Window Heat Issues

Contents

General

I had noticed that one of my AC units was running much more than the other one during the day and had initially guessed that it was due to improper placement of one of the thermostats. However, after moving the thermostat to its correct location, I noticed that, although it had improved considerably, the issue was still present. This led me to dig further into what was causing this imbalance.

By chance I happened to check the temperature around the inside window frames in the bed room that was causing the AC to run longer – image below. Much to my surprise, the upper inside part of the window frame registered at 89F! And this was around noon in a room set to 74F with double pane windows, closed plantation shutters, and solar screens when the outside temperature was 100F.

These windows face eastwards and receive the morning sun. Similar windows under similar conditions (also facing east) but under a porch roof, only registered at 81F.

Solar Screen Concerns

My initial thought was that there was something wrong with the solar screens. Research showed that solar screens lose a large part of their effectiveness after about 10 years. Interestingly I couldn't find any data that showed quantitative values for efficiency over time.

The screens were in good shape and were visibly sturdy and of good quality. I could only guess how old these were as the previous owner didn't leave any information about them. I have to assume that they were over 10 years old as the prior owners lived here for more than 10 years.

To get an idea of the screens remaining effectiveness I did a test the next day. I removed one the solar screens and monitored both of the windows during the day which produced the results shown on the following page.

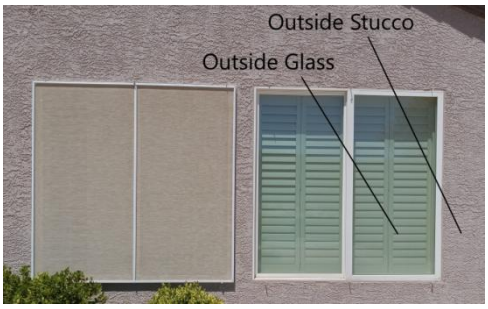
Note: the solar screens in this example are constructed of an unknown material, using strands of approximately 0.030" width with 0.030" gap between strands. This results in a mesh that blocks about 75% of the outside radiation.

Note: all temperature measurements were taken with an industry standard temperature gun.

Test #1 – Solar Screen vs. No Solar Screen

The following test attempts to determine the relative effectiveness of my aged solar screens.

Legend: No solar screen Solar screen



Results:

7/3/2022	1A	1B	1C	2A	2B	2C	Outside Stucco	Outside Glass	Outside Temp
9am	93	92	?	?	?	?	?	?	93
10am	94	92	78	85	83	76	146	119	95
11am	90	90	78	85	83	77	140	115	96
12pm	86	86	77	82	81	76	126	108	97
1pm	85	85	76	81	81	76	113	101	98

This table illustrates a critical (and often non-intuitive) point that the peak material (stucco, glass, etc.) temperature does NOT occur with the peak outside air temperature, but rather when the sun's rays are directly beating down on the surfaces. For vertical walls this is when the sun is still lower in the sky.

As can also be seen from this table, the peak inside temperature occurs at 10am in the window with no solar screen. The window with a solar screen is 9 degree cooler. The difference from room temperature (74F) is 11F for the window WITH a screen, and 20F for the window WITHOUT a screen. Therefore the solar screen is providing about an 82% cooling benefit (over no solar screen and relative to the room temperature.) This is a relative percentage measure and doesn't prove if the screen is fully functional or not, but it does show that there is a clear benefit to using the screen – even though it is old.

What is alarming about this data is that, at 10am, the inside window temperature (without a solar screen) is only 1 degree cooler than the outside temperature! It's as though the window doesn't even exist. Clearly there must be something else in play here as the windows are high quality double pane construction and would be expected to do a better job keeping the heat out.

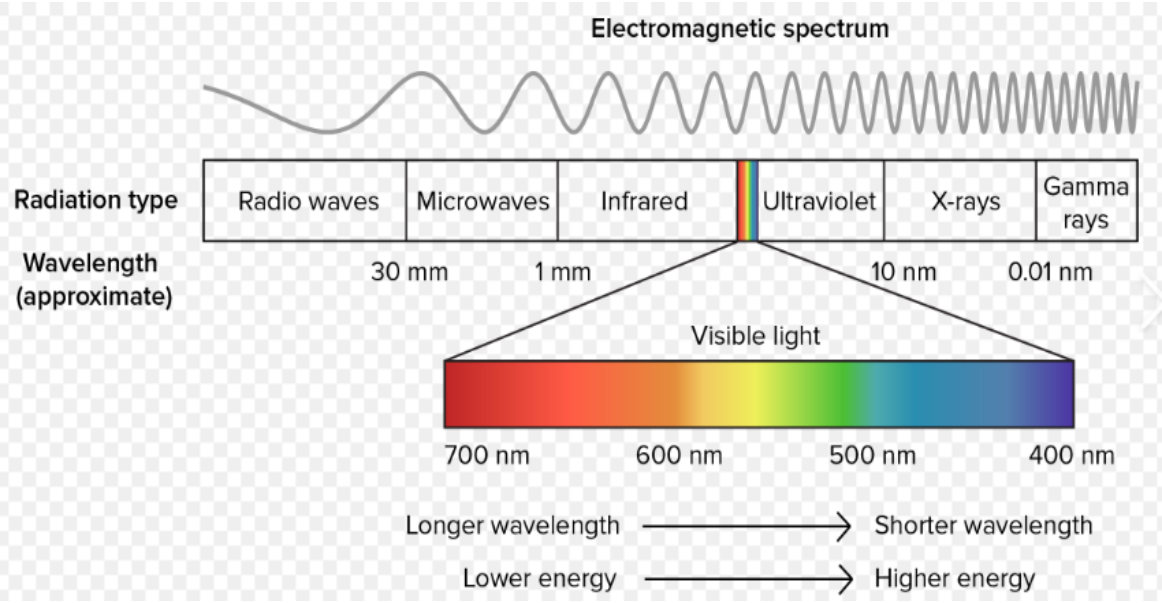
The next section describes my efforts to determine what is causing this "extra" heat.

UV Concerns

The previous Solar Screen section highlighted the fact that there was "extra" heat accumulating in the window area between the window and the plantation shutters. This section delves into what is likely causing this problem.

From [Window Protection From Solar - Radiations (mgsarchitecture.in)] (some grammar corrected) the following is found:

> It is quite obvious that window glasses are practically transparent for short-wave radiation emitted by the sun but almost opaque for long-wave radiation emitted by objects in indoors. The consequence of this is that the radiant heat, once it has entered through the glazed area, is trapped inside the building. This could, in fact increase at times the indoor temperature far above outdoor air temperature, even in moderate climates 'greenhouse effect'. An ordinary window **glass transmits a large proportion of all radiation between 300 and 3000 nm**.(i.e. both visible light and short-wave infra-red), but very little around and outside these values. With the recent advancement in glass technology, it is possible that varying the composition of the glass to reduce substantially the infrared transmission and modify this selective transmittance of the ordinary glass.



3000nm (or 3um) is only 0.23% (2300nm into the 999.3um range) into the Infrared (IR) range, so over 99% of the Infrared is blocked by the glass.

300nm is roughly 25% into the Ultraviolet (UV) range, so a considerable amount of UV is converted to IR when it is absorbed by objects in the room (such as the closed shutters on the window.) This IR energy is trapped in the room and explains how the room can get hotter than the outside temperature.

UV Film Solution

The area between the glass and the plantation shutter acts as a greenhouse that is heated by the sun's UV rays when the plantation shutters are closed. If the plantation shutters are opened, that same heat would simply flow into the room at a quicker rate.

The solution would seem to be to block the UV radiation from entering the room. The most practical way is to apply a film to the window that reflects UV radiation back out the window so that it does not cause the inside to heat up.

The following window film Amazon.com: Filmgoo Window Privacy Film One Way Daytime Mirror Tint Treatments UV Heat Control Vinyl Stickers Sun Block Glass Paper Door Covering Reflective 35.4 Inch x 13.1 Feet Black Silver : Home & Kitchen claims to block 97% of UV rays. I ordered one roll and applied it to the right side window.

As can be seen, it looks nicer, and reduces the glare of the sun.

Comparing Window Performance (1->2 Delta)

In the following tests the "1->2 Delta" column represents the combined temperature difference between window "1" and "2" and is calculated as follows:

"1->2 Delta" = (2a – 1a) + (2b – 1b) + (2c – 1c)

A positive number means window "2" was that much warmer, and a negative number means window "2" was that much cooler than window "1".

In all of these test cases window "1" is the "untouched" comparison window, and window "2" is the window that has somehow been modified to try to reduce the heat transfer. Therefore negative numbers indicate that the test has succeeded in reducing the heat, and positive numbers indicate that the test has failed and actually made the heat transfer worse.

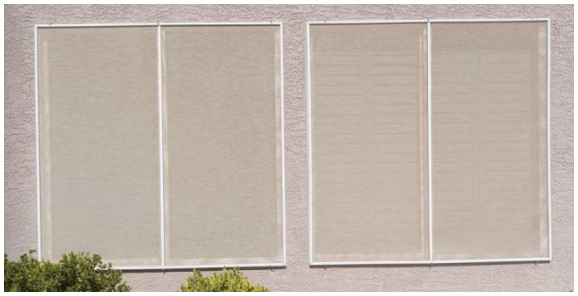
A larger negative number means that the test was more successful than a smaller negative number.

While not perfect, this means of comparing window covering performance is relative, and therefore avoids the problem of comparing results from two different days when the outside temperature was different.

Test #1 – Solar Screen AND UV Film

I then ran a simple test with both solar screens on the windows, both plantation shutters closed, and the right window (2) now having the UV film applied to see if the UV film reduced the overall window heat. The results are shown below.

Legend: solar screen solar screen WITH UV film



Results:

7/8/2022	1A	1B	1C	2A	2B	2C	1->2 Delta	Outside Temp
8:52am	88	84	85	86	88	84	+1	98
10:10am	89	85	86	86	89	84	-1	100
11:11am	88	84	84	84	87	83	-2	102
12:40pm	84	82	81	80	83	81	-3	101
1:25pm	84	82	83	81	83	81	-4	100
2:17pm	83	82	82	81	82	80	-3	101
3:00pm	82	81	81	80	81	79	-4	?

The surprising observation here is that, although the outside edges (A & C) of the UV film window are a degree or two cooler, the center of the UV film window is 1-4 degrees hotter!

This was very perplexing as I was expecting the UV film window to be noticeably cooler than the window without UV film.

After thinking about it for a while, the only conclusion that made any sense was that the solar screen (contrary to previous thinking) was actually doing a good job and blocking most of the UV from entering the window. If this were true then there would be no benefit to adding the UV film – because there wouldn't be any UV left to block.

Then the additional heat could be explained by the fact that the UV film might have added an additional infrared (IR) barrier that reflected some of the trapped heat back into the room that would otherwise have gone outside through the window.

Test #2 – UV Film Without Solar Screen

After the confusing results of Test #1, this test was run to determine if the solar screen and UV film provide equally good solar blocking capabilities. If this is true, then using both would be a waste of time.

This test was run with no solar screen on the inside right window which has the UV film. Both windows still have their plantation shutters closed.

Legend: solar screen UV film only (no solar screen)

Results:

7/9/2022	1A	1B	1C	2A*	2B	2C	1->2 Delta	Outside Temp
6:30am	75	76	75	79	78	78	+9	85
7:26am	80	81	80	91	92	87	+29	90
8:29am	87	87	85	97	97	91	+26	97
9:18am	88	88	87	96	98	91	+21	100

This roughly 10 degree hotter trend on the window without the solar screen closely follows the previous test that was done without a solar screen or UV film.

It should be noted that the UV film is providing some benefit (about 50% of the solar screen benefit) at the edges of the window, but almost no benefit at the center of the window. So overall the UV film would be providing roughly 25% of the benefit provided by the solar screens.

This would indicate that the UV film is providing little benefit (compared to solar screens) in blocking the sun's infrared heat from entering the house. The film may be blocking UV (which can damage fabrics) but from the point of view of reducing infrared heat to reduce AC usage, the UV film does not appear to provide anywhere near the benefit of good solar screens.

*for a possible explanation of why 2A is significantly hotter than 2C please see Defective Caulk.

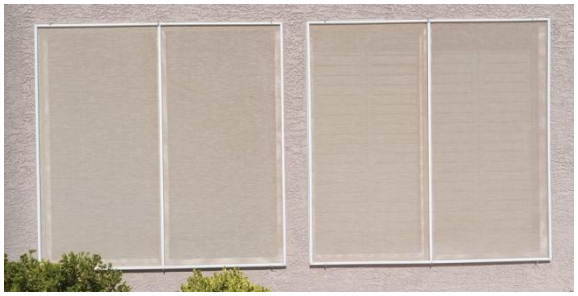
*for a possible explanation of why the blue cells might be lower than they should be please see Tree Shade.

Rejuvenate the Sun Screens

You can rejuvenate your sun screens to increase their sun blocking ability by applying a light coat of Outdoor ScotchGard.

In this test I applied ScotchGard to the "2" window sun screen. This was applied with the sun screen on the window and some of the ScotchGard went through the screen and onto the window glass. It is not very noticeable, but you may want to remove your sun screen before spraying it to avoid this issue if you find it unsightly.

Legend: solar screen solar screen WITH UV film AND ScotchGard



Results:

7/10/2022	1A	1B	1C	2A	2B	2C	1->2 Delta	Outside Temp
6:15am	76	76	76	76	76	76	0	85
7:00am	77	79	79	80	80	78	+3	90
8:00am	86	86	85	86	87	84	0	96
9:00am	90	90	87	86	89	84	-8	104
10:00am	90	91	87	87	90	84	-7	106
11:00am	90	90	87	87	89	85	-6	106

ScotchGard Benefit

Comparing the "1->2 Delta" values from the Before ScotchGard Test and After ScotchGard Test results for the common hours of 9am-11am shows the following.

	Before ScotchGard "1->2 Delta"	After ScotchGard "1->2 Delta"
9:00am	+1	-8
10:00am	-1	-7
11:00am	-2	-6

This is a dramatic cooling improvement of 5-10 degrees!

Side Issue Discovered After Running Tests

Defective Caulking

IMPORTANT – I later realized that this hole is a functional part of the window and should NOT be blocked. All of the windows have this hole and it is referred to as a "weep hole." For more information see: How To: Test the Weep System on Your Milgard® Vinyl Windows and Doors | Milgard

Prior Comments

The window referred to as window "2" in these tests has a large gap (~ 1") in the exterior caulking as shown below (in position "2A".) This gap extends almost 2.5" into the wall. I fixed the gap after the tests – not wanting to confuse the tests by altering the conditions.

This could go a long way to explaining why "2A" temperature readings are a few degrees higher then "2C" readings in the UV film tests when the solar screen was removed from window "2" (the solar screen covers this hole when it is mounted.)

Tree Shading Window "1" in Early Morning

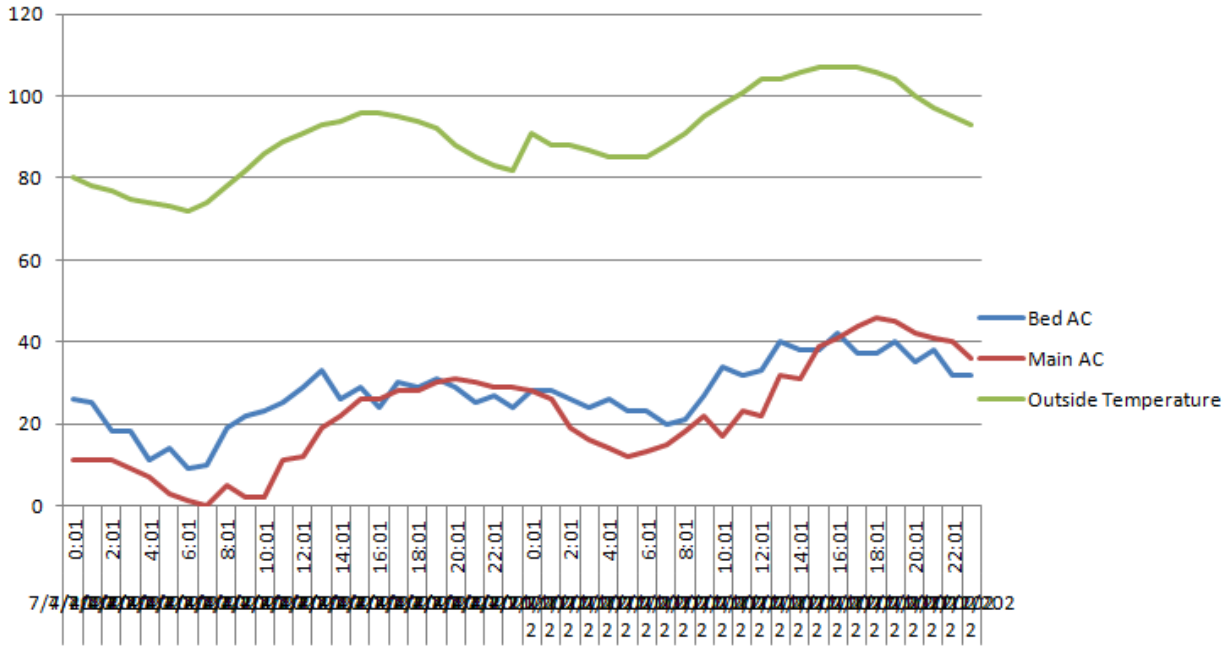
As can be seen in the picture taken 7/9/2022 @ 6:32am, window "1" is partially shaded by one of the back yard trees. This accounts for early morning temperatures being lower on the "A" side of window "1".

The shadow only covers about 10% of the window in the bottom right by 7:00am and is completely gone by 7:20am (07/10/2020.)

AC Usage Changes

The chart below shows two different days' usage data as follows:

1. 7/4/2022 (on the left) before the window heat issues were addressed.
2. 7/11/2022 (on the right) after the window heat issues were addressed (ScotchGard applied to solar screens.)



Although the second day was considerably hotter, the important thing to note here is that the Bed AC (blue) and Main AC (red) lines are now closer together showing that the morning heat issues in the Bed area have been mitigated to some extent.

Note also that on the first day the bed AC barely ever dips below the main AC, whereas on the second day the bed AC clearly dips below the main AC in the afternoon. This is what is expected as the bed AC has to work against the morning sun, whereas the main AC has to work against the afternoon sun.

By reducing the heat coming through the windows to a reasonable amount, the system is now able to function more efficiently because the cooling load is equally balanced between the two AC units.

Power Savings

I had initially expected this to result in noticeably lower power bills, but the initial bill is not showing significant savings. As can be seen in the graph below July 5-August 4 (changes were made July 10) shows an 18% reduction in power from last year.

Average Daily Electric Usage

Usage	No. Days	Avg Daily kWh
This Month	30	57.9
Last Year	32	70.8

Cost Per Day This Month: $8.50

Your average daily electric consumption is **LESS** this month compared to last year. -18%

Meter Information

If NV Energy is unable to read your meter because of circumstances beyond control, you may be billed based on estimated usage for that billing period.

Meter#	Type	Service Period	Bill Days	Previous	Current	Multiplier	Usage
[redacted]	kWh	Jul 5, 2022 to Aug 4, 2022	30	7,286	9,023	1	1,737

However, it is also obvious that all previous months also had approximately the same reduction as well. This 18% reduction is due to the fact that the air circulator feature was turned off (see Air Circulator Savings.)

While there are many other factors that can affect this crude comparison (year to year temperature differences, other electrical usage, etc…) it is clear that simply applying ScotchGard to existing solar screens did not “dramatically” reduce power usage. However it did clearly have an effect on AC operation as it balanced the dual AC systems to operate equally.

So, while the power bill does not provide a clear benefit, it can be concluded from the other evidence presented here that the solar screens and the ScotchGard application does provide a demonstrable improvement – albeit difficult to accurately measure using a power bill.

Conclusions

The window covering solutions are rated below from best (at the top) to worst (at the bottom):

1. A brand new high-quality solar screen properly mounted.
2. An old high-quality solar screen properly mounted and sprayed with ScotchGard.
3. An old high-quality solar screen properly mounted.
4. A quality UV window tint film.
5. A plain old window with nothing added.

Other observations:

- It is not worth putting both solar screens and window tint film at the same time – at least from a heat standpoint, if you want to reduce glare as well this would make sense-.
- It is worth the time to check your windows and seal any exterior cracks or holes.