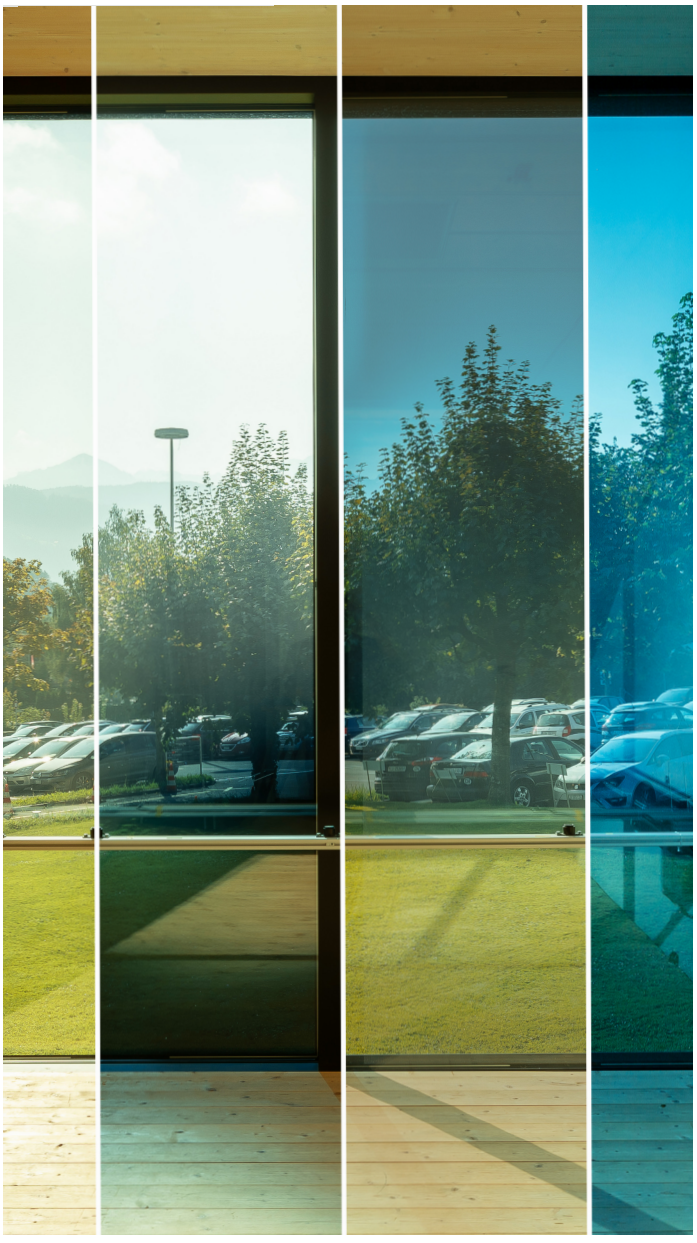
TRANSPARENT ALTERNATIVE TO WINDOW BLINDS

From an energy perspective, windows have an opposite effect depending on the time of year: In winter, they allow solar heat into the interior and thus reduce heating demand. In summer, on the other hand, solar heat gain is often undesirable because it can lead to increased cooling demand. Blinds and other adjustable exterior solar shading systems serve to keep summer heat out of interior spaces. An alternative to this is window glass that can be darkened by applying an electrical voltage, so-called 'electrochromic glass.' The Lucerne University of Applied Sciences and Arts (HSLU) has documented the advantages and disadvantages of this technology in a literature study. The researchers conclude that energetic advantages of electrochromic glass over standard systems can only be determined on a case-by-case basis.



The window of the HSLU light measurement container shows four settings of the electrochromic glass (from left to right): untinted; continuous gradient from top, bright, to bottom, tinted; continuous gradient from top, tinted, to bottom, untinted; tinted. Photomontage: Licht@hslu

Questions about the lighting play an important role in the architecture of residential and commercial buildings. Many

A technical report about the results of a research project in the field of buildings and cities, which was financially supported by the Swiss Federal Office of Energy. The report has been published in the technical magazine Spektrum Gebäudetechnik (issue March 2022).

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people appreciate bright rooms that create a connection to their surroundings through large windows and sometimes accentuate the effect of the interior design and color scheme. Unlike in Switzerland, the subject of light and lighting even has its own field of study abroad. In London, for example, University College London (UCL) offers a Master of Science in Light & Lighting. "Among other things, the course deals with the effect of light on people, but also addresses lighting design techniques," says Janine Stampfli, who completed the master's program.

Stampfli now works as a scientist at the Institute for Building Technology and Energy (IGE) at HSLU. She is a member of the Licht@hslu thematic platform, which is dedicated to various issues relating to artificial light and daylight. On the green lawn of the HSLU campus in Horw, there is a rotatable container that can be used to simulate and investigate daylight situations. The light measurement container can be oriented such that the sun enters its interior from different directions through the façade window. Since 2019, the façade window has electrochromic glazing.

The light measurement container on the HSLU campus in Horw during the installation of the electrochromic glass. Photo: Licht@hslu

Three generations of glass

In a recently completed research project, Janine Stampfli and a team of HSLU researchers studied electrochromic glass in more detail. Electrochromic glass is able to control the optical transmittance electrically (see text box), which, according to the manufacturers, enables the glass to be used as sun and glare protection. Electrochromic glass has been available since the mid-1990s and has gradually improved since then. In the first generation, glass transparency was controlled over the entire surface in fixed, pre-programmed levels (e.g., light, darkened, dark). Later, electrochromic glass was introduced which had three tint zones that could be controlled individually. This made it possible, for example, to darken the three sections of a large glazed patio door to different degrees. Products have also been developed that do not require fixed, pre-programmed tint settings. The latest generation of elec-

HOW ELECTROCHROMIC GLASS WORKS

Eyeglasses equipped with photochromic lenses darken when exposed to solar radiations. This process is different with electrochromic glass: The darkening does not occur automatically. Instead, optical transmission is regulated by the application of an electrical voltage. When the electrical charge is transferred to a thin coating (for example, tungsten oxide), the coating becomes optically active and changes its transmittance, usually giving it a bluish appearance. Depending on the magnitude of the applied voltage, different degrees of transmittance are produced, which affects the light transmittance and the total energy transmittance of the glass. The duration of this process varies depending on the product and depends, among other things, on the surface area of the glass and the outside temperature. When the voltage is removed, the glass returns to its initial untinted state. The voltage can be controlled via a building automation system or manually.

Untinted electrochromic glass has a lower light transmittance than conventional glazing: with conventional triple glazing, 73 to 75 % of the light penetrates into the interior, with electrochromic glass 47 to 61 %. The total energy transmittance is also lower with electrochromic glass. This means that in winter, solar heat gains are lower, as is the light yield, which is important in the darker months. For the summer, on the other hand, electrochromic glass has desirable properties: even in the untinted state, less heat penetrates than with conventional glass. A reduced light yield due to electrochromic glazing is less critical in the summer months because of the longer and brighter days. BV.

Example of glazing divided vertically into three zones whereby darkening of each zone can be controlled separately. Photo: SageGlass/Jeffrey Totaro

trochromic glass has two special settings in addition to full-surface tinting: the tinting transitions within the surface area of the glass are seamless, i.e. from dark at the top to light at the bottom, or from light at the top to dark at the bottom. Aesthetically, this is a step forward compared to the zoned glass.

Despite these advances, electrochromic glass has so far only been used sporadically in Switzerland, mainly in office buildings. The best-known manufacturer is the US company SageGlass, which has around 85 completed projects in Switzerland. "The reason for the reluctance is probably due to the lack of long-term experience. The use of electrochromic glazing is still considered more risky than that of standard glazing with adjustable external solar shading," says Stampfli. The research project she led, which was funded by the SFOE, has now examined the advantages and disadvantages of electrochromic glass. The results are based on a literature study, i.e. an evaluation of the available studies on the subject. Some findings are also based on measurements in the HSLU light measurement container, which are currently being carried out on behalf of the Amt für Hochbauten der Stadt Zürich.

Energetically equivalent, but not necessarily better

Heat protection in the summer is a focus of current building research, as the number of hot days in summer is likely to increase due to climate change. This could lead to residential buildings also being increasingly equipped with cooling systems, combined with an undesirable increase in energy consumption. "The use of electrochromic glass can reduce the cooling demand," the HSLU final report states. However, the evaluated studies give "an inconsistent picture" in this regard, the authors note. Therefore, they advise to study the use of electrochromic glazing on a project-specific basis (e.g.

by means of integral simulation) if an increase in energy efficiency is desired. The final report states that "structural decisions such as the orientation of the façade and the size of the façade openings play just as important a role as the choice of the façade system and the control strategy."

In winter, electrochromic glass has the disadvantage that it lets less thermal energy into rooms than conventional window glass, even when it is not tinted. Nevertheless, the HSLU researchers assume that electrochromic glass will clearly gain in importance when the number of very warm summer days increases due to climate change. They point to several advantages that the glass has over conventionally used sun protection systems (blinds, external venetian blinds): Because the glass does not have any mechanical parts, it is more robust and also more resistant to wind. Moreover, the brightening and darkening takes place silently. Particularly important for residents is that a view to the outside is guaranteed even in darkened conditions.

Life cycle costs matter

Various studies show that the investment costs for electrochromic glazing are higher than those for conventional triple glazing with external solar shading. However, since there are lower cleaning and maintenance costs because there are no mechanical parts, the electrically switchable glass "has a life cycle advantage," says Prof. Björn Schrader, lecturer in building technology at the HSLU and head of the Licht@hslu platform. In addition to functional buildings, he sees an area of application for electrochromic glass in heritage buildings, among others, as they may not be equipped with conventional solar shading due to the resulting change in their external appearance.

In their future research activities, the HSLU researchers want to include the room users in their investigations. After all, it is well known that the energy-optimized control of automated sun-shading systems is sometimes undermined by human intervention, thereby counteracting energy efficiency. "Since

Office buildings have so far been the most important area of application for electrochromic glass. The photo shows a glass front made by the US company SageGlass (part of the French industrial group Saint-Gobain). Other important manufacturers include the German company Econtrol-Glas GmbH & Co. KG, the Japanese-American joint venture Halio International, the US glass manufacturer View Inc. and the Swedish company ChromoGenics. Photo: SageGlass/Valentin Napoli

the process of tinting is barely perceptible, we suspect that such interventions are less likely to occur with electrochromic glass, making it potentially advantageous in achieving energy-saving goals," says Stampfli.

- Interested professionals and groups can **visit** the light measurement container and the electrochromic glass on site in Horw by appointment. Contact: janine.stampfli@hslu.ch.

- The **final report** on the project 'Electrochromic Glass. A literature study' is available at: https://www.aramis.admin.ch/Texte/?ProjectID=46574

- For **information** on the project, please contact Nadège Vetterli (nadege.vetterli[at]anex.ch), external head of the SFOE research program Buildings and Cities.

- For more **technical papers** on research, pilot, demonstration and flagship projects in the field of buildings and cities, please visit www.bfe.admin.ch/ec-gebaeude.

View into a production facility of electrochromic glass. Photo: SageGlass

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