DAYSIM Development

Penn State's Contributions

2013 International Radiance Workshop

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eebHUB Energy Efficient Buildings Hub

PENNSTATE 1855

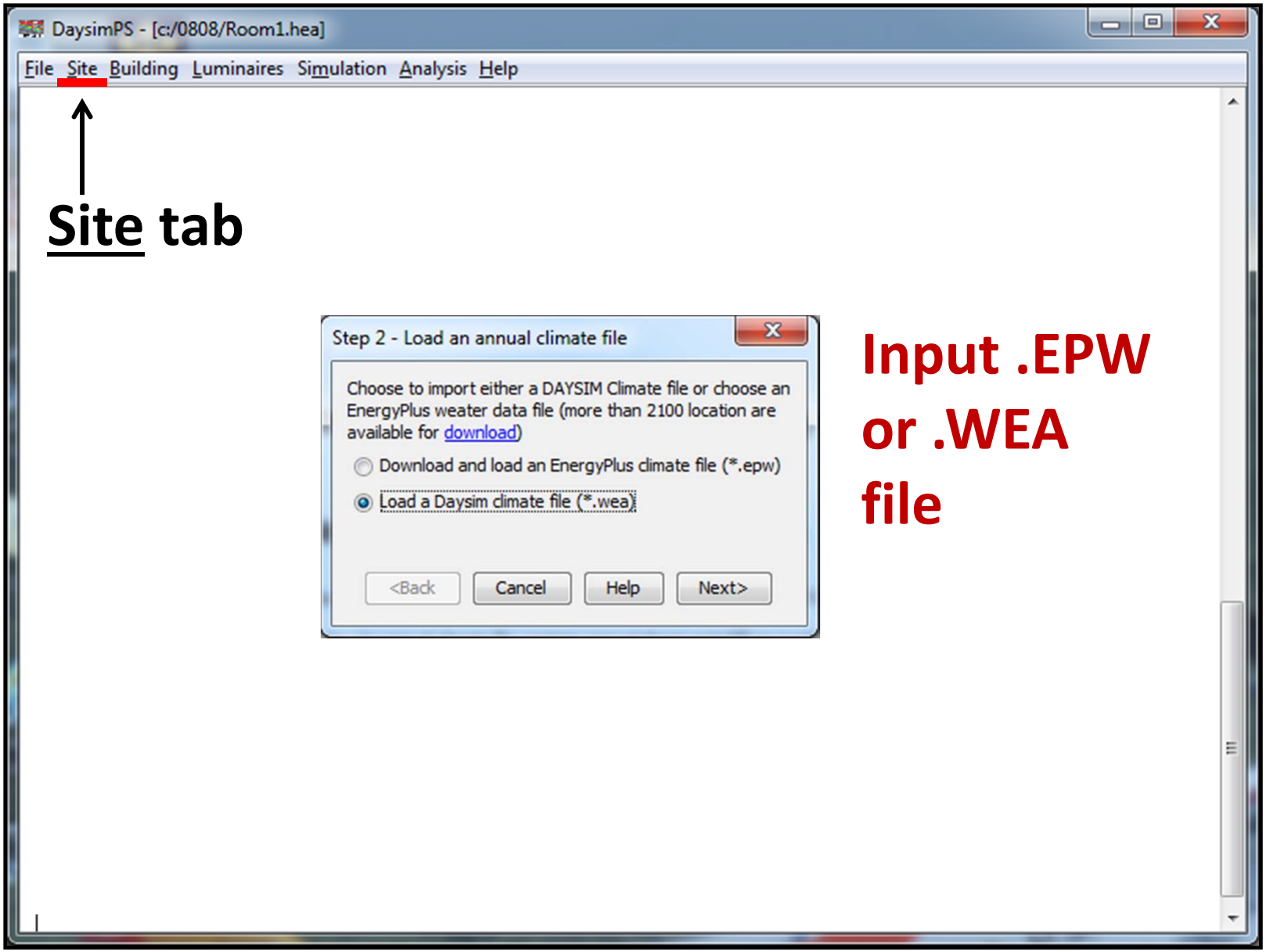
What's new in DAYSIM?

- 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.

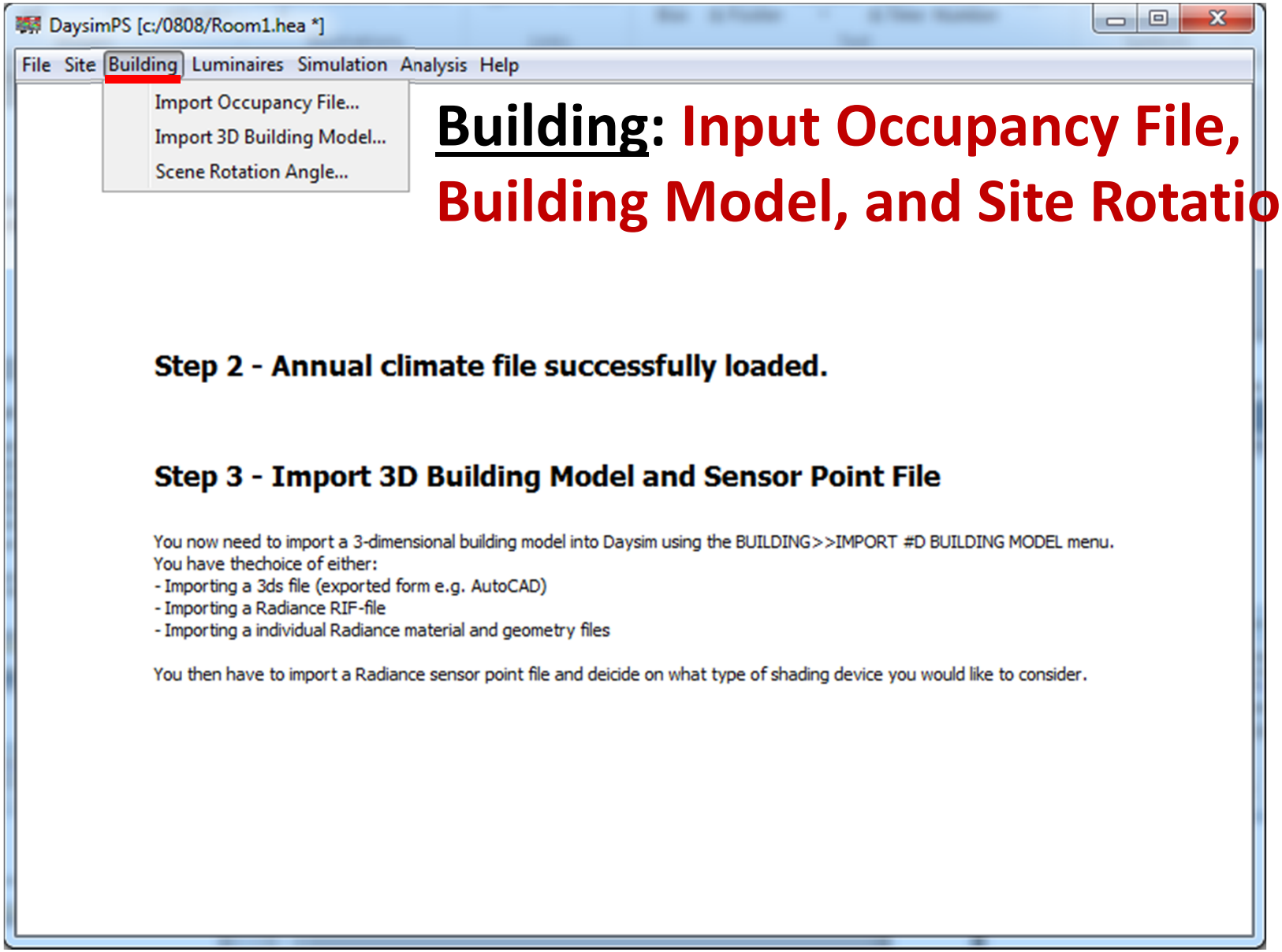
What is DAYSIMps?

- 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

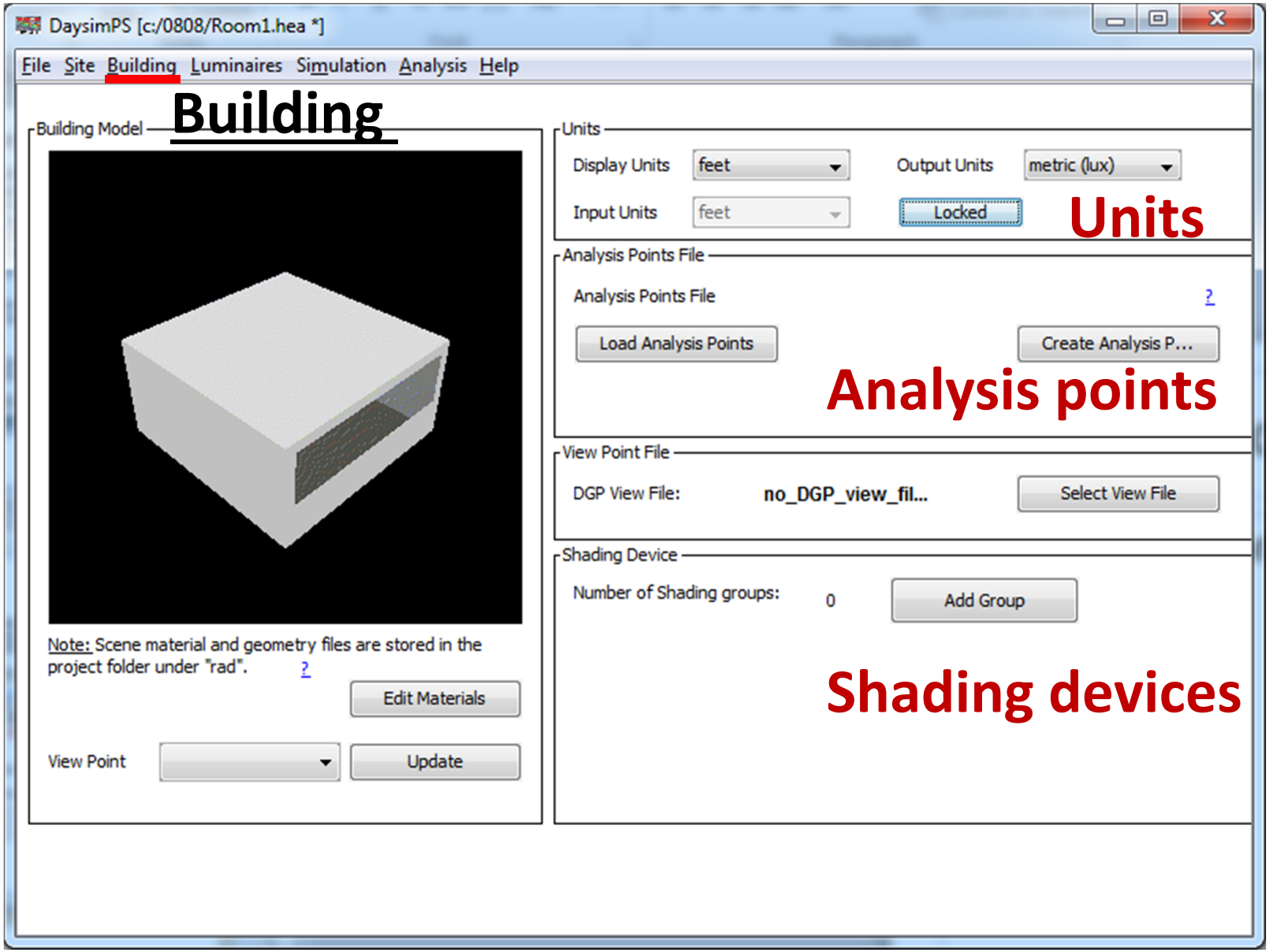


DAYSIMps GUI Input

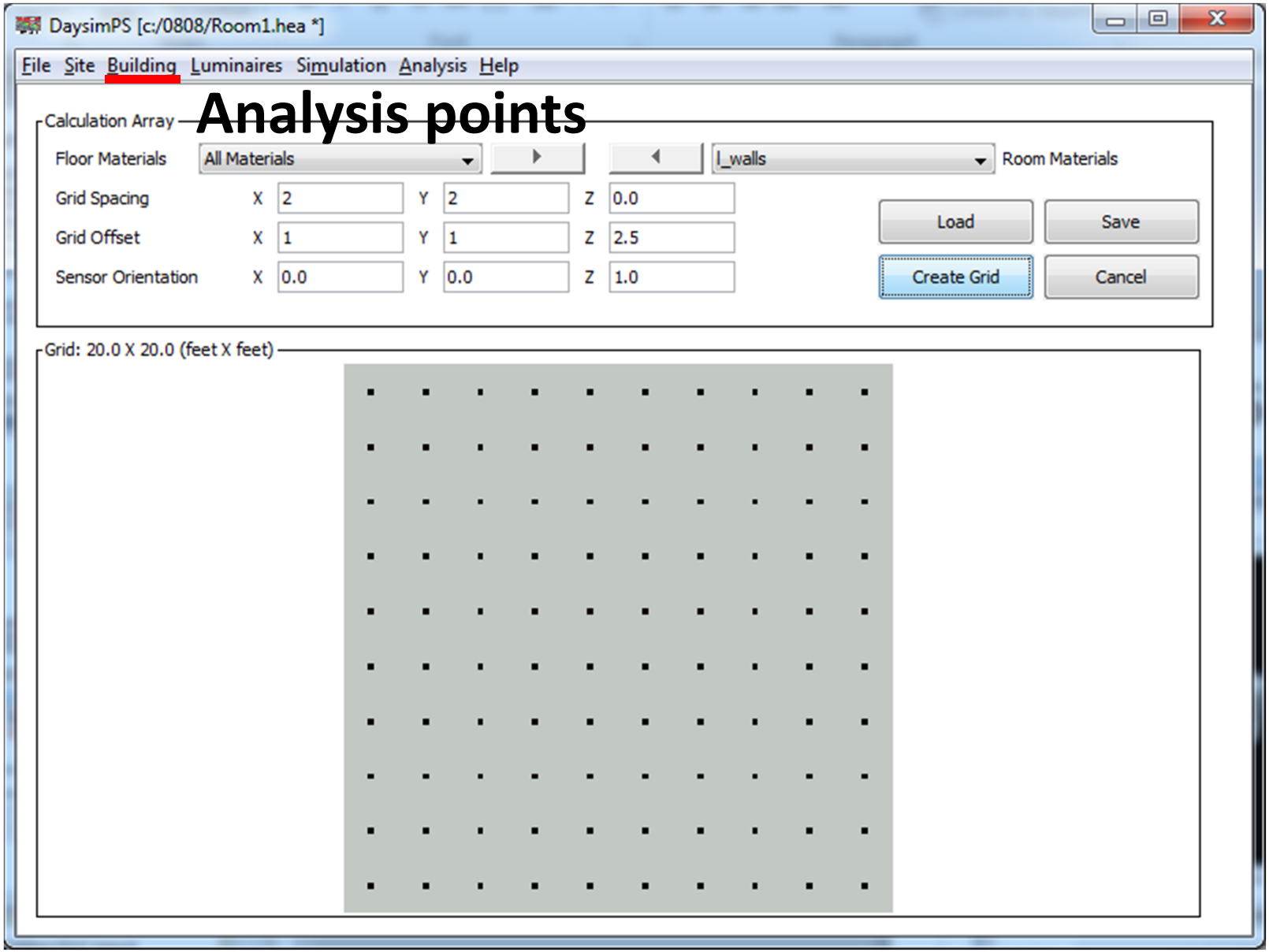


Building: Input Occupancy File, Building Model, and Site Rotation

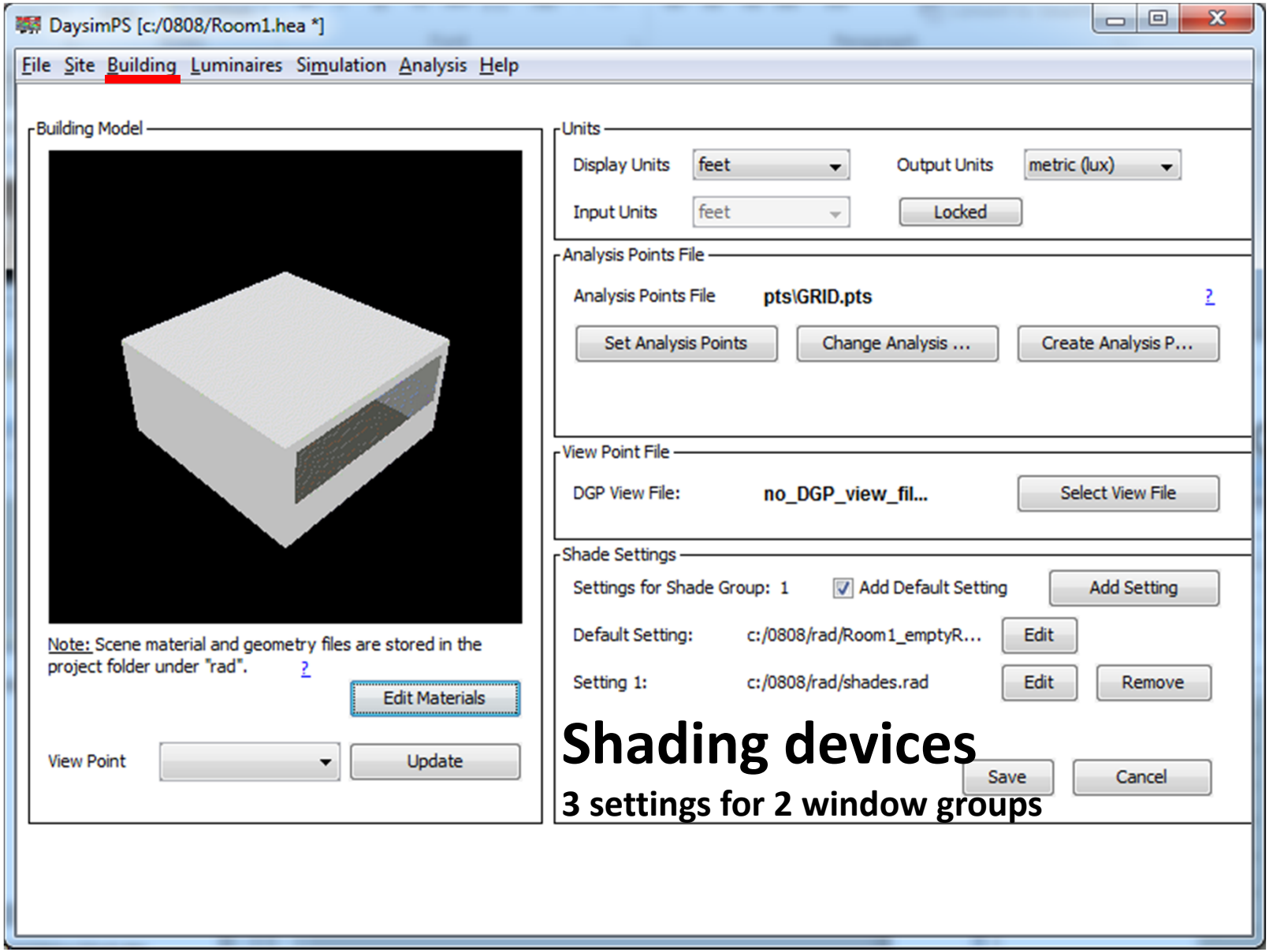
DAYSIMps GUI Input



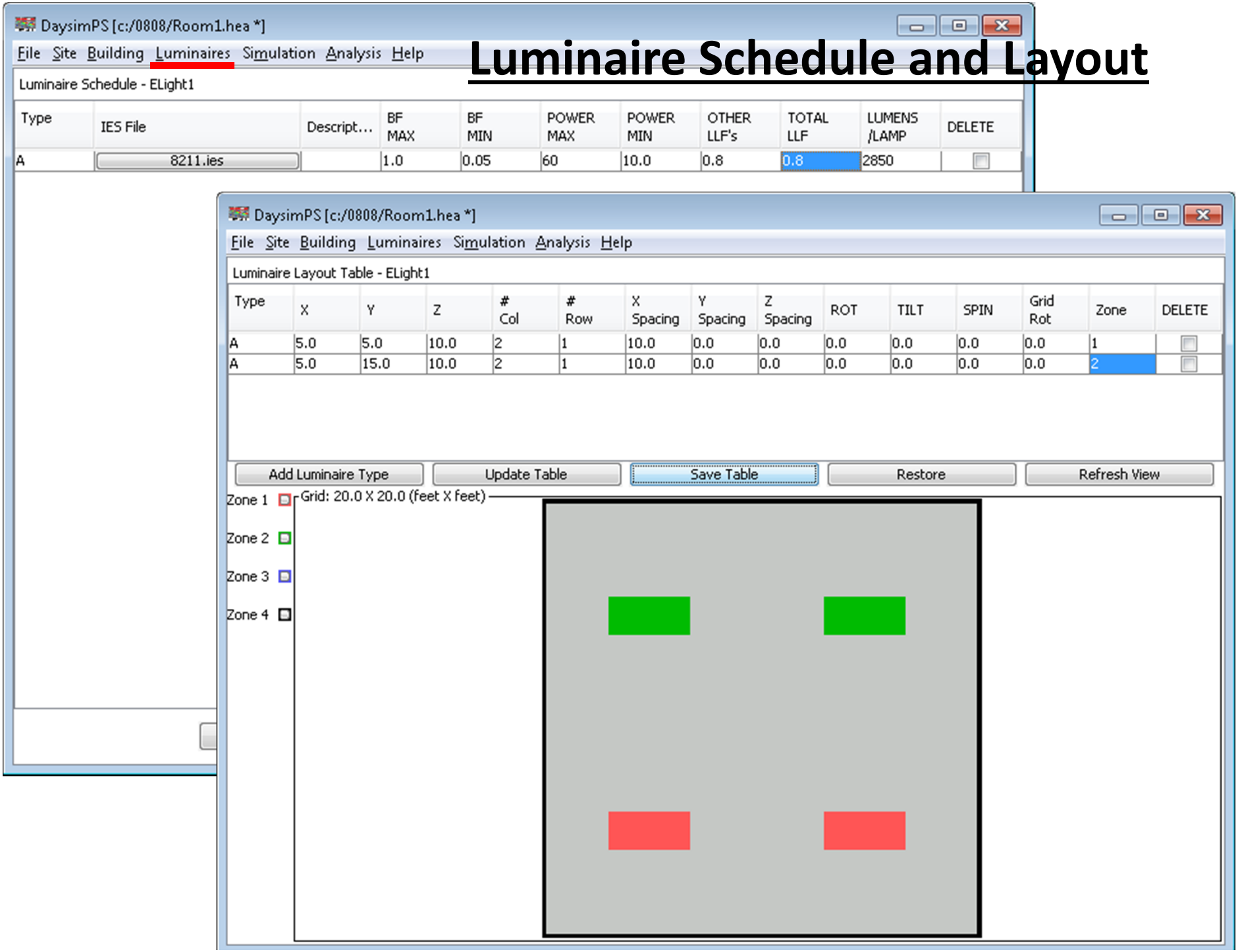
DAYSIMps GUI Input



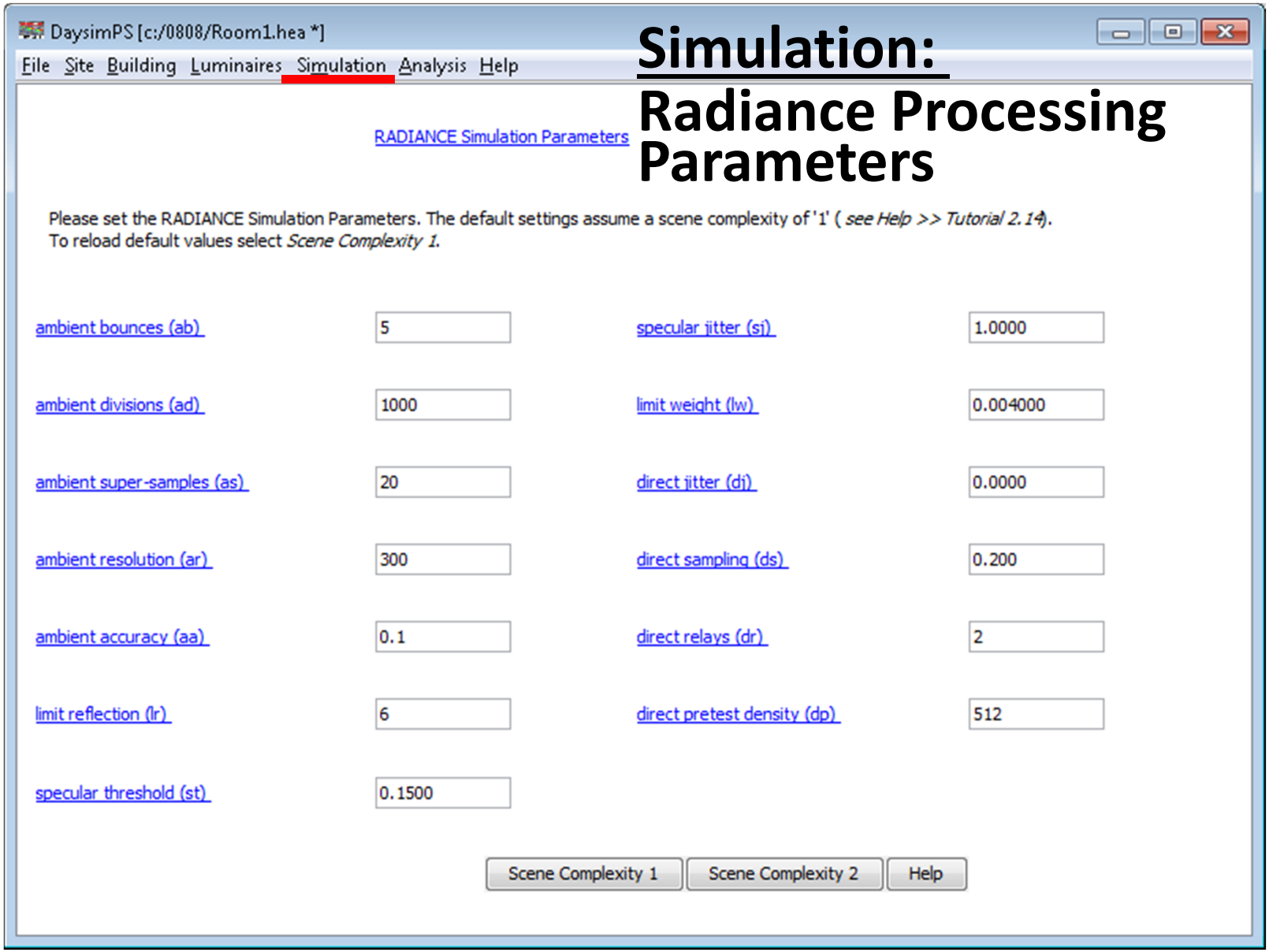
DAYSIMps GUI Input



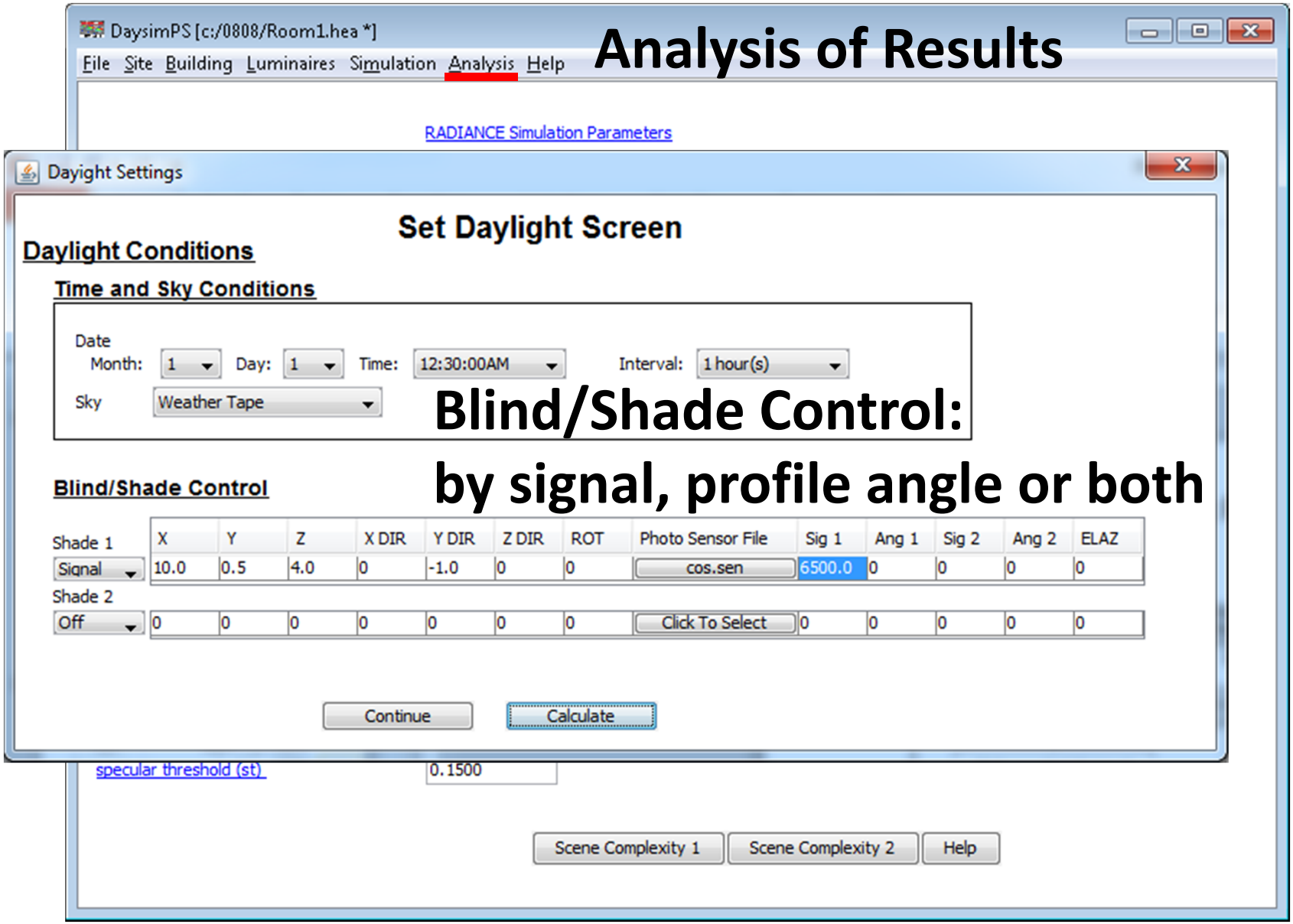
Luminaire Schedule and Layout



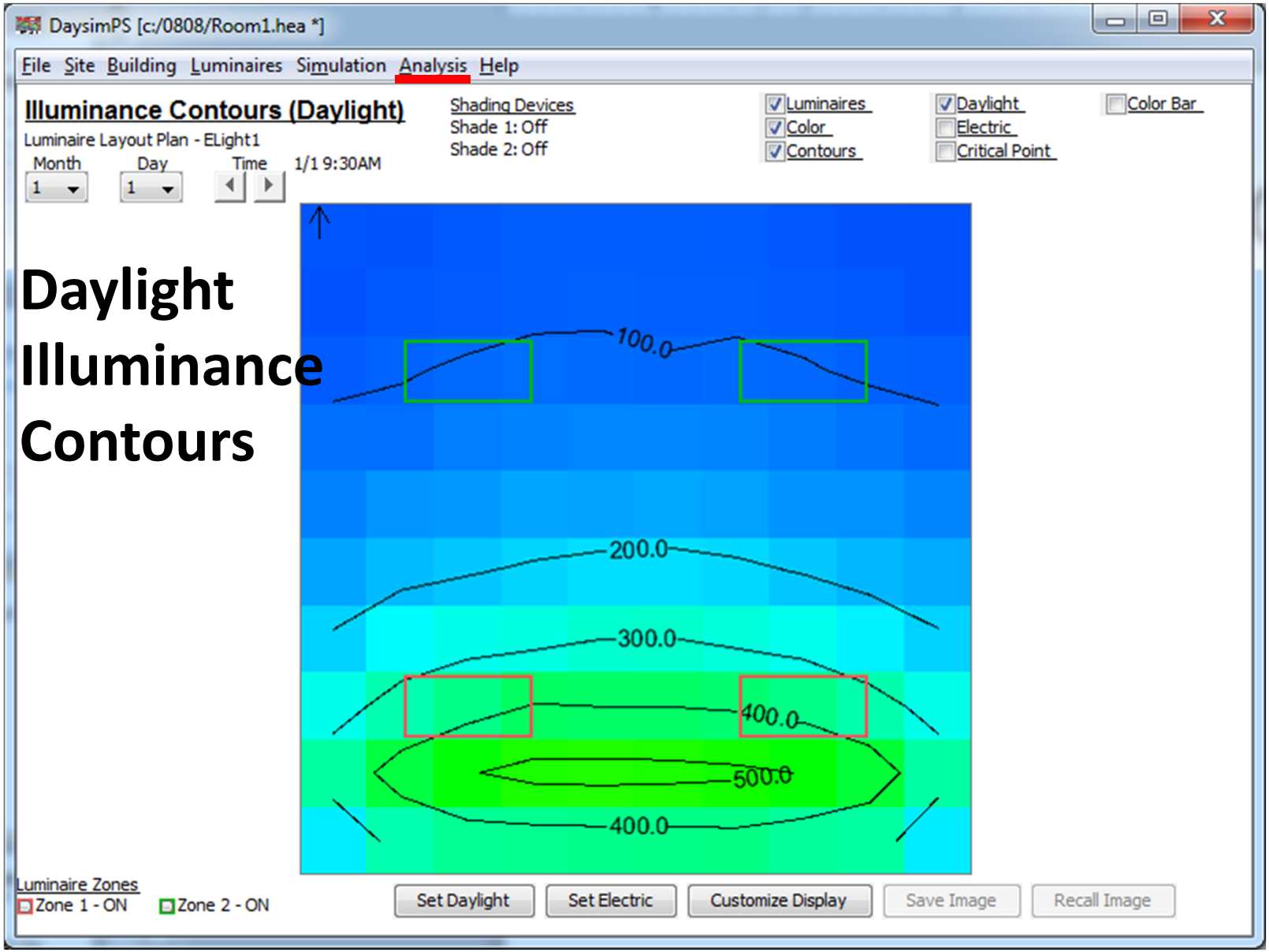
DAYSIMps GUI Input



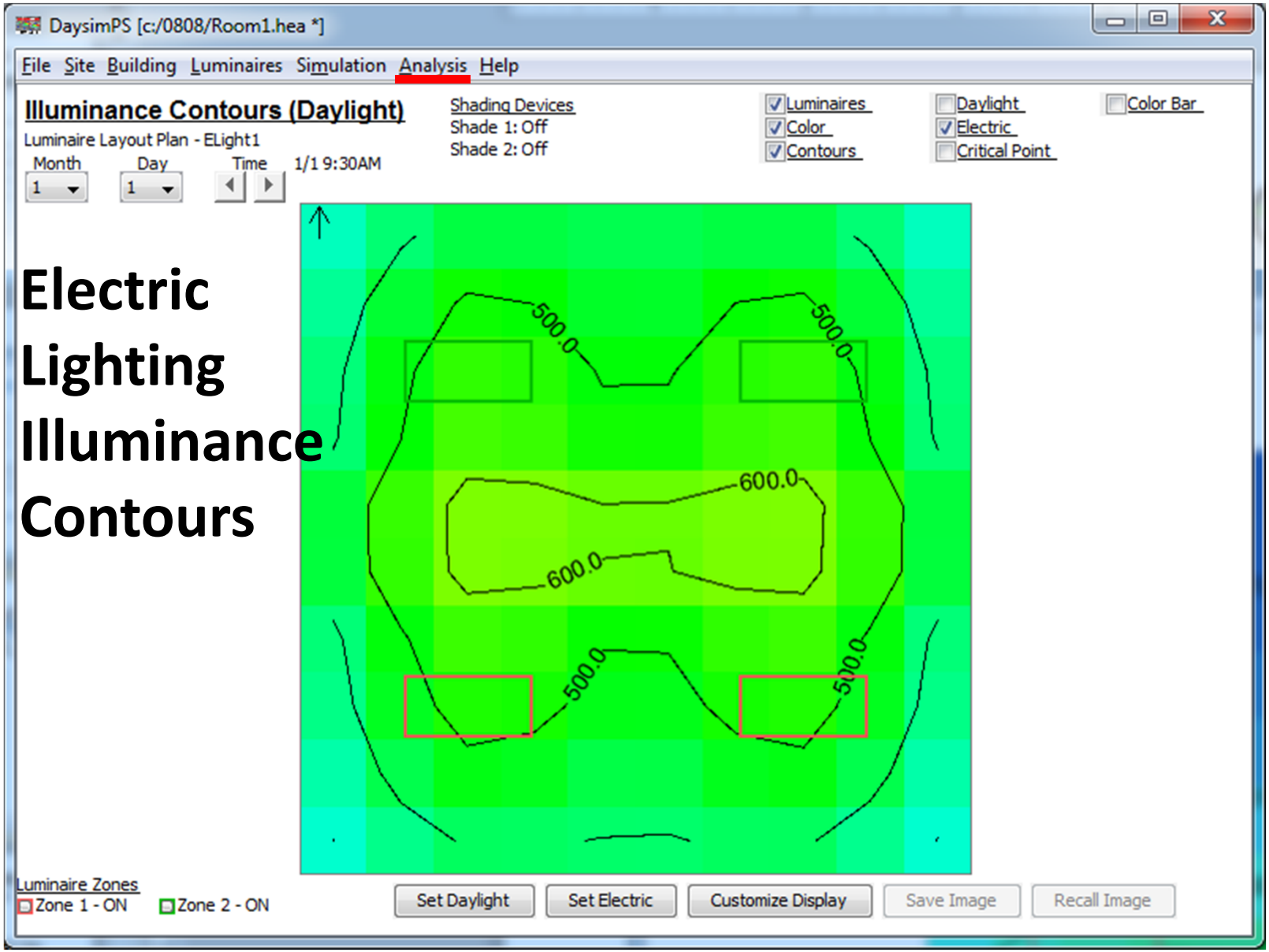
DAYSIMps GUI Input



DAYSIMps GUI Output

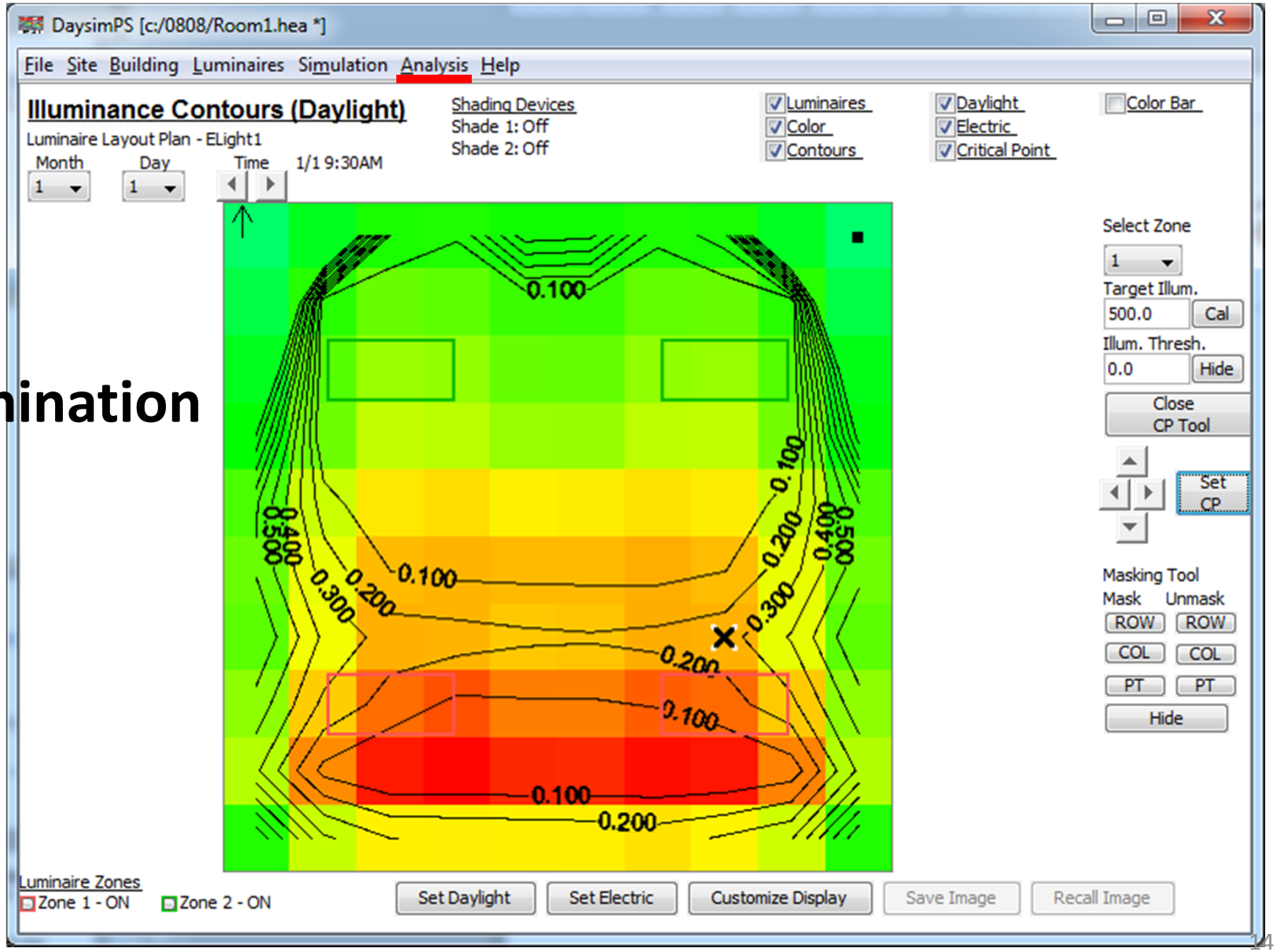


DAYSIMps GUI Output



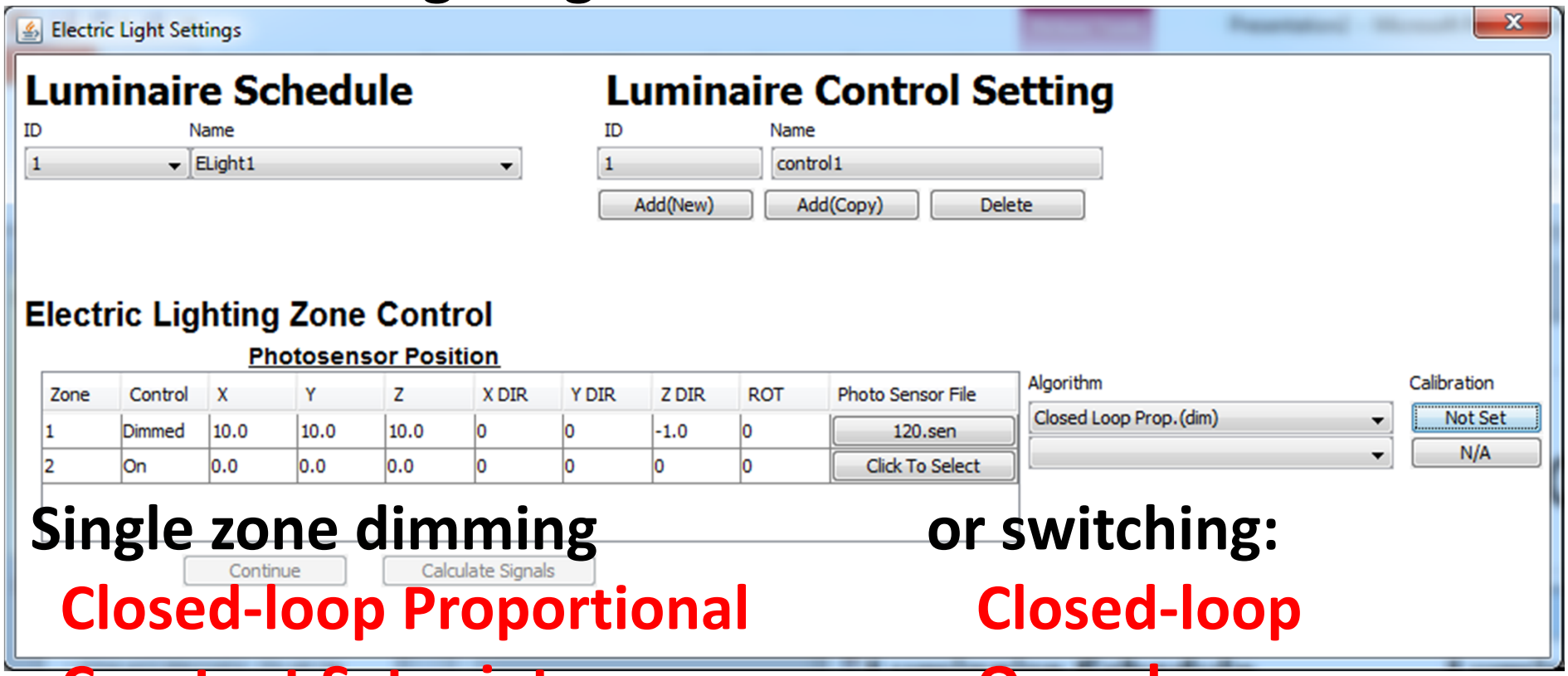
DAYSIMps GUI Output

Critical Point Determination



DAYSIMps GUI Input

Electric Lighting Zone Control



Single zone dimming

Closed-loop Proportional

Constant Setpoint

Open-loop

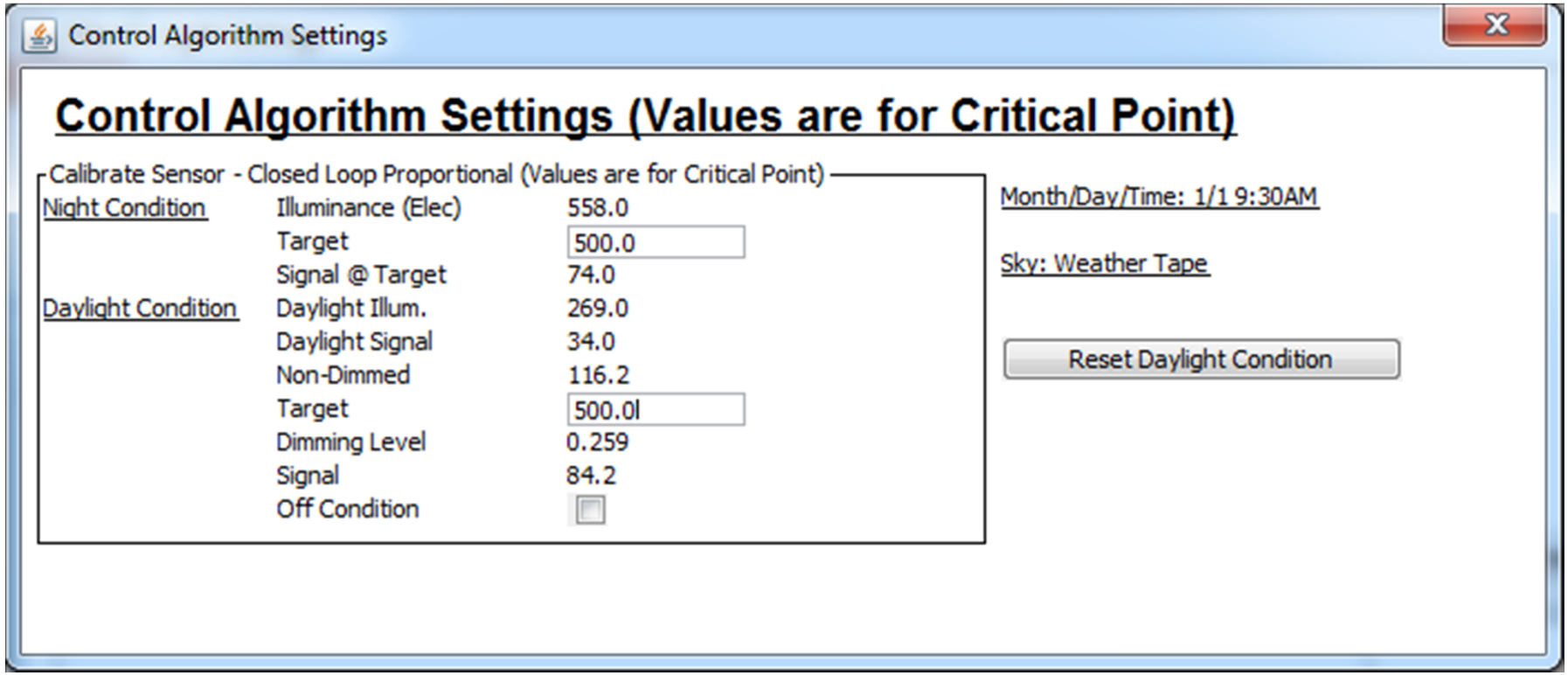
or switching:

Closed-loop

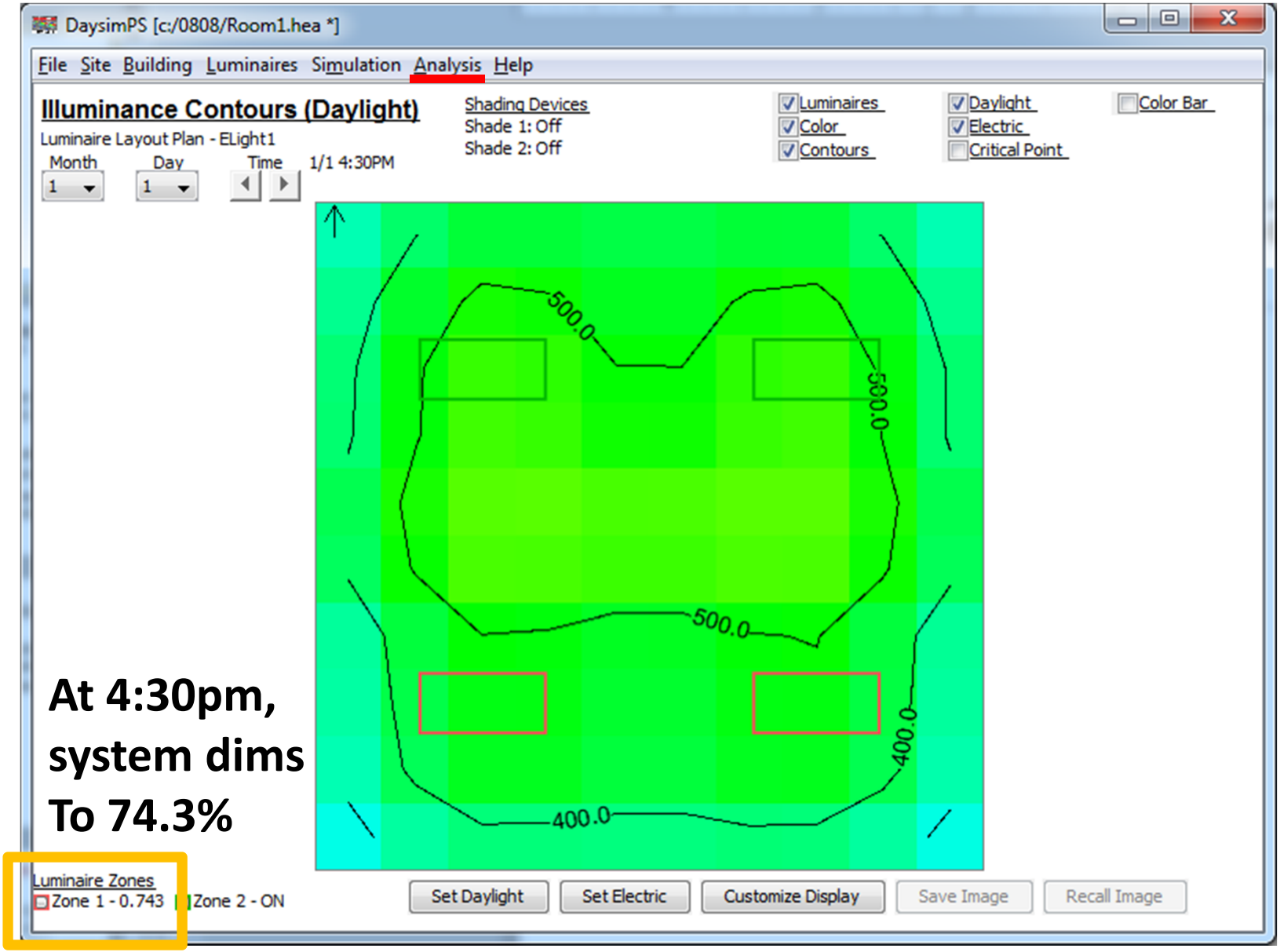
Open-loop

DAYSIMps GUI Input

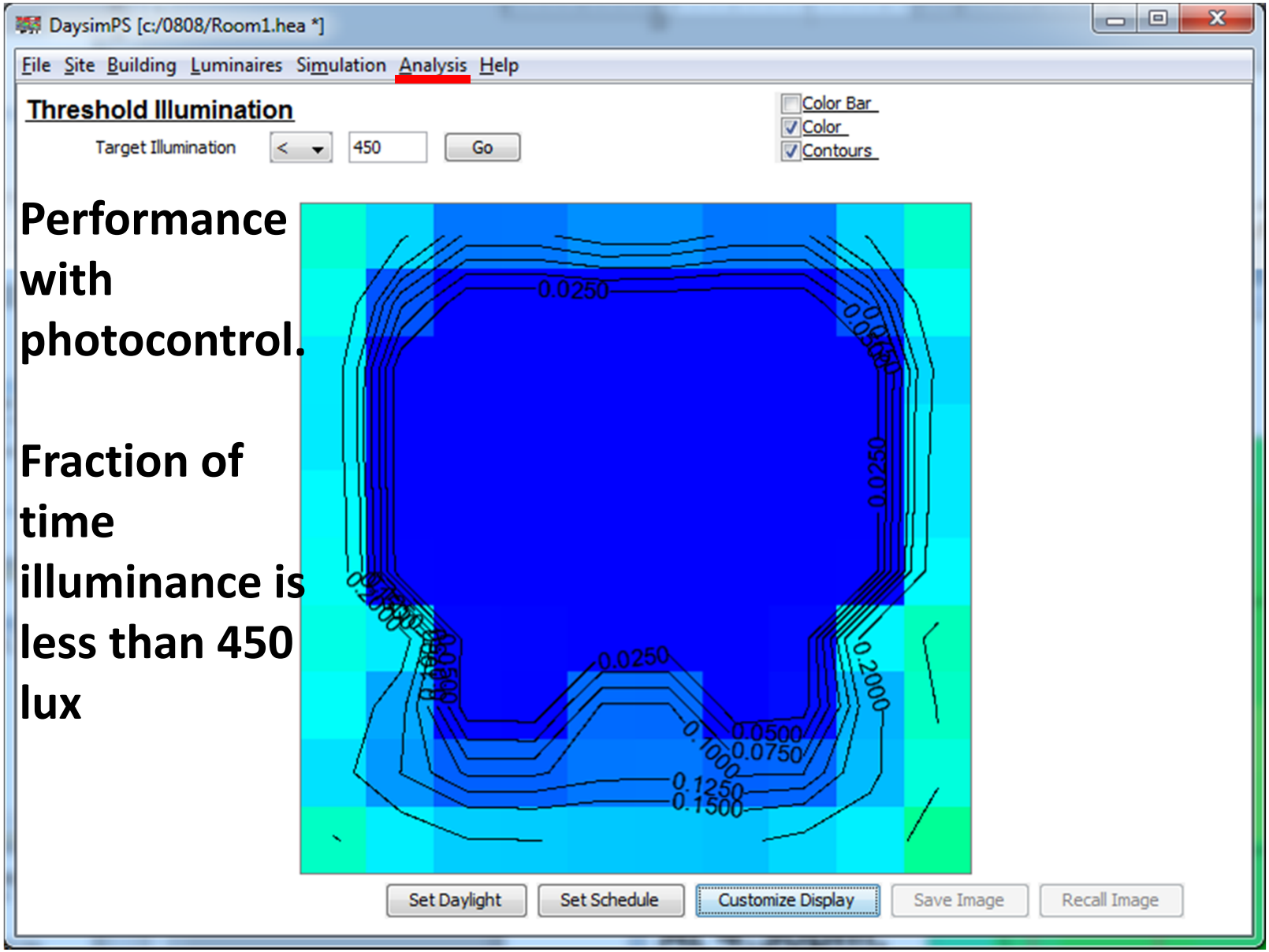
Control Algorithm Calibration at a Selected Time



DAYSIMps GUI Output



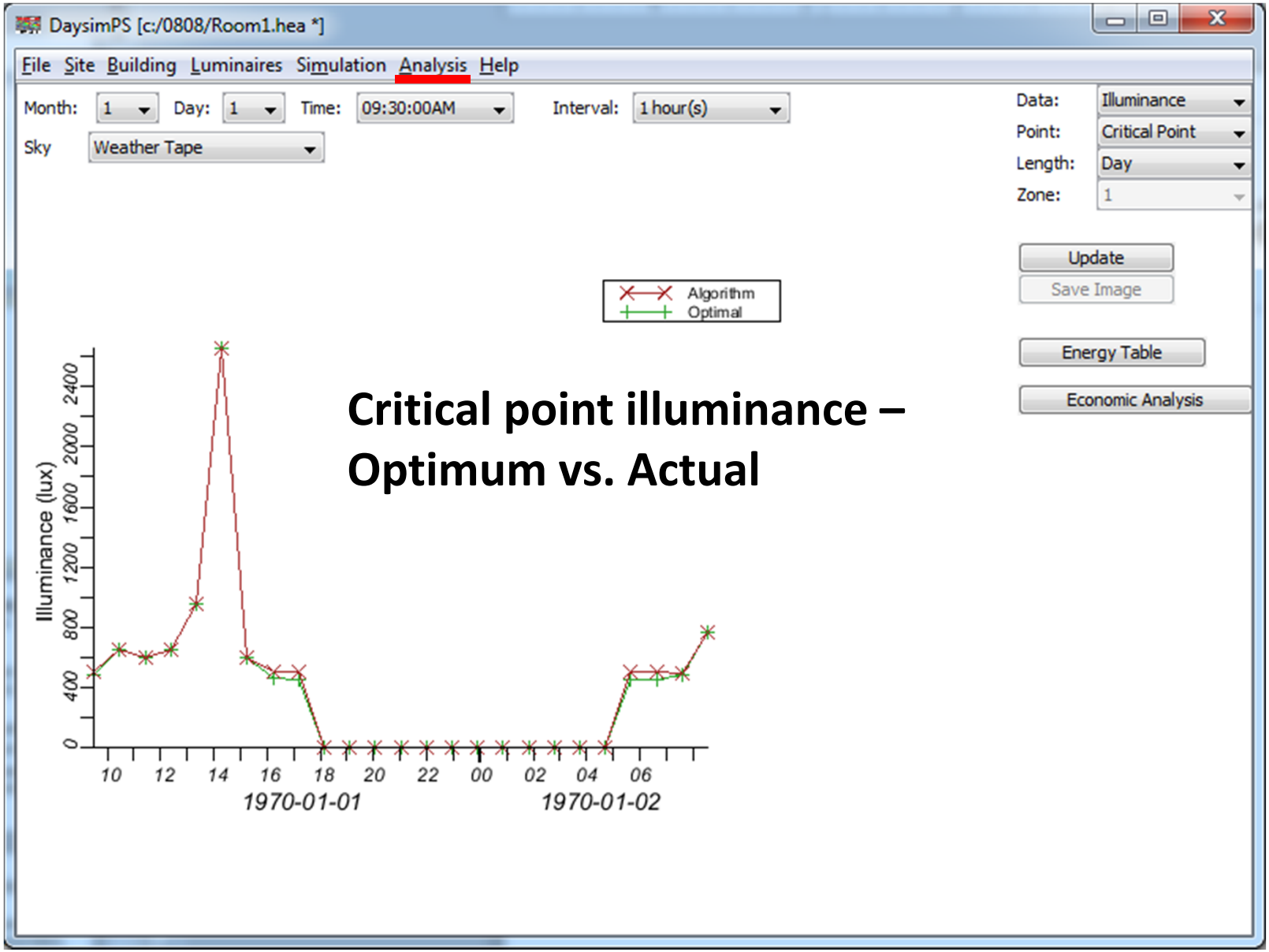
DAYSIMps GUI Output



Performance with photocontrol.

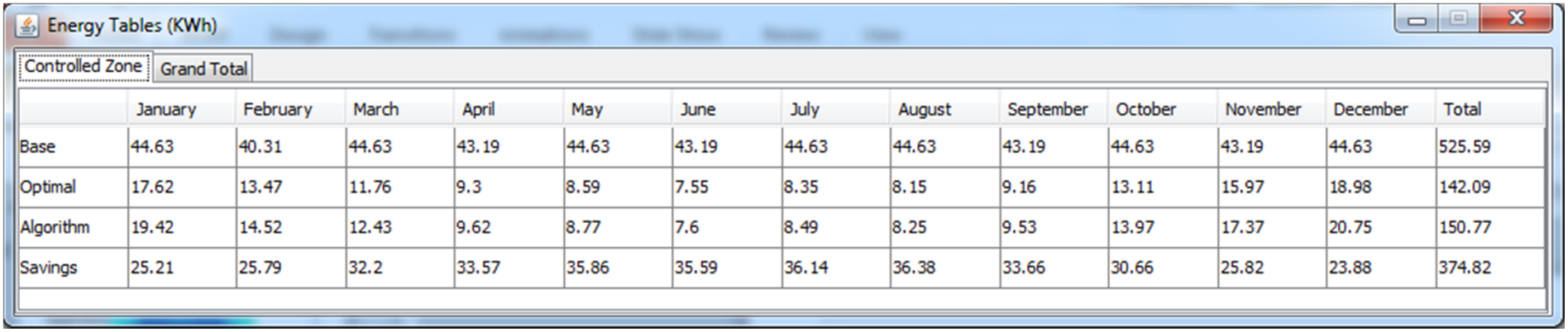
Fraction of time illuminance is less than 450 lux

DAYSIMps GUI Output



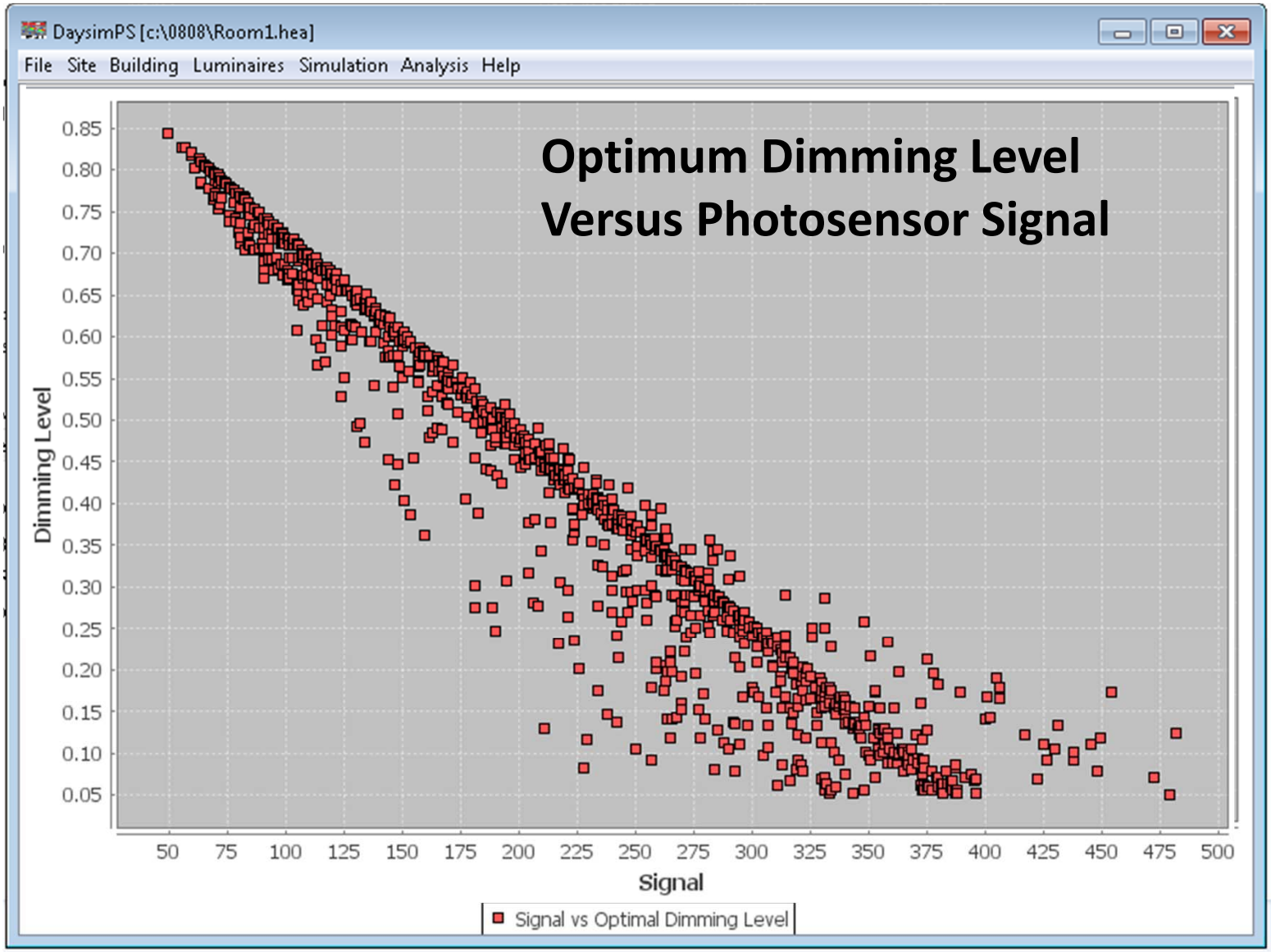
DAYSIMps GUI Output

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



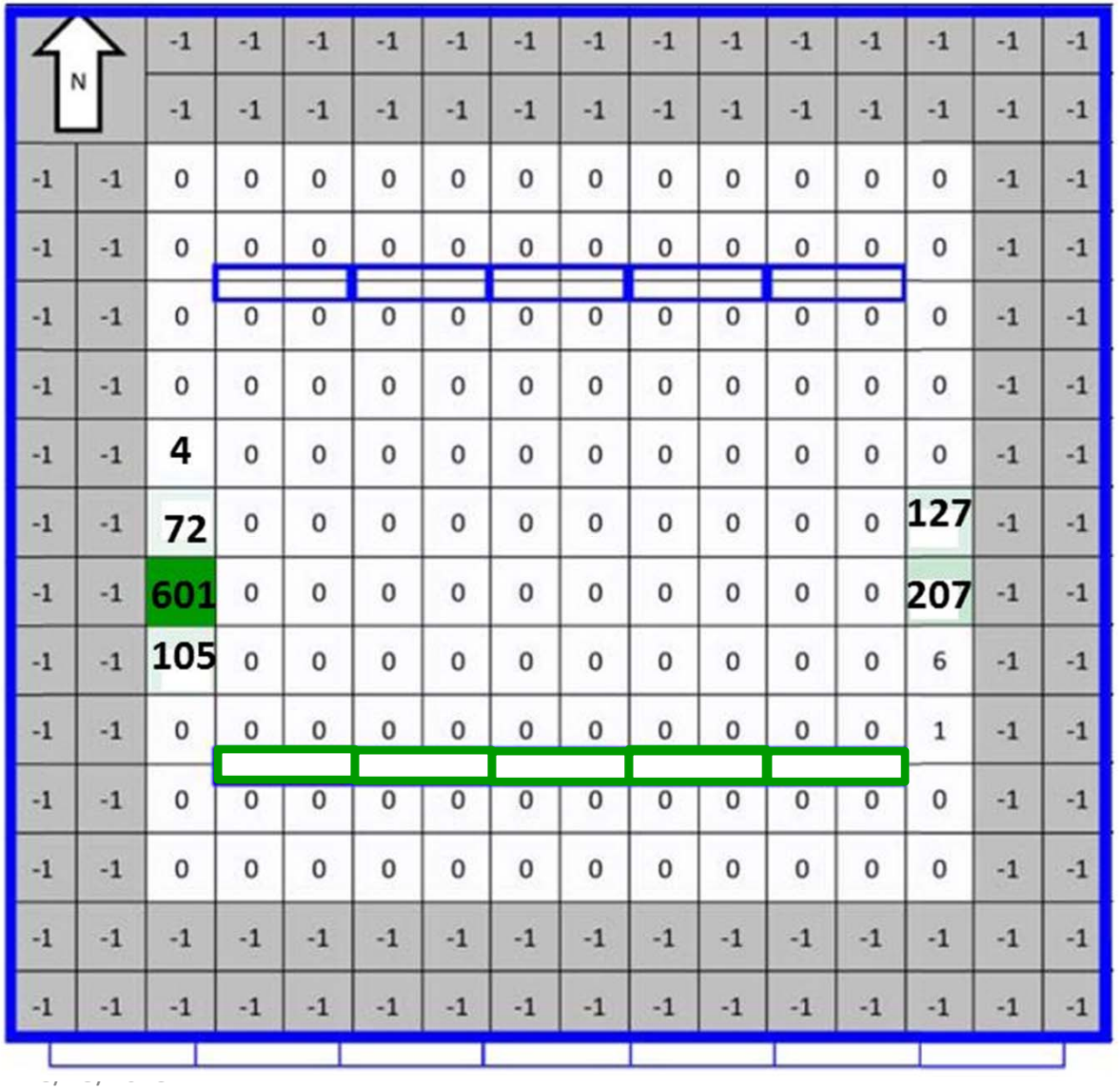
New DAYSIMps Modules/Capabilities

(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).

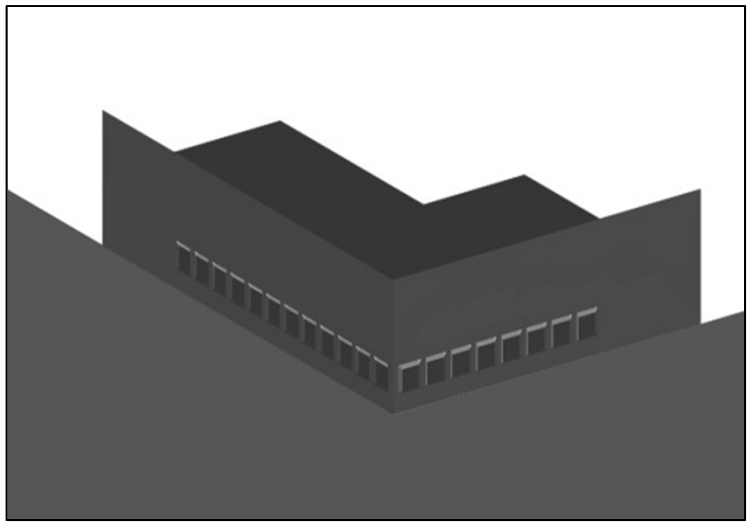
Critical Point Determination

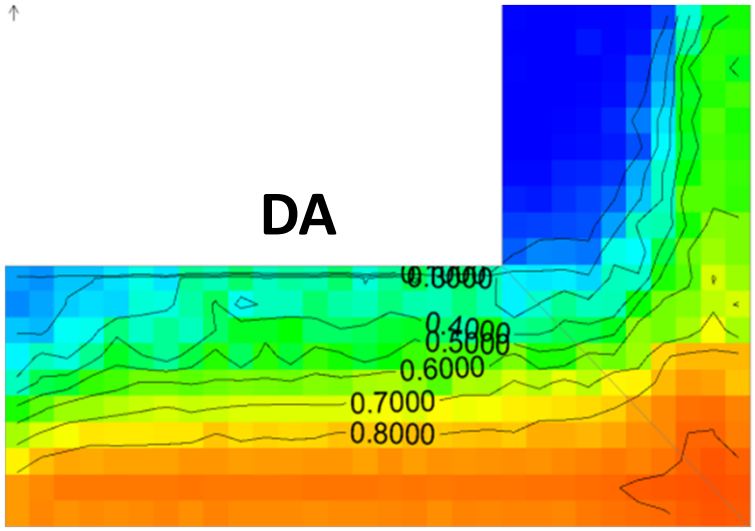
Where does the critical point lie throughout the year?

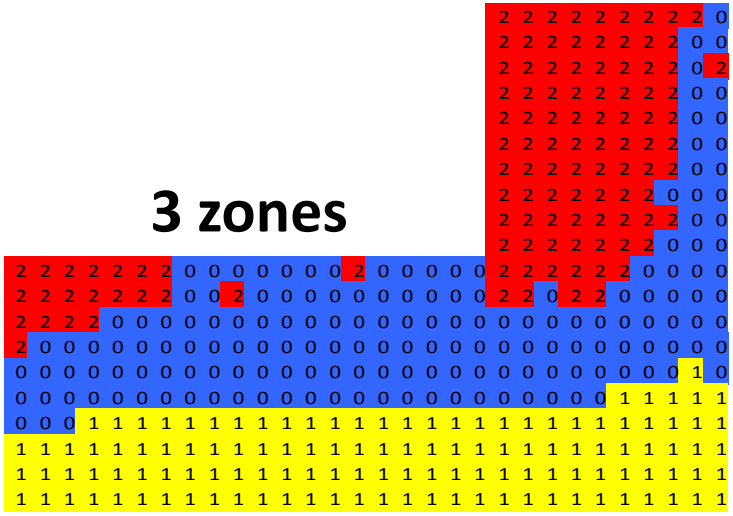


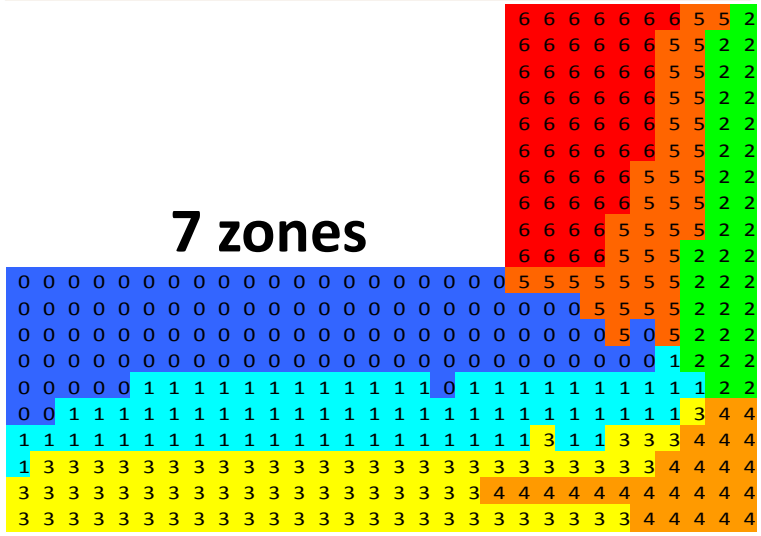
		-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
		-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1
-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1
-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1
-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1
-1	-1	4	0	0	0	0	0	0	0	0	0	0	0	-1	-1
-1	-1	72	0	0	0	0	0	0	0	0	0	0	127	-1	-1
-1	-1	601	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	6	-1	-1
-1	-1	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	-1	-1
-1	-1	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

K-Means Clustering to aid Control Zone Layout

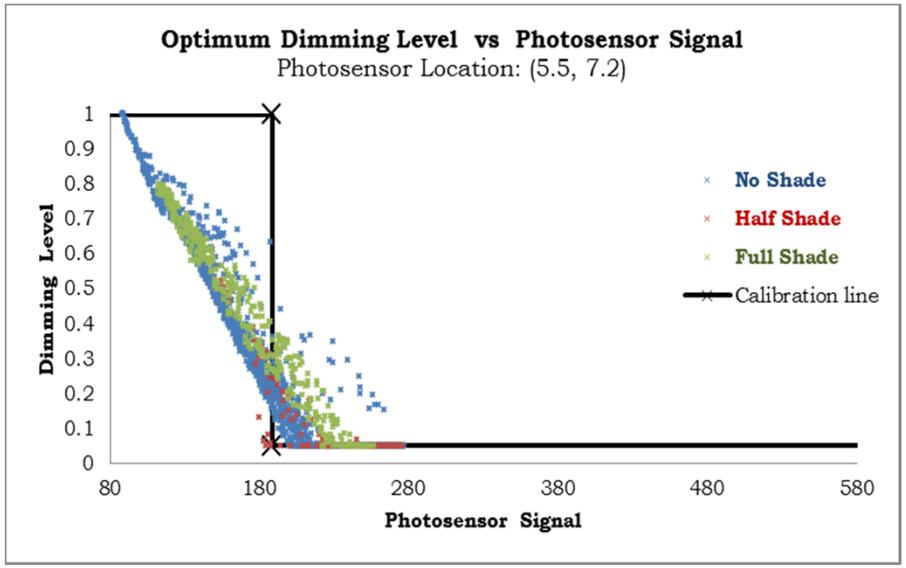
- 







Photosensor Error Relative to Optimum (RMSE)

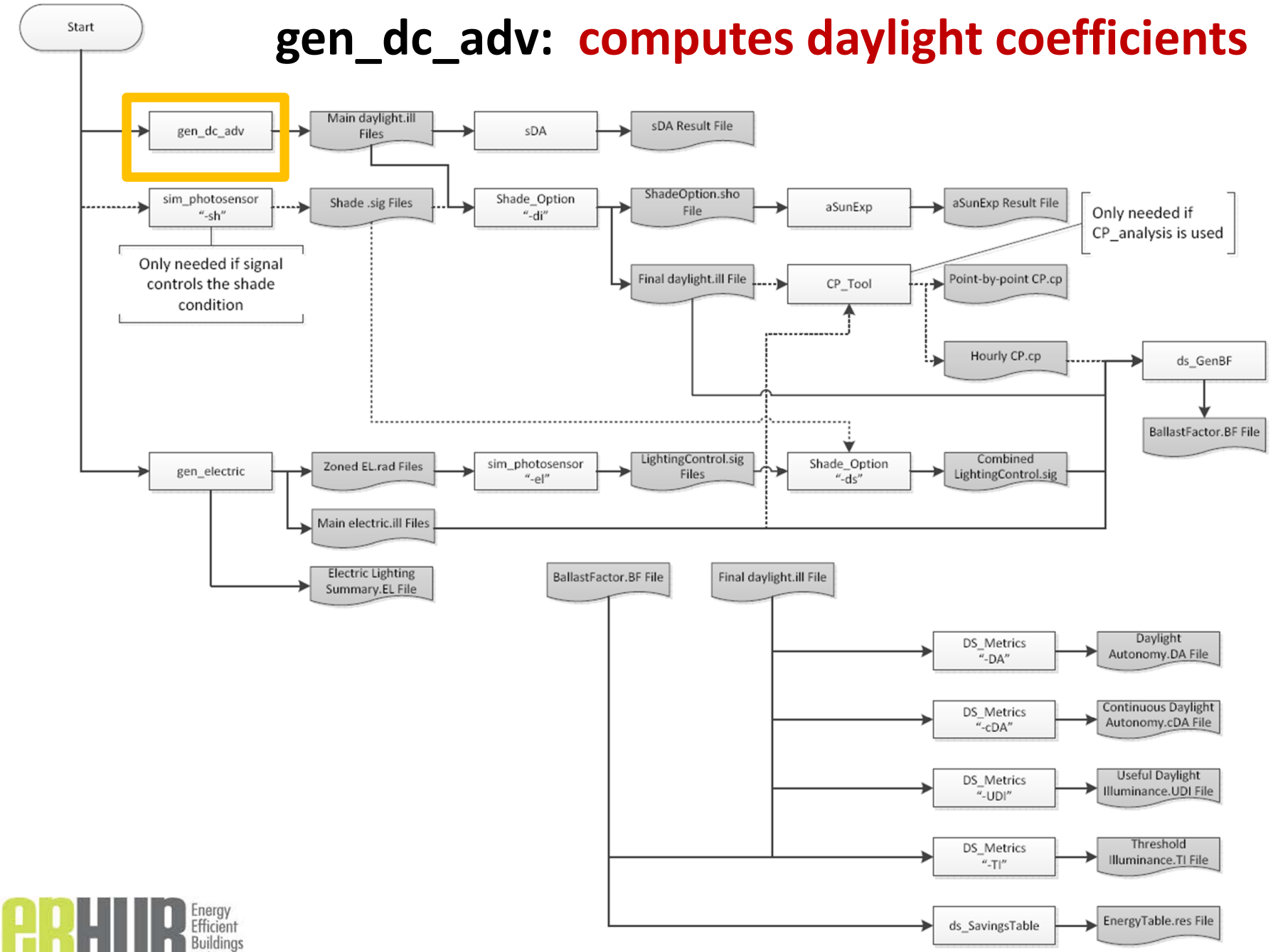


7.2m	21	21	20	21	20	21	20	21	20	21	20	20	21	22	23	23	23
6.6m	22	21	21	20	**20**	**20**	20	**20**	**19**	**19**	**19**	20	21	23	24	25	24
5.9m	21	21	21	20	20	20	**19**	22	**19**	**19**	20	20	22	23	24	26	28
5.3m	22	21	21	21	21	20	22	**20**	20	21	22	23	22	25	28	31	32
4.7m	22	21	20	21	23	21	23	22	22	22	21	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



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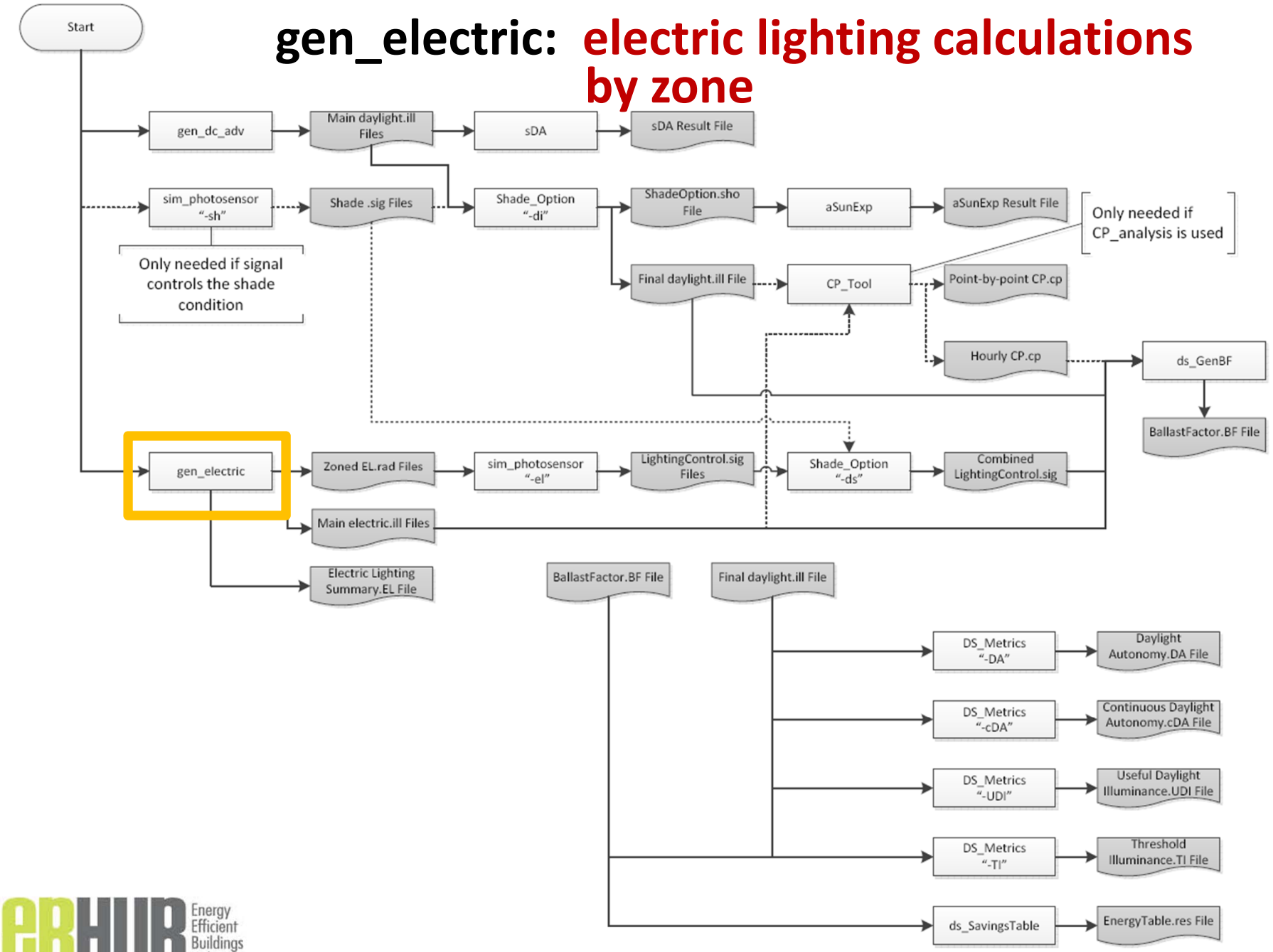
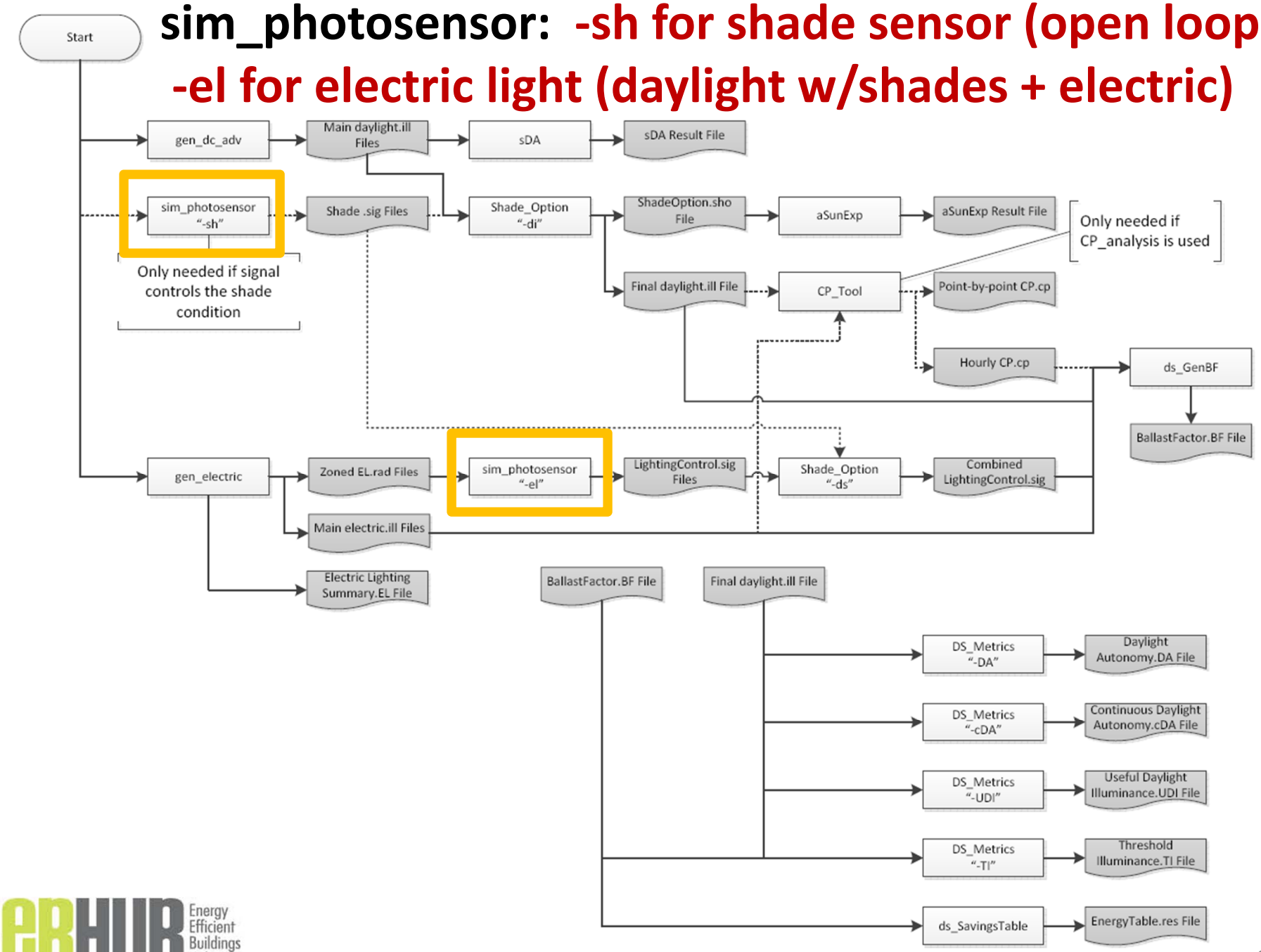
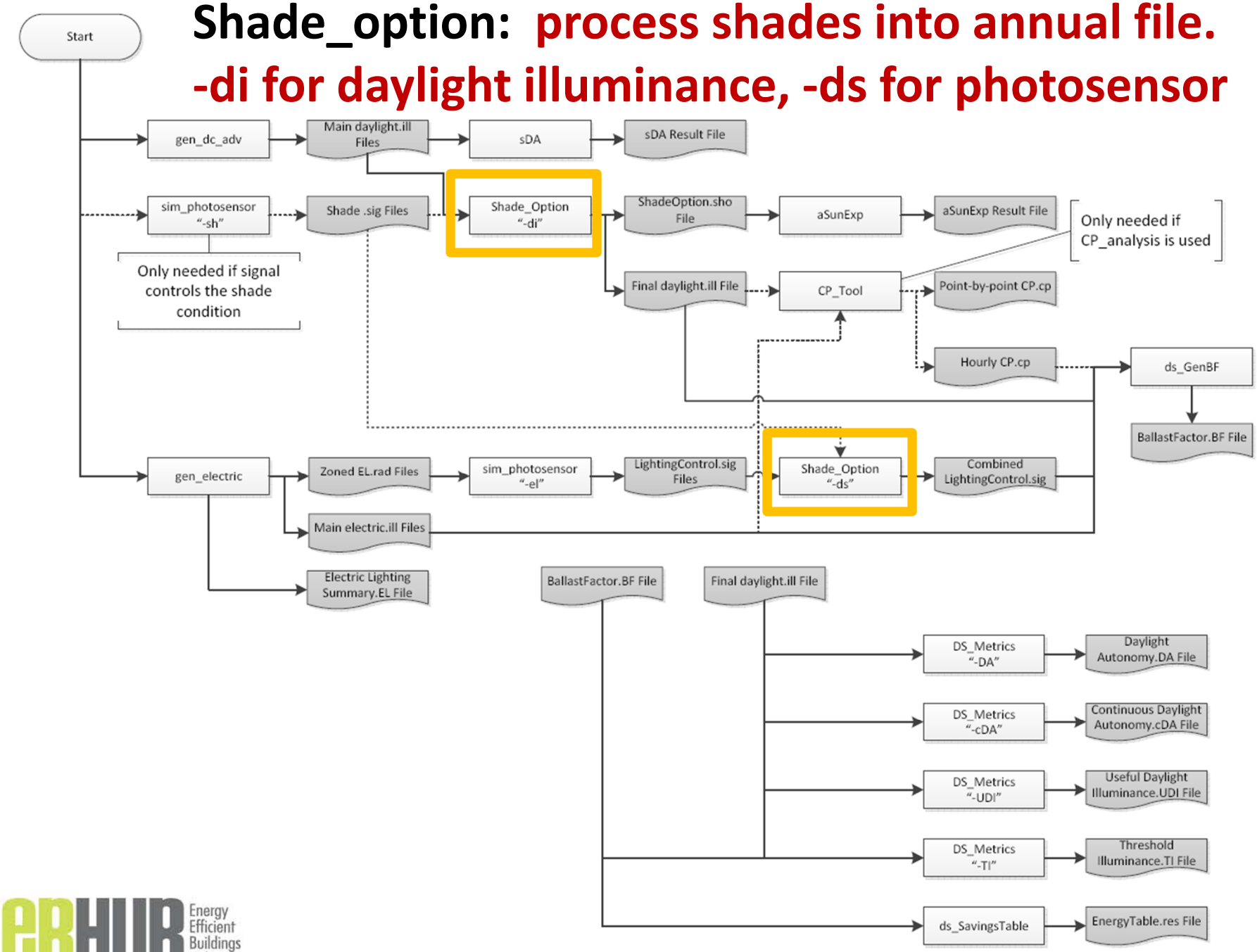
gen_electric: electric lighting calculations by zone



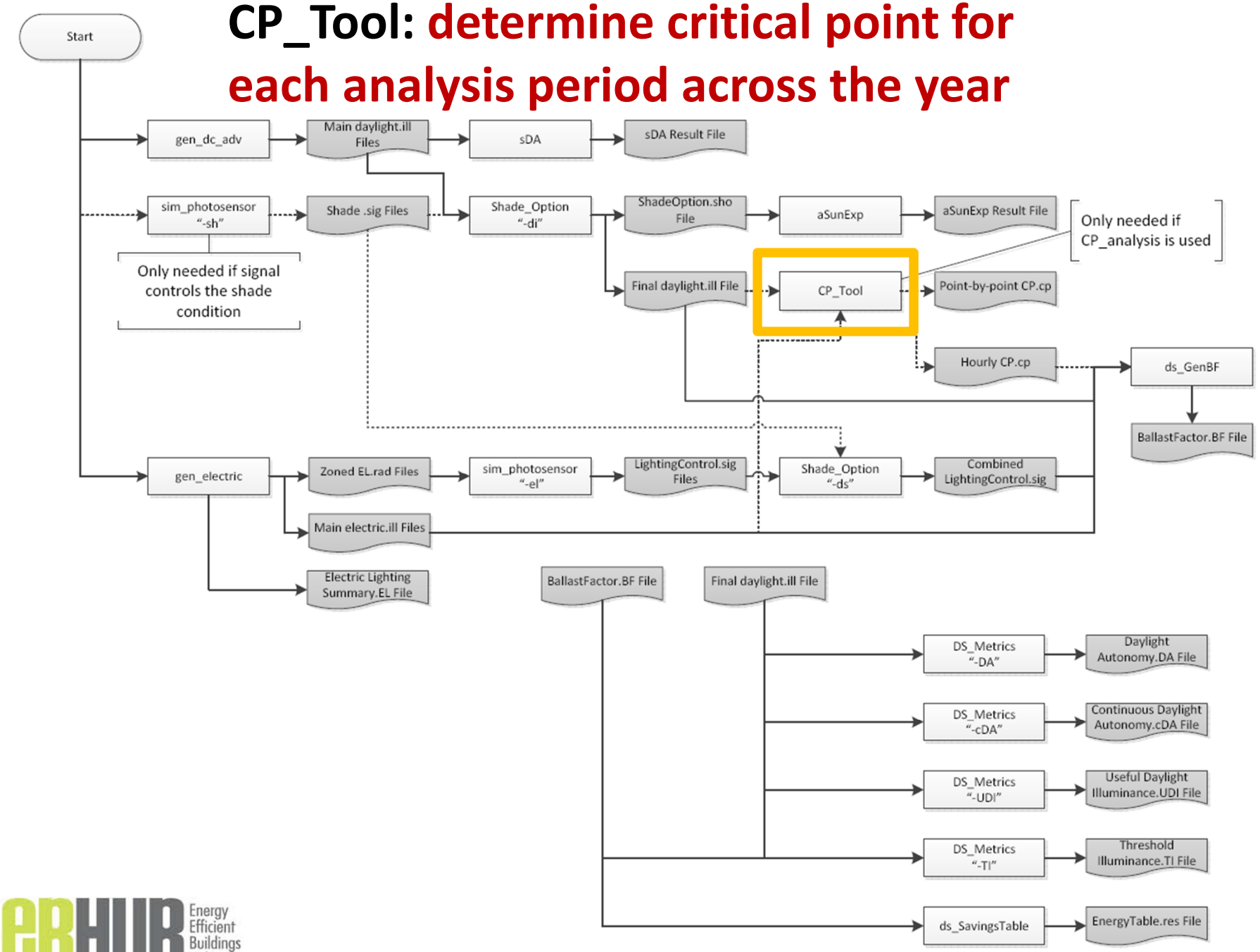
sim_photosensor: -sh for shade sensor (open loop) -el for electric light (daylight w/shades + electric)



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



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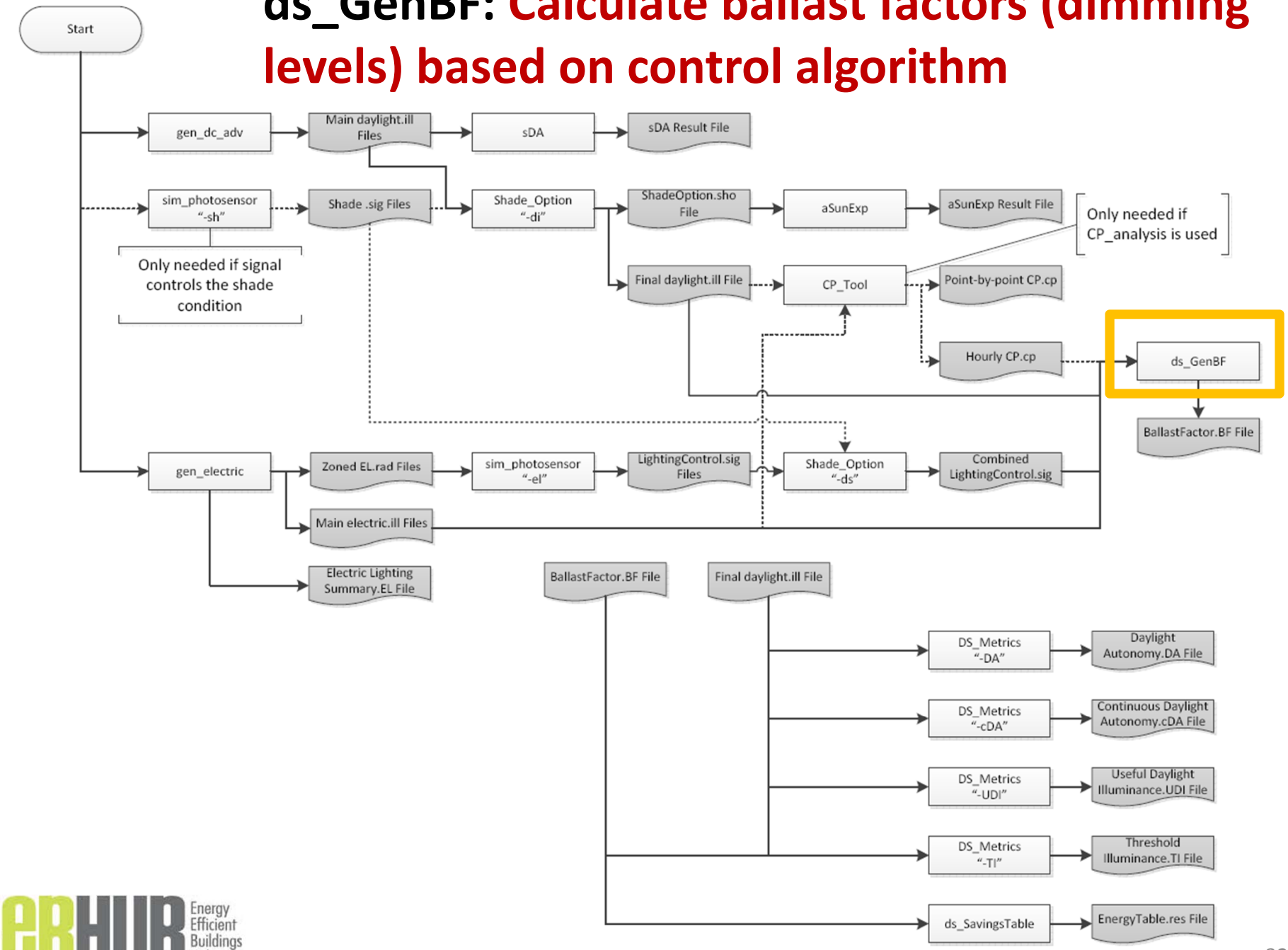
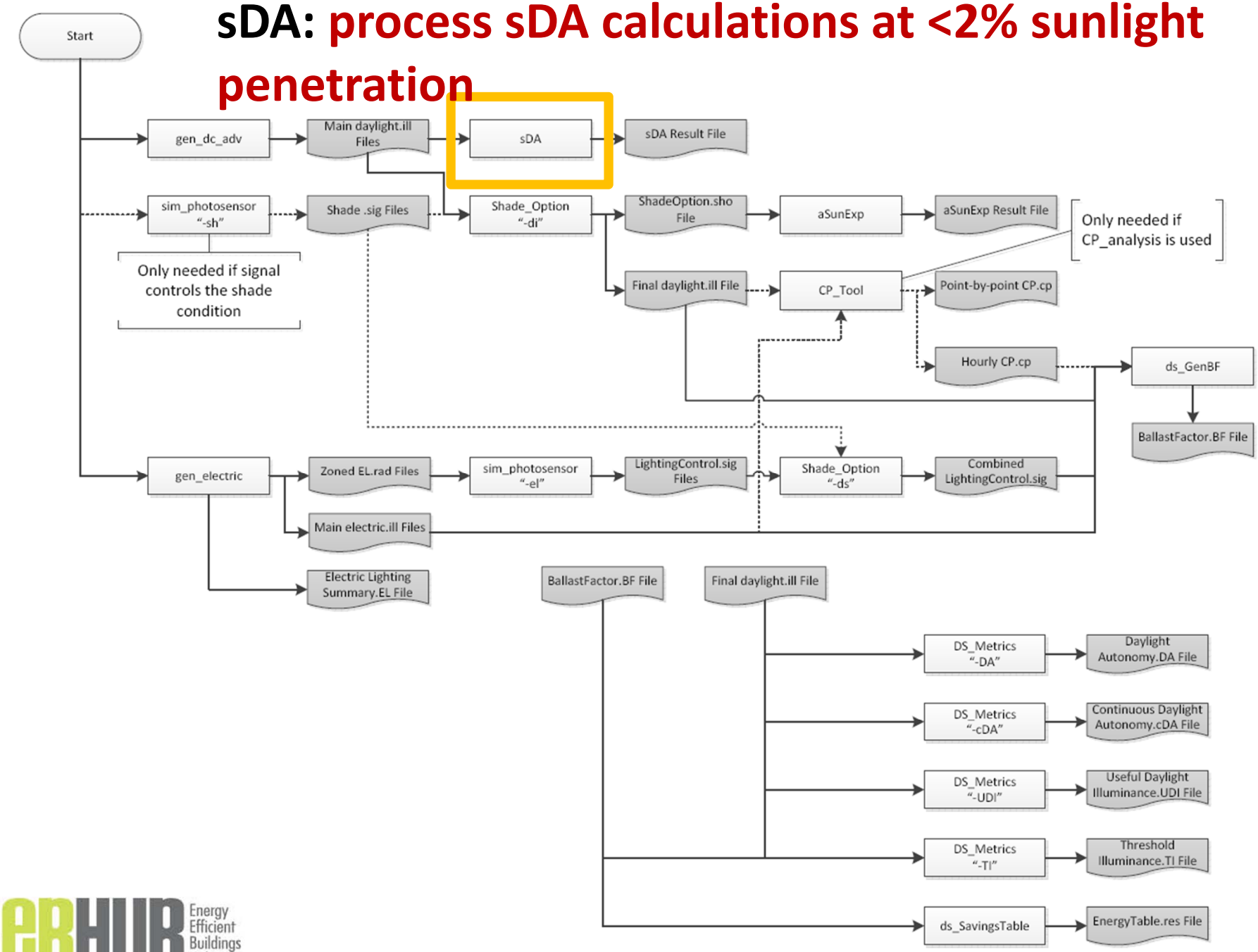
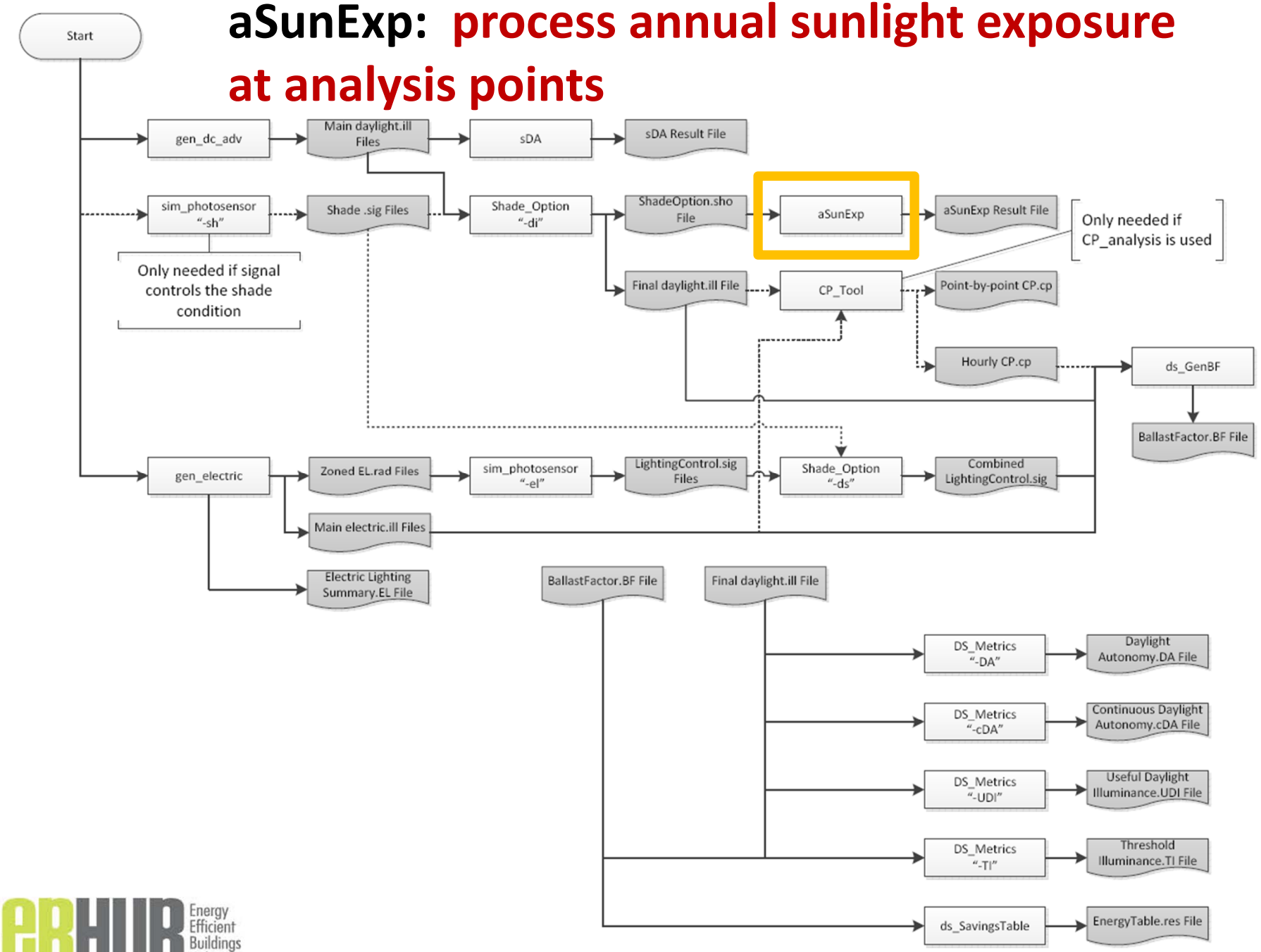
ds_GenBF: Calculate ballast factors (dimming levels) based on control algorithm



sDA: process sDA calculations at <2% sunlight penetration



aSunExp: process annual sunlight exposure at analysis points



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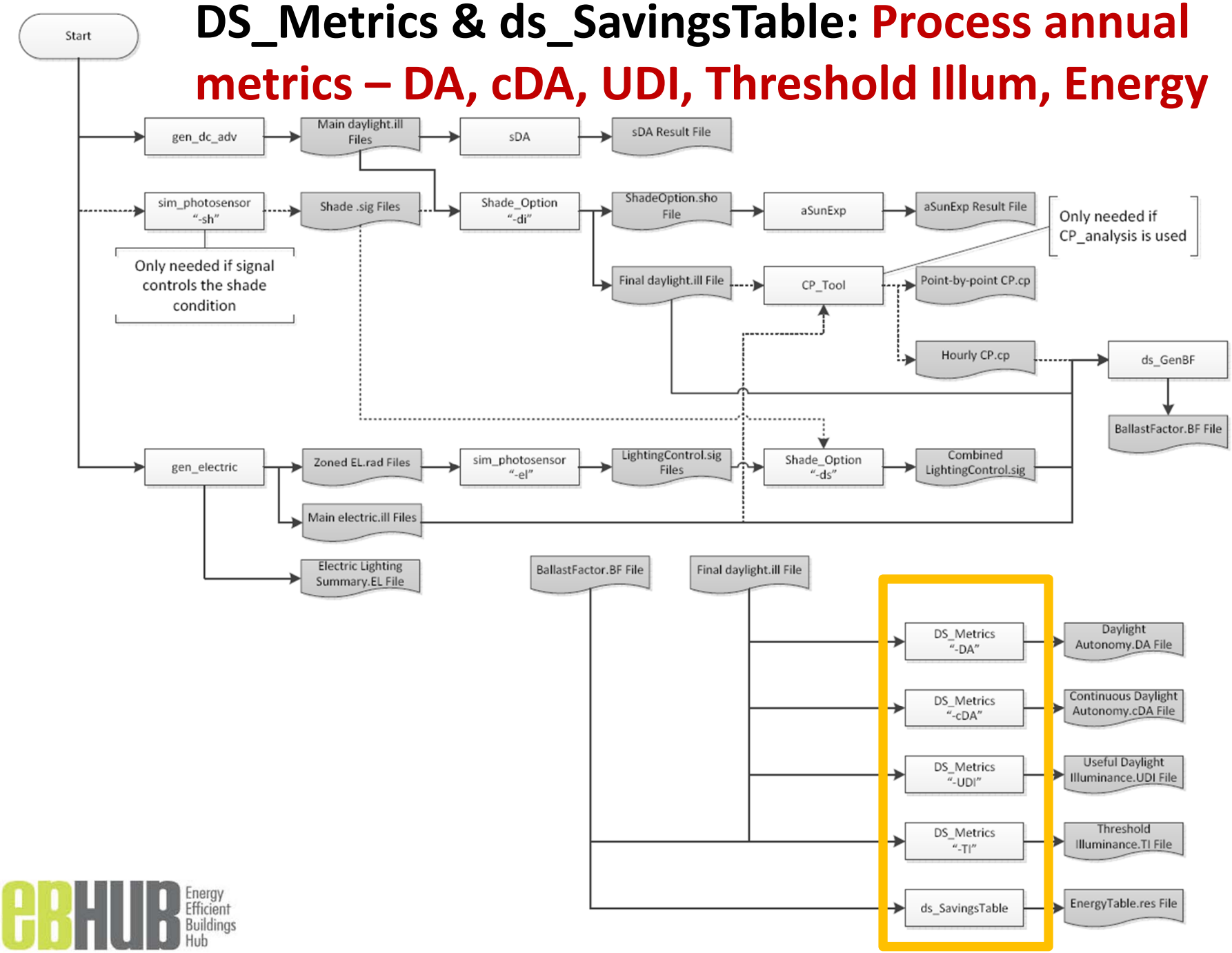
DS_Metrics & ds_SavingsTable: Process annual metrics – DA, cDA, UDI, Threshold Illum, Energy



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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.