# Switchable Glazings

A Pacific Energy Center Factsheet

Pacific Gas and Electric Company
Pacific Energy Center

## Introduction

Building skins encounter a tremendous range of climatic conditions due to orientation, daily variations and annual cycles. The ultimate cladding material would change its properties in response to environmental conditions outdoors and occupant needs indoors.

One material being developed with the ability to change its energy properties is glazing. Switchable glazings change their properties, such as shading coefficient and visible transmittance, in response to either an electric signal or an environmental signal such as light levels. Because of their potential for energy savings, these technologies are being studied in research labs and a few products are commercially available. Switchable glazings fall into four categories defined by the mechanism that gives the signal to change a property: electrochromic, liquid crystal, thermochromic, and photochromic.

### *Electrochromic*

Electrochromic glazings vary their optical and thermal properties due to the action of an electric field and change back again when the field is reversed. Because these materials offer the potential for a window to change from clear to tinted at the flip of a switch, this technology is a very active area of glazing and energy research.

Electrochromic windows switch from clear to fully darkened and can be maintained at any level of tint in between. Visible transmittance can generally be varied in the range of 5-80%. These windows run on very low voltage (1-3 V) and require energy only to change their condition, not to maintain any particular state. The glazing may be spectrally tuned, for example, to absorb only solar infrared. Electrochromic glazings may eventually replace traditional solar control technologies such as tints, reflective films and shading devices.

Electrochromic materials consist of a thin, multi-layer assembly that would typically be sandwiched between traditional glazings. The two outside layers of the assembly are transparent electronic conductors. Next is a counter-electrode layer and an electrochromic layer, with an ion conductor layer in between. A low voltage is applied across the conductors, moving ions from the counter-electrode to the electrochromic layer, tinting the assembly. Reversing the voltage moves ions from the electrochromic layer back to the counter-electrode layer, restoring the device to its previous clear state.

The ability to control the transmittance of glazings for privacy, visual comfort, thermal comfort, peak load management, and other building functions suggests that they will play a critical role in future high-performance commercial building envelopes. Both field testing of lab prototypes and computer simulation indicate very large energy savings potential with electrochromics. In fact, electrochromic windows are expected to outperform any other building envelope component for both cooling and lighting energy, and show excellent potential to minimize peak electrical demand.

A research prototype of electrochromic window glazing is on display the Pacific Energy Center's second floor. The technology has also been used in the rear view mirrors and sunroofs of some cars, where, the driver can simply touch a switch to tint the mirror or sun roof.

Electrochromic windows and Liquid Crystal glazed windows (see next section) are available from:
SAGE Electrochromics, Inc.
2150 Airport Drive
Faribault, Minnesota 55021
www.sage-ec.com
Tel: (507) 333-0078 phone
Fax: (507) 333-0145
E-mail: info@sage-ec.com

Schott Donnelly LLC Smart Glass Solutions produces an electrochromic filter for skylights. Contact Stephan Hansen at (520) 321-7680 or stephan@schottdonnelly.com, or look at their webpage, www.schottdonnelly.com/Pages/ucolite.htm, for more information.

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**Liquid Crystal**

Liquid crystal switchable glazing is also controlled electronically, although the technology is completely different than a true electrochromic. When the current is applied to this material, its appearance changes from translucent to relatively clear. Although useful for privacy control, liquid crystal glazings do not provide energy savings. A sample of this material is on display in the Pacific Energy Center lobby. Currently, only one product exists, which was also the first commercially available switchable glazing. This laminated unit, using any type of heat-strengthened glass, has an interlayer consisting of two PVB films enclosing a "Taliq" film encasing tiny liquid crystals. Both faces of the film are covered with a transparent, electrically conductive metal coating. These conductive coatings are wired to a power supply. When there is no power to the glazing, the liquid crystals are randomly scattered. Light entering the glazing does not have a clear path out - the crystals diffuse light in all directions. In this "off" condition, the glazing is a translucent milky white. When an electric current is applied between the two conductive coatings, the liquid crystals align neatly. In this "on" condition, light passes through relatively unobstructed and the glazing becomes a slightly hazy clear.

The switch between the two states is nearly instantaneous. The optical properties, other than the diffusion of light, are nearly identical between the two states. The shading coefficient is virtually unchanged. The visible transmittance goes from 75% in the on state to 67% in the

off state. Because there is little change in performance properties and because it requires constant energy to maintain its clear state, this product has no energy saving benefits.

Liquid crystal is used indoors for privacy control. There have been some outdoor installations, as in some bathroom windows at the Kauai Sheraton Hotel; however, the manufacturer does not provide information on long-term sensitivity to solar ultraviolet radiation or wide temperature swings and outdoor durability is therefore unknown.

The French glass company St. Gobain currently produces liquid crystal glazing. The product requires a transformer and installation of framing and wiring by a manufacturer-authorized installer. For more information contact Euroglass in White Plains, New York at (914) 683-1390.

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**Thermochromic**

Thermochromic materials change their properties in response to changes in the ambient temperature. Researchers are exploring several different technologies for suitability, with gel-based coatings the most promising thus far. As these materials become warmer, they typically change from clear to diffusing. They also become white and reflective, reducing solar transmittance. In general, this type of glazing can save significant air conditioning energy by automatically reducing solar load when it's hot outside. Because this glazing loses its transparency when it switches, it is probably best used in skylights rather than in view windows.

The only commercially available product, "Cloud Gel," is a thin plastic film that can be incorporated into almost any glazing assembly. The response temperatures of "Cloud Gel" can be adjusted depending on need and location. For more information, contact Suntek in Albuquerque, New Mexico at (505) 345-4115.

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**Photochromic**

Photochromic materials, which darken as incident light levels increase, have been widely used in sunglasses for years. The move up to window-sized applications, however, has not yet been accomplished successfully. One hurdle is cost-effectiveness and manufacturing difficulties for larger pieces. Another problem is limited application because photochromic windows would be suitable for glare control. but not for solar control or heat gain reduction, as incident light and cooling load do not necessarily coincide. For example, low sun angles in the winter cause higher incident radiation on a vertical window than in the summer. In this example, a photochromic window would darken more in the winter than in the summer - opposite the desired effect.

The thermochromic film "Cloud Gel" also exhibits photochromic behavior. Contact the manufacturer for more information.

## Summary

Will we have dynamic building skins in the 21st century? The use of switchable glazings in commercial buildings would reduce peak electricity demand, as well as lighting and HVAC energy consumption. The most promising switchable glazing technology, photochromic coatings, use an applied voltage to modulate solar transmission. Maximum benefits would be achieved by using these materials in conjunction with dimmable electric lighting controls. In the future, switchable glazings may make the envelope an active component in integrated control of the whole building.

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## For More Information

Although they do not yet have a product available, AFG Glass Inc. is also researching the potential applications of electrochromic glazings.
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Kingsport, TN 37660
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Tel: (423) 229-7200 or (800) 251-0441
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You can also call 1-800-468-4743 for more information about PG&E's energy efficiency programs and other services.