THE SHADING IMPERATIVE

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ABSTRACT

Adding shading to existing buildings offers perhaps the best and most affordable combination of architectural design potential and energy savings to combat the increasing temperatures associated with climate change. In the next twenty years we have the potential to dramatically impact the energy performance of about 60% of our building stock. Adding shading systems is affordable, generally cost effective and is minimally invasive. Other basic building systems, such as lighting and HVAC systems, are usually replaced at the end of their useful lives and the new systems are always more energy efficient – and make a great combination for energy retrofits with the exterior shading. Upgrading wall systems by replacing windows and increasing insulation levels and installing air/water barriers is costly and interrupts occupancy for leased commercial space.

Energy performance simulations for Albuquerque were done to evaluate a not-so-distant future that is about 2.5F warmer for both a small 2-story, 12,000 square foot office building and for a single, 20,000 square foot floor of a taller, multi-story office building. The cooling load for the 2-story building increased by 16.5% and 11.5% for the single floor of the taller building. If exterior shading is added to the 2-story building, the cooling load decreased by .2% (or a net of -11.7% from the non-modified building) and 11.7% (or a net of -22.7% for the large floor plate). A similar process was conducted for Salt Lake City with a future temperature rise of 4.5F. Here the results were an increased cooling load of 18.6% for the 2-story office and 21% for the single floor plate. If exterior shading is employed, the cooling load decreased by 5.1% (a net benefit of 23.7%) in the 2 – story building and 10.8% (a net benefit of 30.8%) in the large floor plate. The overall energy cost was not affected as significantly as the cooling because the shading increased the heating load. Cooling loads are significant, however, because they are totally met by electric power – generally much more polluting than heating energy.

1. SETTING

Climate change is well underway in the Southwest. In Albuquerque, for example, the average annual temperature over the last ten years is 1.8F higher than the long-term normal. Most climate change models haven't predicted increases of this magnitude until after 2020. The last time that the Albuquerque temperature was below normal for a year was in 1987. The implications for the built environment, for utility companies, for building owners, and the general public are dramatic if these trends continue unabated into the future. This paper assumes that for the near future, the temperature increases will continue. The average temperature in the Southwest has already increased roughly 1.5F compared to a 1960-1979 baseline period. By the end of the century, average annual temperature is projected to rise approximately 4F to 10F above historical baseline, averaged aver the Southwest region. The likely range of model projections, though lower or higher outcomes are possible

I will make some observations and calculations that are best described as a "thought experiment" in which I will test the implications of providing shading and basic energy efficiency measures on two typical office layouts. I will expand this process to see what the impact *might be* if carried out at a much larger scale.

TABLE 1. COMPARATIVE CLIMATES

	Salt Lake City	Albuquerque	Lubbock
Average Annual Temperature	51.8F (11C)	56.3F (13.5C)	58.8F (14.9)
Average Annual Relative Humidity	53%	41%	56%
Diurnal Change	22F (12.2C)	26F (14.4)	25F (13.9)
Percent Possible Sun	67%	76%	72%
Elevation at Airport	4226 ft (1288m)	5355 ft (1632m)	3281 ft (1000)

2. SIMULATIONS

The small 2-story office building is 60' by 100' with 50% of its' façade glazed. A basic set of design parameters were used that are typical for office buildings of this size. Most of these were default numbers provided by the software used, Energy 10. A few minor adjustments were made based on local data, current codes, and experience to the values for HVAC controls, lighting and plug loads. The sequence of simulations followed the following format for each city: 1) Base buildings were simulated, 2) Base buildings were simulated for a warmer future climate, 3) Base building were modified with exterior shading only, and 4) Base buildings were simulated with a standard selection of energy efficiency strategies in Energy-10. The energy efficient strategies applied *did not include* insulation improvements in the walls, added thermal mass, PV, and solar hot water systems because these require major interventions in the building fabric and were judged less likely to be applied in commercial renovations.

The sample floor plate from an office building of moderate to large size was determined to be 20,000 square feet and also has a façade that is 50% glazed. The same minor adjustments were made to the HVAC, controls, interior lighting and plug loads. Rather than trying to determine what comprises a "typical" taller building, a single floor of a common size was simulated by making the roof and floor r-values = 1000.

The problem of how to simulate a warmer climate in the future was addressed by evaluating current weather data for Southwestern cities that have similar weather and sunlight patterns, but are slightly warmer or cooler now than my base in Albuquerque. Using Regional Climate Center and National Weather Service data, Albuquerque was selected as the future climate for Salt Lake City in about 2030 and Lubbock, Texas as the future climate for Albuquerque in about 2020. It is easily conceivable that Albuquerque's climate will be 2.5F warmer on average in 2020 and Salt Lake City's will be 4.5F warmer by 2030 based on weather data over the past ten years. All three cities are higher altitude, mostly sunny and have high diurnal temperature swings. (See TABLE 1 for a comparison of some basic climate information for the three cities.) Using these three cities in this manner can only be posited as future possibilities in the range of probable climate change. Remember, this is an investigation into potentials.

3.RESULTS

TABLES 2 to 5 tabulate the results of the energy performance and cost simulations performed for the two scenarios for both Salt Lake City and Albuquerque. The future climate with an average temperature increase of 4.5F for Salt Lake City led to increased cooling loads for the Small Office Building of 18.6% and 21% for the Large Floor Plate. As we add shading those numbers are dramatically reduced and can be interpreted as *avoided* cooling load increases of 23.7% and 31.9% respectively. For Albuquerque, the timeline is shorter and the average temperature increase is only 2.5F. Consequently, the cooling load increases are not as dramatic. In this case the cooling loads increased for the Small Office Building by11.5% and16.5% for the Large Floor Plate. The avoided cooling load increases are 16.7% and 23.2% respectively.

In both cases the total cost savings is not in proportion to the reduction in cooling load because the heating load will increase without as much solar gain. The implications for cost and energy savings is still positive even though it doesn't take account of three additional factors: 1) the electrical energy savings will triple when generating and transmission losses from the electrical generating plant are included; 2) the reduction in carbon pollution created at the electrical generating plant which is probably coal fired; and 3) large cost savings when demand charges are included for most office buildings with a peak load over 50kW.

When all the energy efficiency measures are taken that are non-invasive of the building skin/construction are added to shading, the savings become truly impressive in both energy and cost. In Salt Lake City, the cooling loads drop over 50% and the overall costs drop by over 40%. In Albuquerque, the savings in cooling load is over 60% and the overall energy costs drop from 45 to 62%.

TABLE 2. SALT LAKE CITY: SMALL OFFICE BUILDING

	Cooling (kWh/year)	% Change	Cooling Costs ($/year)	All Energy ($/year)	% Change
Current Climate	49,204		$4,920	$24,046	
2030 Climate	58,354	**+ 18.6%**	$5,835	$24,245	+ .8%
2030 + Shading	46,709	**- 5.1%**	$4,670	$22,391	- 6.9%
2030 + EE Strategies	23,218	- 52.8%	$2,321	$13,387	- 44.3%

TABLE 3. ALBUQUERQUE: SMALL OFFICE BUILDING

	Cooling (kWh/year)	% Change	Cooling Costs ($/year)	All Energy ($/year)	% Change
Current Climate	58,354		$5,835	$24,245	
2030 Climate	67,981	**+ 16.5%**	$6,798	$25,028	+ .4.2%
2030 + Shading	58,209	**- .2%**	$5,820	$23,455	- 3.3%
2030 + EE Strategies	21,552	- 63.1%	$2,155	$9,053 - 62.7%	

TABLE 4. SALT LAKE CITY: LARGE FLOOR PLATE

	Cooling (kWh/year)	% Change	Cooling Costs ($/year)	All Energy ($/year)	% Change
Current Climate	83,709		$8,370	$53,498	
2030 Climate	101,280	**+ 21%**	$10,128	$55,853	+ 4.4%
2030 + Shading	74,587	**- 10.8%**	$7,458	$50,711	- 5.2%
2030 + EE Strategies	36,581	- 56.3%	$3,658	$30,903	- 42.2%

TABLE 5. ALBUQUERQUE: LARGE FLOOR PLATE

	Cooling (kWh/year)	% Change	Cooling Costs ($/year)	All Energy ($/year)	% Change
Current Climate	101,280		$10,128	$55,853	
2030 Climate	112,907	**+ 11.5%**	$11,290	$57,834	+ 4.4%
2030 + Shading	89,416	**- 11.7%**	$8,941	$52,869	- 5.2%
2030 + EE Strategies	40,518	- 60%	$4,051	$30,498	- 45.4%

4. PROJECTIONS AND SPECULATIONS

The sample above is tiny but not insignificant in demonstrating the potential of the shading imperative. In Salt Lake City there is about 32,000,000 square feet of office space with over 13,000,000 square feet in Albuquerque. According to the 2003 Commercial Buildings Energy Consumption Survey (CBECS) report (the latest available), there is more than 12 billion square feet of office space and a total of 53 billion square feet in all other building types, excluding industrial uses. A *much* more detailed analysis would be needed to determine how many buildings are poorly shaded in this inventory though I would hazard a guess that it exceeds 50%.

If we make a conservative assumption that 15% of the energy use in office buildings can be saved with just the application of exterior shading systems and half of the inventory needs shading then we can save 7.5% of the energy used in offices. The overall office use is just over 1.1 Quad of energy in Btu's (or 1,134,000,000,000,000 Btu's) so the savings would be about 79,000,000,000,000 Btu's. Converting to kWh and using a current national average of $0.10/kWh leads to a potential saving of $2.3 billion per year! Why not push the speculation and expand it to all building areas? In this case, the savings could exceed $10 billion/year.

Of course, the savings in both energy and dollars in this "thought experiment" can be challenged with every assumption. The range of savings could be substantially higher - or much lower. But, in any case, they are truly significant. And remember, this final exploration of savings is *only for shading* and would be several magnitudes larger if all applicable energy efficiency measures are applied.