SUCCESSFULLY UTILIZING THE WUFI PASSIVE DYNAMIC SHADING TOOL

PASSIVE HOUSE ALLIANCE UNITED STATES

PHIUS®

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14th NAPHC Washington - Dec. 7, 2019

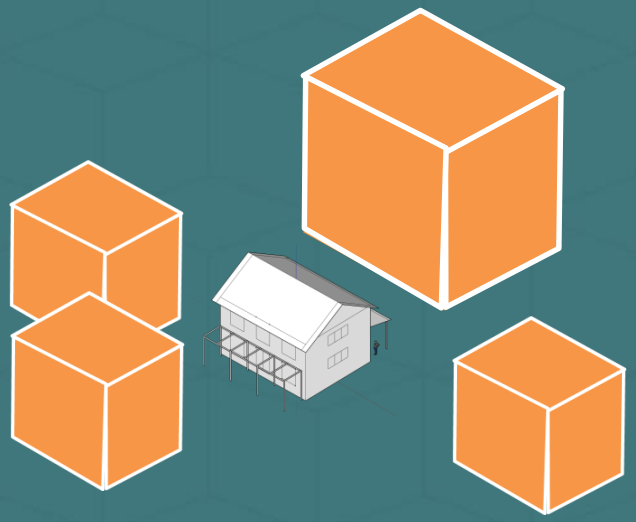
WUFI Passive Dynamic Shading Tool

- Method developed to compute **monthly shading factors** per window.
- It takes into account all shading interactions and is **based on a geometrical representation** of all elements that shade transparent building components.
- It is implemented in the PHIUS Certification **software WUFI** and applied to certified passive projects.

Shading Simulation Techniques

- **Shading simulation** techniques can precisely address the **influence of solar irradiation** on building surfaces, and these **are fundamental to meet environmental targets**.

- Self-shading: geometry depends from building design.
- **Site shading:** geometry depends on context variables.



Outline

1. ‘Site Shading’ in the PHIUS+ Certification Program.
2. ‘Site Shading’ representation.
3. Method for using ‘sky-dome images’ in compliance with the WUFI Passive Shading.
4. Comparative test between ‘building geometry’ and ‘updated pathfinder protocol’.
5. Conclusions.

How ‘Site Shading’ is accounted in the PHIUS+ Building Certification Program ?

Shading Protocol in WUFI Passive

Shading Elements

Reveals (even)

Reveals (uneven)

Landscape Obstructions

Overhangs

Other shading fractions

Sunscreen Devices

‘Site Shading’ of a passive building.

Variations with ‘Shading Methodologies’

Shading Elements	Previous Methodology	New Methodology
Reveals (even)	Numeric entries	Numeric entries modify imported geometry for calculation
Reveals (uneven)	Calculator mulled windows – ‘L’ shapes	
Landscape Obstructions	**Calculated from numeric entries**	**Calculated from imported geometry**
Overhangs		
Other shading fractions		**Calculated from numeric entries**
Sunscreen Devices		

WUFI entries from Certificate Criteria

Shading Elements	PHIUS+ 2015	PHIUS+ 2018
Height of Landscape Obstruction (ft.)	Yes	N/A
Distance of Landscape Obstruction (ft.)	Yes	N/A
Other shading (winter) fraction of solar exposure	Yes	Yes
Other shading summer fraction of solar exposure	Yes	Yes

New methodology – Site Shading possibilities

Shading Elements	New Methodology
Reveals (even)	Numeric entries modify imported geometry for Calculation
Reveals (uneven)	
Landscape Obstructions	**How to make a more precise geometrical representation?**
Overhangs	
Other shading fractions	**How an imported geometry can represent these fractions?**
Sunscreen Devices	

Effective modeling for calculation in WUFI

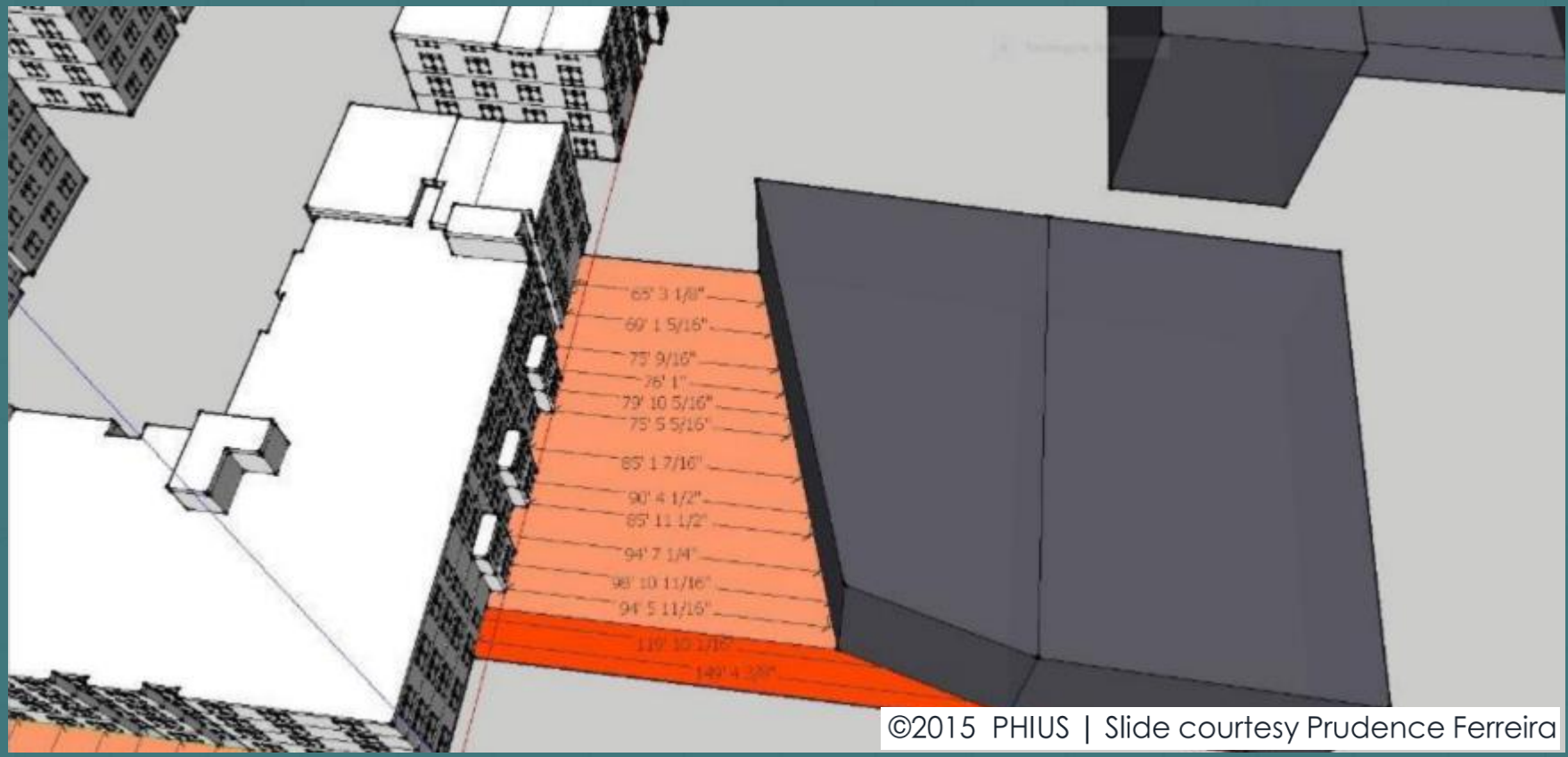
Calculations of seasonal shading within WUFI

PART 2

How to effectively utilize the WUFI dynamic shading tool through ‘site modeling’ representation ?

Landscape Obstructions – Old Method

PHIUS+ 2015 Height and Distance of Landscape Obstruction

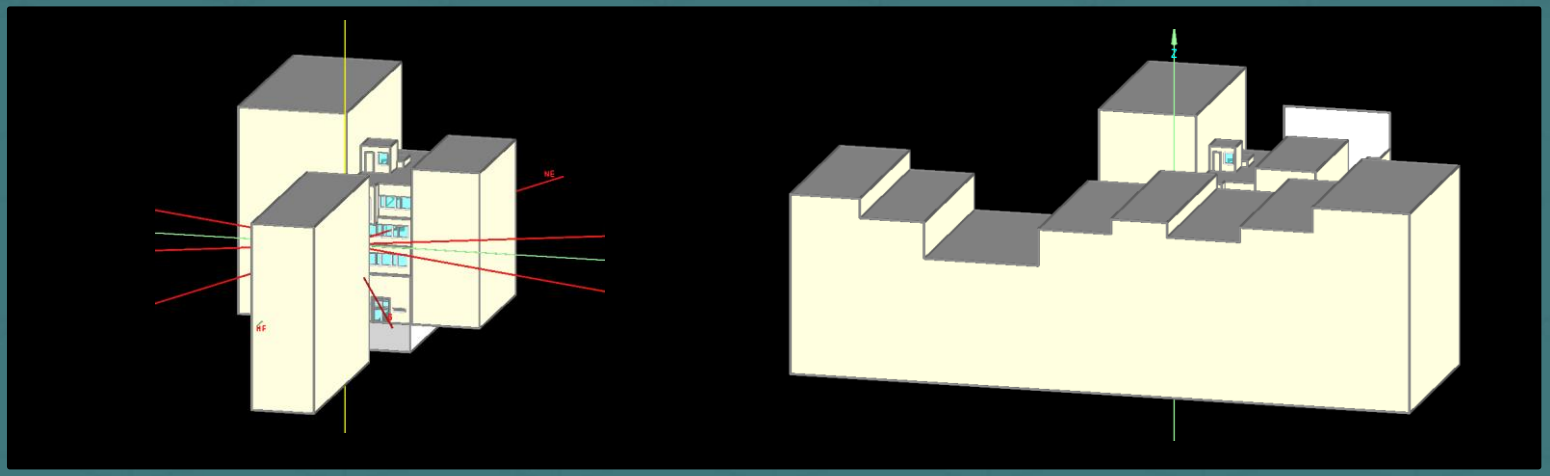


Landscape Obstructions – New Method

PHIUS+ 2018

Adjacent Buildings

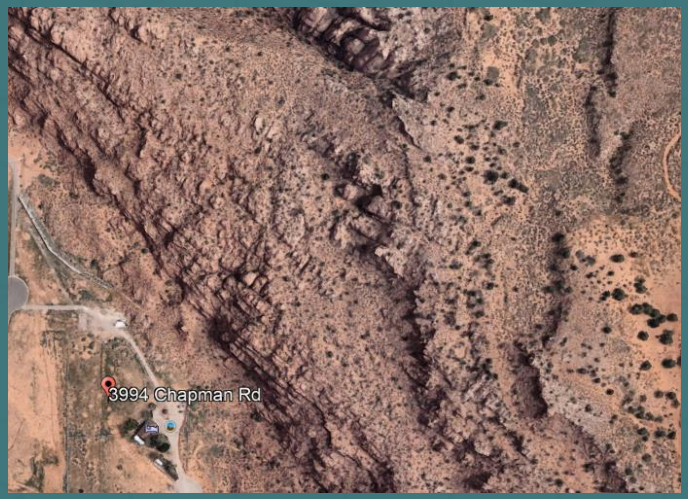
1659 - ABC No Rio



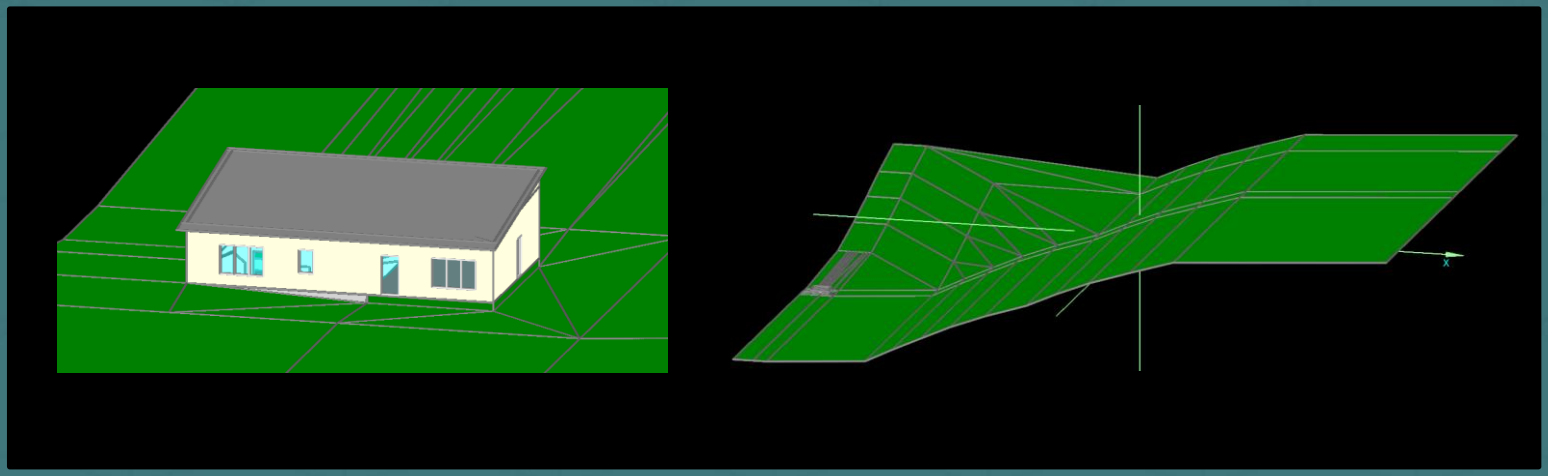
Landscape Obstructions – New Method

PHIUS+ 2018

Topography



1570 – Thompson House

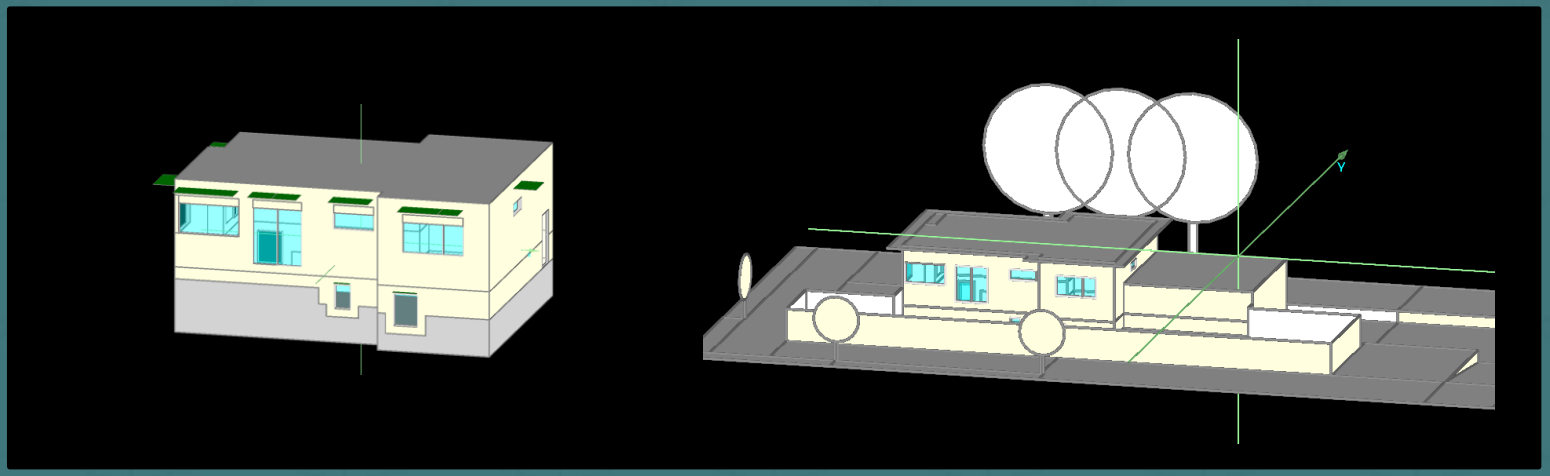


Landscape Obstructions – New Method

PHIUS+ 2018

Fences - Light wells

Emery House

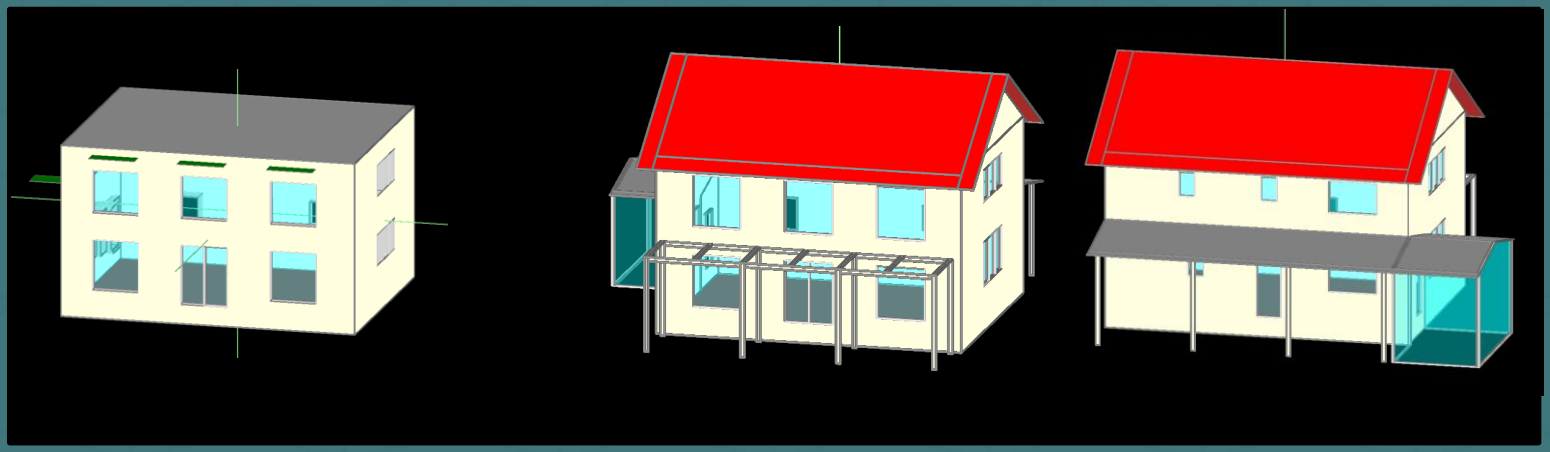


Landscape Obstructions – New Method

PHIUS+ 2018

Canopies - Sunrooms

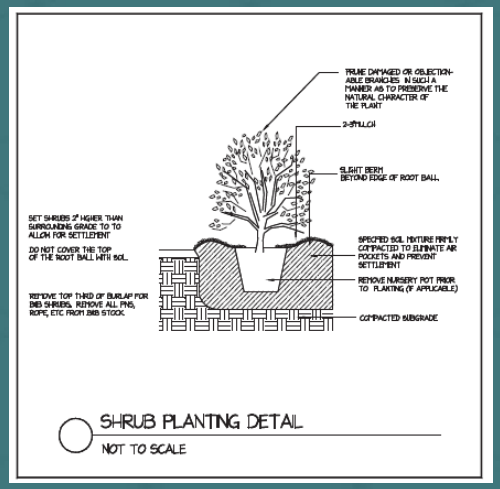
Karpiak House

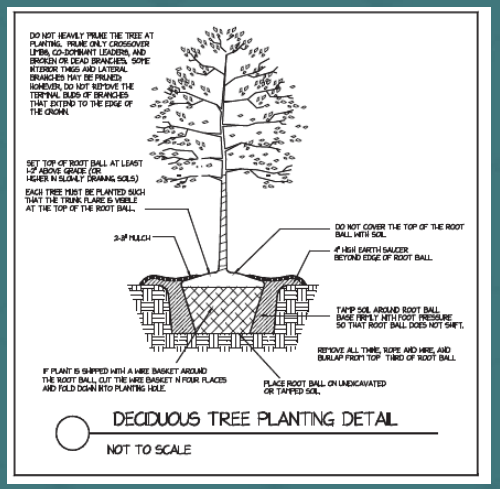


Landscape Obstructions – New Method

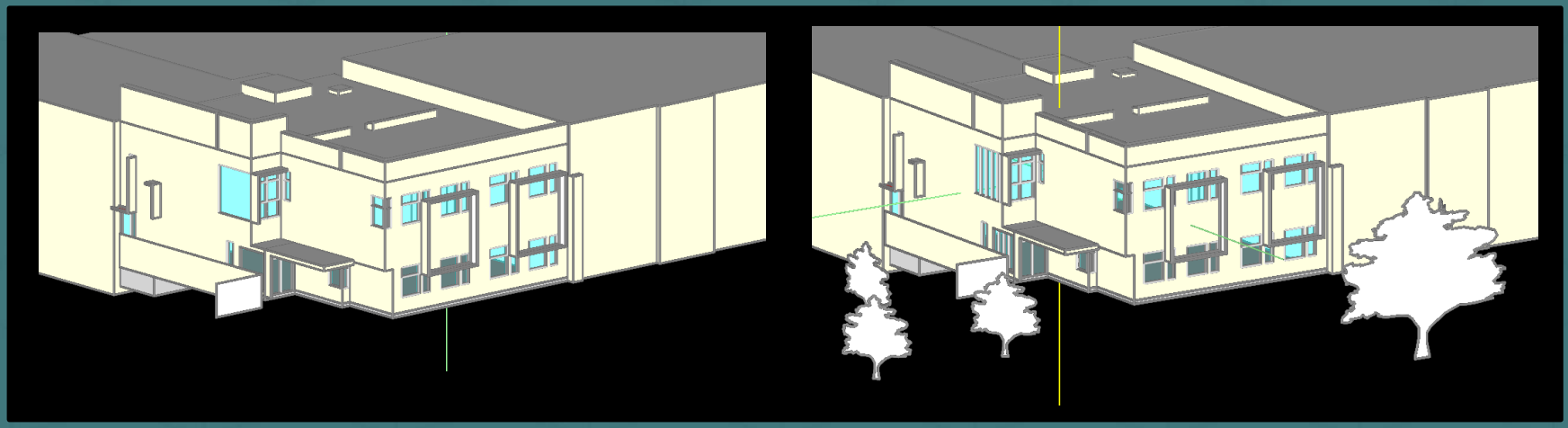
PHIUS+ 2018

Trees





1539 - St. Josephs School

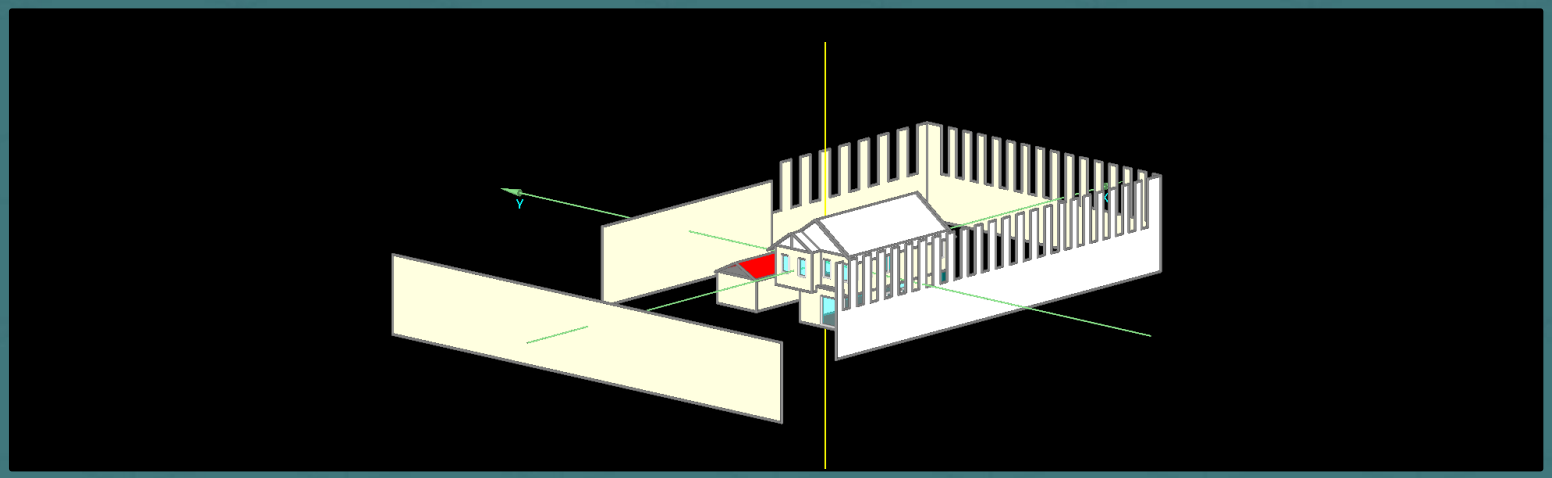


Landscape Obstructions – New Method

PHIUS+ 2018

Crown Shape

1567 - Whisper House

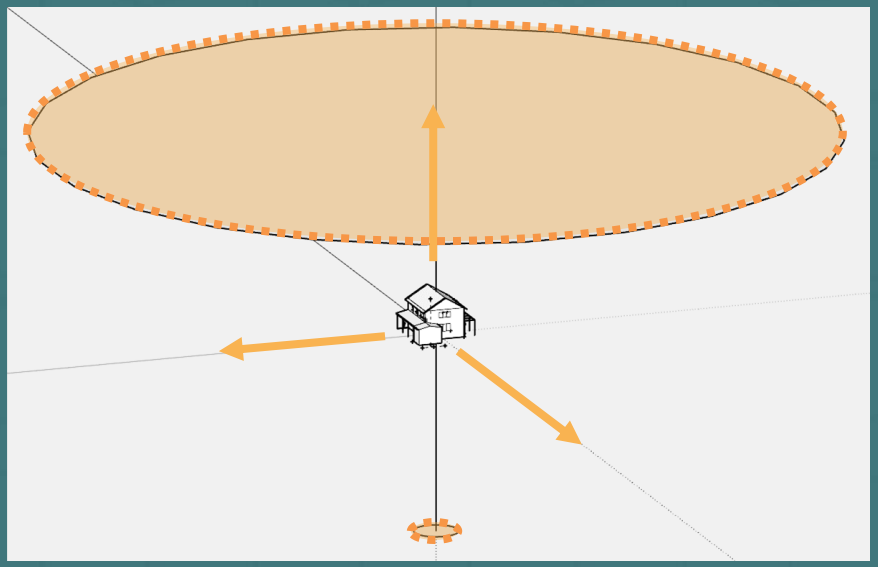


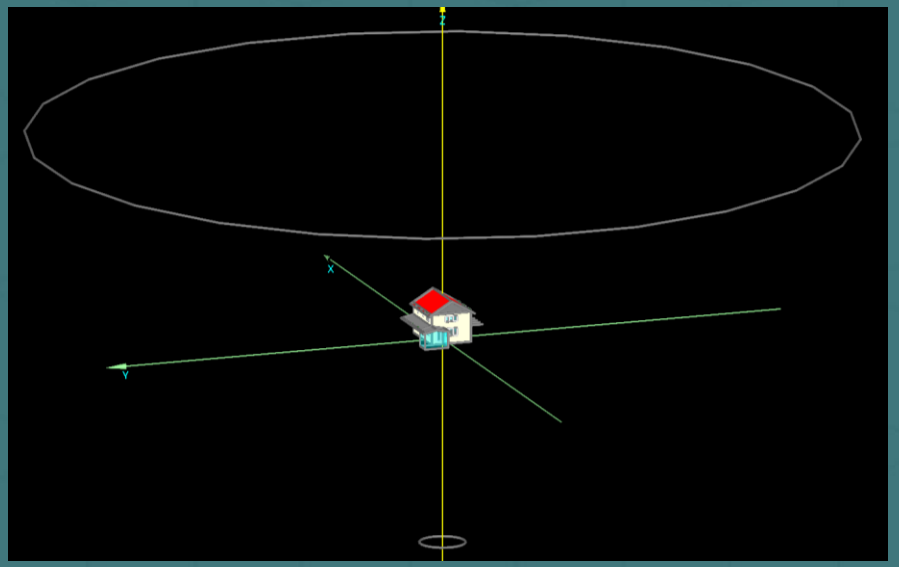
Landscape Obstructions - Centered Geometry

Project's geometrical center at ground level on Axis X,Y,Z (0,0,0)

In SketchUp, create two 'circular fake components'

In WUFI, assign 'fake components' as 'Openings' (type).





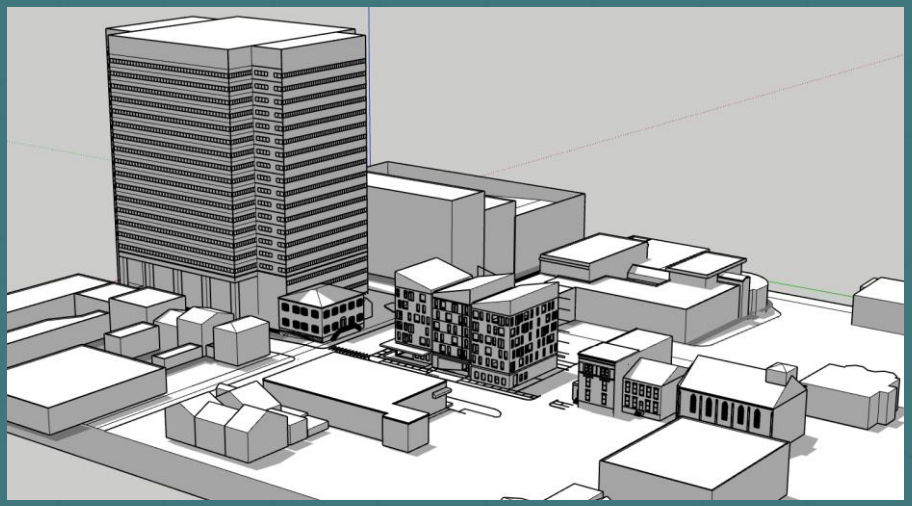
Landscape Obstructions - Simplified Geometry

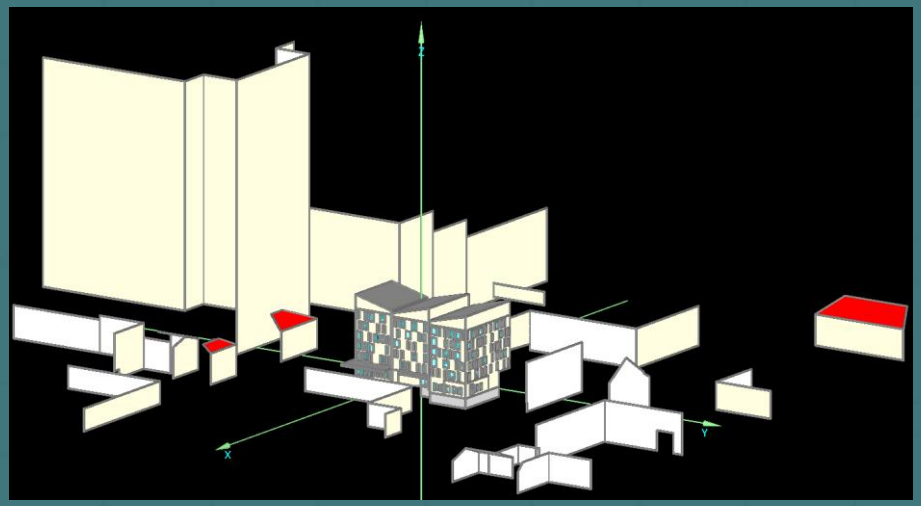
Simple surfaces or volumes of ‘adjacent’ obstructions.

In SketchUp, delete windows of adjacent buildings.

In WUFI, import ‘simple contours’ and ‘volumes’.

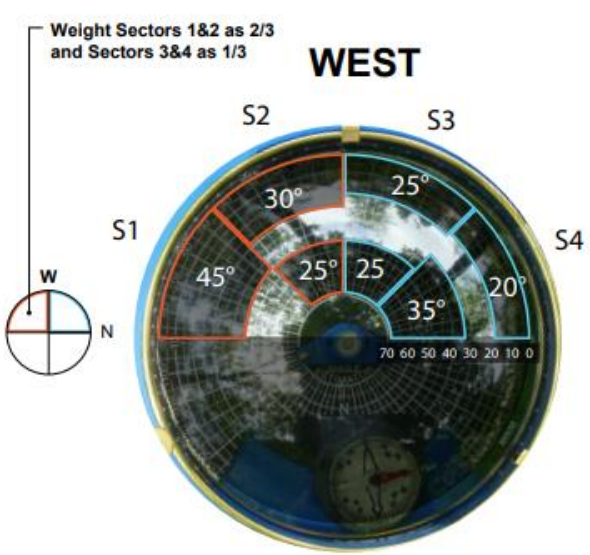
FS – The Beacon





Landscape Obstructions – Angle Estimator

PHIUS+ 2015 Pathfinder Protocol North, East, West Facades

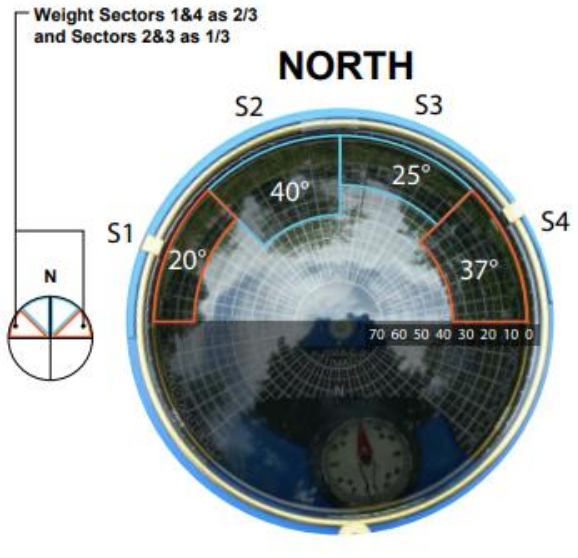


WEST Solar Pathfinder Photo at 1PM on May 20, 2013

Sector 1	45°	x 1/3	=	15.00°	2/3
Sector 2	55°	x 1/3	=	18.33°	
Sector 3	50°	x 1/6	=	8.33°	1/3
Sector 4	55°	x 1/6	=	9.17°	

Average Angle: 50.83°

'Fake Object'
Height of Object: tan(50.83°)*100ft = 123 ft
Distance of Object: 100 ft

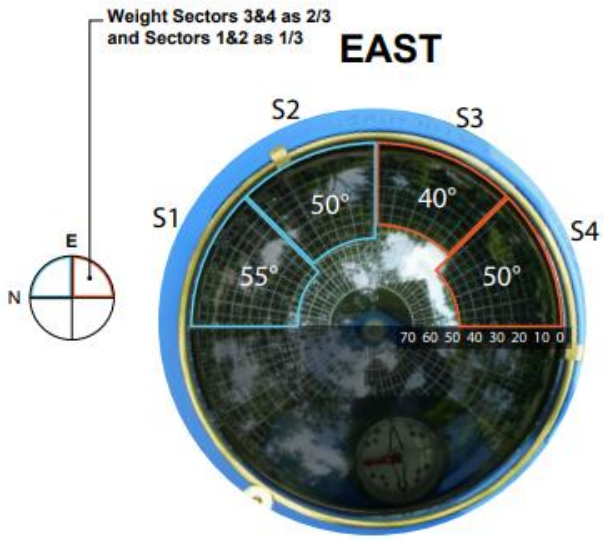


NORTH Solar Pathfinder Photo at 1PM on May 20, 2013

Sector 1	20°	x 1/3	=	6.67°	
Sector 2	40°	x 1/6	=	6.67°	1/3
Sector 3	25°	x 1/6	=	4.17°	2/3
Sector 4	37°	x 1/3	=	12.33°	

Average Angle: 29.84°

'Fake Object'
Height of Object: tan(29.84°)*100ft = 57 ft
Distance of Object: 100 ft



EAST Solar Pathfinder Photo at 1PM on May 20, 2013

Sector 1	55°	x 1/6	=	9.17°	1/3
Sector 2	50°	x 1/6	=	8.33°	
Sector 3	40°	x 1/3	=	13.33°	2/3
Sector 4	50°	x 1/3	=	16.67°	

Average Angle: 47.50°

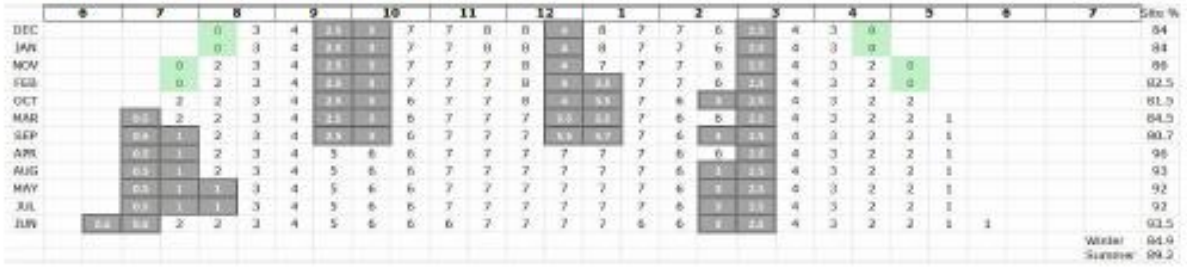
'Fake Object'
Height of Object: tan(47.50°)*100ft = 109 ft
Distance of Object: 100 ft

Other shading (winter) fraction – Sun Estimator

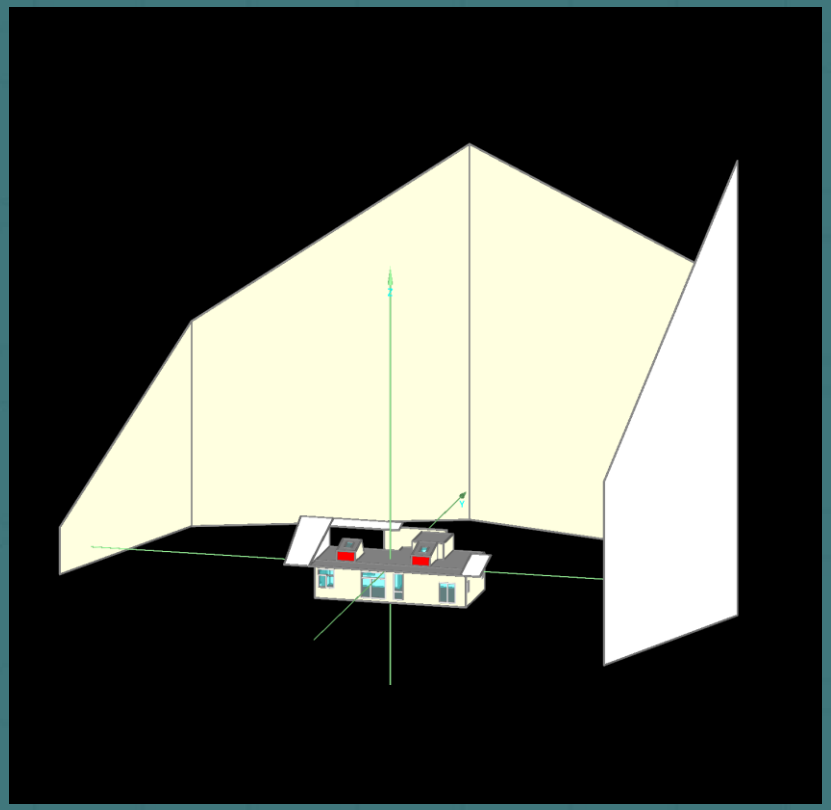
PHIUS+ 2015 Pathfinder Protocol South Façade / Winter & summer fractions

SOUTH

SOUTH Solar Pathfinder Photo at 11AM on March 27, 2013



Other Shading Fractions – New alternatives



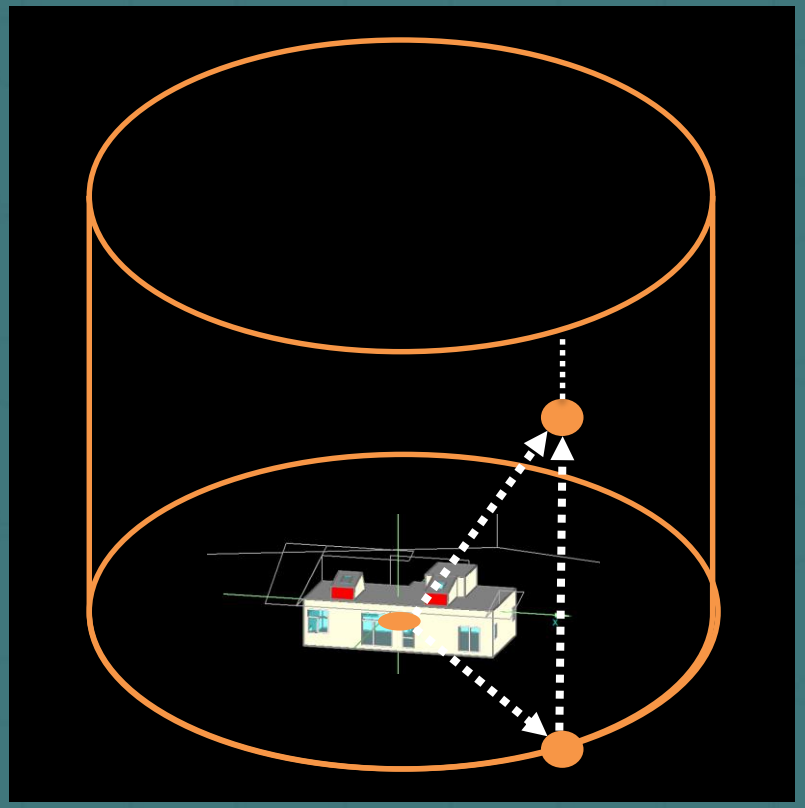
1636 – Maple Corner House

PART 3

How to replicate sky-dome images to be used in conjunction with the WUFI Passive Shading tool ?

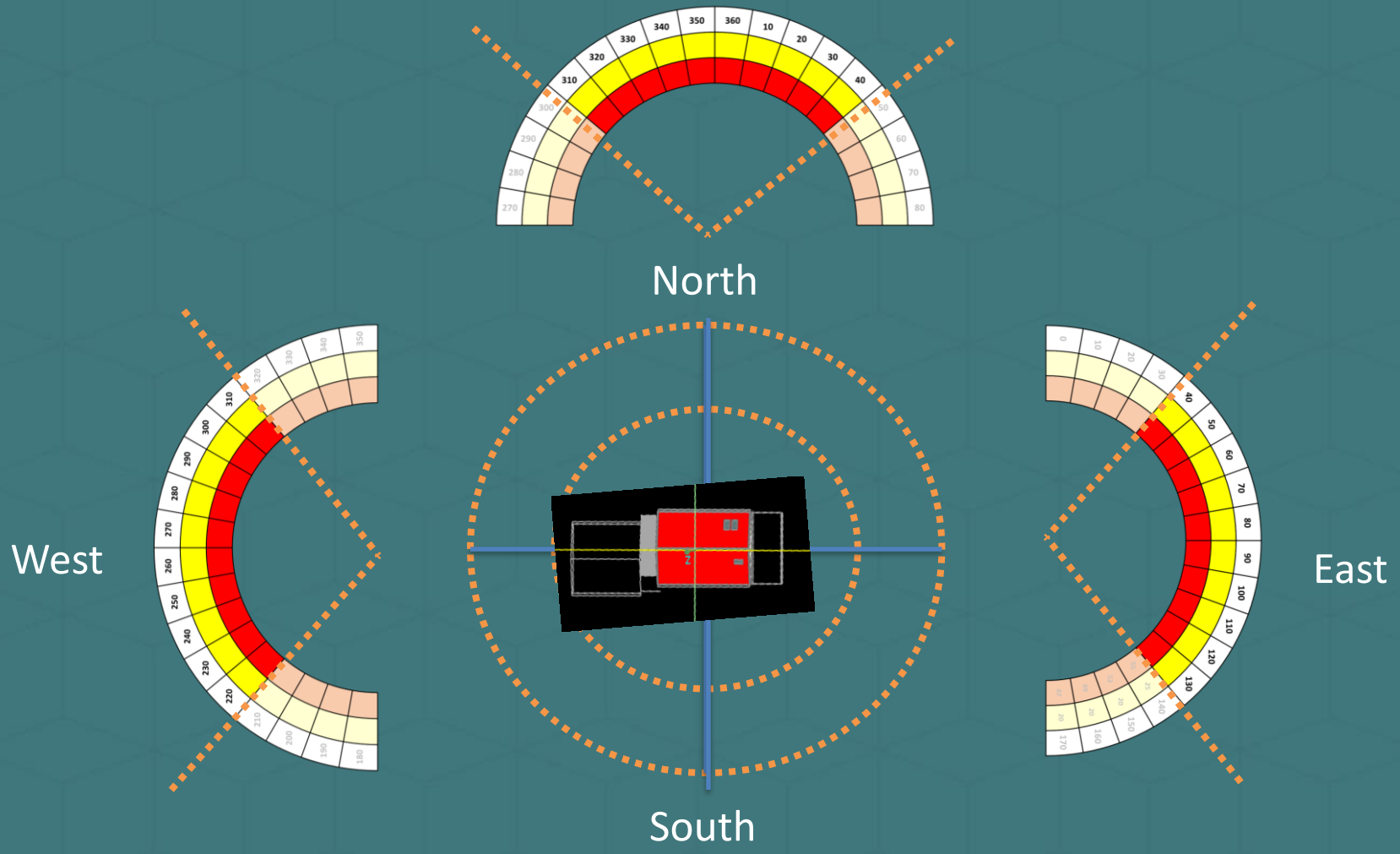
Horizon Geometry - shading angles' component

PHIUS updates



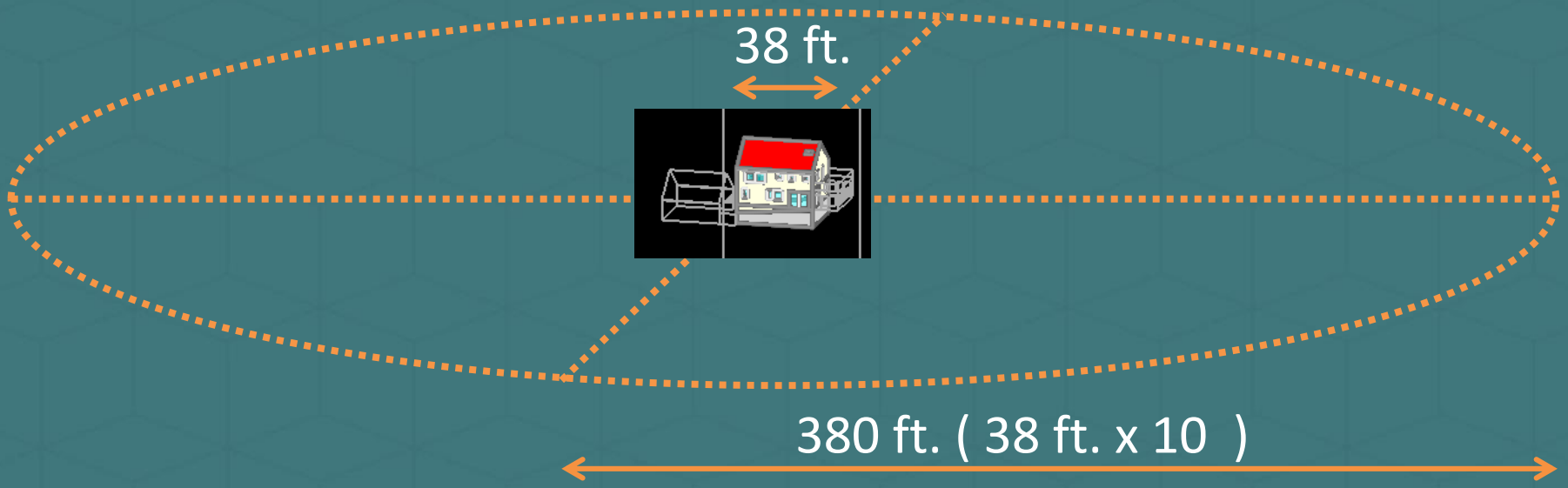
Width (W)
Height (H)
Elevation Angle (ß)

Dual Pathfinder Protocol – Tracking shading angles



Dual Pathfinder Protocol - Field Extension

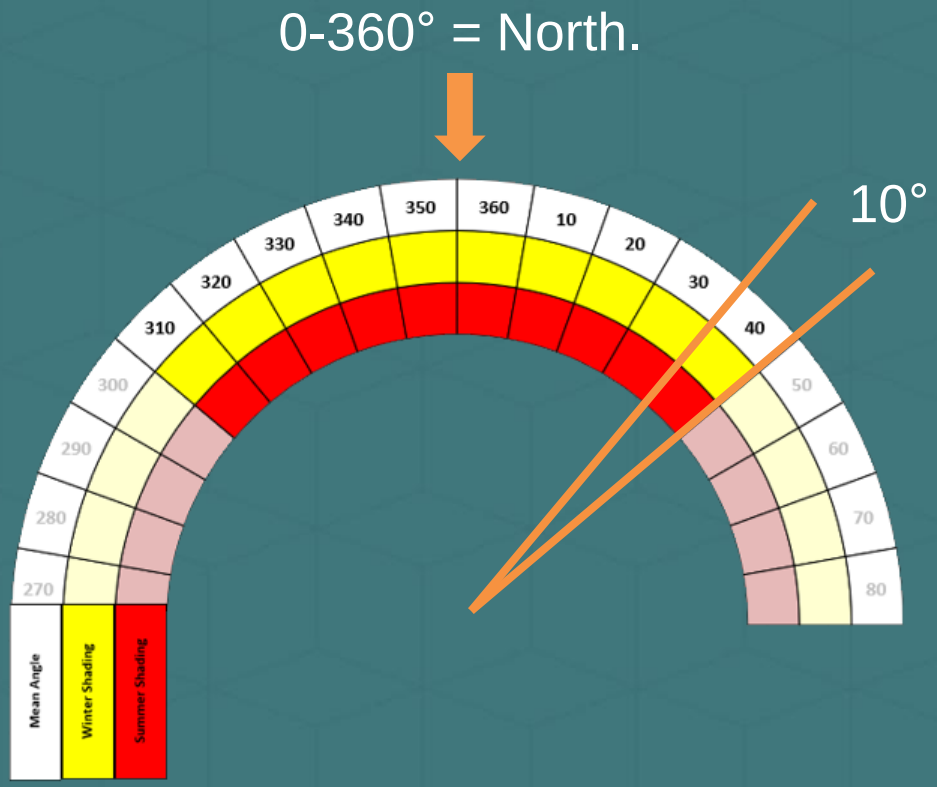
Radius Multiplier	10
Length of Bldg	38



'Length of Building': longest side. Combined with radius multiplier (x10) creates radius for 'Horizon Geometry'

Tracked orientation angles per direction

NORTH		
Degrees	Winter	Summer
270		
280		
290		
300		
310		
320		
330		
340		
350		
360		
10		
20		
30		
40		
50		
60		
70		
80		
90		

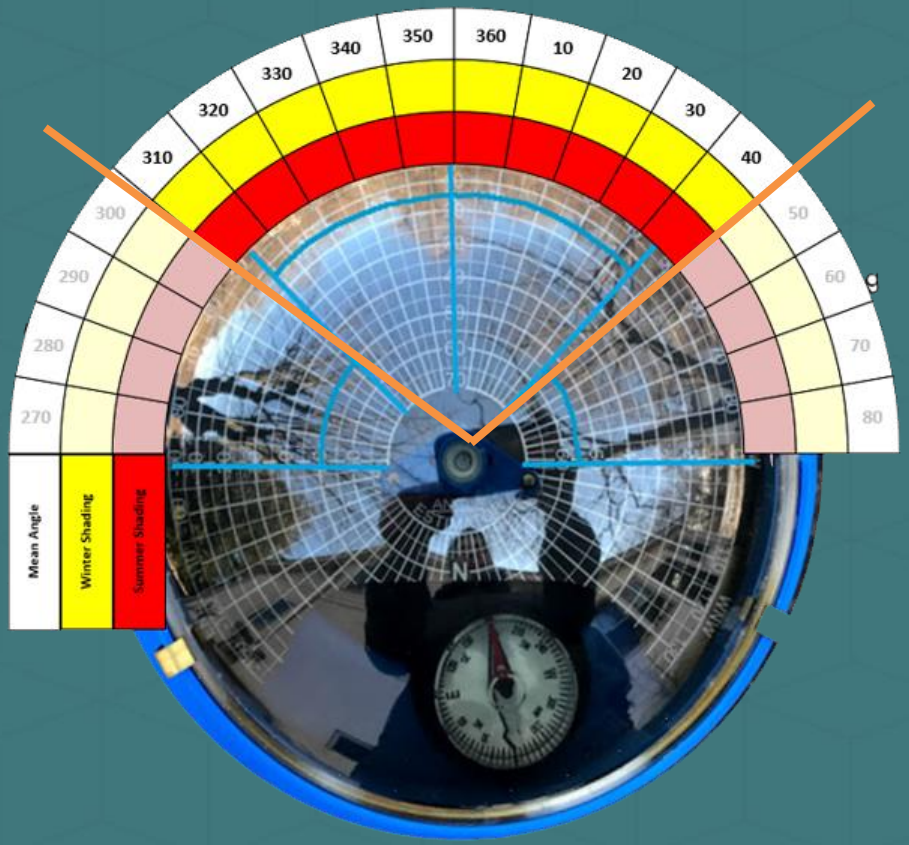


White ring

Graph and Sky-dome image alignment

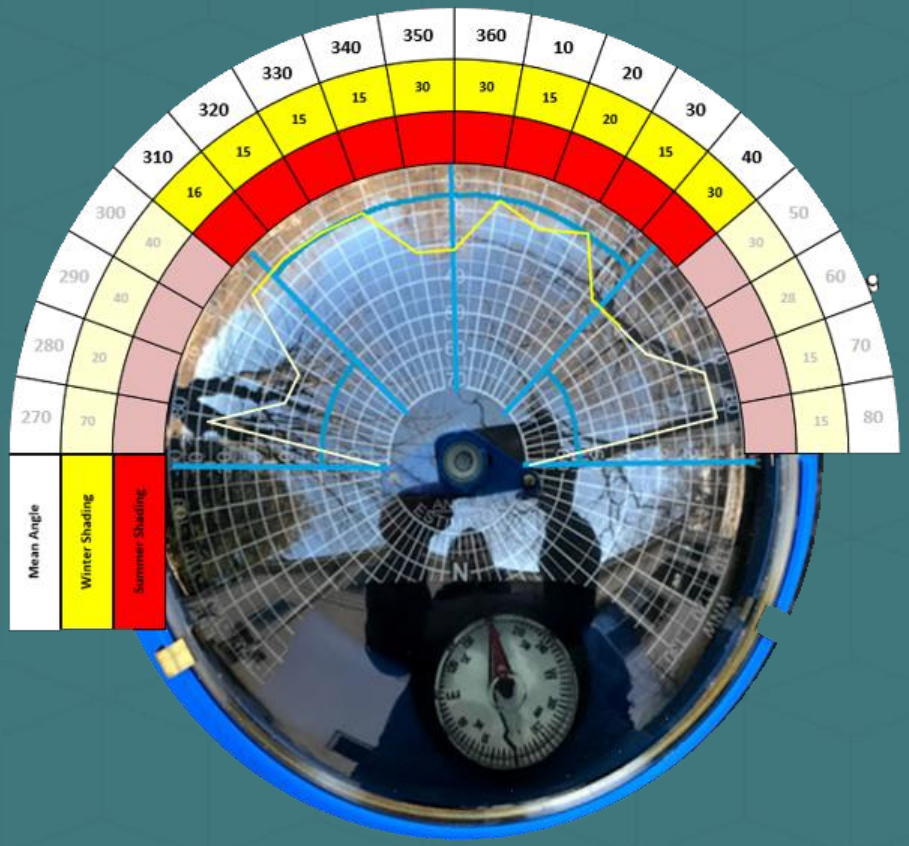
NORTH		
Degrees	Winter	Summer
270		
280		
290		
300		
310		
320		
330		
340		
350		
360		
10		
20		
30		
40		
50		
60		
70		
80		
90		

100° range per orientation.



Tracing Winter Shading Angles

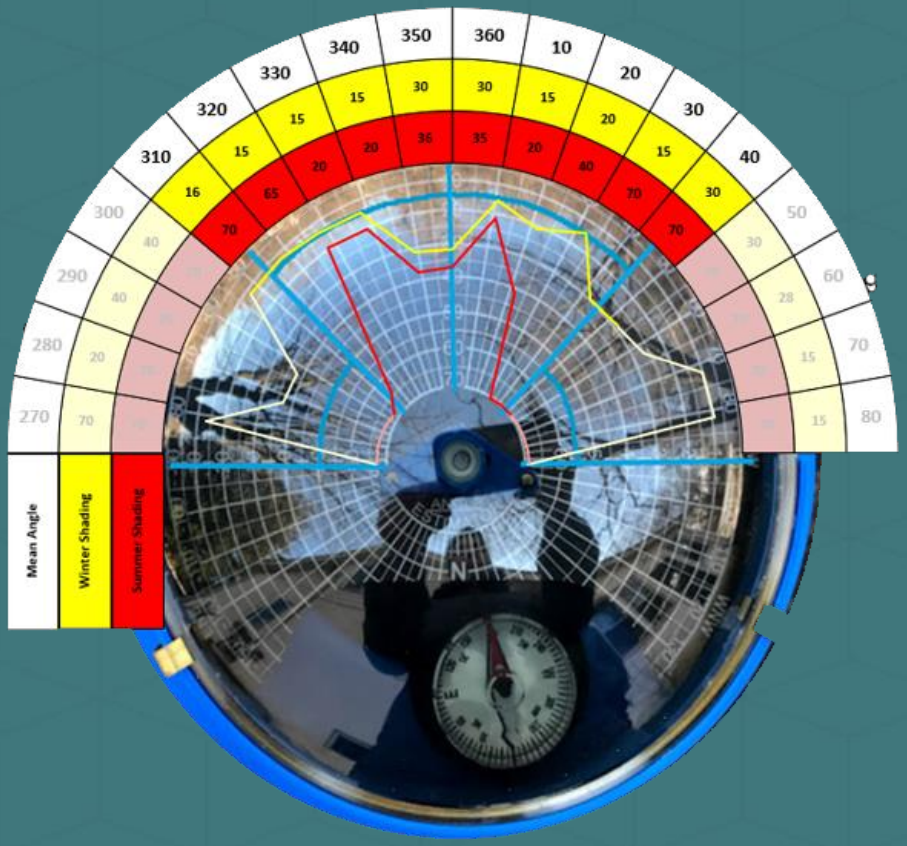
NORTH		
Degrees	Winter	Summer
270	70	
280	20	
290	40	
300	40	
310	16	
320	15	
330	15	
340	15	
350	30	
360	30	
10	15	
20	20	
30	15	
40	30	
50	30	
60	28	
70	15	
80	15	
90	70	



Yellow ring and line - coniferous

Tracing Summer Shading Angles

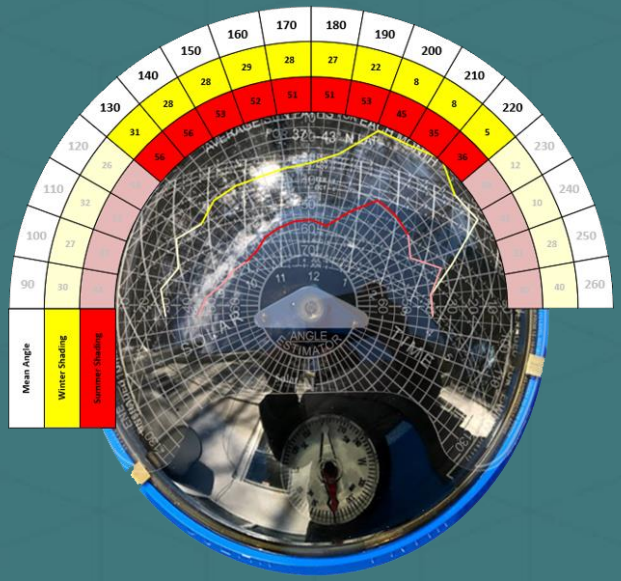
NORTH		
Degrees	Winter	Summer
270	70	70
280	20	70
290	40	70
300	40	70
310	16	70
320	15	65
330	15	20
340	15	20
350	30	36
360	30	35
10	15	20
20	20	40
30	15	70
40	30	70
50	30	70
60	28	70
70	15	70
80	15	70
90	70	70



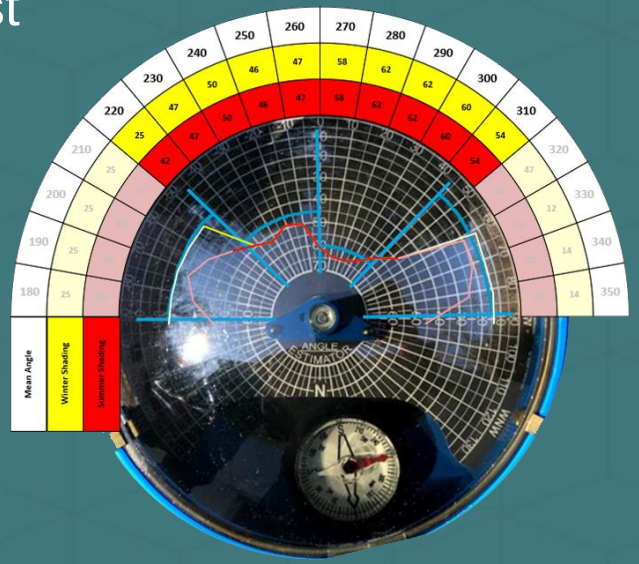
Red ring and line – deciduous

Summer and winter obstruction lines

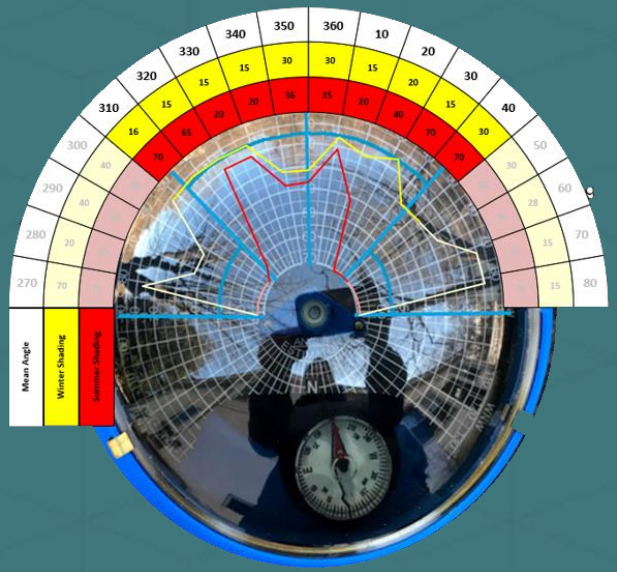
South



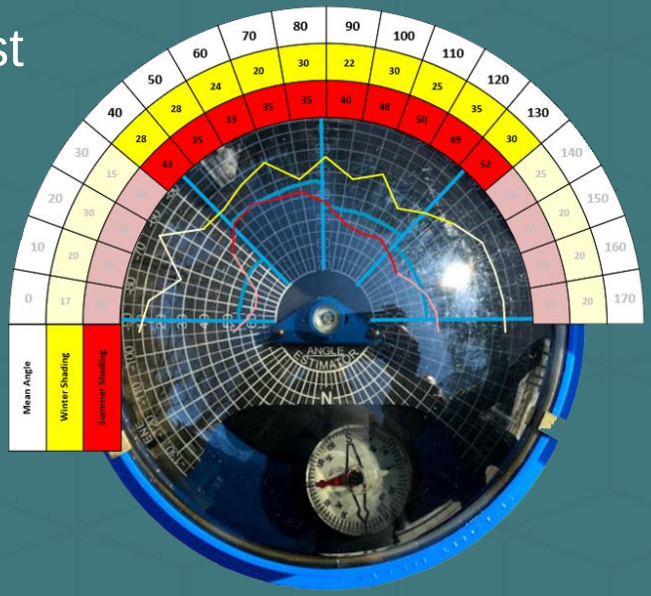
West



North



East



Credit: Holzraum System.

Shading Summary

Ent

Calc

1 2 3

ORIENTATION	DISTANCE	HEIGHT		Pathfinder Shading mean angle									
				NORTH		SOUTH		EAST		WEST		AVERAGE	
		WINTER	SUMMER	WINTER	SUMMER	WINTER	SUMMER	WINTER	SUMMER	WINTER	SUMMER	WINTER	SUMMER
0	380	219.39	266.08	30	35							30	35
10	380	101.82	138.31	15	20							15	20
20	380	138.31	318.86	20	40							20	40
30	380	101.82	1044.04	15	70							15	70
40	380	210.64	574.12	30	70			28	43			29	56.5
50	380	202.05	266.08					28	35			28	35
60	380	169.19	246.77					24	33			24	33
70	380	138.31	266.08					20	35			20	35
80	380	219.39	266.08					30	35			30	35
90	380	153.53	318.86					22	40			22	40
100	380	219.39	422.03					30	48			30	48
110	380	177.20	452.87					25	50			25	50
120	380	266.08	437.14					35	49			35	49
130	380	223.84	523.03			31	56	30	52			30.5	54
140	380	202.05	563.37			28	56					28	56
150	380	202.05	504.28			28	53					28	53
160	380	210.64	486.38			29	52					29	52
170	380	202.05	469.26			28	51					28	51
180	380	193.62	469.26			27	51					27	51
190	380	153.53	504.28			22	53					22	53
200	380	53.41	380.00			8	45					8	45
210	380	53.41	266.08			8	35					8	35
220	380	101.82	307.72			5	36			25	42	15	39
230	380	407.50	407.50							47	47	47	47
240	380	452.87	452.87							50	50	50	50
250	380	393.50	393.50							46	46	46	46
260	380	407.50	407.50							47	47	47	47
270	380	608.13	608.13							58	58	58	58
280	380	714.68	714.68							62	62	62	62
290	380	714.68	714.68							62	62	62	62
300	380	658.18	658.18							60	60	60	60
310	380	266.08	714.68	16	70					54	54	35	62
320	380	101.82	814.91	15	65							15	65
330	380	101.82	138.31	15	20							15	20
340	380	101.82	138.31	15	20							15	20

Geometry Generation – Solar Pathfinder Extension

W

0	380	219.3931
10	380	101.8207
20	380	138.3087
30	380	101.8207
40	380	210.6374
50	380	202.0496
60	380	169.1869
70	380	138.3087
80	380	219.3931
90	380	153.53
100	380	219.3931
110	380	177.1969
120	380	266.0789
130	380	223.8371
140	380	202.0496
150	380	202.0496
160	380	210.6374
170	380	202.0496
180	380	193.6197
190	380	153.53
200	380	53.40552
210	380	53.40552
220	380	101.8207
230	380	407.5001
240	380	452.8664
250	380	393.5015
260	380	407.5001
270	380	608.1271
280	380	714.6761
290	380	714.6761
300	380	658.1793
310	380	266.0789
320	380	101.8207
330	380	101.8207
340	380	101.8207
350	380	219.3931

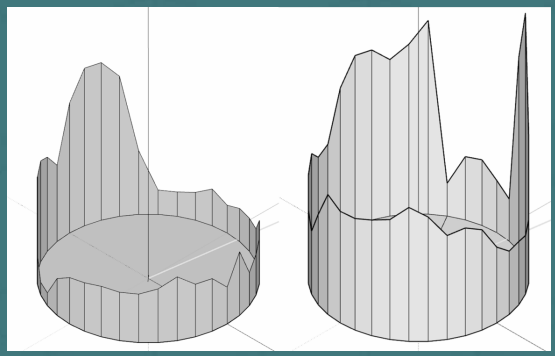
S

0	380	266.08
10	380	138.31
20	380	318.86
30	380	1044.04
40	380	574.12
50	380	266.08
60	380	246.77
70	380	266.08
80	380	266.08
90	380	318.86
100	380	422.03
110	380	452.87
120	380	437.14
130	380	523.03
140	380	563.37
150	380	504.28
160	380	486.38
170	380	469.26
180	380	469.26
190	380	504.28
200	380	380.00
210	380	266.08
220	380	307.72
230	380	407.50
240	380	452.87
250	380	393.50
260	380	407.50
270	380	608.13
280	380	714.68
290	380	714.68
300	380	658.18
310	380	714.68
320	380	814.91
330	380	138.31
340	380	138.31
350	380	276.09

Solar Pathfinder

Takes in a csv file and converts it into geometry

W S



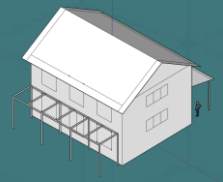
Developed by:

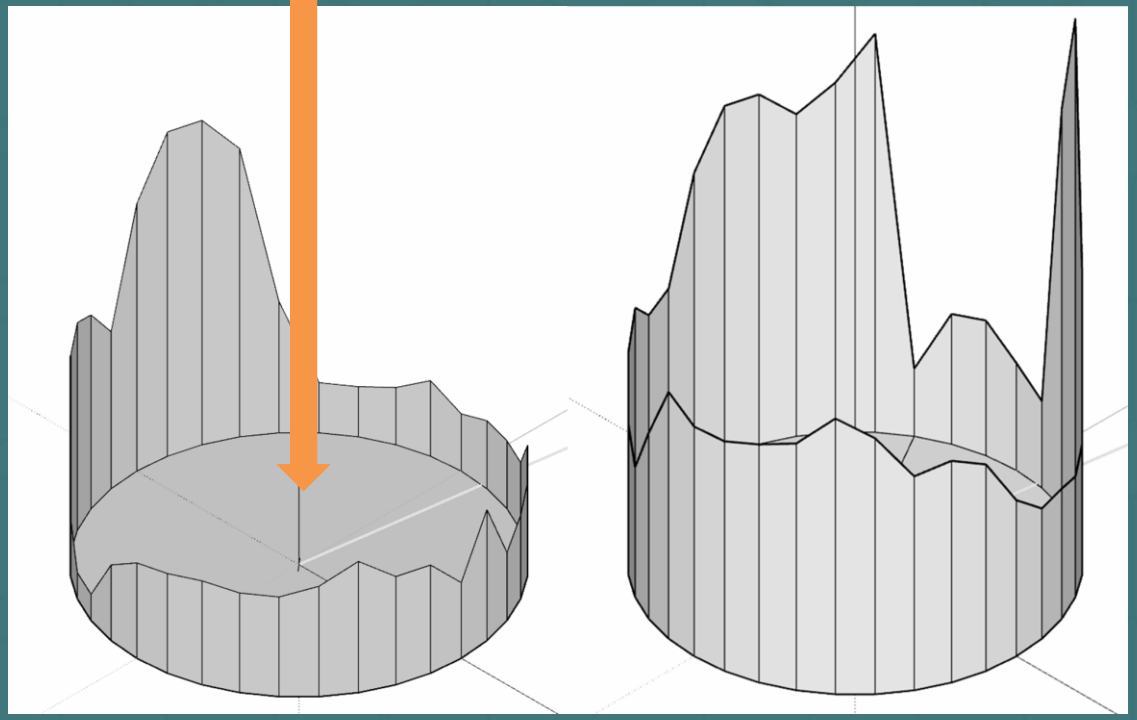
Skylar Swinford

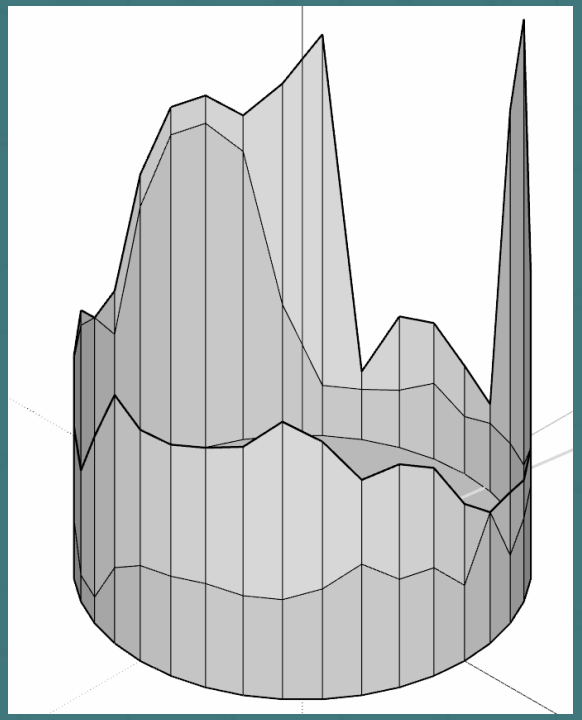
Energy & Enclosure Consultant

Compatible with SketchUp 2018-19

Assigning WUFI properties and combined horizons



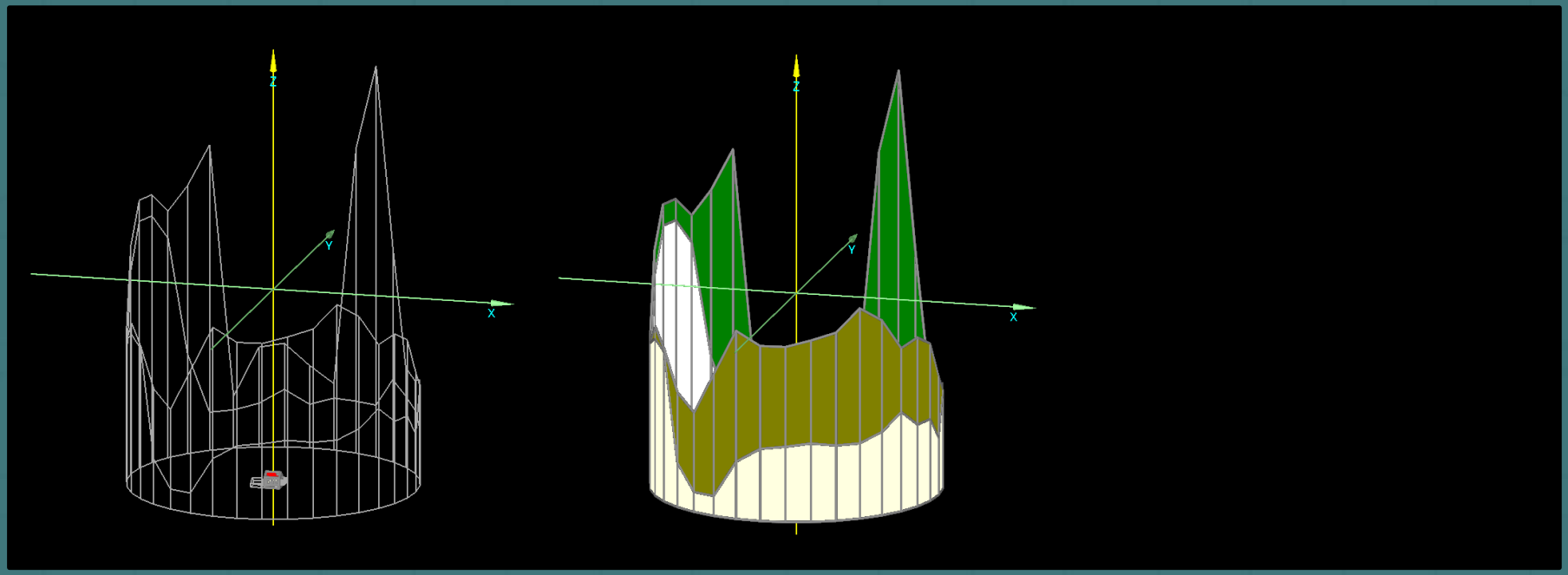




WINTER
OUTER AIR
Inner and Outer Sides

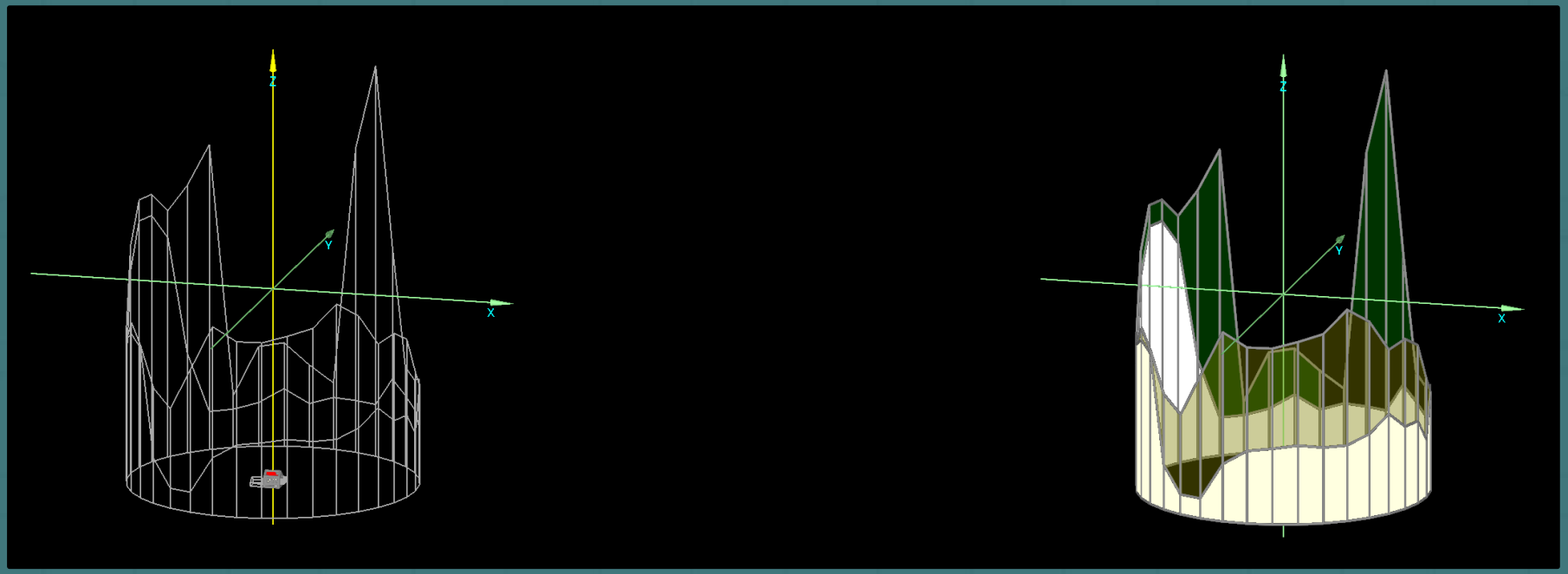
SUMMER
OUTER AIR Inner Side
GROUND Outer Side

Summer Shading Test



Heating demand:	**7.17** kBtu/ft²yr
Cooling demand:	**2.46** kBtu/ft²yr
Heating load:	**4.6** Btu/hr ft²
Cooling load:	**1.78** Btu/hr ft²

Winter Shading Test



Heating demand:	**5.82** kBtu/ft²yr
Cooling demand:	**2.9** kBtu/ft²yr
Heating load:	**4.3** Btu/hr ft²
Cooling load:	**1.93** Btu/hr ft²

Unified Case for Precertification

Heating demand:	**7.17** kBtu/ft²yr
Cooling demand:	**2.46** kBtu/ft²yr
Heating load:	**4.6** Btu/hr ft²
Cooling load:	**1.78** Btu/hr ft²

Summer Shading Test

Heating demand:	**5.82** kBtu/ft²yr
Cooling demand:	**2.9** kBtu/ft²yr
Heating load:	**4.3** Btu/hr ft²
Cooling load:	**1.93** Btu/hr ft²

Winter Shading Test

Winter Shading Test + Summer Red Factor

Other shading fraction of solar exposure (1=full exposure, 0=total shading) [-]	1
Other shading summer fraction of solar exposure (1=full exposure, 0=total shadin	1

Other shading fraction of solar exposure (1=full exposure, 0=total shading) [-]	1
Other shading summer fraction of solar exposure (1=full exposure, 0=total shadin	0.8

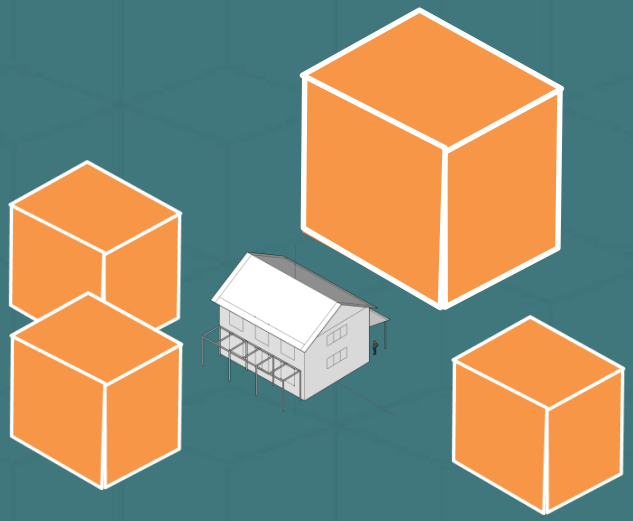
Heating demand:	**5.82** kBtu/ft²yr
Cooling demand:	**2.47** kBtu/ft²yr
Heating load:	**4.3** Btu/hr ft²
Cooling load:	**1.77** Btu/hr ft²

PART 4

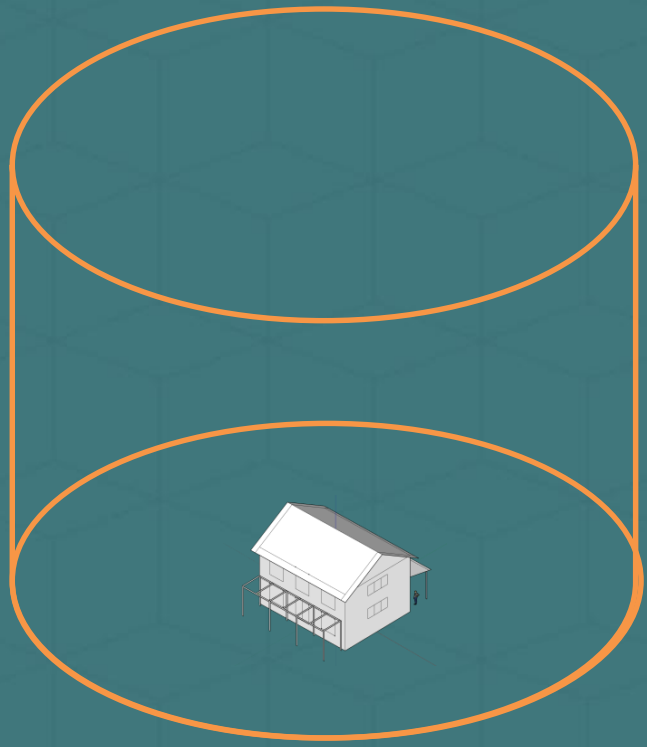
How much ‘site context’ should be included in the WUFI model ?

Comparison of Site Shading Methods

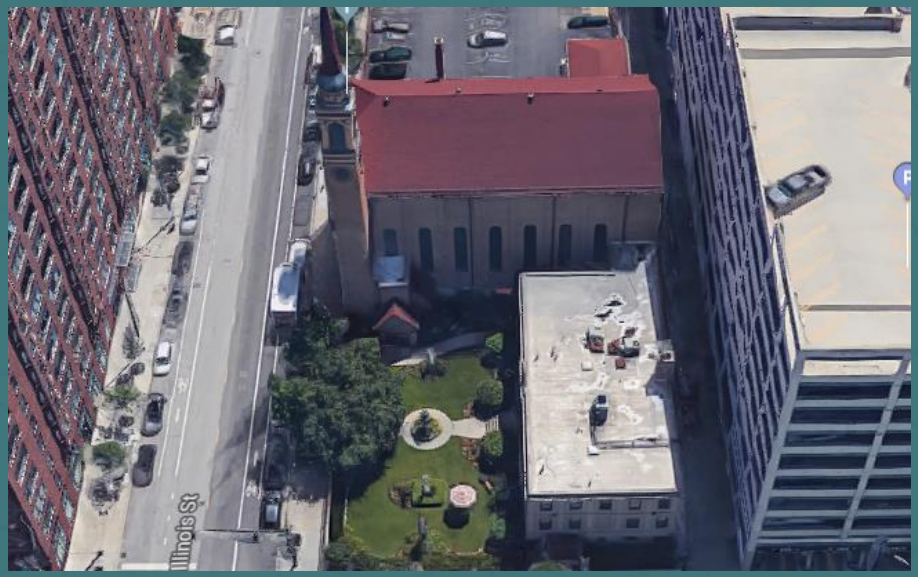
2D - 3D Volumes



Horizon Geometry



Sensitivity Test – Case Study - Context



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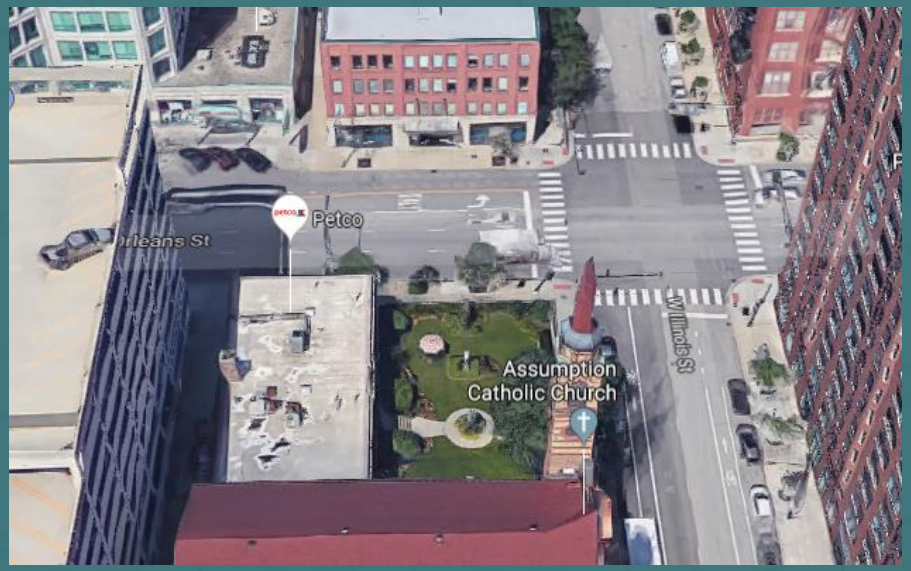
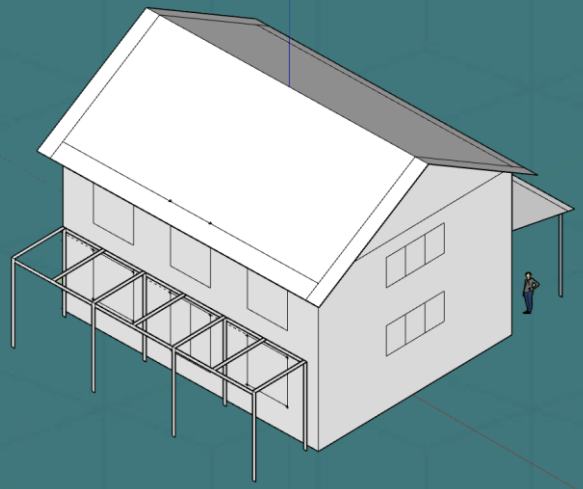


N

Sensitivity Test – Case Study



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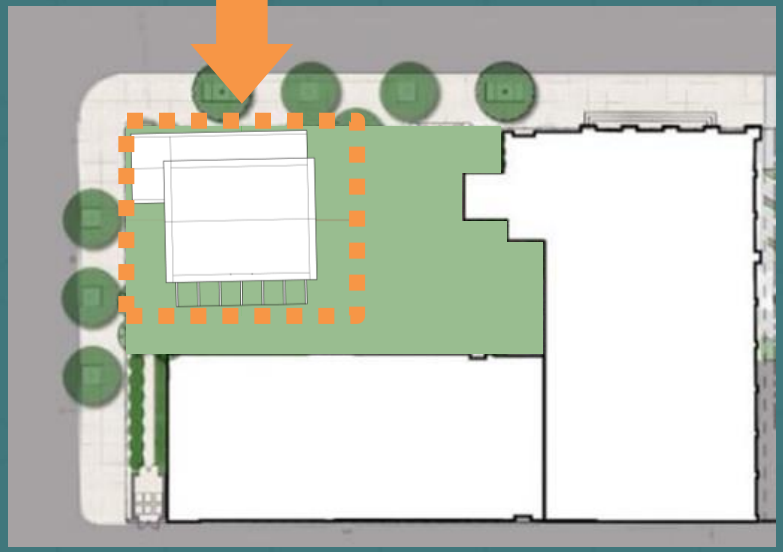
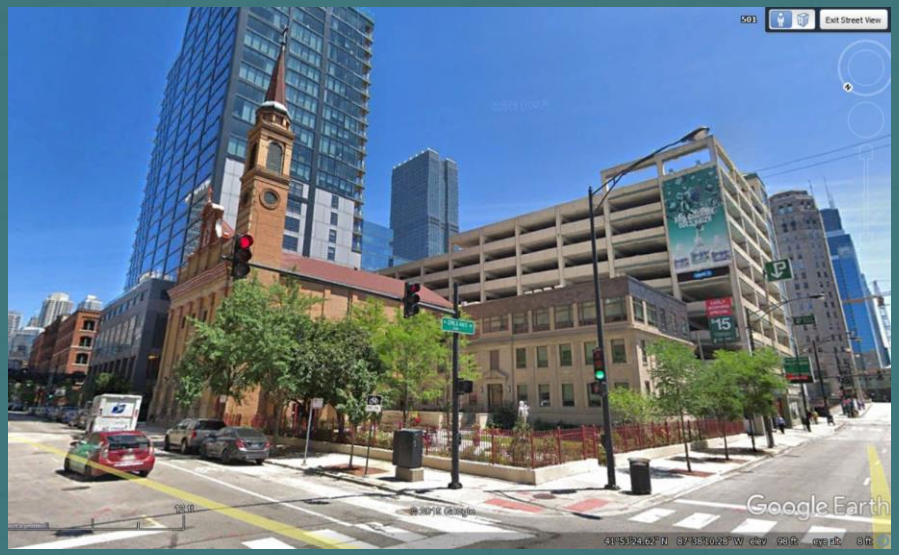


Input for Site Shading

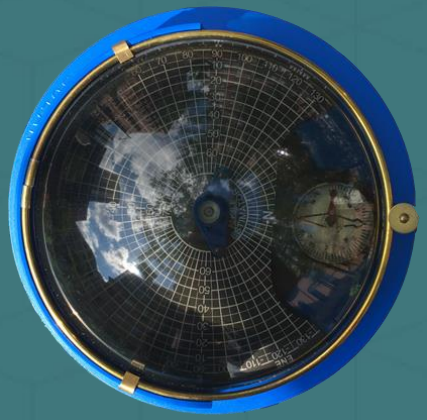
2D - 3D Volumes



Horizon Geometry

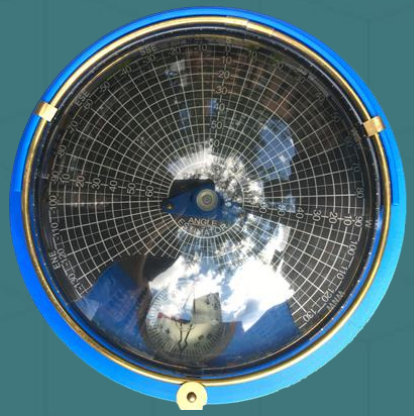
South

West



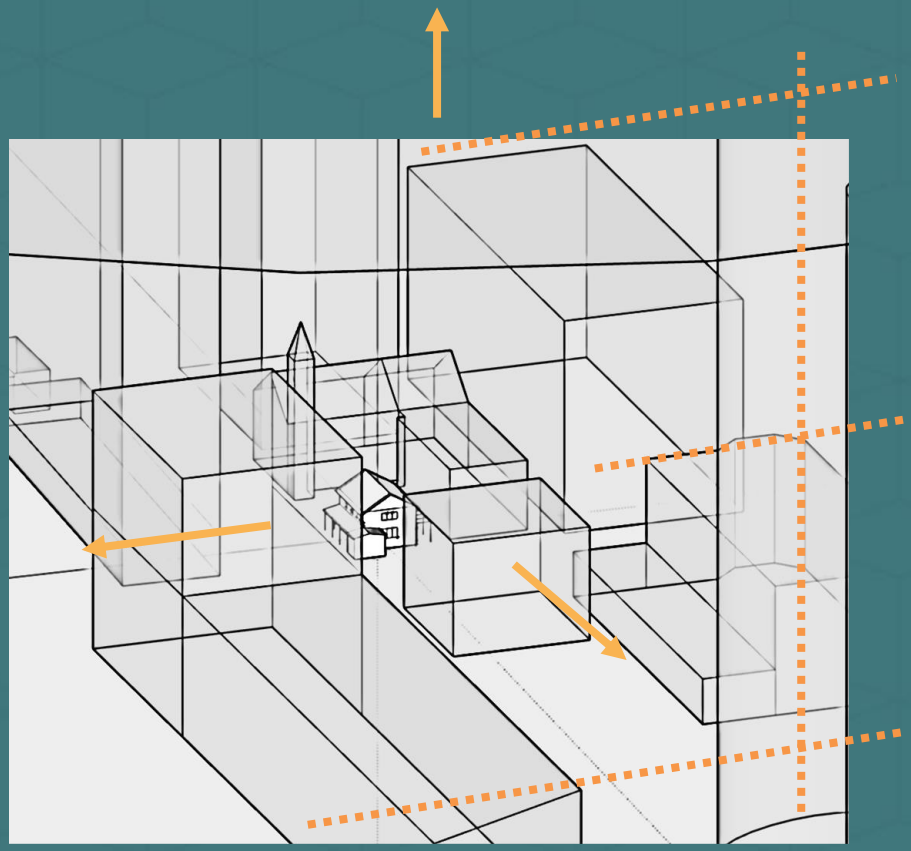
North

East

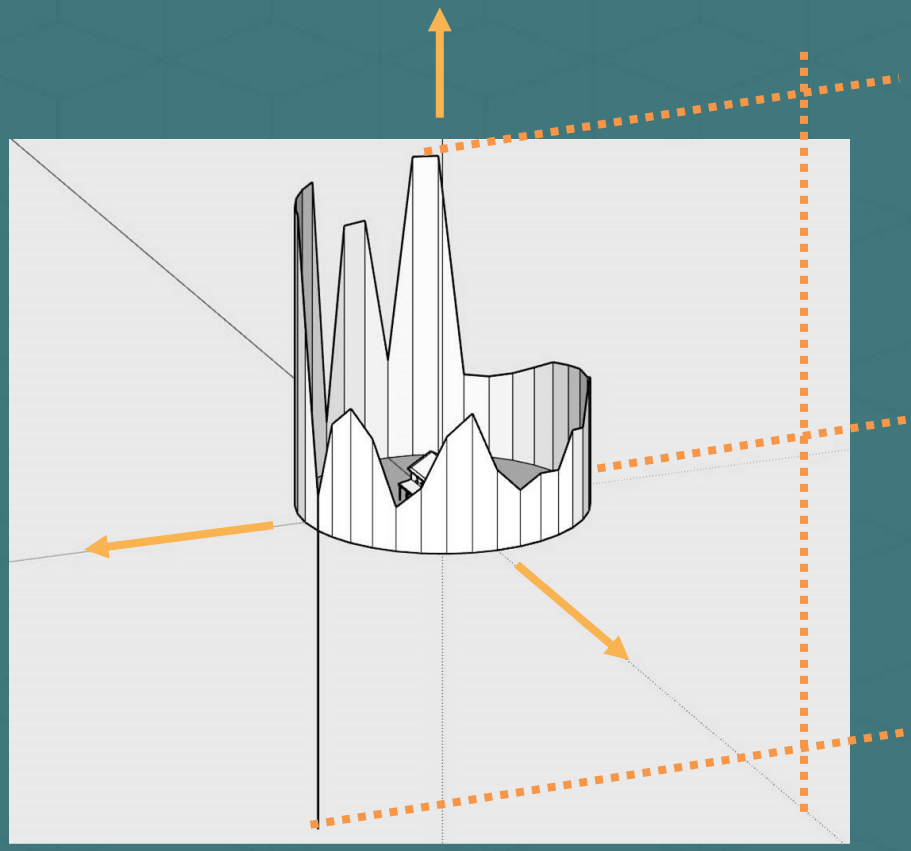


Modeled ‘Site Shading’ Comparison

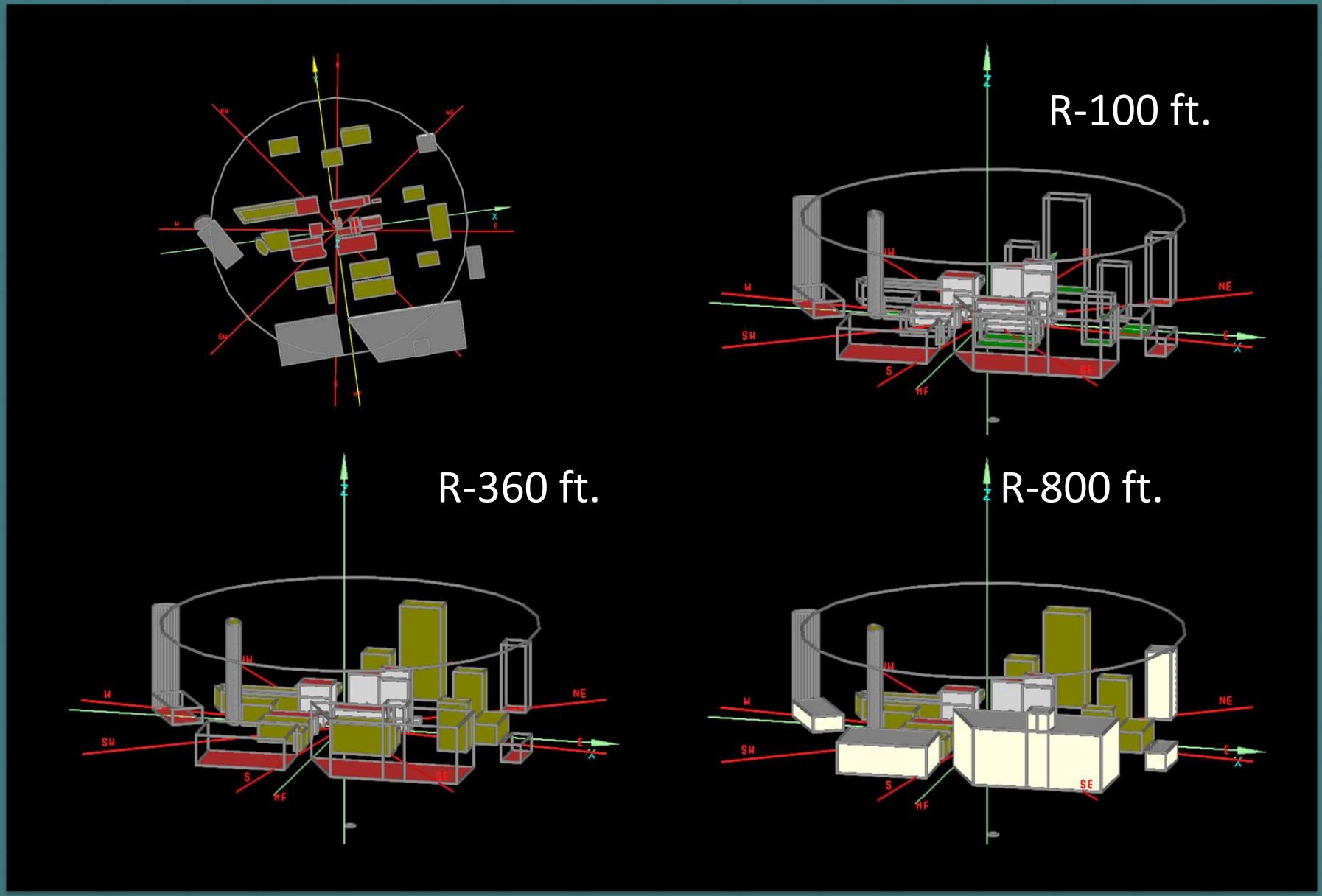
2D - 3D Volumes



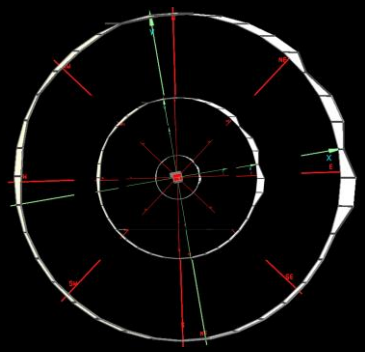
Horizon Geometry

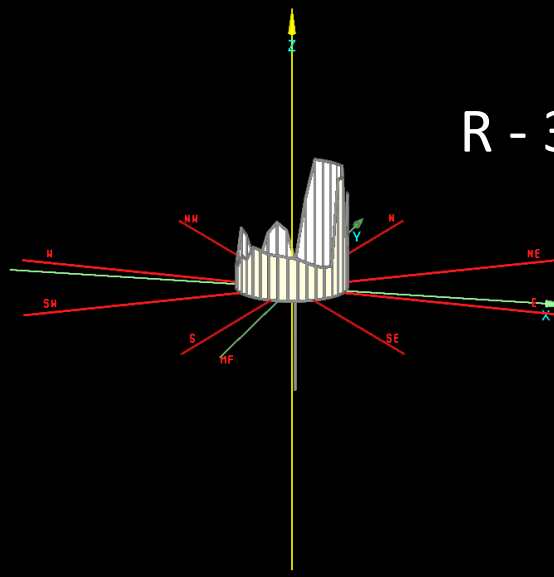


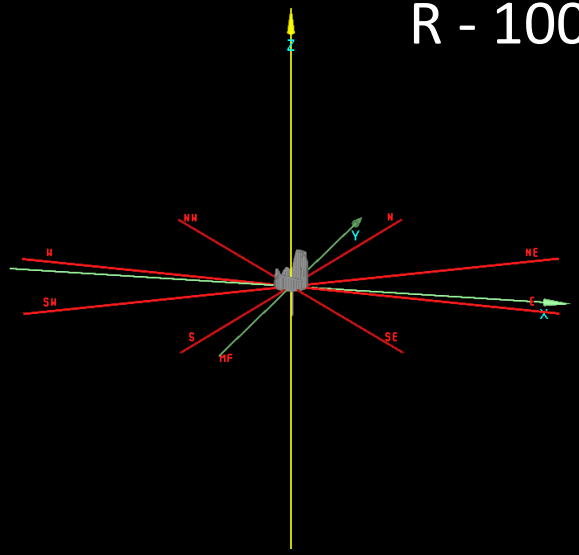
3D volumes – Field Extension Radius

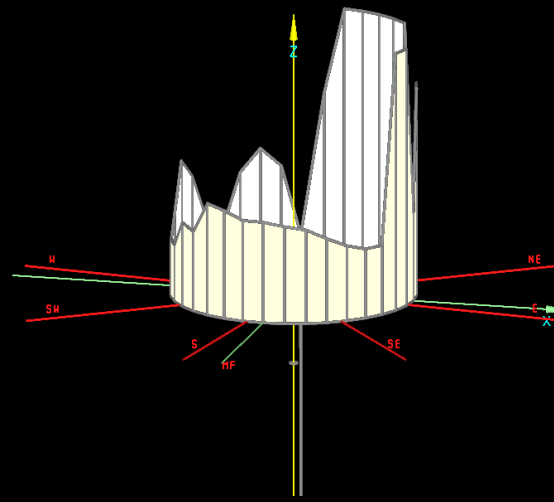


Horizon Geometry – Field Extension Radius





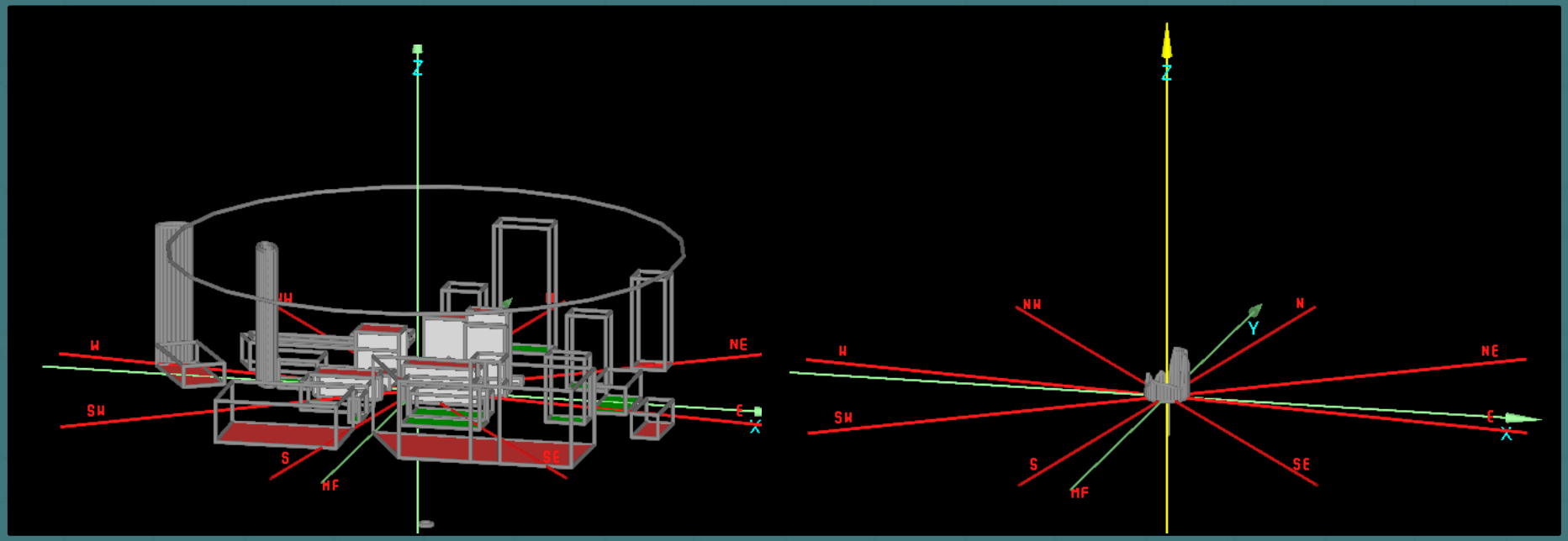




Comparison 1 – Radius 100 ft.

2D - 3D Volumes

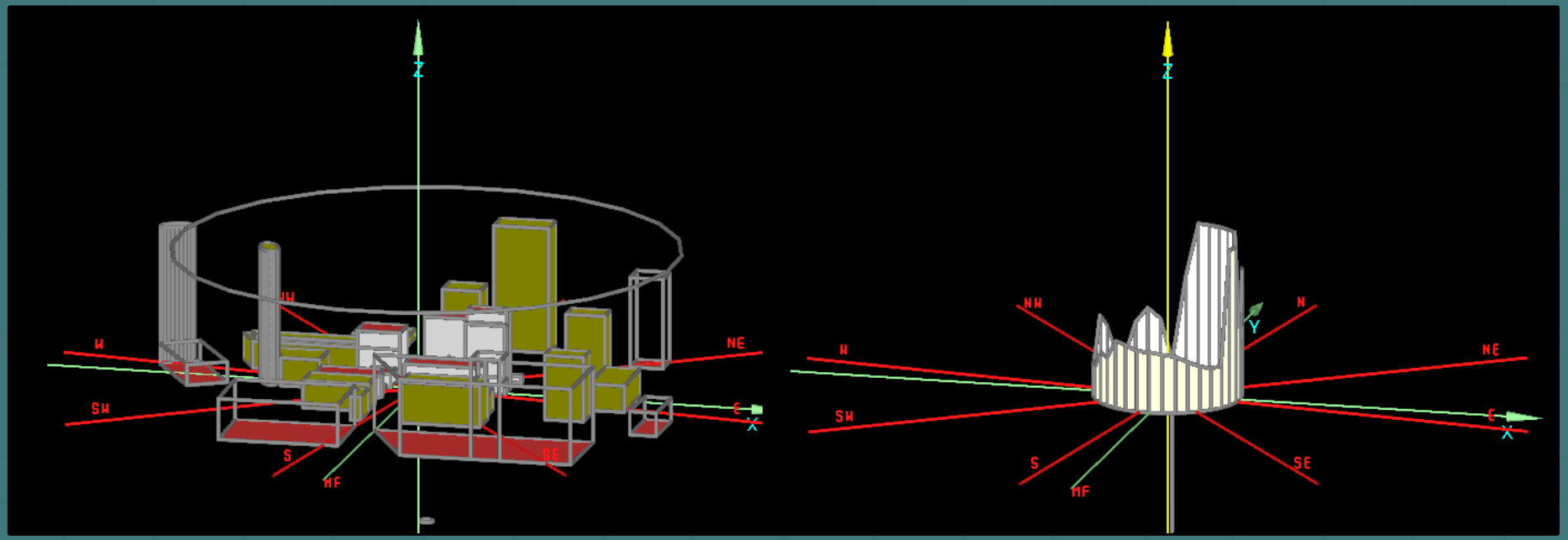
Horizon Geometry



Comparison 2– Radius 360 ft.

2D - 3D Volumes

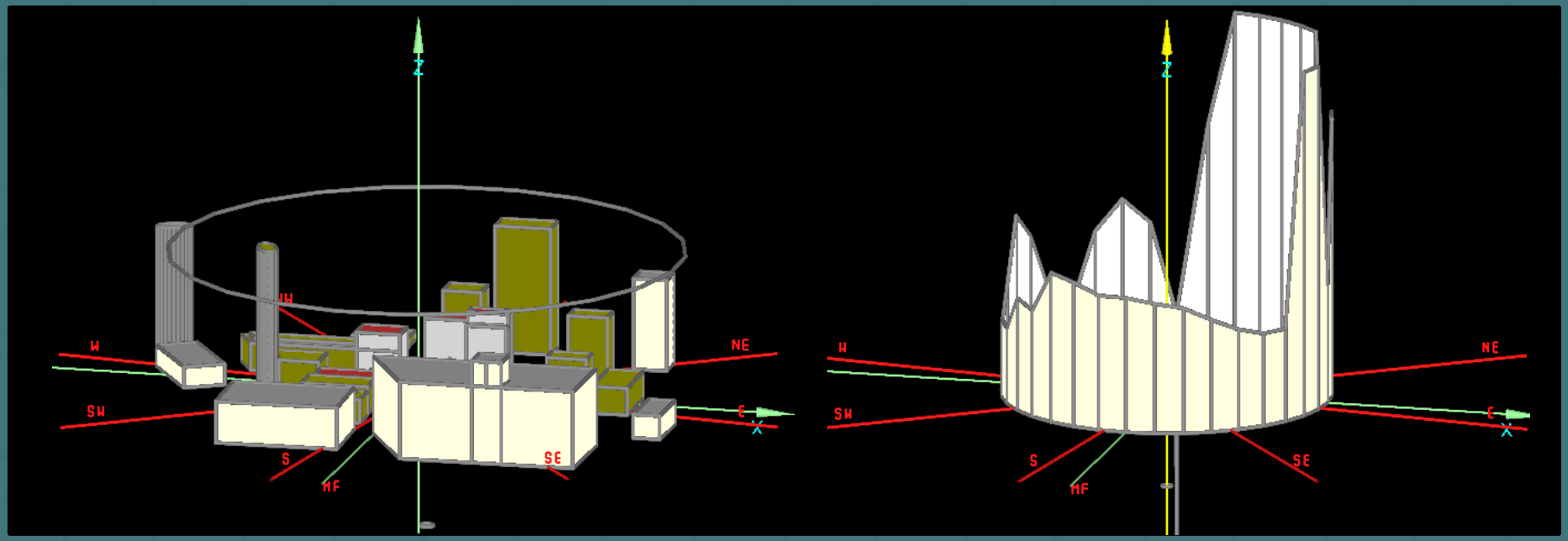
Horizon Geometry



Comparison 3 – Radius 800 ft.

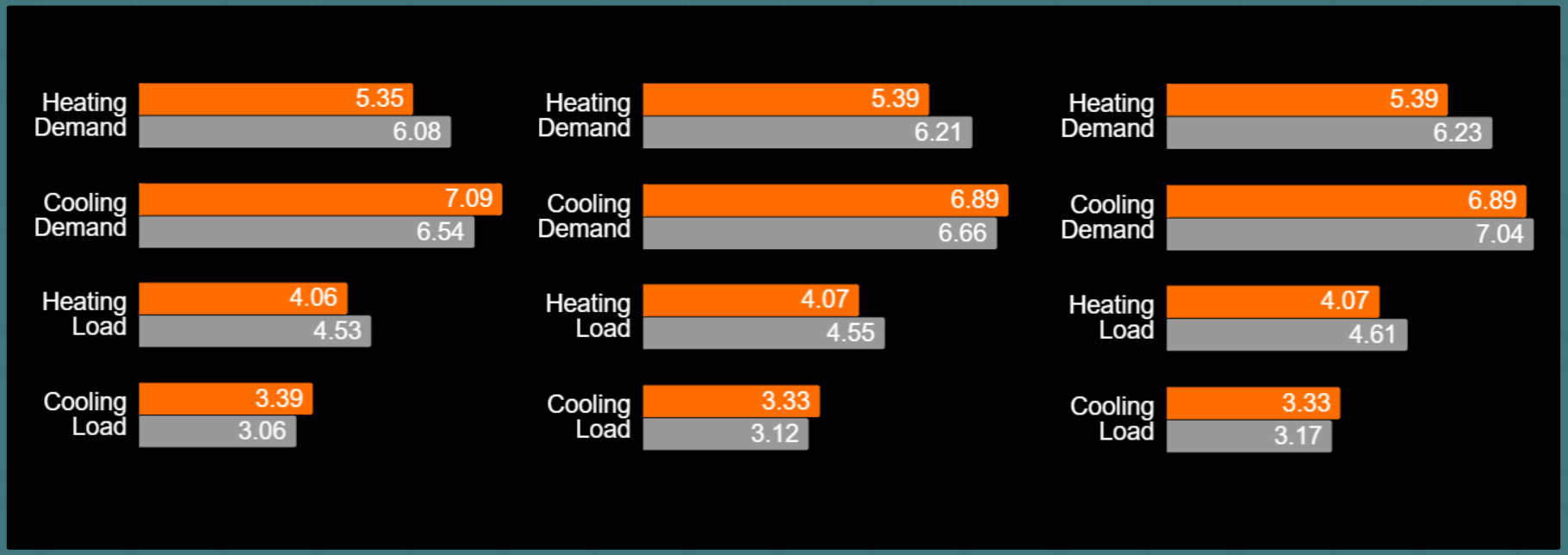
2D - 3D Volumes

Horizon Geometry



Results - Space Conditioning Targets

Comparison 1	Comparison 2	Comparison 3
R – 100 ft.	R – 360 ft.	R – 860 ft.

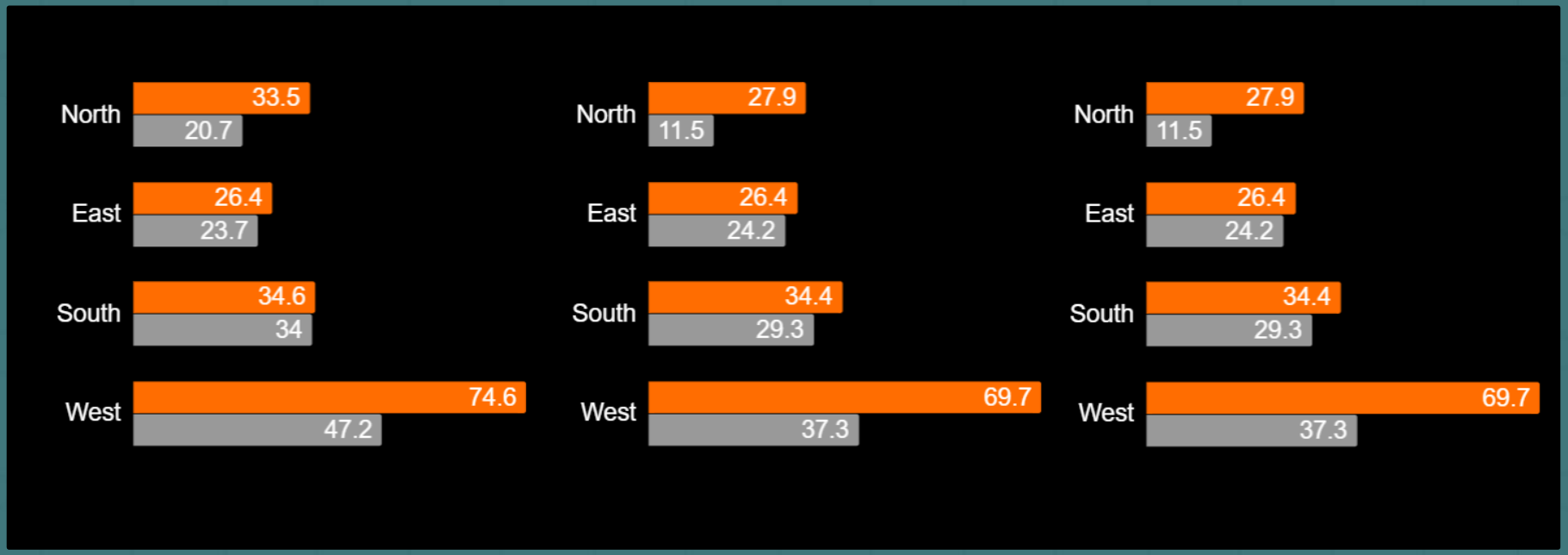


3D Volumes

Horizon Geometry

Results - Solar Access - Winter (Heating)

Comparison 1	Comparison 2	Comparison 3
R – 100 ft.	R – 360 ft.	R – 860 ft.

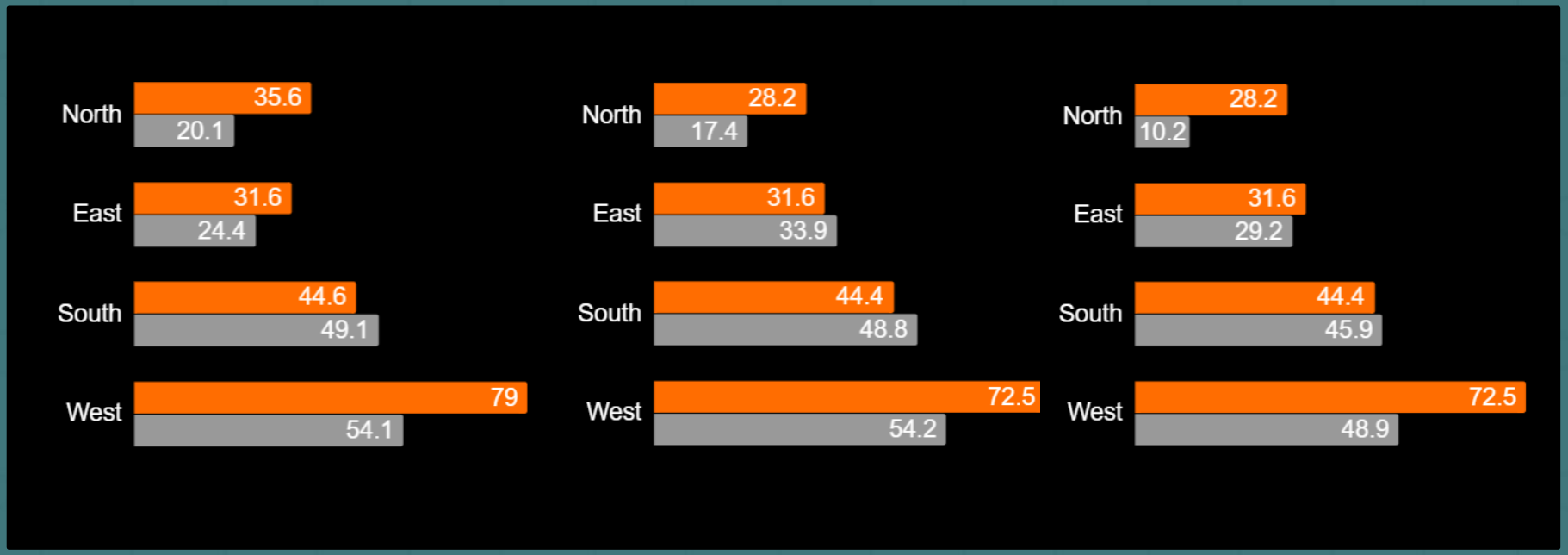


Reduction Factors
(100% - Full exposure)

3D Volumes
Horizon Geometry

Results - Solar Access - Summer (Cooling)

Comparison 1	Comparison 2	Comparison 3
R – 100 ft.	R – 360 ft.	R – 860 ft.



Reduction Factors
(100% - Full exposure)

3D Volumes
Horizon Geometry

Conclusions

- The new WUFI Dynamic Shading Methodology allows an **expedite calculation of site shading**.
- The **'dual pathfinder protocol + horizon geometry'** are intended to account for **'seasonal shading'** within the imported geometry in WUFI.
- From the comparative test, modeling **'3D volumes'** or modeling the **'Horizon Geometry'** bring similar results on site shading.
- These **updates** help to determine the **potential benefit** of shading from adjacent structures for **decreasing summer energy requirements**, or the loss of warming influences which increases demands during winter.

Thank you !

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apinzon@phius.org