CHALLENGES AND OPPORTUNITIES OF INCORPORATING LM-83 INTO BUILDING SIMULATIONS

2017 International Radiance Workshop

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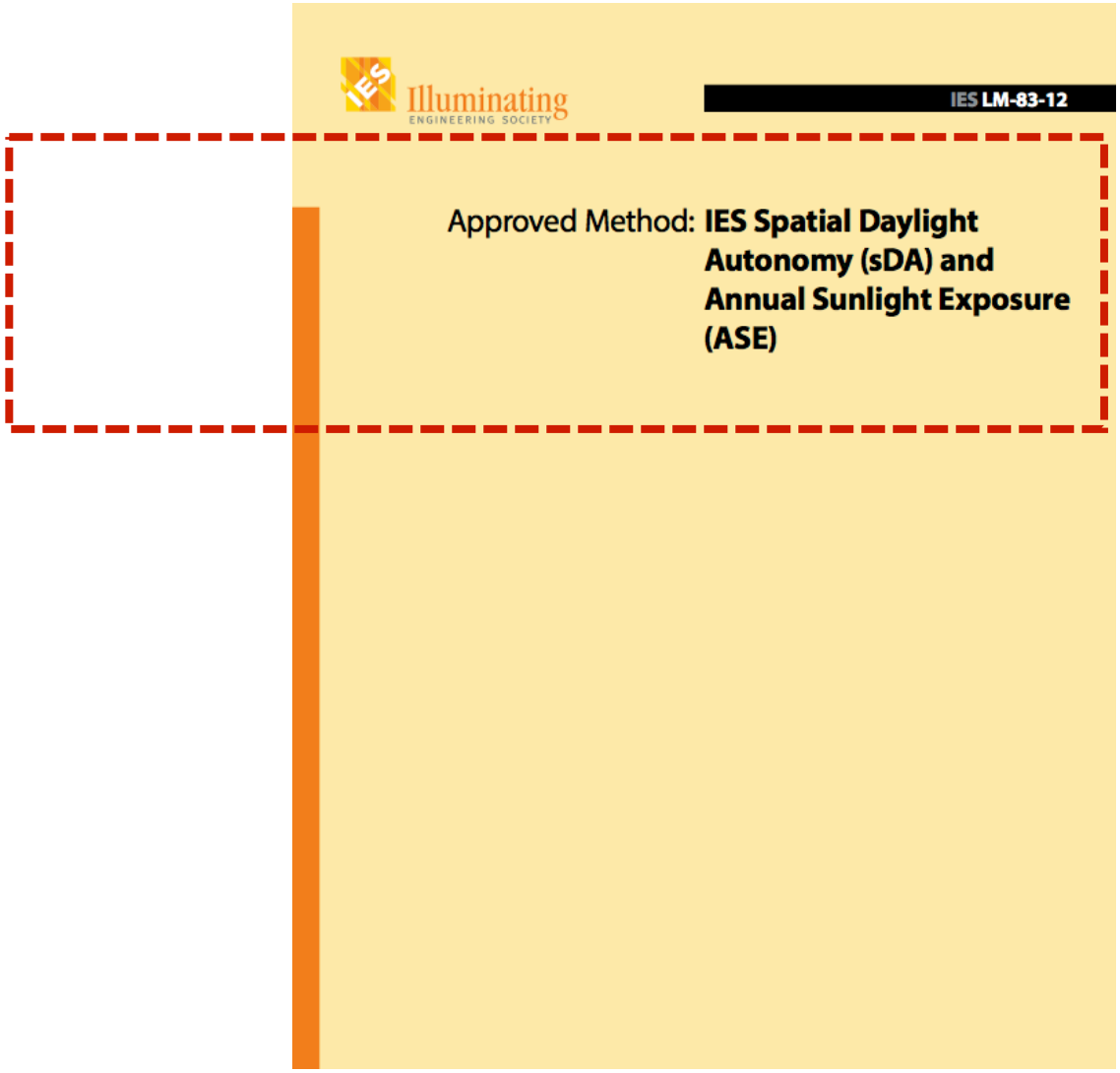
IES LM-83

1. **Annual dynamic daylight metrics**
2. Proposing a manual blind control pattern



IES LM-83-12 Approved Method:

Spatial Daylight Autonomy (sDA)

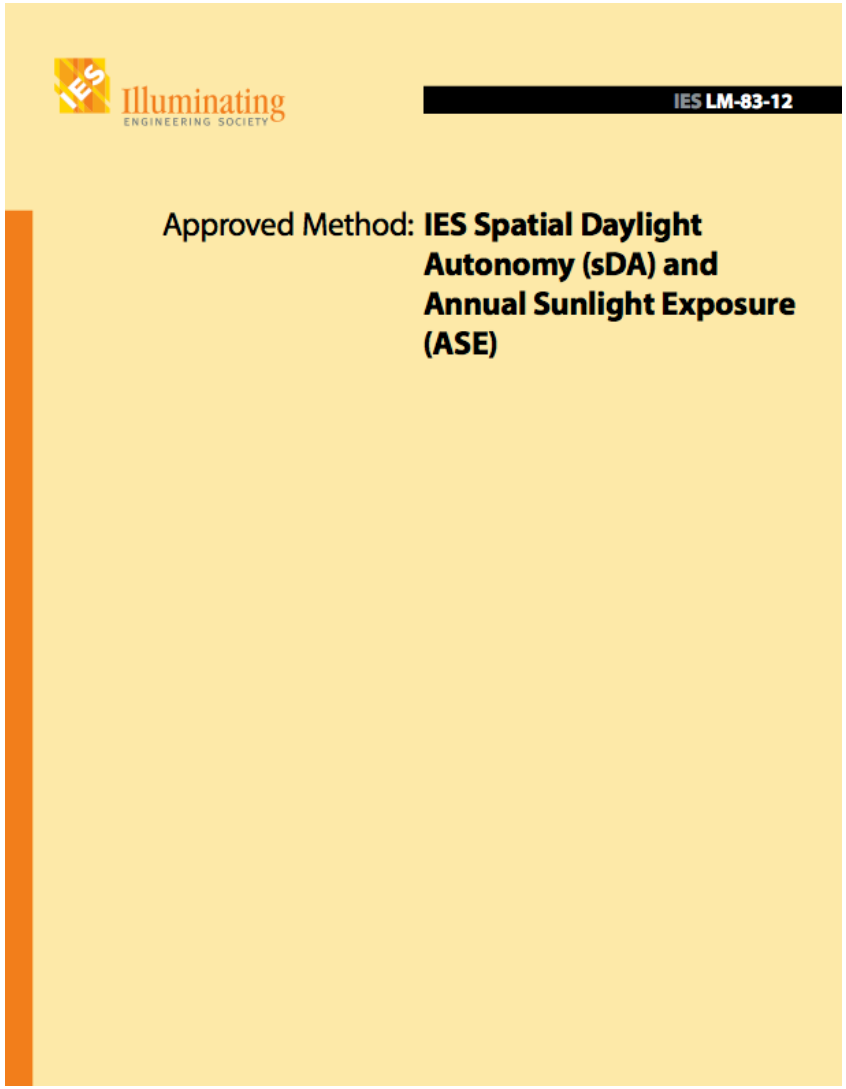
Is there enough daylight in the space? (measured using annual hourly illuminance):

- During analysis hours (8am-6pm)
- What % of floor area exceeds 300 lux for at least 50% of analysis hours?
- Exceed 55% of the floor area for “nominally acceptable daylight”
- Exceed 75% of the floor area for “preferred daylight”

Annual Sunlight Exposure (ASE)

Is there excessive daylight in the space (measured using annual hourly illuminance):

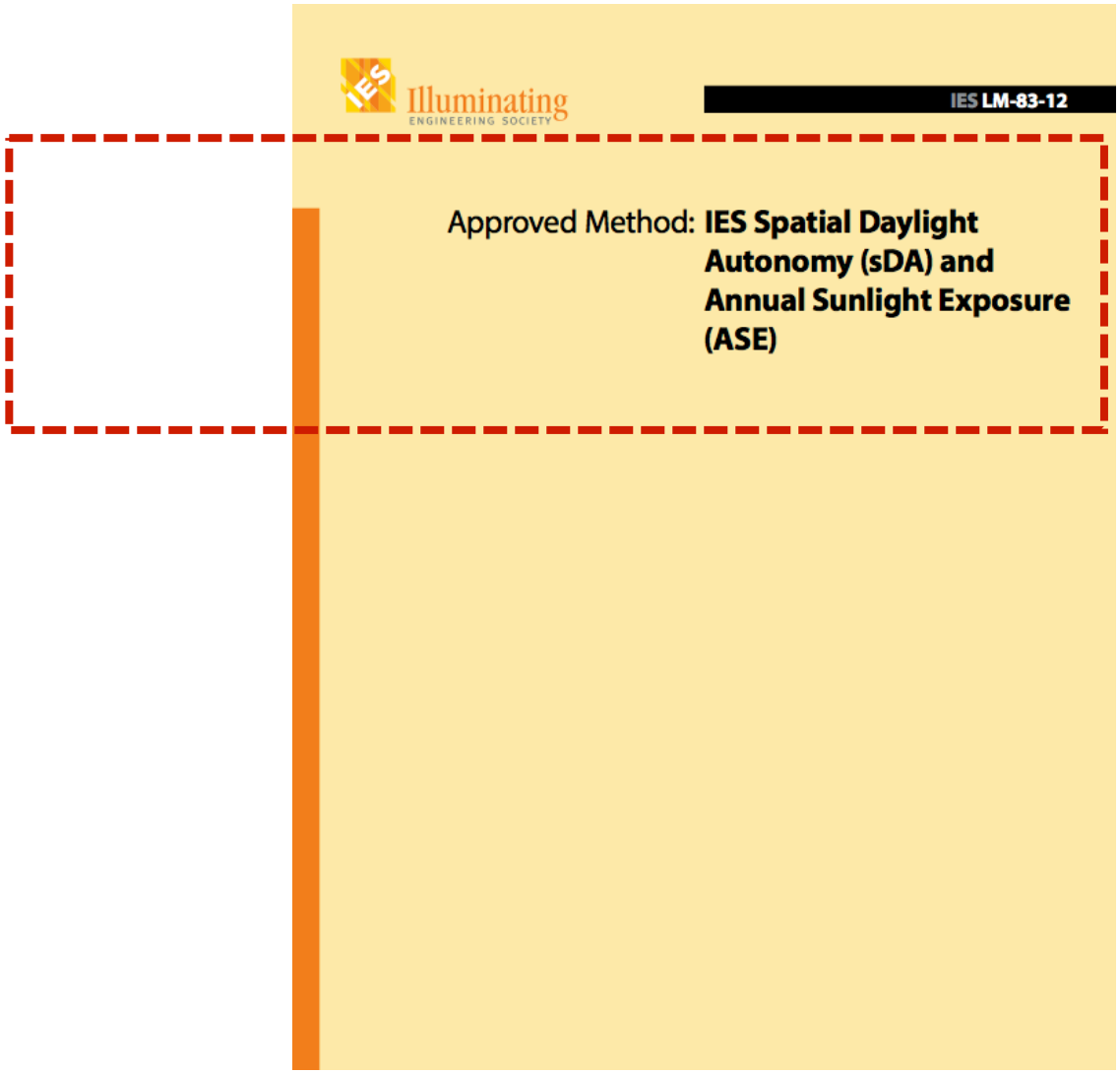
- During analysis hours (8am-6pm)
- What % of the floor area exceeds 1000 lux “computational direct sunlight” (sun spots) for more than 250 annual analysis hours?
- Below 10% of the floor area for less discomfort, lower is better
- Exceeding 20% of the floor area suggests need for automated blinds or additional fixed shading strategies



IES LM-83

1. Annual dynamic daylight metrics

2. **Proposing a manual blind control pattern**

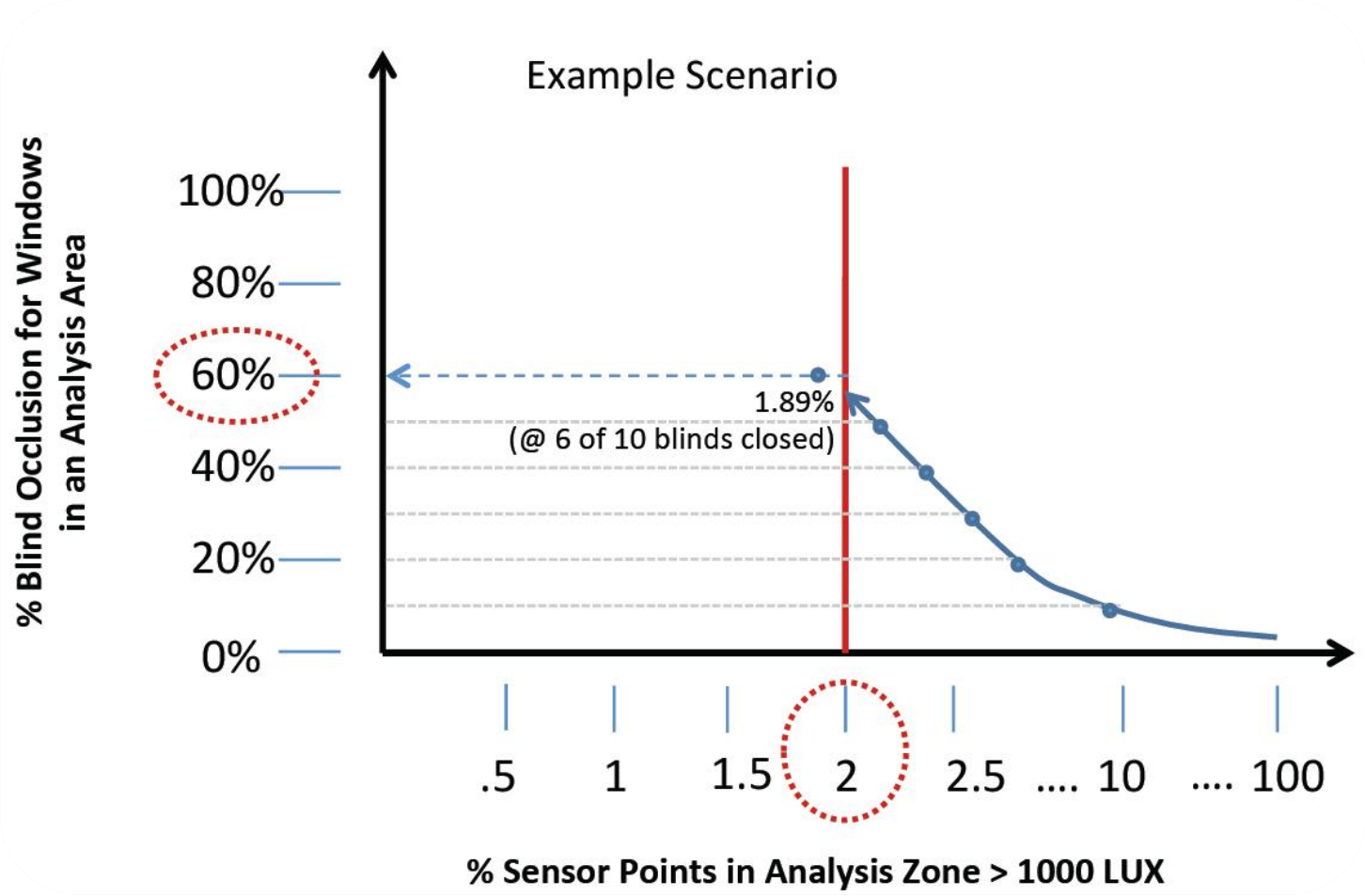




Manual blinds are quite common in spaces designed for daylighting



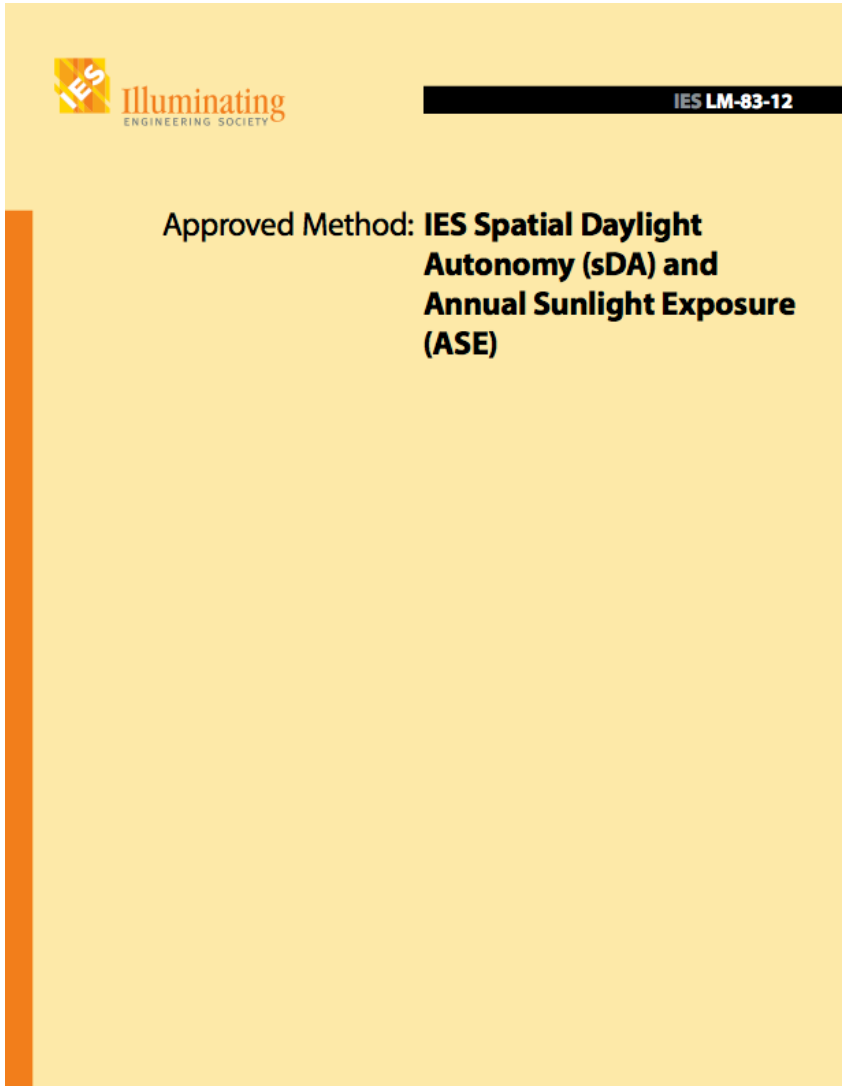
- Blinds engage if more than 2% of the analysis area is receiving direct sunlight. (1000lux)



AGENDA

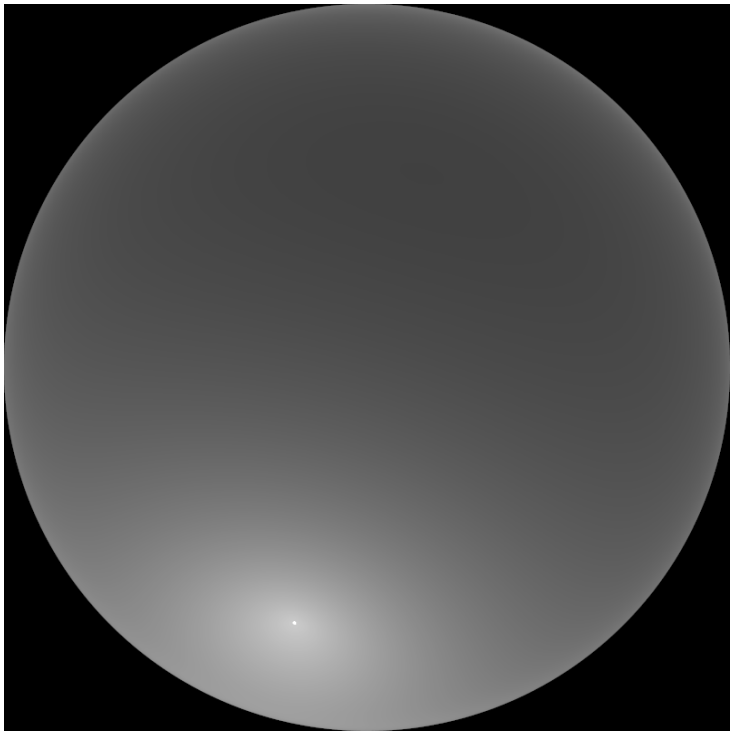
Lessons learned from using LM-83 metrics

1) Maximum sDA based on location/climate
2) Unpacking the metrics
3) Blinds operation order/logic
4) Alternate ASE Calculation
5) Daylight zoning
6) Modeling geometry



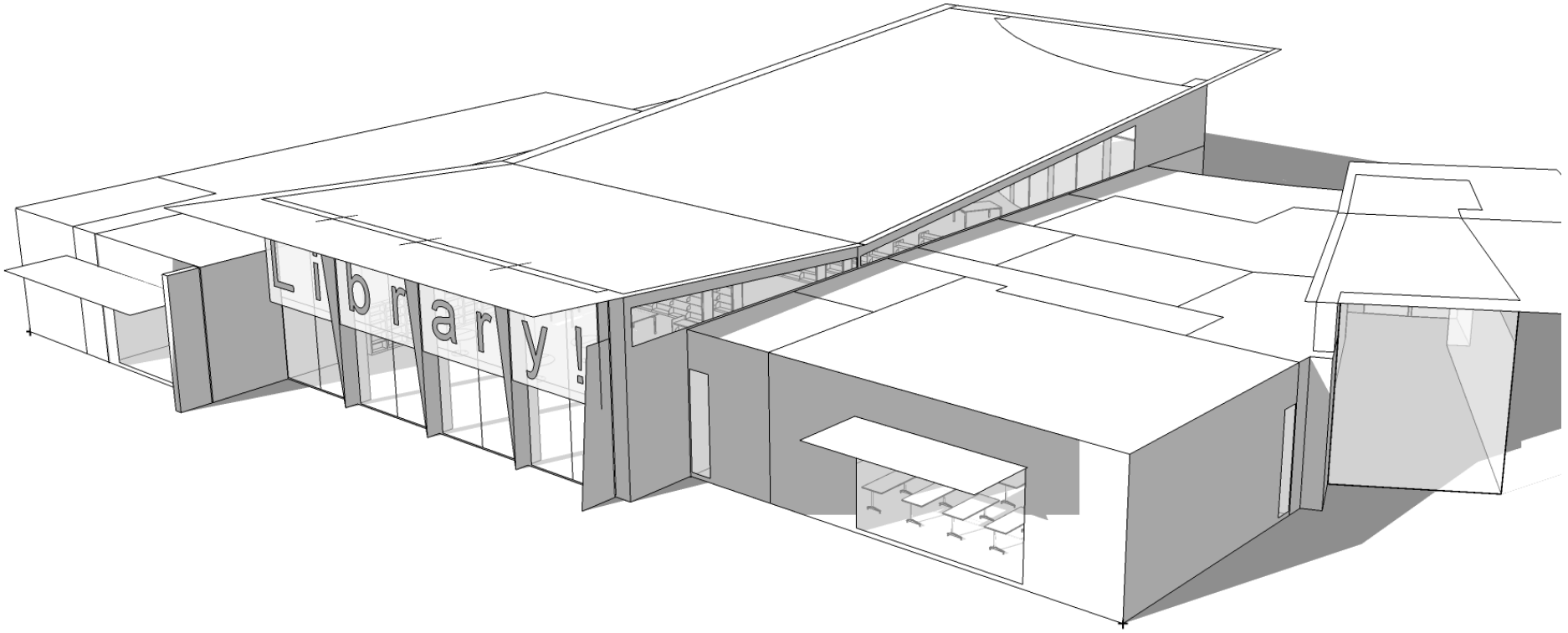
1) Maximum sDA based on location/climate

Weather Data	sDA(300/50%)	Avg. DA(300)
CAN_NB_Fredericton.717000_CWEC	100.00	98.60
CAN_NS_Shearwater.716010_CWEC	100.00	95.84
USA_AZ_Phoenix-Sky.Harbor.Intl.AP.722780_TMY3	100.00	98.89
USA_CA_San.Francisco.Intl.AP.724940_TMY3	100.00	95.97
USA_CO_Denver.Intl.AP.725650_TMY3	100.00	96.38
USA_IA_Des.Moines.Intl.AP.725460_TMY3	100.00	97.45
USA_ID_Boise.Air.Terminal.726810_TMY3	100.00	98.27
USA_ID_Idaho.Falls-Fanning.Field.725785_TMY3	100.00	96.40
USA_IL_Chicago-OHare.Intl.AP.725300_TMY3	100.00	96.63
USA_KS_Wichita-Mid.Continent.AP.724500_TMY3	100.00	99.21
USA_MN_Minneapolis-St.Paul.Intl.AP.726580_TMY3	100.00	96.79
USA_NE_Omaha-Eppley.Airfield.725500_TMY3	100.00	97.48
USA_NY_New.York-Central.Park.725033_TMY3	100.00	96.90
USA_NY_New.York-LaGuardia.AP.725030_TMY3	100.00	95.45
USA_VA_Arlington-Ronald.Reagan.Washington.Natl.AP.724050_TMY3	100.00	97.10
USA_WA_Pullman-Moscow.Rgnl.AP.727857_TMY3	100.00	91.12
USA_WA_Seattle-Boeing.Field.727935_TMY3	100.00	92.32
USA_WA_Seattle-Tacoma.Intl.AP.727930_TMY3	100.00	95.72

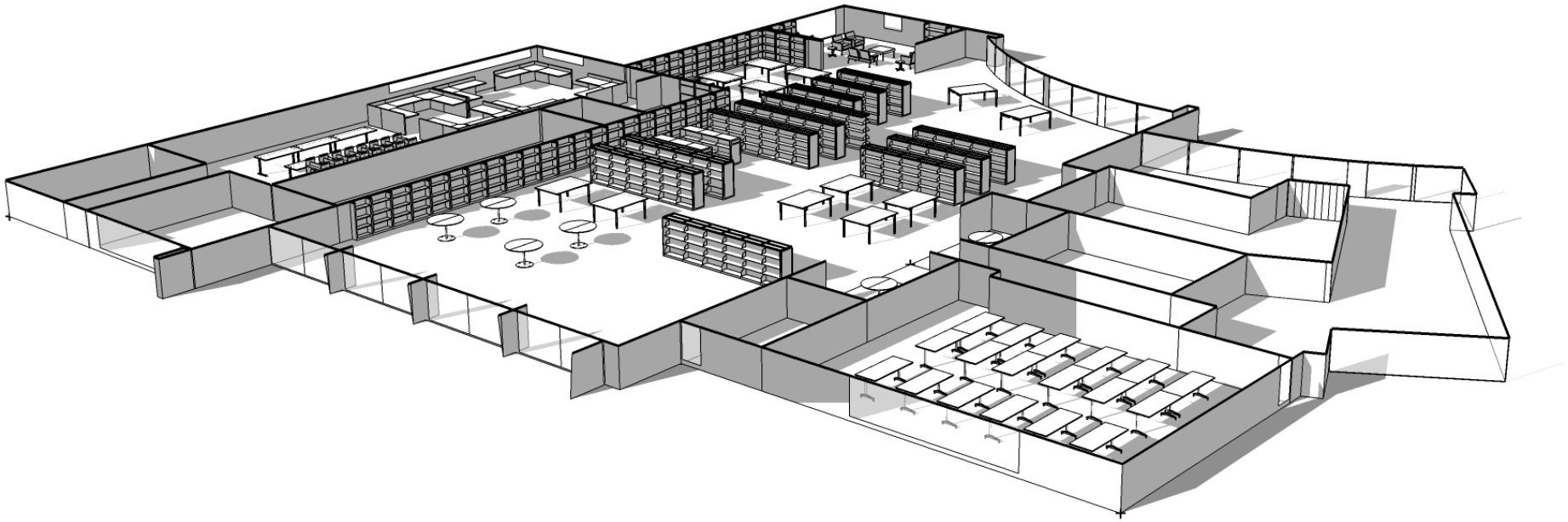


No geometry in the model with a 400-point grid as input.

2) Unpacking the annual metrics



2) Unpacking the annual metrics



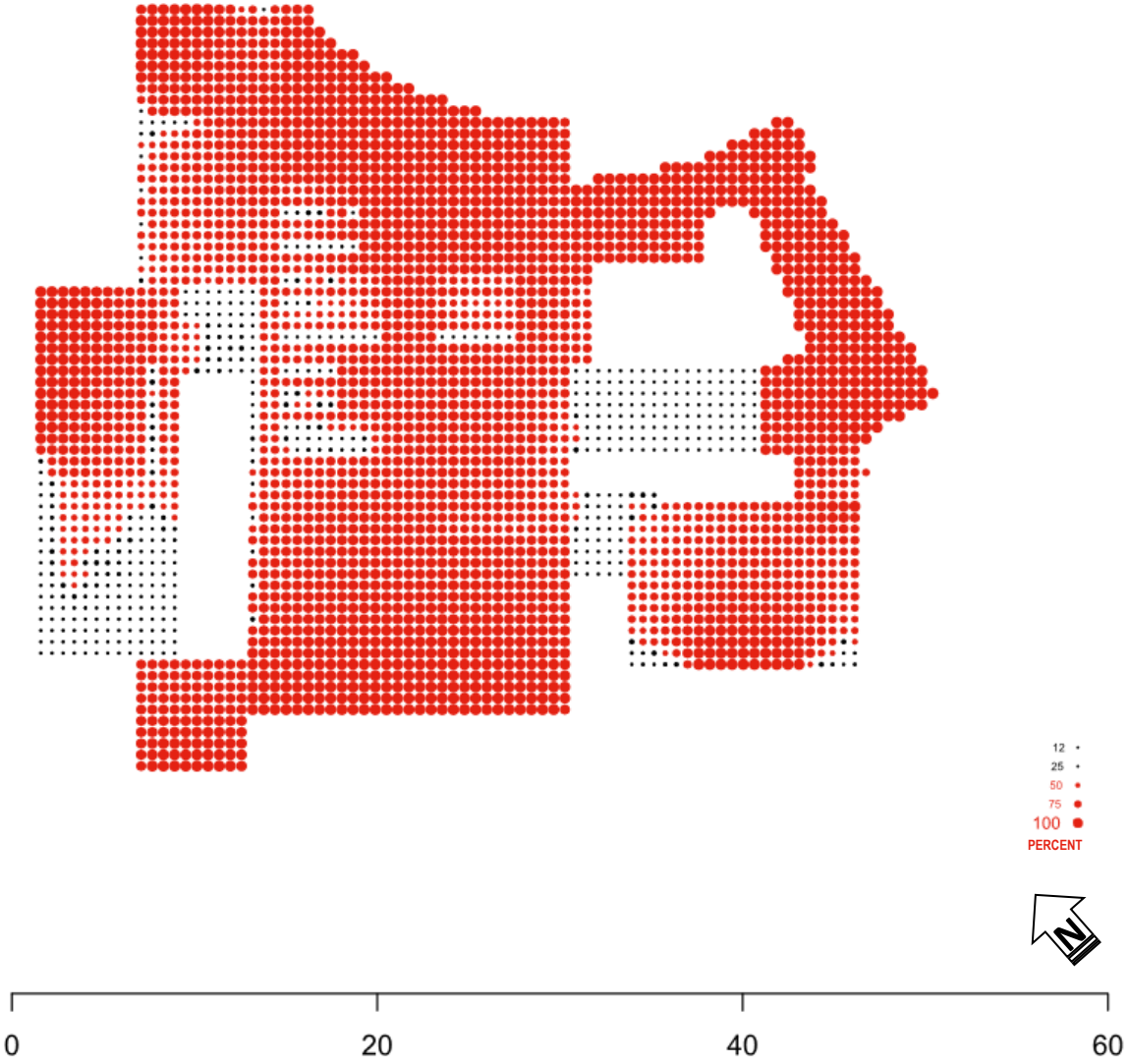
2) Unpacking the annual metrics

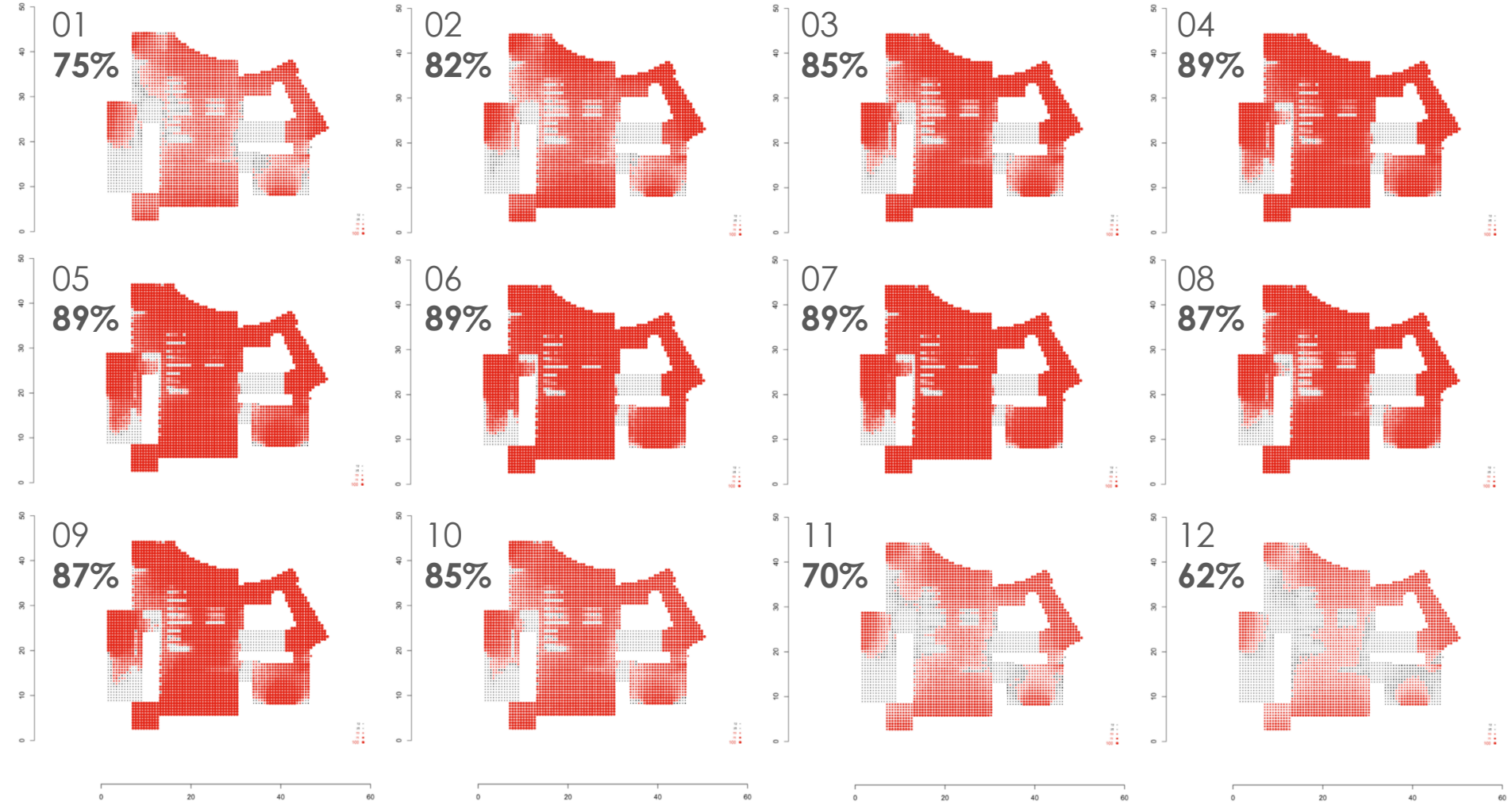
LEED Credit 8.1 Daylight & Views (v4, BD+C New Construction)

Spatial Daylight Autonomy (without blinds operation)

- **85.6%**

...of regularly occupied area is at or above 300 Lux for at least 50% of the occupied hours of the year.




01
75%
02
82%
03
85%
04
89%
05
89%
06
89%
07
89%
08
87%
09
87%
10
85%
11
70%
12
62%
0
20
40
60

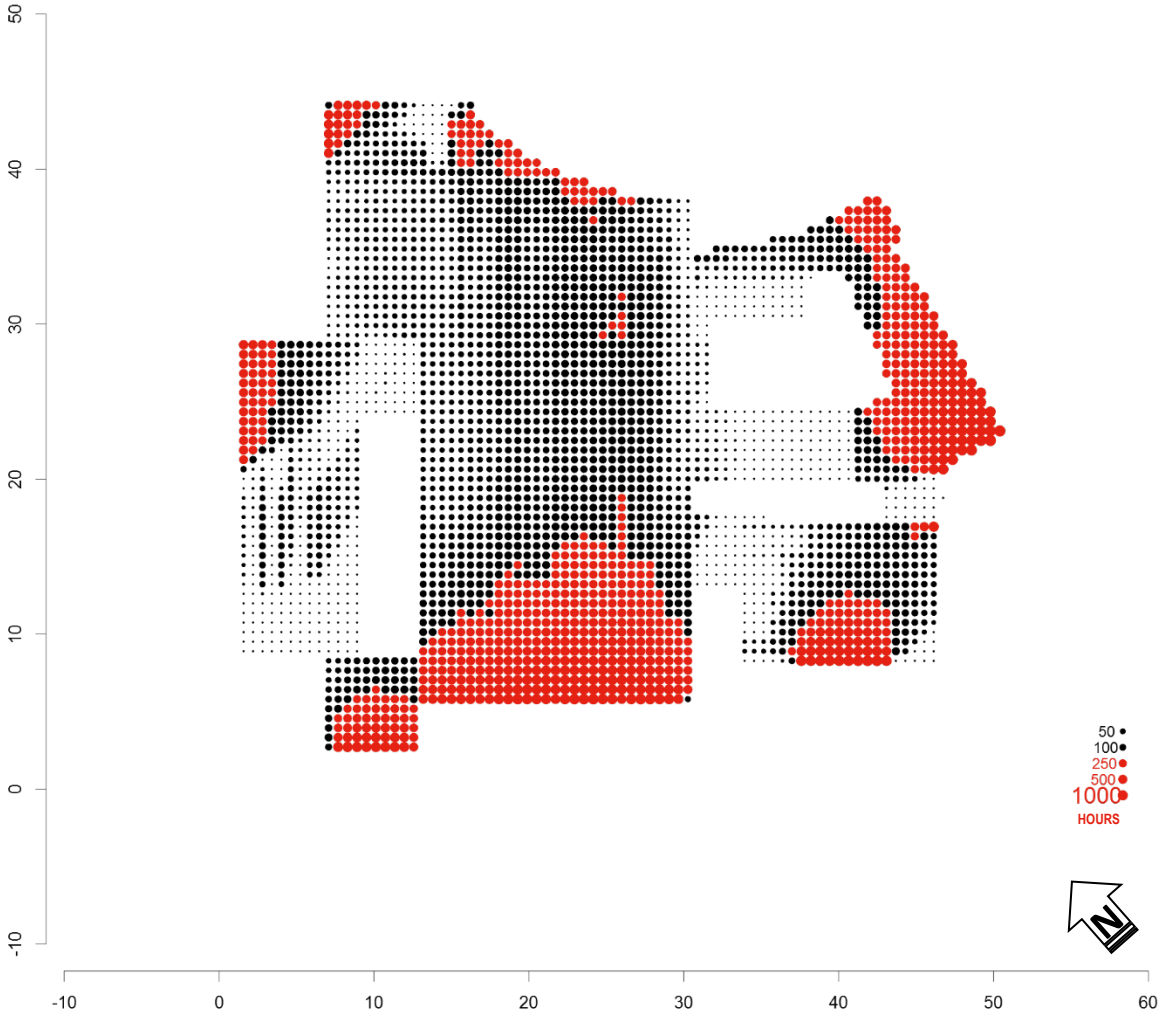
2) Unpacking the annual metrics

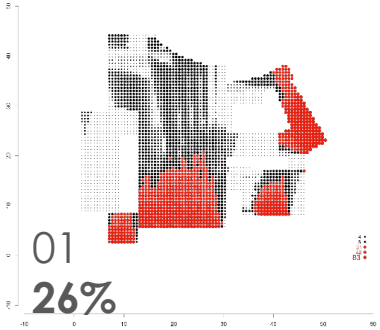
LEED Credit 8.1 Daylight & Views (v4, BD+C New Construction)

Annual Sunlight Exposure

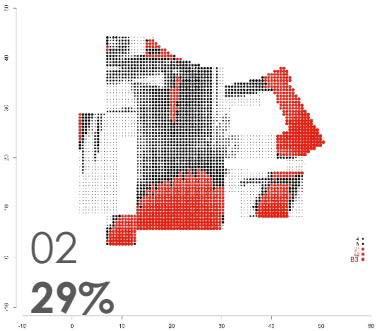
- **24.0%**

...of regularly occupied area exceeds 250 hours of direct sunlight exposure for the occupied hours of the year.

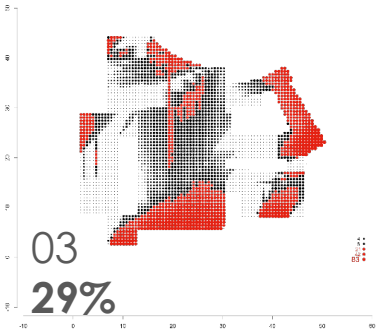




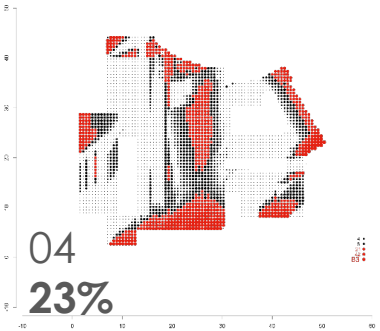
01
26%



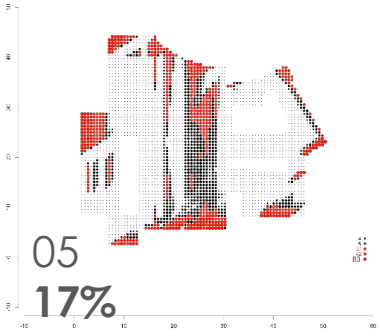
02
29%



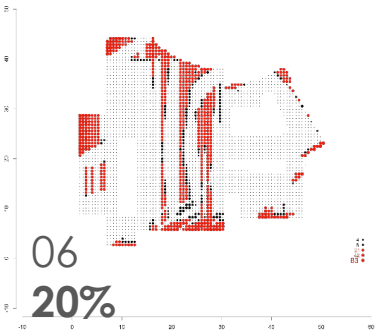
03
29%



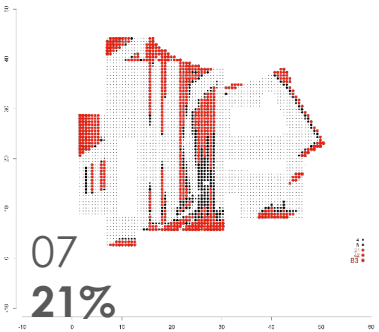
04
23%



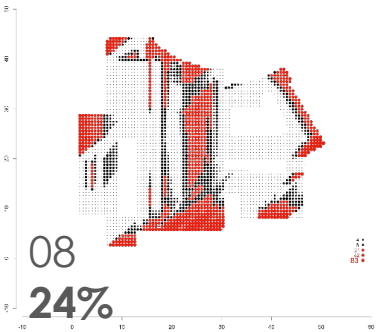
05
17%



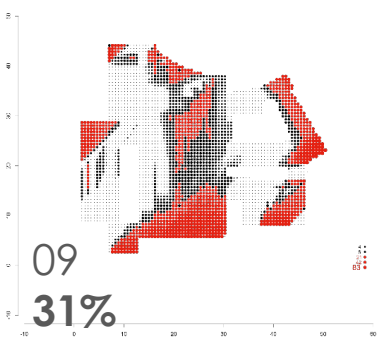
06
20%



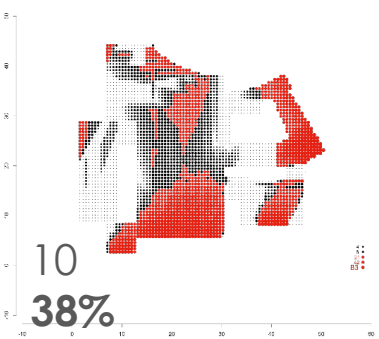
07
21%



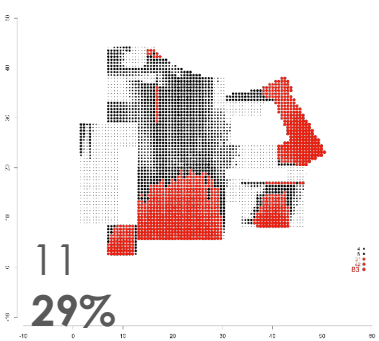
08
24%



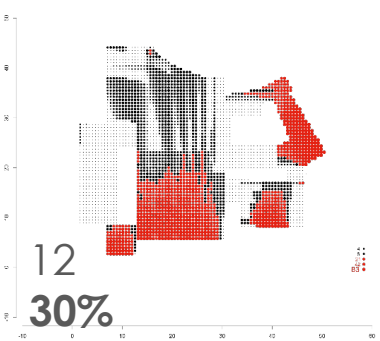
09
31%



10
38%



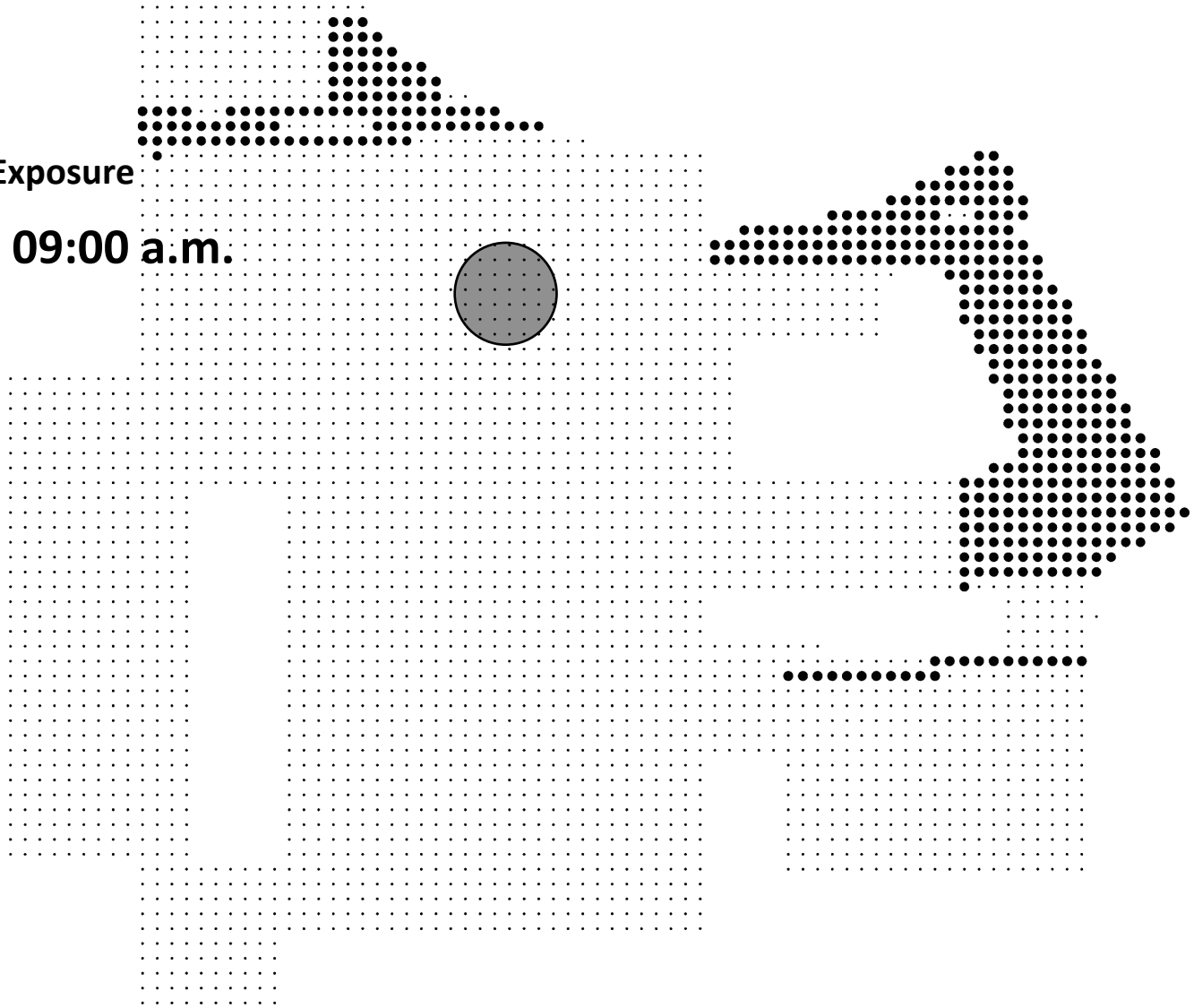
11
29%



12
30%

Hourly Sunlight Exposure

- **01/11 09:00 a.m.**



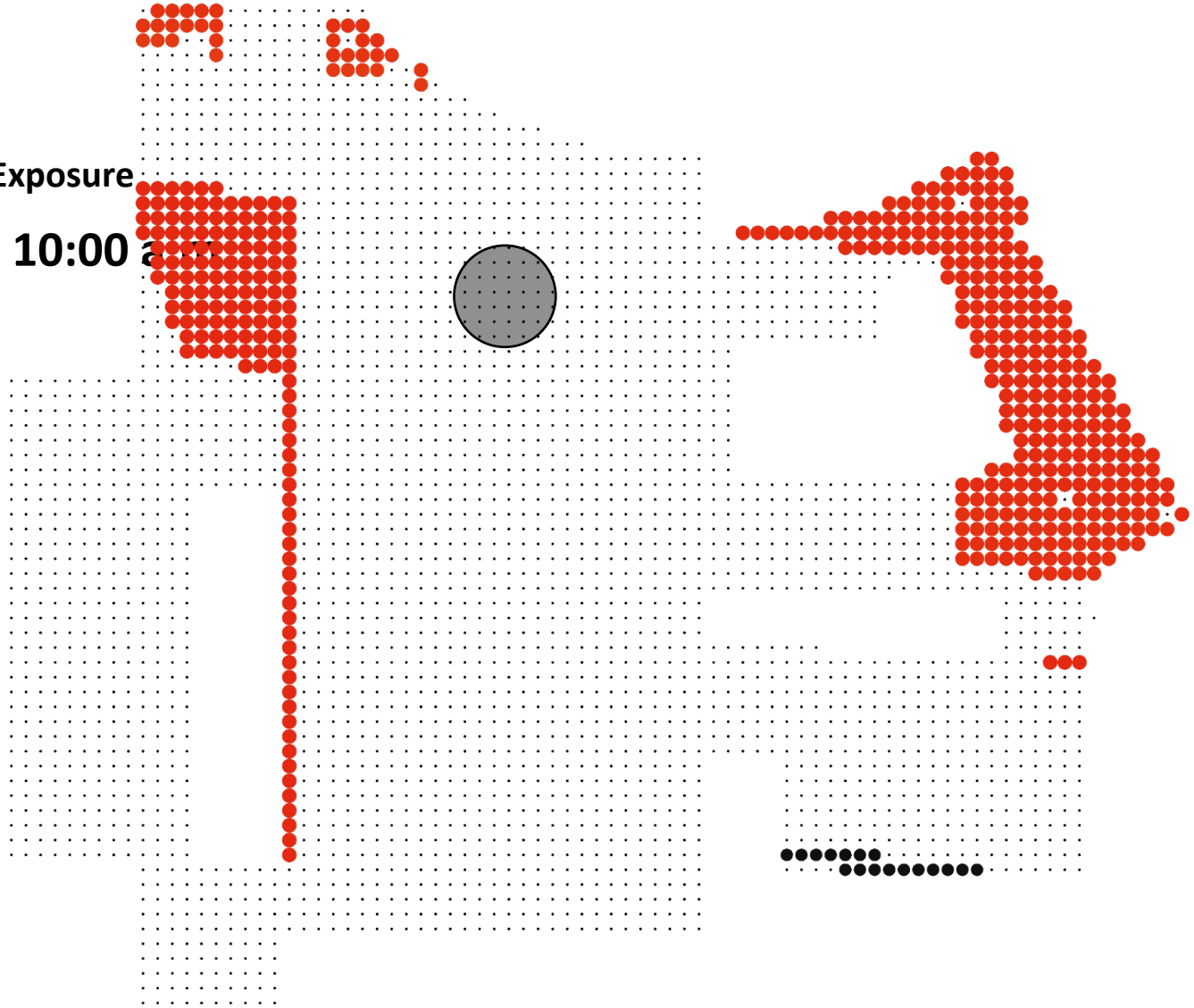
below 1000

1000

LUX

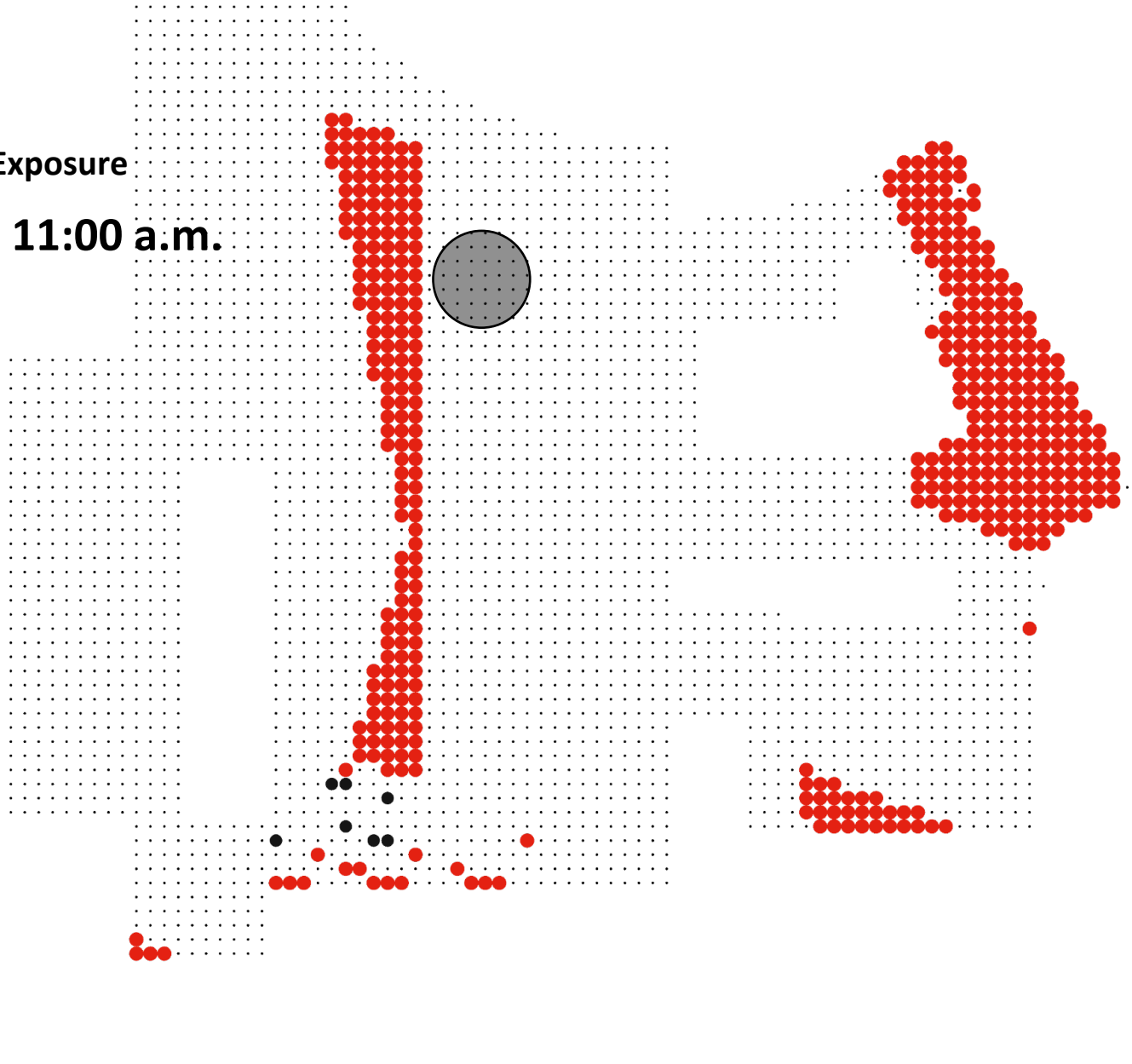
Hourly Sunlight Exposure

- 01/11 10:00 a.m.



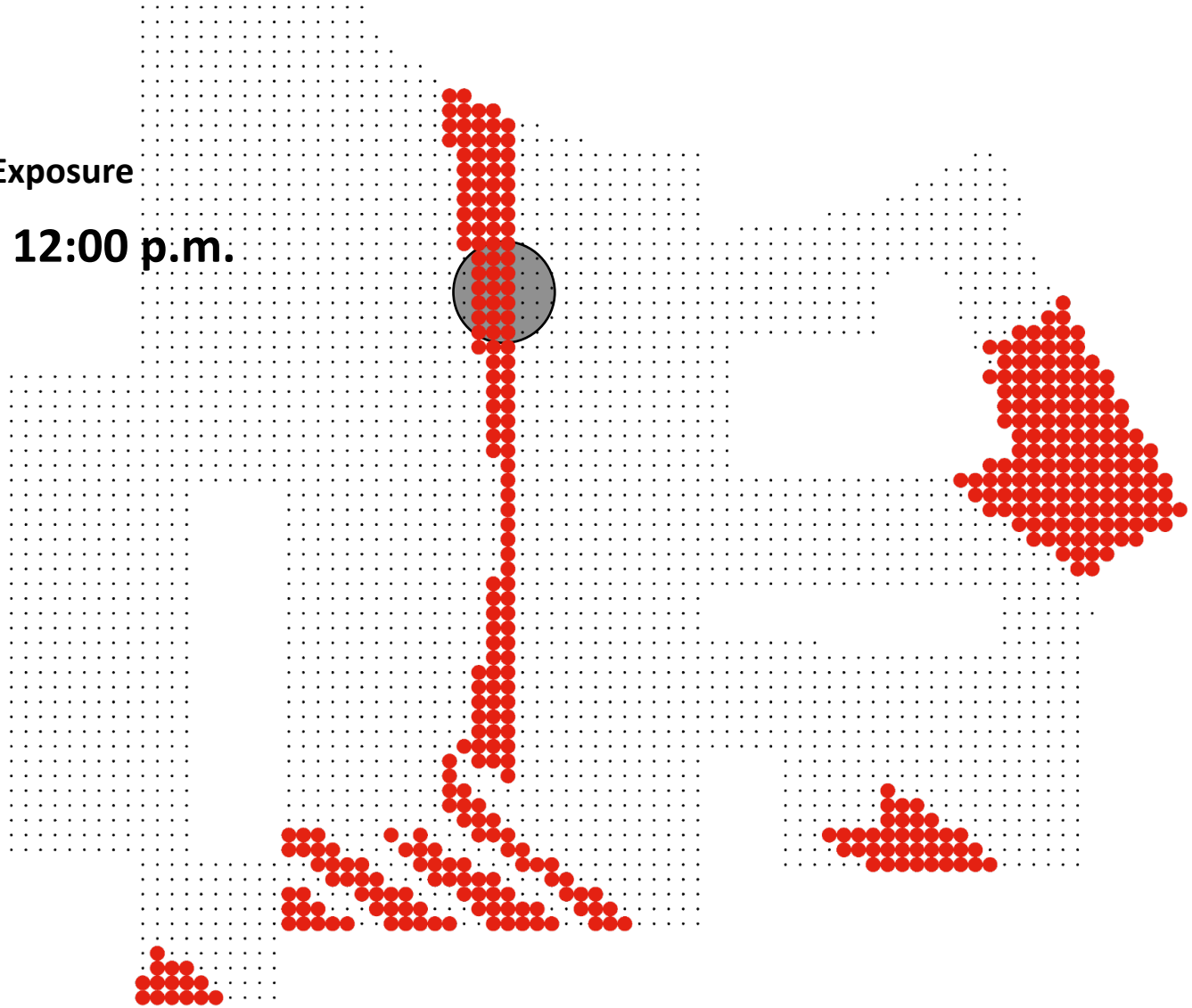
Hourly Sunlight Exposure

- **01/11 11:00 a.m.**



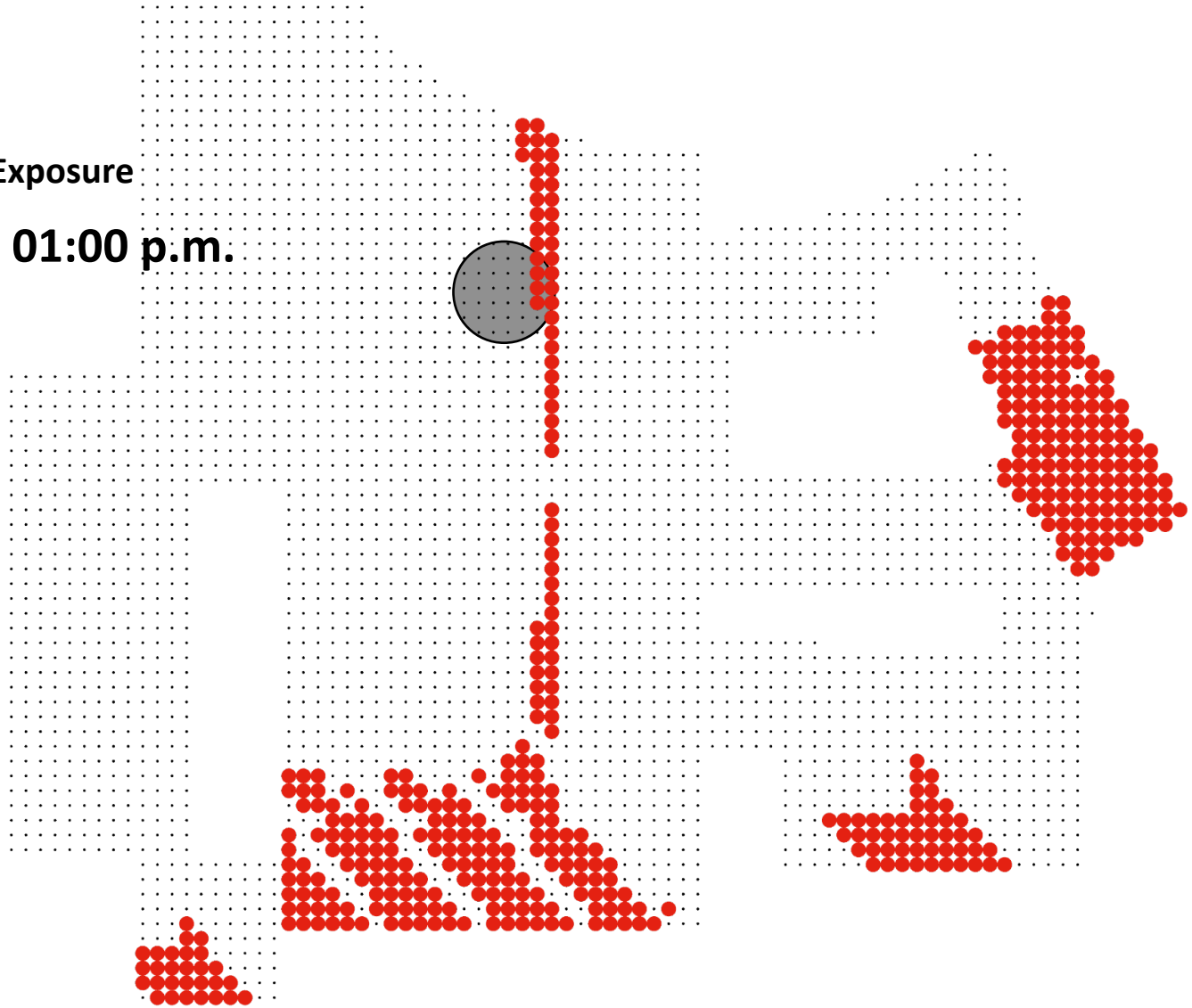
Hourly Sunlight Exposure

- **01/11 12:00 p.m.**



Hourly Sunlight Exposure

- **01/11 01:00 p.m.**



Hourly Sunlight Exposure

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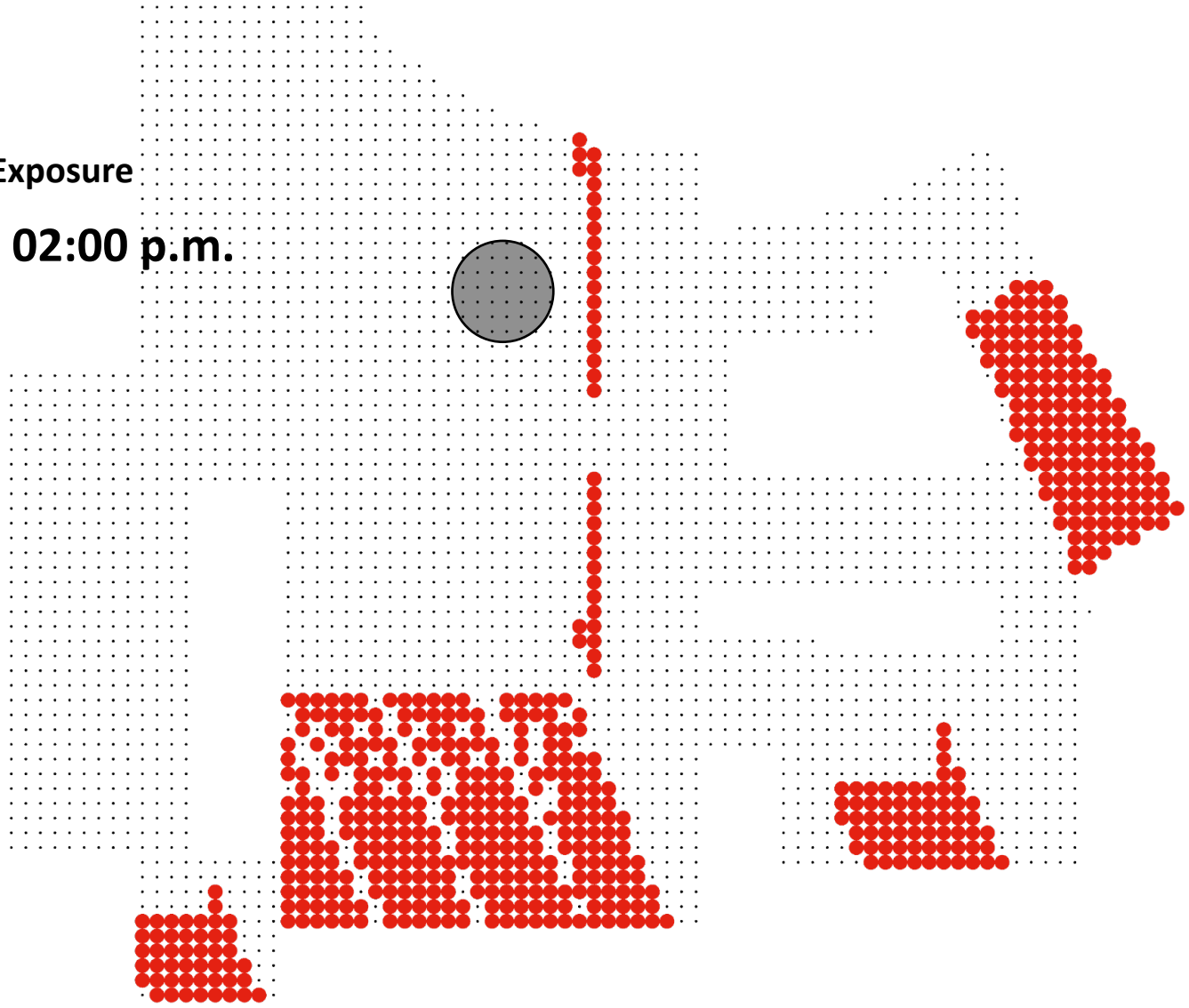

Hourly Sunlight Exposure

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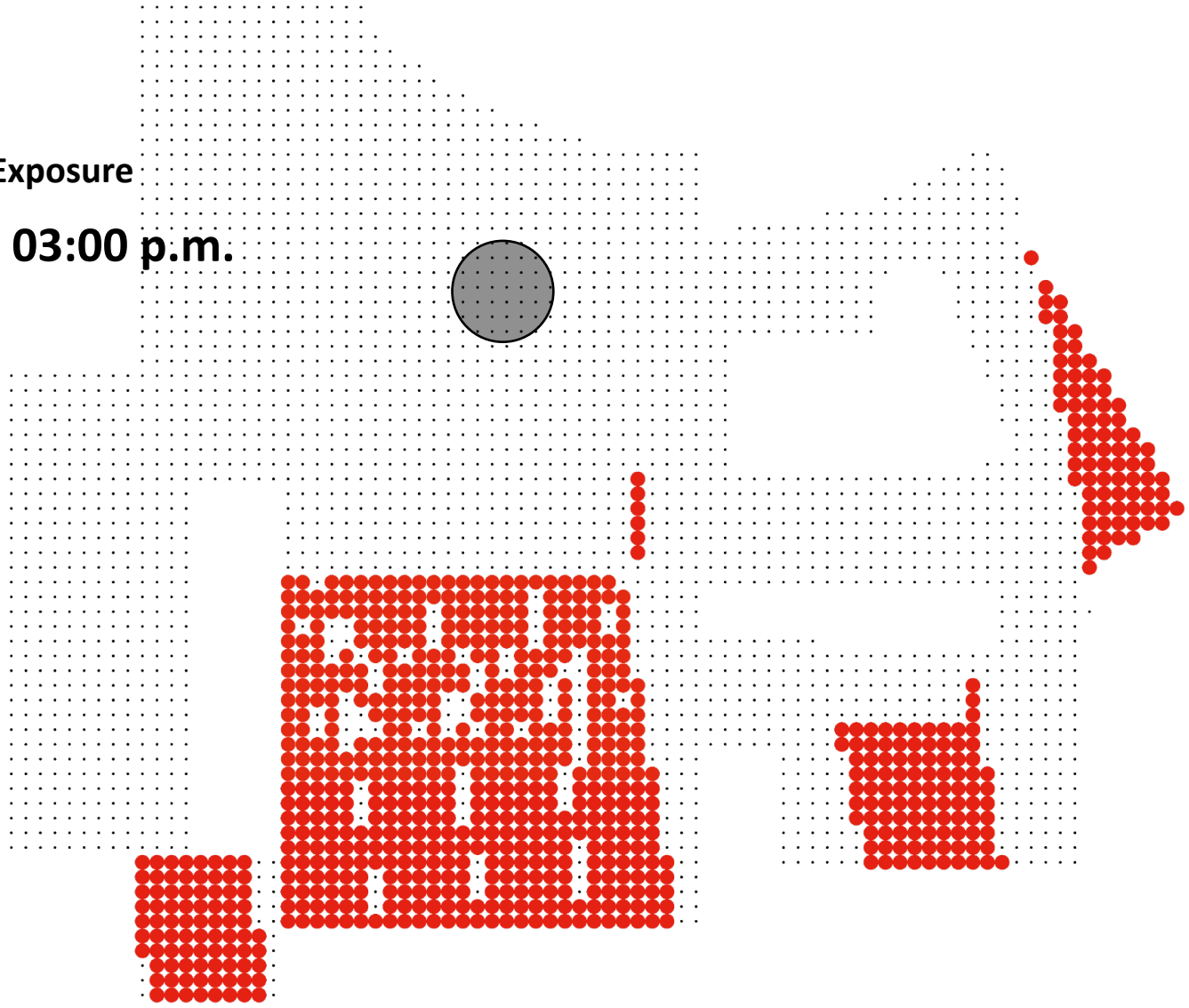
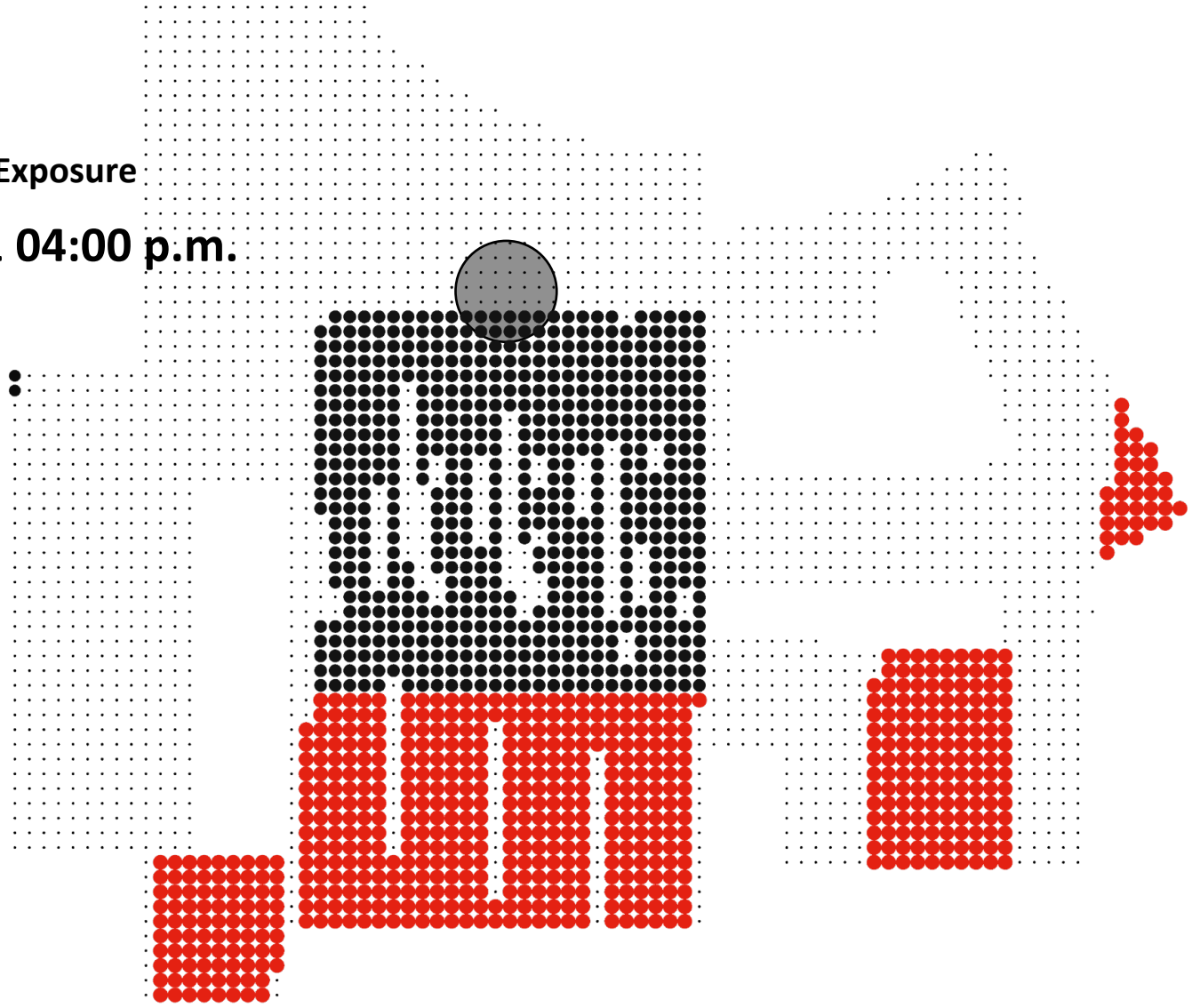


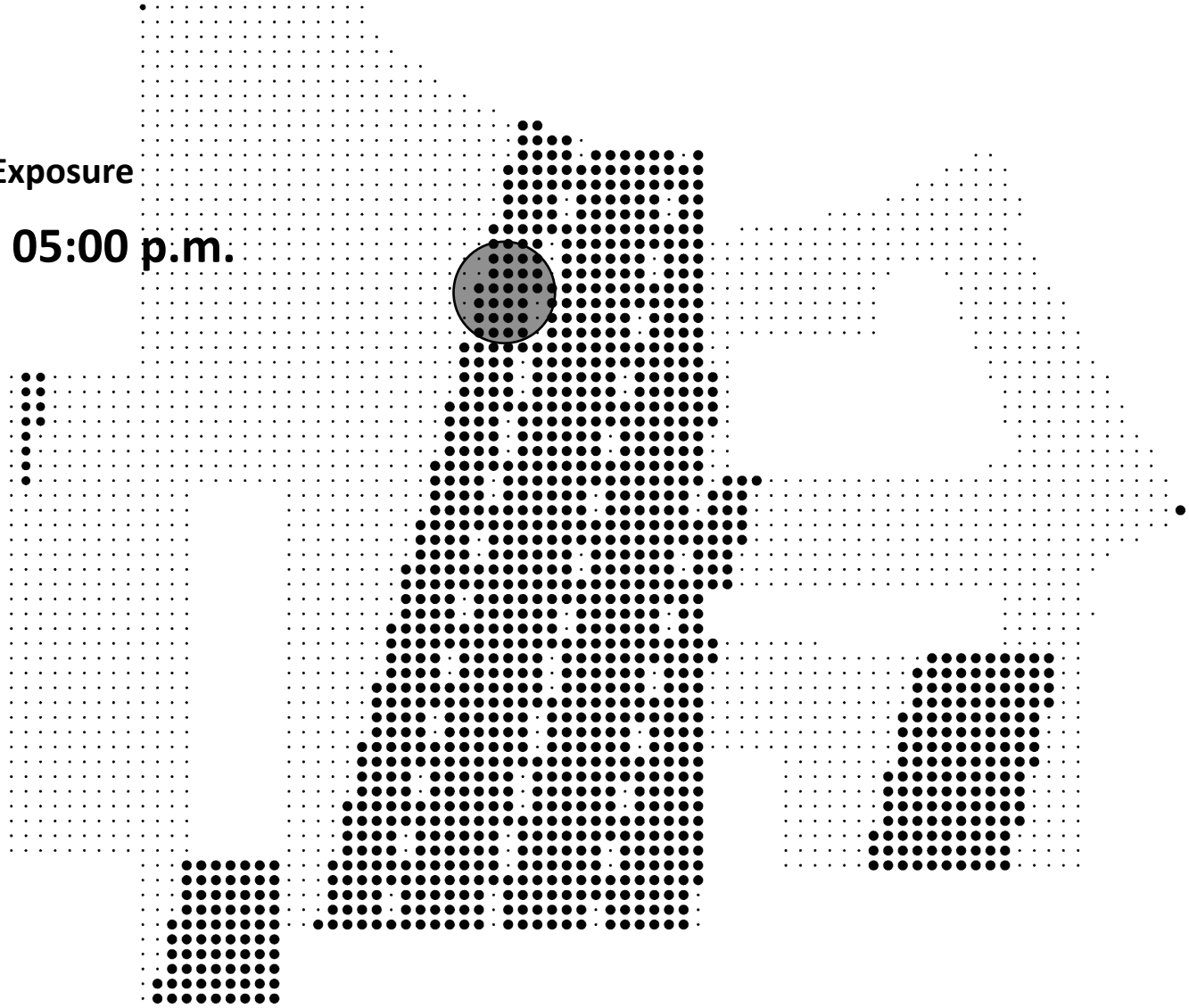
Hourly Sunlight Exposure

- **01/11 04:00 p.m.**

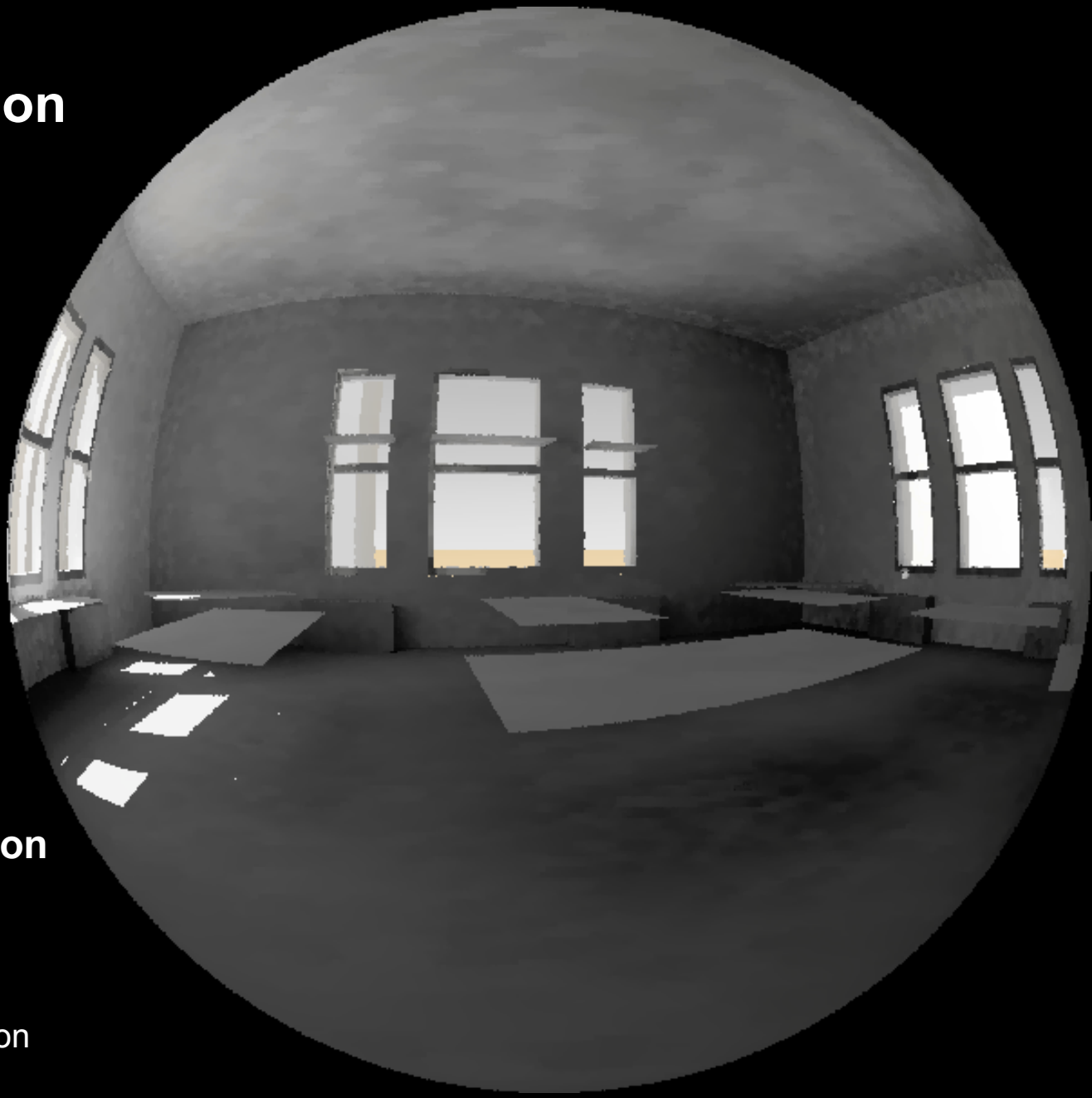


Hourly Sunlight Exposure

- **01/11 05:00 p.m.**



3) Blinds Operation

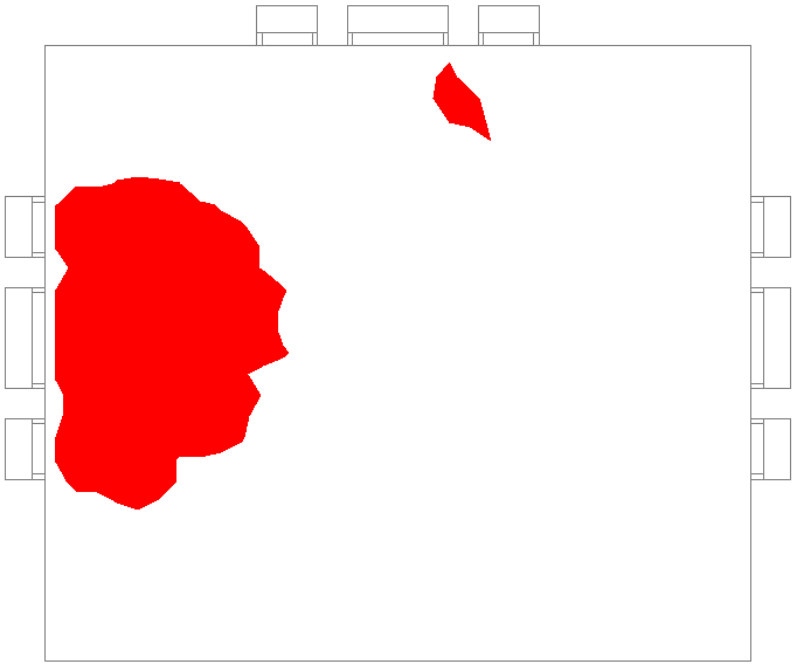


Methodology verification

- ASE with RTRACE
- ASE with RCONTRIB
- Operated sDA results
- HMG and IDL comparison

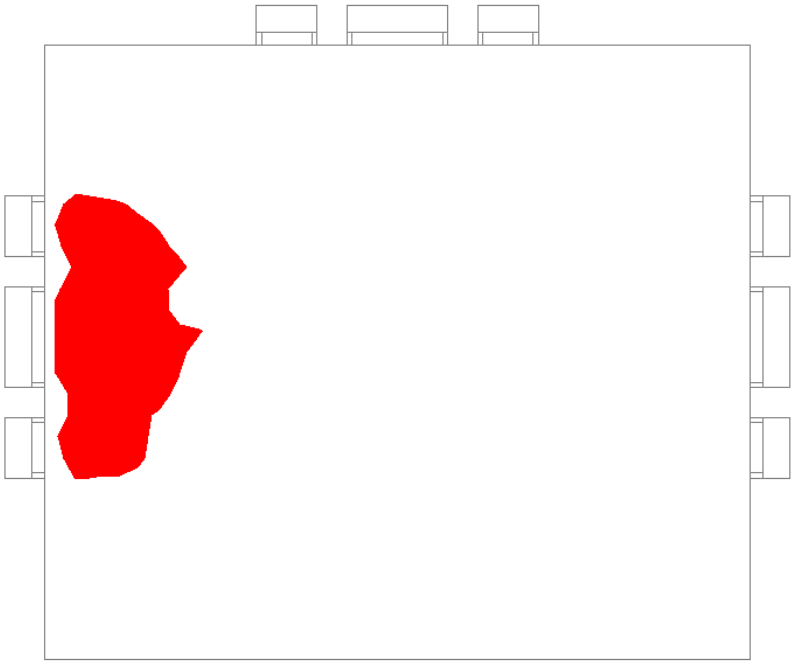
3) Blinds Operation

IDL RCONTRIB 1-bounce calculation



14.6% ASE

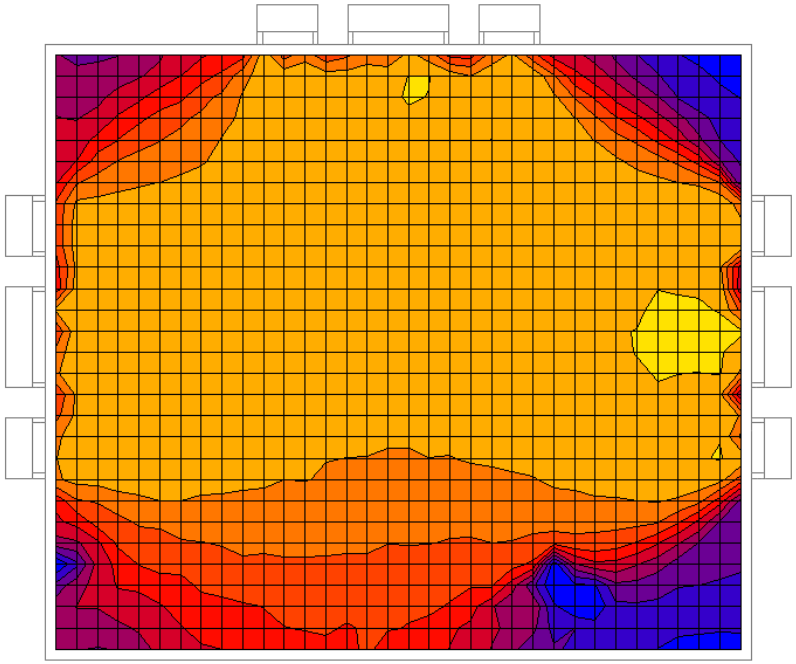
IDL RTRACE 0-bounce calculation



7.0% ASE

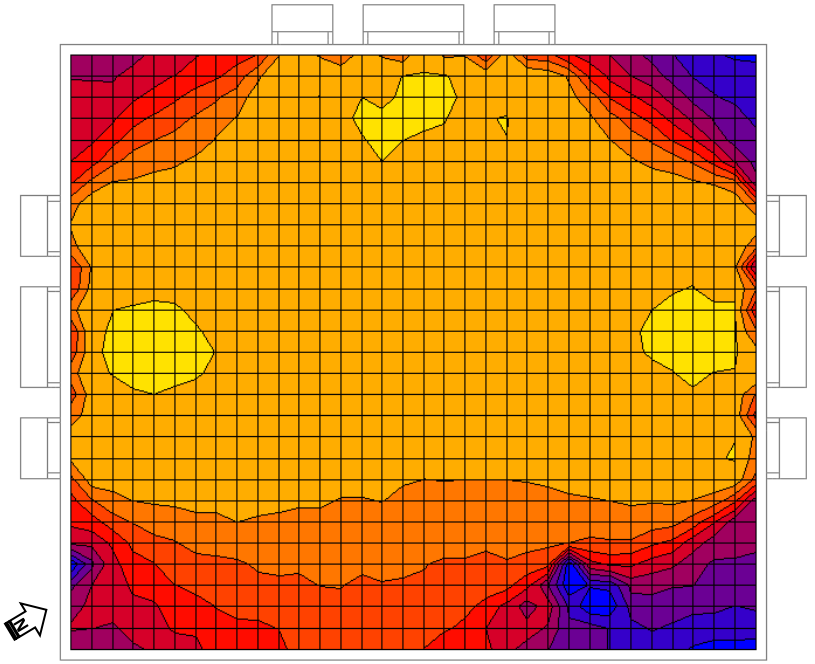
3) Blinds Operation

Operated under rcontrib solardisc analysis



82.8% sDA

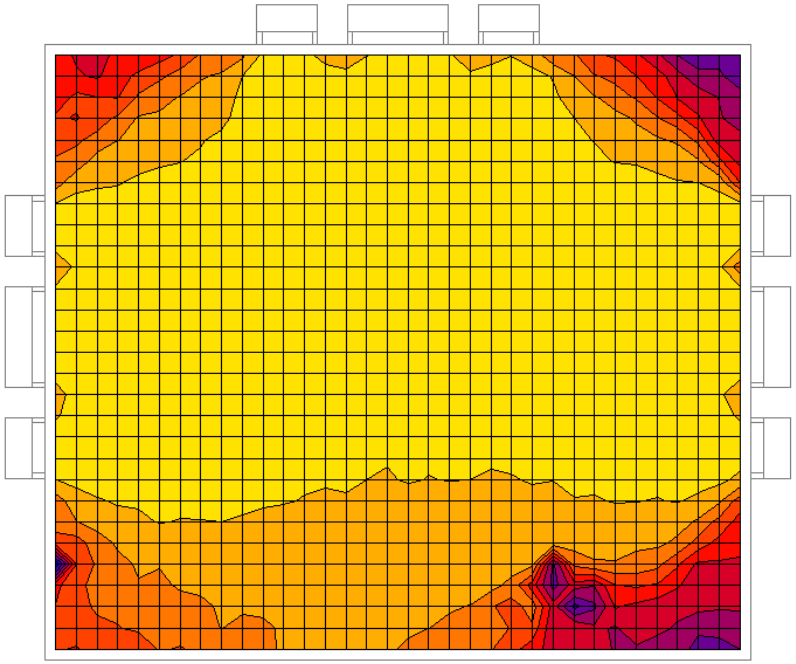
Operated under rtrace solardisc analysis



85.1% sDA

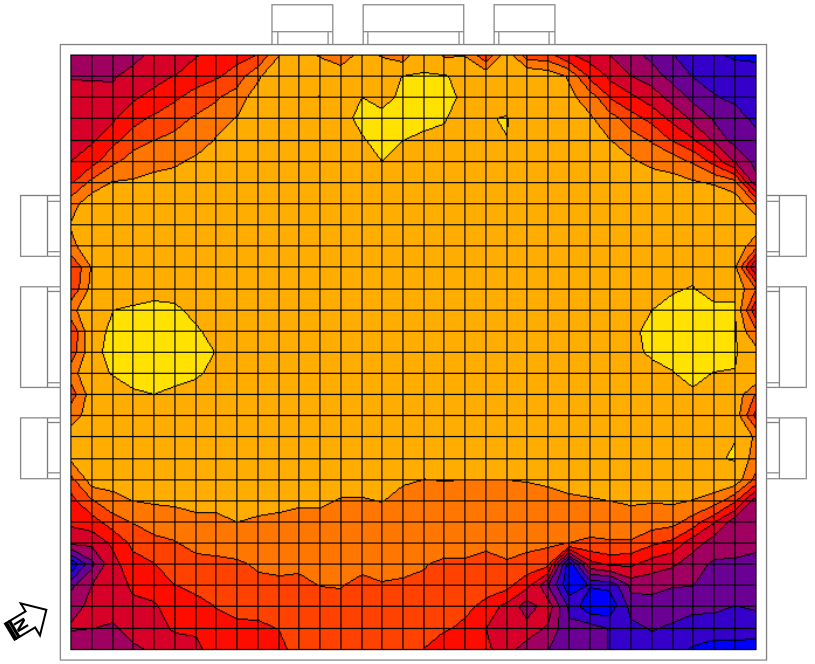
3) Blinds Operation

HMG data



93.8% sDA

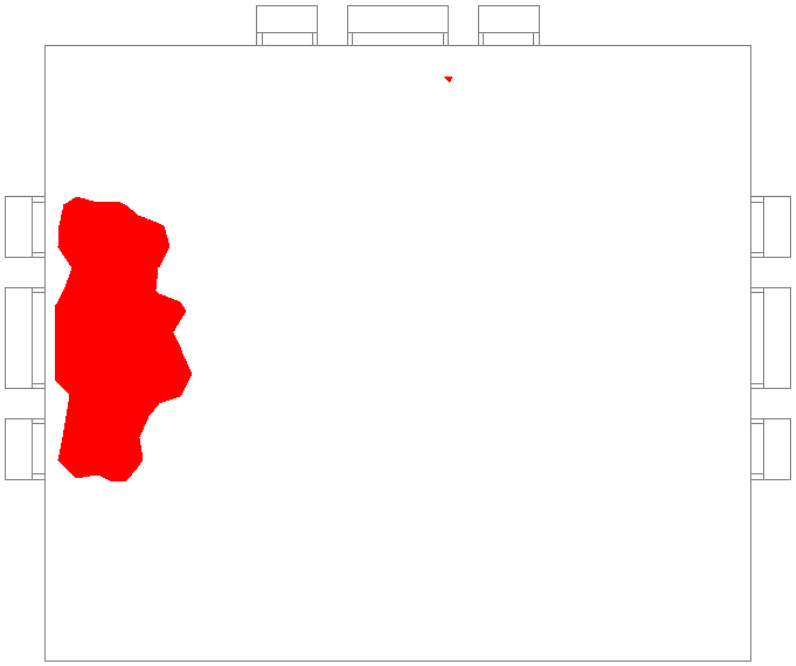
RTRACE-operated sDA



85.1% sDA

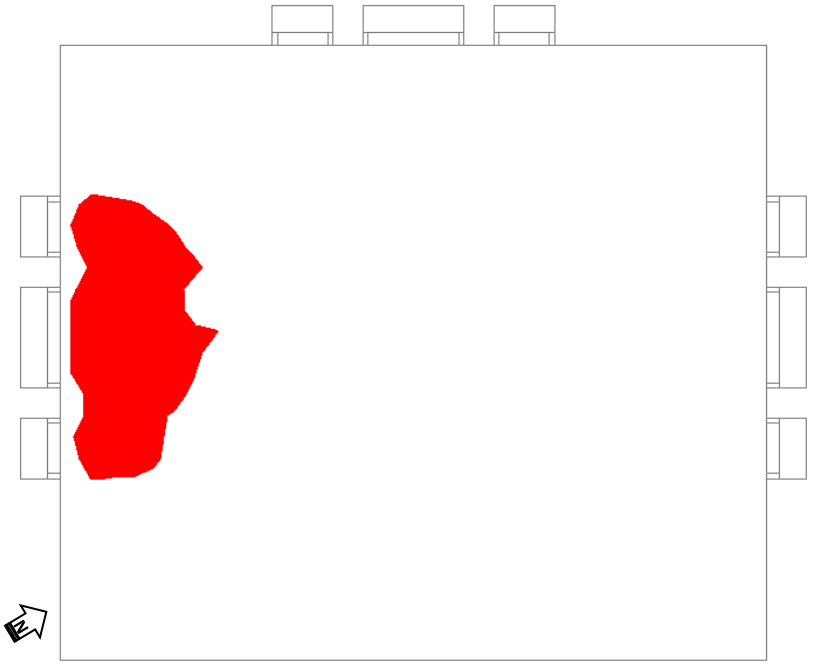
3) Blinds Operation

HMG data



6.9% ASE

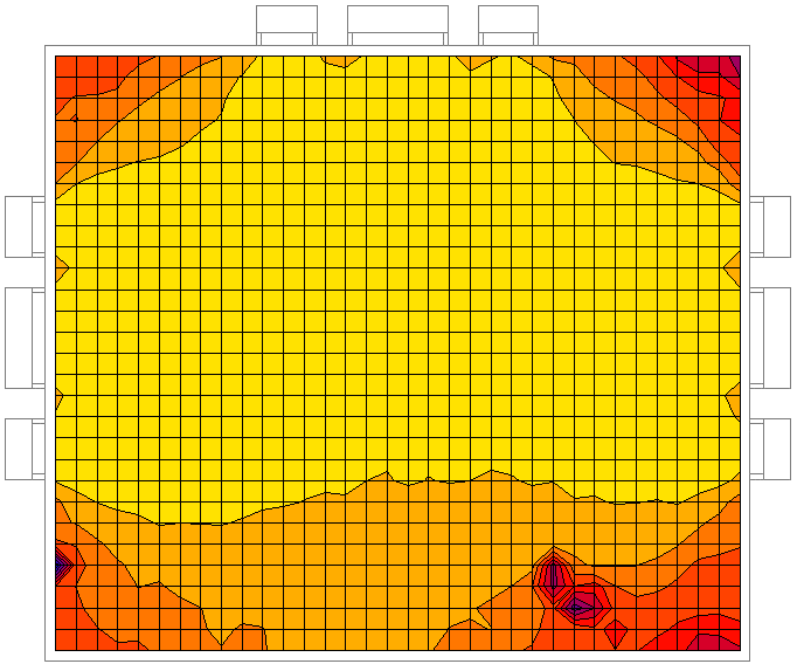
RTRACE 0-bounce calculation



7.0% ASE

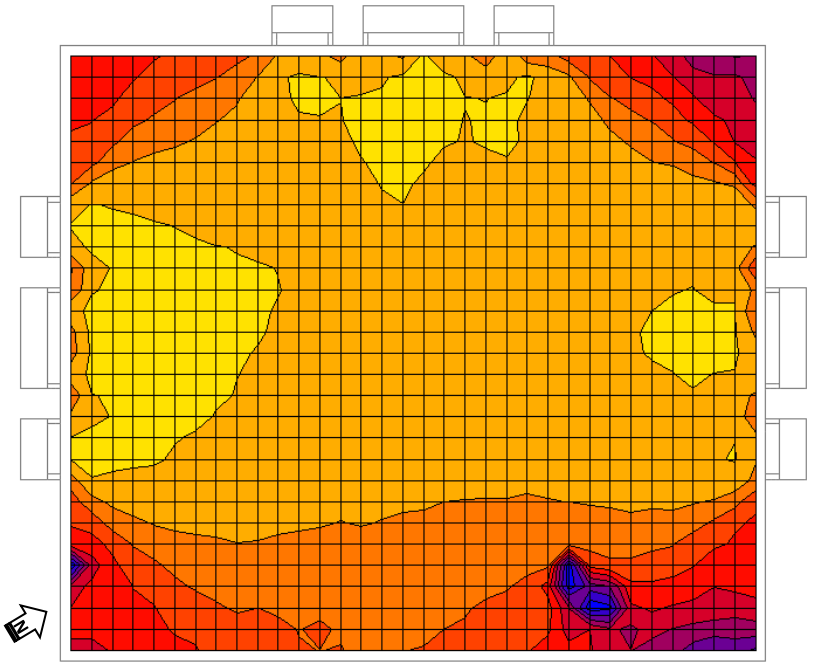
3) Blinds Operation

HMG data



86.8% Avg. DA

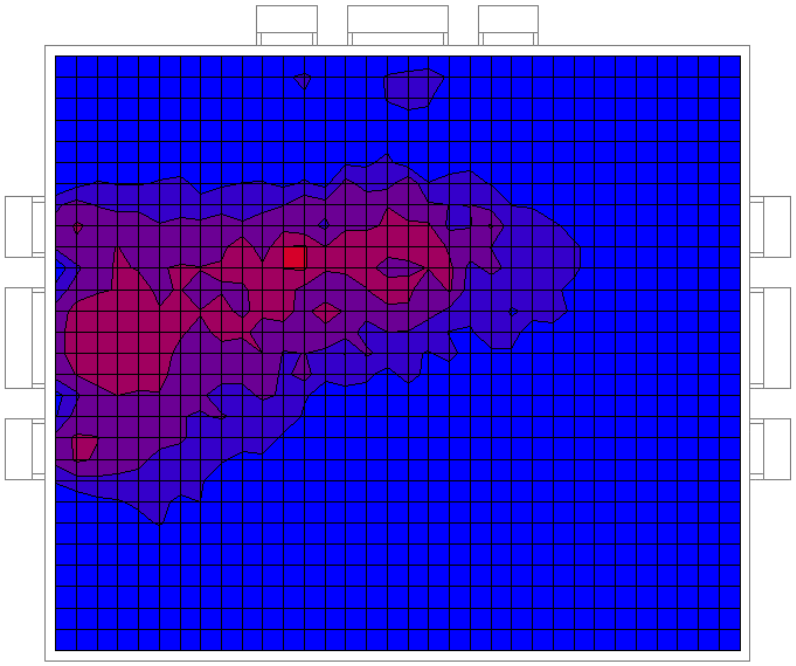
IDL three-phase calculation



79.1% Avg. DA

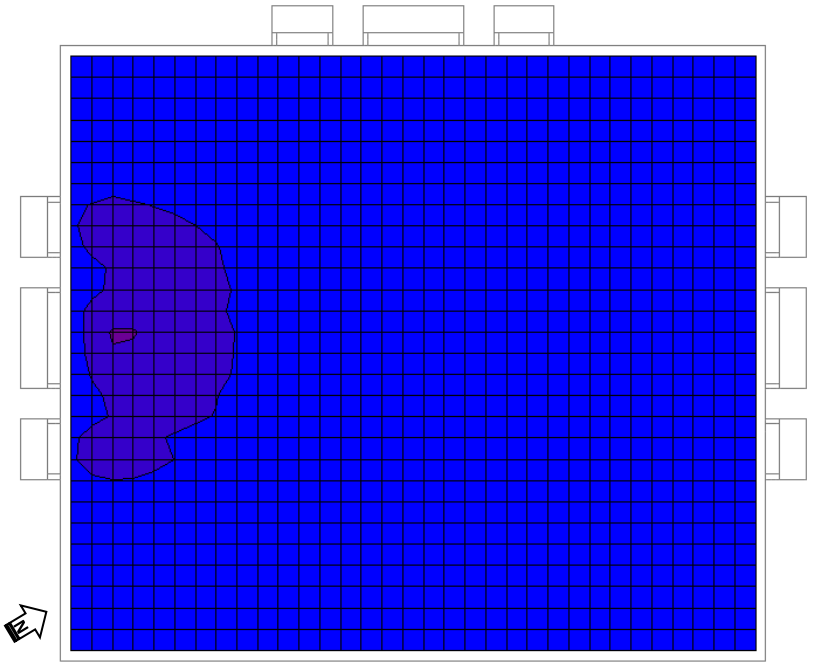
3) Blinds Operation

HMG data



8.6% Avg. DA

IDL three-phase calculation



2.5% Avg. DA

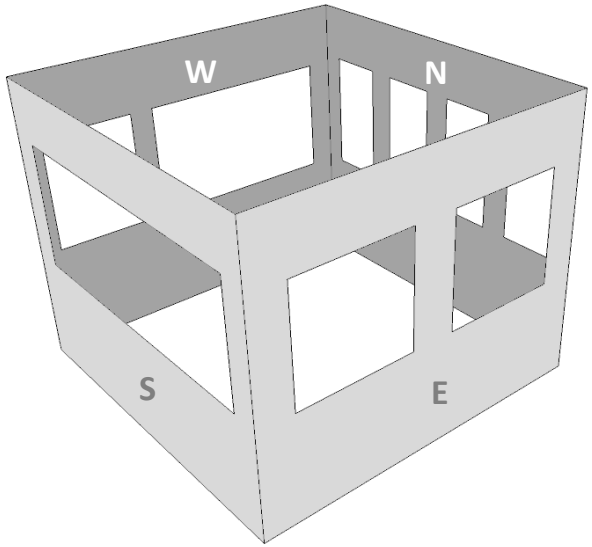
3) Blinds Operation

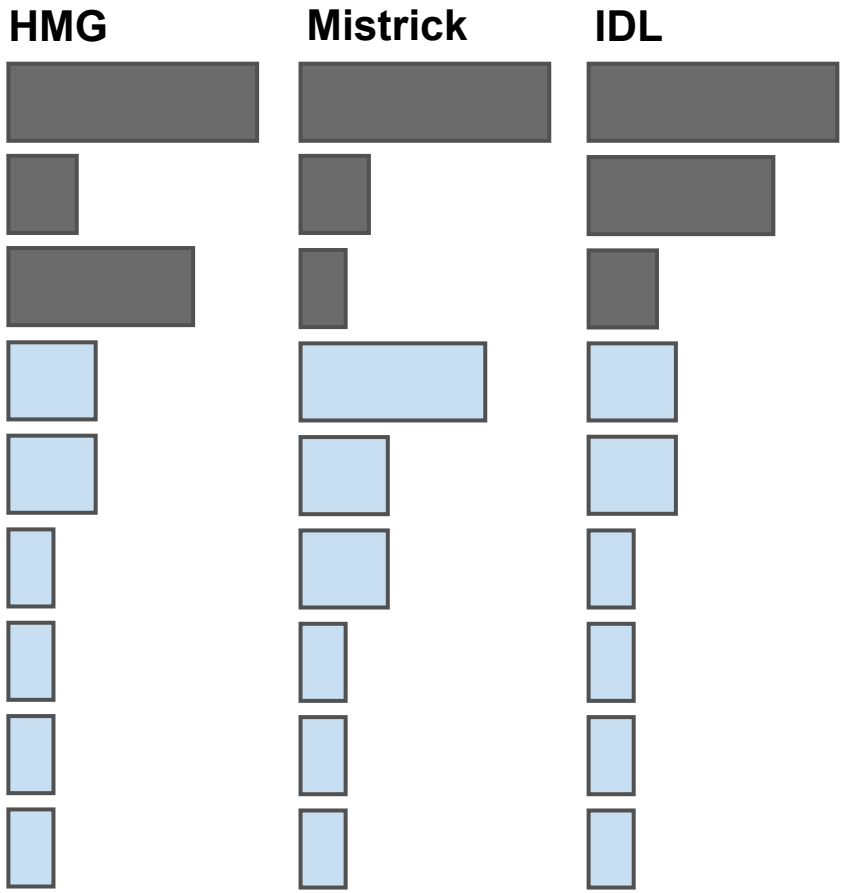
Space 1 (NYC) Summary	HMG	IDL
Annual Sunlight Exposure	6.9%	7.0%
Spatial Daylight Autonomy	93.8%	85.1%
Average Daylight Autonomy	84.6%	74.0%
Average Daylight Autonomy (open)	86.8%	79.1%
Average Daylight Autonomy (closed)	8.6%	2.5%

Space 2 (SEA) Summary		
Annual Sunlight Exposure	1.2%	5.7%
Spatial Daylight Autonomy	66.2%	44.9%

3) Blinds Operation logic and closing order …

- HMG, North-East-South-West
- Mistrick, optimized
- IDL, worst-to-least offender order
- LightStanza?
- SPOT?





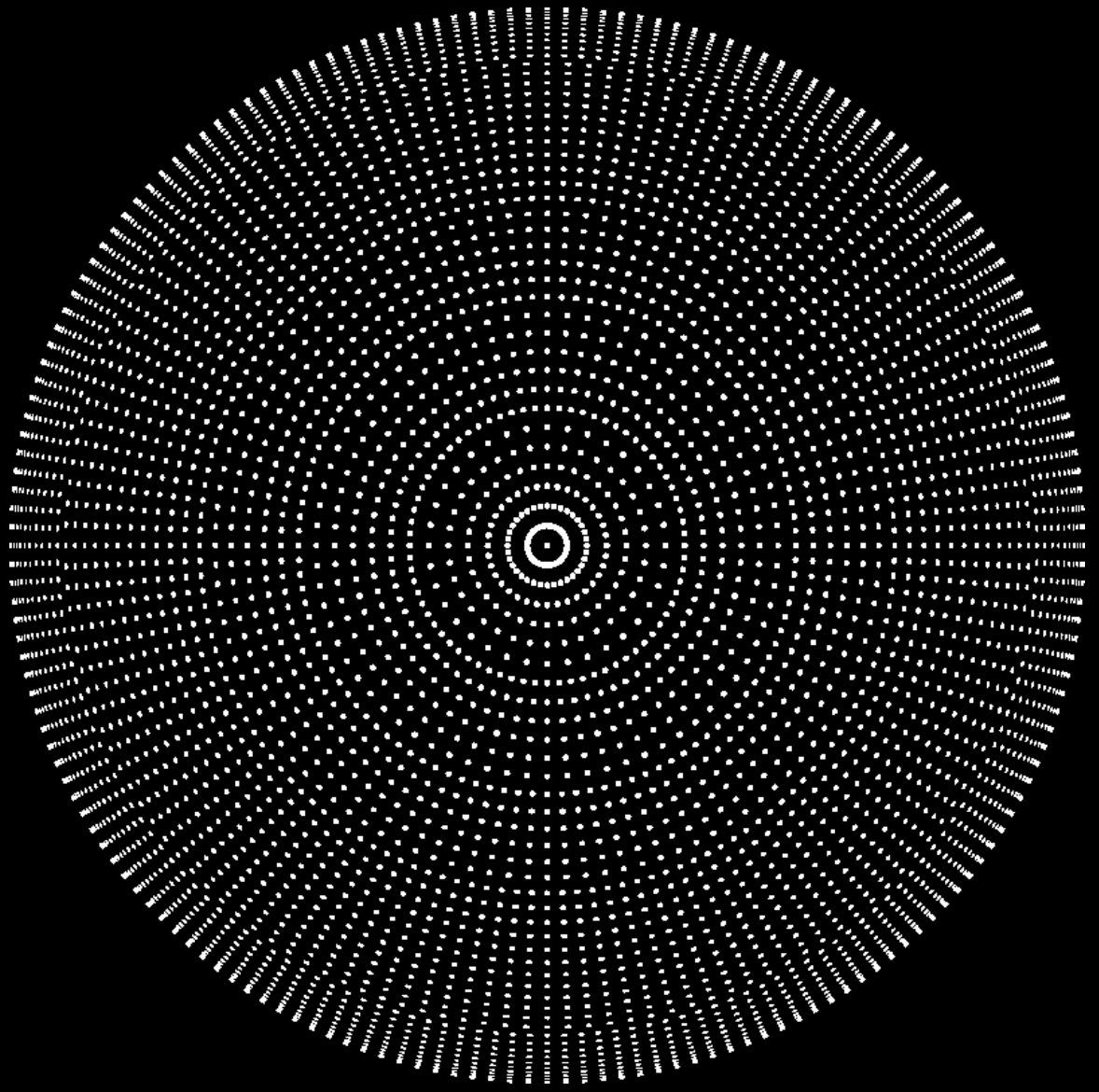
3) Blinds Operation

Space 1 (NYC) Summary	HMG	IDL	Daysim PS	SPOT	LightStanza
Annual Sunlight Exposure	6.9%	7.0%	?	?	?
Spatial Daylight Autonomy	93.8%	85.1%	?	?	?
Average Daylight Autonomy	84.6%	74.0%	?	?	?
Average Daylight Autonomy (open)	86.8%	79.1%	?	?	?
Average Daylight Autonomy (closed)	8.6%	2.5%	?	?	?

Space 2 (SEA) Summary		
Annual Sunlight Exposure	1.2%	5.7%
Spatial Daylight Autonomy	66.2%	44.9%

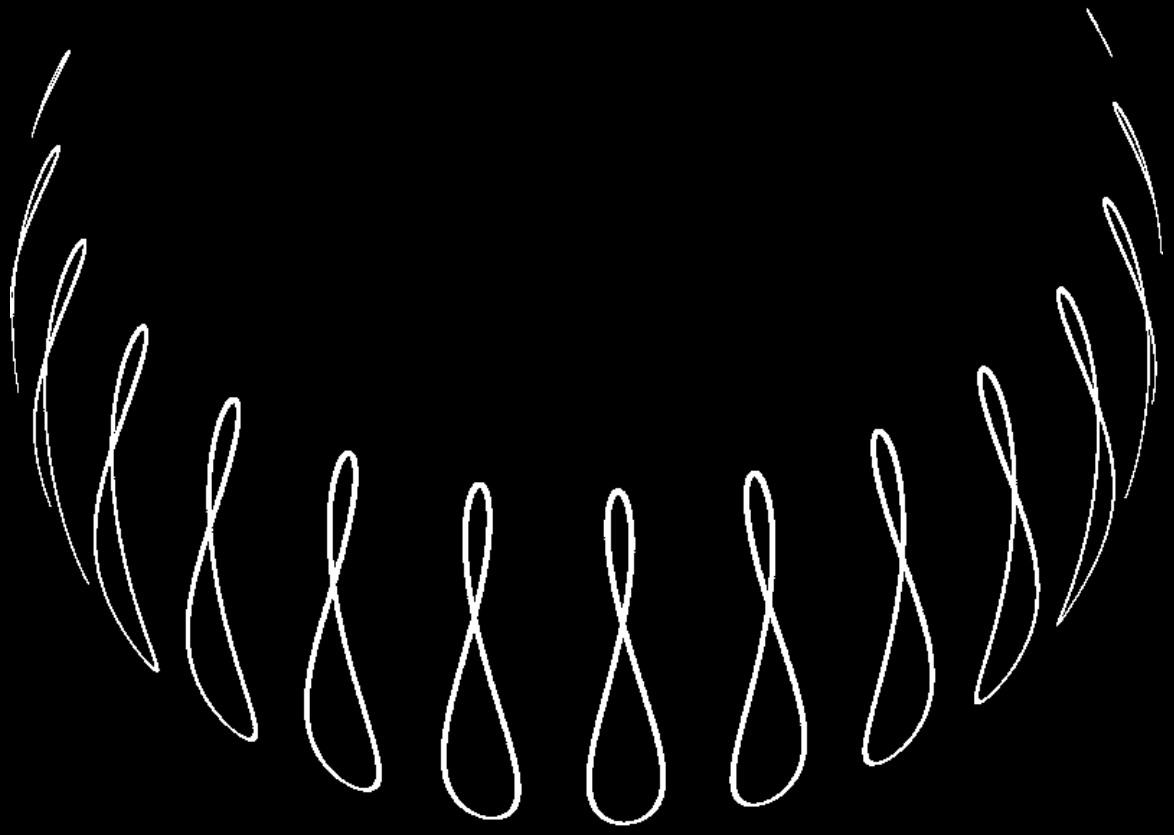
4) Alternate ASE calculations

- Based on 5-phase
  - 5,185 suns (MF:6)



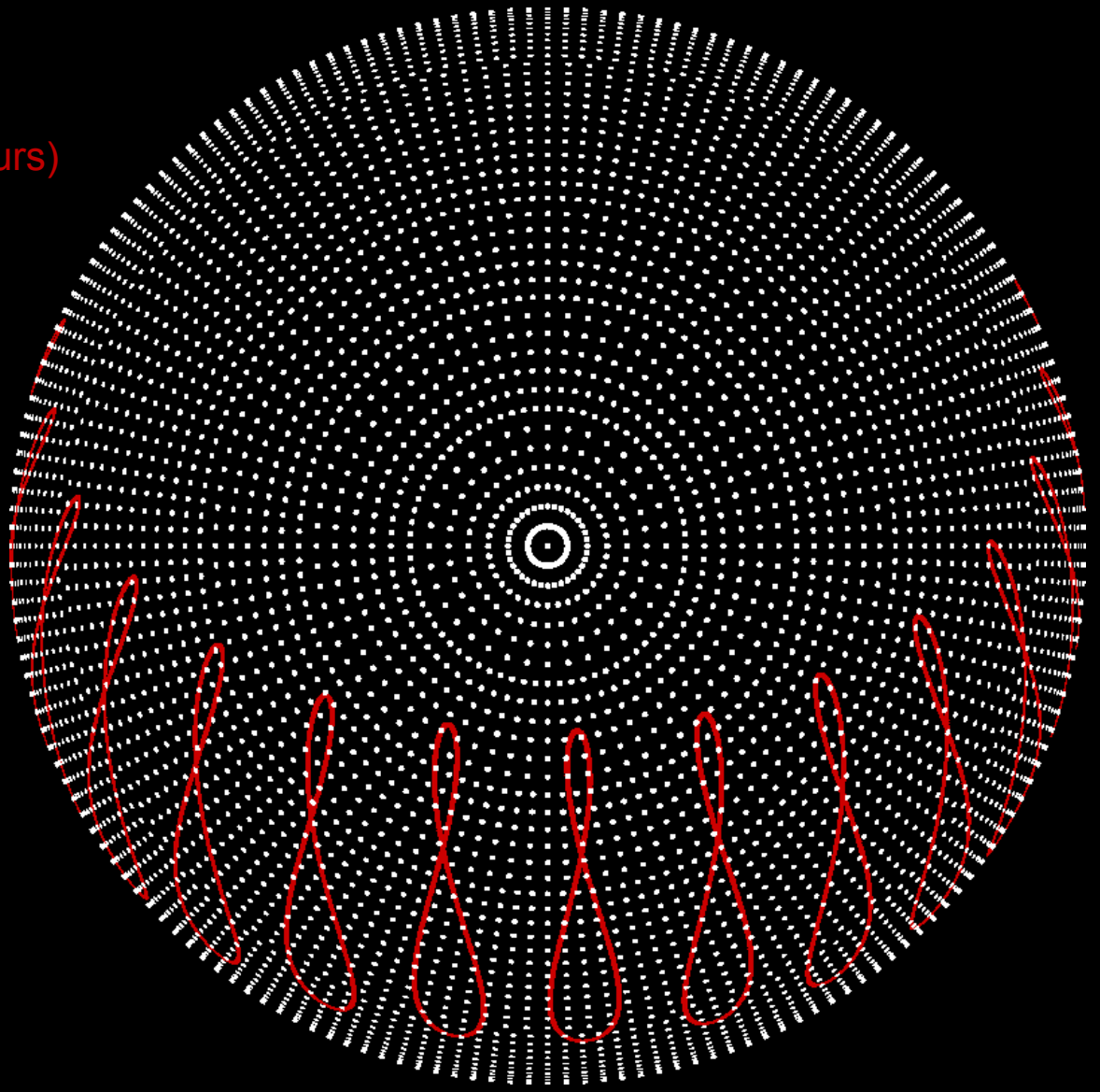
4) Alternate ASE calculations

- Based on 5-phase
  - 4,397 suns (daylit hours)
  - Location-specific (Boise, ID)



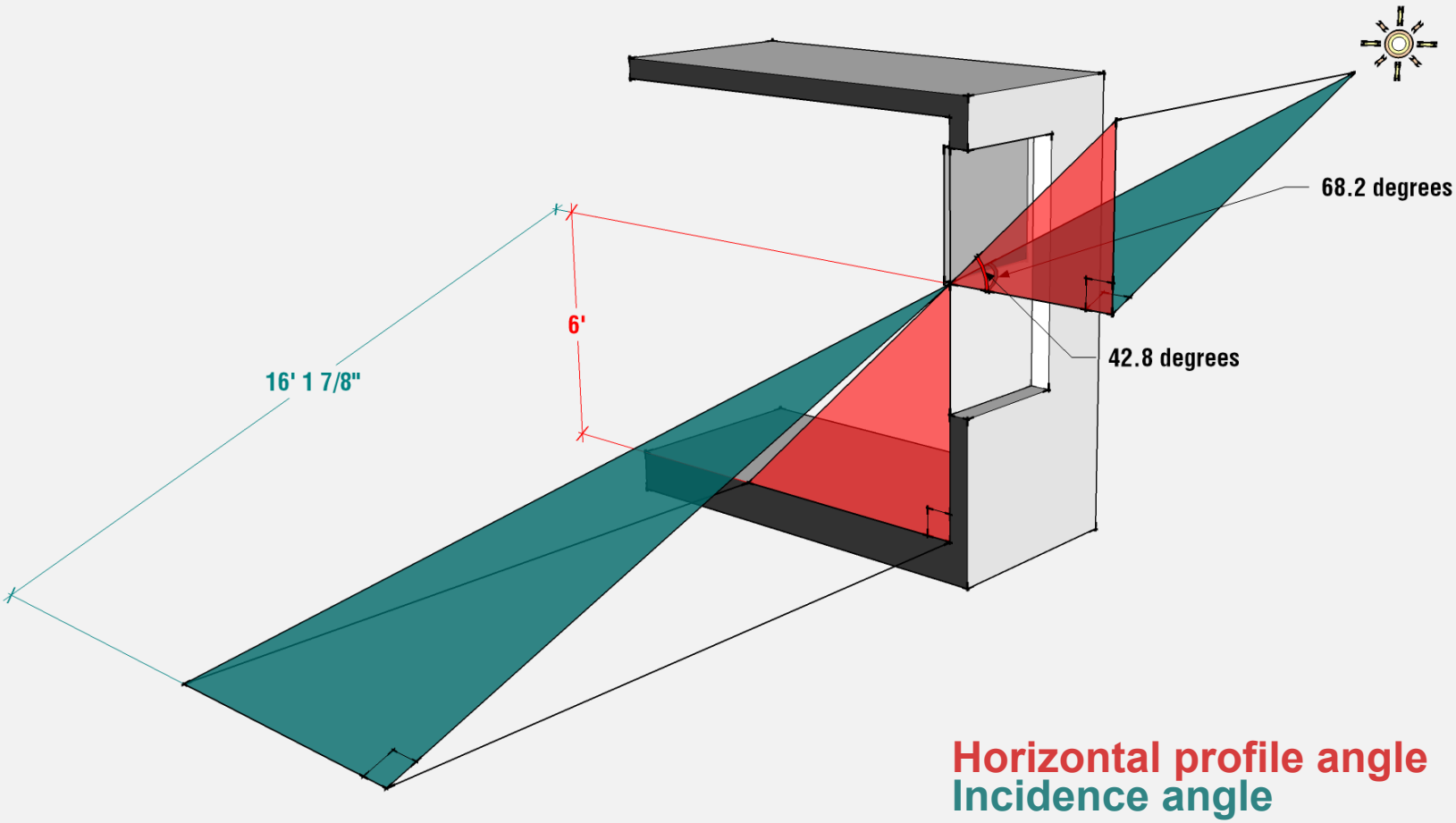
4) Alternate ASE calculations

- Based on 5-phase
  - 4,397 suns (daylit hours)
  - 5,185 suns (MF:6)

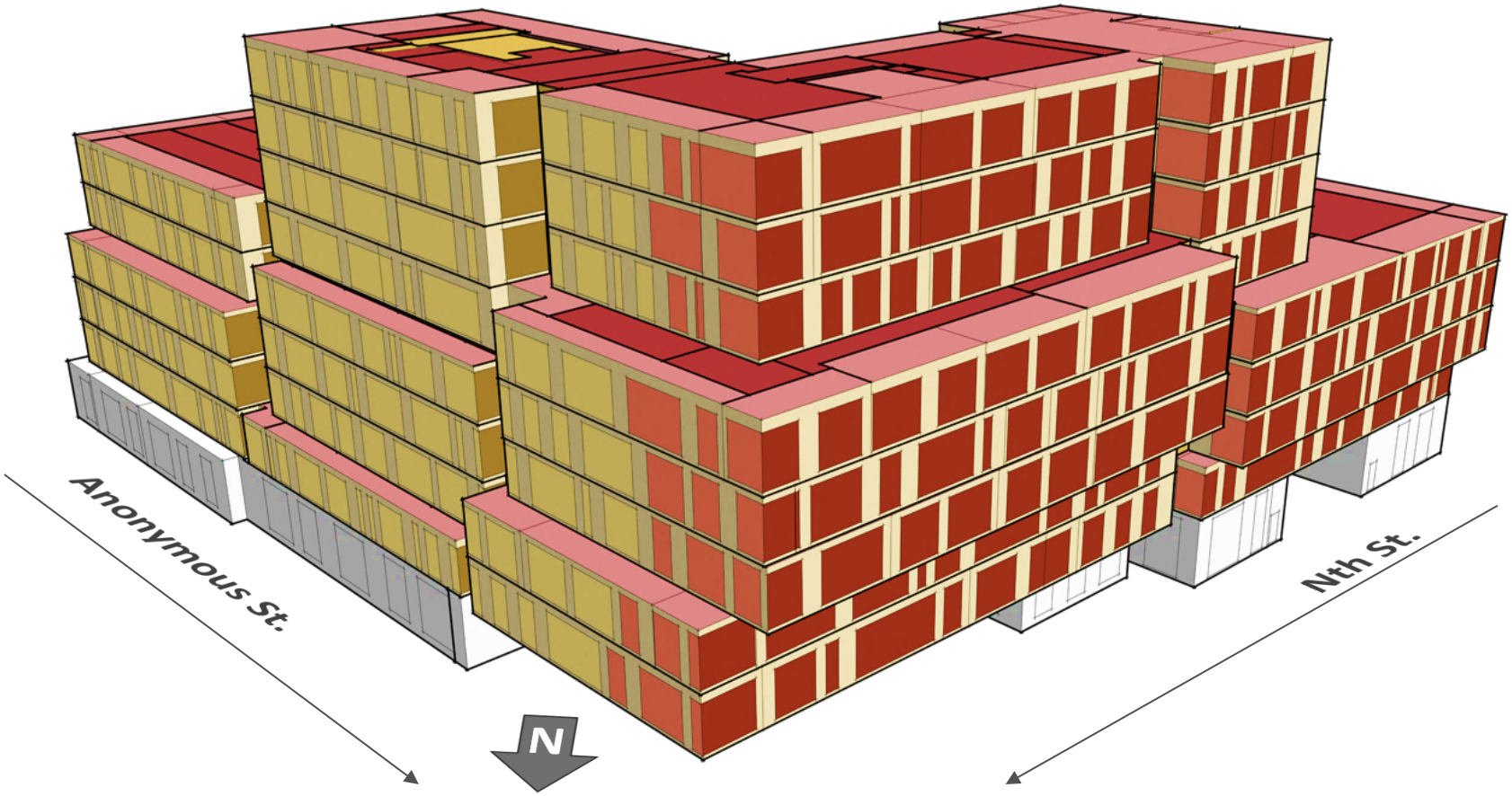


4) Alternate ASE calculations

- Using horizontal and parallel profile angles to trace exact shape of direct sunlight exposure.
- Compare area to floor surface. (2% trigger)



5) Daylight Zoning

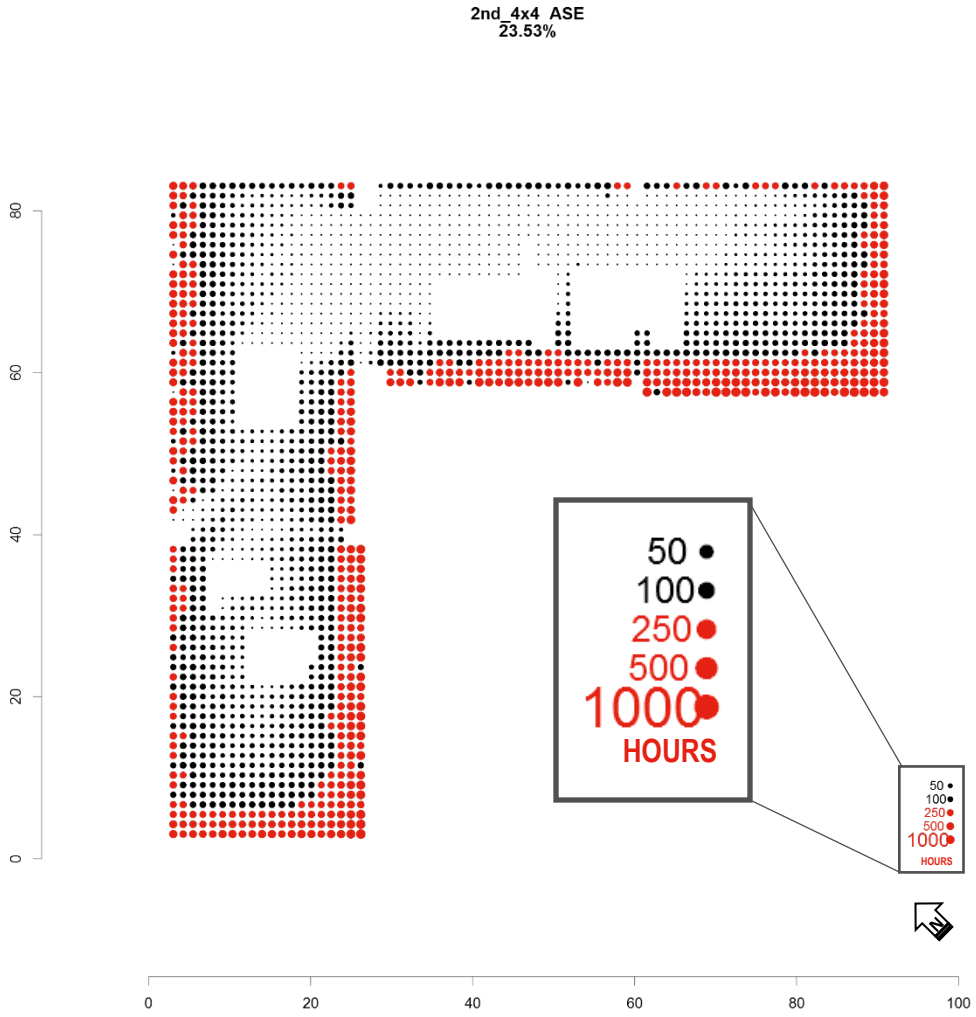


5) Daylight Zoning

ASE based on single analysis grid

- 4’x4’ analysis grid spacing.
- Cores excluded.

Floor		Zone	Time		ASE(%)
2nd		all	Annual		23.53
3rd		all	Annual		24.90
4th		all	Annual		24.88
5th		all	Annual		24.72
6th		all	Annual		28.52
7th		all	Annual		29.59
8th		all	Annual		32.08
9th		all	Annual		34.48

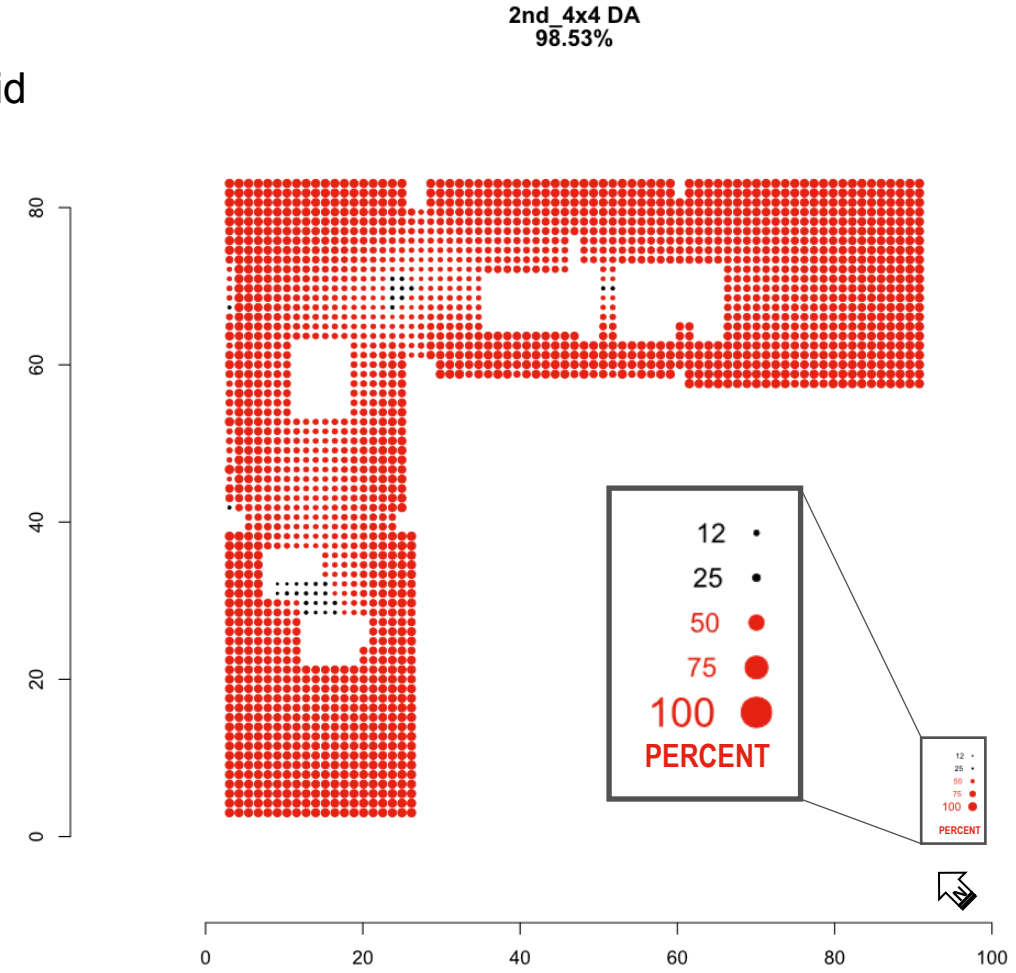


5) Daylight Zoning

sDA based on single analysis grid

- 4’x4’ analysis grid spacing.
- Cores excluded.

Floor		Zone	Time		sDA(%)
2nd		all	Annual		98.5
3rd		all	Annual		97.3
4th		all	Annual		99.2
5th		all	Annual		99.8
6th		all	Annual		100.0
7th		all	Annual		99.6
8th		all	Annual		99.4
9th		all	Annual		99.1

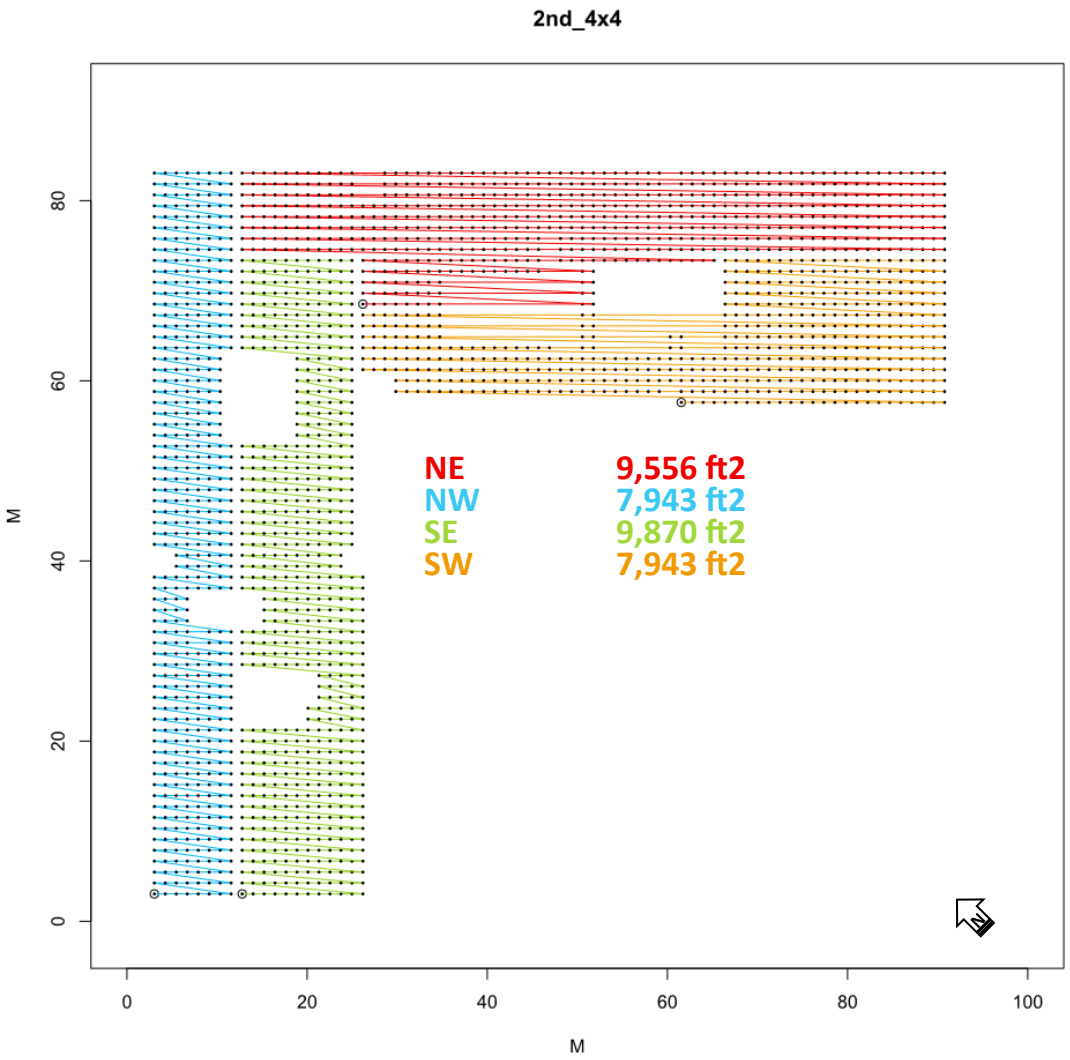


5) Daylight Zoning

LM-83-12 2.2.6

For the purpose of deriving the blinds operation schedules, analysis areas shall be considered by façade orientation, and never exceed 10,000 sf. The analysis grids must also extend across the entire space.

- Blinds operation based on zoning of spaces and window groups.
- Four spatial zones per floor.
- Windows grouped as designed and operated as part of each spatial zone.
- 4'x4' analysis grid spacing.
- Cores excluded.



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- Four spatial zones per floor.
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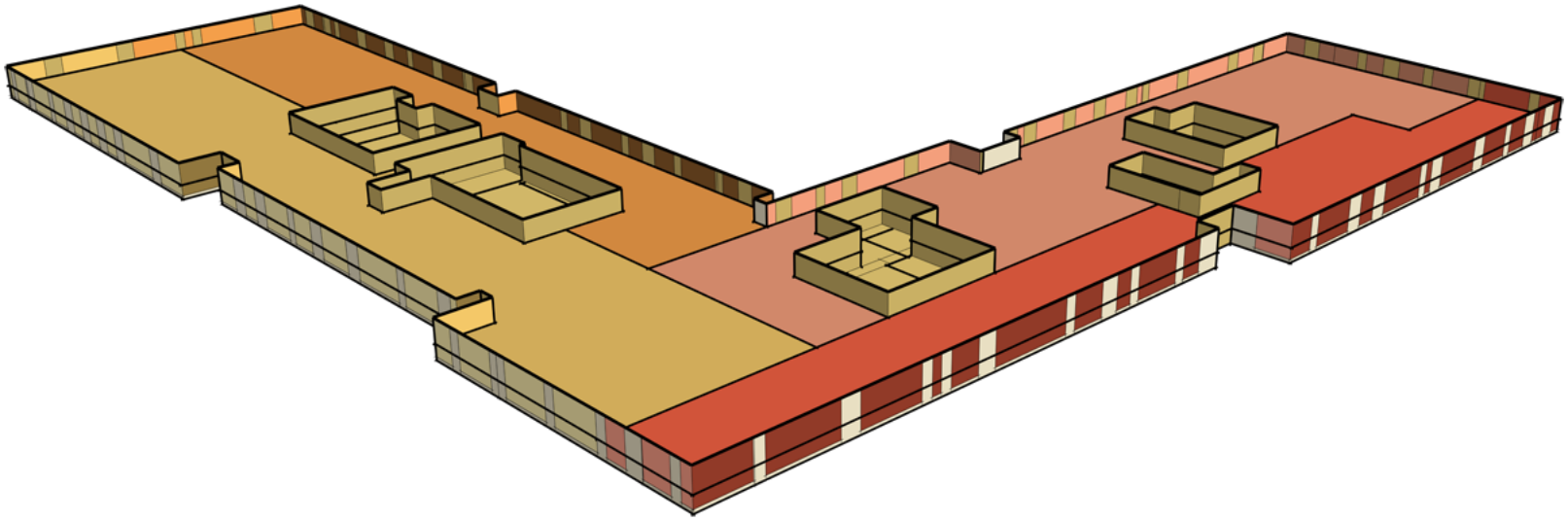
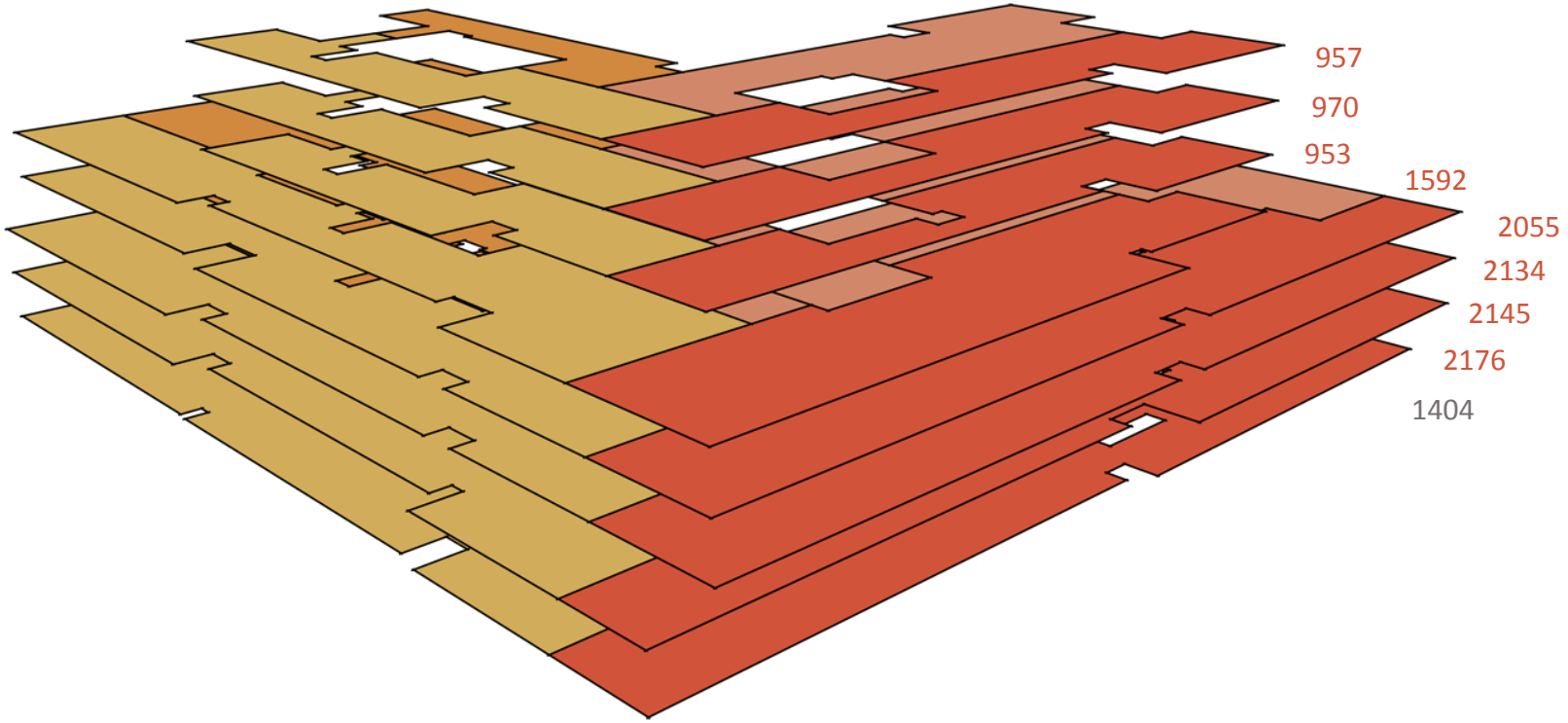
- 4’x4’ analysis grid spacing.
- Cores excluded.



5) Daylight Zoning

14,386 analysis points. (4'x4' grids)



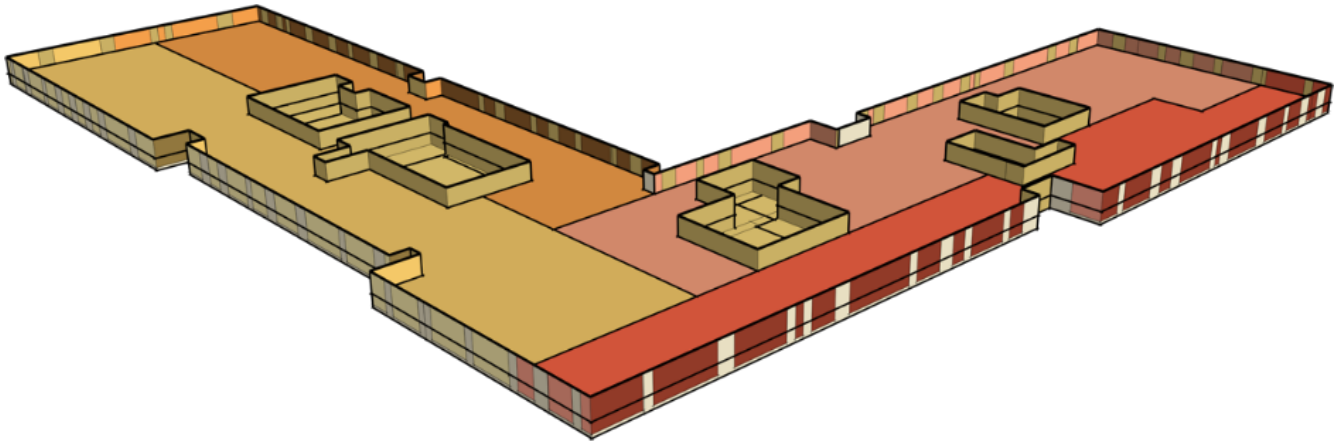
5) Daylight Zoning

Model organization

- LM-83 Radiance model structure
  - Generation of blinds operation schedules per spatial zone:
    - North-East Zone
    - North-West Zone
    - South-East Zone
    - South-West Zone

    } 691 window groups
  - Application of blinds schedule to entire floor plate:
    - Whole floor

    } 691 window groups

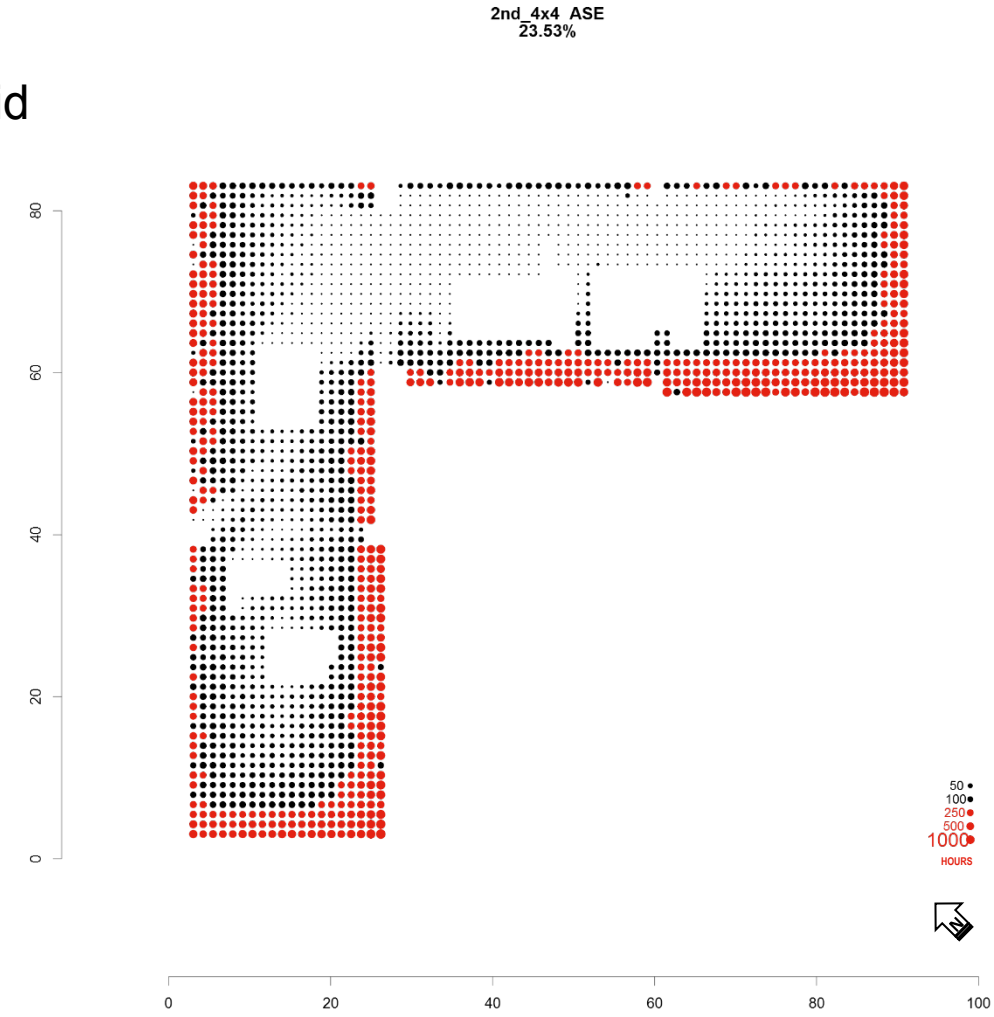


5) Daylight Zoning

ASE based on single analysis grid

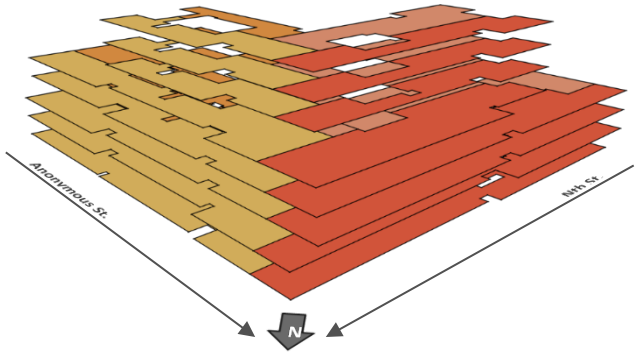
- 4’x4’ analysis grid spacing.
- Cores excluded.

Floor		Zone	Time		ASE(%)
2nd		all	Annual		23.53
3rd		all	Annual		24.90
4th		all	Annual		24.88
5th		all	Annual		24.72
6th		all	Annual		28.52
7th		all	Annual		29.59
8th		all	Annual		32.08
9th		all	Annual		34.48



5) Daylight Zoning

ASE based on zoned analysis grids



- Annual Sunlight Exposure

Floor	Zone	Time	ASE(%)
2nd	ne	Annual	5.75
3rd	ne	Annual	8.60
4th	ne	Annual	3.17
5th	ne	Annual	5.76
6th	ne	Annual	7.98
7th	ne	Annual	3.39
8th	ne	Annual	5.50
9th	ne	Annual	6.78

Floor	Zone	Time	ASE(%)
2nd	sw	Annual	41.72
3rd	sw	Annual	47.26
4th	sw	Annual	42.25
5th	sw	Annual	46.33
6th	sw	Annual	57.10
7th	sw	Annual	63.78
8th	sw	Annual	69.29
9th	sw	Annual	74.02

Floor	Zone	Time	ASE(%)
2nd	nw	Annual	23.53
3rd	nw	Annual	19.10
4th	nw	Annual	23.41
5th	nw	Annual	21.23
6th	nw	Annual	26.59
7th	nw	Annual	34.46
8th	nw	Annual	38.01
9th	nw	Annual	41.70

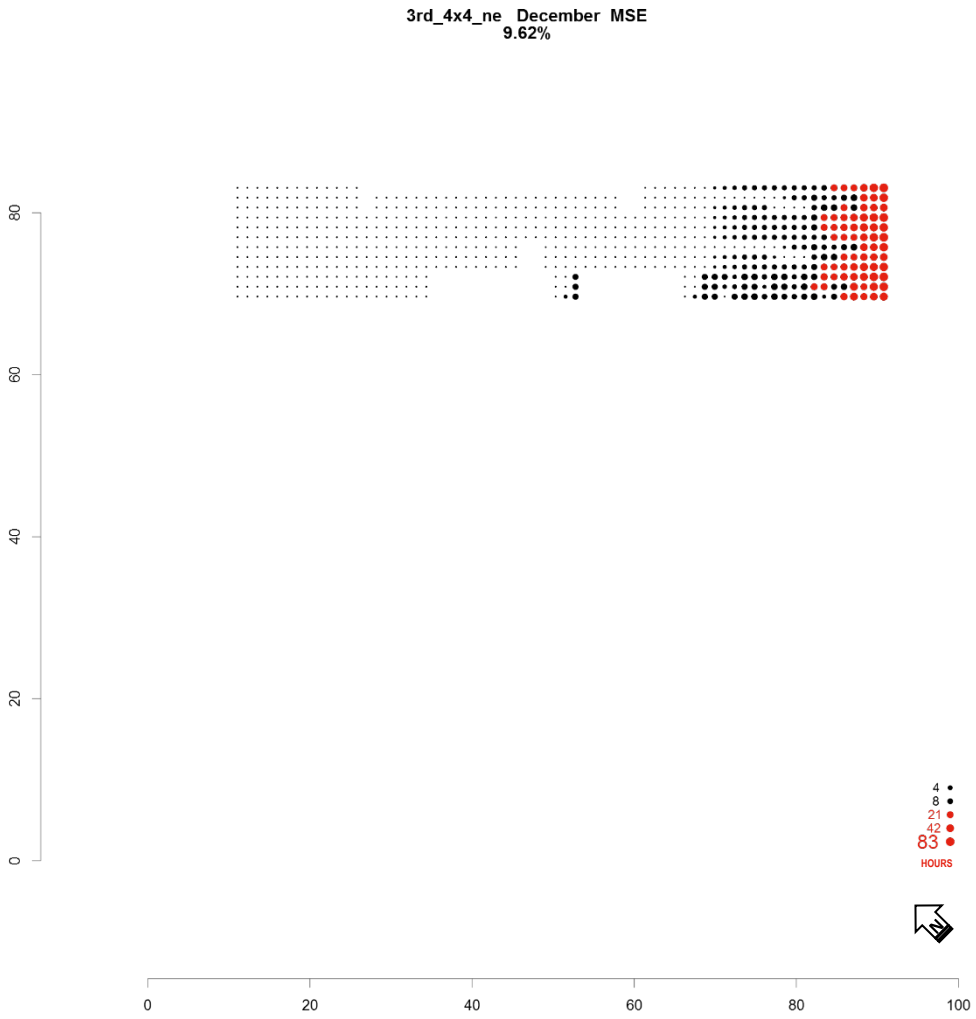
Floor	Zone	Time	ASE(%)
2nd	se	Annual	26.59
3rd	se	Annual	31.77
4th	se	Annual	34.88
5th	se	Annual	29.87
6th	se	Annual	32.04
7th	se	Annual	31.27
8th	se	Annual	31.89
9th	se	Annual	33.13

5) Daylight Zoning

ASE in North-East zone

- Monthly breakdown

Floor		Zone	Time		ASE(%)
3rd		ne	January		7.00
3rd		ne	February		7.29
3rd		ne	March		7.43
3rd		ne	April		9.04
3rd		ne	May		8.89
3rd		ne	June		12.68
3rd		ne	July		12.24
3rd		ne	August		11.22
3rd		ne	September		8.16
3rd		ne	October		8.89
3rd		ne	November		7.29
3rd		ne	December		9.62



5) Daylight Zoning

ASE in North-East zone

- Monthly breakdown

Floor		Zone	Time		ASE(%)
3rd		ne	January		7.00
3rd		ne	February		7.29
3rd		ne	March		7.43
3rd		ne	April		9.04
3rd		ne	May		8.89
3rd		ne	June		12.68
3rd		ne	July		12.24
3rd		ne	August		11.22
3rd		ne	September		8.16
3rd		ne	October		8.89
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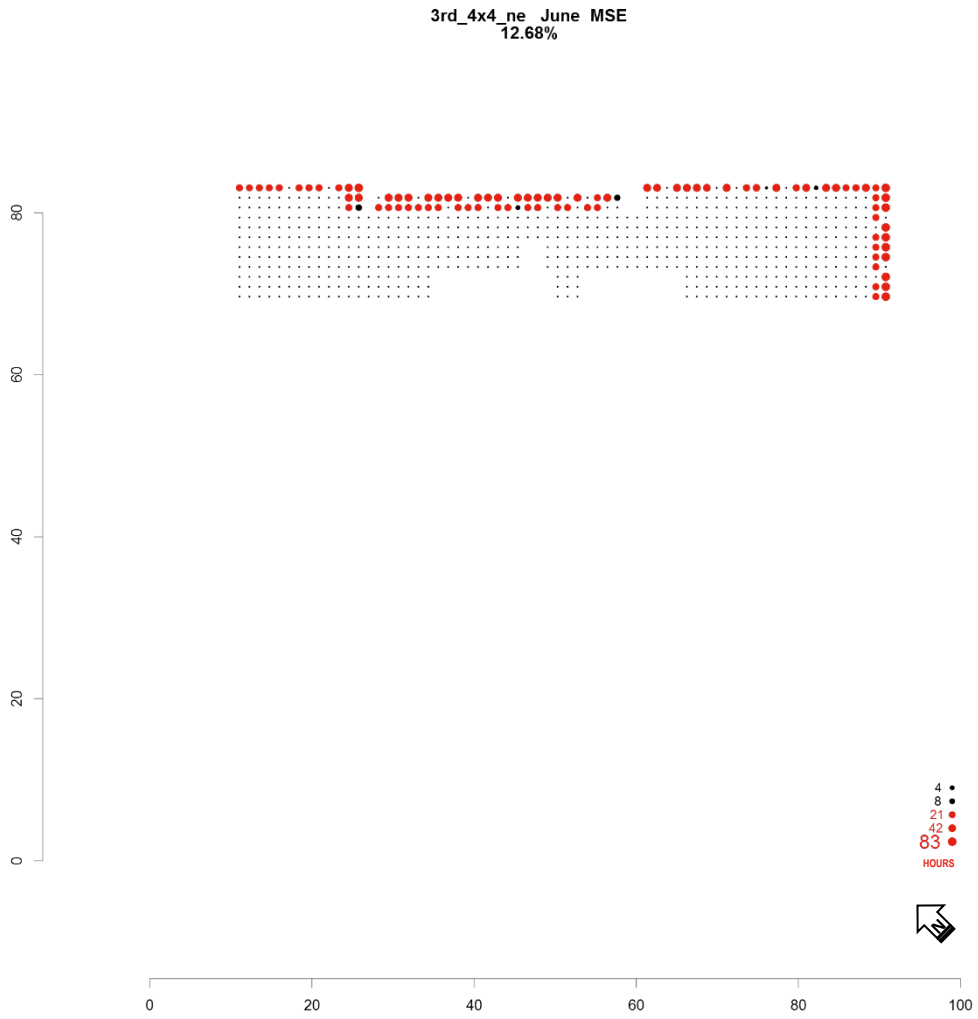
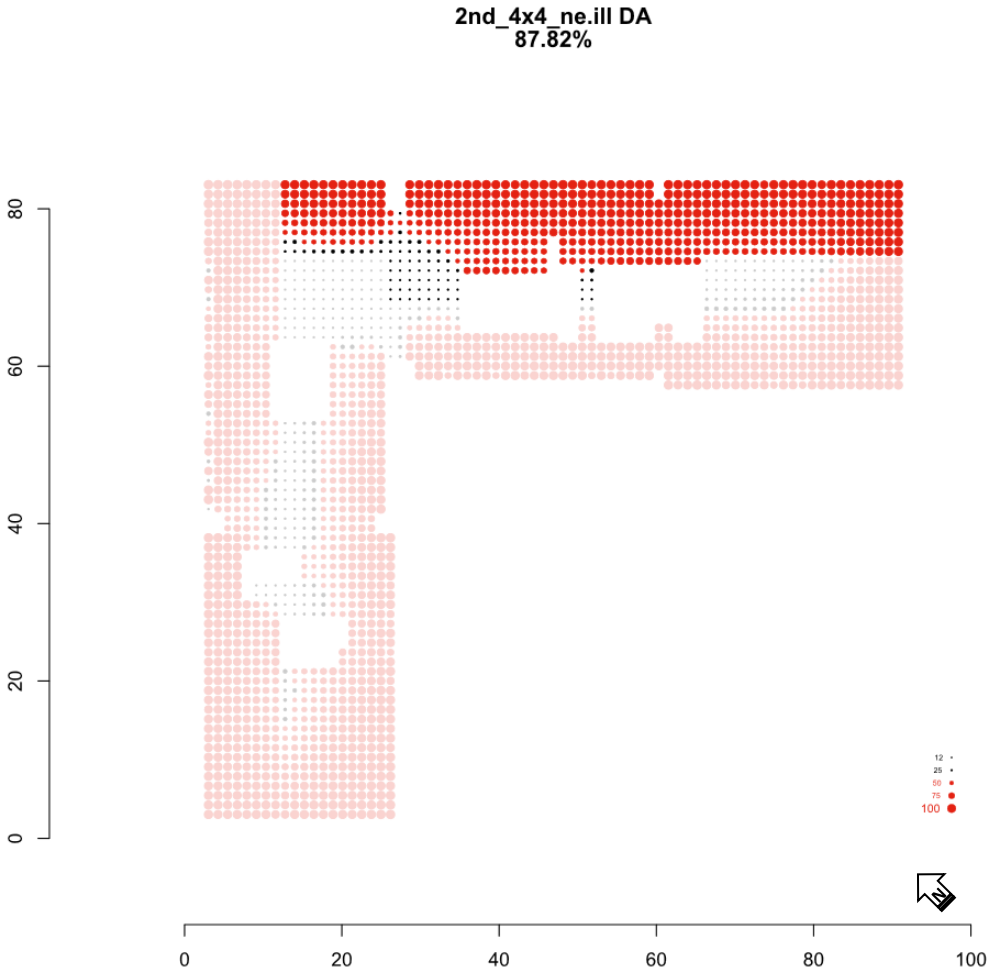


5) Daylight Zoning

Blinds operation

- Daylight Autonomy based on **LM83** and **zoned grids (4)** per floor.
- **Each zone operated individually.**

Floor		Zone	Time		DA(%)
2nd		ne	Annual		87.8
2nd		nw	Annual		94.1
2nd		se	Annual		69.4
2nd		sw	Annual		80.7
2nd		all	Annual		82.7



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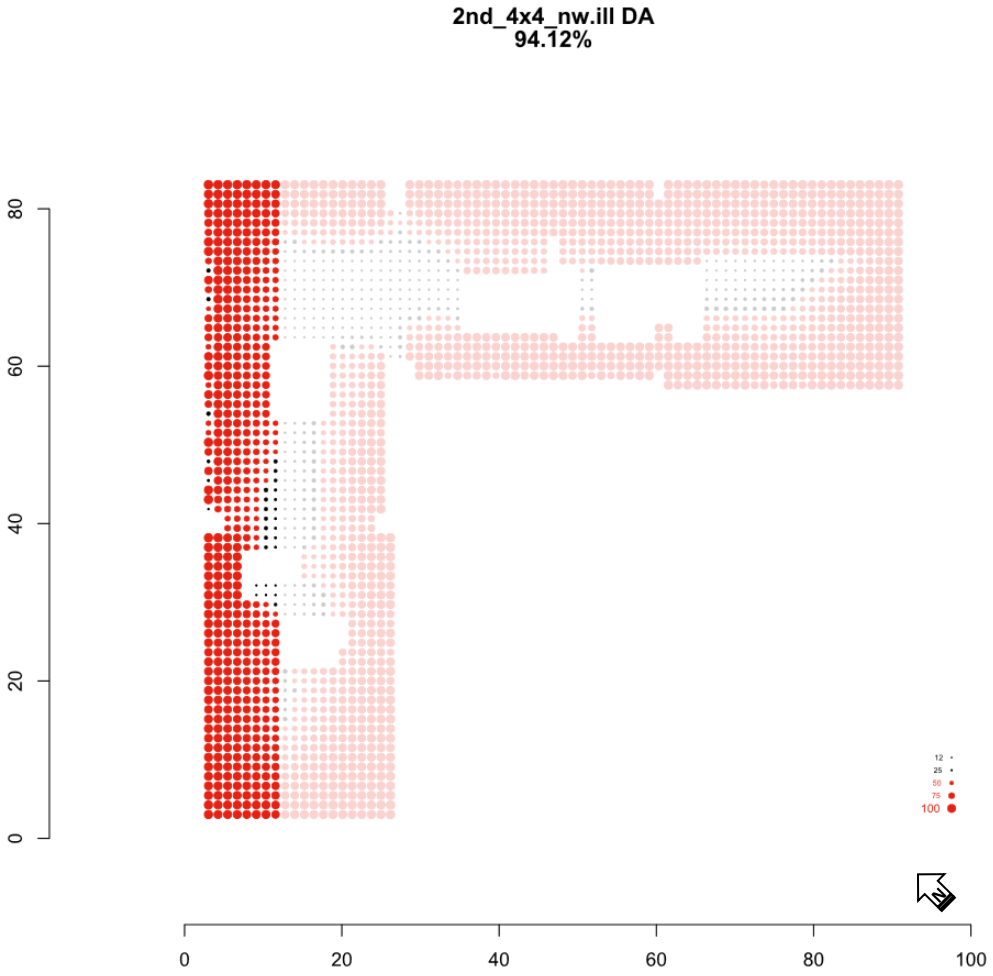

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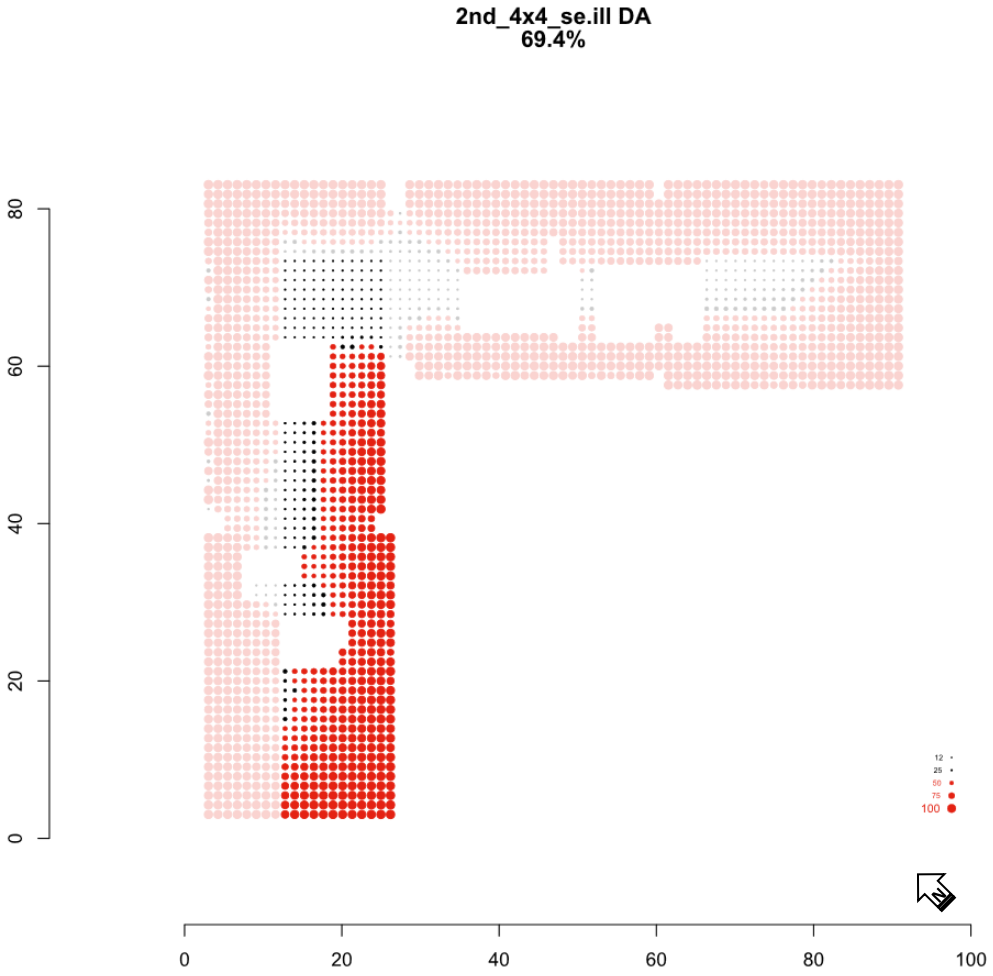

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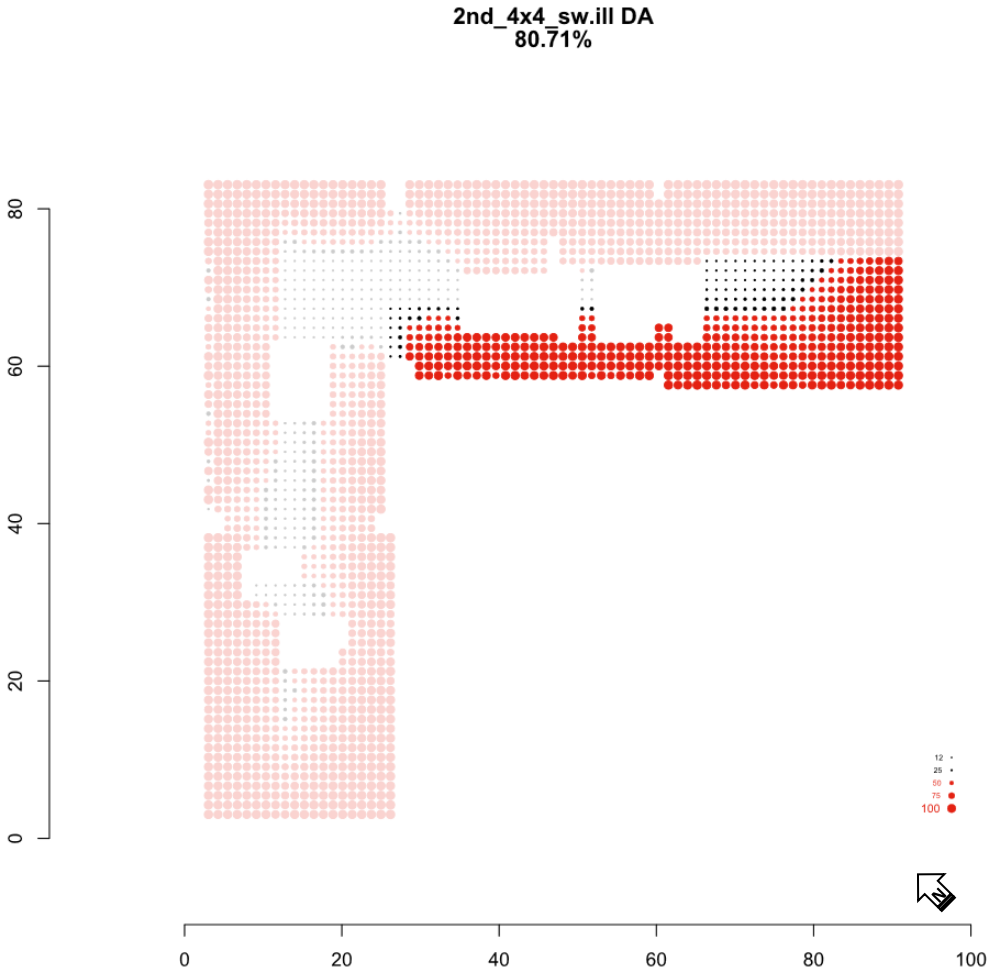

5) Daylight Zoning

Blinds operation

- Daylight Autonomy based on **LM83** and **zoned grids (4)** per floor.
- **Each zone operated individually.**

Floor		Zone	Time		sDA(%)
2nd		ne	Annual		87.8
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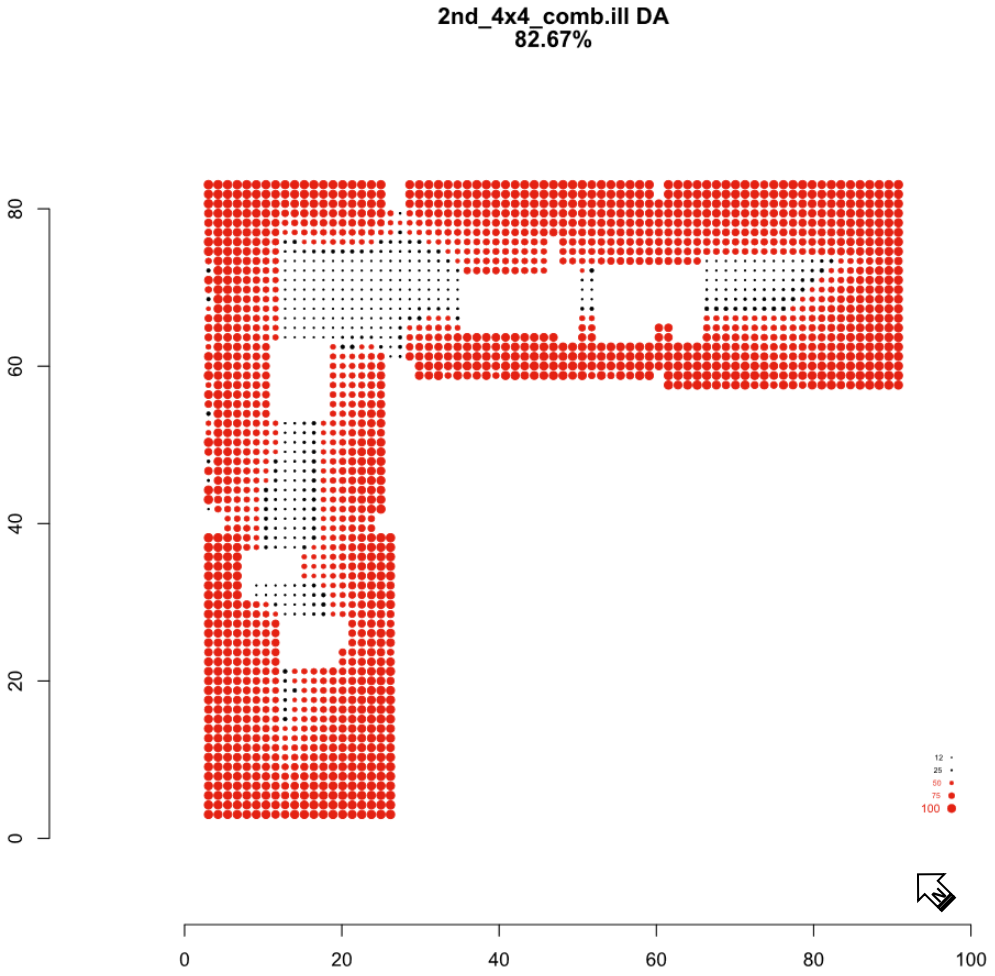
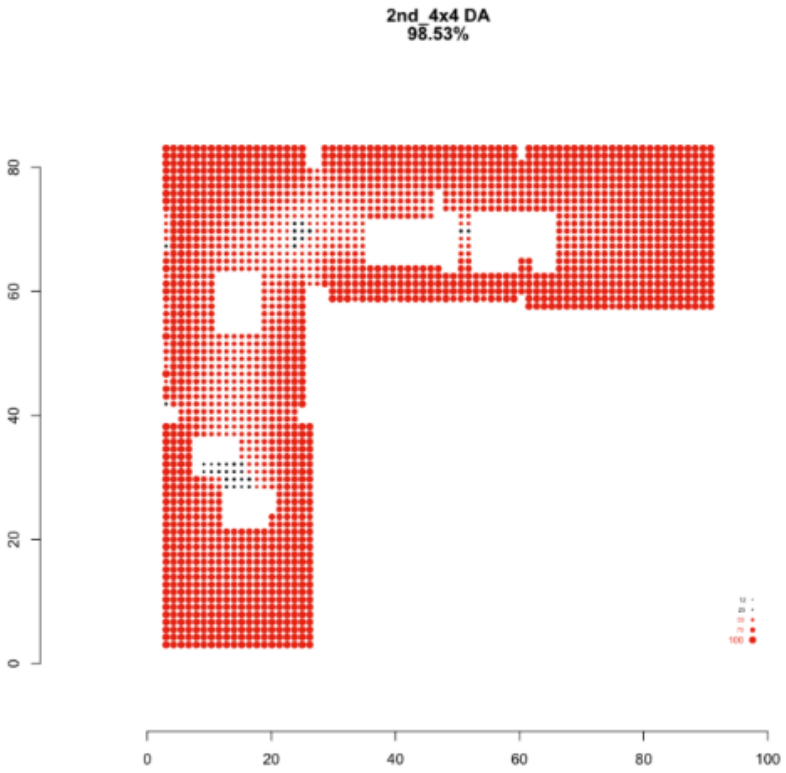
2nd		sw	Annual		80.7
2nd		all	Annual		82.7



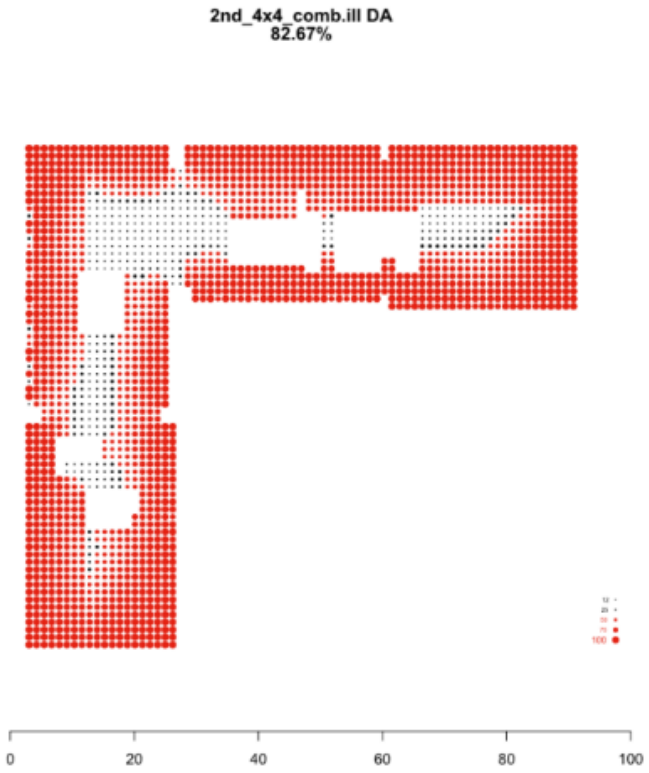
5) Daylight Zoning of Floor Plates

FULL FLOOR PLATE



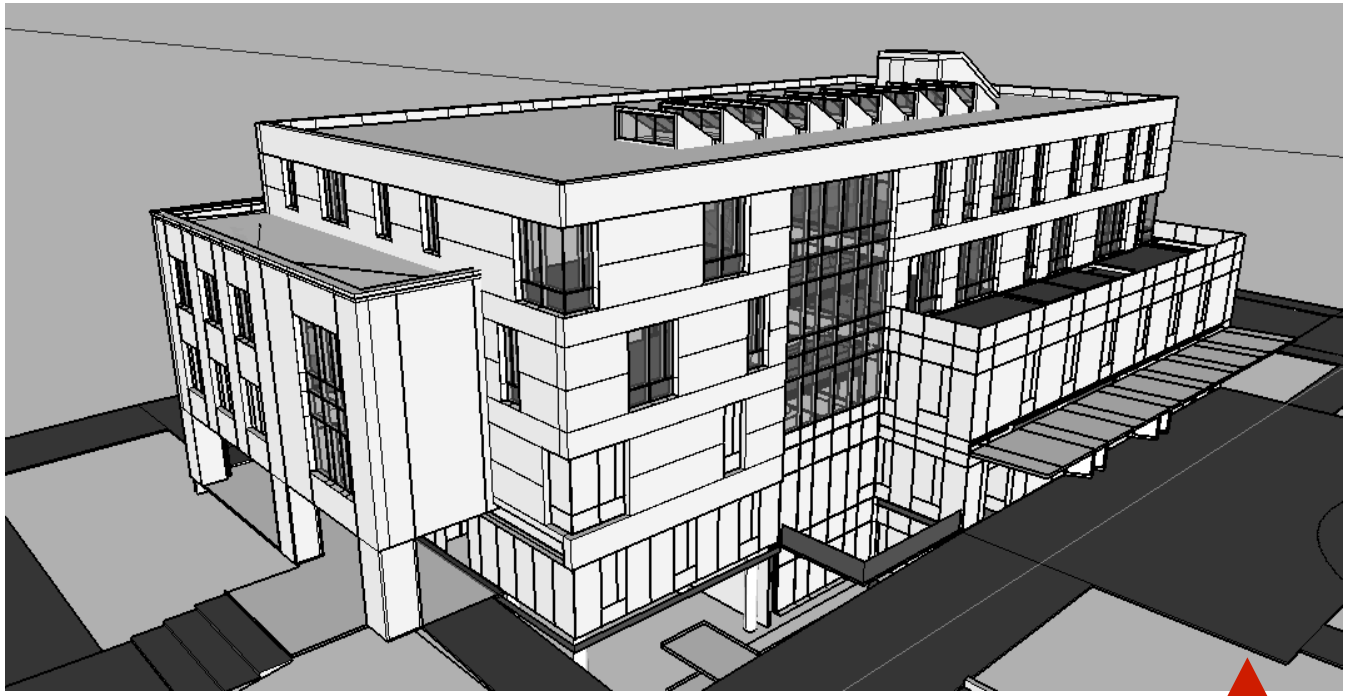
98.5% sDA

ZONED

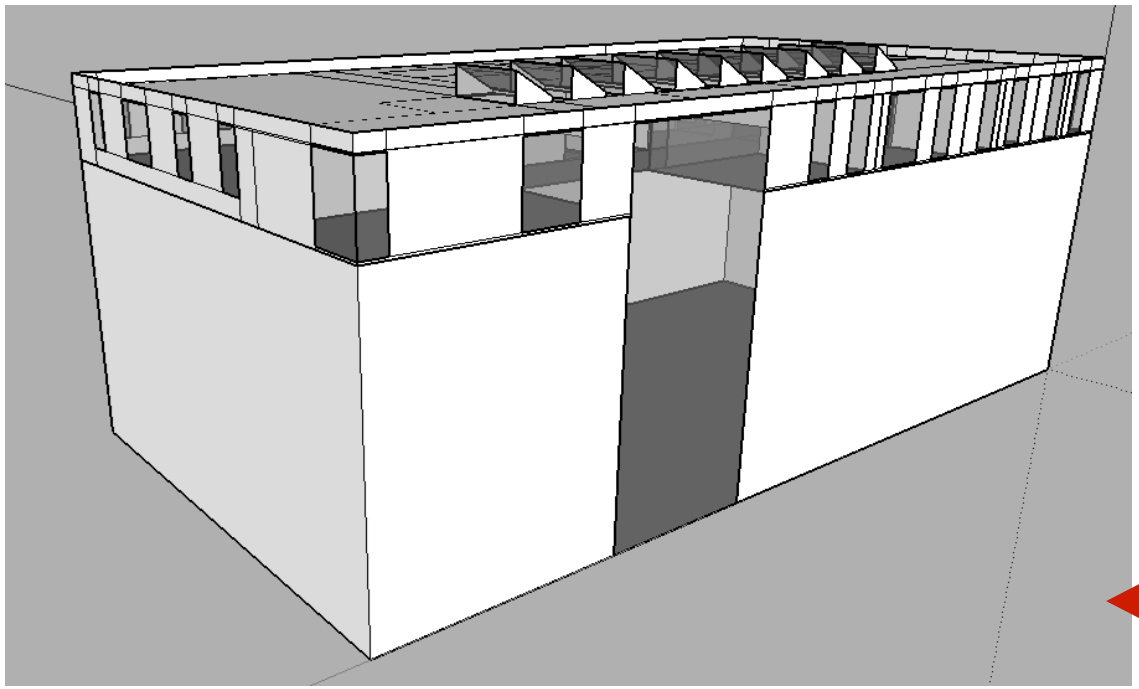


82.7% sDA

6) Detailed Geometry



Detailed Original Model

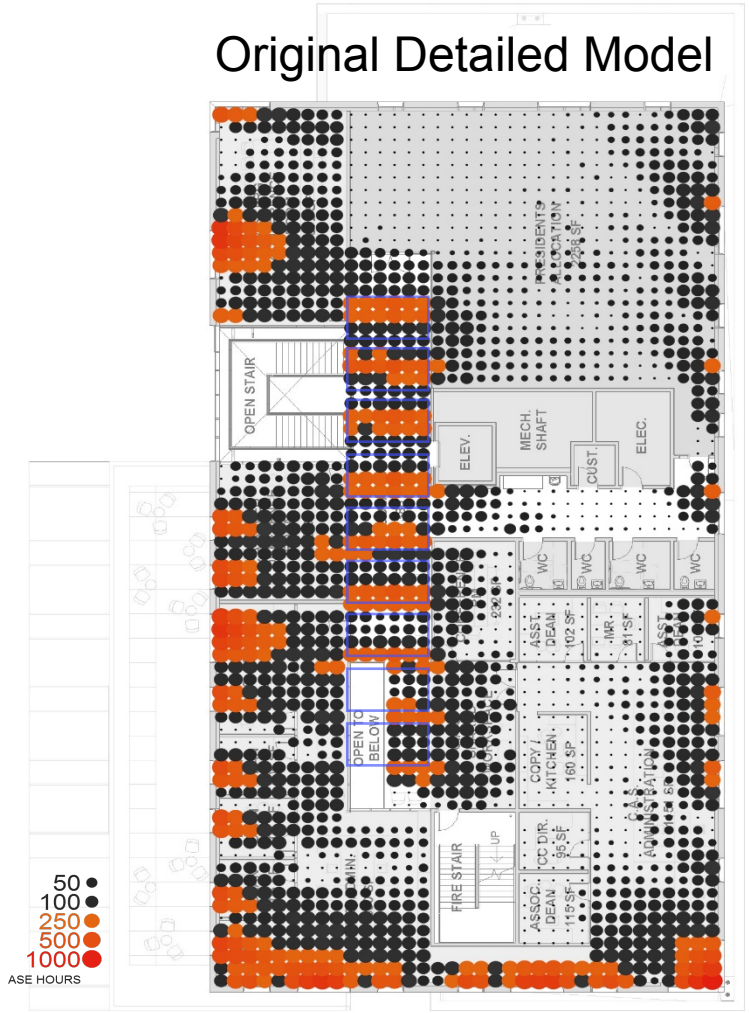


Reduced Model

4TH FLOOR

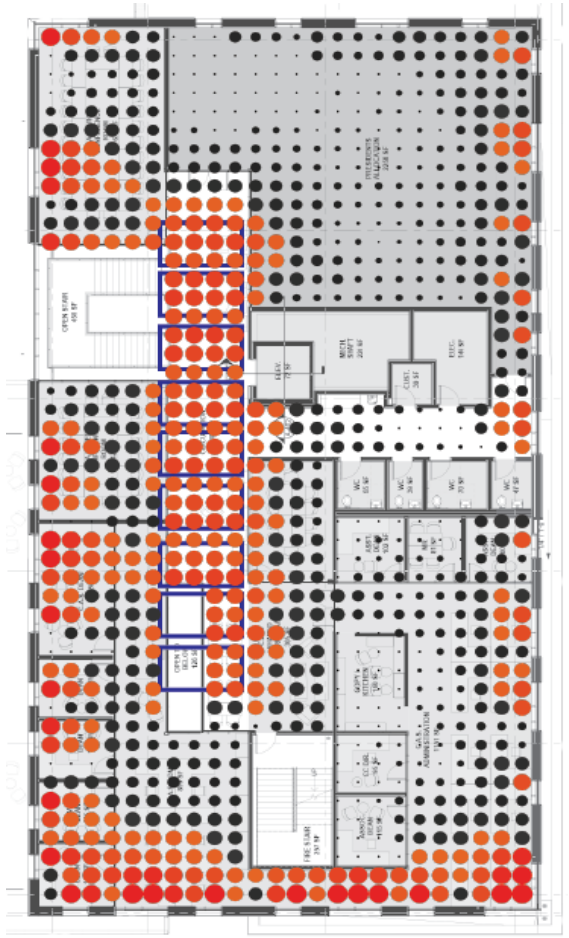
4TH FLOOR (As-designed)

Original Detailed Model



ASE: **12.3%**

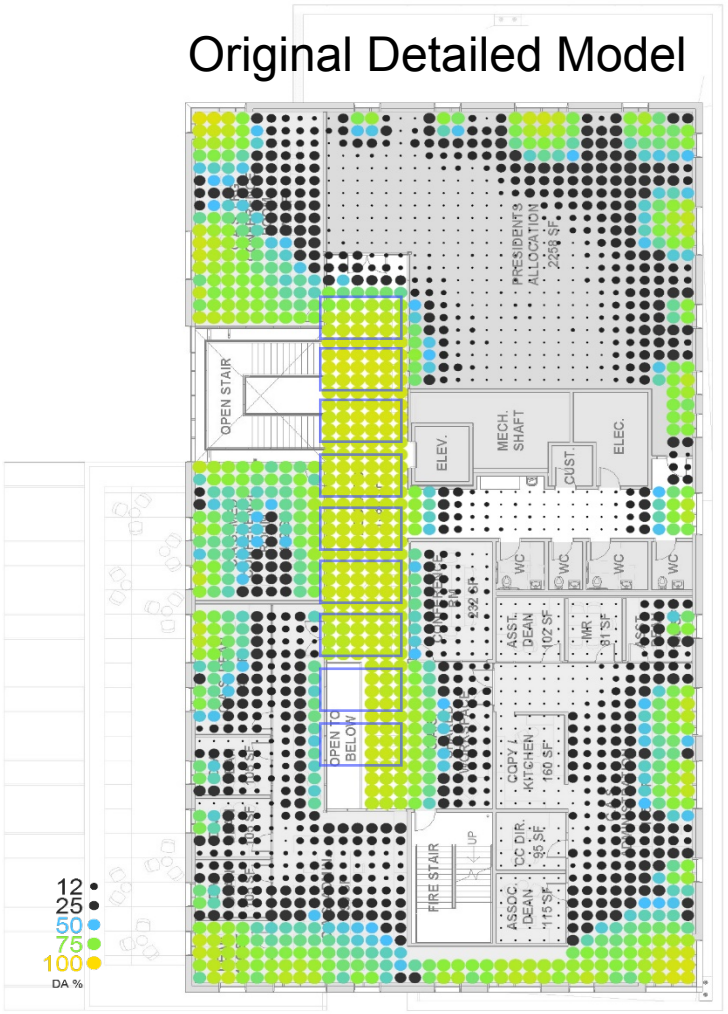
Reduced Model



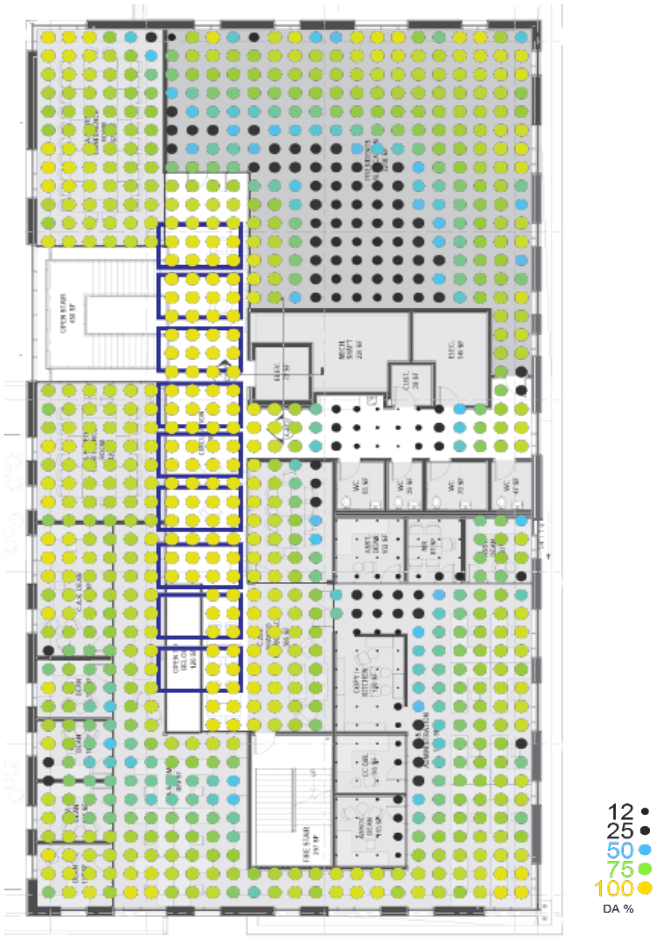
ASE: **33.0%**

4TH FLOOR (As-designed)

Original Detailed Model



Reduced Model



N

sDA: **39.2%**

sDA: **80.4%**

THANK YOU!

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Amir Nezamdoost (amirn@uoregon.edu)

UNIVERSITY OF OREGON | Energy Studies in Buildings Laboratory

INTEGRATED idl DESIGN LAB
University of Idaho