ApacheSim and the SunCast Link

IES Technical Support

21/01/2021

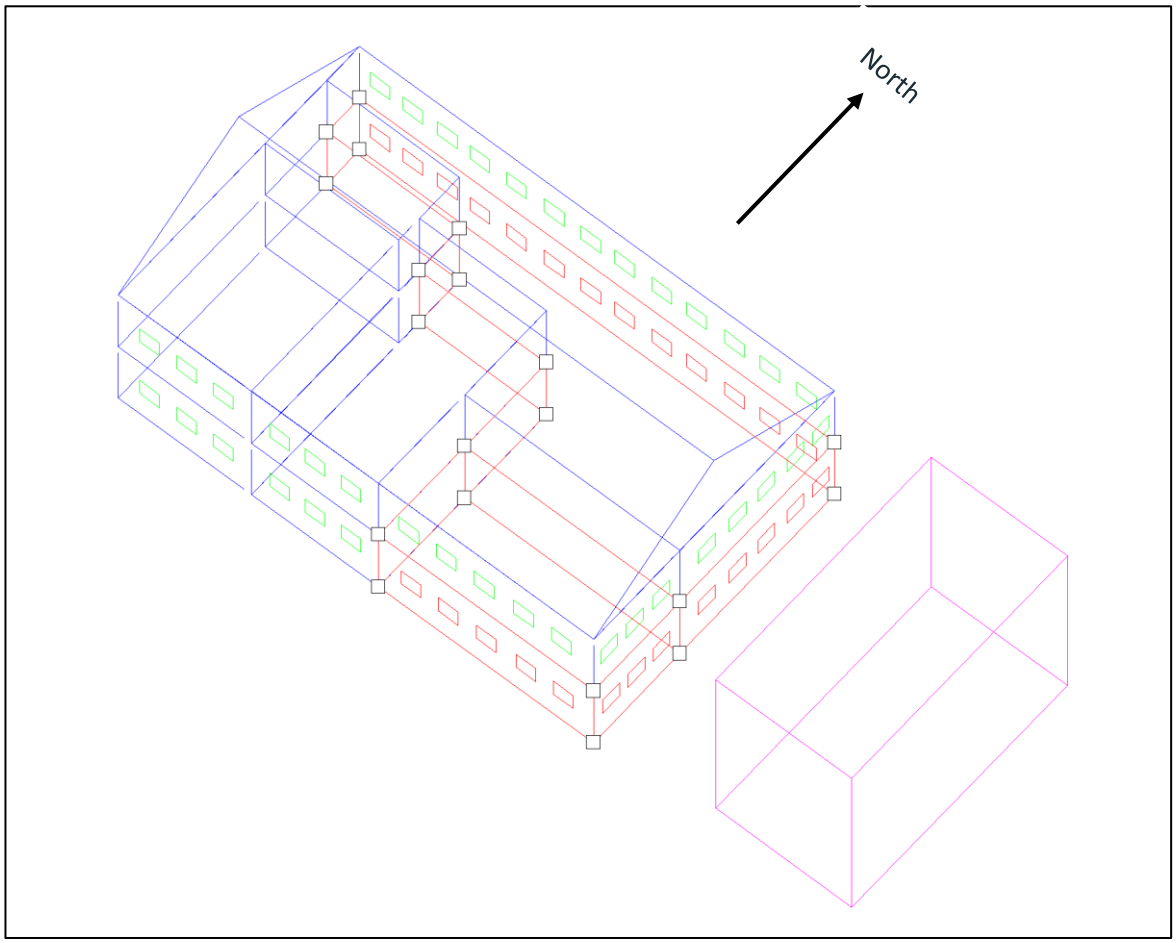
FAQ Document for Users

RUN APACHESIM WITH AND WITHOUT ENABLING THE SUNCAST LINK

This FAQ uses a few examples to study the effect of including the SunCast solar shading analysis in an ApacheSim dynamic simulation. For each section, the shading technique will be discussed, and a screenshot of the model will be included, together with the solar gain for selected rooms after running the simulation both with and without enabling the SunCast link.

Case 1: Adjacent Building

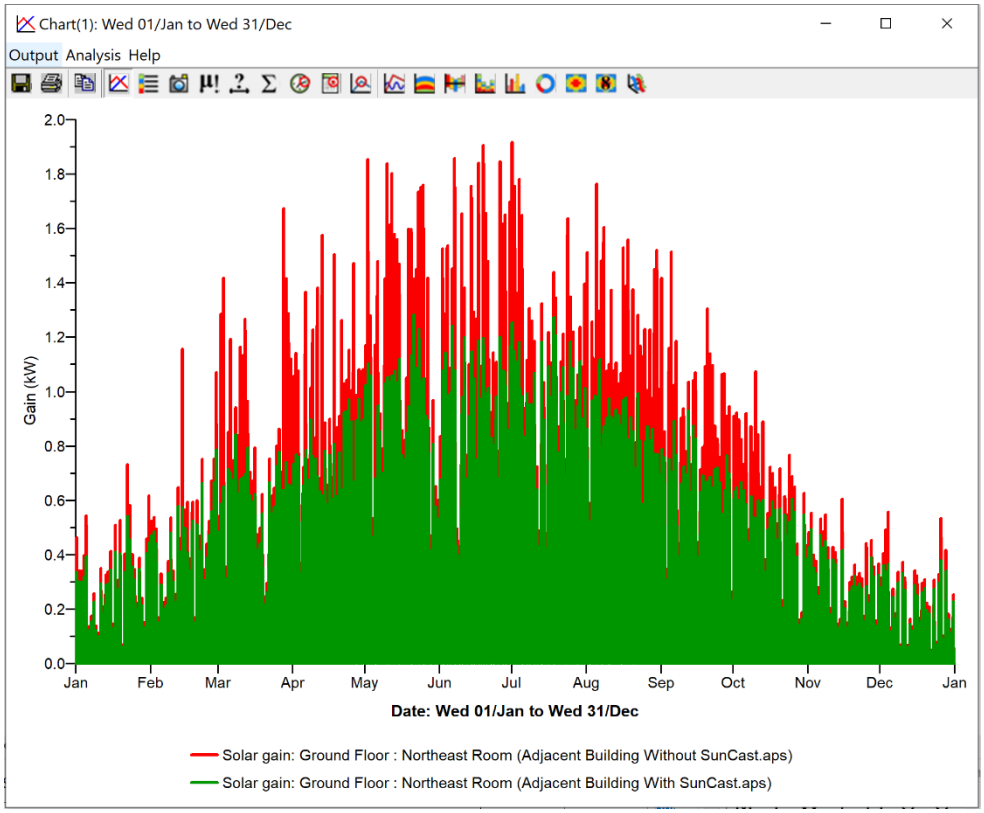
This image shows a model with an adjacent building. The two highlighted rooms downstairs (named: Northeast and Southeast rooms) are the focus of this study. The building is located in the northern hemisphere (London, UK).



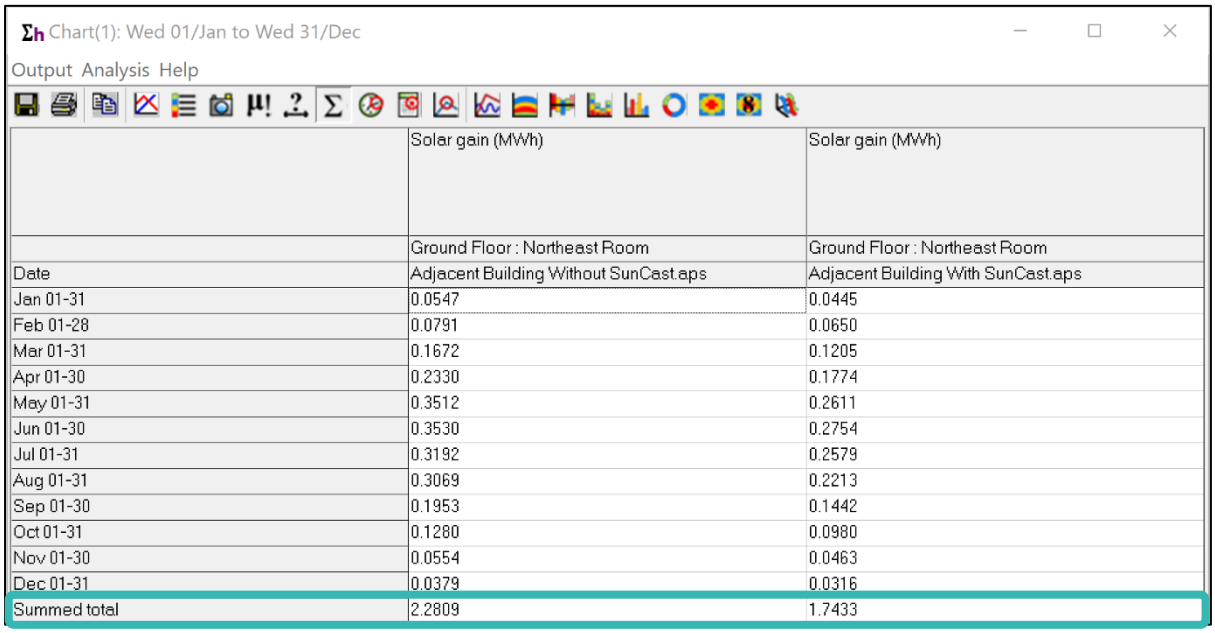
After running ApacheSim twice (with and without enabling the SunCast link), the solar gains for the two rooms were compared for the two cases:

1.1 Ground Floor: Northeast Room (the bigger room):

We can see a significant reduction in solar gain when the SunCast shading analysis was included in the simulation.



The table below shows the total annual solar gain for the same room with about 24% reduction when SunCast solar shading analysis was included in running the simulation:



	Solar gain (MWh)	Solar gain (MWh)
	Ground Floor : Northeast Room	Ground Floor : Northeast Room
Date	Adjacent Building Without SunCast.aps	Adjacent Building With SunCast.aps
Jan 01-31	0.0547	0.0445
Feb 01-28	0.0791	0.0650
Mar 01-31	0.1672	0.1205
Apr 01-30	0.2330	0.1774
May 01-31	0.3512	0.2611
Jun 01-30	0.3530	0.2754
Jul 01-31	0.3192	0.2579
Aug 01-31	0.3069	0.2213
Sep 01-30	0.1953	0.1442
Oct 01-31	0.1280	0.0980
Nov 01-30	0.0554	0.0463
Dec 01-31	0.0379	0.0316
Summed total	2.2809	1.7433

2.1 Ground Floor: Southeast Room (the smaller room)

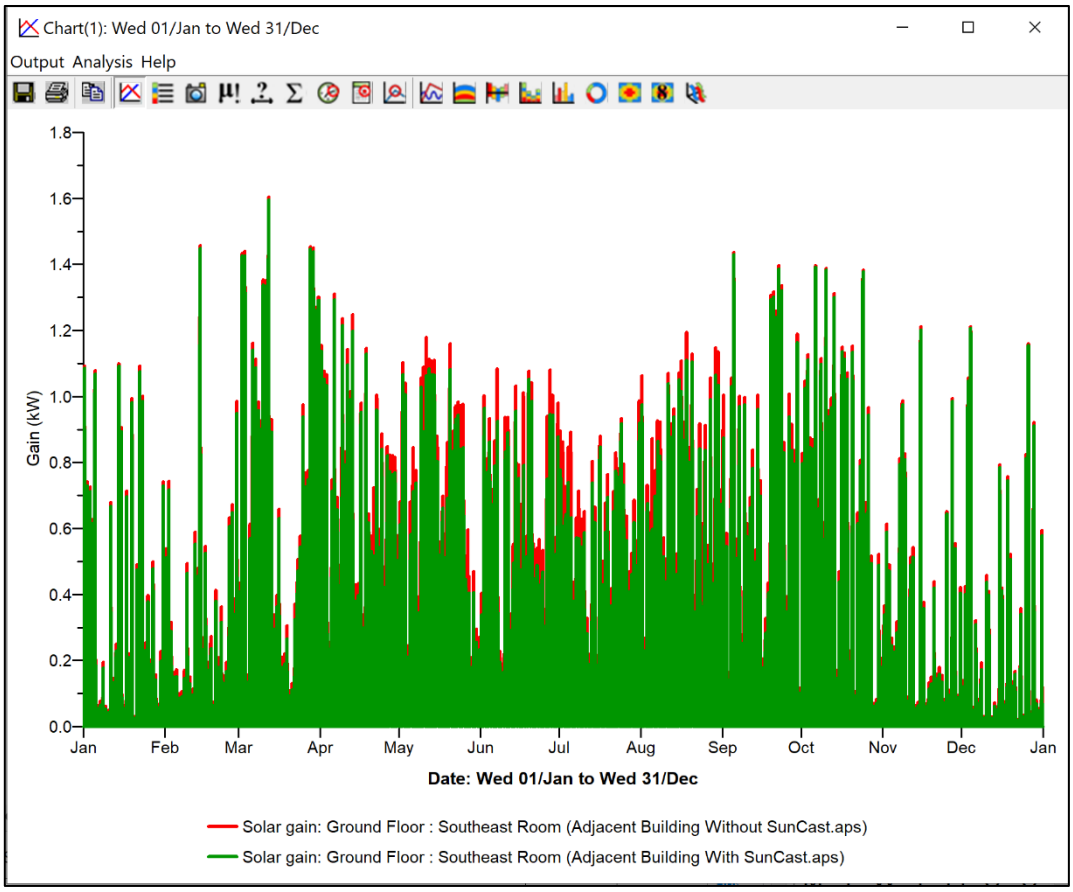
The total solar gain in this room is lower than in the first one, and its solar gain reduction is not as high as the first one. That's because the location of this room with respect to the sun and the adjacent building is different from the other room. This will be explained further:

Σh Chart(1): Wed 01/Jan to Wed 31/Dec

Output Analysis Help

	Solar gain (MWh)	Solar gain (MWh)
	Ground Floor : Southeast Room	Ground Floor : Southeast Room
Date	Adjacent Building Without SunCast.aps	Adjacent Building With SunCast.aps
Jan 01-31	0.0676	0.0635
Feb 01-28	0.0547	0.0494
Mar 01-31	0.1625	0.1497
Apr 01-30	0.1677	0.1457
May 01-31	0.2060	0.1603
Jun 01-30	0.1930	0.1500
Jul 01-31	0.1647	0.1313
Aug 01-31	0.1926	0.1550
Sep 01-30	0.1575	0.1405
Oct 01-31	0.1421	0.1334
Nov 01-30	0.0591	0.0553
Dec 01-31	0.0523	0.0489
Summed total	1.6197	1.3832

The table below shows a 15% reduction in solar gain when the SunCast link was enabled:

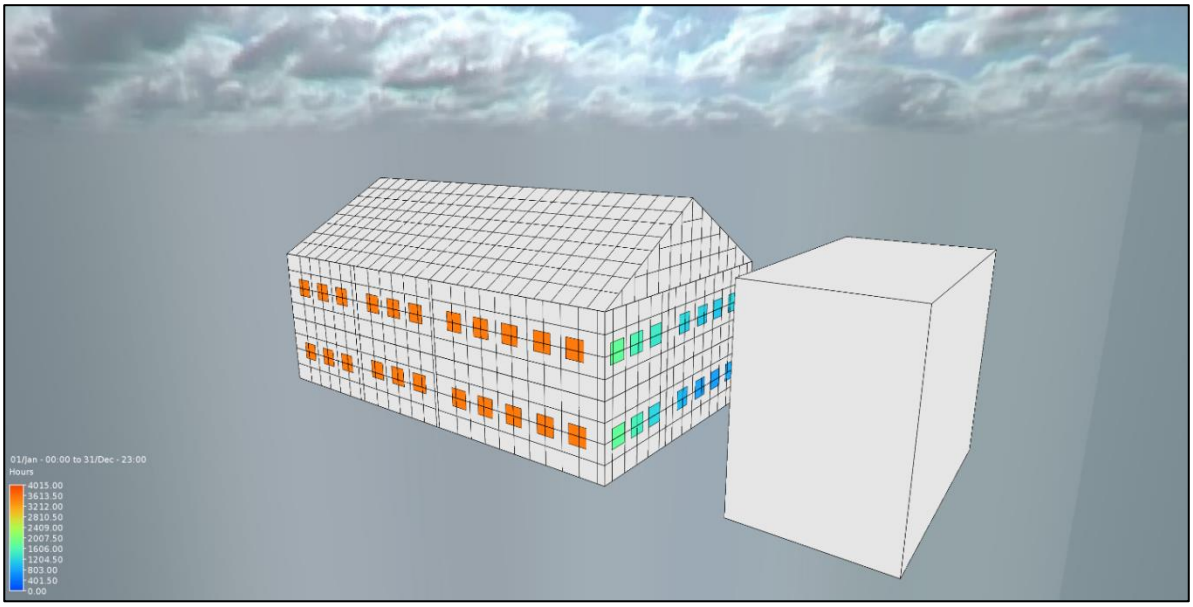


3.1 Why do we see this difference in solar gain?

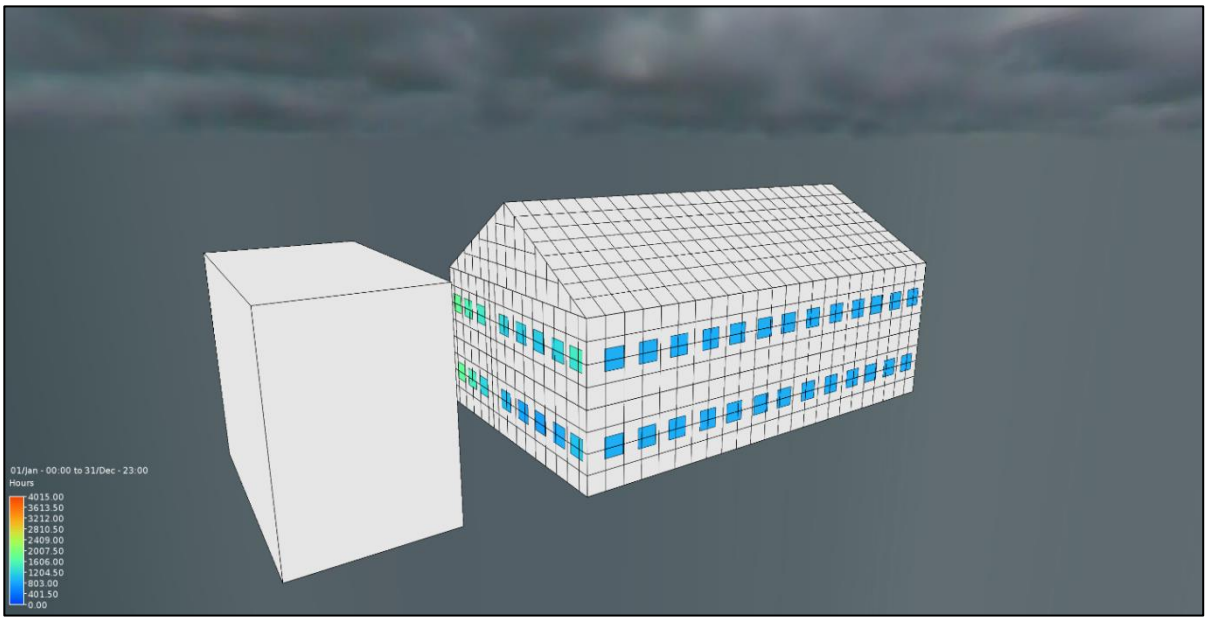
When the SunCast link is enabled, ApacheSim will use the shading file generated by SunCast, which includes shading factors and, optionally, diffuse shading factors, to track solar radiation through building surfaces. In the case of shading factors, at each simulation timestep, ApacheSim uses the incident solar flux, surface geometry and shading factor to calculate the solar radiation intercepted by that surface. Diffuse shading factors are used to block part of the diffuse solar radiation, the unblocked part is added to the direct radiation component from the sky and the radiation reflected from the ground, to give the total diffuse solar radiation incident on an exterior building surface. When the SunCast link is not enabled (no shading file is used), ApacheSim will not take into account shading objects, e.g. adjacent building in this case, and that is why solar gain is higher. The exception to this rule is any shading devices defined in the Apache Constructions Database. These are always used by ApacheSim and not used by SunCast. They are not used in this model.

4.1 Solar Exposure Analysis of Case 1

Solar exposure analysis results in SunCast show that the windows in the southeastern room are exposed to solar radiation for more hours during the year than the northeastern room. This image shows solar exposure hours for the southeastern room, with over 3000 hours of annual solar exposure on most windows.



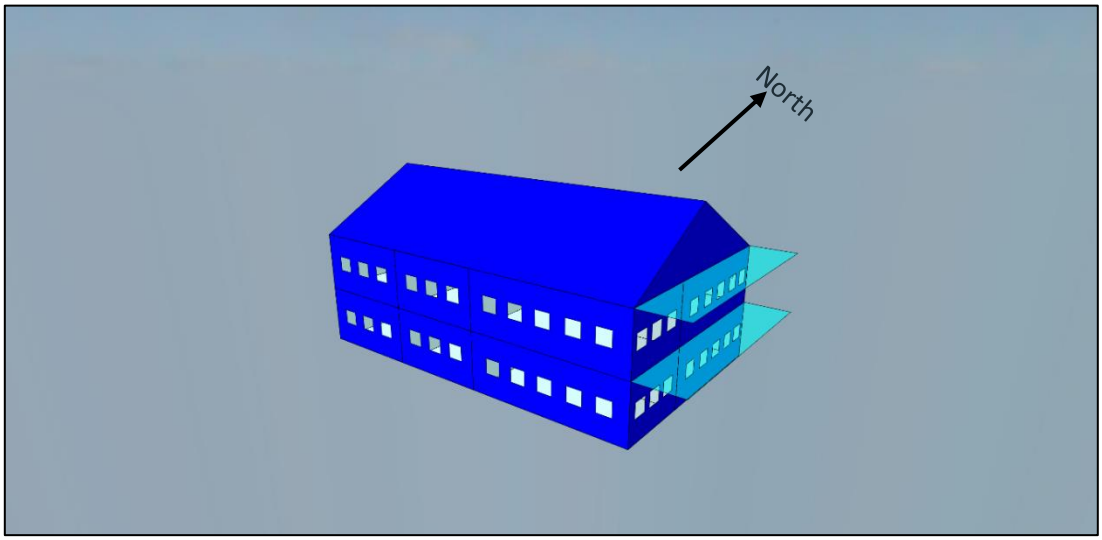
This image shows the northeastern room’s windows with about 800 hours of annual solar exposure.



It is worth mentioning that the dimensions of the adjacent building affect shading and solar exposure. For example, if the building is shorter; upstairs rooms will be exposed to sun for longer hours.

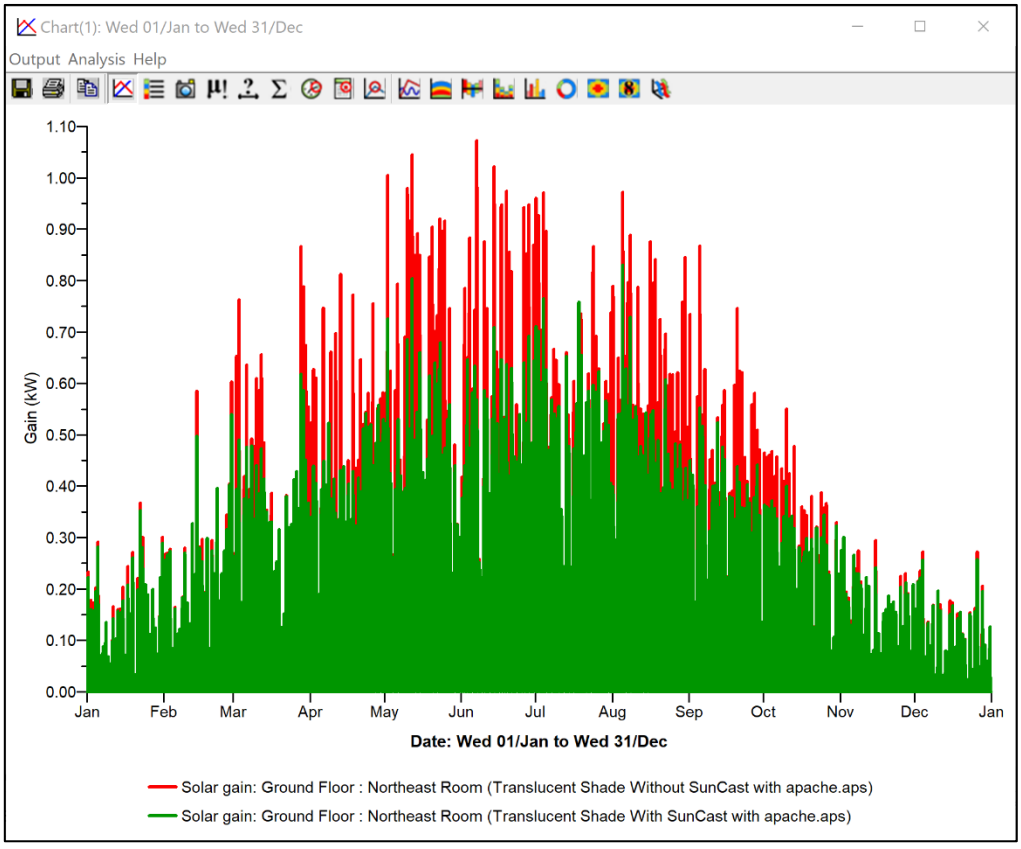
Case 2: Translucent Shade:

The image below shows our building with translucent shades on the east side of the upstairs and downstairs spaces. Let's look at the impact on the solar gain in our two rooms from adding translucent shades to the building.



2.1 Ground Floor: Northeast Room (the bigger room):

We see a reduction in the room solar gain when the SunCast link was enabled.



The table below shows a 13% reduction in solar gain when the SunCast link was enabled:

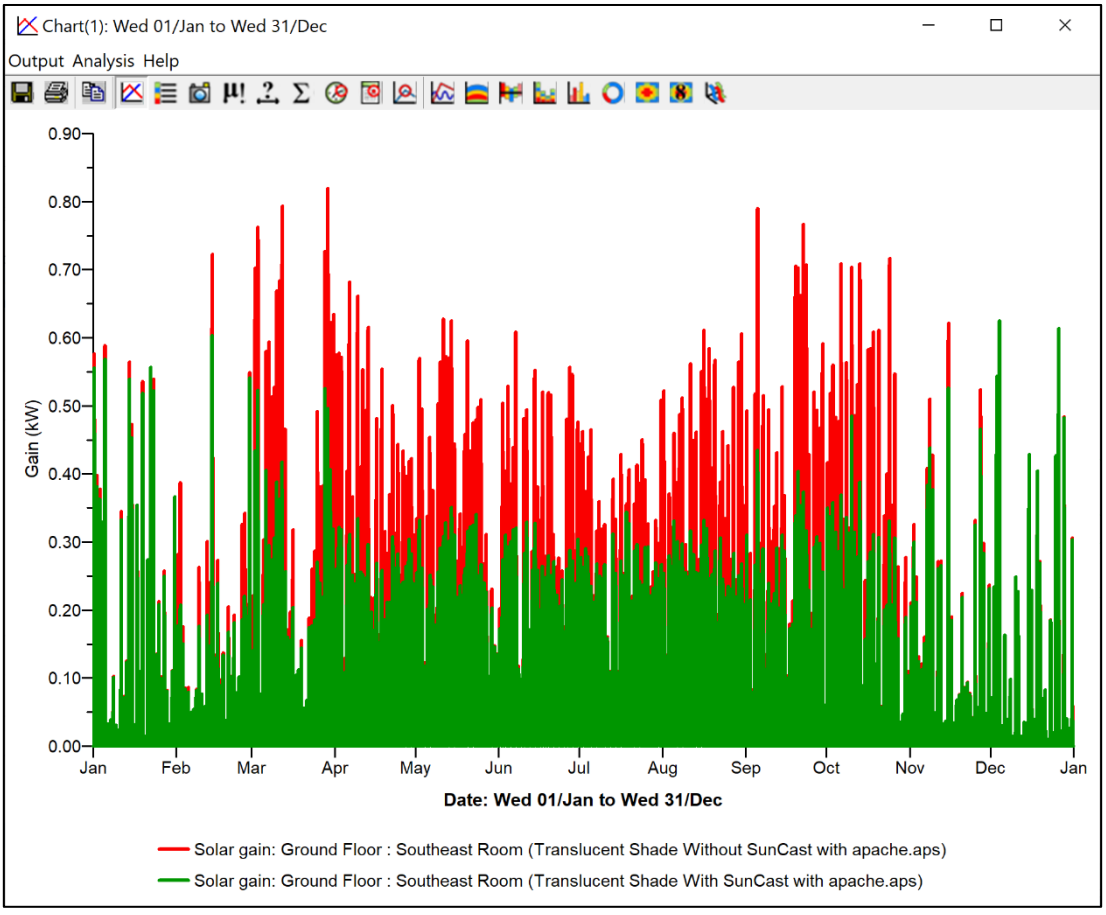
Σh Chart(2): Wed 01/Jan to Wed 31/Dec

Output Analysis Help

	Solar gain (MWh)	Solar gain (MWh)
	Ground Floor : Northeast Room	Ground Floor : Northeast Room
Date	Translucent Shade Without SunCast with	Translucent Shade With SunCast with apache.aps
Jan 01-31	0.0277	0.0266
Feb 01-28	0.0404	0.0391
Mar 01-31	0.0852	0.0743
Apr 01-30	0.1197	0.1050
May 01-31	0.1808	0.1487
Jun 01-30	0.1827	0.1532
Jul 01-31	0.1632	0.1464
Aug 01-31	0.1589	0.1327
Sep 01-30	0.1017	0.0889
Oct 01-31	0.0665	0.0604
Nov 01-30	0.0283	0.0275
Dec 01-31	0.0193	0.0186
Summed total	1.1744	1.0212

2.2 Ground Floor: Southeast Room (the smaller room)

The same happened to this room. There was a total annual solar gain reduction of 26% when the effect of SunCast was included in the dynamic simulation.



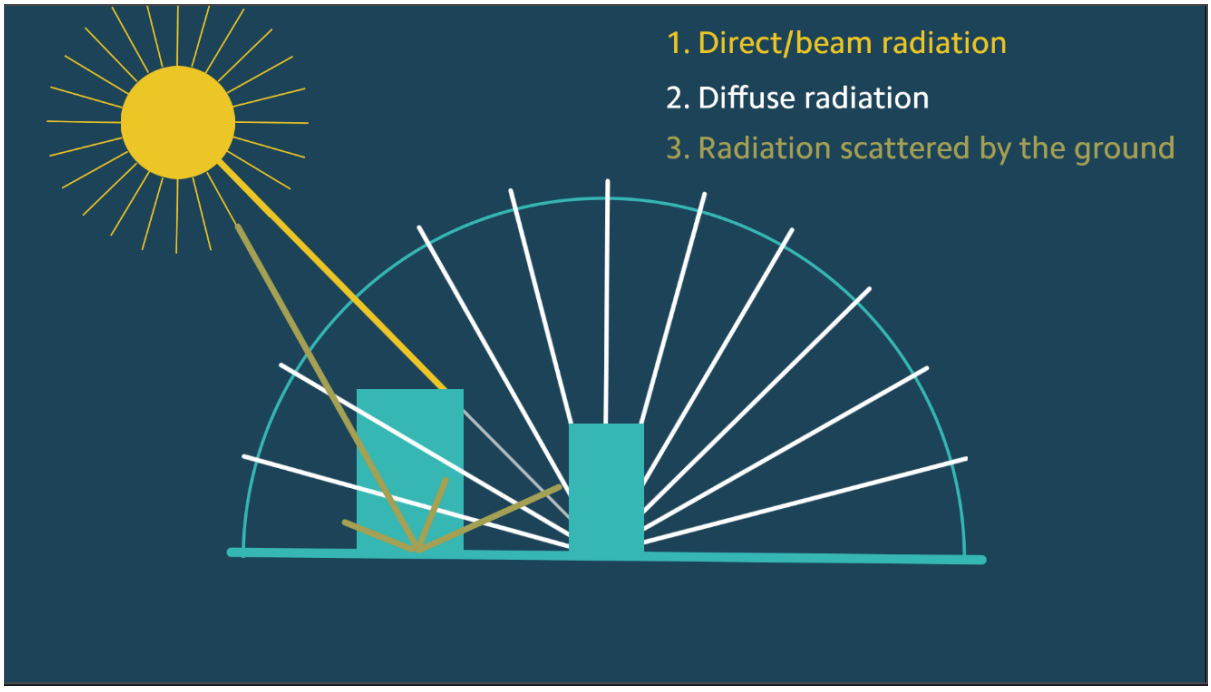
Σh Chart(1): Wed 01/Jan to Wed 31/Dec

Output Analysis Help

	Solar gain (MWh)	Solar gain (MWh)
	Ground Floor : Southeast Room	Ground Floor : Southeast Room
Date	Translucent Shade Without SunCast with	Translucent Shade With SunCast with apache.aps
Jan 01-31	0.0350	0.0340
Feb 01-28	0.0280	0.0233
Mar 01-31	0.0823	0.0529
Apr 01-30	0.0853	0.0592
May 01-31	0.1052	0.0741
Jun 01-30	0.0994	0.0734
Jul 01-31	0.0837	0.0681
Aug 01-31	0.0988	0.0696
Sep 01-30	0.0816	0.0554
Oct 01-31	0.0735	0.0484
Nov 01-30	0.0304	0.0282
Dec 01-31	0.0271	0.0266
Summed total	0.8302	0.6131

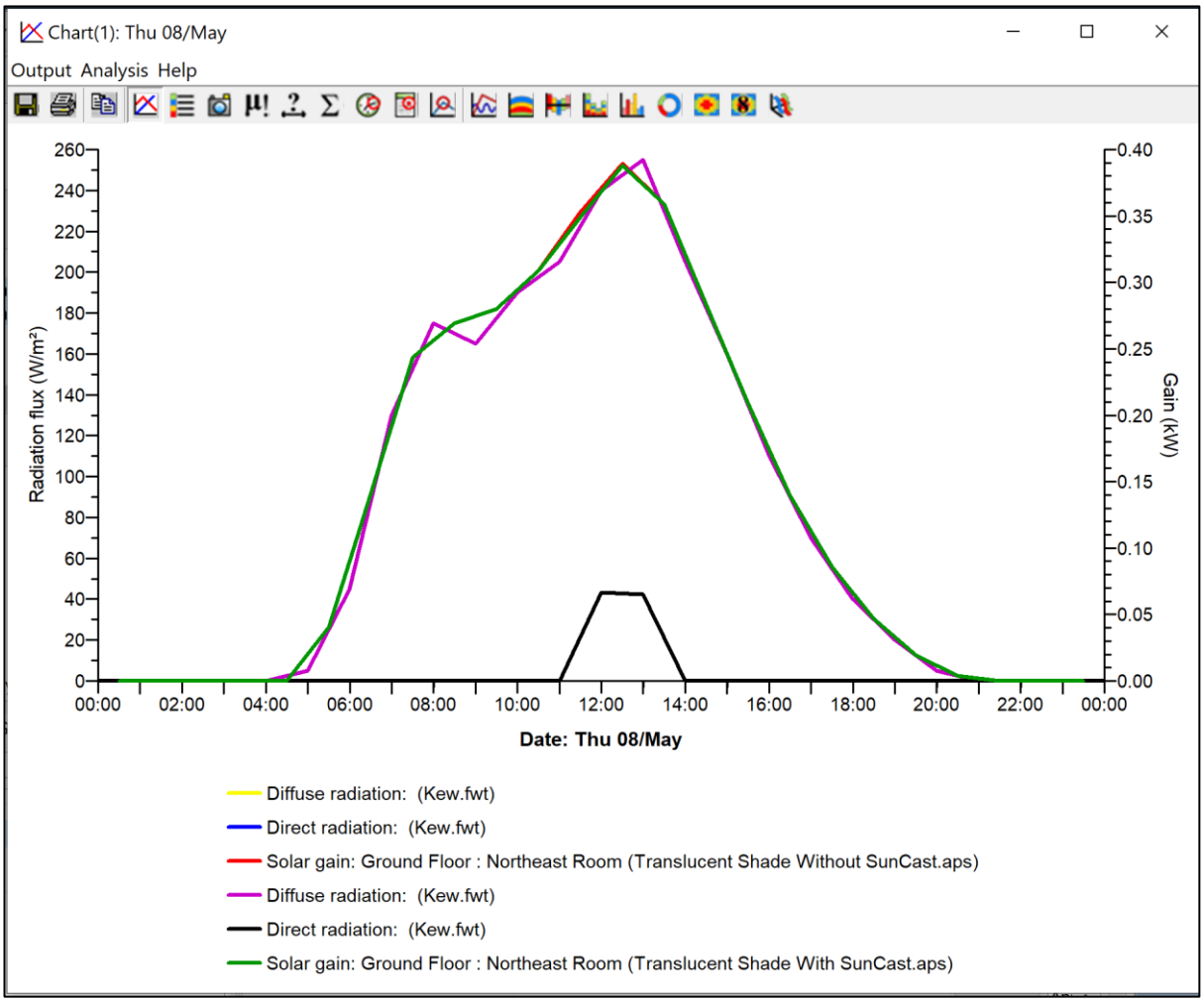
2.3 Diffuse Radiation and Translucent Shade:

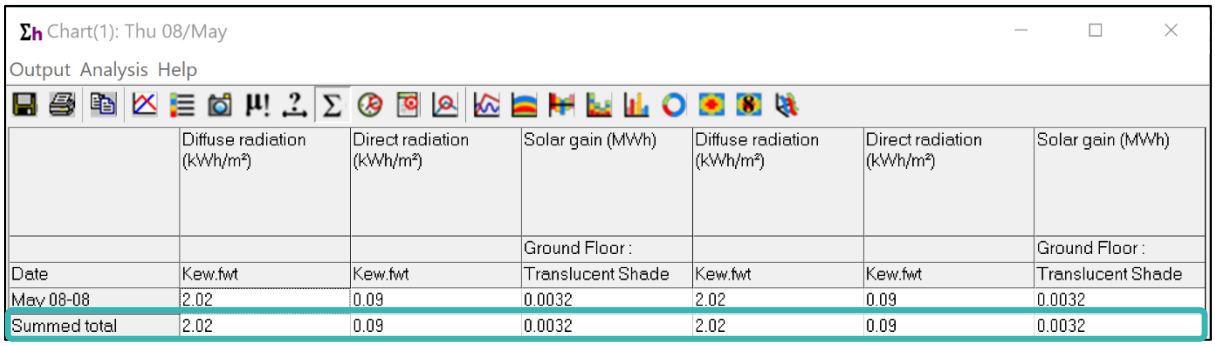
Solar gain in a room is primarily caused by its exposure to solar radiation. Solar radiation has three components: direct (beam) radiation, diffuse radiation and scattered radiation.



It is worth mentioning here that translucent shading does not reduce solar gain caused by diffuse solar radiation. It only reduces solar gains from direct solar radiation. So, if we compare solar gain in one room with and without translucent shades on a day with high levels of diffuse solar radiation, we will not find a significant difference between the two values.

For example, the northeast's room solar gain on May, 8th did not change when the SunCast analysis was enabled in the dynamic simulation as shown in the images below. Diffuse radiation (magenta curve) was significantly higher than direct radiation (black curve) on that day. The legend shows two "direct radiation" and two "diffuse radiation" values, because two files are compared here: with SunCast and without it. But they are identical in both cases, since the weather file is the same.





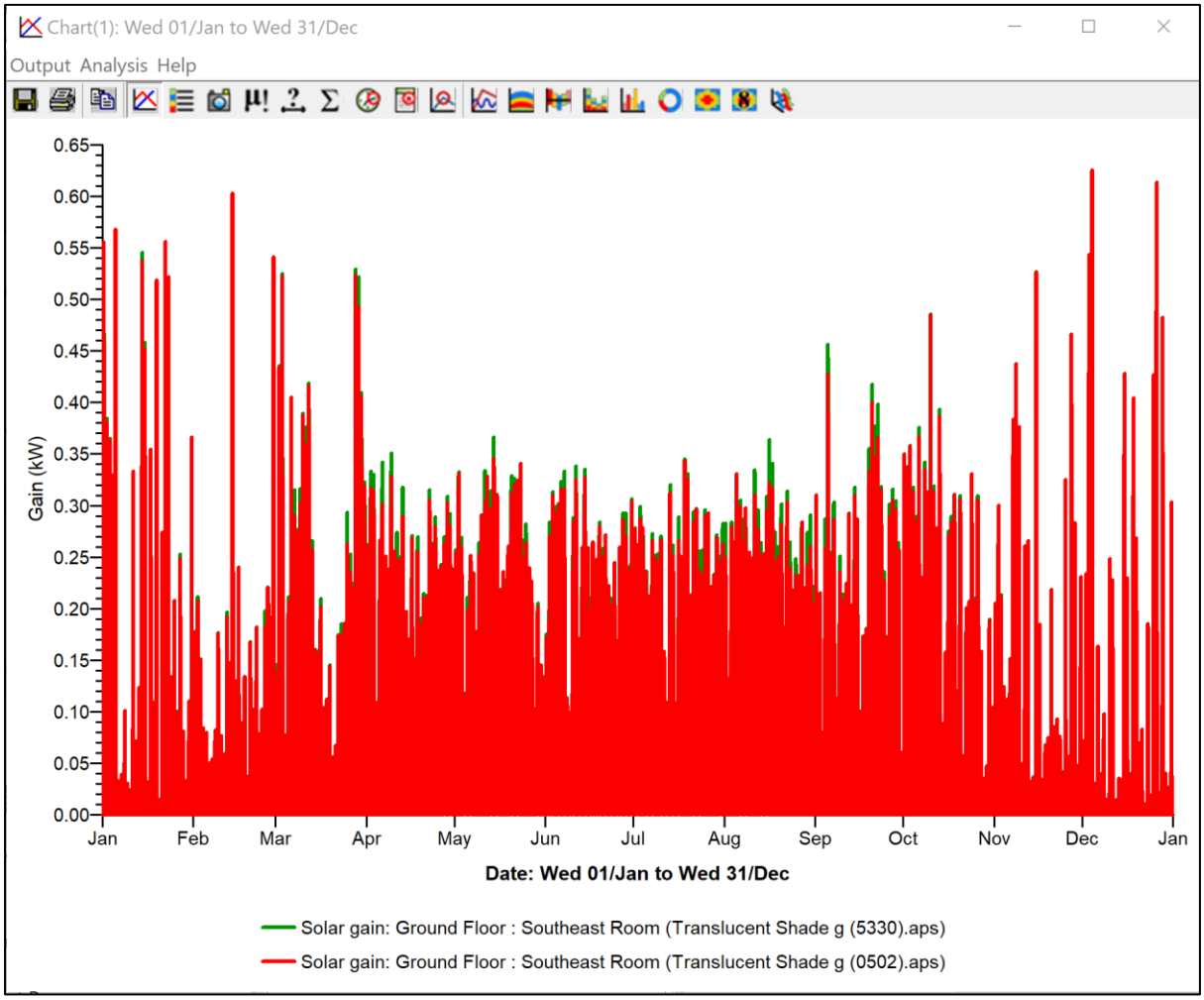
	Diffuse radiation (kWh/m²)	Direct radiation (kWh/m²)	Solar gain (MWh)	Diffuse radiation (kWh/m²)	Direct radiation (kWh/m²)	Solar gain (MWh)
			Ground Floor :			Ground Floor :
Date	Kew.fwt	Kew.fwt	Translucent Shade	Kew.fwt	Kew.fwt	Translucent Shade
May 08-08	2.02	0.09	0.0032	2.02	0.09	0.0032
Summed total	2.02	0.09	0.0032	2.02	0.09	0.0032

2.4 Translucent shade and g-value:

G-value is a coefficient that is used to measure the solar energy transmittance of windows. It has a value between 0 and 1, where 0 represents a window with no solar energy transmittance and 1 represents a window with full solar radiation transmittance.

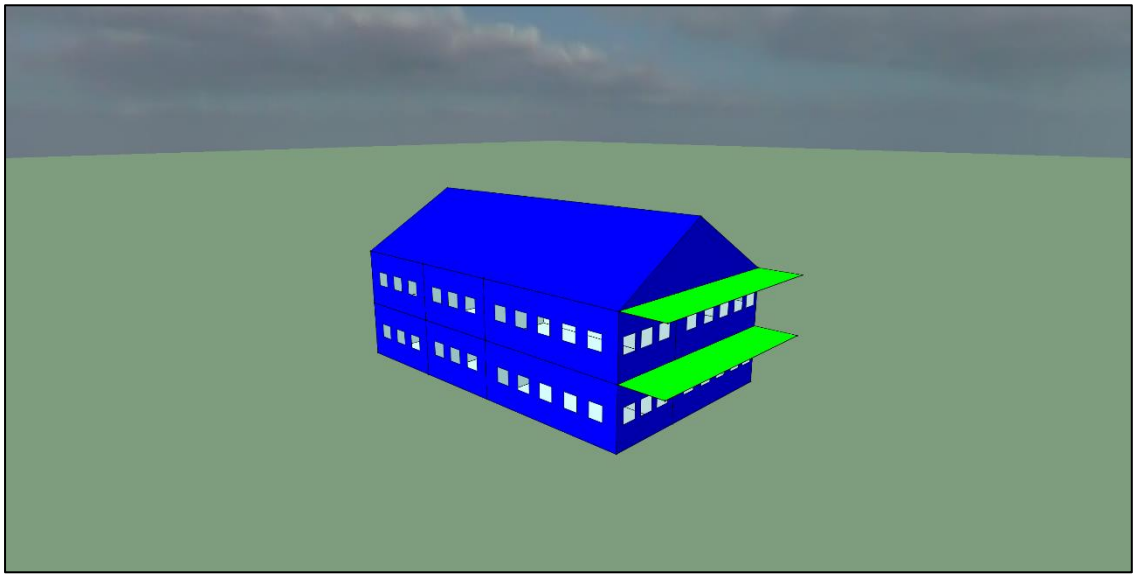
In the VE, translucent shades use this value in the same way as windows, so the lower the g-value, the more effectively the shade is blocking solar gain. The image below shows the difference in solar gain between two translucent shades with different g-values.

The red lines show the lower solar gain for the translucent shade with a lower g-value (g=0.0502) than the green lines for a translucent shade with a higher g value (g=0.5330).



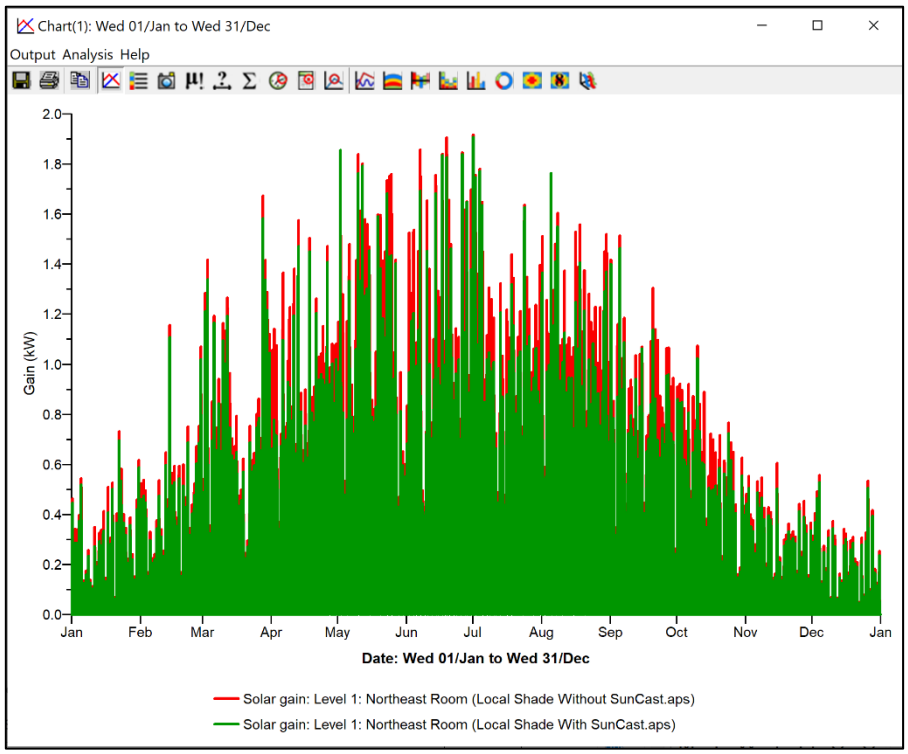
Case 3: Local Shades:

Local shades were added to the upstairs and downstairs on the east side of the building. Solar gain to the rooms on the southeast and northeast sides and the effect of SunCast was studied:



5.1 Ground Floor: Northeast Room (the bigger room):

Here, we see the same trend as before, when we added translucent shades and an adjacent building: solar gain was reduced when the SunCast link was enabled in the ApachSim dynamic simulation.



The tabular view of the data, shows a 14% reduction in solar gain in this room when the SunCast link is enabled:

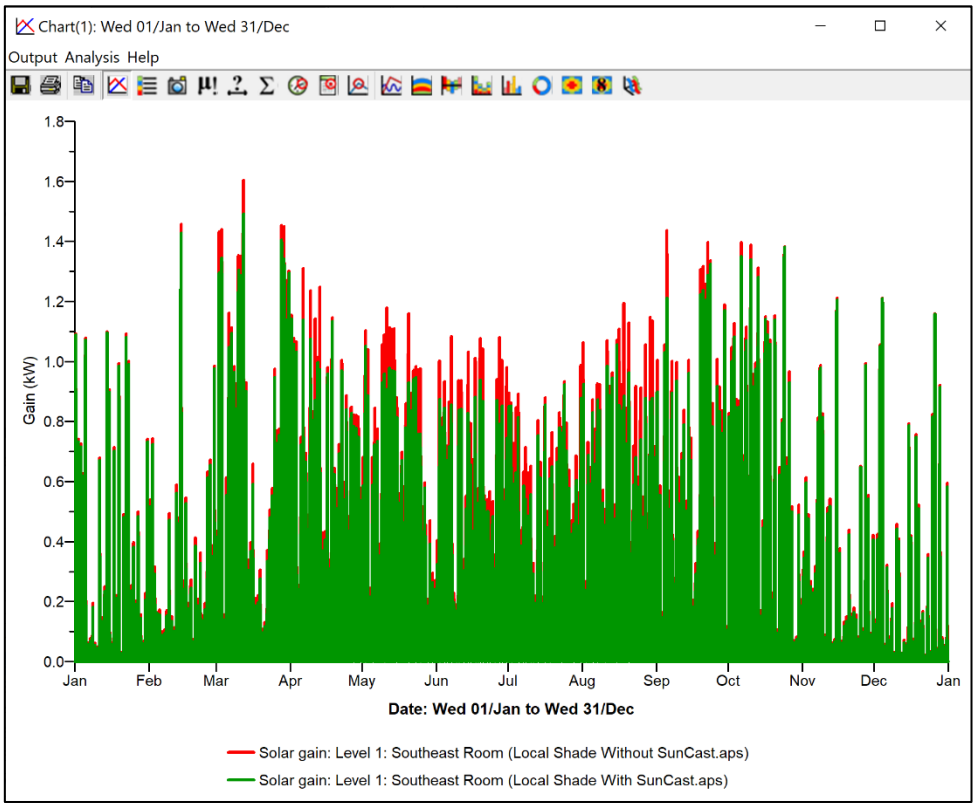
Σh Chart(1): Wed 01/Jan to Wed 31/Dec

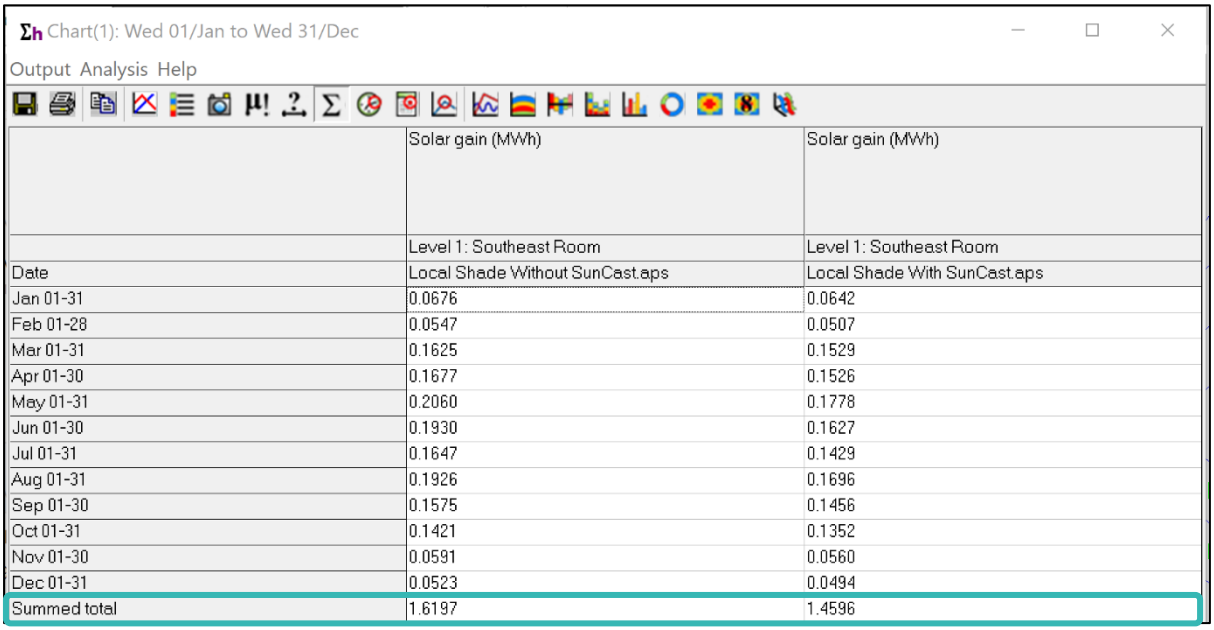
Output Analysis Help

	Solar gain (MWh)	Solar gain (MWh)
	Level 1: Northeast Room	Level 1: Northeast Room
Date	Local Shade Without SunCast.aps	Local Shade With SunCast.aps
Jan 01-31	0.0547	0.0484
Feb 01-28	0.0791	0.0711
Mar 01-31	0.1672	0.1436
Apr 01-30	0.2330	0.2014
May 01-31	0.3512	0.2955
Jun 01-30	0.3530	0.3001
Jul 01-31	0.3192	0.2789
Aug 01-31	0.3069	0.2600
Sep 01-30	0.1953	0.1688
Oct 01-31	0.1280	0.1113
Nov 01-30	0.0554	0.0498
Dec 01-31	0.0379	0.0339
Summed total	2.2809	1.9627

6.1 Ground Floor: Southeast Room (the smaller room)

The same happened in this room with a 10% solar gain reduction. The value differed due to the different room configuration and orientation.

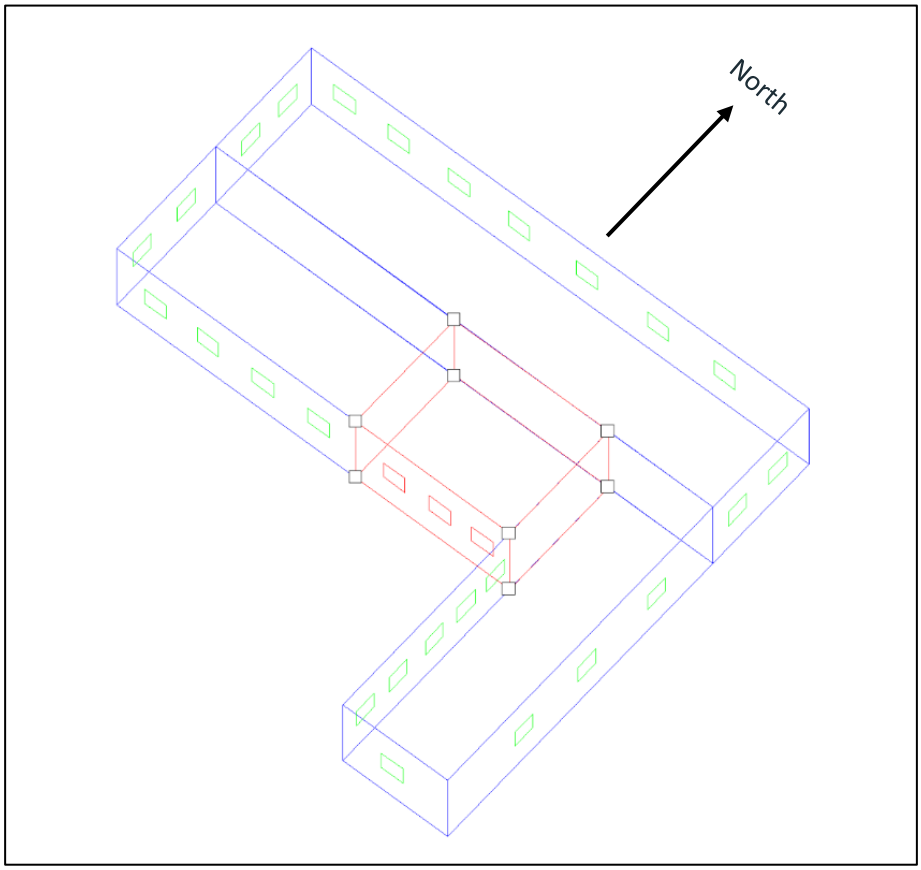




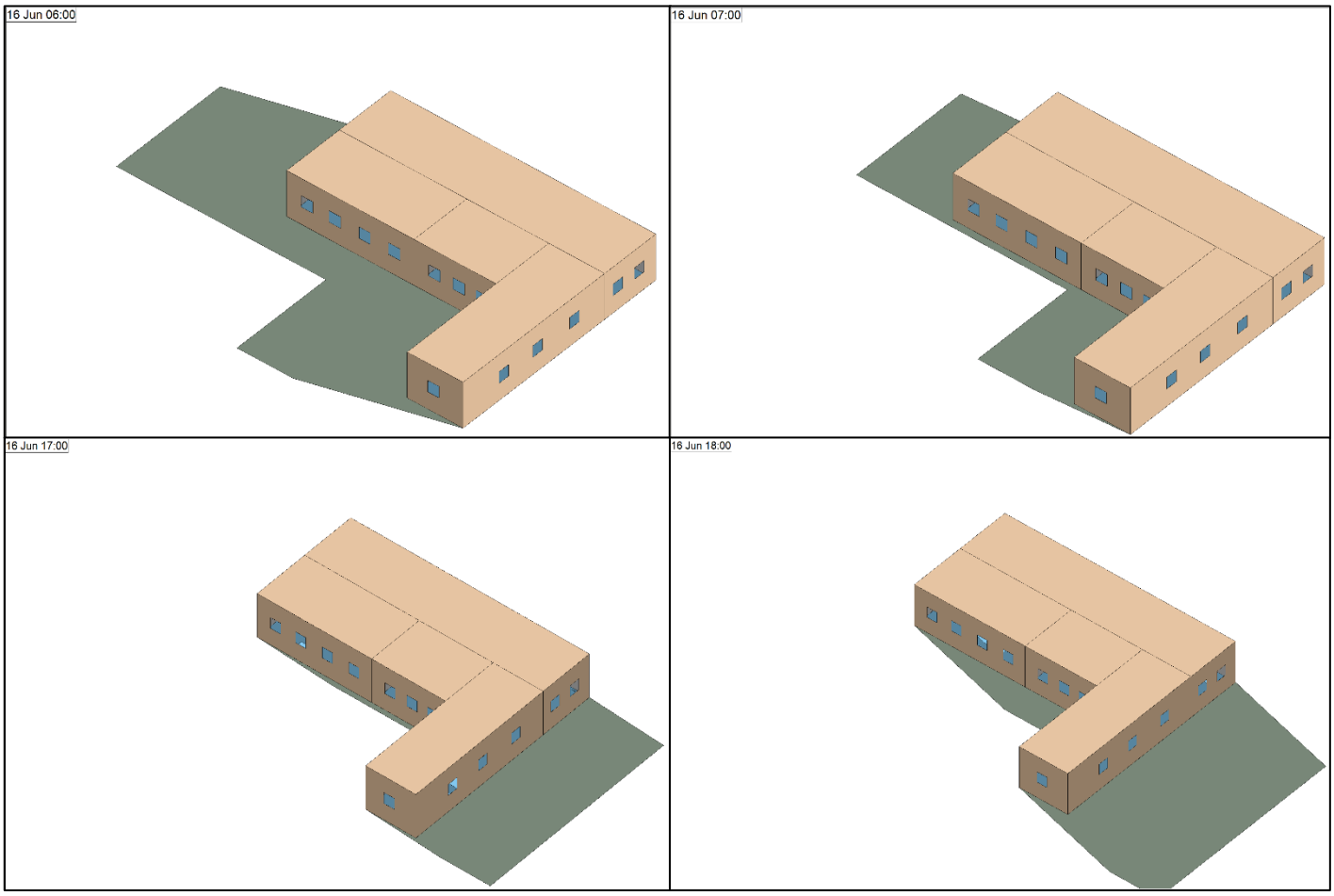
	Solar gain (MWh)	Solar gain (MWh)
	Level 1: Southeast Room	Level 1: Southeast Room
Date	Local Shade Without SunCast.aps	Local Shade With SunCast.aps
Jan 01-31	0.0676	0.0642
Feb 01-28	0.0547	0.0507
Mar 01-31	0.1625	0.1529
Apr 01-30	0.1677	0.1526
May 01-31	0.2060	0.1778
Jun 01-30	0.1930	0.1627
Jul 01-31	0.1647	0.1429
Aug 01-31	0.1926	0.1696
Sep 01-30	0.1575	0.1456
Oct 01-31	0.1421	0.1352
Nov 01-30	0.0591	0.0560
Dec 01-31	0.0523	0.0494
Summed total	1.6197	1.4596

Case 4: Self-shading (L-shaped Building):

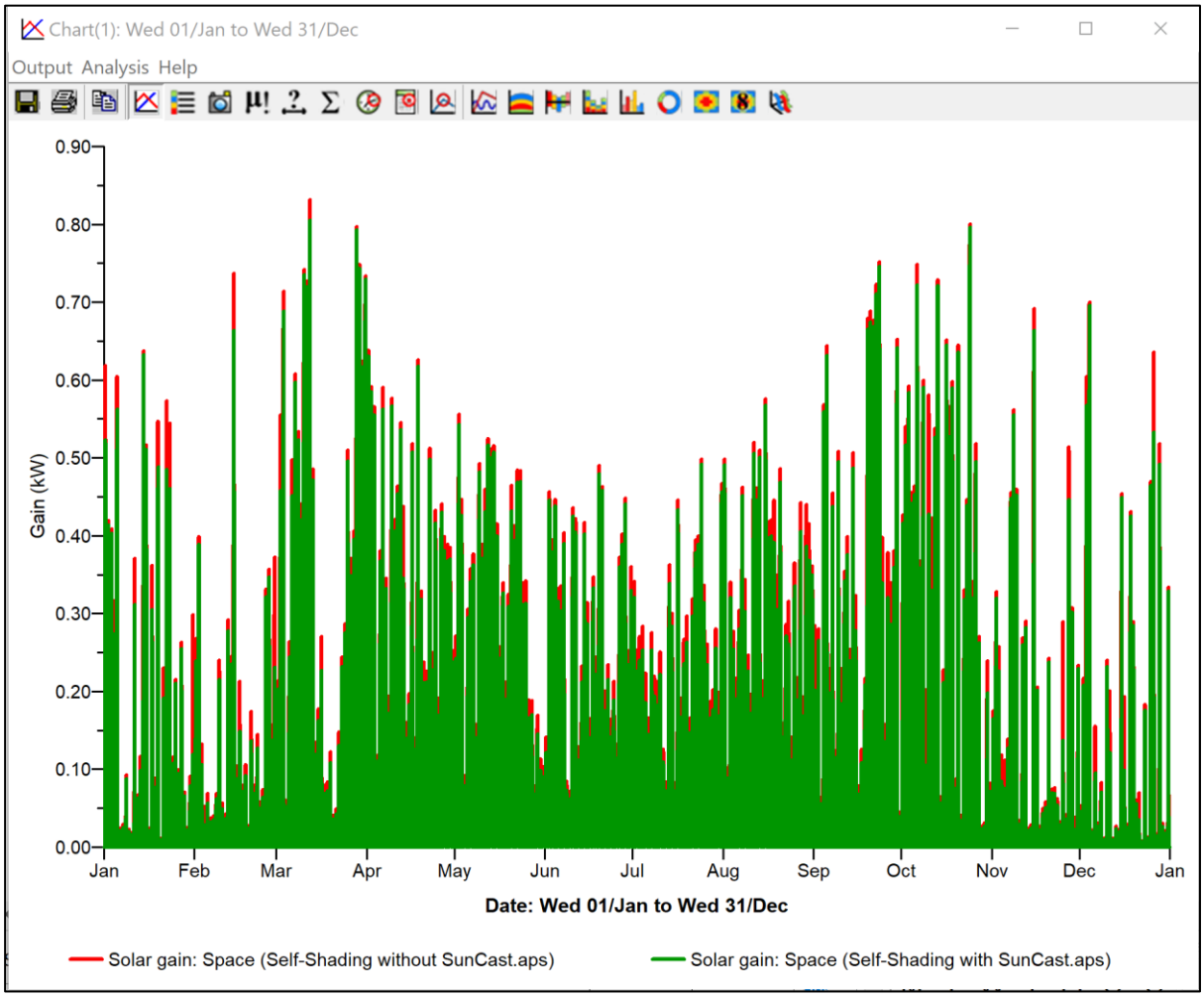
This case represents shading due to the form of the building itself. Building shapes can have a significant impact on reducing their own solar gain. The image below shows a building with an L-shape: The highlighted room will be our focus for investigating the impact of the SunCast solar shading analysis inclusion on an ApacheSim dynamic simulation.



Using SunCast, the below shading images highlight the extent of the self-shading on the room during the day (both in the morning and the afternoon).



The images below show the annual solar reduction (13%) caused by self-shading when the SunCast link is enabled.



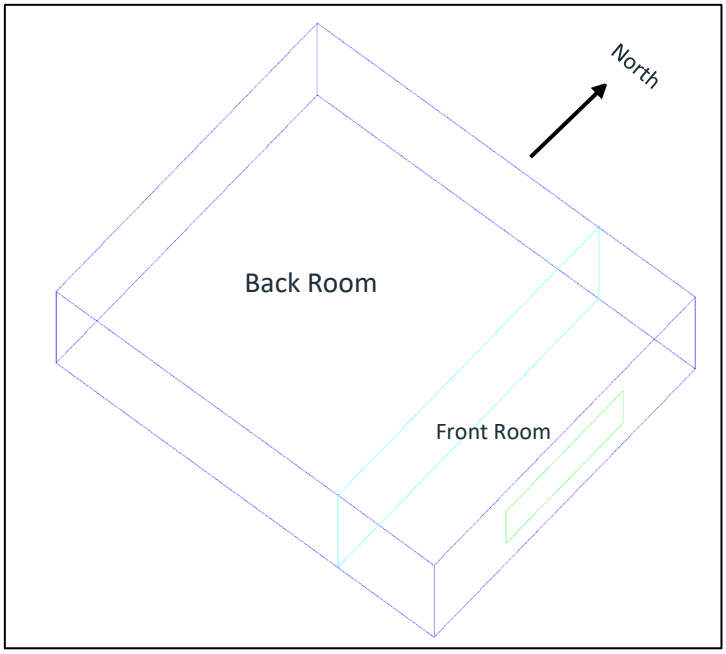
Σh Chart(1): Wed 01/Jan to Wed 31/Dec

Output Analysis Help

	Solar gain (MWh)	Solar gain (MWh)
	Space	Space
Date	Self-Shading without SunCast.aps	Self-Shading with SunCast.aps
Jan 01-31	0.0334	0.0262
Feb 01-28	0.0233	0.0191
Mar 01-31	0.0716	0.0629
Apr 01-30	0.0682	0.0623
May 01-31	0.0713	0.0647
Jun 01-30	0.0655	0.0594
Jul 01-31	0.0580	0.0518
Aug 01-31	0.0687	0.0610
Sep 01-30	0.0656	0.0570
Oct 01-31	0.0670	0.0556
Nov 01-30	0.0289	0.0223
Dec 01-31	0.0267	0.0206
Summed total	0.6482	0.5627

Case 5: Solar Radiation through Internal Openings:

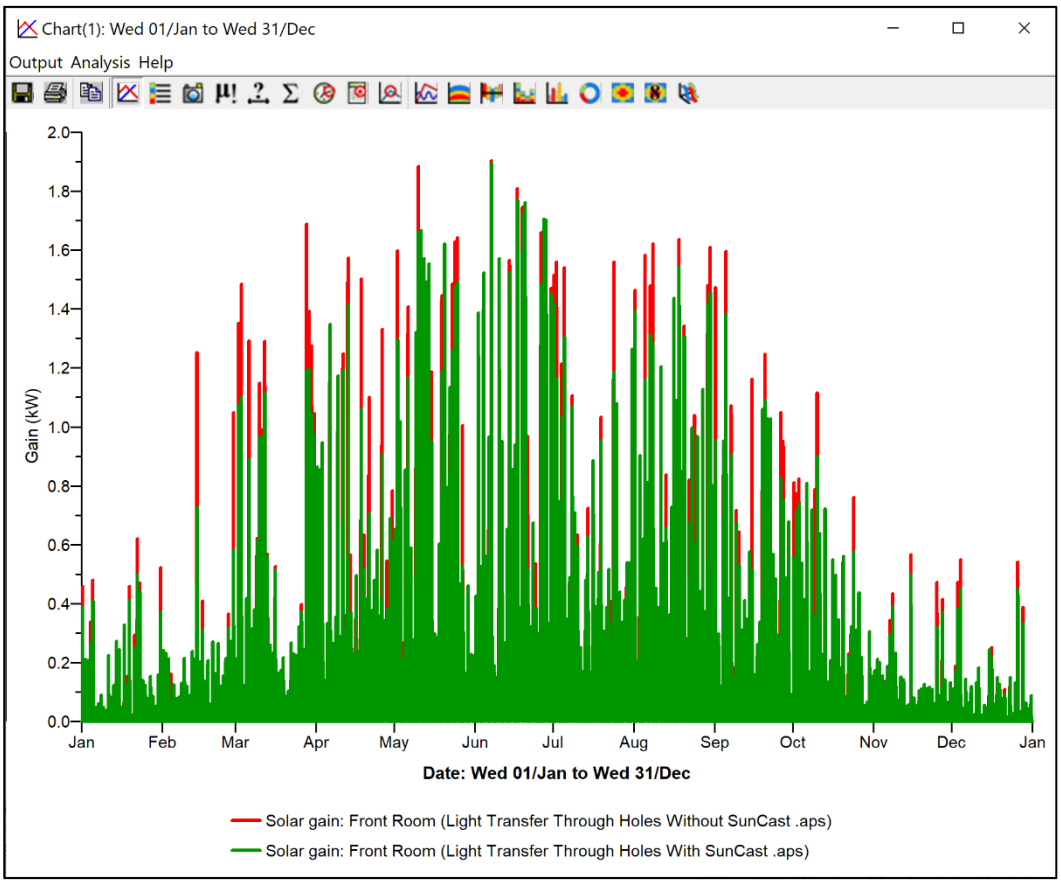
Now we will look at how solar radiation transfers through holes in a model, by testing the impact on solar gains from including/excluding the SunCast analysis in our dynamic simulation of the building. Below is a two room model with a hole between the rooms.



After running the simulation, the results for the two cases are as follows:

5.1. Front Room:

For the front room, solar gain with SunCast was less than solar gain for the same room without SunCast:



The table below shows a reduction of about 11% in solar gain in the room when SunCast is used:

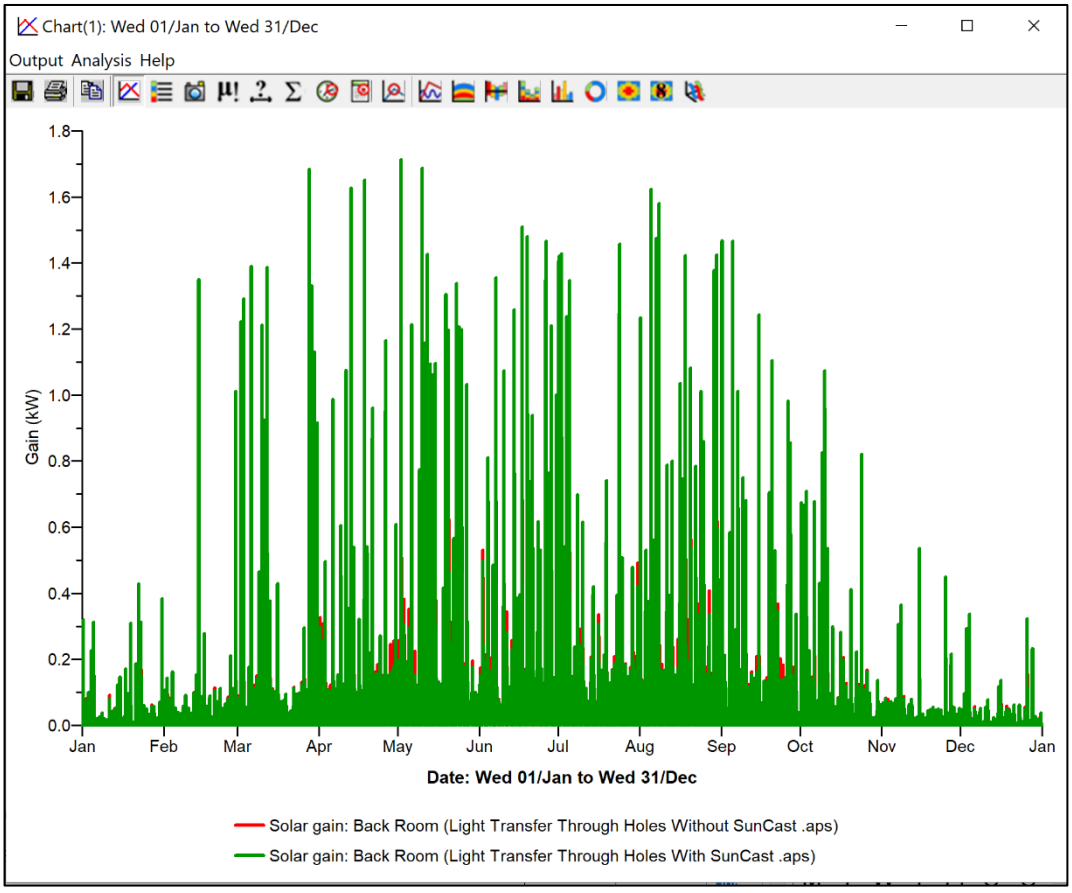
Σh Chart(1): Wed 01/Jan to Wed 31/Dec

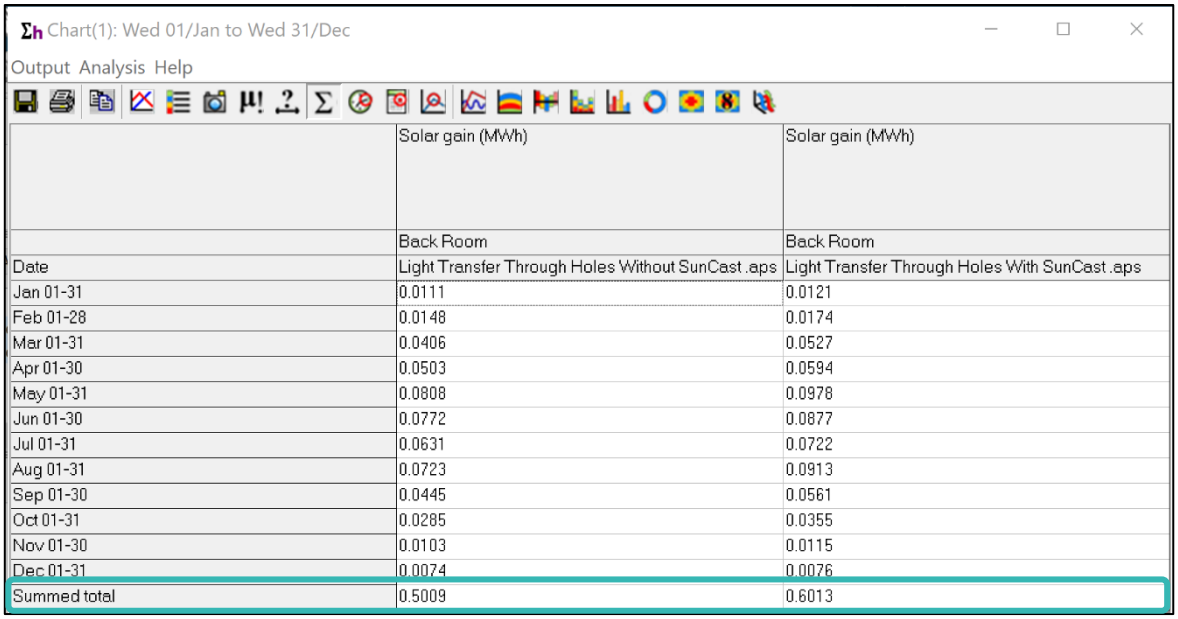
Output Analysis Help

	Solar gain (MWh)	Solar gain (MWh)
	Front Room	Front Room
Date	Light Transfer Through Holes Without SunCast .aps	Light Transfer Through Holes With SunCast .aps
Jan 01-31	0.0261	0.0237
Feb 01-28	0.0342	0.0304
Mar 01-31	0.0933	0.0774
Apr 01-30	0.1159	0.1029
May 01-31	0.1862	0.1653
Jun 01-30	0.1791	0.1685
Jul 01-31	0.1451	0.1336
Aug 01-31	0.1668	0.1466
Sep 01-30	0.1039	0.0901
Oct 01-31	0.0668	0.0576
Nov 01-30	0.0241	0.0222
Dec 01-31	0.0175	0.0163
Summed total	1.1591	1.0347

5.2. Back Room

The below chart and table show the difference in solar gain between two cases for the back room. In this room, there was a 20% increase in total solar gain when SunCast analysis was included when running the simulation. That's because SunCast used solar tracking to track incident solar radiation through the external window, then through the hole between the two rooms, into the back room.





	Solar gain (MWh)	Solar gain (MWh)
	Back Room	Back Room
Date	Light Transfer Through Holes Without SunCast .aps	Light Transfer Through Holes With SunCast .aps
Jan 01-31	0.0111	0.0121
Feb 01-28	0.0148	0.0174
Mar 01-31	0.0406	0.0527
Apr 01-30	0.0503	0.0594
May 01-31	0.0808	0.0978
Jun 01-30	0.0772	0.0877
Jul 01-31	0.0631	0.0722
Aug 01-31	0.0723	0.0913
Sep 01-30	0.0445	0.0561
Oct 01-31	0.0285	0.0355
Nov 01-30	0.0103	0.0115
Dec 01-31	0.0074	0.0076
Summed total	0.5009	0.6013

5.3. Why has this happened?

This is because ApacheSim doesn't perform solar tracking for the direct radiation when the SunCast link is not enabled which means direct/beam solar radiation is not tracked from the front room to the back room and it is treated as diffuse radiation. Instead of seeing the incident solar transmission as a solar gain, we would expect the results to show an increase in heat transfer in the form of conduction.

With SunCast enabled, direct solar radiation will be tracked from the front room to the back room, so that is why we see the decrease in solar gain in the front room and an increase in solar gain in the back room. It is worth mentioning here that holes are treated by SunCast as perfectly transparent.

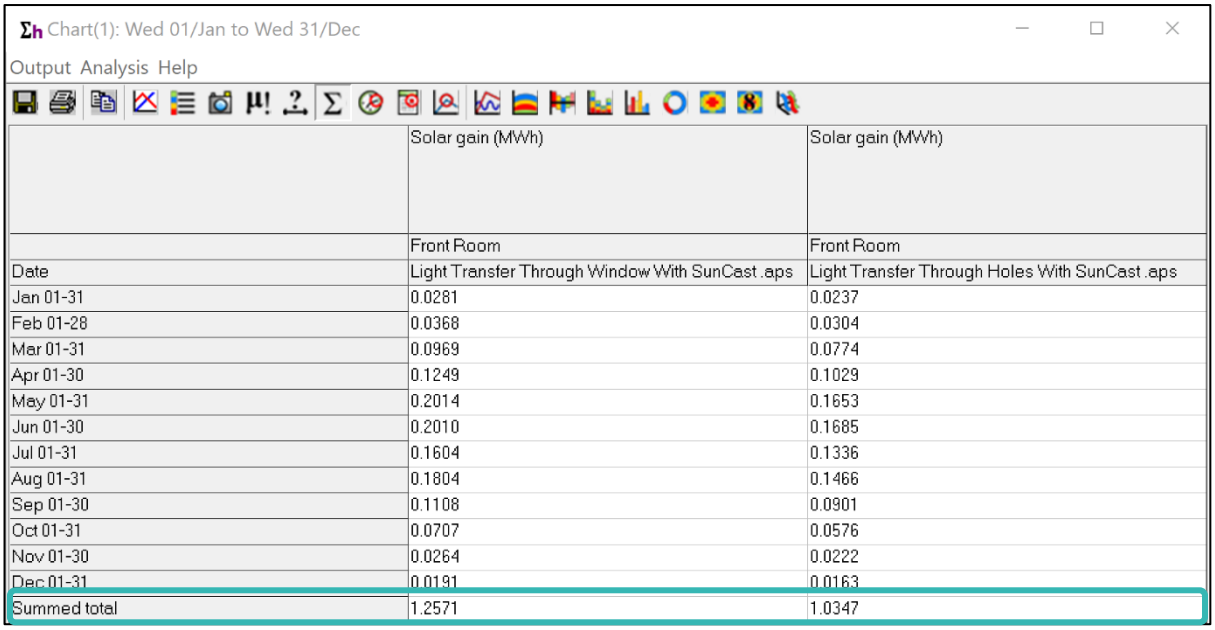
For more information on Solar Tracking, please visit Solar Radiation section in ApacheSim calculation methods.

5.3.1 Distribution Diffuse Radiation

Diffuse radiation that enters the building through external glazing is partially transmitted and partially absorbed by the element. In simple cases like this one, the transmitted part is distributed over the other surfaces in the room in proportion to their areas. Receiving surfaces will in turn reflect, absorb and transmit (if transparent or translucent) this radiation in appropriate proportions. Holes are treated as perfectly transparent as mentioned earlier. This means that when the distributed radiation falls on the hole between the two spaces, this surface will transmit it from the front room to the back room, as the properties of the hole will neither reflect nor absorb radiation.

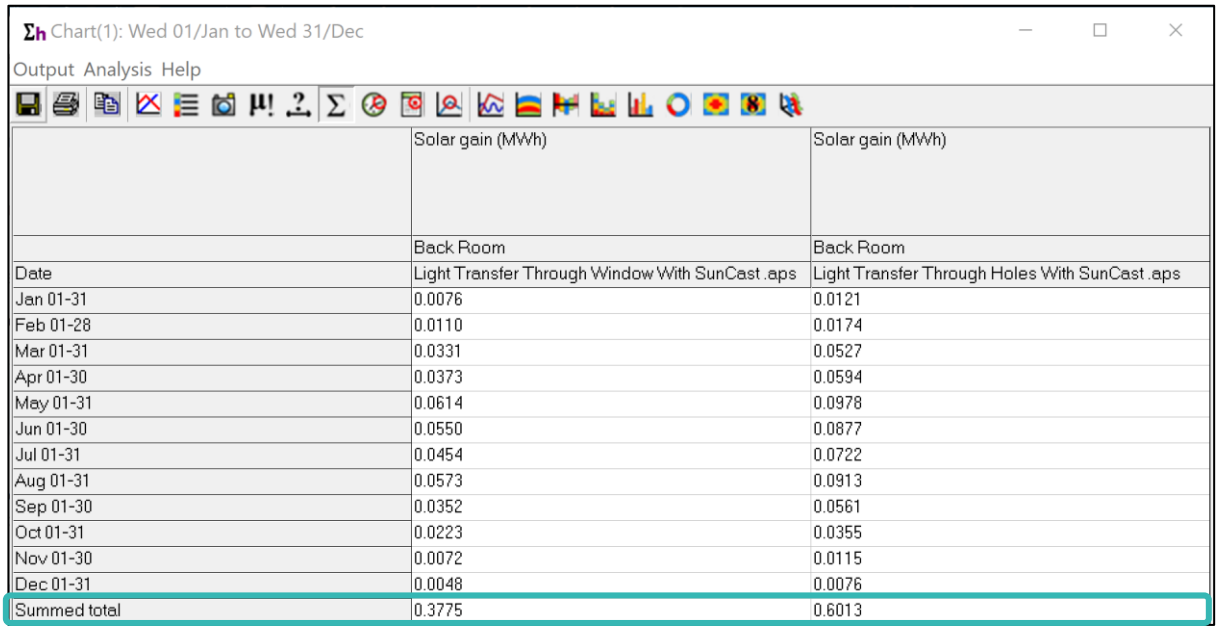
5.4. Test with an internal window instead of a hole

When the hole is converted into a window, solar gain in the front room increased, because the window is not fully transparent like the hole, hence some of the radiation will be reflected by the window back into the front room. The glazing of the window will also absorb some of the solar radiation.



	Solar gain (MWh)	Solar gain (MWh)
	Front Room	Front Room
Date	Light Transfer Through Window With SunCast .aps	Light Transfer Through Holes With SunCast .aps
Jan 01-31	0.0281	0.0237
Feb 01-28	0.0368	0.0304
Mar 01-31	0.0969	0.0774
Apr 01-30	0.1249	0.1029
May 01-31	0.2014	0.1653
Jun 01-30	0.2010	0.1685
Jul 01-31	0.1604	0.1336
Aug 01-31	0.1804	0.1466
Sep 01-30	0.1108	0.0901
Oct 01-31	0.0707	0.0576
Nov 01-30	0.0264	0.0222
Dec 01-31	0.0191	0.0163
Summed total	1.2571	1.0347

This reflected radiation is therefore not added to the back room, so its solar gain will decrease:



	Solar gain (MWh)	Solar gain (MWh)
	Back Room	Back Room
Date	Light Transfer Through Window With SunCast .aps	Light Transfer Through Holes With SunCast .aps
Jan 01-31	0.0076	0.0121
Feb 01-28	0.0110	0.0174
Mar 01-31	0.0331	0.0527
Apr 01-30	0.0373	0.0594
May 01-31	0.0614	0.0978
Jun 01-30	0.0550	0.0877
Jul 01-31	0.0454	0.0722
Aug 01-31	0.0573	0.0913
Sep 01-30	0.0352	0.0561
Oct 01-31	0.0223	0.0355
Nov 01-30	0.0072	0.0115
Dec 01-31	0.0048	0.0076
Summed total	0.3775	0.6013