

DAYSIM Development

Penn State's Contributions

2013 International Radiance Workshop

Richard Mistrick

Penn State University

Email: Rmistrick@psu.edu

August 13, 2013

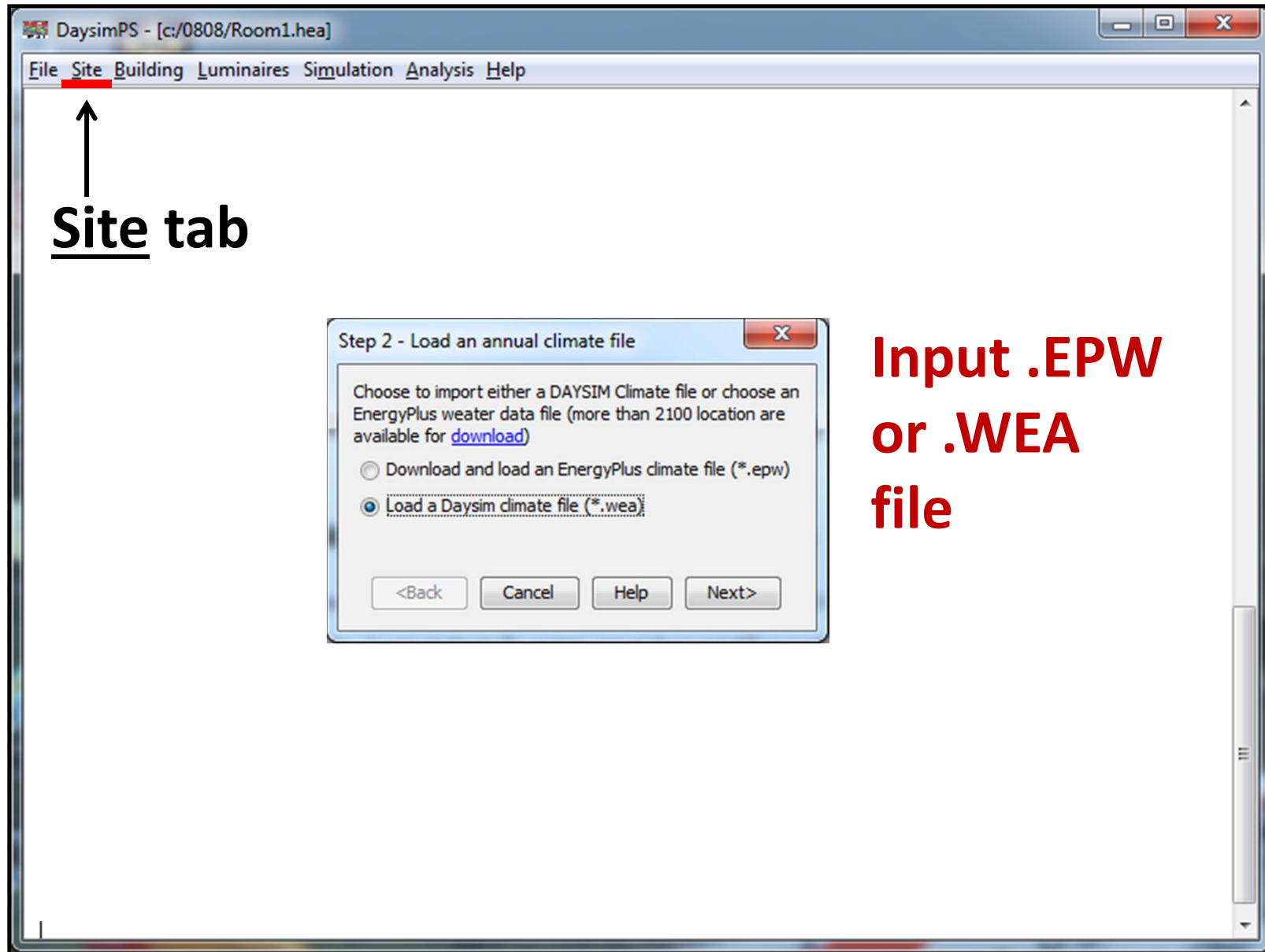
What's new in DAYSIM?

- DAYSIMps
 - Simple GUI for daylighting and photocontrol system modeling.
- New DAYSIM modules
 - Open-source modules designed for incorporation into other modeling software.
 - Expanded header file formatting (The .hea file is the DAYSIM input file) and output files.

What is DAYSIMps?

- A daylight modeling tool that:
 - Computes annual daylighting metrics and energy savings.
 - Considers photosensor spatial sensitivity, location, aiming, control algorithm, and calibration.
 - Applies photosensor system performance data (*which we don't yet have*).
- A major expansion of the Daysim 3.1 GUI.
- Note: Current GUI does not address all of the new modules (A new GUI is under development to address these features).
- Available through www.daysim.ning.com (soon).

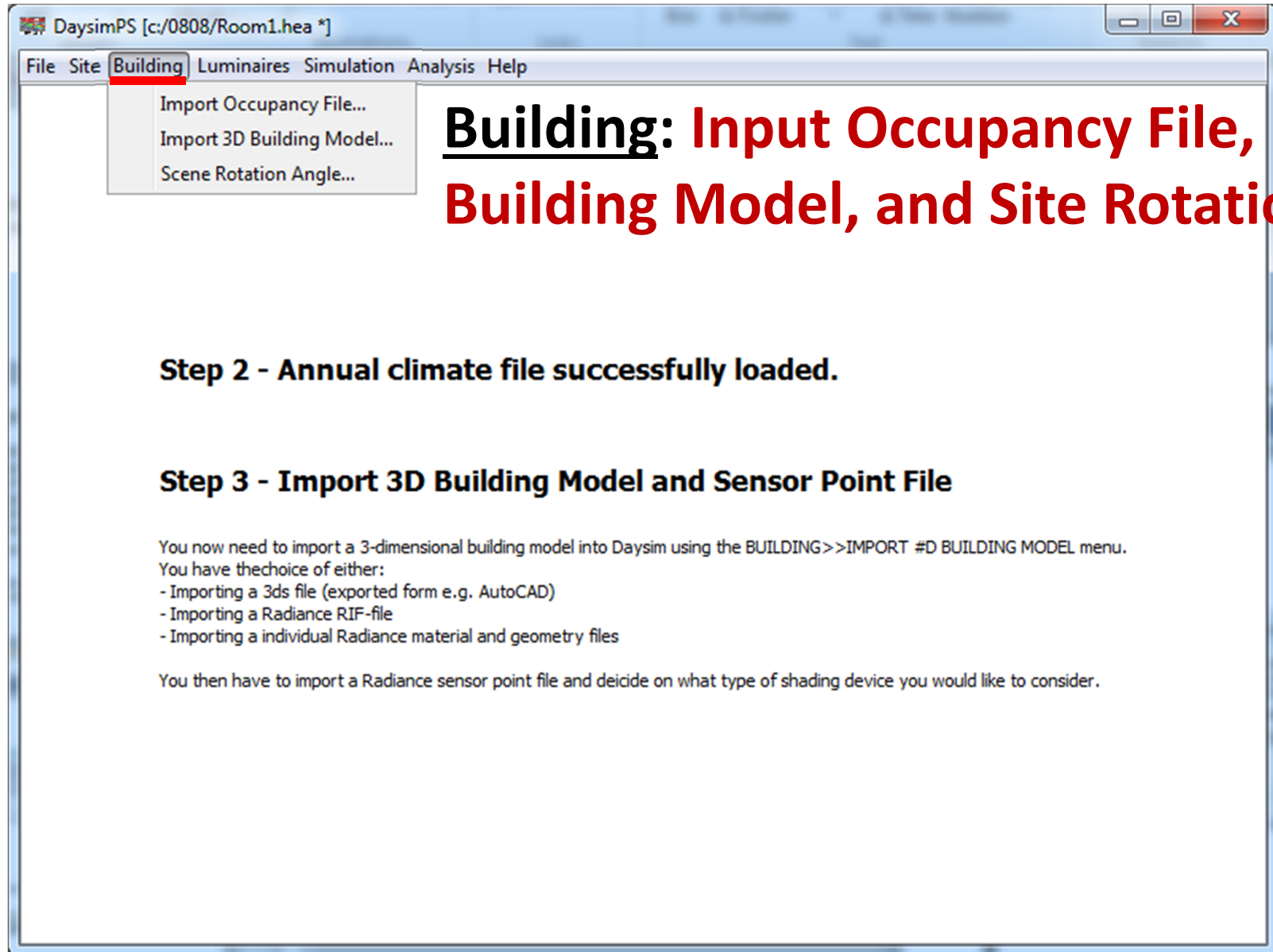
Current DAYSIMps GUI Input



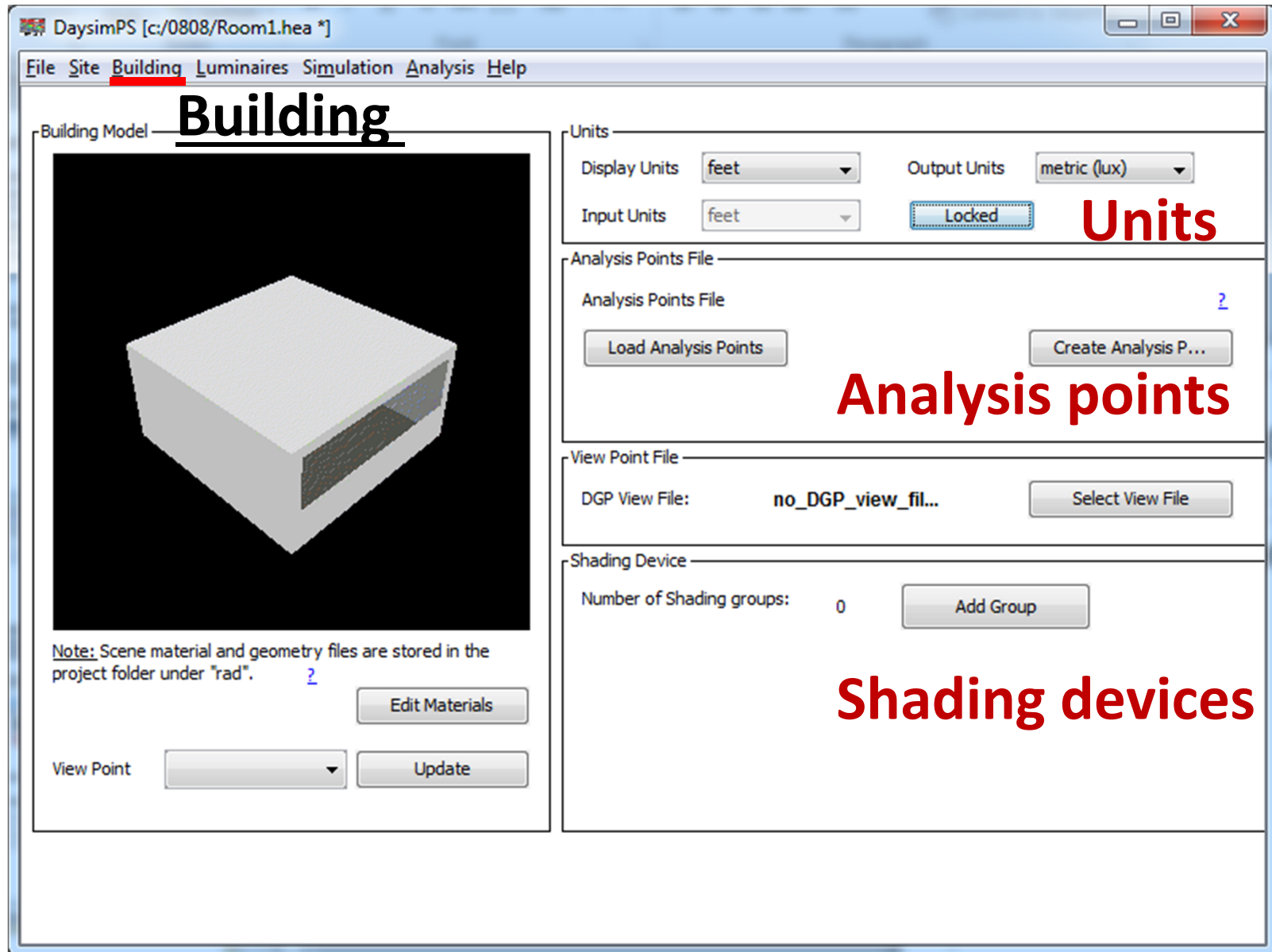
↑
Site tab

**Input .EPW
or .WEA
file**

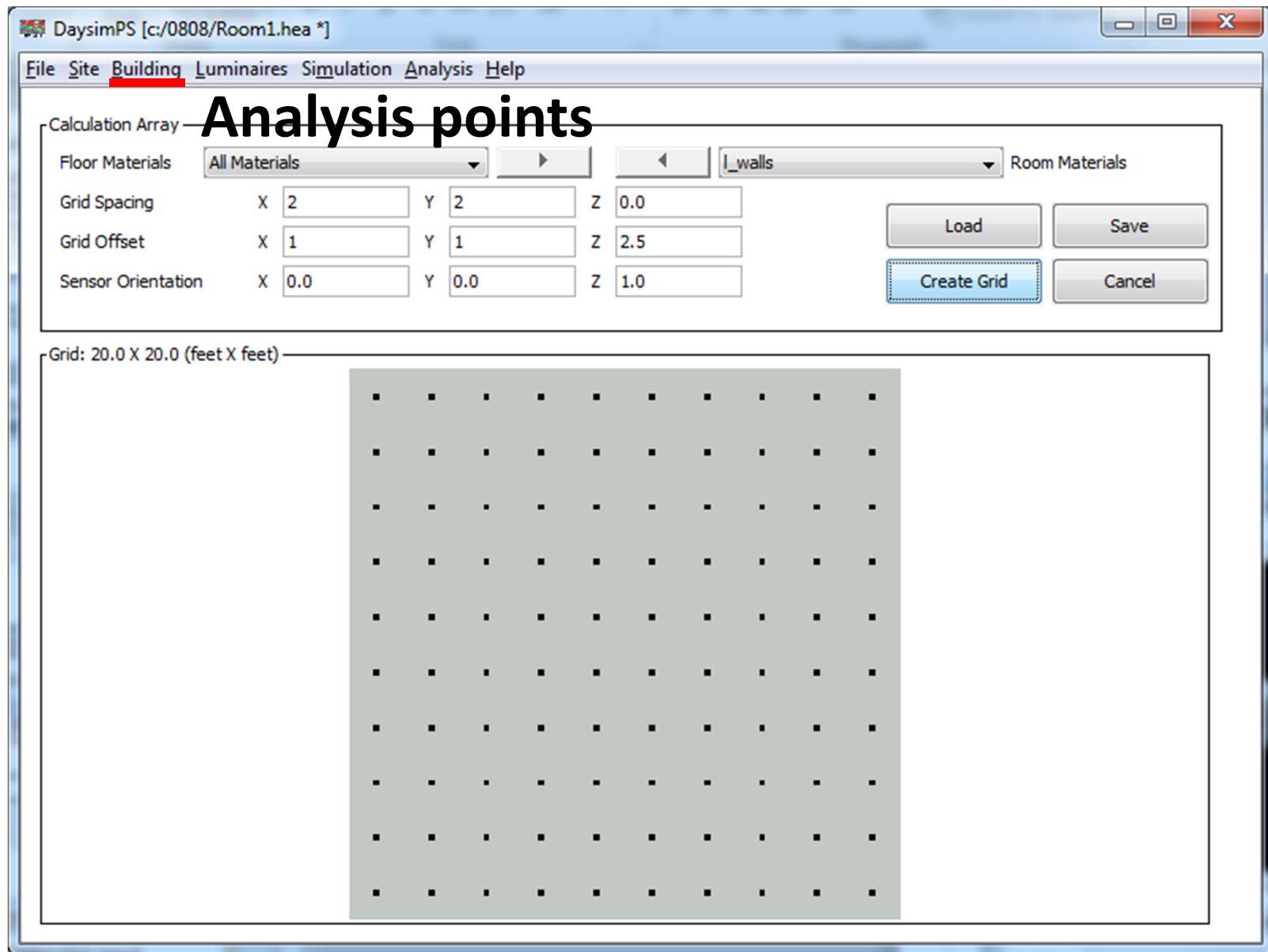
DAYSIMps GUI Input



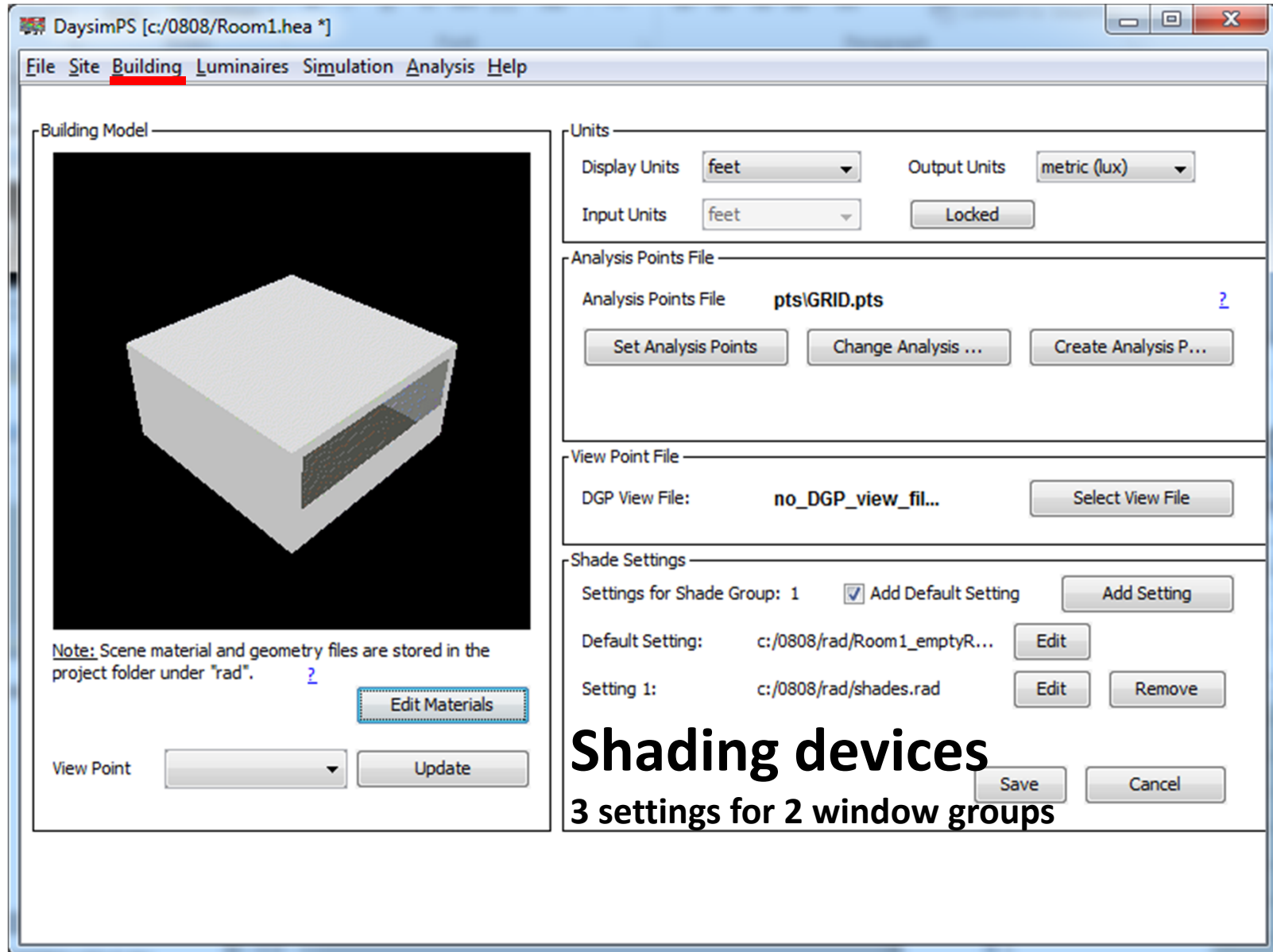
DAYSIMps GUI Input



DAYSIMps GUI Input



DAYSIMps GUI Input



Luminaire Schedule and Layout

DaysimPS [c:/0808/Room1.heg *]

File Site Building Luminaires Simulation Analysis Help

Luminaire Schedule - ELight1

Type	IES File	Descript...	BF MAX	BF MIN	POWER MAX	POWER MIN	OTHER LLF's	TOTAL LLF	LUMENS /LAMP	DELETE
A	8211.ies		1.0	0.05	60	10.0	0.8	0.8	2850	<input type="checkbox"/>

DaysimPS [c:/0808/Room1.heg *]

File Site Building Luminaires Simulation Analysis Help

Luminaire Layout Table - ELight1

Type	X	Y	Z	# Col	# Row	X Spacing	Y Spacing	Z Spacing	ROT	TILT	SPIN	Grid Rot	Zone	DELETE
A	5.0	5.0	10.0	2	1	10.0	0.0	0.0	0.0	0.0	0.0	0.0	1	<input type="checkbox"/>
A	5.0	15.0	10.0	2	1	10.0	0.0	0.0	0.0	0.0	0.0	0.0	2	<input type="checkbox"/>

Add Luminaire Type Update Table **Save Table** Restore Refresh View

Zone 1 -Grid: 20.0 X 20.0 (feet X feet)-

Zone 2

Zone 3

Zone 4

DAYSIMps GUI Input

DaysimPS [c:/0808/Room1.hea *]

File Site Building Luminaires **Simulation** Analysis Help

Simulation: Radiance Processing Parameters

[RADIANCE Simulation Parameters](#)

Please set the RADIANCE Simulation Parameters. The default settings assume a scene complexity of '1' (see Help >> Tutorial 2.14).
To reload default values select *Scene Complexity 1*.

ambient bounces (ab)	<input type="text" value="5"/>	specular jitter (sj)	<input type="text" value="1.0000"/>
ambient divisions (ad)	<input type="text" value="1000"/>	limit weight (lw)	<input type="text" value="0.004000"/>
ambient super-samples (as)	<input type="text" value="20"/>	direct jitter (dj)	<input type="text" value="0.0000"/>
ambient resolution (ar)	<input type="text" value="300"/>	direct sampling (ds)	<input type="text" value="0.200"/>
ambient accuracy (aa)	<input type="text" value="0.1"/>	direct relays (dr)	<input type="text" value="2"/>
limit reflection (lr)	<input type="text" value="6"/>	direct pretest density (dp)	<input type="text" value="512"/>
specular threshold (st)	<input type="text" value="0.1500"/>		

DAYSIMps GUI Input

Analysis of Results

[RADIANCE Simulation Parameters](#)

Daylight Settings

Set Daylight Screen

Daylight Conditions

Time and Sky Conditions

Date
Month: 1 Day: 1 Time: 12:30:00AM Interval: 1 hour(s)
Sky: Weather Tape

Blind/Shade Control

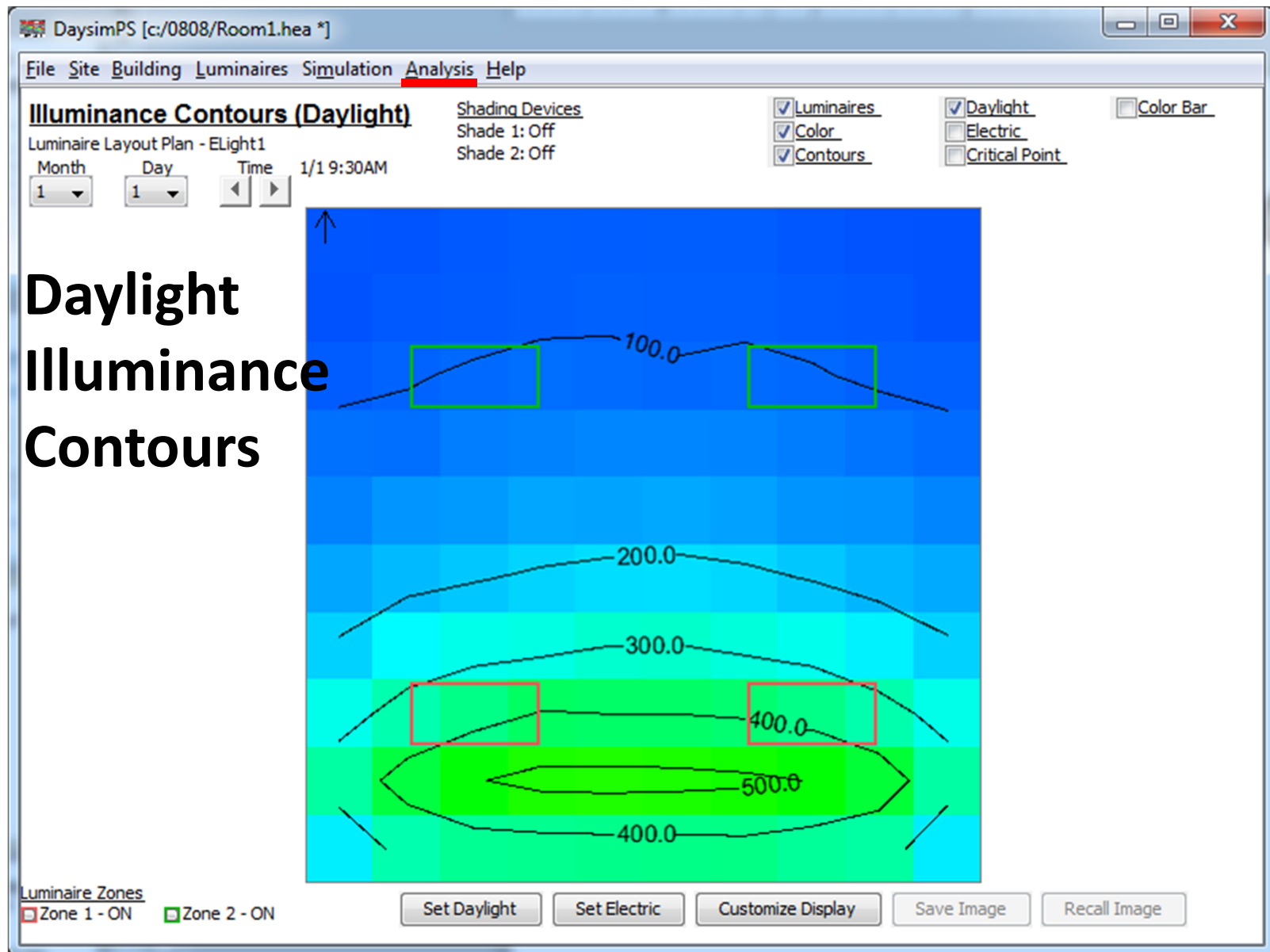
	X	Y	Z	X DIR	Y DIR	Z DIR	ROT	Photo Sensor File	Sig 1	Ang 1	Sig 2	Ang 2	ELAZ
Shade 1 Signal	10.0	0.5	4.0	0	-1.0	0	0	cos.sen	6500.0	0	0	0	0
Shade 2 Off	0	0	0	0	0	0	0	Click To Select	0	0	0	0	0

Continue Calculate

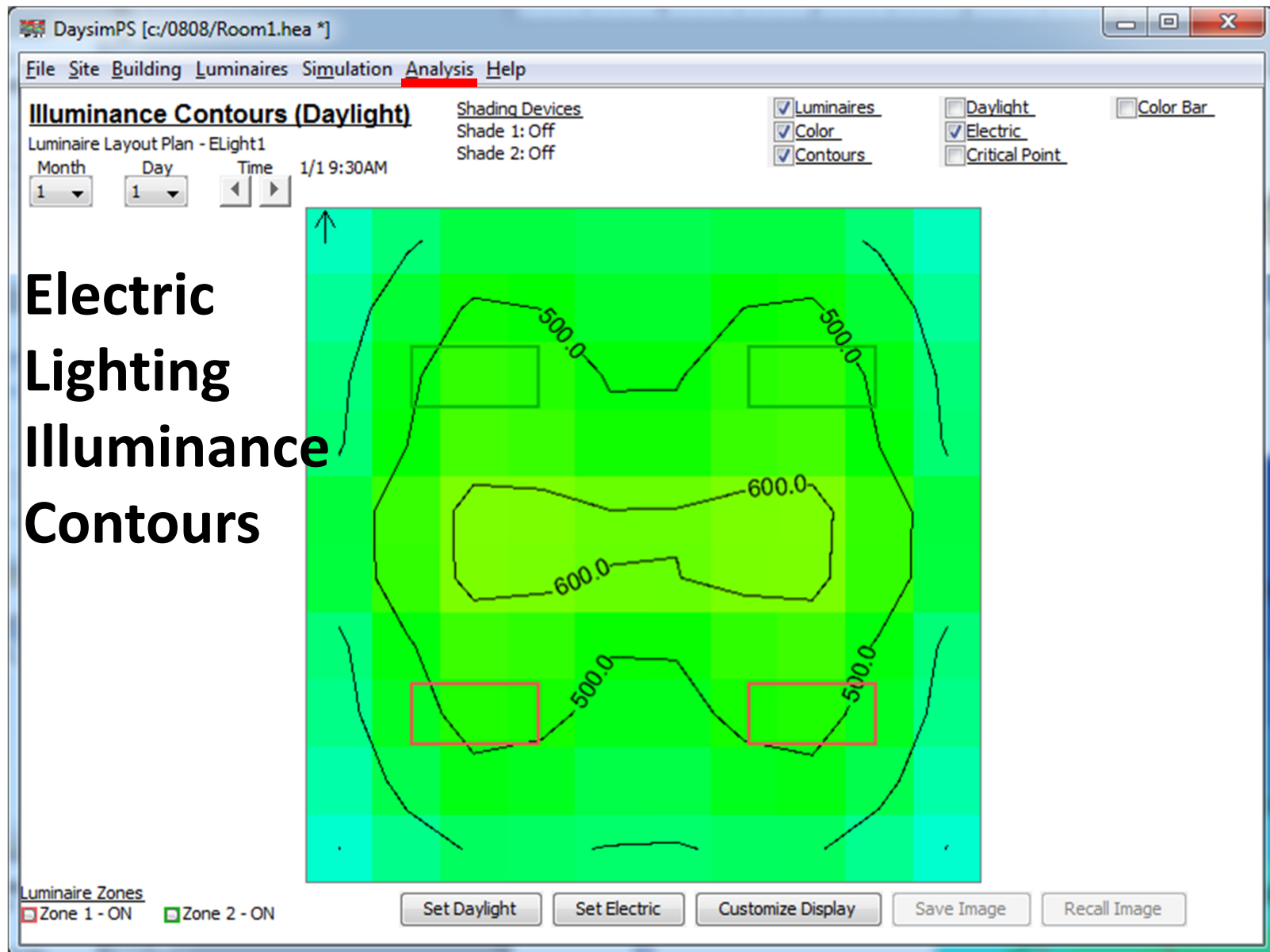
[specular threshold \(st\)](#) 0.1500

Scene Complexity 1 Scene Complexity 2 Help

DAYSIMps GUI Output



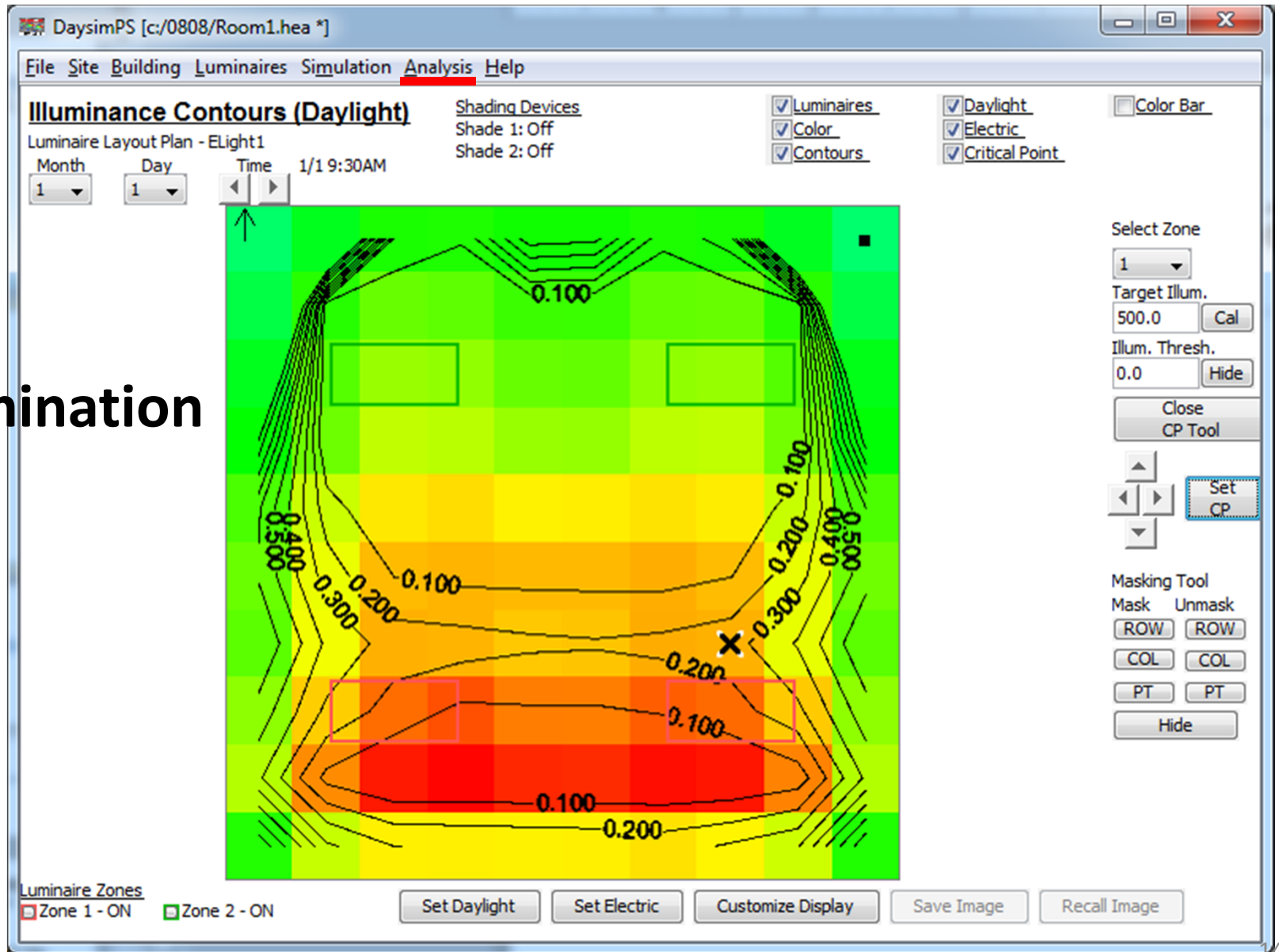
DAYSIMps GUI Output



**Electric
Lighting
Illuminance
Contours**

DAYSIMps GUI Output

Critical
Point
Determination



DAYSIMps GUI Input

Electric Lighting Zone Control

The screenshot shows the 'Electric Light Settings' window. It is divided into three main sections:

- Luminaire Schedule:** A table with columns 'ID' and 'Name'. It contains one entry: ID 1, Name 'ELight1'.
- Luminaire Control Setting:** A table with columns 'ID' and 'Name'. It contains one entry: ID 1, Name 'control1'. Below this table are buttons for 'Add(New)', 'Add(Copy)', and 'Delete'.
- Electric Lighting Zone Control:** A table with columns: Zone, Control, X, Y, Z, X DIR, Y DIR, Z DIR, ROT, Photo Sensor File, Algorithm, and Calibration. It contains two entries: Zone 1 (Control: Dimmed, X: 10.0, Y: 10.0, Z: 10.0, X DIR: 0, Y DIR: 0, Z DIR: -1.0, ROT: 0, Photo Sensor File: 120.sen, Algorithm: Closed Loop Prop. (dim), Calibration: Not Set) and Zone 2 (Control: On, X: 0.0, Y: 0.0, Z: 0.0, X DIR: 0, Y DIR: 0, Z DIR: 0, ROT: 0, Photo Sensor File: Click To Select, Algorithm: (empty), Calibration: N/A).

At the bottom of the window, there are buttons for 'Continue' and 'Calculate Signals'.

Single zone dimming

or switching:

Closed-loop Proportional

Closed-loop

Constant Setpoint

Open-loop

Open-loop

DAYSIMps GUI Input

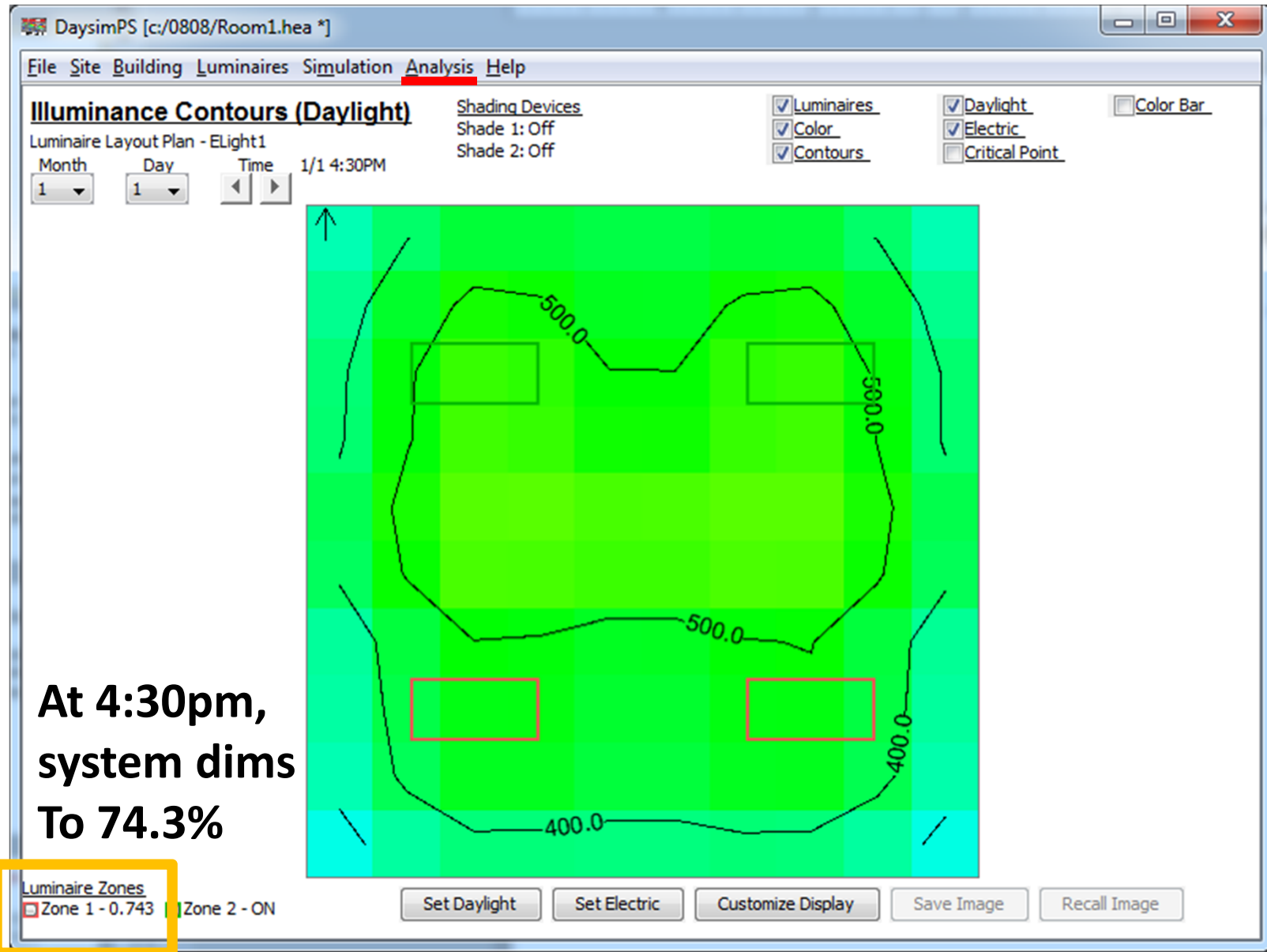
Control Algorithm Calibration at a Selected Time

Control Algorithm Settings (Values are for Critical Point)

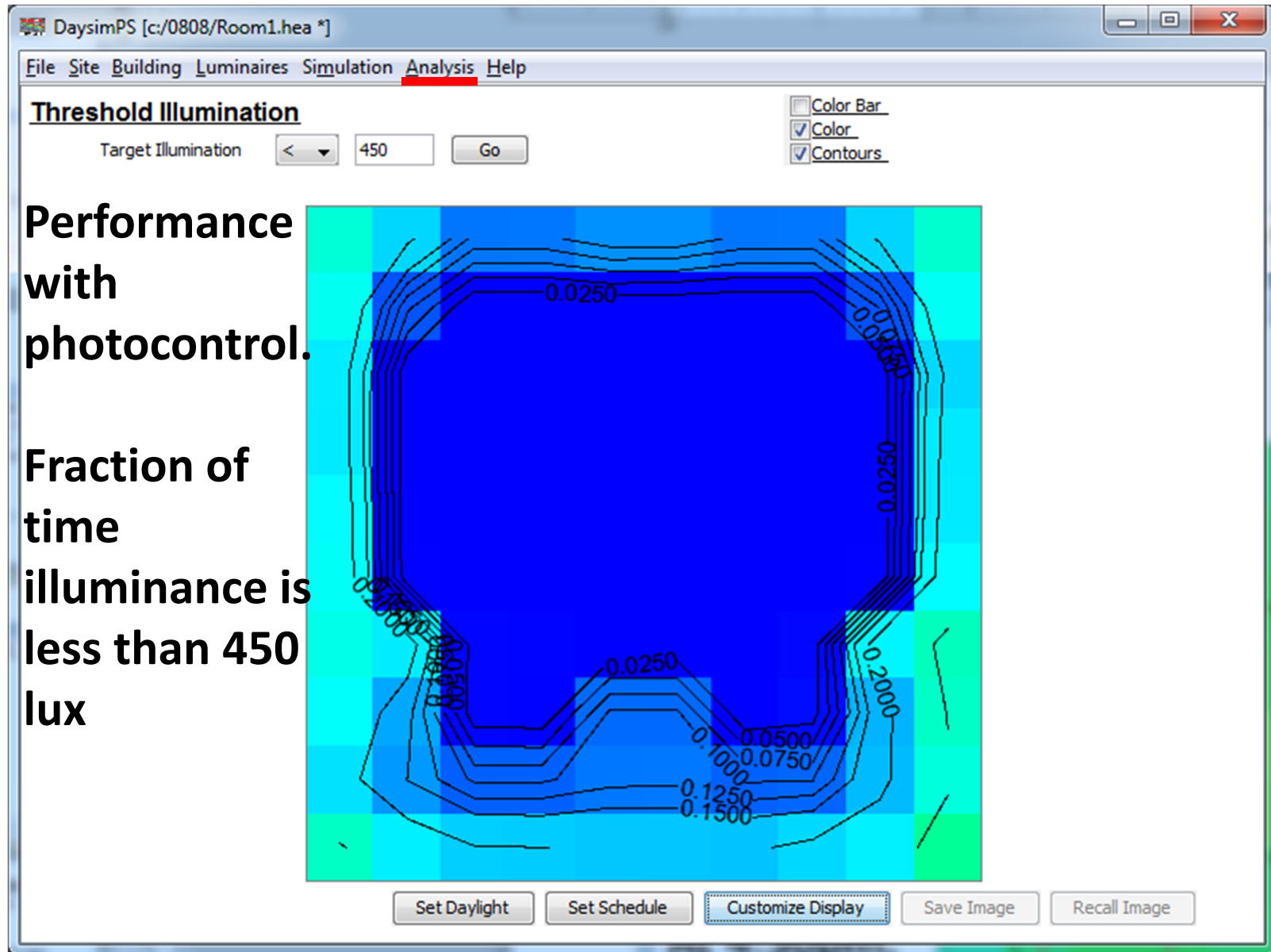
Calibrate Sensor - Closed Loop Proportional (Values are for Critical Point)

<u>Night Condition</u>	Illuminance (Elec)	558.0	<u>Month/Day/Time: 1/1 9:30AM</u>
	Target	<input type="text" value="500.0"/>	
	Signal @ Target	74.0	<u>Sky: Weather Tape</u>
<u>Daylight Condition</u>	Daylight Illum.	269.0	
	Daylight Signal	34.0	<input type="button" value="Reset Daylight Condition"/>
	Non-Dimmed	116.2	
	Target	<input type="text" value="500.0"/>	
	Dimming Level	0.259	
	Signal	84.2	
	Off Condition	<input type="checkbox"/>	

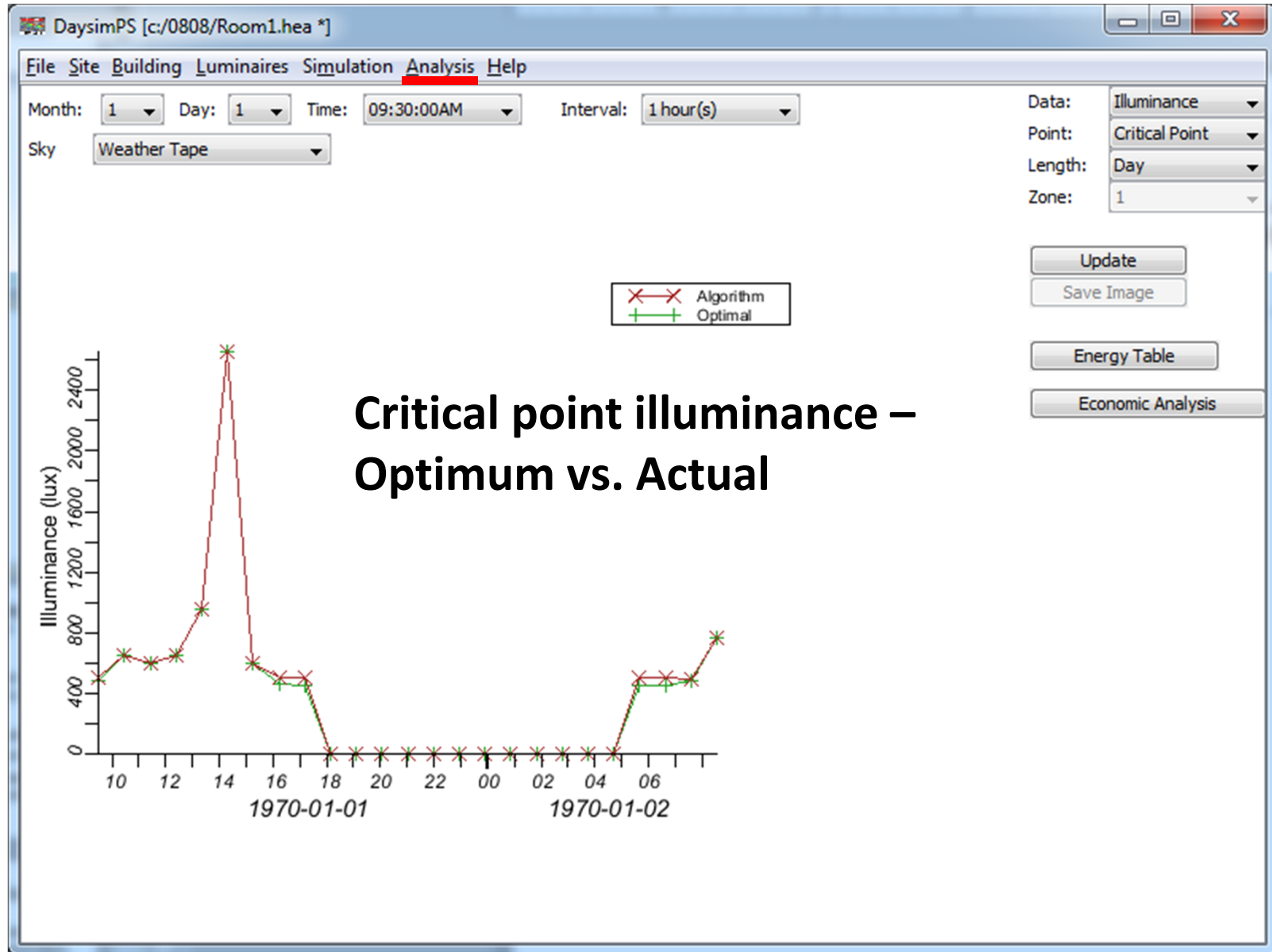
DAYSIMps GUI Output



DAYSIMps GUI Output

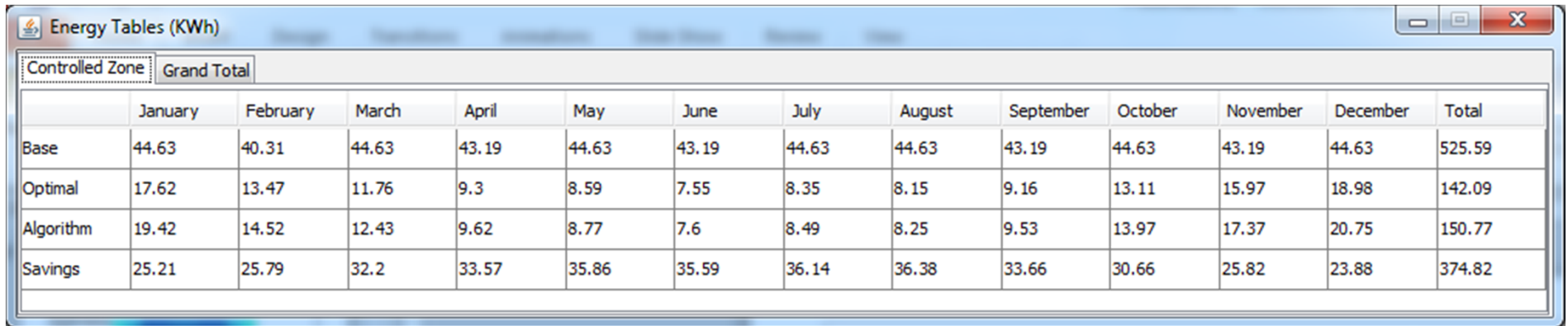


DAYSIMps GUI Output



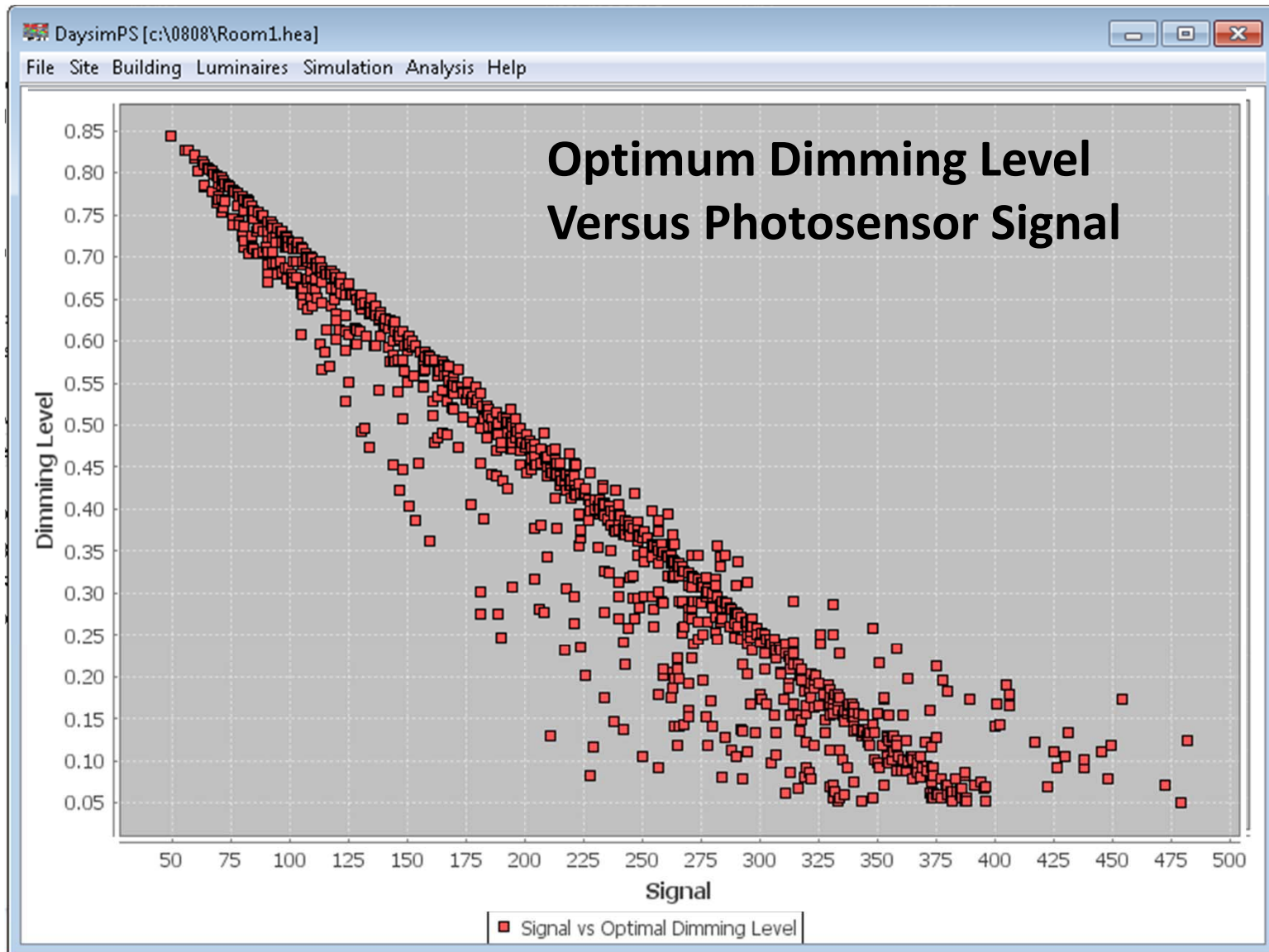
DAYSIMps GUI Output

**Monthly energy consumption in controlled lighting zone,
Optimum vs. actual with algorithm setting.**



	January	February	March	April	May	June	July	August	September	October	November	December	Total
Base	44.63	40.31	44.63	43.19	44.63	43.19	44.63	44.63	43.19	44.63	43.19	44.63	525.59
Optimal	17.62	13.47	11.76	9.3	8.59	7.55	8.35	8.15	9.16	13.11	15.97	18.98	142.09
Algorithm	19.42	14.52	12.43	9.62	8.77	7.6	8.49	8.25	9.53	13.97	17.37	20.75	150.77
Savings	25.21	25.79	32.2	33.57	35.86	35.59	36.14	36.38	33.66	30.66	25.82	23.88	374.82

DAYSIMps GUI Output



New DAYSIMps Modules/Capabilities

(non-GUI supported)

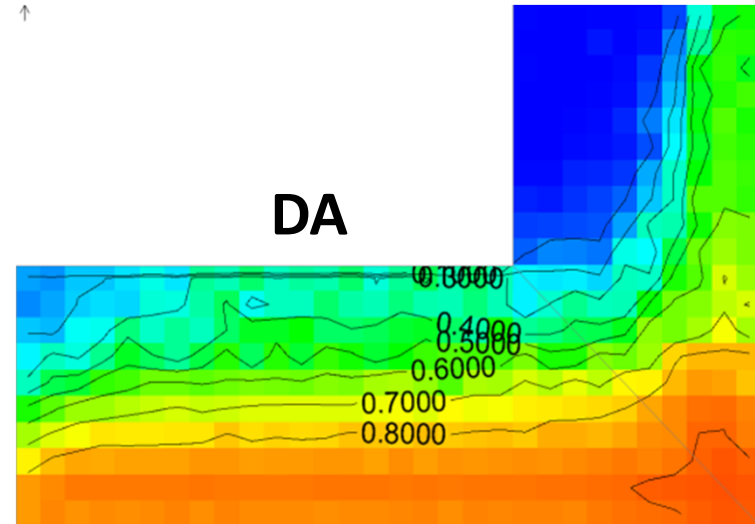
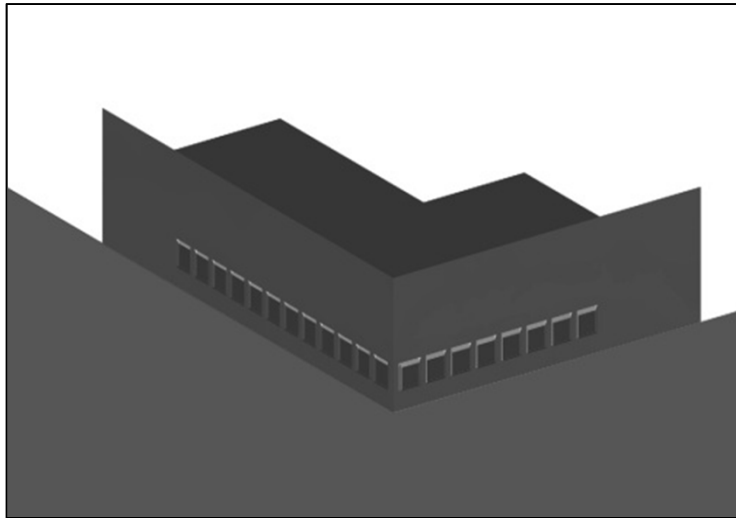
- 10 shade settings on up to 10 window groups
- Spatial Daylight Autonomy
- Annual Sunlight Exposure
- Critical point determination (1 or multiple CP's)
- Custom, user-specified control algorithms
- Optimum control of a multi-zone system.
- K-means clustering of work plane points (soon).
- Evaluation of photosensor layouts using RMSE for best case calibration (limited to 2% overdimming).
- Five-phase BSDF modeling (soon).

Critical Point Determination

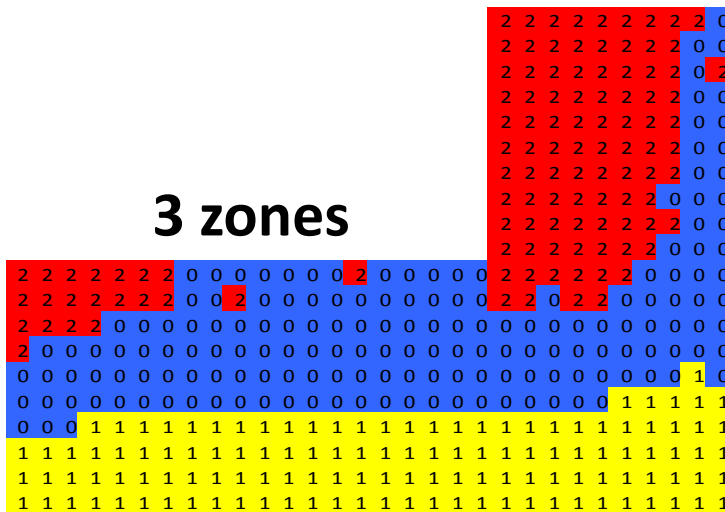
Where does the critical point lie throughout the year?

↑ N	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	
-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1
-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1
-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1
-1	-1	4	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1
-1	-1	72	0	0	0	0	0	0	0	0	0	0	0	127	-1	-1
-1	-1	601	0	0	0	0	0	0	0	0	0	0	0	207	-1	-1
-1	-1	105	0	0	0	0	0	0	0	0	0	0	0	6	-1	-1
-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	-1
-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1
-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

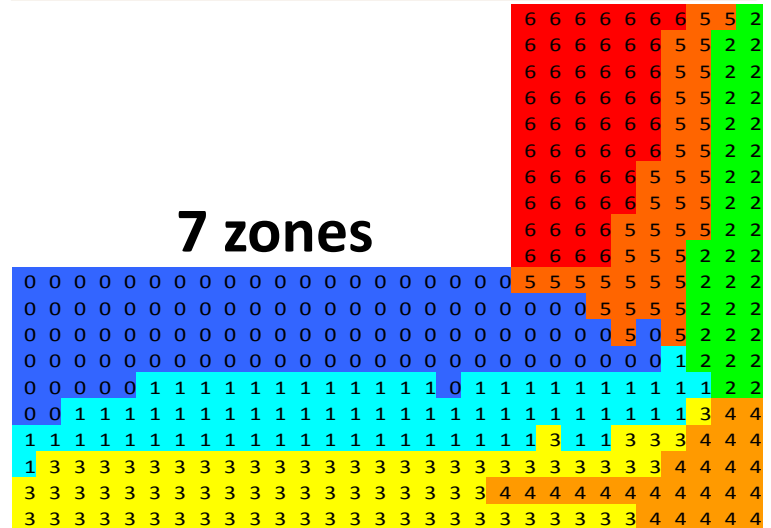
K-Means Clustering to aid Control Zone Layout



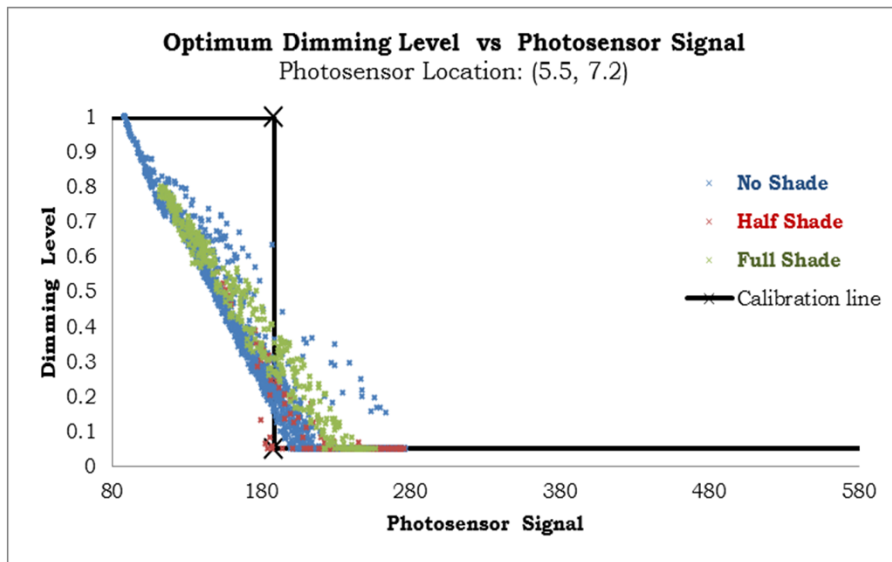
3 zones



7 zones



Photosensor Error Relative to Optimum (RMSE)



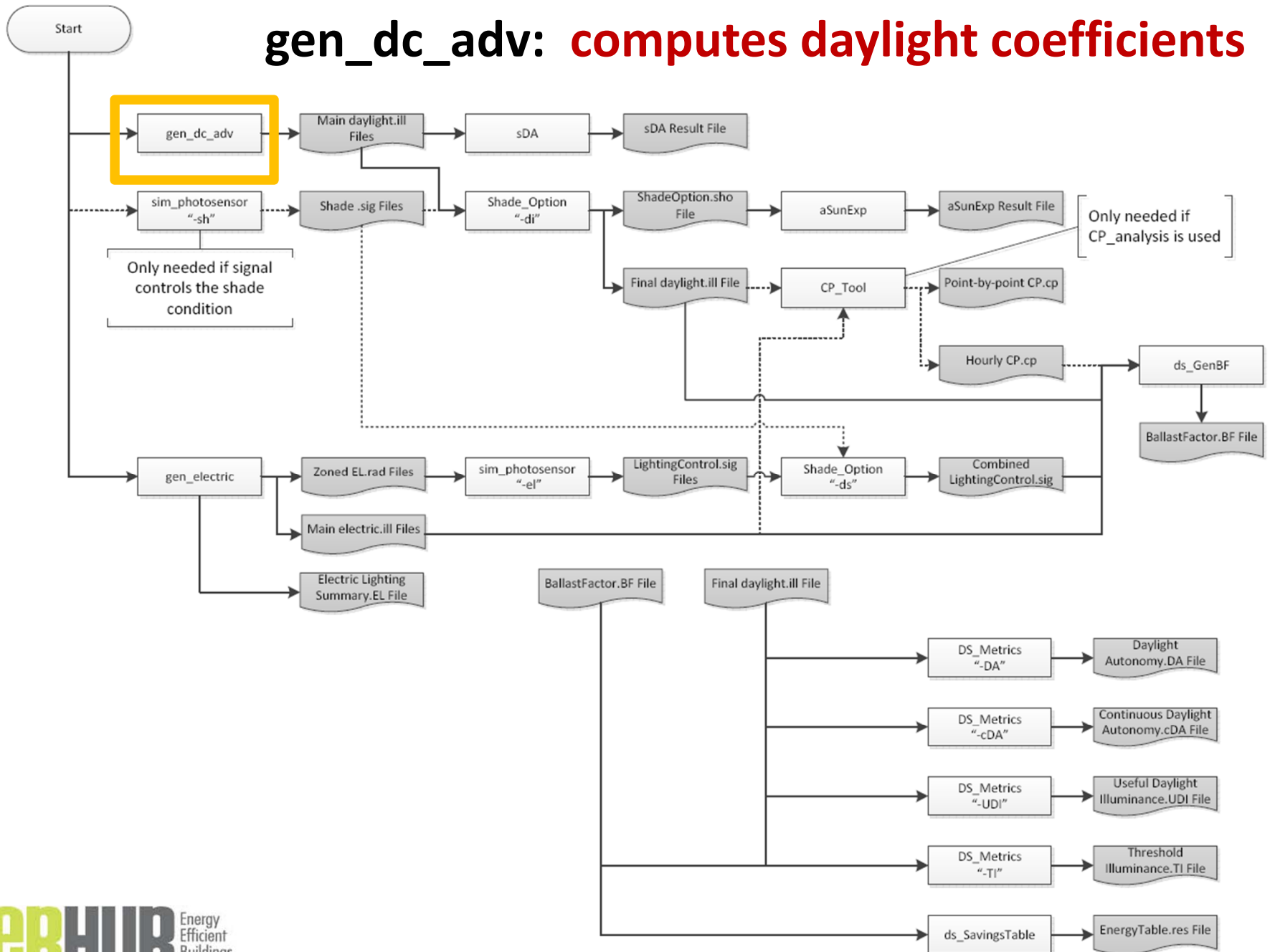
7.2m	21	21	20	21	20	21	20	21	20	21	20	20	21	22	23	23	23
6.6m	22	21	21	20	20	20	20	20	19	19	19	20	21	23	24	25	24
5.9m	21	21	21	20	20	20	19	22	19	19	20	20	22	23	24	26	28
5.3m	22	21	21	21	21	20	22	20	20	21	22	23	22	25	28	31	32
4.7m	22	21	20	21	23	21	23	22	22	22	21	22	23	27	30	31	32
4.1m	22	22	23	24	25	24	24	23	24	24	24	25	25	28	31	31	31
3.5m	22	23	24	24	24	25	25	25	27	27	26	27	27	28	32	33	32
2.9m	24	23	25	27	26	25	27	25	27	29	29	27	27	29	30	35	35
2.3m	26	24	25	27	27	29	28	26	28	29	29	30	27	30	31	33	41
1.7m	24	25	25	25	26	27	26	27	27	26	27	29	27	27	27	31	41
1.1m	22	24	28	31	31	30	28	27	27	27	30	31	30	30	27	27	34
0.5m	20	25	33	34	34	34	34	30	28	33	34	35	36	34	31	25	29
North ↑	0.6m	1.2m	1.8m	2.4m	3.m	3.7m	4.3m	4.9m	5.5m	6.1m	6.7m	7.3m	7.9m	8.5m	9.1m	9.8m	10.4m



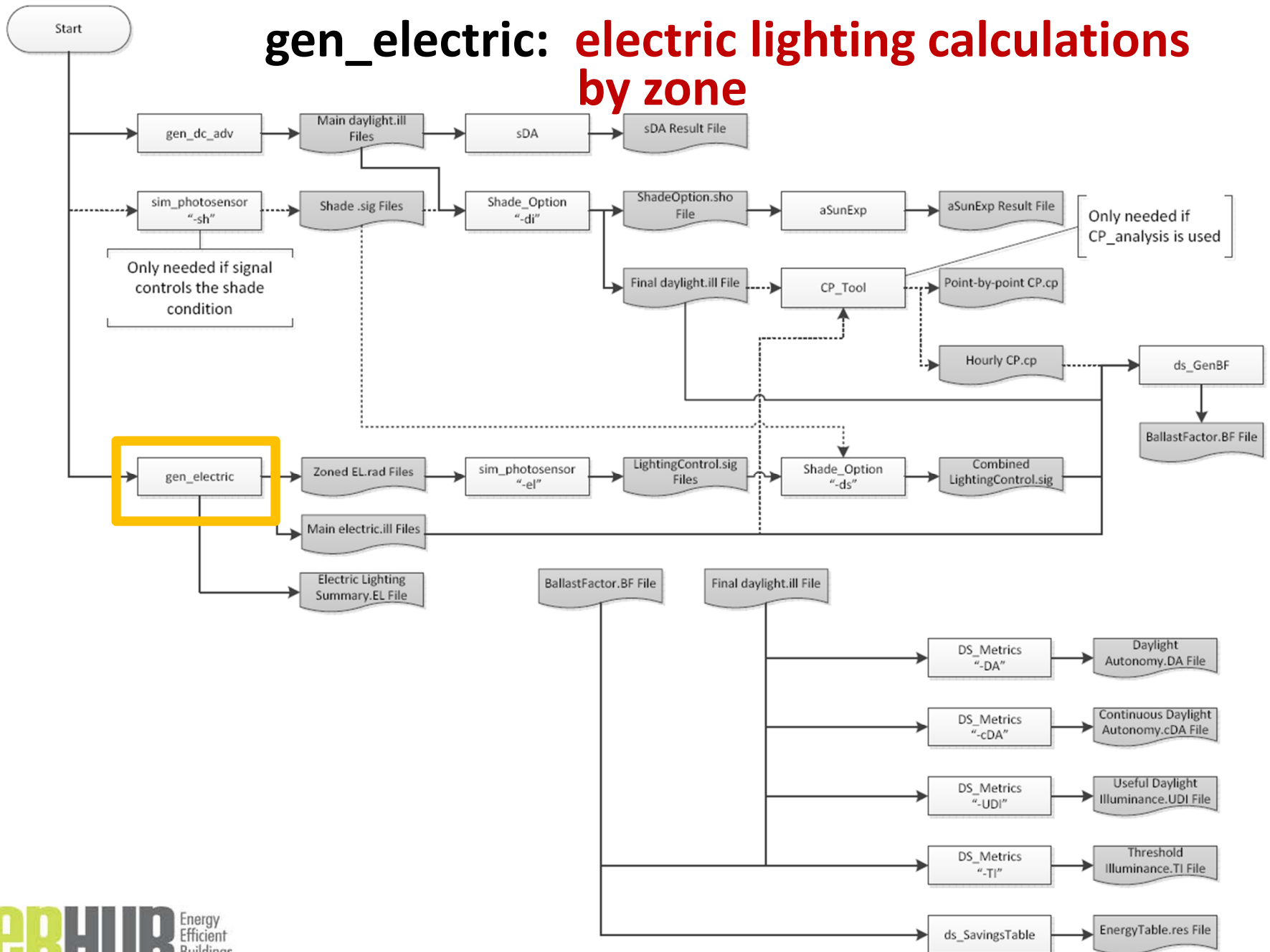
Advanced DAYSIMps Operation

- Create header file with system description, file links, requested output, and processing parameters.
- Run Daysim executable modules referencing the header file (see flowchart on following slides).
- Output files contain calculation results.

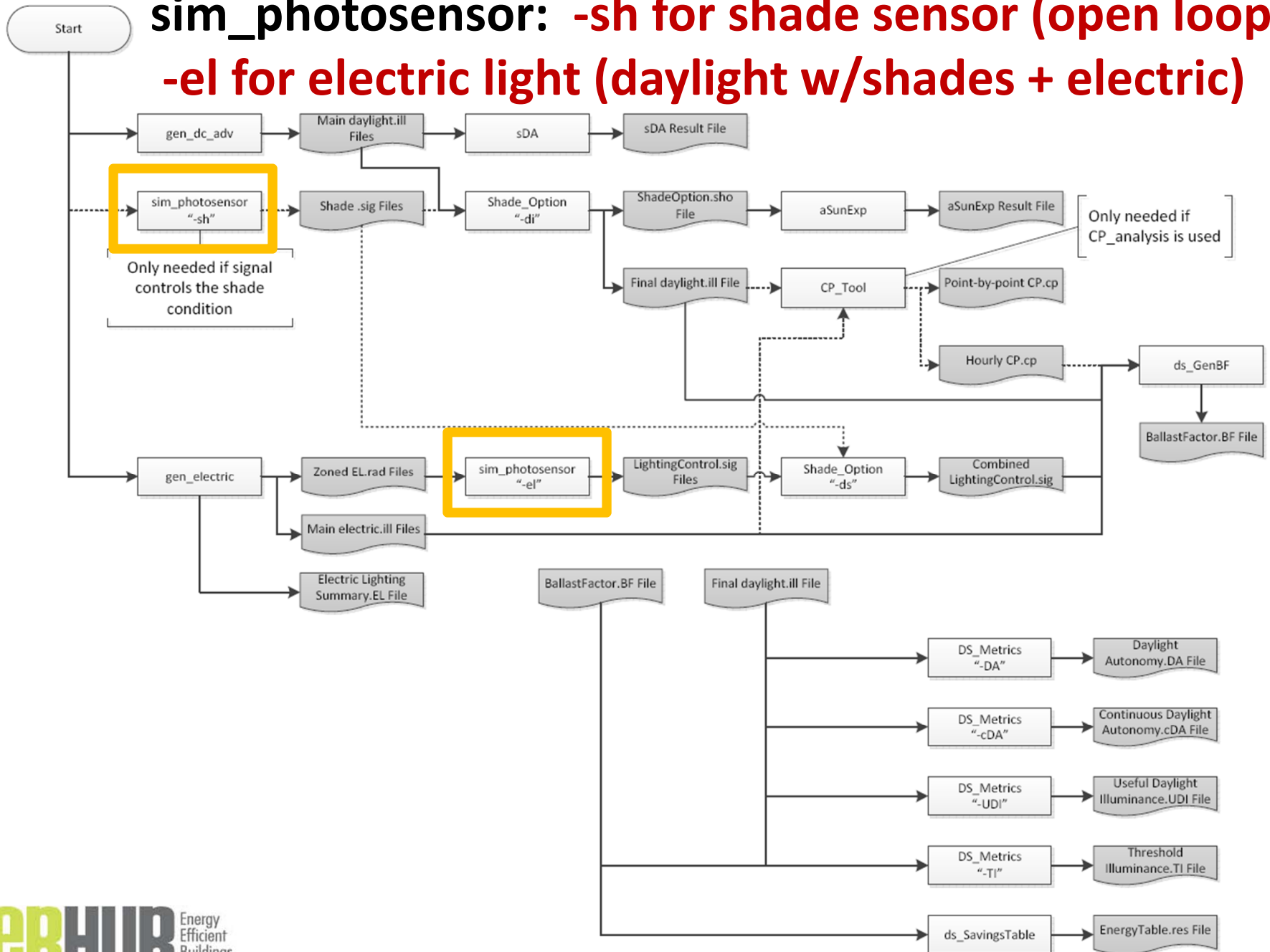
gen_dc_adv: computes daylight coefficients



gen_electric: electric lighting calculations by zone

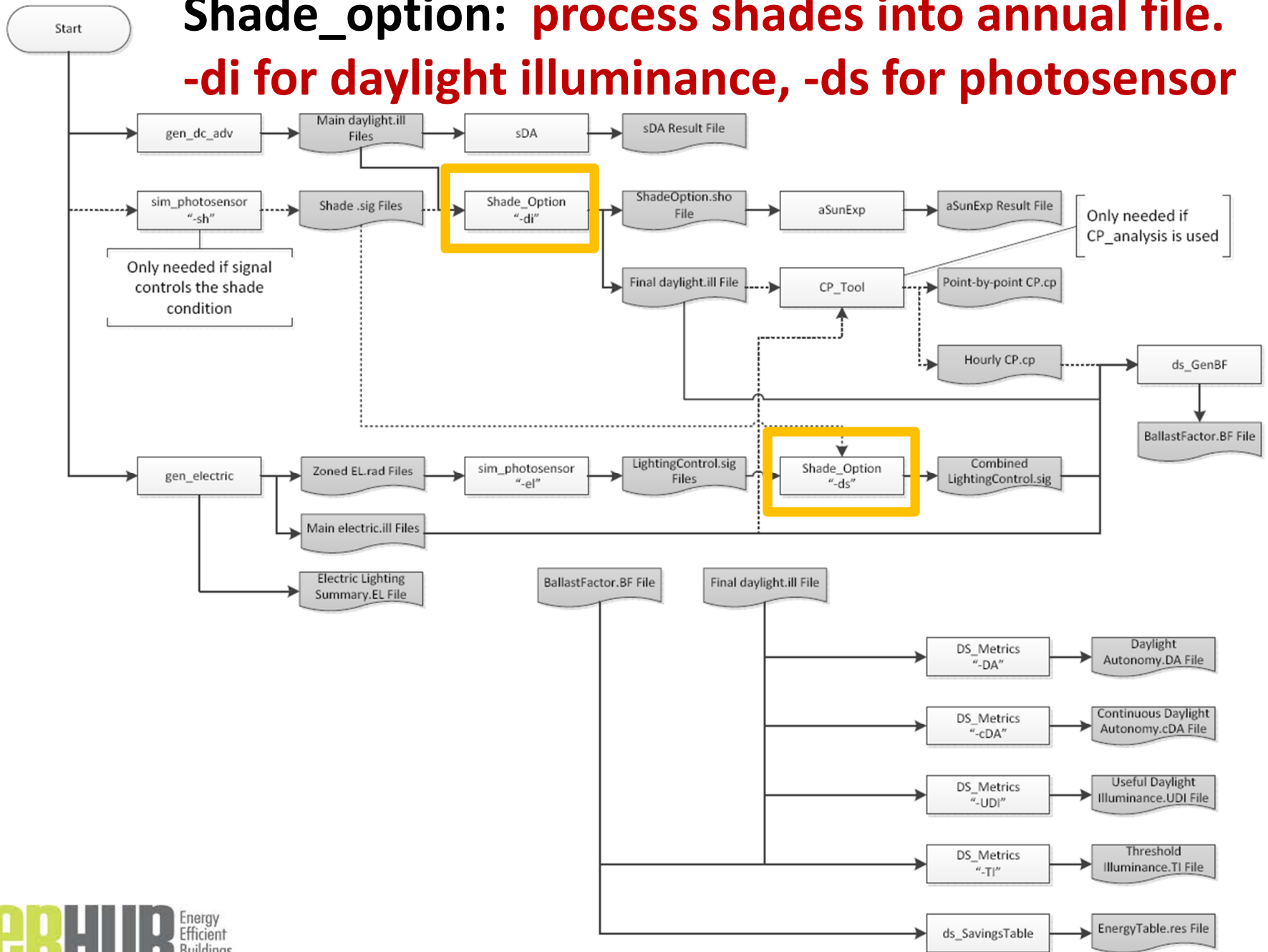


sim_photosensor: -sh for shade sensor (open loop) -el for electric light (daylight w/shades + electric)

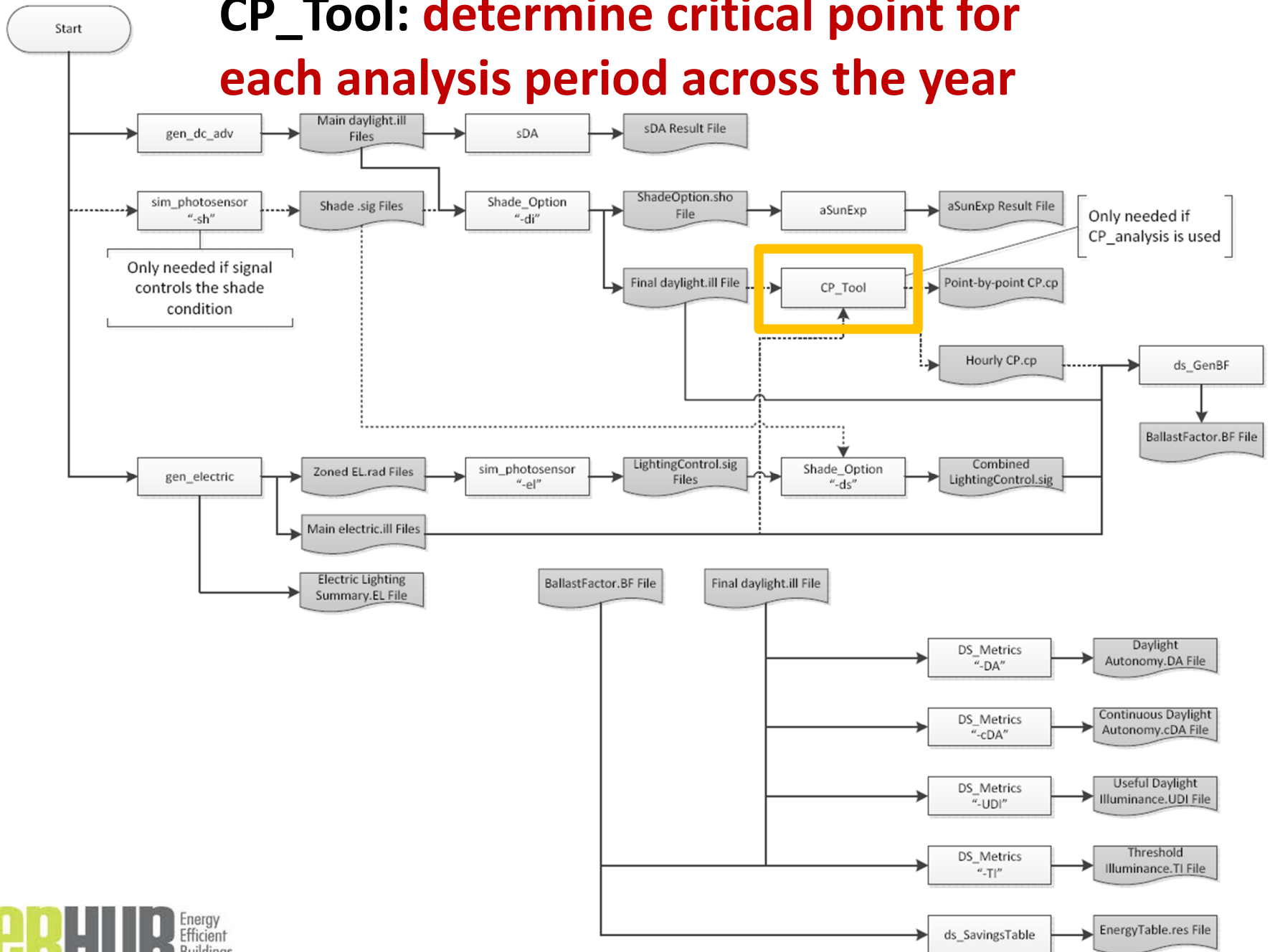


Shade_option: process shades into annual file.

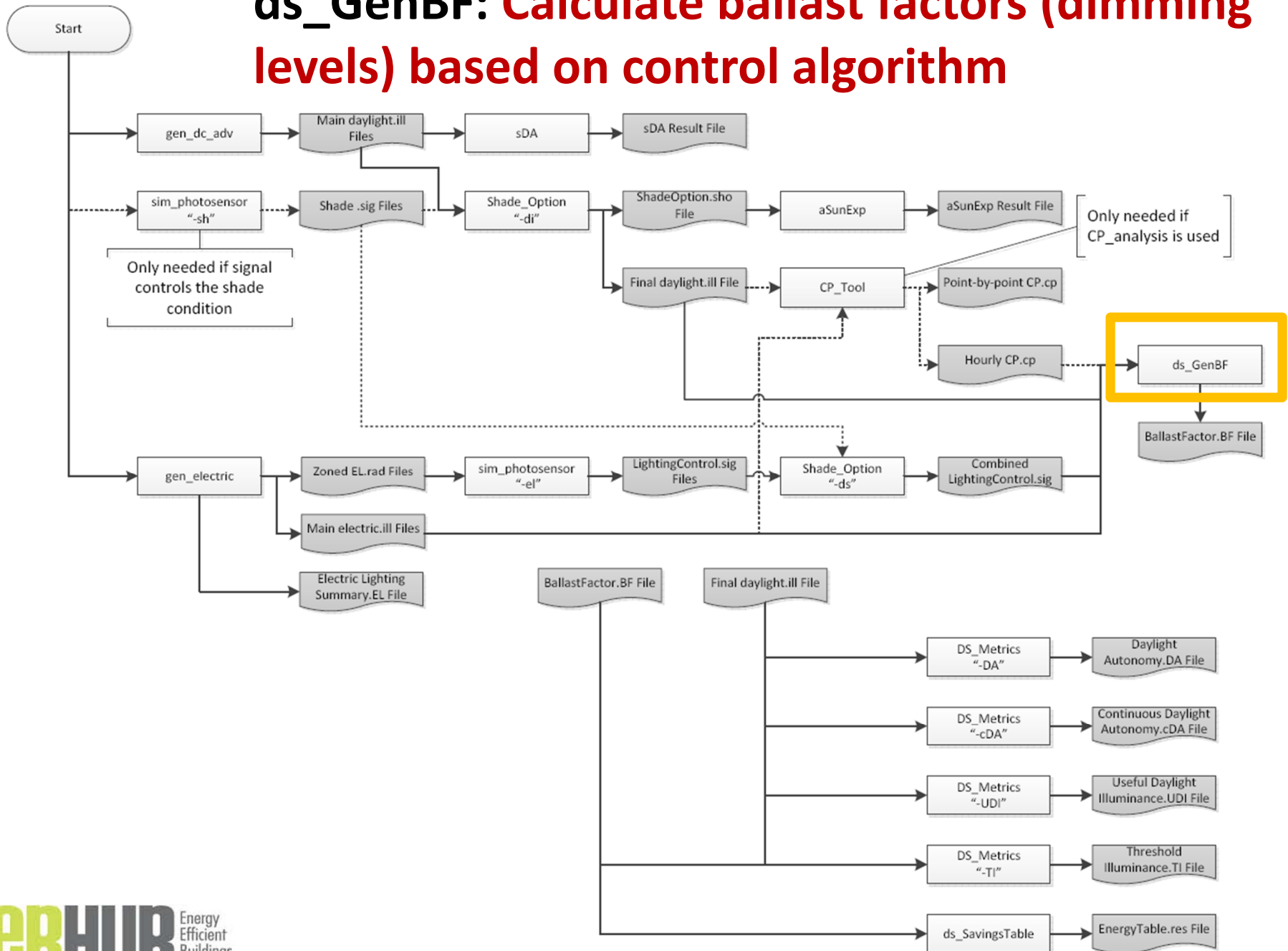
-di for daylight illuminance, -ds for photosensor



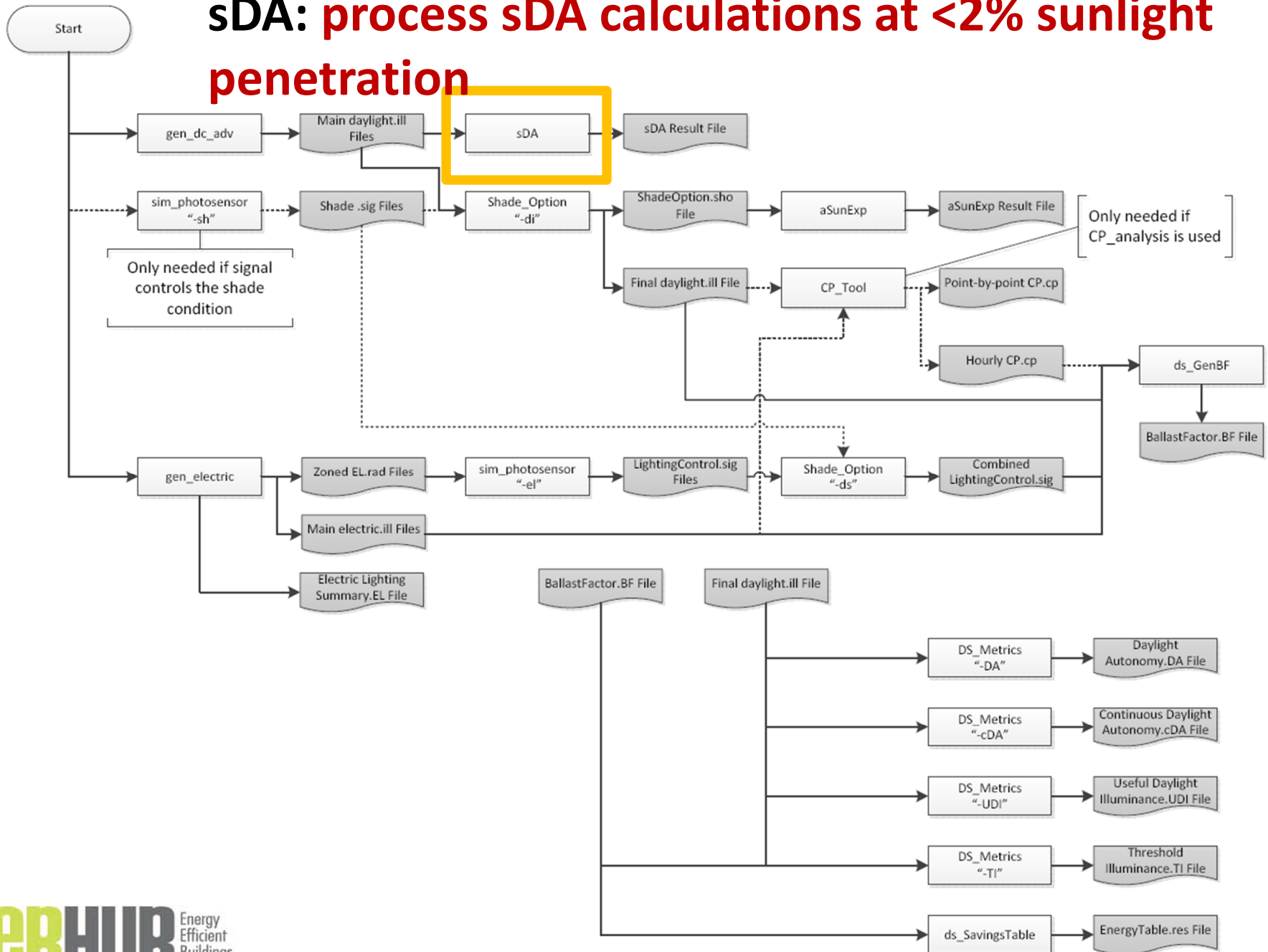
CP_Tool: determine critical point for each analysis period across the year



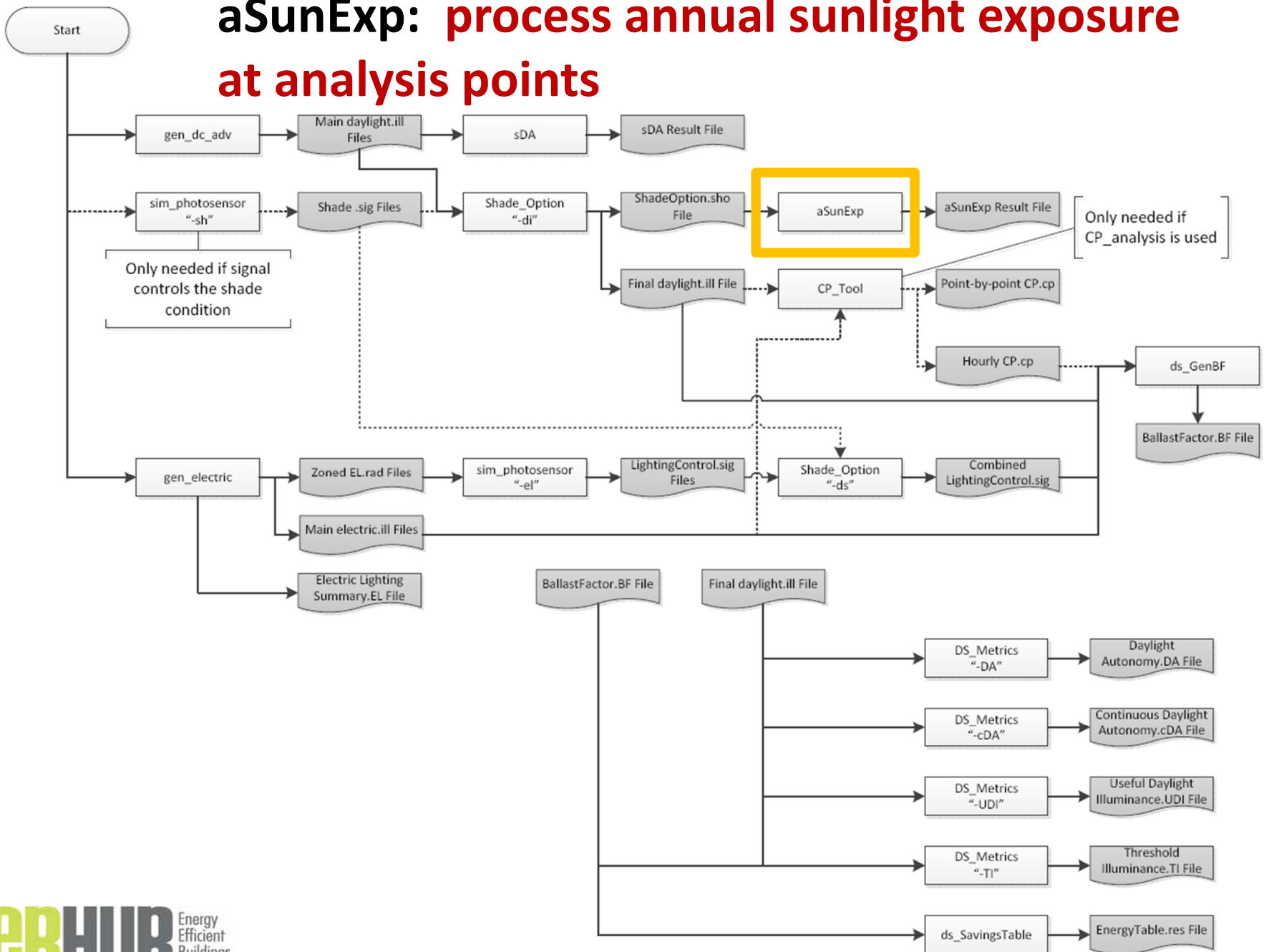
ds_GenBF: Calculate ballast factors (dimming levels) based on control algorithm



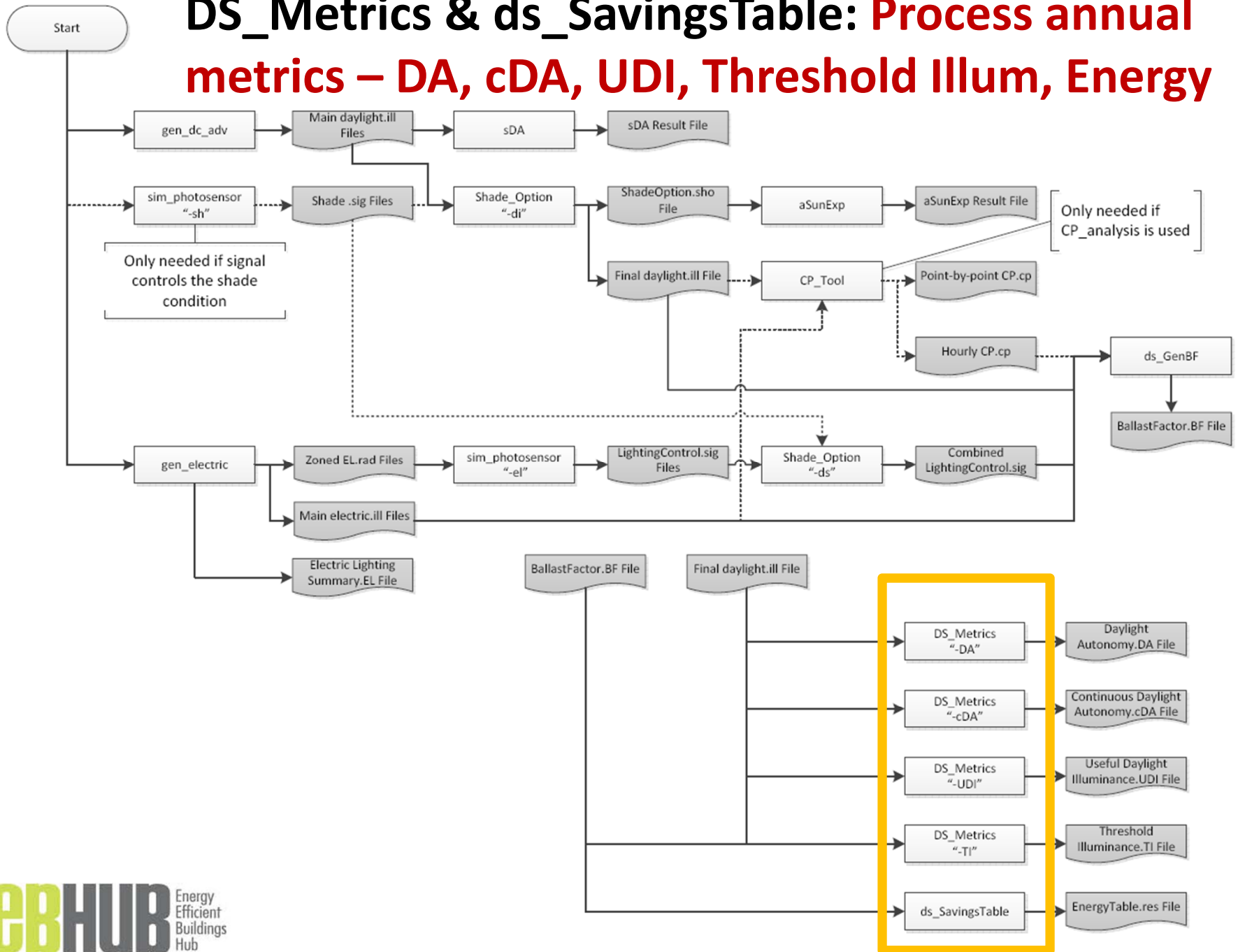
sDA: process sDA calculations at <2% sunlight penetration



aSunExp: process annual sunlight exposure at analysis points



DS_Metrics & ds_SavingsTable: Process annual metrics – DA, cDA, UDI, Threshold Illum, Energy



Summary

- Daysim's modules are designed to:
 - advance and improve daylighting design and integrated electrical lighting control systems.
 - provide much needed daylighting analysis capabilities.
 - be easy to apply in stand-alone GUI and other energy and daylight modeling software.

Acknowledgments

- NRC Canada, Fraunhofer ISE
- Samsung C&T, EEB Hub
- Technical support provided by Christoph Reinhart, Greg Ward, Andy McNeil, Rob Guglielmetti (and others at NREL).
- Penn State graduate students (AE and IST) who helped to develop the Daysim modules and GUI's.