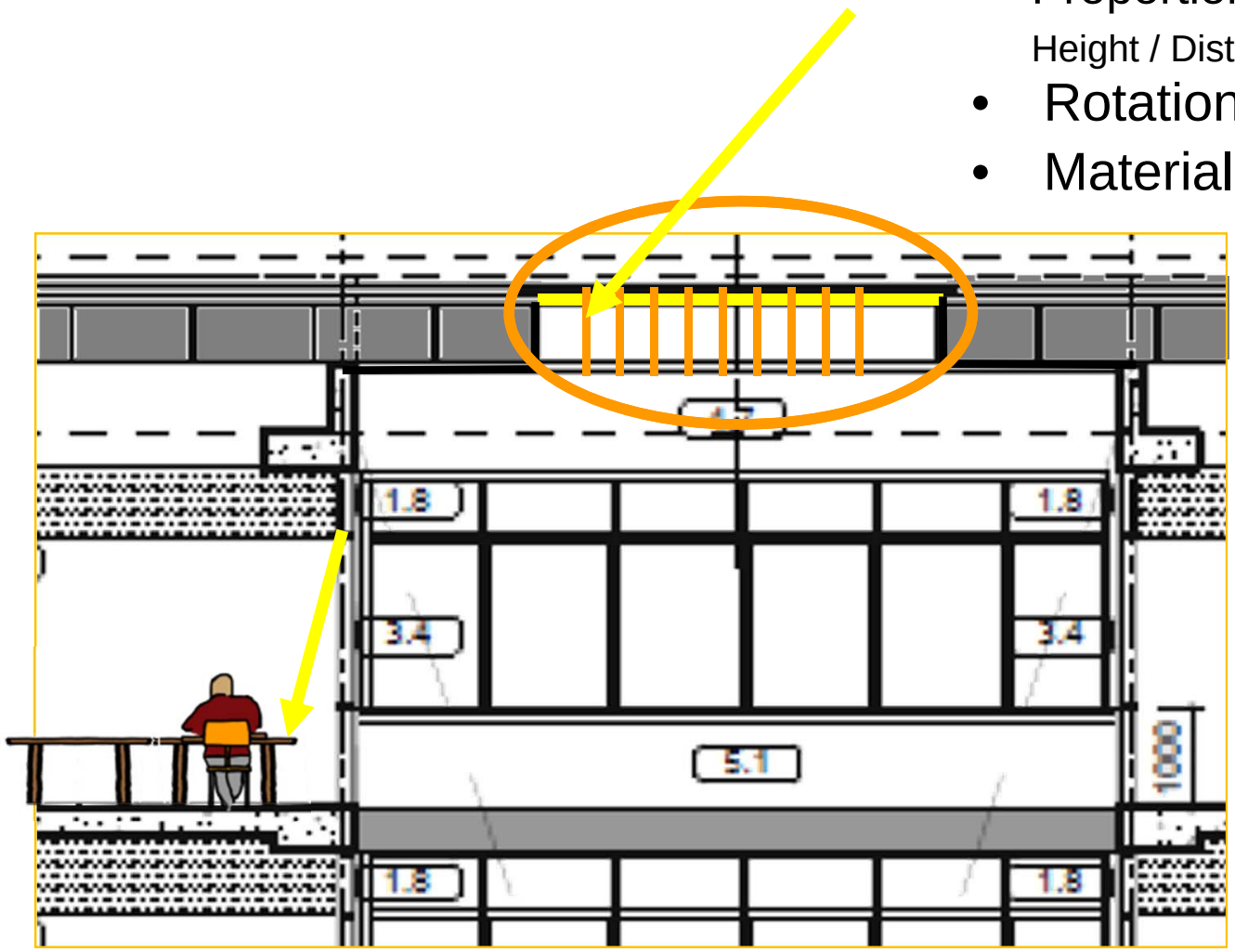


SHADING DESIGN

- Proportion
  Height / Distance
- Rotation (z-axis)
- Material



Rhino

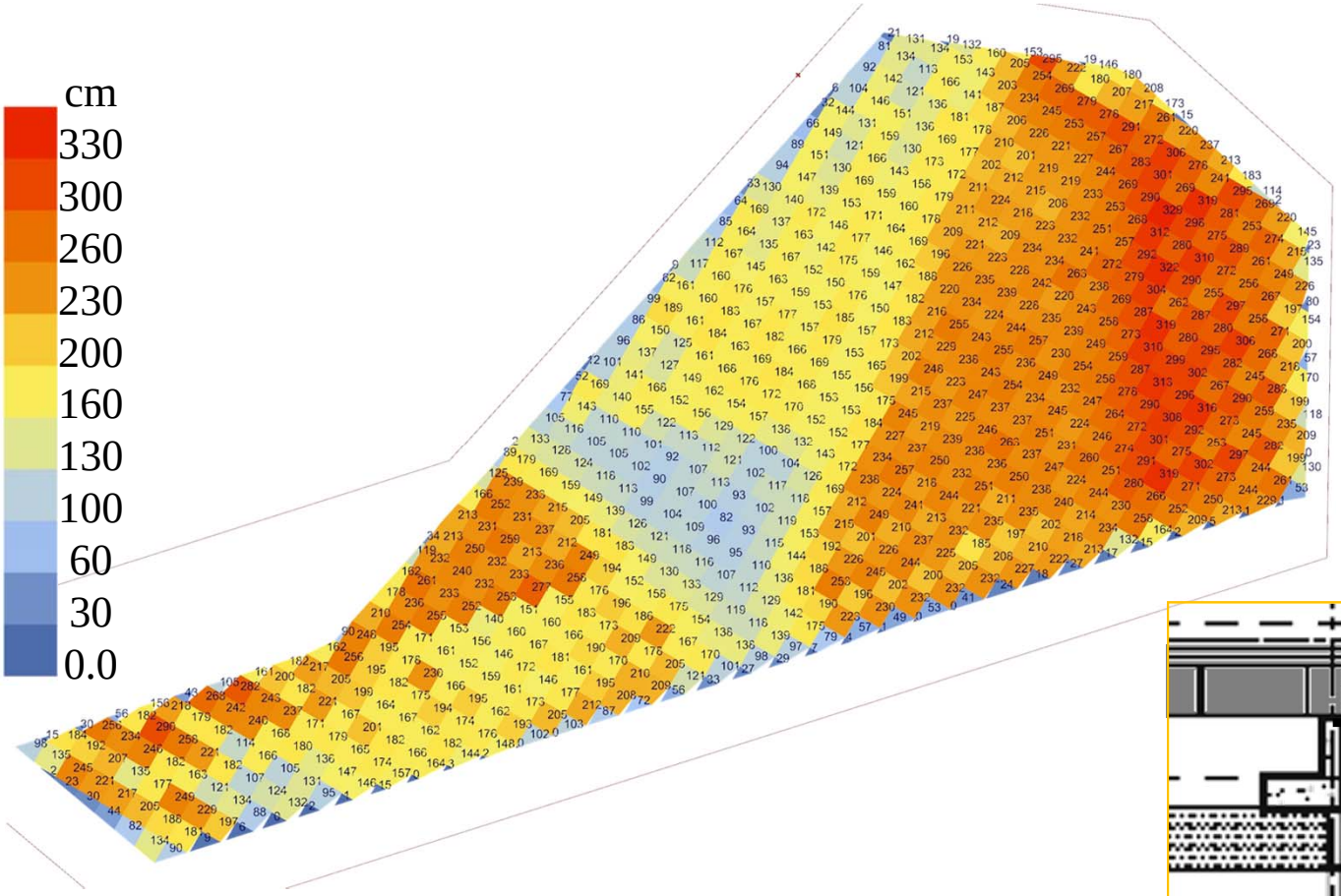
Grasshopper

DIVA

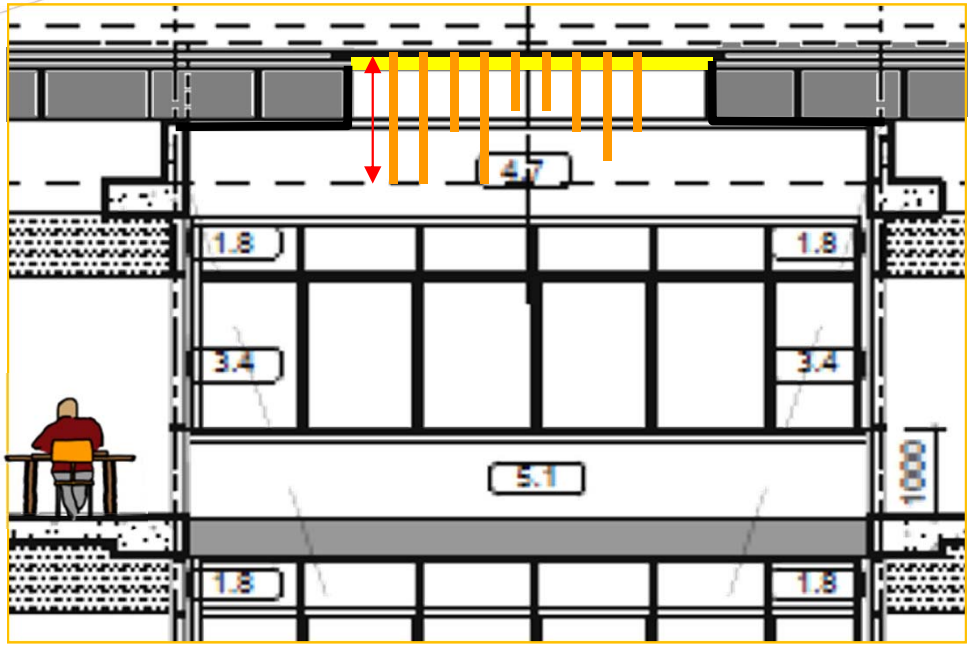
Ladybug

Honeybee

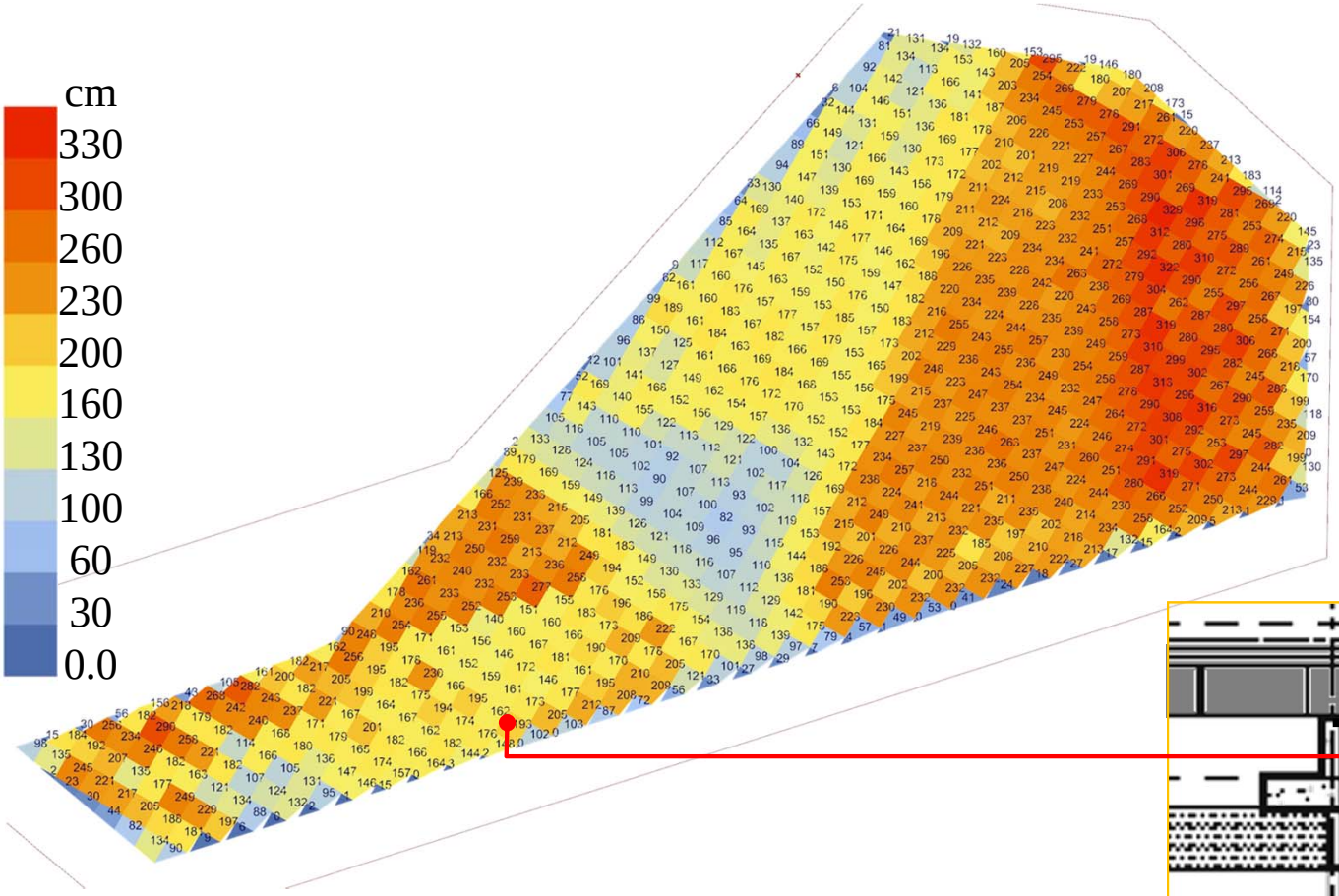
SHADING DESIGN – PROPORTION



This diagram shows the analysis of a grid with one meter by one meter. It shows the height on each point that is needed to avoid glare.



SHADING DESIGN – PROPORTION



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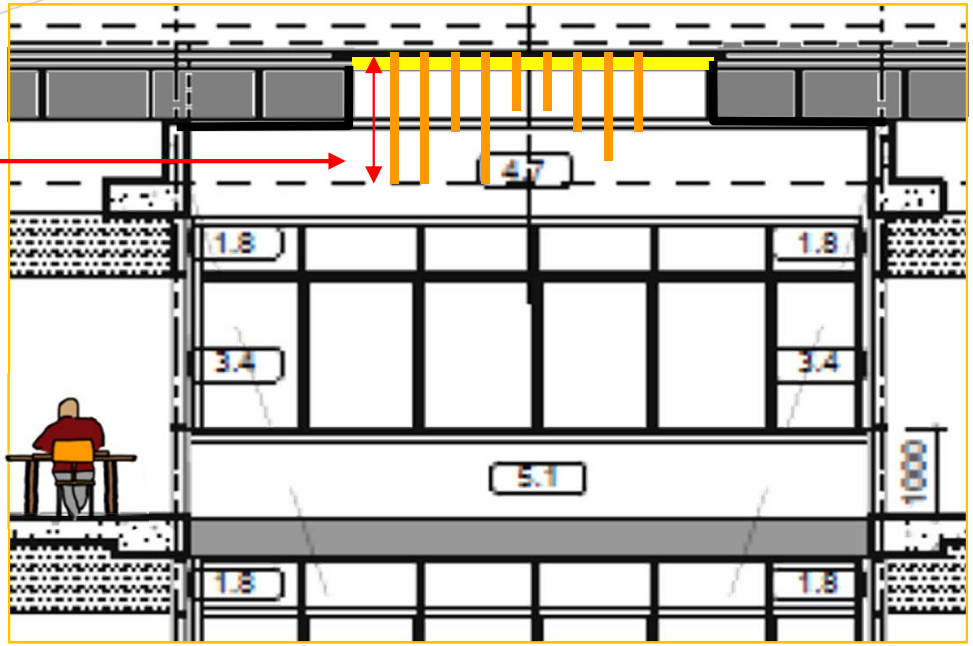
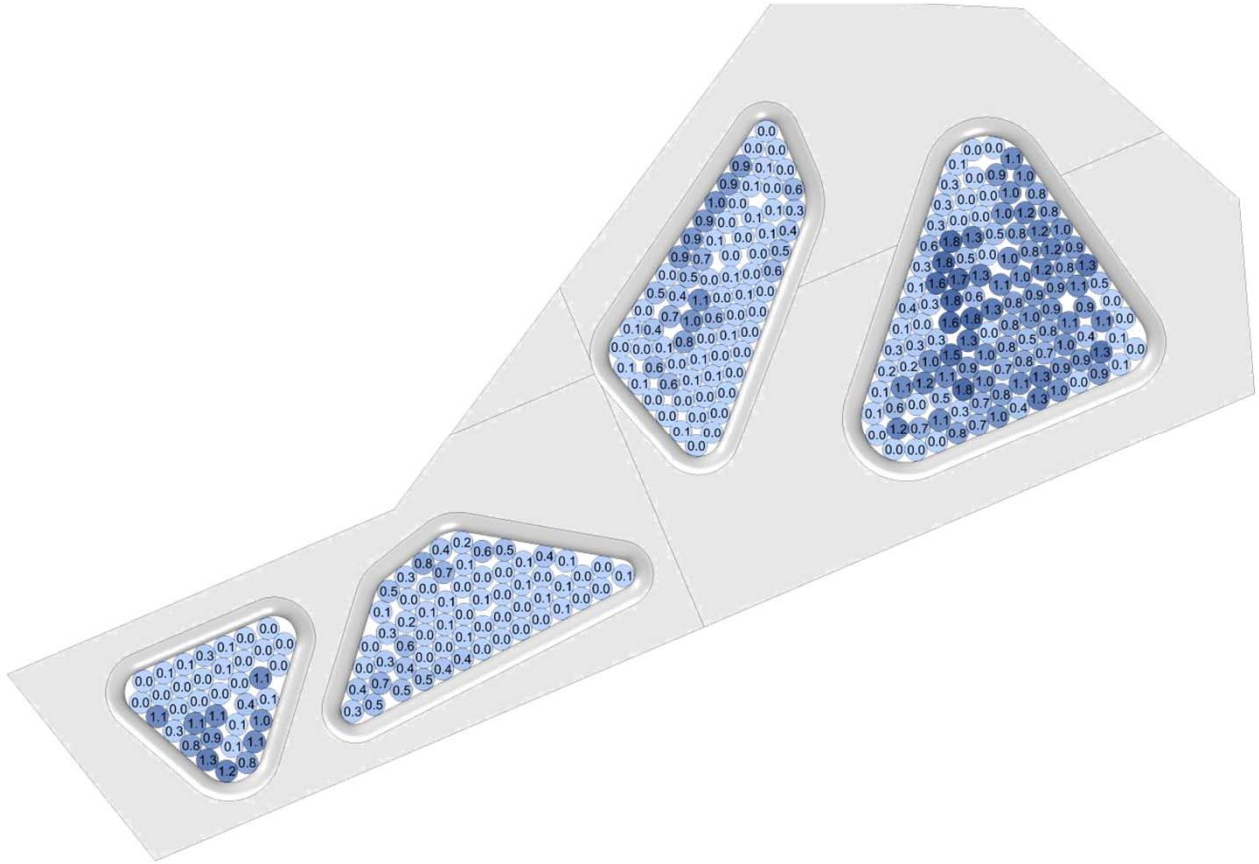
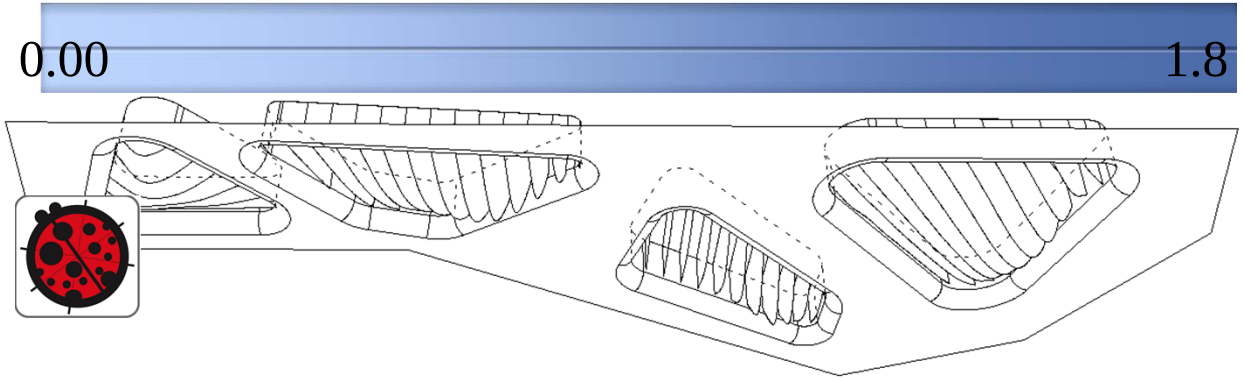
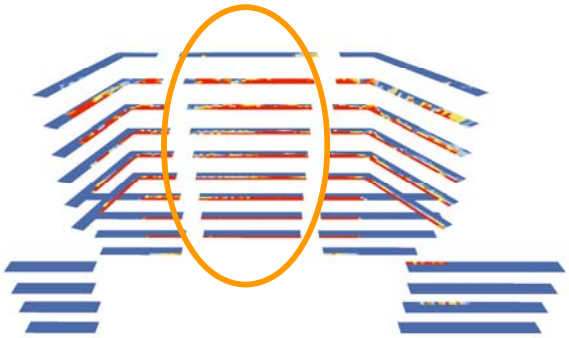


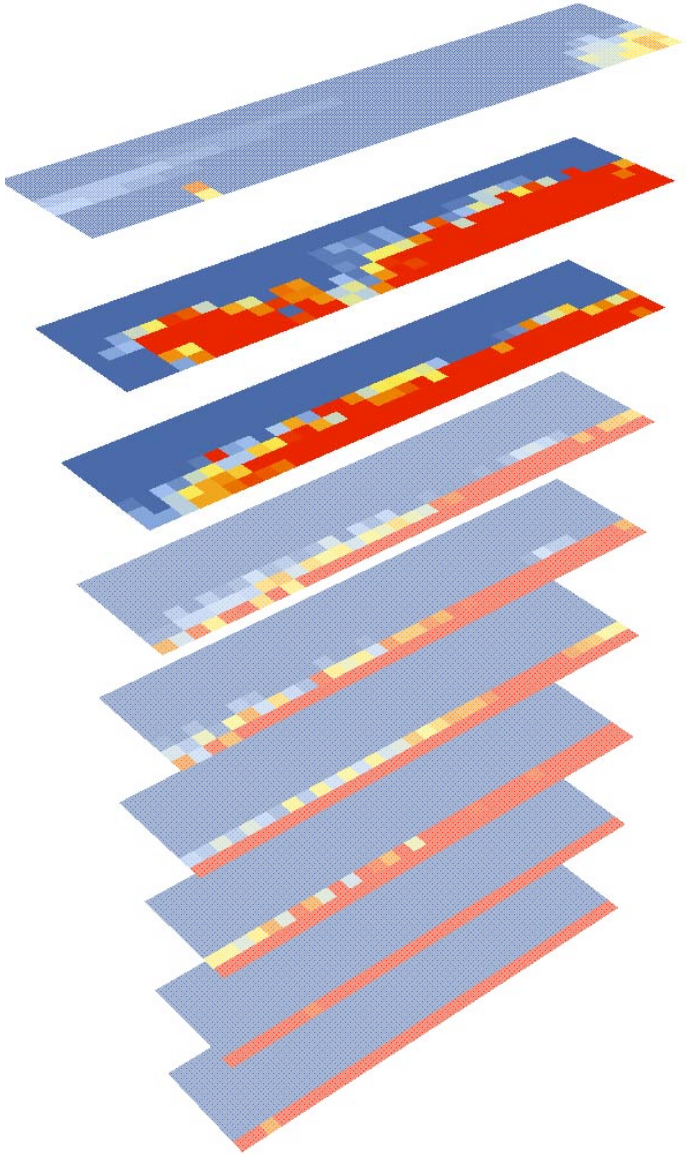
SHADE DESIGN – PROPORTION

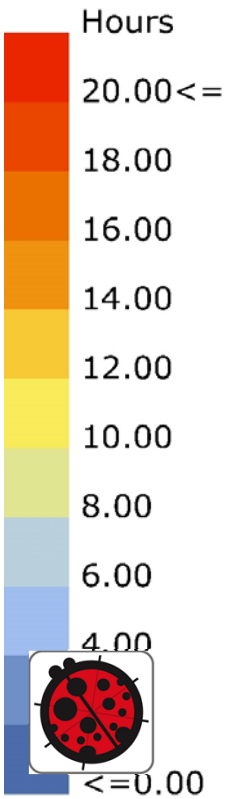


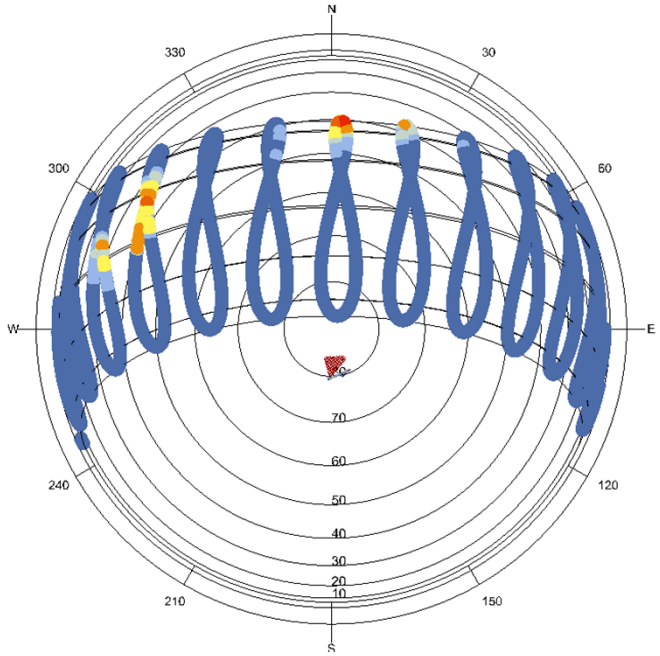


GLARE ANALYSIS

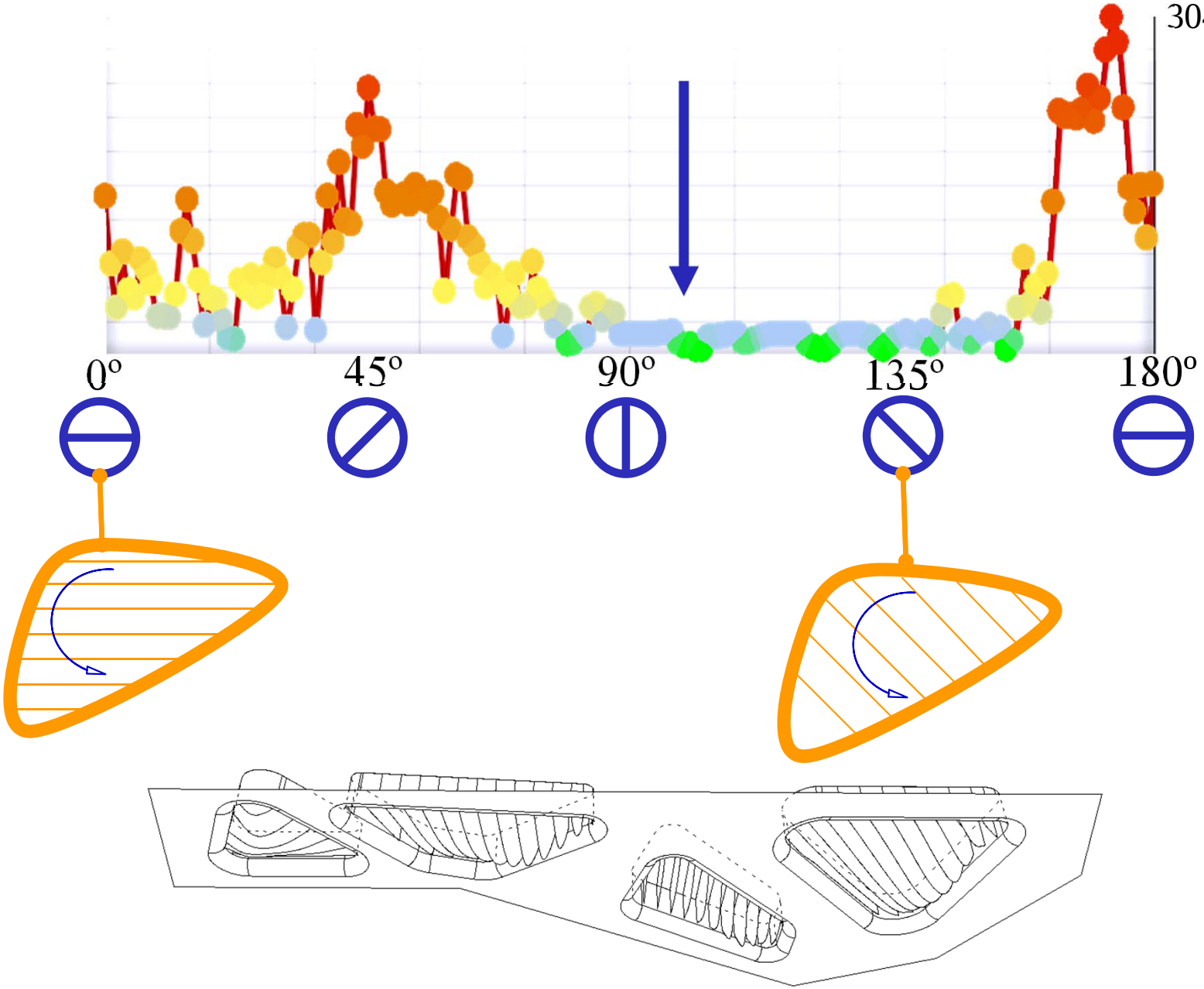




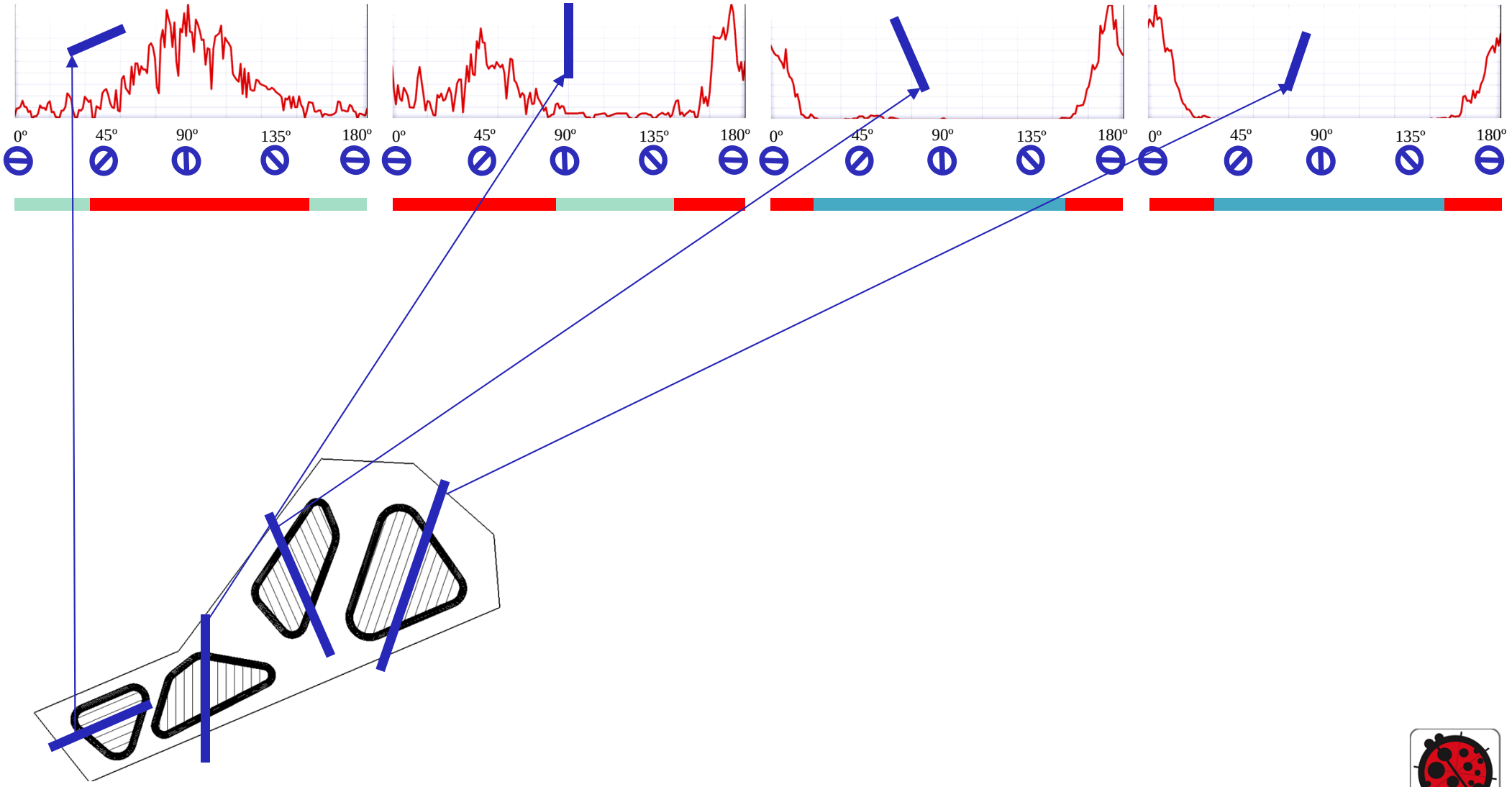




SHADING DESIGN - ROTATION

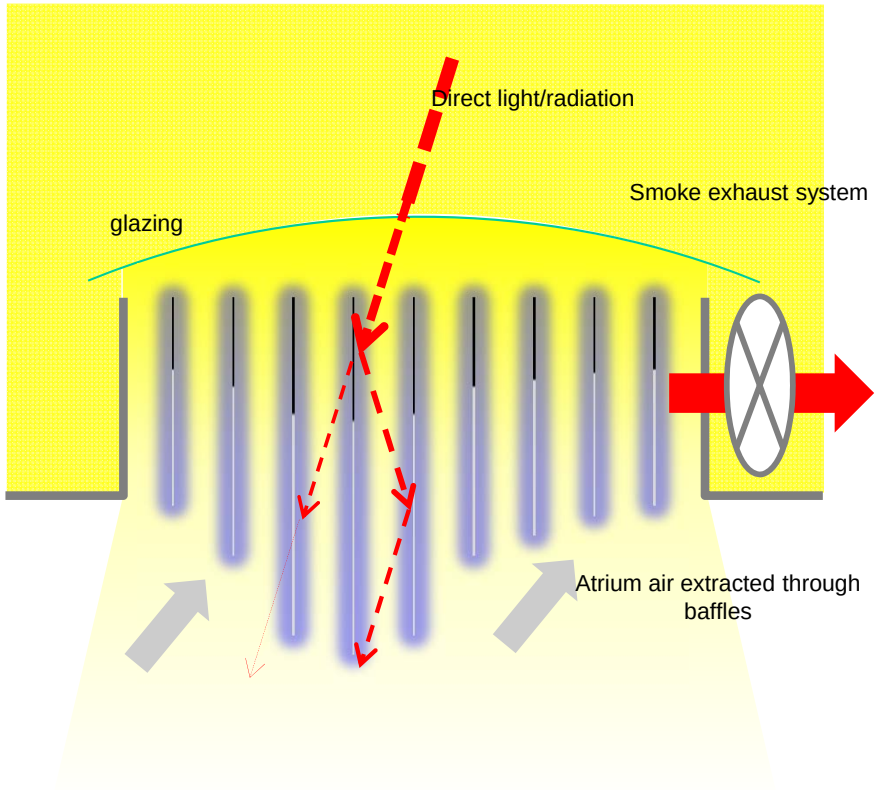


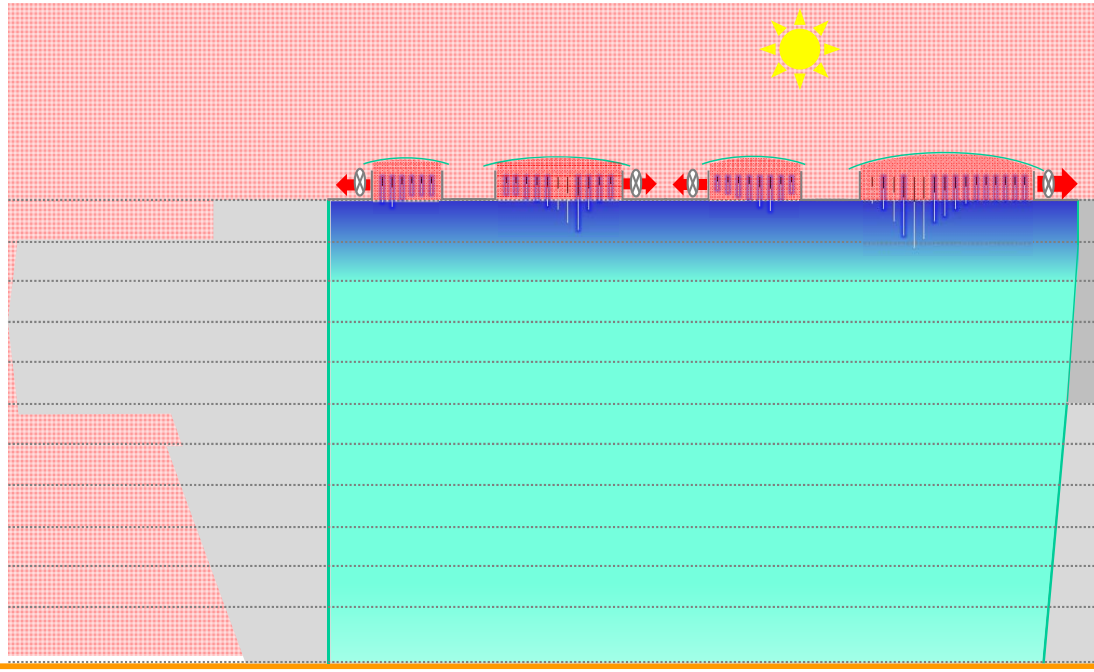
North Atrium



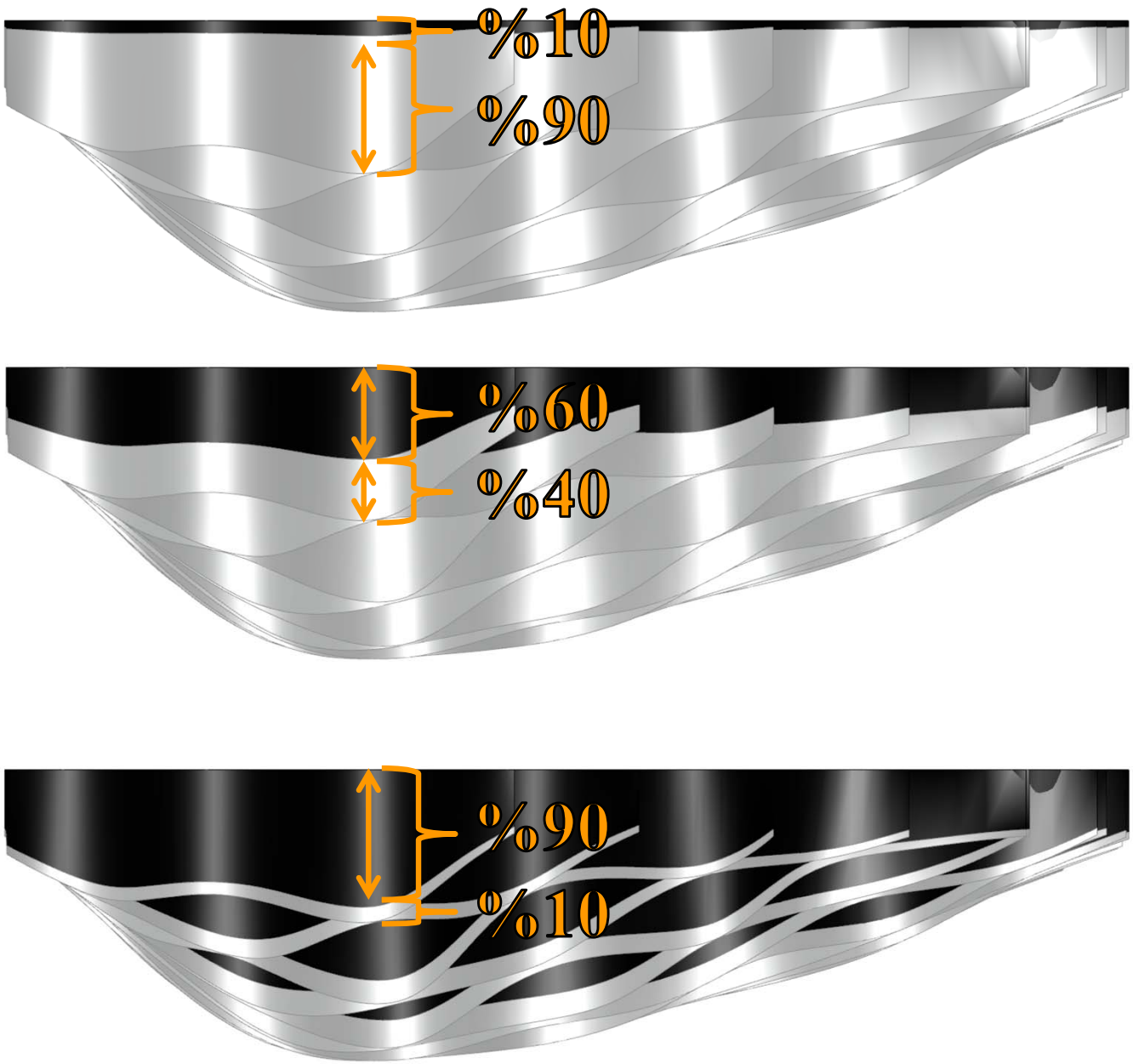
HVAC PEAK CAPACITY

HEAT EXTRACTION DESIGN





BAFFLE MATERIAL



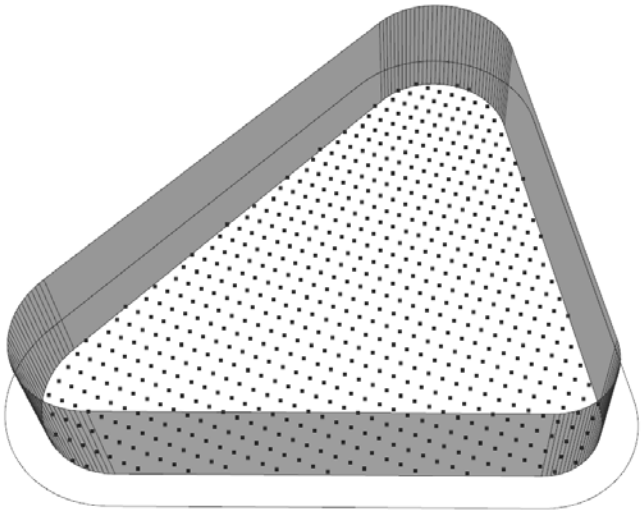
TRL Fabric

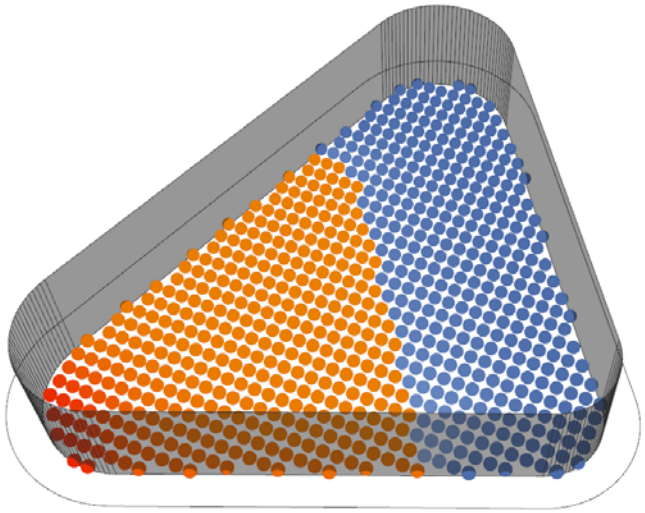
Transmission: 42%

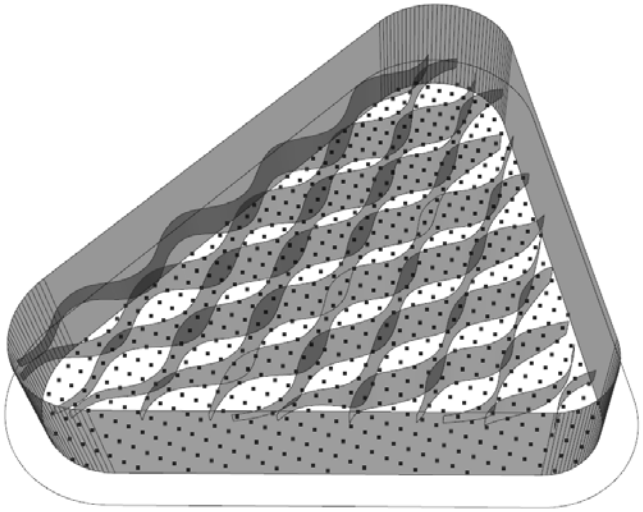
Reflection: 52%

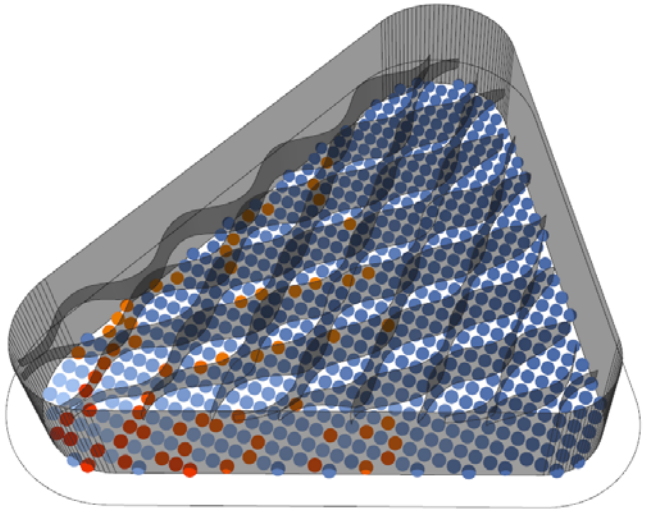
Absorption: 6%

RADIATION ANALYSIS

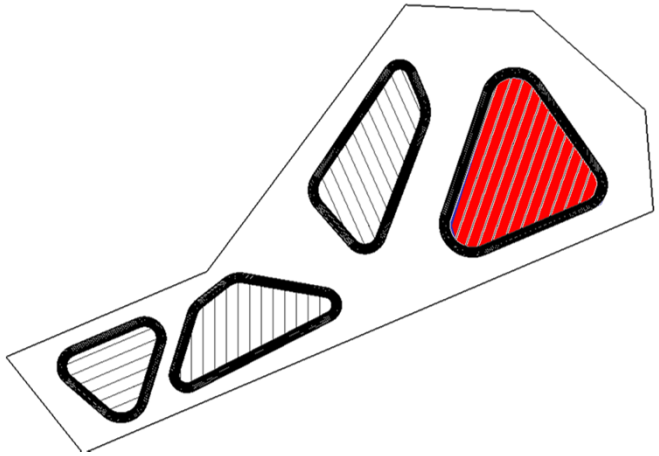






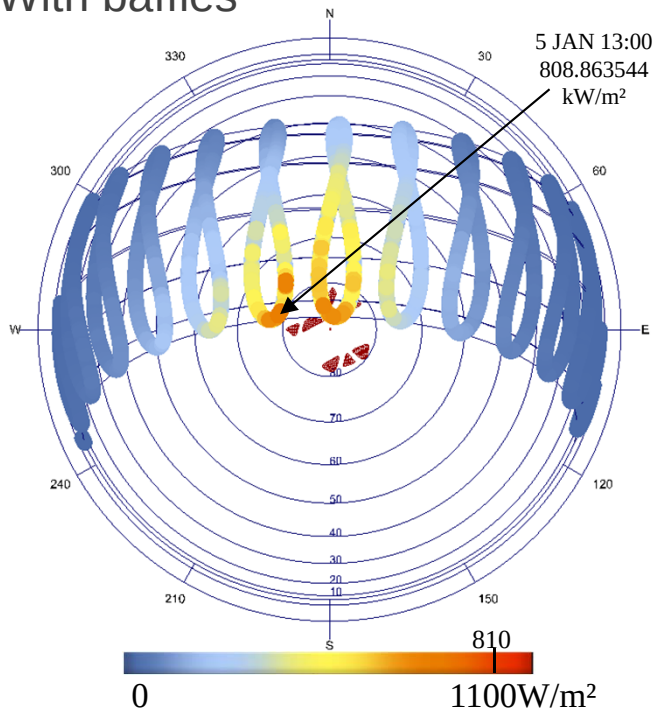


RADIATION ANALYSIS

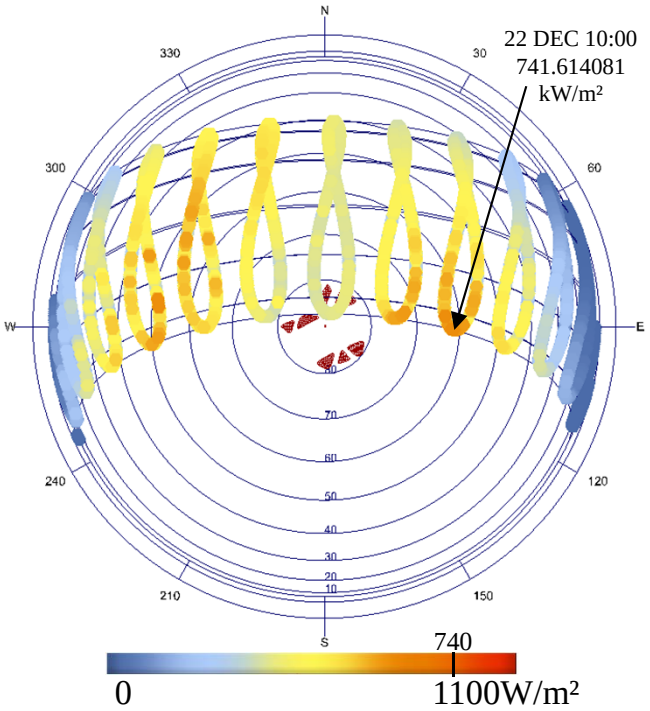


Total Radiation [W/m²]

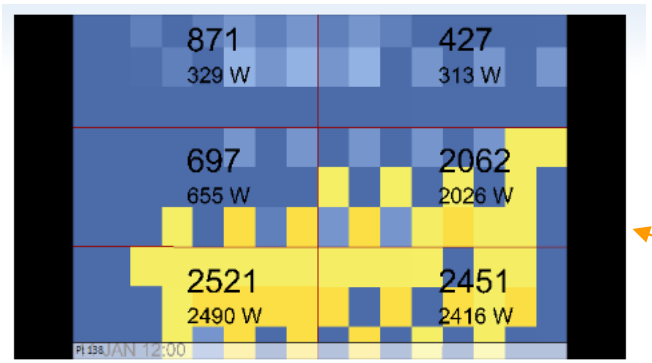
With baffles

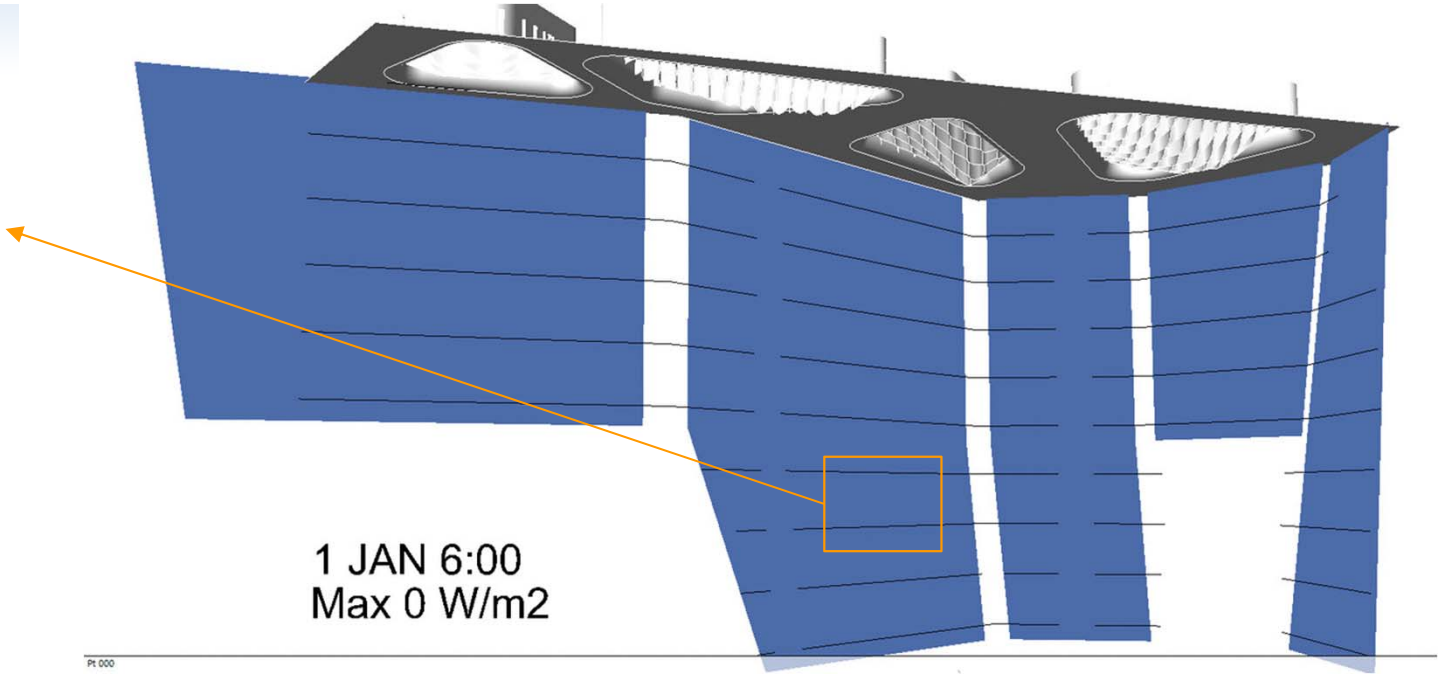


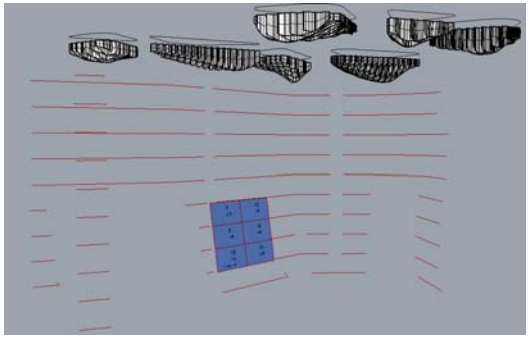
Radiation absorbed by baffles



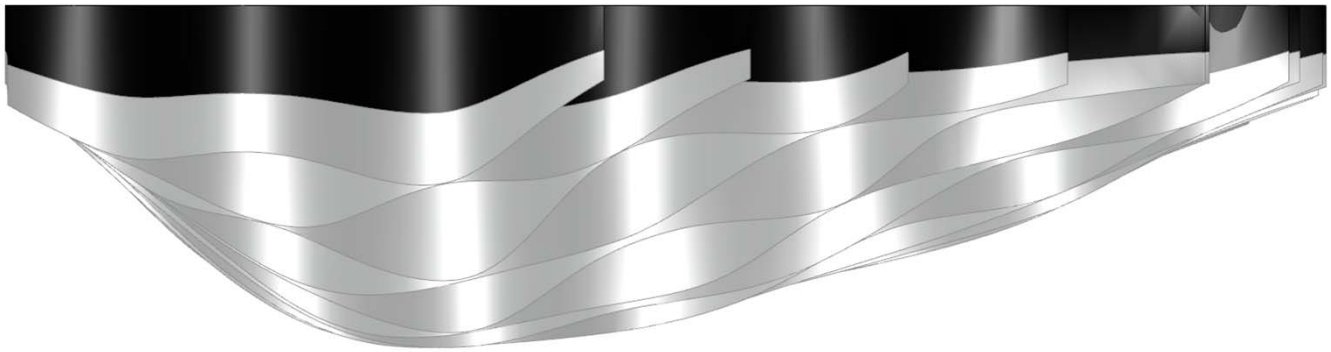
RADIATION ANALYSIS

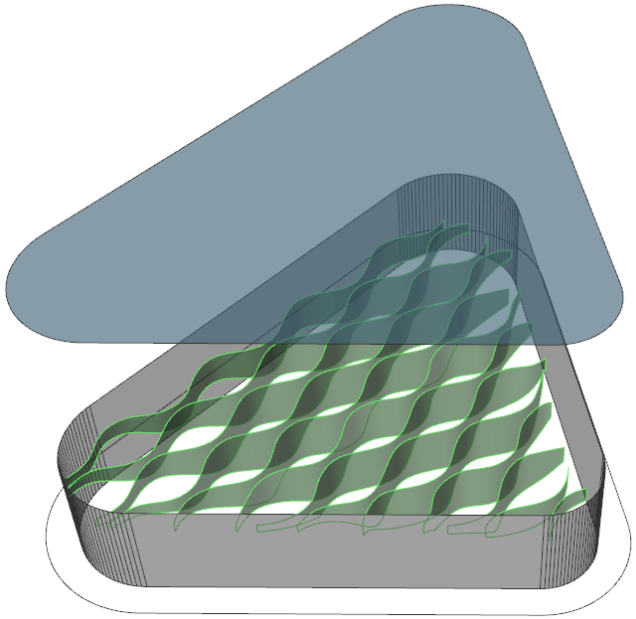






PARAMETRIC HEAT EXTRACTION DESIGN





Parametric input:

TRL Fabric

Transmission: 42%

Reflection: 52%

Absorption: 6%

Clear Glass:

SC: 0822

Tvis: 0.847

Grey Glass:

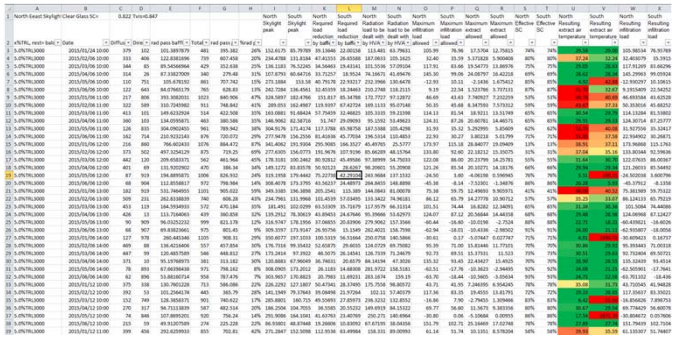
SC: 0.645

Tvis: 0.503

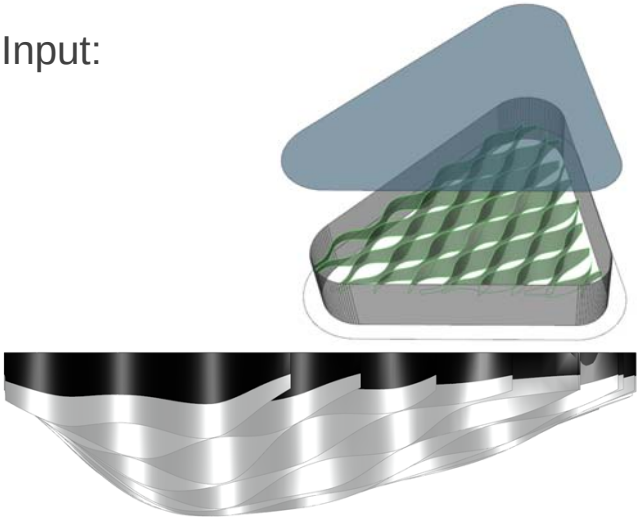
HEAT EXTRACTION DESIGN - RESULTS

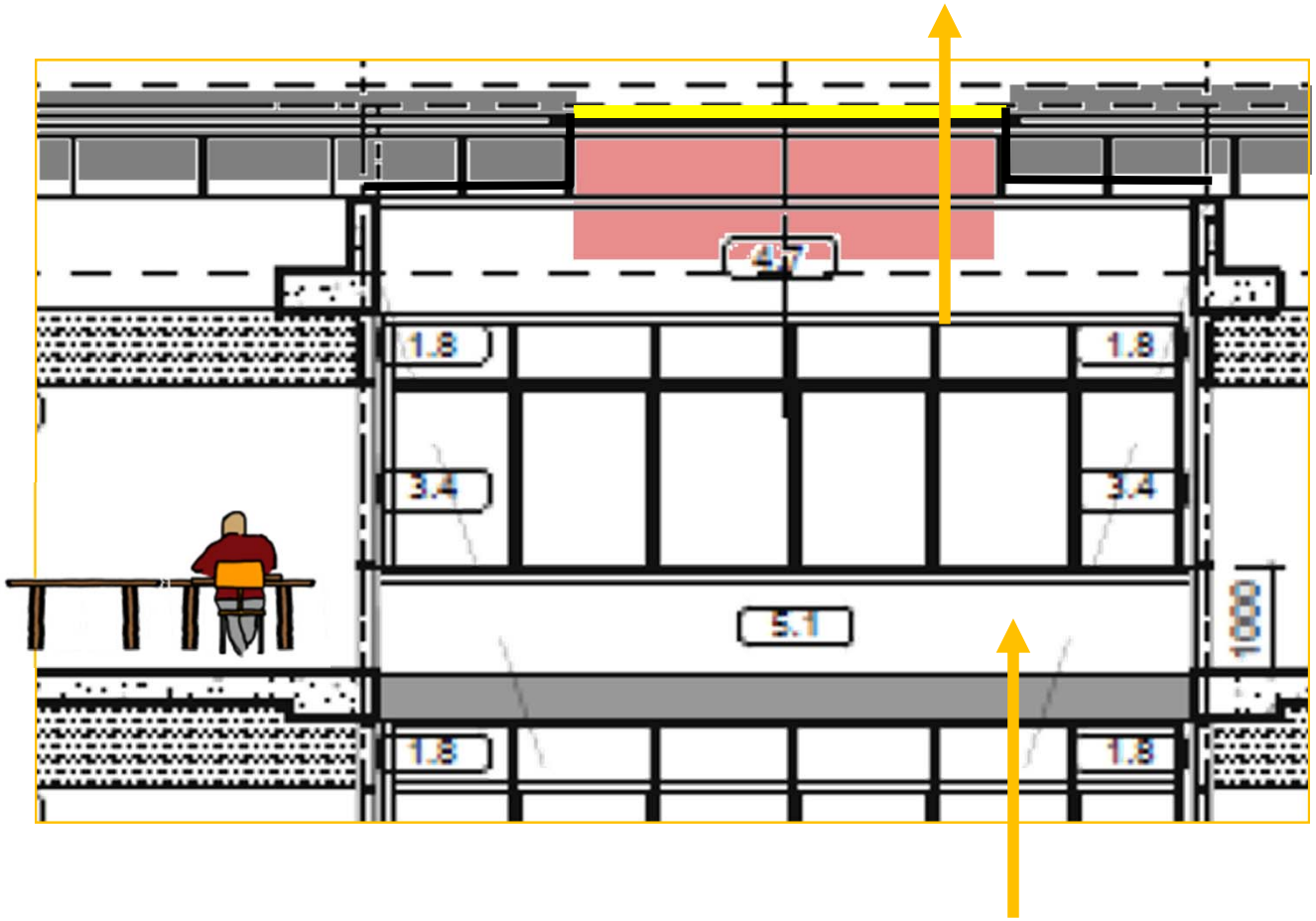
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1	North Eeast Skylight	Clear Glass SC=	0.822	Tvis=0.847					North	South	North	South	North	South	North	South	North	South	North	South	North	South	North	South
2	x%TRL, rest= bald	Date	Diffus	Dire	rad pass baffl	Total	rad pass	%rad p	Skylight peak	Skylight peak	Required load reduction by baffle	Required load reduction by baffle	Radiation load to be dealt with by HVA	Radiation load to be dealt with by HVA	Maximum infiltration load allowed	Maximum infiltration load allowed	Maximum extract allowed	Maximum extract allowed	Effective SC	Effective SC	Resulting extract air temperature	Resulting extract air temperature	Resulting infiltration load	Resulting infiltration load
3	5.0%TRL3000	2015/01/24 10:00	379	102	101.3897879	481	395.382	26%	152.6175	85.79789	39.13646	22.00158	113.481	63.79631	105.99	76.96	17.5704	12.75815	74%	74%	29.58	29.00	105.98534	76.95769
4	5.0%TRL3000	2015/02/06 10:00	333	406	122.8381696	739	607.458	20%	234.4788	131.8184	47.41553	26.65588	187.0633	105.1625	32.40	35.59	5.371828	5.900408	80%	80%	37.24	32.24	32.403079	35.5915
5	5.0%TRL3000	2015/03/06 10:00	344	85	89.54566964	429	352.638	25%	136.1183	76.52245	34.56463	19.43141	101.5536	57.09104	117.91	83.66	19.54773	13.86976	75%	75%	29.05	28.63	117.91269	83.66296
6	5.0%TRL3000	2015/04/06 10:00	314	26	87.33827009	340	279.48	31%	107.8793	60.64716	33.71257	18.9524	74.16671	41.69476	145.30	99.06	24.08797	16.42218	69%	69%	28.62	28.34	145.29963	99.05924
7	5.0%TRL3000	2015/05/06 10:00	110	751	105.678192	861	707.742	15%	273.1884	153.58	40.79178	22.93217	232.3966	130.6478	-12.93	10.11	-2.1436	1.675412	85%	85%	4.92	42.88	-12.930297	10.10615
8	5.0%TRL3000	2015/06/06 10:00	122	643	84.07665179	765	628.83	13%	242.7284	136.4561	32.45359	18.24463	210.2748	118.2115	9.19	22.54	1.523786	3.737131	87%	87%	51.72	32.67	9.1915409	22.54252
9	5.0%TRL3000	2015/01/06 11:00	217	806	393.3082031	1023	840.906	47%	324.5897	182.4766	151.817	85.34788	172.7727	97.12872	46.69	43.63	7.740927	7.232259	53%	53%	49.76	40.69	46.693584	43.62528
10	5.0%TRL3000	2015/02/06 11:00	322	589	310.7245982	911	748.842	41%	289.053	162.4987	119.9397	67.42724	169.1133	95.07148	50.35	45.68	8.347593	7.573312	59%	59%	43.67	37.33	50.353016	45.68252
11	5.0%TRL3000	2015/03/06 11:00	413	101	149.6232924	514	422.508	35%	163.0881	91.68424	57.75459	32.46825	105.3335	59.21598	114.13	81.54	18.9211	13.51749	65%	65%	30.54	29.79	114.13284	81.53802
12	5.0%TRL3000	2015/04/06 11:00	360	103	134.0595871	463	380.586	35%	146.9062	82.58716	51.747	29.09093	95.1592	53.49623	124.31	87.26	20.60781	14.46571	65%	65%	29.91	29.33	124.30714	87.25777
13	5.0%TRL3000	2015/05/06 11:00	126	835	304.0902455	961	789.942	38%	304.9176	171.4174	117.3788	65.98758	187.5388	105.4298	31.93	35.32	5.292995	5.85609	62%	62%	52.73	40.08	31.927556	35.32417
14	5.0%TRL3000	2015/06/06 11:00	162	714	210.9232143	876	720.072	29%	277.9478	156.2556	81.41636	45.77034	196.5314	110.4853	22.93	30.27	3.80218	5.01799	71%	71%	51.85	37.58	22.934902	30.26871
15	5.0%TRL3000	2015/01/06 12:00	216	860	766.602433	1076	884.472	87%	341.4062	191.9304	295.9085	166.3527	45.49765	25.5777	173.97	115.18	28.84077	19.09409	13%	13%	38.91	37.11	173.96868	115.1763
16	5.0%TRL3000	2015/02/06 12:00	373	502	497.3254129	875	719.25	69%	277.6305	156.0773	191.9676	107.9196	85.66289	48.15764	133.80	92.60	22.18212	15.35075	31%	31%	37.04	35.16	133.80344	92.59636
17	5.0%TRL3000	2015/03/06 12:00	442	120	209.6583371	562	461.964	45%	178.3181	100.2462	80.92812	45.49586	97.38999	54.75033	122.08	86.00	20.23799	14.25781	55%	55%	31.64	30.70	122.07635	86.00367
18	5.0%TRL3000	2015/04/06 12:00	401	69	131.9202902	470	386.34	34%	149.1272	83.83578	50.92123	28.6267	98.20601	55.20908	121.26	85.54	20.10271	14.18176	66%	66%	29.94	29.34	121.26033	85.54492
19	5.0%TRL3000	2015/05/06 12:00	87	919	194.8895871	1006	826.932	24%	319.1958	179.4442	75.22738	42.29104	243.9684	137.1532	-24.50	3.60	-4.06198	0.596945	76%	76%	5.51	109.21	-24.502038	3.600796
20	5.0%TRL3000	2015/06/06 12:00	68	904	112.8558817	972	798.984	14%	308.4078	173.3795	43.56237	24.48973	264.8455	148.8898	-45.38	-8.14	-7.52301	-1.34876	86%	86%	20.28	5.93	-45.37912	-8.1358
21	5.0%TRL3000	2015/01/06 13:00	182	919	531.7464955	1101	905.022	59%	349.3385	196.3898	205.2541	115.389	144.0843	81.00078	75.38	59.75	12.49693	9.905971	41%	41%	46.06	40.52	75.381989	59.75322
22	5.0%TRL3000	2015/02/06 13:00	509	231	262.8338839	740	608.28	43%	234.7961	131.9968	101.4539	57.03495	133.3422	74.96181	86.12	65.79	14.27778	10.90712	57%	57%	35.25	33.07	86.124133	65.79219
23	5.0%TRL3000	2015/03/06 13:00	453	119	164.5934933	572	470.184	35%	181.491	102.0299	63.53309	35.71679	117.9579	66.31314	101.51	74.44	16.8282	12.34091	65%	65%	31.38	30.36	101.5084	74.44086
24	5.0%TRL3000	2015/04/06 13:00	426	13	113.7164063	439	360.858	32%	139.2912	78.30619	43.89453	24.67646	95.39666	53.62973	124.07	87.12	20.56844	14.44358	68%	68%	29.48	28.98	124.06968	87.12427
25	5.0%TRL3000	2015/05/06 13:00	90	909	96.03252232	999	821.178	12%	316.9747	178.1956	37.06855	20.83906	279.9062	157.3566	-60.44	-16.60	-10.0198	-2.7524	88%	88%	22.71	18.21	-60.439821	-16.6026
26	5.0%TRL3000	2015/06/06 13:00	68	907	69.83823661	975	801.45	9%	309.3597	173.9147	26.95756	15.1549	282.4021	158.7598	-62.94	-18.01	-10.4336	-2.98502	91%	91%	24.00	21.11	-62.935807	-18.0058
27	5.0%TRL3000	2015/01/06 14:00	127	978	260.445346	1105	908.31	29%	350.6077	197.1033	100.5319	56.51664	250.0758	140.5866	-30.61	0.17	-5.07447	0.027747	71%	71%	4.01	2390.72	-30.609423	0.16737
28	5.0%TRL3000	2015/02/06 14:00	469	88	136.4216406	557	457.854	30%	176.7316	99.35432	52.65875	29.6035	124.0729	69.75082	95.39	71.00	15.81446	11.77101	70%	70%	30.86	29.92	95.393443	71.00318
29	5.0%TRL3000	2015/03/06 14:00	447	99	120.4857589	546	448.812	27%	173.2414	97.3922	46.5075	26.14541	126.7339	71.24679	92.73	69.51	15.37331	11.523	73%	73%	30.51	29.63	92.732404	69.50721
30	5.0%TRL3000	2015/04/06 14:00	371	10	95.19768973	381	313.182	30%	120.8883	67.96049	36.74631	20.6579	84.14194	47.3026	135.32	93.45	22.43427	15.4925	70%	70%	28.90	28.55	135.32439	93.4514
31	5.0%TRL3000	2015/05/06 14:00	78	893	67.66398438	971	798.162	8%	308.0905	173.2012	26.1183	14.68308	281.9722	158.5181	-62.51	-17.76	-10.3623	-2.94495	92%	92%	24.08	21.21	-62.505901	-17.7641
32	5.0%TRL3000	2015/06/06 14:00	62	896	53.88160714	958	787.476	7%	303.9657	170.8823	20.7983	11.69231	283.1674	159.19	-63.70	-18.44	-10.5605	-3.05634	93%	93%	24.71	22.56	-63.701102	-18.436
33	5.0%TRL3000	2015/01/12 10:00	375	338	130.7601228	713	586.086	22%	226.2292	127.1807	50.47341	28.37495	175.7558	98.80572	43.71	41.95	7.246395	6.954245	78%	78%	35.08	31.73	43.710545	41.94828
34	5.0%TRL3000	2015/02/12 10:00	392	53	101.2564174	445	365.79	28%	141.1949	79.37643	39.08498	21.97264	102.11	57.40379	117.36	83.35	19.4555	13.81791	72%	72%	29.33	28.85	117.35637	83.35021
35	5.0%TRL3000	2015/03/12 10:00	152	749	128.3858371	901	740.622	17%	285.8801	160.715	49.55693	27.85973	236.3232	132.8552	-16.86	7.90	-2.79455	1.309466	83%	83%	6.42	51.69	-16.856826	7.898753
36	5.0%TRL3000	2015/04/12 10:00	270	317	94.71113839	587	482.514	20%	186.2504	104.7055	36.5585	20.55232	149.6919	84.15322	69.77	56.60	11.5673	9.383356	80%	80%	30.67	29.54	69.774429	56.60078
37	5.0%TRL3000	2015/05/12 10:00	74	846	107.8695201	920	756.24	14%	291.9086	164.1041	41.63763	23.40769	250.271	140.6964	-30.80	0.06	-5.10684	0.00955	86%	86%	17.54	2871.39	-30.804672	0.057606
38	5.0%TRL3000	2015/06/12 10:00	215	59	49.91207589	274	225.228	22%	86.93801	48.87448	19.26606	10.83092	67.67195	38.04356	151.79	102.71	25.16469	17.02748	78%	78%	27.89	27.74	151.79439	102.7104
39	5.0%TRL3000	2015/01/12 11:00	399	456	292.6259933	855	702.81	42%	271.2847	152.5098	112.9536	63.49984	158.331	89.00993	61.14	51.74	10.1351	8.578204	58%	58%	39.93	35.59	61.135307	51.74407

HEAT EXTRACTION DESIGN - RESULTS



Input:





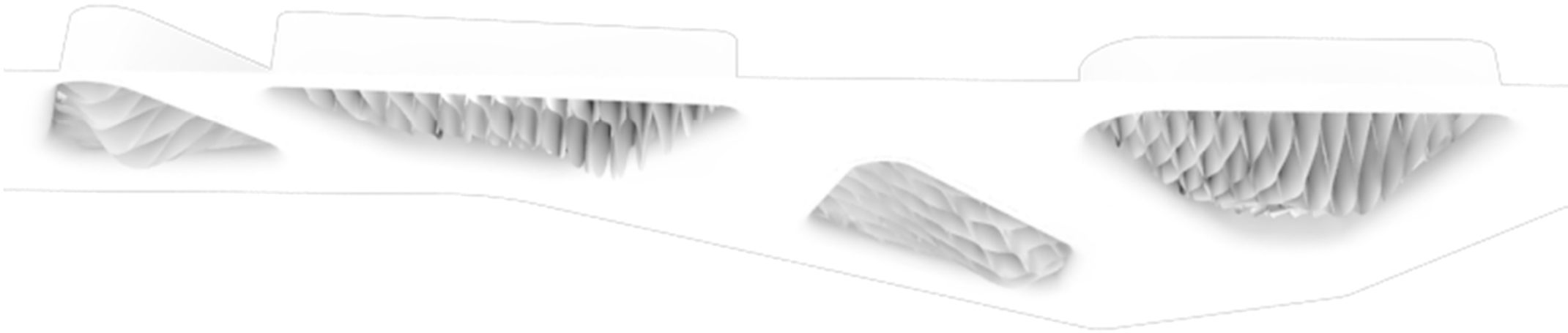
Output:

Exhaust temperature for option A and B

Is the temperature below the maximum allowed temperature?

Option B

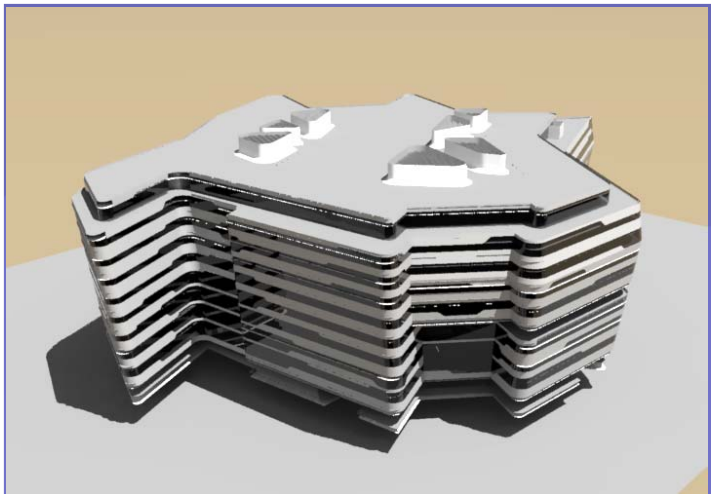
RESULTING GEOMETRY



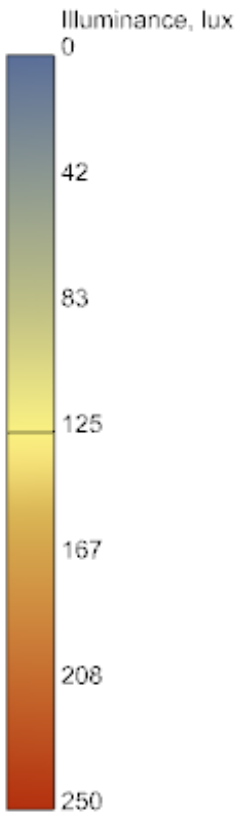
DAYLIGHT CONDITIONS

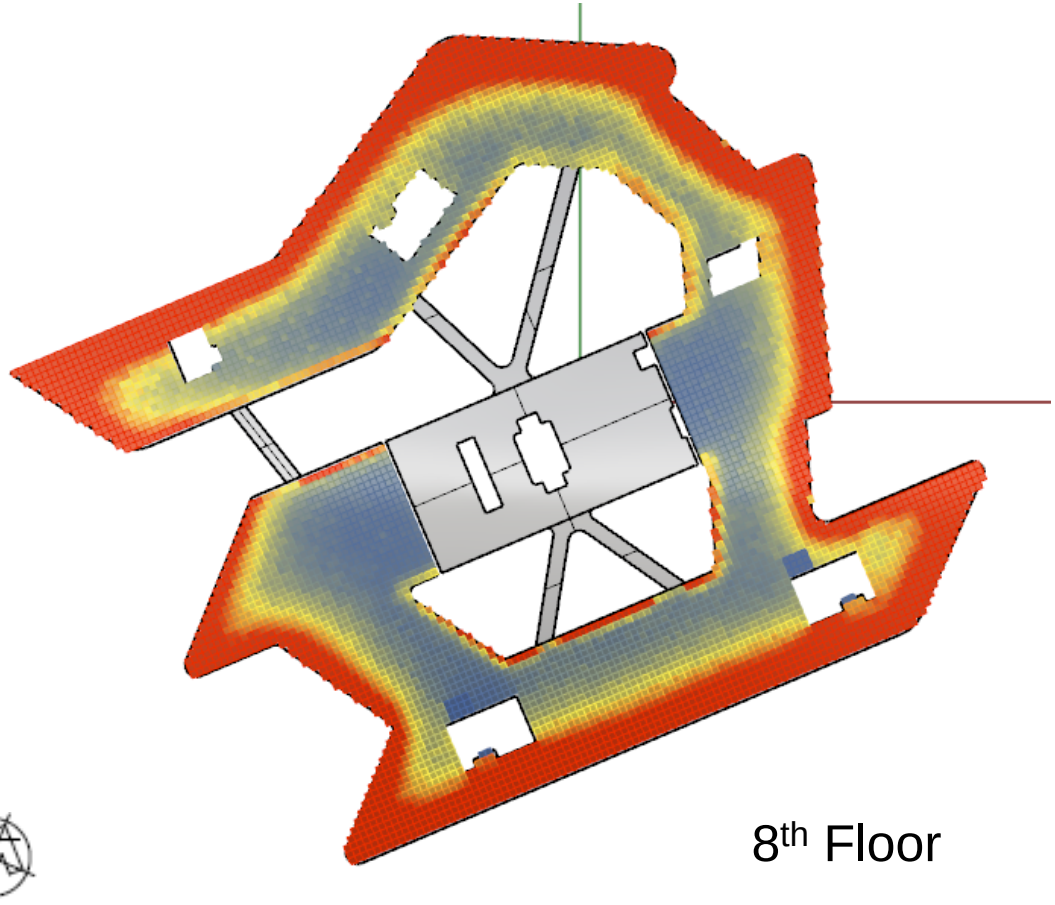
DAYLIGHT ANALYSIS

DIVA-for-Rhino Illuminance Nodes Analysis
Sky Condition, Month, Date and Time: -s 09 21 12
nodegroup00: Mean Illuminance =229.59 lux
nodegroup00: 69.9% of Area between 0 & 250 lux
nodegroup00: 30.1% of Area > 250 lux; 0% of Area < 0 lux



Radiance render – Easterly view





8th Floor

P8

GREEN STAR – SPATIAL DAYLIGHT AUTONOMY (SDA)

4th floor

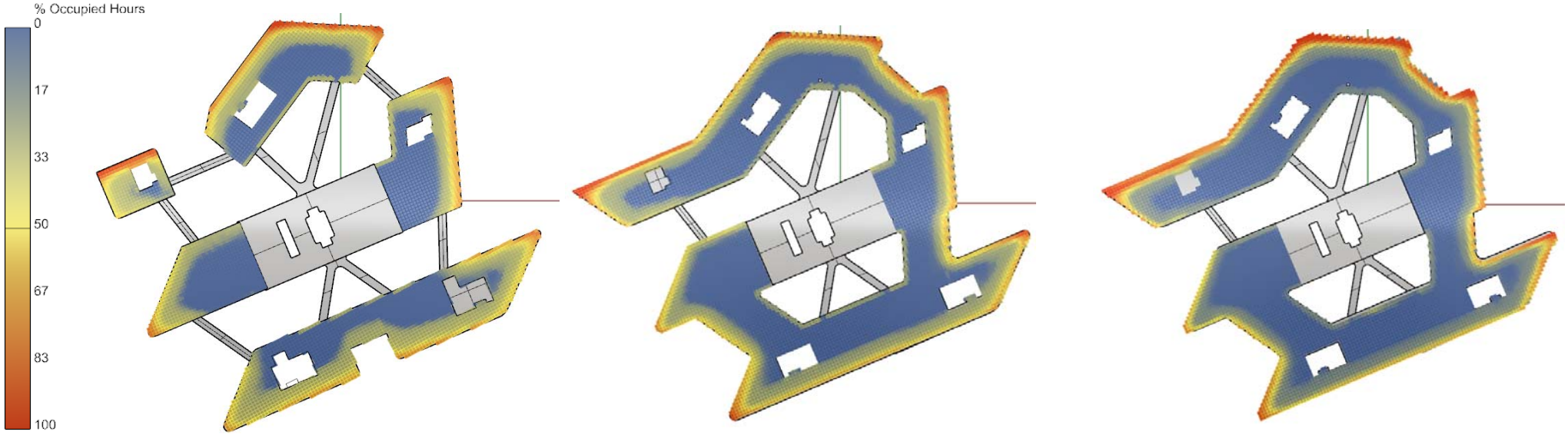
DIVA-for-Rhino Simulation
Daylight Autonomy (300 lux, IES-LM-83 sDA control schema)
nodegroup00: Percent of Space where sDA >= 50% is 16.1 % of space
nodegroup01: Percent of Space where sDA >= 50% is 14.3 % of space
nodegroup02: Percent of Space where sDA >= 50% is 11.2 % of space
nodegroup03: Percent of Space where sDA >= 50% is 4.6 % of space
nodegroup04: Percent of Space where sDA >= 50% is 25.6 % of space

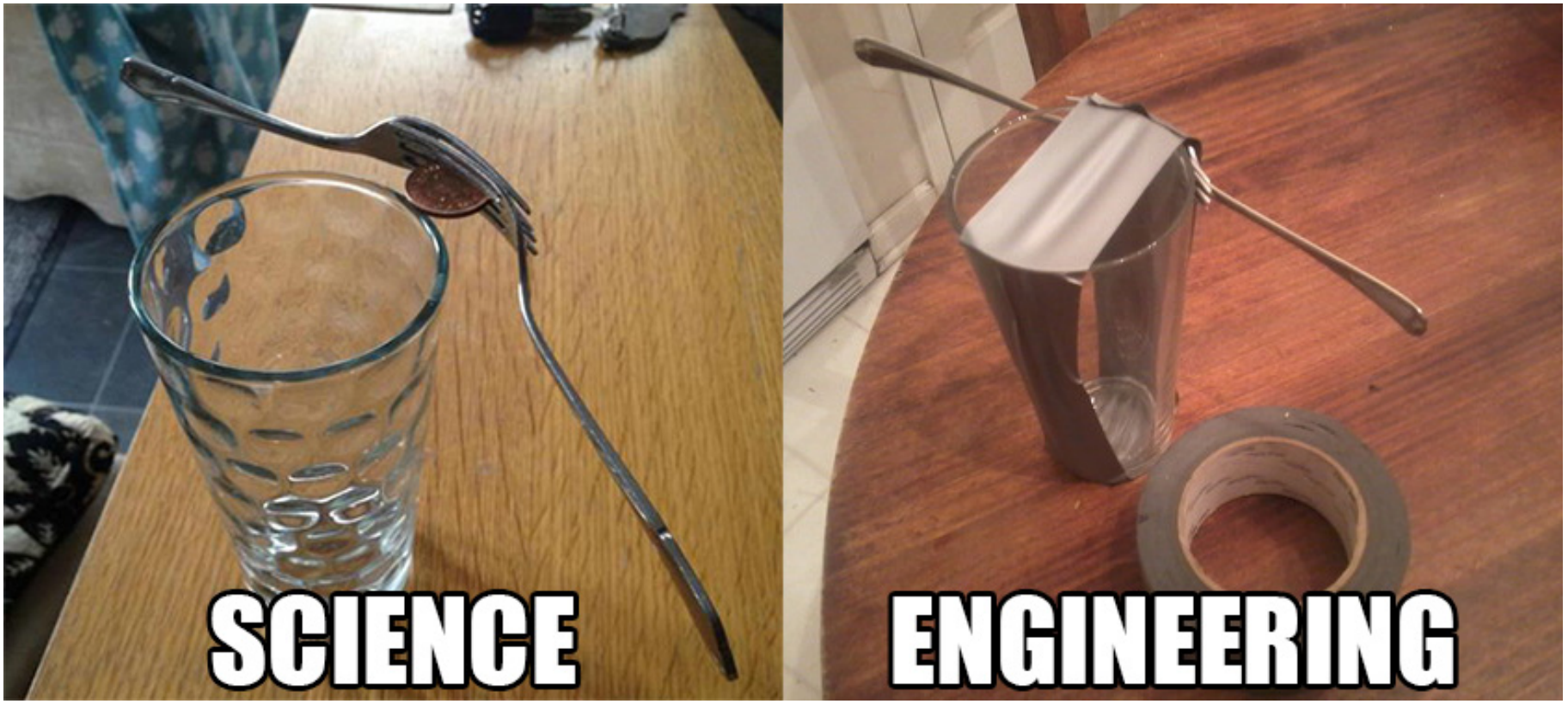
6th floor

DIVA-for-Rhino Simulation
Daylight Autonomy (300 lux, IES-LM-83 sDA control schema)
nodegroup00: Percent of Space where sDA >= 50% is 11.6 % of space

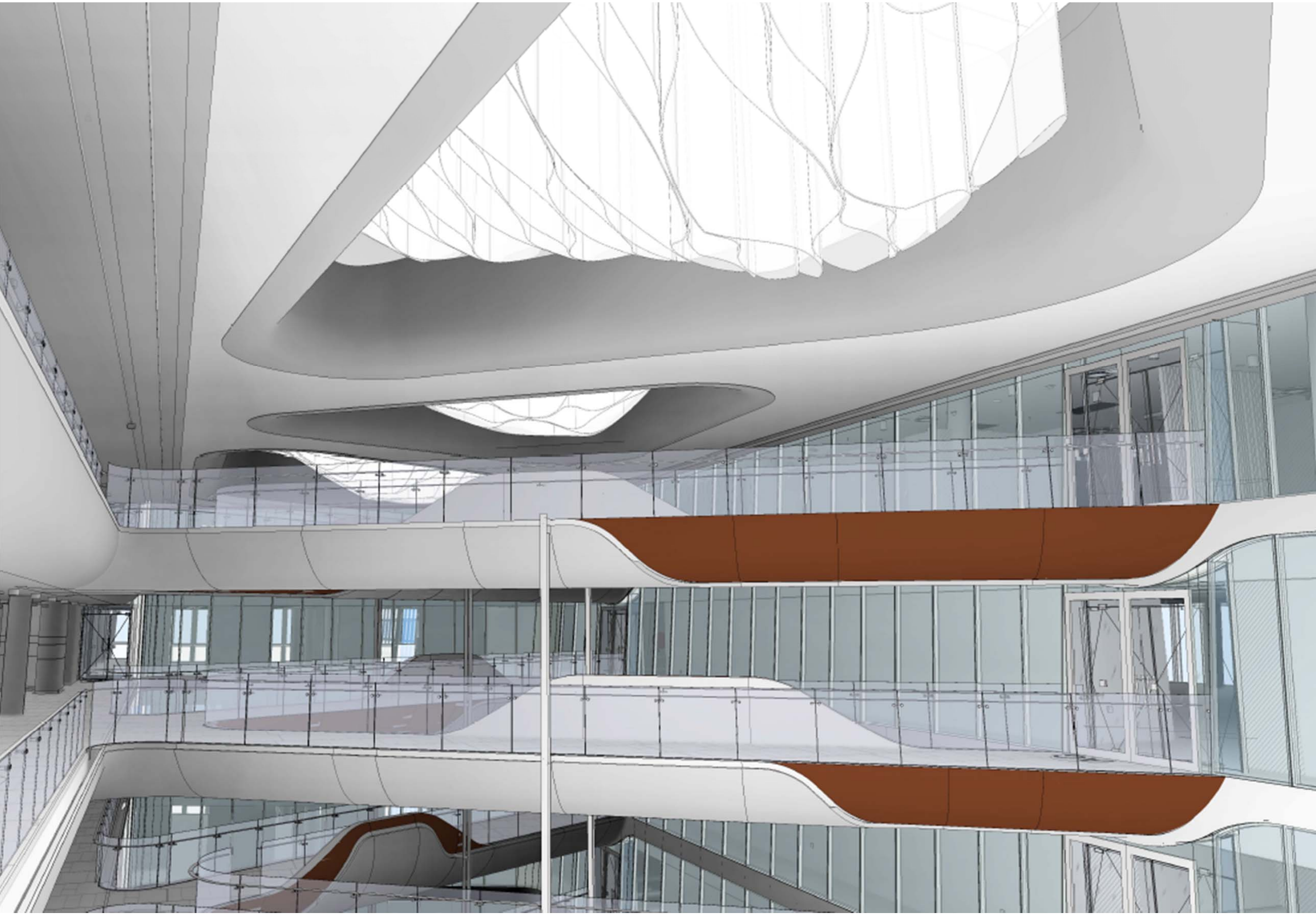
8th floor

DIVA-for-Rhino Simulation
Daylight Autonomy (300 lux, IES-LM-83 sDA control schema)
nodegroup00: Percent of Space where sDA >= 50% is 12.5 % of space




SCIENCE
ENGINEERING

FINAL RESULT



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- PARAGON ARCHITECTS
- ARE HVAC ENGINEERS
- NAVID HATEFNIA

QUESTIONS?


pjCarew
Consulting
passive + low energy design