FLEXLAB®
IMPROVING WINDOW FILMS TO REDUCE COOLING LOADS AND GLARE

Use of FLEXLAB's unique facilities identifies promising window film candidates for energy savings and visual comfort.

THE CHALLENGE

Identifying the best applications for a novel, 3D printed, window film

Innovative window films can improve control of solar radiation at windows, reducing cooling loads and improving distribution of daylight. Companies developing these films need to determine their performance under a variety of real-world conditions so they can improve their products..

THE SOLUTION

Funded by the California Energy Commission's CalTestBed clean energy voucher program, Lucent Optics turned to the U.S. Department of Energy's FLEXLAB® facility at Lawrence Berkeley National Laboratory to help narrow down their window film design parameters to values more likely to achieve superior performance. They had two goals: (1) to measure the bidirectional scattering distribution function (BSDF) of a number of samples and (2) to conduct a full-scale measurement of the energy (HVAC, lighting) and comfort (visual, thermal) impacts of at least one film prototype, for two solar angle "seasons" ("high" and "low" solar angle).

> **"With the Berkeley Lab's FLEXLAB®, we are able to experiment and evaluate our prototypes of window films in an actual real world environment. This allows us to thoroughly review our technologies in order to ensure maximum energy savings and occupant comfort, as well as to gain confidence in our designs."**

Sergey Vasylyev, Ph.D., President & CEO, Lucent Optics, Inc.

THE BOTTOM LINE

Use of the films reduces solar heat gain and cooling needs.

FLEXLAB® tests demonstrated that Lucent Optics films are able to reduce heat gains and cooling needs, while also identifying which films performed better in reducing daylight glare. One prototype was unexpectedly good at solar control. Based on these results, Lucent focused subsequent prototype development on solar control rather than light redirection.The company can now use this information to fine-tune its best-performing products.

THE EXPERIMENT

- Three window films and two reference conditions (window without film and window with commercially available tinted film selected to match the solar heat gain coefficient of one of the test film samples) were evaluated in spring and fall. Each test condition was evaluated for a full 24-hour period and had at least one sunny day. Two window orientations were evaluated for each window film.
- FLEXLAB has thousands of sensors including hundreds of sensors for evaluating indoor environment conditions and performance. Supporting measurements—interior and exterior vertical irradiance, interior window temperature, infrared (IR) images—were used to validate the main results.
- Discomfort glare was evaluated using the visual comfort rating based on Daylight Glare Probability (DGP). The maximum DGP value for 95% of the data and the average DGP for the top 5% of DGP data were calculated and used to classify the level of discomfort glare.
- Thermal comfort was determined using predicted mean vote (PMV), a method to predict the mean value of votes of occupants on a seven-point thermal sensation scale. The analysis used data from two thermal comfort stations, each measuring dry-bulb temperature, mean radiant temperature, relative humidity, and air speed. A percentage of time PMV between -0.5 and 0.5, which complies with ASHRAE Standard 55, was computed.

THE RESULTS

- Daily cooling energy use was generally found to be lower for all film configurations tested, compared to the reference. The highest savings were consistently for south-facing tests in the fall. Cooling savings for west-facing tests also were significant during the spring. For daily heating energy use, differences between film and reference configurations were generally small, and possibly not significant.
- Useful daylight illuminance (UDI) is the percentage of a time period during which illuminance levels are within a range deemed sufficient for general visual tasks but not so excessive that glare is likely. In the spring test, daily UDI was slightly higher for most film configurations. For the fall test, daily UDI was lower for most film configurations. Generally, the film configurations improve UDI when reducing horizontal illuminance relative to an unshaded window. Facing south, when solar altitude is low, Film 2 clearly performed better than the others due to its absorptive properties. For west-facing tests, Film 3 appeared to have an advantage.
- DGP showed similar glare performance between film and reference conditions in all cases except for Film 2 versus reference condition 1 (no film) when south-facing (both test periods) and west-facing (fall test period). During the fall test period, DGP improved significantly in the test room with Film 2 for the wall-facing view. In one instance, with Film 1, with the window facing west, the DGP for the wall-facing view worsened.
- In the spring test, PMV thermal comfort differences between the two cells were small but consistent, with the test cell feeling slightly cooler than the reference cell at 6 feet from the window, and slightly warmer at 12 feet. During the fall tests, the test cells felt consistently warmer than the reference cell at 6 feet from the window, with a smaller magnitude and less consistent effect at 12 feet.
- IR images that were captured as a quality check, further substantiating claims of reduced solar heat gain and cooling needs.

Energy Technologies Area
BERKELEY LAB