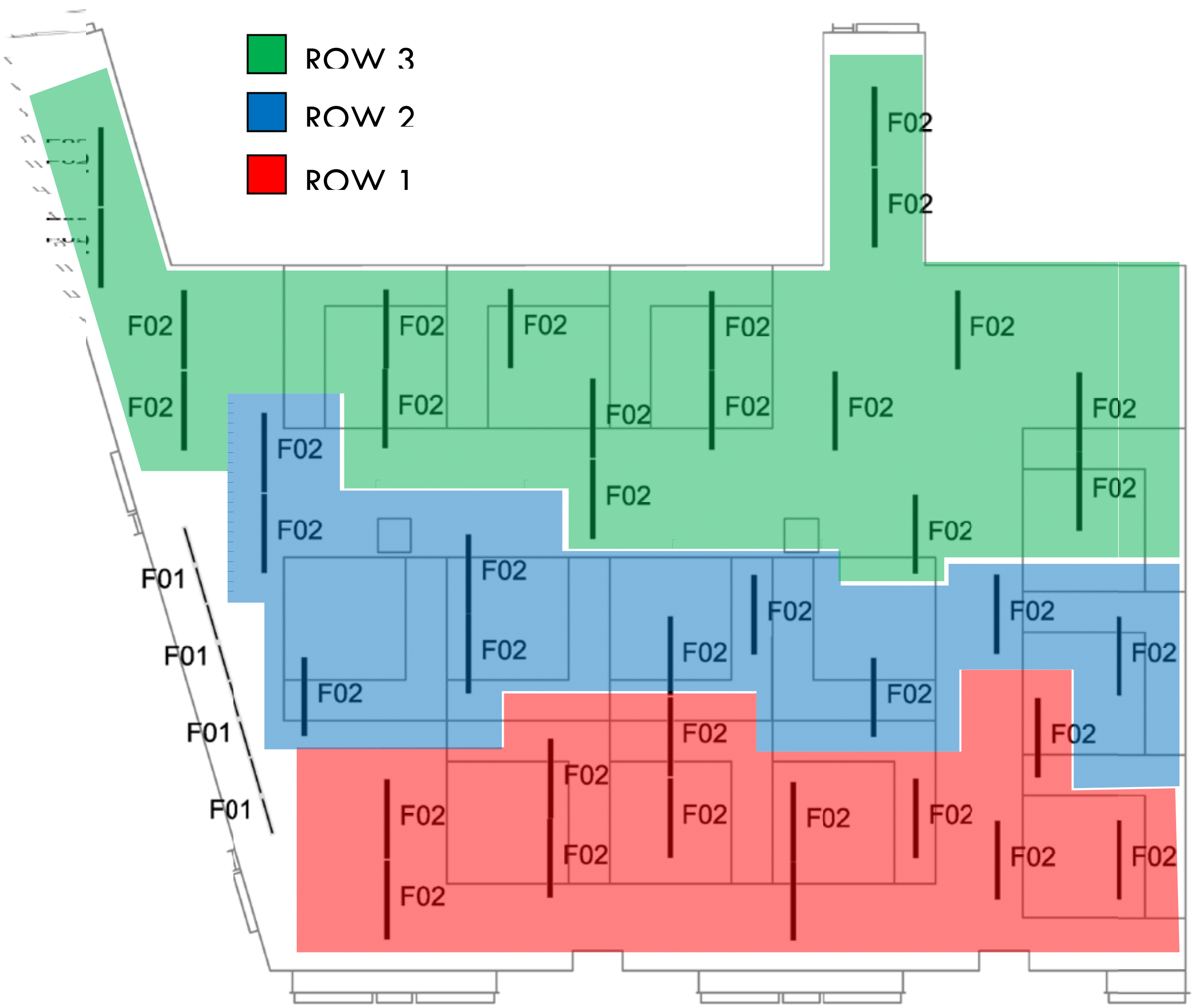
MAE DEPTH – DAYLIGHTING STUDY

To complete the MAE additional depth requirement for thesis, a daylighting analysis for the third floor open office space has been performed. Three northern windows provide diffuse natural light into the space throughout the year. The purpose of the following study is to propose an effective photosensor dimming system for the open office with the goal of providing long-term economic benefits. Once an appropriate system has been determined, the annual energy saved can then be estimated based on the lighting power use in the space.



Office Lighting Plan

Critical Point Analysis

AGI32 lighting software was used to study several daylight scenarios for the building. The worst-case scenario (the time of year when the least natural daylight is available on the workplane) was determined to be the winter solstice, December 21. Due to the north-facing orientation of the windows, low-angle winter sun rays are unable to enter the space directly. A rough solar study of the northern wall is also performed within the photovoltaic electrical depth analysis for this report.

Using December 21 as a date inputting the longitude and latitude of Irvine, California to simulate the project's location, a calculation with sunny and overcast sky conditions was performed and recorded. In addition to natural light, the artificial lighting system within the office has been divided into three distinctly controllable zones—one near the windows, one toward the opposite wall, and one in between with row one being nearest the windows. Through the coordinated dimming of the ceiling recessed fixtures in the space, a fairly uniform light condition should be attainable in the office without the distraction of the luminaires being switched on and off as the light varies throughout the day.

Each combination of active rows has been calculated with no added natural light. The AGI calculation output was then imported into Microsoft Excel for comparison. Based on this data, an appropriate photosensor location has been chosen for the space and is shown here outlined in black.

5.1	5.2	5.2	5.1	5.5	6.3	6.7	6.4	5.3	6.5	6.6	6.2	5.1	5.3	5.9	6.9	6.8	6.8	6.6	6.3	6.2	5.6
4.7	5.2	5.5	5.3	5	6.2	6.8	6.7	5.1	5.9	6.5	6.6	5	5.8	6.5	7	6.8	6.7	6.4	5.7	5.6	5.4
4	5.2	6.1	5.5	4.7	5.5	7.7	7.4	4.7	5.2	6.5	6.6	5	6.2	6.7	6.7	6.7	6.9	6.1	5.2	5.2	5.2
2.5	3.3	6.1	6.4	2.9	3.5	8.1	8	3	3.6	7.5	7	6.1	6.4	6.8	7.1	7.2	7.2	3.4	3.7	3.6	3.6
7.1	6.7	5.8	6.5	8	8.4	8	8.2	8.4	8.2	7.3	6.6	5.7	6	7.2	8.1	8.1	7.8	5.5	7.7	7.4	7.4
8.2	7.7	4	6.5	9	9.1	7.6	7.7	9.1	9.8	7.7	6.1	4.1	5.7	8.7	9.3	8.6	8.4	7.9	7.5	7.2	7.1
9.6	9.7	10.9	3.9	10.2	11.6	4.7	4.7	10.1	11.5	4.7	4.2	10.9	3.4	10.7	10.1	8.3	9.4	9	7.1	6.9	6.8
10.9	11.7	12.3	11.9	11.7	13.4	13.3	11.4	11.5	13.3	14.1	13.3	12.9	13.5	13	11.8	9.5	11.2	3.8	3.9	4	4.5
12.1	13.1	13.5	12.8	13	14.6	14.7	12.7	12.5	14.7	15.1	14.4	13.9	14.5	14.5	13.1	11.1	13.8	10.1	13.8	13.5	12.9
11.2	12.2	13.1	12.4	12.5	13.6	13.6	12.6	12.4	13.9	14	13.7	13.2	13.9	13.7	12.6	13.2	16.1	15.7	15.7	14.7	13.9
7.2	7.9	8.4	8	8.2	8.9	8.9	8.5	8.4	9.1	9.2	9	8.6	9	8.8	8.2	15.6	18.4	17.3	14.1	13.7	13.2
28.5	32.4	33.4	32.2	27.4	30.9	29.4	25.2	25.1	29.2	31.3	29.9	31	32.6	32	29.5	18.4	21.5	6.9	6.9	6.9	7.1
34.7	39	41.4	40.2	31.6	35.6	33	27	27.3	32.3	35.2	34.5	36.1	38	37.5	34.8	21.3	25.3	21.9	28.2	29.9	29
44.5	50.8	54.3	53.6	39.5	43.9	37.5	26.9	30	35.5	37.8	38.3	40.5	41.8	45.6	44.1	23.2	31.5	31.7	33.5	35.4	34.6
56.6	66.8	72.4	71.6	62.9	53.3	19.2	16.4	34.8	44.9	22.4	22	21.9	23.2	64.2	54.5	38.7	33.5	31.6	34.7	39	40.3
70.6	88.8	98.5	97.7	85.6	64.2	41.1	29.4	29.8	44.8	72.5	92	103	102	87.2	64.9	40.1	29	15.3	16.1	17.5	19.7

Clear Sky

1.8	1.7	1.7	1.6	1.9	2.2	2.3	2.2	1.7	2.3	2.2	1.9	1.6	1.8	2	2.3	2.3	2.2	2.2	2	2	1.7
1.5	1.7	1.6	1.8	1.5	1.9	2.1	2.1	1.6	1.7	2	2.1	1.6	1.9	2.2	2.2	2.1	2.2	2.3	1.8	1.7	1.8
1.3	1.6	2.2	1.8	1.6	1.7	2.5	2.4	1.4	1.5	2	2.2	1.5	2	2.2	2.2	2.2	2.4	1.9	1.6	1.7	1.8
0.7	1	1.9	2	0.9	1	2.5	2.5	0.9	1.1	2.5	2.2	1.9	2.1	2.3	2.3	2.3	2.4	1	1.1	1.1	1.1
2.5	2.3	1.8	2	2.6	2.7	2.6	2.6	2.8	2.7	2.3	2	1.7	1.8	2.4	2.8	2.7	2.6	1.8	2.7	2.4	2.4
2.8	2.8	1.2	2	3	3	2.2	2.3	2.9	3.3	2.4	1.8	1.1	1.7	3	3.2	2.8	2.8	2.6	2.3	2.3	2.2
3.4	3.5	25.6	1.1	3.5	4.1	1.3	1.3	3.3	4	1.3	1.2	25.6	1	3.9	3.5	2.7	3.3	3.1	2.2	2.1	2
4.1	4.4	4.6	4.5	4.2	4.9	4.8	3.9	4	4.8	5.1	4.8	4.8	5	4.8	4.2	3.2	4	1.1	1.1	1.2	1.3
4.7	5	5.2	5	4.7	5.5	5.4	4.4	4.4	5.4	5.6	5.3	5.3	5.5	5.4	4.8	3.8	5.2	3.6	5.1	4.8	4.8
3.5	3.8	4	3.8	3.8	4.1	4.1	3.8	3.8	4.1	4.2	4.1	4	4.2	4.1	3.8	4.7	6.1	5.9	5.8	5.6	5.1
2.4	2.5	2.6	2.5	2.5	2.7	2.7	2.6	2.5	2.7	2.8	2.7	2.6	2.7	2.7	2.5	5.7	7	6	4.3	4.3	4.2
13.2	15.3	16	15.5	12.1	13.7	12.4	9.6	10.2	12.5	14	13.6	14.9	15.5	14.6	13.1	6.9	8.3	2.1	2.1	2.1	2.2
17.9	20.7	22.3	21.7	15.7	17.3	14.5	10.5	11.7	15	17.7	17.6	19.9	20.4	19.3	17	8.3	10.4	9.6	12.7	14	14
25.7	30.8	33.6	33.1	22.8	23.5	17.6	10.4	13.7	18.2	20.8	22.2	25.3	25.3	26.7	23.8	9.6	13.6	14.3	16.5	19.1	19.6
39	48.8	54.3	52.8	44.1	33.1	5.9	5.2	16.4	25.6	6.7	6.6	6.8	7	44.4	33.9	19.5	13.9	13.9	19	25.2	27.1
60.8	81.3	90.7	88	72.6	46.2	18.8	10.5	12.5	28.4	62.1	83.6	93.4	90.6	73.6	46.6	18.4	10.3	5	5.3	6	7.4

Overcast

0.4	0.5	0.5	0.4	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.7	0.7	0.7
0.5	0.5	0.5	0.4	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.8	0.6	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.8	0.7
0.3	0.5	0.6	0.5	0.5	0.6	1.1	1	0.5	0.6	1.1	1	0.9	1	1	1	1	1	0.7	0.6	0.5	0.5
0.2	0.2	0.8	1	0.2	0.3	1.4	1.5	0.3	0.3	1.4	1.4	1.3	1.2	1.2	1.3	1.4	1.3	0.3	0.3	0.3	0.4
0.7	0.7	0.8	1.3	1.6	1.7	1.9	2	2.1	2.1	2	1.7	1.5	1.4	1.5	1.8	1.8	1.8	1.3	1.6	1.6	1.5
1	0.8	0.3	1.5	2	2.2	2.2	2.4	2.8	2.9	2.5	2	0.7	1.4	2.3	2.5	2.5	2.5	2.4	2.3	2.1	1.9
1.5	1.7	0	0.5	2.9	3.3	0.6	0.7	4.1	4.4	0.7	0.6	0	0.5	3.5	3.3	2.8	3.4	3	2.6	2.3	2
2.2	2.5	2.9	2.9	4.3	4.8	5.5	5.6	6.5	6.8	6.7	5.6	3.7	5.3	5	4.8	4.2	5.2	0.6	0.6	0.6	0.8
3	3.5	4.1	4.2	6.3	7.2	8.2	8.8	10.4	10.9	10.2	8.3	5.1	7.3	7	6.9	6.5	8.2	7.3	7.8	6.5	5.3
4.1	5.1	6.1	6.4	9.3	10.8	12.7	13.9	16.4	17.3	15.8	12.5	7.3	10.4	10.1	10.1	9.9	12.9	13.6	12.1	9.4	7.2
1.4	1.6	2.1	2.5	5.1	7.2	9.7	11.7	14.3	14.7	12.6	8.7	2.7	4.6	4.4	5.3	14.5	18.4	19.2	17	12.8	9.6
8	11.8	14.8	15.3	19.2	22.4	26.6	28.2	31.1	32	29.4	24.2	17	21.5	21	21.4	19.7	23.5	7.3	6.4	7.8	3.8
10.4	15.8	20	20.5	23.1	26.2	30.7	31.4	33.1	33.9	32	28.4	22.4	27.1	26.2	26.4	24.3	27.2	22.6	23.5	20	16
12	18.6	23.7	23.5	24.7	27	30.6	30.3	30.9	31.5	31	29.7	26.4	30	28.2	28	25.8	28.5	23.2	24.4	22	18.2
12.2	18.6	23.5	23	22.9	24	26.9	25.6	24.9	25.6	26.1	26.4	24	26.9	25.6	24.6	22.4	25.9	24.7	22.9	21.1	17.6
10.9	16	19.7	19.9	18.2	18.8	20	19.7	19	19	20.1	22.7	24.4	23	20.2	19.4	19.9	20.2	20.4	19	17.8	15

Row One Active

4.8	4.6	4	3.4	2.5	3.1	2.9	2.5	2	2.5	2.5	2.3	1.8	2.1	2	1.9	2.1	2.1	2.1	2	1.9	1.8
7.3	6.3	5.3	4.3	3.1	3.8	3.5	3	2.4	3	2.9	2.7	2.2	2.6	2.4	2.3	2.4	2.5	2.4	2.3	2.2	2
10.8	8.6	7.2	5.7	3.3	4.3	4.6	3.9	2.3	3	3.6	3.4	3	3.2	3	2.9	3.1	3.2	2.7	2.3	2.1	2
1.2	1.3	9.6	8.1	1	1.1	6.2	5.9	0.8	1	5.2	5	4.7	3.7	3.7	4	4.4	4.5	0.9	0.9	0.9	1
19.3	13.9	11.3	11.1	10.9	10.4	8.9	8	7.7	7.7	7.7	7	6.3	4.5	4.8	6	6.5	6.8	5.6	6.1	5.6	5.1
20.9	14.4	7.5	14.2	16.3	14.8	12.4	10.8	10.7	11.1	11.2	10.7	3.2	4.9	7.9	9.3	10.1	10.5	10.2	9.2	8.2	7.2
21.4	18	0	8.5	20.9	20.3	6.6	4.9	13.6	16.7	5.6	5.8	0	4.2	13.1	12.8	14	16	15	13.2	11.6	9.9
20.8	20.1	21.4	24.1	26.3	25.8	21.8	18.2	18.4	24.2	26.3	25.6	19.3	20.3	18.4	17.9	18.8	22.2	1.8	1.8	2	2.8
21.1	21.5	23	26.1	28.8	29	25.3	22.8	25.1	31.6	32.9	30.5	22.4	25.2	24.1	23.1	23.1	27	24.5	25.6	23.6	20
22.6	23.4	24	25.9	28.7	30.1	28.3	27.3	31.2	37.5	37	32.8	23.5	29.5	29.4	27.9	25.8	29.5	29	28.9	26.3	21.9
19.5	19.3	18.5	18.9	20.6	23.2	23.3	23.5	27.1	31.9	30.2	25.5	16.9	23	23.7	22.4	27.6	31.1	31.7	30.1	26.1	21.2
19.8	23.2	25.2	24.9	27.9	31.9	35.1	35.8	38.9	42.3	40	34.7	26.4	34.3	34.7	33.4	29.2	32.5	17.1	16.4	17.6	12.6
18.1	23.6	27.2	26.9	28.5	32.6	36.7	36.7	38.3	40.6	39	35.4	28.8	35.6	35	34.4	30.7	33.3	26.8	28.9	25.2	20.8
16.8	23.5	28.4	27.6	28.2	31.3	34.8	34	34.3	36	35.7	34.4	30.6	35.5	33.7	33	29.9	32.6	26	28	25.5	21.4
15.2	21.8	26.5	25.7	25.2	27	30.3	28.4	27.4	28.8	29.9	30.1	27.3	31.1	29.1	27.8	25.2	28.9	27.5	25.5	23.5	19.9
13	18	21.8	22	20.3	20.7	21.3	21	20.9	21.1	21.5	23.8	25.6	24.3	22.3	21.8	22.3	22.4	22.9	21.3	19.9	16.9

Rows One and Two Active

18.6	26.6	29.3	28	27.5	28.1	26.6	24.1	19.9	26.4	27.9	25.1	22.9	25.8	26.6	27.3	25	21	17.7	14.9	12.3	10
22.8	31.5	34.4	31.6	30.9	31.7	30.9	29.2	25.6	32	33.9	30.5	27.2	27.9	27.2	27.4	27.3	24.9	22	19.7	16.5	12.9
26.3	33.8	35.8	31.5	30.1	31.7	32.9	33.3	30.3	35.1	36.1	32.7	29.6	29.9	28.5	26.9	26.5	25.8	25.6	24.9	21.3	15.9
14.7	23.4	33.5	30.4	20.8	20.6	33.3	36	19.1	25.7	34.5	31.9	30.1	29.4	28.2	26.3	25.7	26.1	13.7	12.4	10.4	8.7
33	29.5	28.9	28.2	27.7	29.3	32.8	36	35	32	30.6	28.6	27.6	26.4	26.7	26.9	26.4	27	23.7	30.1	26.5	19.9
30.2	24.9	20.2	26	28.1	29.3	31.5	33.3	32	28.9	26.7	25.2	19	22.4	26.6	28.8	28.7	28	25.3	28.7	25.4	19.6
26.6	22.9	0	17	27.9	29.3	23.1	23.8	26.6	26.7	18.5	16.9	0	16.2	26.5	28.8	29.6	29	28.4	27	23.6	19
22.4	22.2	21.6	22.9	29	29.1	25.5	22.3	22.6	27	27.5	25.3	21.1	23.7	25.3	25.9	26.9	29	14.5	13.8	12.4	11.2
20.8	21.6	21.8	23.9	27.5	27.5	23.5	20.7	21.4	27.5	28.9	26.5	22.1	24.6	25.2	24.3	24.8	26.8	21.8	24.1	22.8	19.5
20.6	21.1	20.3	21.2	23	23.4	20.1	17.8	19.3	24.9	25.6	23.6	19.9	24.2	24.7	22.9	21	21.9	18.4	21.1	21	18.3
20.2	20.4	18.7	18.1	18.6	19.7	17.6	15.5	16.6	21.3	21.5	19.8	17.5	22.8	23.9	21.3	16.4	16.2	15.8	16.2	16.3	14.3
12.4	12.2	11.1	10.3	9.5	10.4	9.5	8.5	8.8	11.4	11.7	11.4	10.6	14.1	15	13.4	11.8	11.5	13	12.9	12.5	11.2
8.8	8.9	8.2	7.2	6.7	7.9	7.6	6.8	6.6	8.4	8.6	8.3	7.8	10.3	10.7	9.5	8	7.9	4.9	6.4	6.2	5.7
5.7	5.8	5.6	4.8	4.6	5.6	5.5	4.9	4.7	5.9	6	5.8	5.4	6.9	7	6.3	5.4	5.5	3.7	4.8	4.6	4.3
3.9	3.9	3.8	3.3	3.2	4	4.6	3.9	3.4	4.3	5.1	4.9	4.5	5.5	4.7	4.2	3.8	4	3.8	3.6	3.4	3.2
2.8	2.7	2.7	2.6	2.8	2.7	1.8	1.8	2.8	3	1.9	1.5	1.5	1.7	2.9	3.3	3.3	3.1	3.6	3.4	3.1	2.9

Rows Two and Three Active

14.2	22.5	25.7	25.1	25.7	25.8	24.4	22.3	18.6	24.8	26.3	23.6	21.6	24.3	25.3	26	23.7	19.8	16.4	13.7	11.2	8.9
15.9	25.8	29.6	27.8	28.6	28.7	28.2	27	24	29.9	31.9	28.7	25.7	26.1	25.7	25.9	25.7	23.3	20.5	18.2	15.1	11.6
15.8	25.7	29.2	26.3	27.3	28	29.4	30.4	28.6	32.7	33.5	30.4	27.5	27.8	26.5	24.9	24.5	23.6	23.6	23.2	19.7	14.5
13.6	22.3	24.7	23.3	20	19.8	28.4	31.6	18.5	25.1	30.7	28.4	26.6	26.9	25.7	23.6	22.6	23	13.2	11.9	9.9	8.1
14.4	16.3	18.4	18.5	18.3	20.6	25.7	29.9	29.4	26.5	24.9	23.3	22.8	23.3	23.5	22.8	21.8	22	19.4	25.6	22.5	16.3
10.4	11.3	13	13.2	13.9	16.6	21.3	24.8	24.1	20.6	18	16.5	16.5	18.8	21	22	21.1	20	17.6	21.8	19.3	14.3
6.8	6.6	0	9	10	12.3	17.1	19.5	17.1	14.4	13.6	11.8	0	12.5	17	19.3	18.4	16.5	16.5	16.5	14.4	11.2
3.7	4.6	3.2	1.6	7	8.1	9.2	9.8	10.6	9.7	7.8	5.4	5.6	8.7	11.9	12.8	12.4	12	13.4	12.6	11.1	9.3
2.7	3.6	3	2	4.9	5.7	6.5	6.7	6.7	6.7	6.2	4.3	4.8	6.6	8.2	8	8.1	8.1	4.5	6.3	5.7	4.9
2.1	2.7	2.4	1.7	3.6	4.1	4.4	4.4	4.5	4.7	4.4	3.3	3.7	5.1	5.4	5.1	5.1	5.2	3	4.4	4.1	3.7
2.1	2.6	2.3	1.7	3.1	3.7	3.9	3.7	3.8	4.1	3.9	3.1	3.3	4.5	4.6	4.1	3.3	3.5	3.3	3.1	3	2.7
0.7	0.7	0.7	0.7	0.8	0.9	0.9	0.9	1	1.1	1.1	0.9	1.2	1.3	1.4	1.4	2.3	2.5	3.2	2.9	2.7	2.4
1.1	1.1	1	0.8	1.3	1.5	1.6	1.4	1.5	1.6	1.7	1.3	1.5	1.8	1.8	1.6	1.6	1.8	0.7	0.9	0.9	0.9
1	1	0.9	0.7	1.1	1.3	1.3	1.2	1.2	1.4	1.4	1.1	1.2	1.5	1.5	1.3	1.2	1.3	0.9	1.2	1.2	1.1
0.8	0.8	0.7	0.6	0.9	1	1.2	1.1	1	1.1	1.3	1.1	1.2	1.4	1.2	1	1	1	1	1	1	0.9
0.7	0.6	0.6	0.5	0.7	0.8	0.6	0.6	0.9	0.9	0.5	0.4	0.4	0.4	0.8	0.9	0.9	0.9	1.1	1	1	1

Row Three Active

62.3	49.6	49.6	62.3	35	33.9	33.3	33.7	35.3	29.4	29.3	29.8	41.5	35.3	34.4	33	33.1	29	29.3	33.9	34	34.86
90.6	89.6	89	112	56.3	54.8	54	54.1	56.1	49	48.3	54.3	75	55.3	54.4	53.8	54	48.1	54.5	55.4	55.5	35.14
153	89.6	73.2	89	90.6	74.2	38.5	42.6	90.6	74.7	39.5	43.4	50	43.8	43.3	43.3	43.3	43.1	62.7	74.7	89.6	49.6
238	234	54.9	43.6	236	155	29.9	28	157	155	30.4	30.7	33.8	36.3	36	33	30.6	32.9	155	154	155	66
61.3	61.9	55.3	33.5	26.3	24.5	22.1	20.9	19.8	19.9	21.4	25.5	29.5	31.4	28.5	23.3	23.3	23.4	34.2	26.4	26.6	15.07
41.8	52.9	153	29	20.5	18.6	19.3	17.6	14.6	13.9	16.9	22	65.6	31.6	18	16.3	16.6	16.6	17.5	18.5	20.4	12.05
26.9	23.7		92.2	13.7	11.6	75.5	64.7	9.73	8.75	64.7	76.3		93.2	11.2	12.1	14.9	11.9	13.7	16.5	18.7	11.6
17.8	15.3	13	13.1	8.91	7.63	6.67	6.89	5.92	5.4	5.36	6.55	10	6.89	7.4	7.96	9.64	7.46	77	76.8	76.7	31.88
12.6	10.5	8.9	8.86	5.87	4.92	4.3	4.24	3.61	3.24	3.42	4.29	7.08	4.86	5.07	5.35	5.98	4.41	5.47	4.64	5.62	3.226
9.46	7.41	6.05	5.88	4.03	3.37	2.87	2.69	2.29	2.09	2.28	2.9	5.04	3.47	3.59	3.7	3.72	2.63	2.52	2.83	3.76	2.236
30.6	26.3	19.8	16.8	8.2	5.71	4.24	3.55	2.91	2.78	3.24	4.71	15.3	8.91	9.36	7.89	2.37	1.72	1.7	2.11	2.84	1.75
2.69	1.49	1.12	1.16	1.18	0.85	0.77	0.88	0.8	0.65	0.64	0.83	1.12	0.81	0.86	0.96	1.6	1.21	5.9	6.73	5.53	6.026
1.47	0.7	0.43	0.48	0.8	0.55	0.55	0.73	0.69	0.52	0.46	0.55	0.62	0.44	0.48	0.58	1.18	0.91	1.24	0.93	1.01	0.063
0.46	-0	-0.2	-0.2	0.43	0.23	0.41	0.76	0.65	0.46	0.39	0.39	0.36	0.27	0.16	0.21	1.04	0.65	0.79	0.68	0.66	-0.25
-0.5	-0.9	-1	-0.9	-0.6	-0.1	1.14	1.31	0.61	0.2	1.06	1.06	1.17	1	-0.6	-0.2	0.5	0.64	0.74	0.67	0.52	-0.59
-3.7	-3.7	-3.5	-3.4	-3.1	-1.8	-0.6	0.03	0.01	-0.8	-2.1	-2.7	-3	-3.1	-2.8	-1.8	-0.5	0.05	0.72	0.73	0.7	0.687

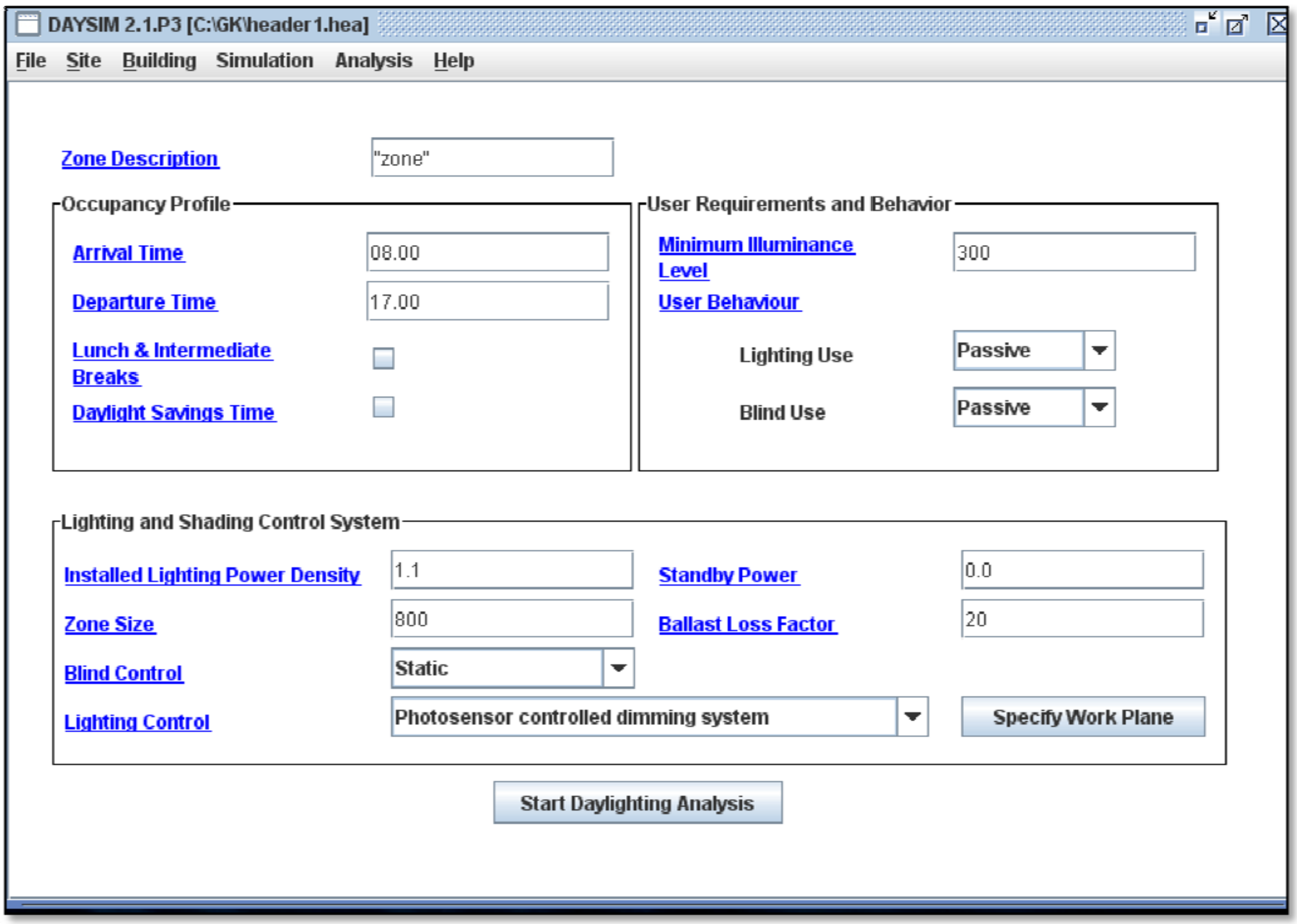
Dim Level = (Target Level – Clear Condition) / Row One Active

*NOTE: These plots also show striations formed by the cubicle walls within the room, and care was taken not to select a photosensor location which could be shaded at some point during the day.

Daysim Analysis

After the critical point has been determined, Daysim simulation software can be used to quantify any savings which might be achieved by the implementation of a dimming photosensor system. The room and surrounding geometry were modeled in AutoCAD and then imported into the program. Daysim is then able to simulate long-term use of the system and provide estimates of the total energy used by the lighting system annually. The original target value for illuminance on the work plane was 30fc without the use of personal task lighting. The analysis was run without blinds or shades because the windows are well protected from direct solar glare by their orientation and position within the building. An additional analysis was completed using a target illuminance value of over 1 million, thereby preventing the system from ever dimming and providing a data set for a comparable non-dimming lighting solution.

Daysim Inputs



Results

Daysim Simulation Report (Non-Dimming System)

In short...

- Daylight Factor (DF) Analysis: 100% of all illuminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone should qualify for the LEED-NC 2.1 daylighting credit 8.1 (see www.usgbc.org/LEED/).
- Daylight Autonomy (DA) Analysis: The daylight autonomy for the core workplane sensor is 0% .
- Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are $UDI_{<100}$=1%, $UDI_{100-2000}$=38%, $UDI_{>2000}$=61% .
- Continuous Daylight Autonomy (DA_{con})and DA_{max} Analysis: 0% of all illuminance sensors have a DA_{con} above 40% . 0% of all illuminance sensors have a DA_{max} above 5% .
- Electric Lighting Use: The predicted annual electric lighting energy use in the investigated lighting zone is: 3.6 kWh/unit area. Assuming a lighting zone size of 800 [unit area], this corresponds to a **total annual lighting energy use of 2914.7 kWh.**

Daysim Simulation Report (Photosensor Dimming System)

In short...

- Daylight Factor (DF) Analysis: 100% of all illuminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone should qualify for the LEED-NC 2.1 daylighting credit 8.1 (see www.usgbc.org/LEED/).
- Daylight Autonomy (DA) Analysis: The daylight autonomy for the core workplane sensor is 98% .
- Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are $UDI_{<100}$=1%, $UDI_{100-2000}$=38%, $UDI_{>2000}$=61% .
- Continuous Daylight Autonomy (DA_{con})and DA_{max} Analysis: 100% of all illuminance sensors have a DA_{con} above 80% . 100% of all illuminance sensors have a DA_{max} above 5% .
- Electric Lighting Use: The predicted annual electric lighting energy use in the investigated lighting zone is: 0.6 kWh/unit area. Assuming a lighting zone size of 800 [unit area], this corresponds to a **total annual lighting energy use of 477.0 kWh.**

Conclusion

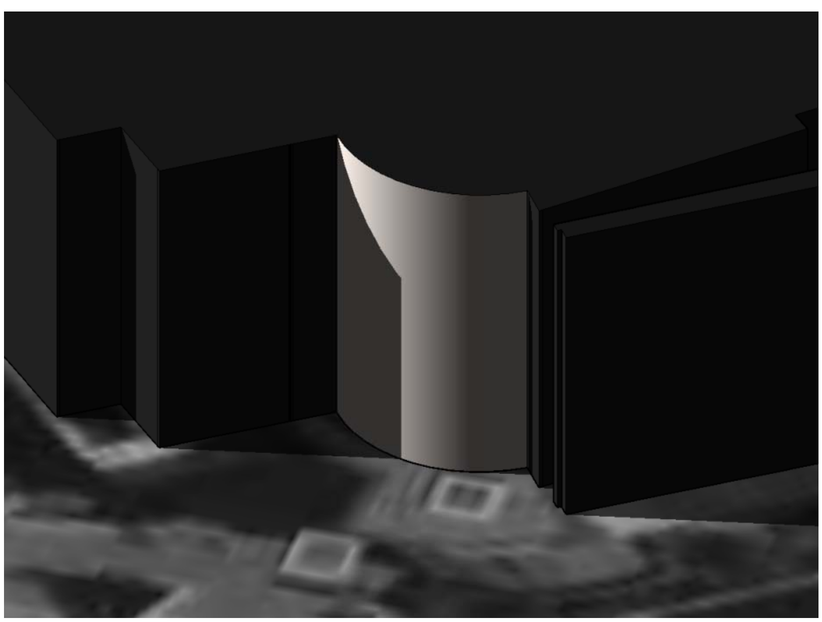
The simulation results indicated a possible lighting power savings of approximately 2437.7 kWh. At an approximate utility cost of $0.09033 per kWh (see the derivation of this value in the photovoltaic electrical depth study), the installation of a photosensor dimming system in the office space has the potential to save just $220 per year. This is likely not enough savings to warrant the installation of photosensor system in this space financially. The low savings is likely due to the relatively small size of the windows in comparison to the space. In addition, since the orientation of the windows is to the north, the amount of available daylight is limited.

MECHANICAL BREADTH – CURTAIN WALL STUDY

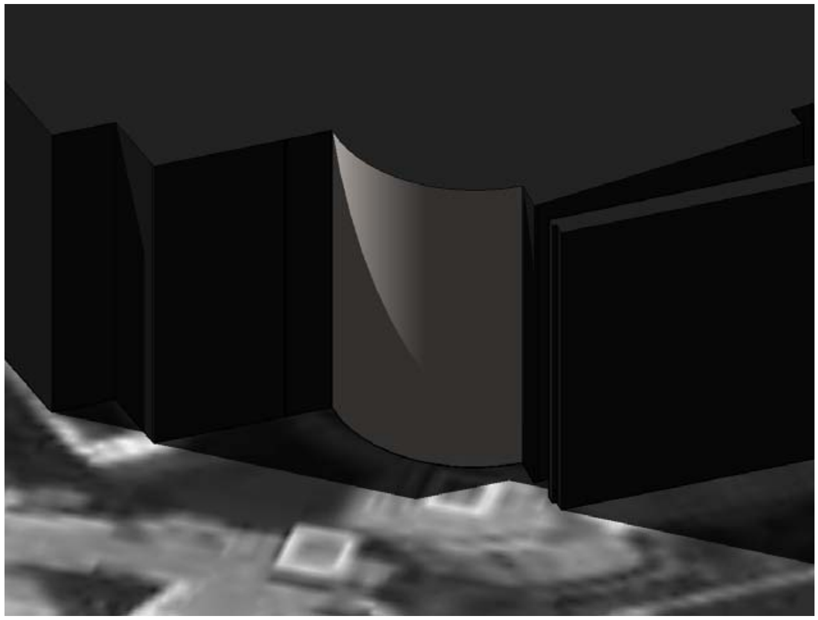
One of the most prominent architectural features of the building is the four-story glass curtain wall between the lobby and the north plaza space. Although visually important to the architecture, this large expanse of glazing has the potential to be a weak point in the building envelope. The thermal impact of the north curtain wall is the subject of this mechanical breadth study.

Solar Study

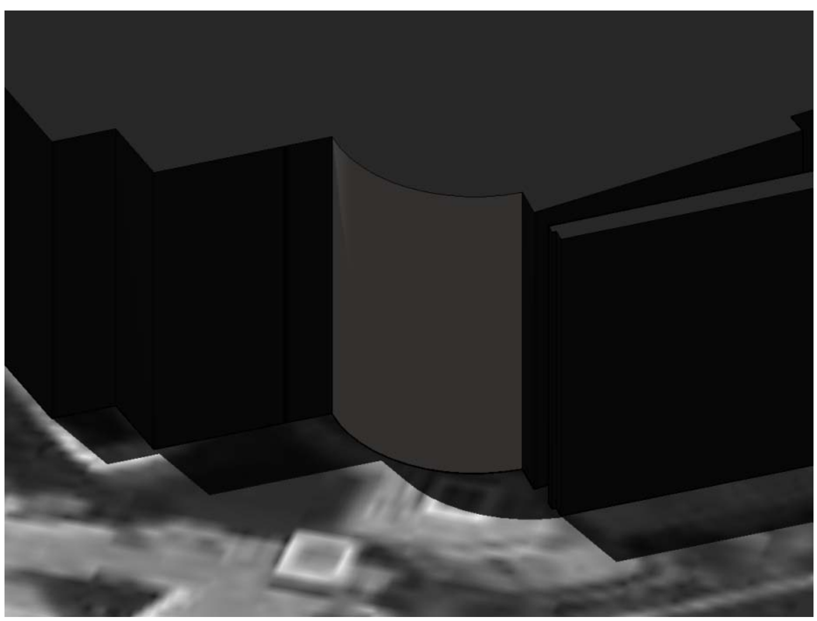
A solar penetration study was performed for the curtain wall to determine the amount of possible solar gain for the lobby. Because the curtain wall faces roughly north, the summer solstice was determined to be the worst-case scenario for daylight penetration into the space, as the sun travels to its most northern point in the sky at noon. Several times were analyzed on this day. As illustrated by the figures below, very little direct sunlight is able to enter the space, even on the solstice. This information suggests that the solar heat gain calculated in this study may be somewhat high as compared to the real value if the calculation assumes no additional shading of the curtain wall.



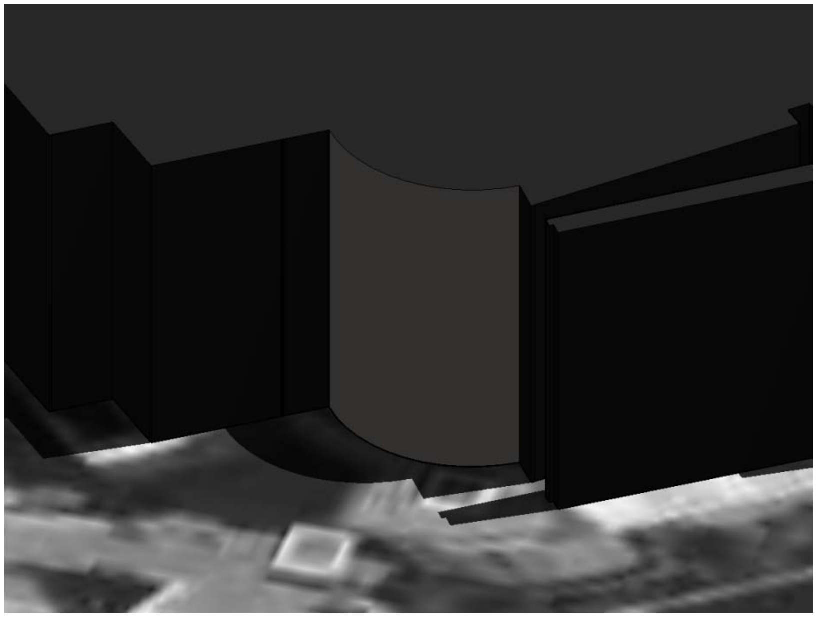
Summer Solstice – June 21 – 7AM



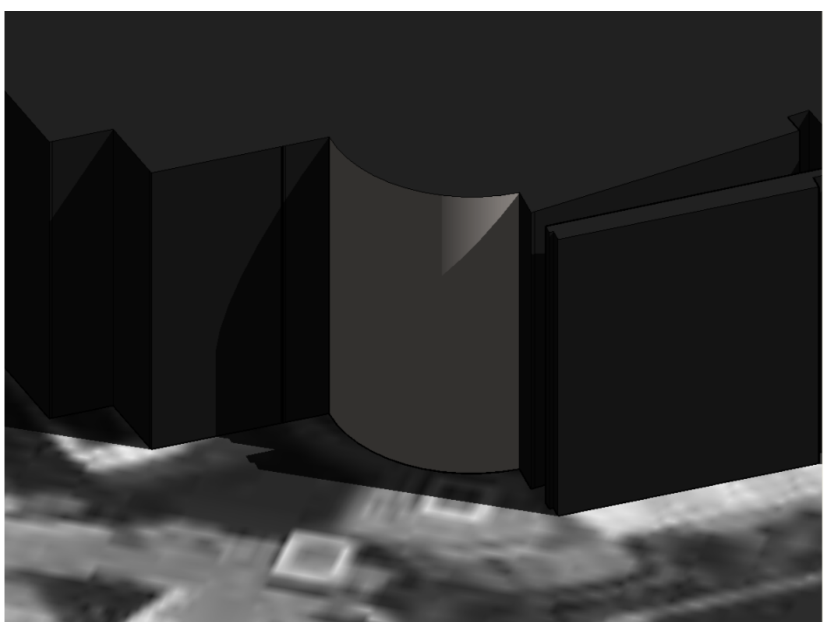
Summer Solstice – June 21 – 9AM



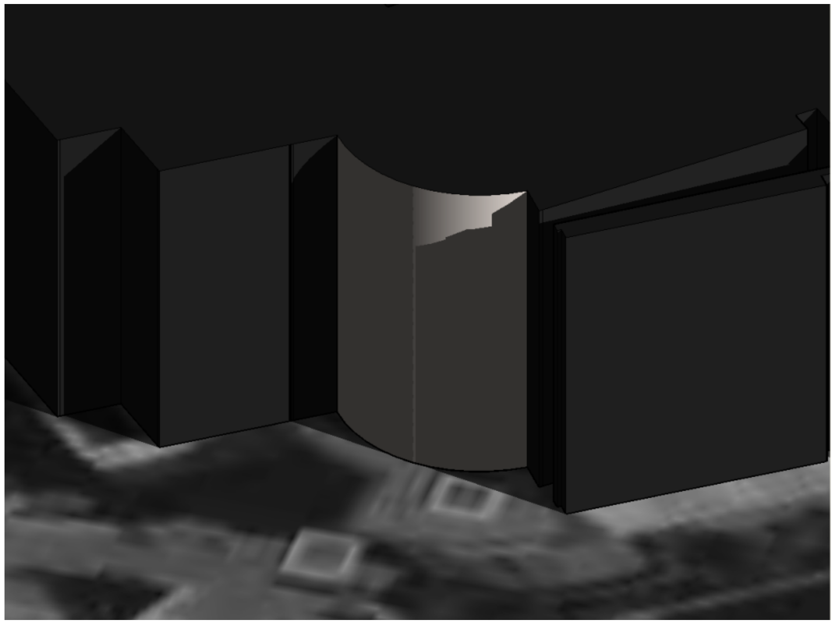
Summer Solstice – June 21 – 11AM



Summer Solstice – June 21 – 1PM



Summer Solstice – June 21 – 3PM



Summer Solstice – June 21 – 5PM

Existing Glazing

The curtain wall glazing is defined in the project specifications to be 1" thick insulated Heat Mirror 66 Clear with a U-value of 0.29 and a minimum shading coefficient (SC) of 0.44. Using the online window heat gain calculation tool at *http://susdesign.com/windowheatgain/index.php*, approximate heat gain values in BTU/ft^2/day have been calculated for each month based on climate data for Los Angeles, California.

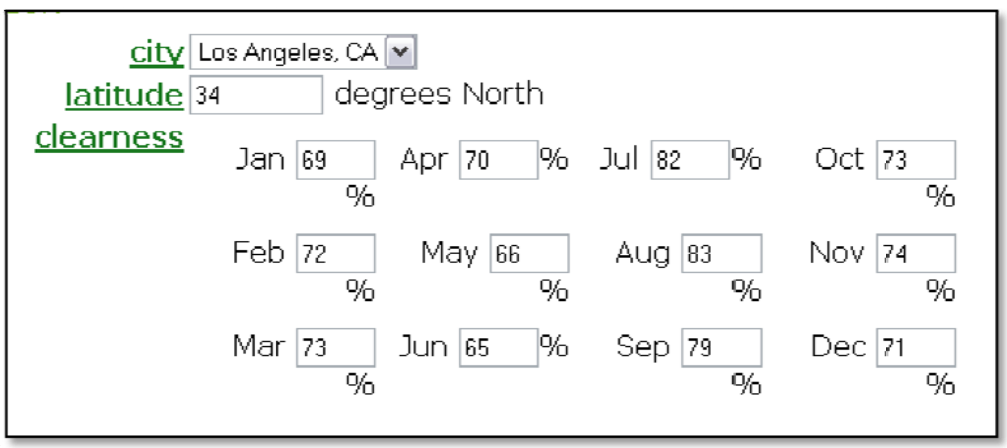
Input Data Assumptions / Calculations

Solar Heat Gain Coefficient (SHGC):
SHGC = SC x 0.87 = 0.44 x 0.87 = 0.3696 ≈ 0.37

Ground Surface Reflectance:
New Concrete = 0.32

Façade Orientation:
North

Climate Data



city: Los Angeles, CA
latitude: 34 degrees North
clearness:

Jan 69 %	Apr 70 %	Jul 82 %	Oct 73 %
Feb 72 %	May 66 %	Aug 83 %	Nov 74 %
Mar 73 %	Jun 65 %	Sep 79 %	Dec 71 %

* Based on National Climatic Data Center (NCDC) measurements – www.ncdc.noaa.gov

Output and Calculated Heat Gain

Month	Heat Gain Rate (BTU per ft² per Day)	Calculated Heat Gain (BTU per Day)	Days	Monthly Heat Gain (BTU)
January	52	139457	31	4323182
February	71	190413	28	5331567
March	93	249414	31	7731845
April	113	303052	30	9091556
May	139	372781	31	11556199
June	157	421054	31	12631630
July	178	477374	30	14798585
August	140	375462	31	11263874
September	102	273551	30	8480088
October	74	198459	31	5953762
November	56	150185	31	4655735
December	47	126048	30	3781444
		ANNUAL TOTAL	365	99599467

* Curtain wall glass area used for these calculations: 2681.9 ft²

Modified Glazing ↓

A new curtain wall glazing has been selected as a comparison to analyze energy savings over the existing system. PPG SOLARBAN 70XL glass has been chosen for its low solar heat gain coefficient and superior visible light transmission, which is an important architectural design quality. Partial product specifications are included below.

Solarban® 70XL Glass Performance — Commercial Insulating Glass Unit

Insulating Vision Unit Performance Comparisons 1-inch (25mm) units with 1/2-inch (13mm) airspace and two 1/4-inch (6mm) lites; interior lite clear unless otherwise noted

Glass Type	Transmittance			Reflectance		U-Value (Imperial)		European U-Value	Shading Coefficient	Solar Heat Gain Coefficient	Light to Solar Gain (LSG)
	Ultra-violet %	Visible %	Total Solar Energy %	Visible Light %	Total Solar Energy %	Winter Night-time	Summer Day-time				
Coated											
SOLARBAN® 70XL Solar Control Low-E Glass*											
SOLARBAN 70XL (2) STARPHIRE	6	64	25	12	52	0.28	0.26	1.50	0.32	0.27	2.37
SOLARBAN 70XL (3) SOLEXIA	3	56	20	11	13	0.28	0.26	1.50	0.37	0.32	1.74
SOLARBAN 70XL (3) ATLANTICA	2	49	17	10	8	0.28	0.26	1.50	0.32	0.28	1.74
SOLARBAN 70XL (3) CARIBIA	2	49	17	9	8	0.28	0.26	1.50	0.32	0.28	1.75
SOLARBAN 70XL (3) AZURIA	4	49	17	9	8	0.28	0.26	1.50	0.33	0.29	1.70
SOLARBAN 70XL (3) Bronze	3	38	15	8	20	0.28	0.26	1.50	0.30	0.26	1.48
SOLARBAN 70XL (3) Gray	2	32	13	7	15	0.28	0.26	1.50	0.27	0.24	1.34
SOLARBAN 70XL (3) OPTIGRAY 23	1	17	7	5	7	0.28	0.26	1.50	0.19	0.16	1.04
SOLARBAN 70XL (3) GRAYLITE	1	10	5	5	11	0.28	0.26	1.50	0.16	0.14	0.71

www.ppg.com

Input Data

Solar Heat Gain Coefficient (SHGC):

SHGC = 0.27

Output and Calculated Heat Gain

Month	Heat Gain Rate (BTU per ft² per Day)	Calculated Heat Gain (BTU per Day)	Days	Monthly Heat Gain (BTU)
January	38	101911	31	3159249
February	52	139457	28	3904810
March	67	179686	31	5570254
April	82	219914	30	6597412
May	101	270869	31	8396950
June	114	305734	31	9172012
July	130	348644	30	10807956
August	102	273551	31	8206537
September	75	201141	30	6235359
October	54	144821	31	4344637
November	41	109957	31	3408663
December	34	91184	30	2735512
		ANNUAL TOTAL	365	72539350

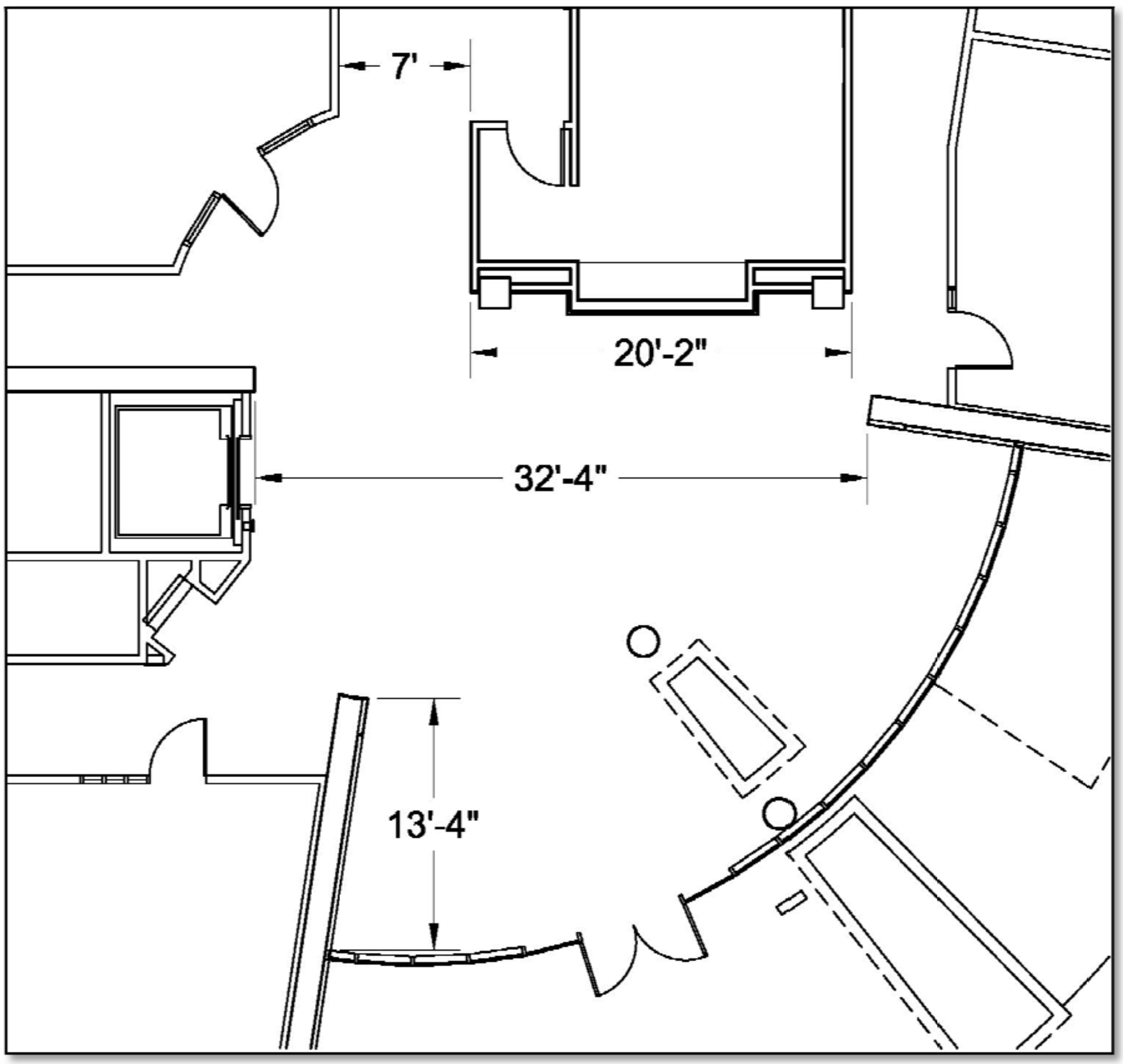
Conclusions

After completing the thermal gain analysis, the modified curtain wall system using PPG SOLARBAN 70XL glass is expected to reduce the annual heat gain from 99,599 kBTU to 72,539 kBTU. This represents an approximate 27% reduction in cooling load for this space. Although the initial installation cost would be higher, consideration of a more thermally resistant glazing system for the north curtain wall is recommended.

ACOUSTICS BREADTH – LOBBY ANALYSIS

The main entry lobby of the building is an important space within Natural Science Unit II and the surrounding campus. This area is intended to be a place for social and academic interaction between student and faculty at the university. In order to accommodate comfortable conversation in this space, an appropriate acoustic environment is required. For this reason, an analysis of the acoustics in the first floor lobby space has been analyzed in this study. The main purpose of the analysis is to determine whether the lobby area meets recommended professional standards of acoustical quality. It is unlikely that this type of analysis was performed during the design and construction of the project. In addition, an architectural change to a portion of the ceiling (from acoustic ceiling tile to gypsum) was made during the lighting redesign of this space. The effects of this change have also been determined in the following analysis.

Room Dimensions



Partial First Floor Plan
Scale: NTS

Material Properties

DESCRIPTION	MATERIAL	ABSORPTION COEEFFICIENT (α)					
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Floor 1	Carpet on Concrete	0.020	0.060	0.140	0.370	0.600	0.650
Floor 2	Stone	0.010	0.010	0.015	0.020	0.020	0.020
Interior Walls	Gypsum Wall Board	0.290	0.100	0.050	0.040	0.070	0.090
Wooden Panel Wall	Wood	0.150	0.110	0.100	0.070	0.060	0.070
Concrete Walls	Concrete	0.010	0.010	0.015	0.020	0.020	0.020
ACT Ceiling	Acoustic Ceiling Tile	0.760	0.930	0.830	0.990	0.990	0.940
Ceiling 2	Gypsum	0.290	0.10	0.050	0.040	0.070	0.090
Interior Doors	Wood	0.190	0.140	0.090	0.060	0.060	0.050
Elevator Doors	Steel	0.050	0.100	0.100	0.100	0.070	0.020
Exterior Doors	Steel	0.050	0.100	0.100	0.100	0.070	0.020
Curtain Wall	Glass - Heavy	0.180	0.060	0.040	0.050	0.020	0.020
Curtain Wall Framing	Steel	0.050	0.100	0.100	0.100	0.070	0.020
Interior Windows	Glass - Ordinary	0.180	0.060	0.040	0.030	0.020	0.020
Corridor Openings	Open	0.600	0.600	0.600	0.600	0.600	0.600

Reverberation Time – Existing

DESCRIPTION	SURFACE AREA S [ft²]	S x α					
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Floor 1	696	13.92	41.76	97.44	257.52	417.60	452.40
Floor 2	534	5.34	5.34	8.01	10.68	10.68	10.68
Interior Walls	517	149.93	51.70	25.85	20.68	36.19	46.53
Wooden Panel Wall	132	19.80	14.52	13.20	9.24	7.92	9.24
Concrete Walls	330	3.30	3.30	4.95	6.60	6.60	6.60
ACT Ceiling	499	372.40	455.70	406.70	485.10	485.10	460.60
Ceiling 2	490	144.71	49.90	24.95	19.96	34.93	44.91
Interior Doors	42	7.98	5.88	3.78	2.52	2.52	2.10
Elevator Doors	24	1.20	2.40	2.40	2.40	1.68	0.48
Exterior Doors	42	2.10	4.20	4.20	4.20	2.94	0.84
Curtain Wall	594	106.92	35.64	23.76	29.70	11.88	11.88
Curtain Wall Framing	18	0.90	1.80	1.80	1.80	1.26	0.36
Interior Windows	48	8.64	2.88	1.92	1.44	0.96	0.96
Corridor Openings	226	135.60	135.60	135.60	135.60	135.60	135.60
	Space Volume (V)	13,530 ft³					
	$a = \Sigma (S \times \alpha)$	837.14	810.62	754.56	987.44	1155.86	1183.18
	$T_{60} = 0.05 \times V/a$	0.808	0.835	0.897	0.685	0.585	0.572

a = Room Absorption (Sabins)

T_{60} = Reverberation Time (Seconds)

Reverberation Time – Designed

DESCRIPTION	SURFACE AREA S [ft²]	S x α					
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Floor 1	696	13.92	41.76	97.44	257.52	417.60	452.40
Floor 2	534	5.34	5.34	8.01	10.68	10.68	10.68
Interior Walls	517	149.93	51.70	25.85	20.68	36.19	46.53
Wooden Panel Wall	132	19.80	14.52	13.20	9.24	7.92	9.24
Concrete Walls	330	3.30	3.30	4.95	6.60	6.60	6.60
ACT Ceiling	0	0.00	0.00	0.00	0.00	0.00	0.00
Ceiling 2	989	286.81	98.90	49.45	39.56	69.23	89.01
Interior Doors	42	7.98	5.88	3.78	2.52	2.52	2.10
Elevator Doors	24	1.20	2.40	2.40	2.40	1.68	0.48
Exterior Doors	42	2.10	4.20	4.20	4.20	2.94	0.84
Curtain Wall	594	106.92	35.64	23.76	29.70	11.88	11.88
Curtain Wall Framing	18	0.90	1.80	1.80	1.80	1.26	0.36
Interior Windows	48	8.64	2.88	1.92	1.44	0.96	0.96
Corridor Openings	226	135.60	135.60	135.60	135.60	135.60	135.60
	Space Volume (V)	13,530 ft³					
	a = Σ (S x α)	742.44	403.92	372.36	521.94	705.06	766.68
	T_{60} = 0.05 x V/a	0.911	1.675	1.817	1.296	0.959	0.882

Comparison / Analysis

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
T_{60} – Existing (Seconds)	0.808	0.835	0.897	0.685	0.585	0.572
T_{60} – Designed (Seconds)	0.911	1.675	1.817	1.296	0.959	0.882
Difference (Seconds)	0.103	0.840	0.920	0.611	0.374	0.310

The removal of the acoustic ceiling tile from the center of the lobby creates a notable increase in the reverberation times within the space. This difference has the potential to adversely affect the quality of speech recognition in the lobby. Any increase in reverberation time is undesirable in the space. However, the final values for reverberation time are still marginally acceptable for a large public space such as this. Several unknown variables such as plant life and human occupancy in the space will also likely act to decrease the reverberation time here.

If the project budget allows, addition of sound absorbing materials back into the space should be used to improve the acoustic performance. Another option is to change the lighting design back to be integrated into an acoustic tile ceiling in the lobby. For this project, the lighting design and visual experience of the space from indoors and outdoors are of greater importance than a minor improvement in acoustic quality. Ideally, a new sound dampening method would allow the lighting appearance to stay fairly constant while still reducing the reverberation time in the room.