SOLAR SHADING SYSTEM DESIGN

The River Building contains a curtain wall system with over 50% glass. The building's east, north, and south façade are all glass with two different tints ordered to create a checkered pattern. The glass U-values and solar shading coefficients can be found in the *ASHRAE Standard 90.1 Compliance Requirements* section. With over 50% glass coverage, the HSS River Building has no system to shade the windows, reducing the solar heat gain passing through the windows.

This proposal will evaluate the internal heat load reduction by using solar shades on the southern and eastern façades. It will also look at solar shade placements in order to gain maximum energy savings and shadings.

METHODOLOGY

To evaluate solar shade placements and overhang lengths, the location of the HSS River Building needs to be shown in latitude and longitude.

- Latitude: 40'47"
- Longitude: 73'58"

Also, the location of the sun on any given day is also important. By finding the altitude and azimuth angle of the sun position in New York, the HSS River building can know exactly where the sun will be at the given time. The number of clear days given in a month describes the average amount of days that contains clear skies. **Table 15** shows the altitude and azimuth of the sun at noon on the 15th of every month along with the clear days of each month.

Table 15 – Monthly Altitude and Azimuth

Month	Altitude	Azimuth	Clear Days
Jan	28.1	178.7	8
Feb	36.5	177	8
Mar	47.5	178.4	8
Apr	59.3	182.1	8
May	68.3	185.1	7
Jun	72.6	182.8	8
Jul	70.7	178.8	7
Aug	63.1	180	8
Sep	51.9	183.8	10
Oct	40.3	186.1	11
Nov	30.4	185.4	7
Dec	26	182.3	8

Table 15 shows all the azimuth angles at the peak of the day is roughly around 180 degrees, meaning the sun is on the south face of the building at noon at all months.

The shaded area on the southern and western façade can be calculated with the altitude given. **Figure 12** shows the mathematical relationship with the overhang length, shaded length, and altitude.

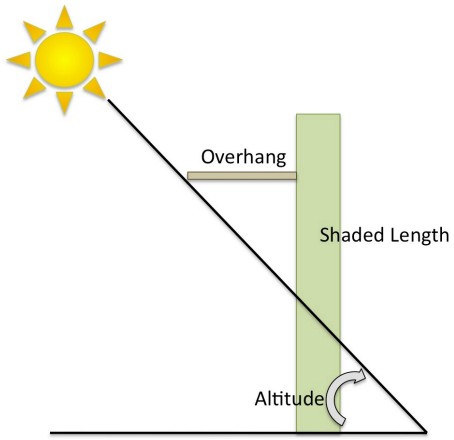

Figure 12. Sun angles with overhang.

The shaded length on the window can be calculated for each month given the geometric relationship of the sun angle and overhang length. To evaluate which overhang length shades the most, an excel sheet was created with an option of three feet, four feet, and five feet overhangs. **Table 16** shows the shaded length at noon for the 15th of each month.

Table 16 – Monthly Shaded Length – South

	Overhead Length		
	3 feet	4 feet	5 feet
Jan	1.60	2.14	2.67
Feb	2.22	2.96	3.70
Mar	3.27	4.37	5.46
Apr	5.05	6.74	8.42
May	7.54	10.05	12.56
Jun	9.57	12.76	15.96
Jul	8.57	11.42	14.28
Aug	5.91	7.88	9.86
Sep	3.83	5.10	6.38
Oct	2.54	3.39	4.24
Nov	1.76	2.35	2.93
Dec	1.46	1.95	2.44
Average	**4.44**	**5.93**	**7.41**

The equation to find the solar heat gain is given below:

$$Solar\ Heat\ Gain(BTU/Hr) = (1-R)(A)(SHGF)$$, where

R = shaded area/window area

A= total window area

SHGF= Solar heat gain factor = 64 BTU/Ft^2 for southern exposure

Table 17 shows the amount of solar energy coming through each month by multiplying the solar heat gain by the number of clear days. This case was analyzed for shades at the lengths of three feet, four feet, and five feet. Lastly, a percentage was taken of the difference in BTU savings with the difference in length with no solar shades.

Table 17 – Solar Gain (BTUs) For Each Month

	3ft Overhang	4ft Overhang	5ft Overhang	No Solar Shade
Jan	40,248,324	38,181,552	36,114,780	46,448,640
Feb	37,856,094	34,991,911	32,127,729	46,448,640
Mar	33,776,191	29,552,041	25,327,892	46,448,640
Apr	26,891,534	20,372,498	13,853,463	46,448,640
May	15,109,999	6,599,146	1,911,708	40,642,560
Jun	9,394,192	2,957,290	15,308,773	46,448,640
Jul	11,628,327	1,956,916	7,714,496	40,642,560
Aug	23,559,822	15,930,216	8,300,610	46,448,640
Sep	39,548,879	33,378,239	27,207,599	58,060,800
Oct	50,326,117	45,812,529	41,298,941	63,866,880
Nov	34,681,348	32,694,277	30,707,207	40,642,560
Dec	40,785,011	38,897,135	37,009,259	46,448,640
Total	**363,805,838**	**301,323,751**	**276,882,456**	**568,995,840**
Percent/Length	**21.31%**	**13.24%**	**9.73%**	

The calculations show that by adding a three feet overhang, the HSS River Building can see a 21% reduction in solar energy per length added. As more length is added to the overhang, the solar energy savings is reduced.

ENERGY ANALYSIS

The calculations demonstrated that by providing a solar shade of three feet, the HSS River building is able to decrease solar energy gain by 21% per length, which is better than the 13% and 10% reduction done by adding a four and five feet overhang respectively. In order to maximize energy savings and minimize cost, the three feet overhang will be used to model our building with external solar shades. By modeling the solar shades in Trane Trace, the HSS River Building saves 189,750 kWh a year in energy. **Table 18** shows the energy breakdown and savings yearly. **Appendix F** shows detail breakdown of energy savings for all system components.

Table 18 – Yearly Energy Breakdown

	Cooling	Total kWhr
No Solar Shades	245 Tons	3,148,800
Solar Shades – 3ft	225 Tons	3,035,346
Savings	**20 Tons**	**189,750**

The solar shade system will provide enough shading to the building to reduce the cooling load by 20 tons and save as much as 189,750 kWhr a year.

COST ANALYSIS

The cost analysis will analyze the payback for installing and purchasing such a system for the HSS River Building. The solar shades that were selected for this project are made by Construction Specialties, located in Cranford, New Jersey. CS specializes in architectural grilles and solar shades for curtain wall systems. A quote from a CS representative states that:

- Solar Shades: $50/sqft
- Solar Shades weight: 7lb/sqft
- Installation cost: 15% material

The solar shade system being installed on the HSS River Building will have:

- 3 ft – Overhang
- 1,100 linear feet of solar shades

Table 19 provides the break down of the initial cost of the solar shade system and also the cost of removing a 20-ton Heat Pump from the system. This will assume that the reduction in 20 Tons will remove equipments and piping equivalent to a 20-ton Heat Pump.

Table 19 – Solar Shade System Cost Breakdown

	Qty	Price/Ea.	Total
Solar Shades			
6" Airfoils ($/sq.ft.)	3,300	$50	$165,000
Installation			
Labor & Parts (15% Material)	495	$50	$24,750
SOLAR SHADE SYSTEM TOTAL			**$189,750**
Heat Pump			
20 Tons	1	$18,800	$18,800
Installation & Piping			
30% of Total Cost	.3	$18,800	$5,640.0
DIFFERENCE TOTAL			**$165,310**

The solar shade system will have an initial cost of $189,750 but by reducing the cooling load by 20 tons, the analysis assumes that the 20-ton reduction will be the removal of 20-ton heat pump equipment, therefore subtracting that cost from the initial cost to get the difference initial cost of $165,310.

CONCLUSION

In conclusion, the solar shade system will provide amble shading for the curtain wall glass façade of the River Building. By reducing the amount of solar gain from increasing the internal loads, the solar shade system saves 20 tons in cooling load while also saving 189,750 kWhr in energy use a year. Besides from saving energy, the solar shades provide less glare from entering each office along the perimeter of the building, improving work productivity. Also, with a simple payback of 4.3 years, equaling four years and four months, the solar shades are a great system to provide energy and heat reduction while promoting better lighting and productivity.