IESVE
Trial Support Material

www.iesve.com

RadianceIES
Sensors for CBDM/ Daylight Simulation Metrics

RadianceIES Sensors for CBDM/ Daylight Simulation Metrics

Sensor Settings

Choosing the sensors option in the simulate tab will let you place sensors, then run a simulation to generate sensor data.

You can choose between different types of calculations and parameters:

The Apache options will produce a (model.ill) file for use in the ApacheSim Radiance link

- Apache (default) - use rtrace with hard-wired parameters
- Apache (custom) - use rtrace with user defined parameters
  rtrace is a radiance calculation that uses high quality ray-tracing for every time step. It is computationally expensive and not generally required for CBDM/Daylight Simulation Metrics.
- Apache (dynamic) - use rcontrib with hard-wired parameters
  rcontrib is a radiance calculation that performs one higher quality ray-tracing calculation to create daylight coefficients for sensor or grid points, the coefficients are then used to calculate illuminance at each time step. This simulation method is therefore faster than the rtrace method and a sensible choice for CBDM/Daylight Simulation Metrics.
- Radiance (dynamic) – will produce an illuminance file (rad.ril) for use within Radiance only. This can be used to investigate the light levels on one or more light sensors in a space, with a single, selected sky, with fixed dynamic parameters.

The **SENSOR SETTINGS** tab lets you measure daylight in different zones

By default all sensors are OFF until they are switched on.

Sensor Positions

When "Use Sensors" option is ticked on for the first time the sensors are created - a warning message pops up.

"No sensors defined yet. This will be done."

When you click OK you can choose where the sensors are placed (all zones in the model or selected zones only) and their position (ceiling pointing down or working plane pointing up).

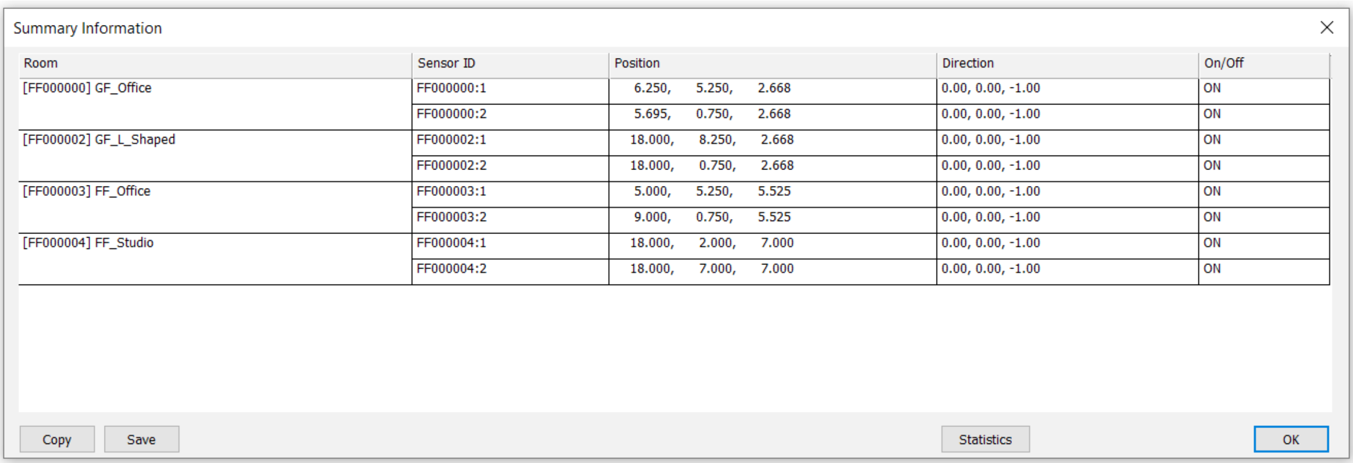
Typically, sensors are first added for default locations at a user-defined work-plane height in each space and then manually adjusted in the plan view as needed. Daylighting analysis should be used first to optimize the building design to provide design daylighting levels (using a suitable metric). When this is complete, or there are alternative scenarios defined for testing with respect to energy savings, etc., images from the daylight analysis are used to determine appropriate sensor locations.

To position a sensor manually after default sensors have been placed, select the zone and go down one Level of Decomposition to Room Level, then Double-Right mouse click in a position where you want to move a sensor to and select "Set Sensor Position". In plan view, set the x,y-position of the sensor then in any vertical view set the z-position. You can also set the sensor position by typing in the X, Y and Z position in the table. If a sensor is moved above the mid height of the room, a dialog will appear giving the option to make the sensor point downwards.

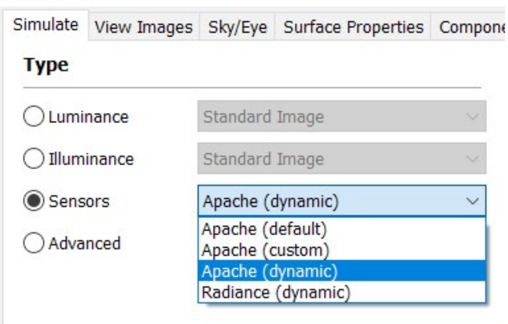
https://help.iesve.com/ve2019/settings_2.htm#

Placing Sensors for Daylight Harvesting

If you click on summary, you will get a list of all the sensors that have been placed in the model.
If you have spaces with no windows, no sensors will be assigned to them.

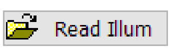


Room	Sensor ID	Position	Direction	On/Off
[FF000000] GF_Office	FF000000:1	6.250, 5.250, 2.668	0.00, 0.00, -1.00	ON
	FF000000:2	5.695, 0.750, 2.668	0.00, 0.00, -1.00	ON
[FF000002] GF_L_Shaped	FF000002:1	18.000, 8.250, 2.668	0.00, 0.00, -1.00	ON
	FF000002:2	18.000, 0.750, 2.668	0.00, 0.00, -1.00	ON
[FF000003] FF_Office	FF000003:1	5.000, 5.250, 5.525	0.00, 0.00, -1.00	ON
	FF000003:2	9.000, 0.750, 5.525	0.00, 0.00, -1.00	ON
[FF000004] FF_Studio	FF000004:1	18.000, 2.000, 7.000	0.00, 0.00, -1.00	ON
	FF000004:2	18.000, 7.000, 7.000	0.00, 0.00, -1.00	ON



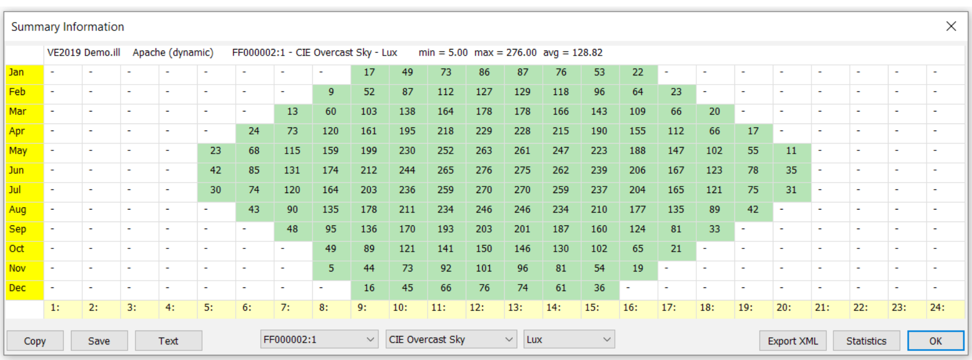
Return to the simulate tab, and click on the Sensor button.
Choose Apache (dynamic) to run the simulation.
This will write an .ill file, that can be read later by Apache.

The sensor results file will be saved with the project name and the extension .ill in the Radiance folder within your project folder.



You can view these results by returning to the Sensor Settings tab, and clicking on the button on the Read Illum button, on the bottom left.

The data will be displayed as a table, showing the illumination measurements made by the sensor.
You can select the sensor, and the unit of measurement and type of sky for which you would like this data to be displayed.



Jan	-	-	-	-	-	-	-	-	17	49	73	86	87	76	53	22	-	-	-	-	-	-	-	-
Feb	-	-	-	-	-	-	-	9	52	87	112	127	129	118	96	64	23	-	-	-	-	-	-	-
Mar	-	-	-	-	-	-	13	60	103	138	164	178	178	166	143	109	66	20	-	-	-	-	-	-
Apr	-	-	-	-	-	24	73	120	161	195	218	229	228	215	190	155	112	66	17	-	-	-	-	-
May	-	-	-	-	23	68	115	159	199	230	252	263	261	247	223	188	147	102	55	11	-	-	-	-
Jun	-	-	-	-	42	85	131	174	212	244	265	276	275	262	239	206	167	123	78	35	-	-	-	-
Jul	-	-	-	-	30	74	120	164	203	236	259	270	270	259	237	204	165	121	75	31	-	-	-	-
Aug	-	-	-	-	-	43	90	135	178	211	234	246	246	234	210	177	135	89	42	-	-	-	-	-
Sep	-	-	-	-	-	-	48	95	136	170	193	203	201	187	160	124	81	33	-	-	-	-	-	-
Oct	-	-	-	-	-	-	-	49	89	121	141	150	146	130	102	65	21	-	-	-	-	-	-	-
Nov	-	-	-	-	-	-	-	5	44	73	92	101	96	81	54	19	-	-	-	-	-	-	-	-
Dec	-	-	-	-	-	-	-	-	16	45	66	76	74	61	36	-	-	-	-	-	-	-	-	-
	1:	2:	3:	4:	5:	6:	7:	8:	9:	10:	11:	12:	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:	24:

Illuminance values over certain thresholds are highlighted in this tabular display, as below:

For Lux measurements:

- <100 is white
- 100-2000 is green
- >2000 is red

For foot-candles

- <10 is white
- 10-200 is green
- >200 is red

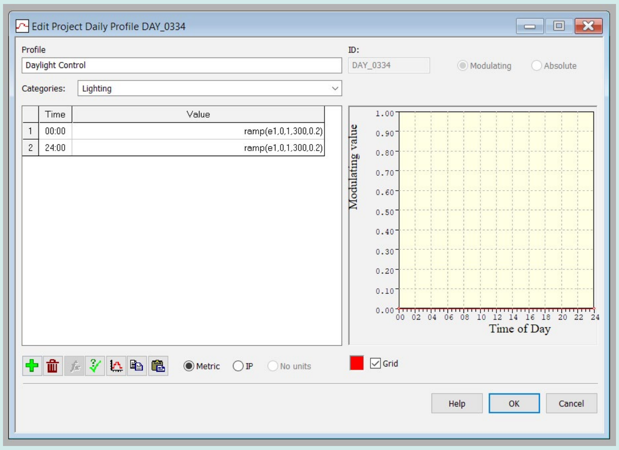
Using Radiance Sensors to Create Dimming Profiles in Apache

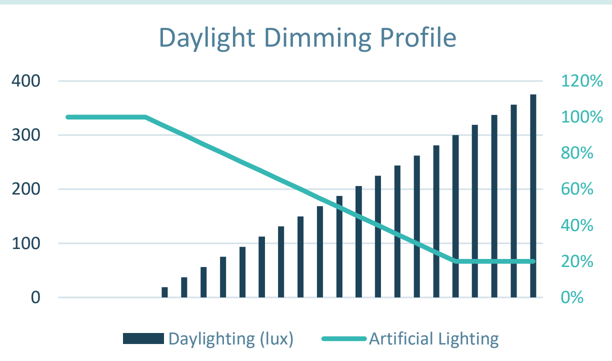
Once the sensors have been simulated in Radiance, return to the Apache application.

The illuminance file contains data for the Daylight Factor (CIE Overcast Sky) and at each time-step the Circumsolar and Diffuse component for each sensor (derived from the Sunny Sky and Clear Sky).
Note that Apache only uses two sensor inputs (e1 and e2) for the illuminance value.

In Apache, these simulated sensor data values are factored with the weather file's direct and diffuse solar variables to give the best fit illuminance value for e1.w

To apply this sensor data, we need to create a new profile, to apply as a dimming profile that will modify the artificial lighting that's already in the model.





We can for example create a profile called **Daylight Control**.

- Go to APPro and create a new daily modulating profile.
- Do not add any extra lines for time. Use the two existing lines and insert a profile into both, so that it applies from a start time of 0:00, to the end time at 24:00 i.e. it is applicable to the full 24 hour period of each day.
- You can copy and paste in this formula **ramp(e1,0,1,300,0.2)** to use the e1 sensor info.
  The ramp function takes the format of ramp (a,b,c,d,e), where ramp is the function,
  a=sensed variable (Illuminance),
  b=sensed value at lower end of ramp (min daylight to start dimming profile),
  c=returned value at lower end of ramp,
  d=sensed value at upper end of ramp (illuminance target level),
  e=returned value at upper end of ramp.

This means that this formula will dim the lights in proportion to the measured solar gain at the sensor (The e1 value referred to as Room Illuminance). If the measured gain is 0 lux, the profile value is 1, and if the measured value is 300 lux or more, the profile value is 0.2. i.e. the lights dim to a minimum of 20% You could adjust the values to suit your requirements.

- Another example would be to use a profile **if(e1<500,1,0.5)** This profile applies fuzzy logic, to say that if the lux level is above 500lux then the lighting load is set to 0.5 and below 500lux it is 100% on.
- Stepped dimming could also be simulated, for example where diming is achieved by turning off one or two lamps per multi-lamp luminaire (fixture), rather than dimming the output per lamp.

This would take the format **if(e1>33, 0.38, if(e1>16.5, 0.71, 1.0)** based on the functions as *if(e1> [2/3 illuminance target], [fraction of gain at 1/3 lighting level], if(e1> [1/3 illuminance target], [fraction of gain at 2/3 lighting level], 1.0)*

When we set up the lighting internal gain, we will then set the **gain variation profile** to the profile determining the hours during which our lights can be turned on, eg. Office occupancy of 9AM to 5PM. We will then set the **gain dimming profile** to use the Daylight Control profile we have just created. By default, the dimming profile is set to on continuously, which means that the lights do not dim.

Space ID	Space Name	Space Sub Type	Gain 1 Variation Profile	Gain 1 Dimming Profile
FF000002	GF_L_Shaped	Room	9 - 5 no lunch	Daylight Control
FF000003	FF_Office	Room	9 - 5 no lunch	Daylight Control
FF000004	FF_Studio	Room	9 - 5 no lunch	Daylight Control
FF000001	GF_Store	Room	9 - 5 no lunch	Daylight Control
FF000000	GF_Office	Room	9 - 5 no lunch	Daylight Control

As such, during the hours when our lights can be turned on, they will be fully turned on if the sensor measures zero illuminance in the daylit space, and the gain will decrease in proportion to the measured values, to a minimum gain of 20% for times when the daylighting is providing 300 lux or more.

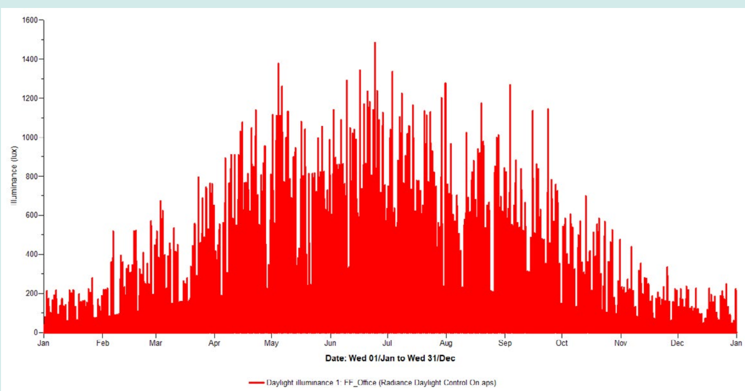
It is important to remember that the dimming profile will modulate the lighting gain indicated for a space in addition to any modulation provided by the lighting schedule profile and any diversity factor that has been included in the lighting gain dialog.

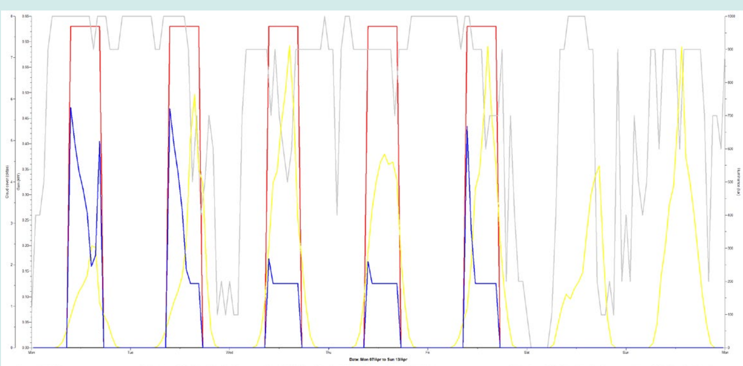
Now, if you run an Apache Dynamic Simulation with the link to Radiance box ticked, the daylight dimming will come into effect on the measured internal gains, but if you run the same simulation without ticking the link to Radiance, the internal gains will not be moderated by the dimming profile. Running the two simulations and comparing the difference will show the potential savings.

In the simulation using the link to Radiance, when we view the results in VistaPro, we can see a room variable called Daylight illuminance 1 – this is the measured lux level for the room at the sensor, due to daylighting alone.

Note that these values will differ from what you can view in RadianceIES. Within RadianceIES, the 3 metrics shown are based upon normalised sky conditions, but in the Vista results, we see a result based on the Apache calculations, that mix a fraction of the clear and overcast sky conditions to match the solar radiation weather variables and create a single illuminance value for each time step.

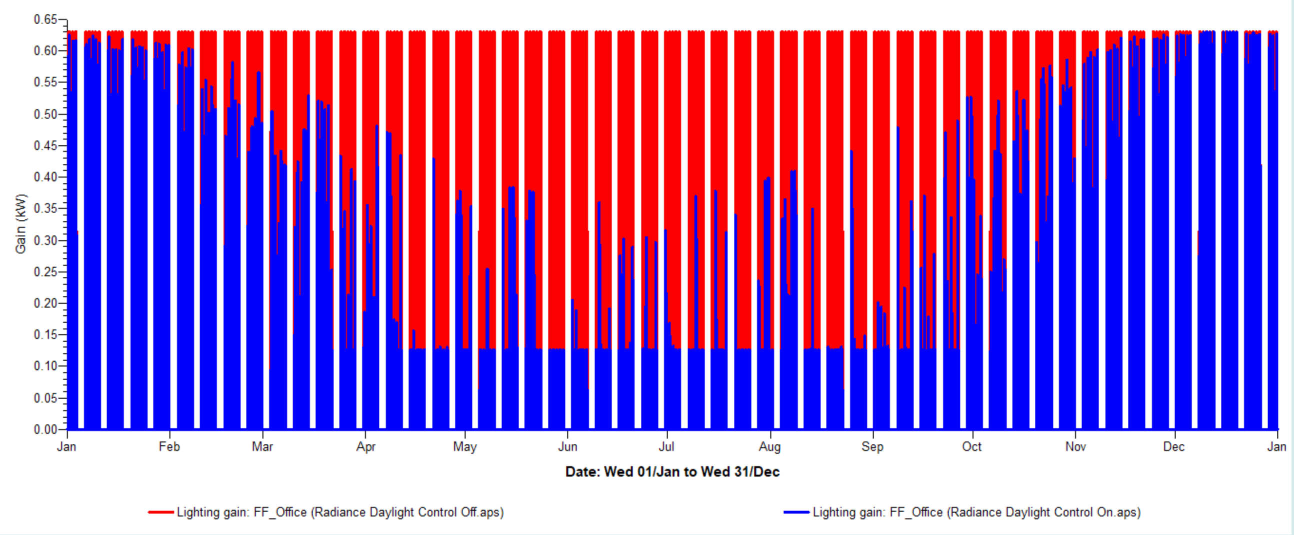
If you run a range test on this data, you will also be able to show which spaces achieve the required criteria for the credit HEA1 in BREEAM or other similar criteria in rating systems requiring output on the number of hours above a fixed lux level within a space.





We can see how cloud cover decreases illuminance, and hence decreases the potential savings from the dimming.

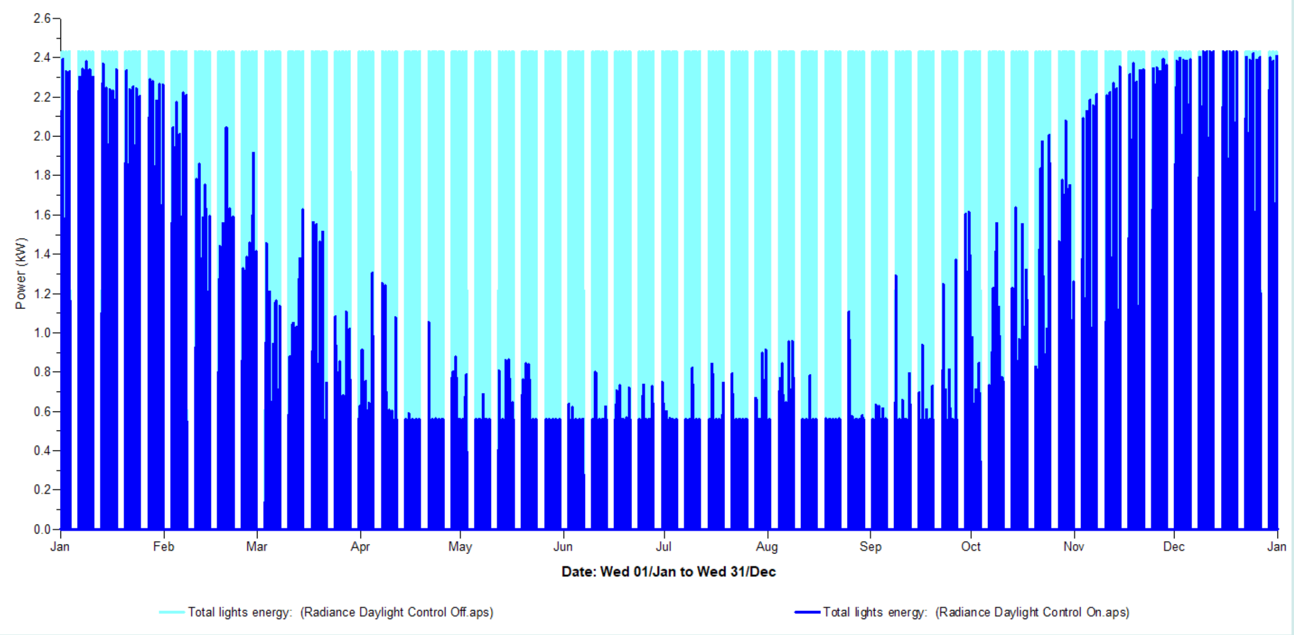
If we look at the variable called **Lighting Gain** – we can see the savings possible with dimming by looking at an annual graph of the lighting in the space.



We can also see this in the monthly totals for the space

	Lighting gain (MWh)	Lighting gain (MWh)
	FF_Office	FF_Office
Date	Radiance Daylight Control Off.aps	Radiance Daylight Control On.aps
Jan 01-31	0.1159	0.0895
Feb 01-28	0.1008	0.0531
Mar 01-31	0.1058	0.0408
Apr 01-30	0.1109	0.0314
May 01-31	0.1109	0.0282
Jun 01-30	0.1058	0.0245
Jul 01-31	0.1159	0.0276
Aug 01-31	0.1058	0.0266
Sep 01-30	0.1109	0.0324
Oct 01-31	0.1159	0.0516
Nov 01-30	0.1008	0.068
Dec 01-31	0.1159	0.0915
Summed total	1.3154	0.5651

If we look instead at the variable called **Total lights energy** – in the energy results, we can see the impact on the whole building if we apply daylight dimming to all spaces.



Here again, the **Total lights energy** – can also be viewed as monthly totals

Date	Total lights energy (MWh) Radiance Daylight Control Off.aps	Total lights energy (MWh) Radiance Daylight Control On.aps
Jan 01-31	0.4471	0.2789
Feb 01-28	0.3888	0.1629
Mar 01-31	0.4082	0.1246
Apr 01-30	0.4277	0.1096
May 01-31	0.4277	0.1045
Jun 01-30	0.4082	0.0971
Jul 01-31	0.4471	0.1073
Aug 01-31	0.4082	0.0997
Sep 01-30	0.4277	0.1132
Oct 01-31	0.4471	0.1594
Nov 01-30	0.3888	0.2095
Dec 01-31	0.4471	0.2943
Summed	5.0738	1.8611

***Note** that these benefits can be carried through as an improvement in a dynamic simulation for the DSM compliance method in the UK.*