Electrochromic Smart Glass:
Supplier Comparison Return on Investment Analysis

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In recent years, sustainability in construction has become the focus of how the industry can progress with minimal environmental impact. As sustainability certifications become more desirable, key companies in the construction industry have started to seek greener alternatives to standard building systems. There are many sustainable products that are released, but these products are typically so complex that members of the industry are not familiar with these new systems. One novel piece of technology introduced to the industry is electrochromic glass, or smart glass. Electrochromic glass windows examine sunlight and heat exposure from the surrounding environment and change their opacity to maximize utility of the natural environment and increase indoor environmental quality. This report will determine the feasibility, advantages, and disadvantages of utilizing electrochromic glass windows in commercial construction projects. The primary focus of this report is a Return on Investment (ROI) comparison between three smart glass manufacturers. Currently, there is very limited data on the effectiveness of this technology as it only appeared in the industry in 2010. Through conducting interviews with several smart glass suppliers and material data analysis, the most current implications of electrochromic technology in commercial construction have been compared and analyzed in this report.

Key Words: Sustainability, Electrochromic, Technology, Return on Investment, Environmental, Comparison

Introduction

Indoor environmental quality control is essential to every functional building. Keeping up with the current market trends, the construction industry is beginning to explore sustainable alternatives to standard systems that manage indoor environmental quality. In addition, third-party certifications such as LEED (Leadership in Energy and Environmental Design) credentials increase a building's value and are becoming increasingly sought after by contractors for new projects. Of the many ways to achieve a higher LEED rating, one key factor is by reducing energy consumption in a building. Most of the building's energy cost is attributed to the heating, cooling, and lighting of a building. Electrochromic glass, or smart glass, is a technology that analyzes the amount of sunlight and heat exposure from the sun and alters its opacity in response. This altering of opacity controls how much

light enters the building envelope at certain times of the day, which naturally heats, cools, and lights the building. This can greatly reduce energy expenditures that would typically be used for lighting and temperature control, especially in commercial buildings with large windows exposed to the sun. Electrochromic glass costs more upfront than a standard glazing system but has the ability to substantially save energy costs of a building in the long run. Additionally, smart glass can influence three separate LEED categories affecting indoor environmental quality, building energy and atmosphere, and innovation in the design process.

Literature Review Discussion

There are many articles on the advantages of using smart glass technology, however, there is little data on return-on-investment analysis with supplier comparisons. One article by Heather Benjamin titled, "LEED-Certified Office Buildings Found to Bring High Sale Premiums" details a study that demonstrates how LEED accredited buildings offer a premium increased market value over standard buildings of the same size. It demonstrates one of the benefits of gaining LEED accreditation from utilization of smart glass. In Thomas Caprio's "Electrochromic Windows: Return on Investment Analysis" he performed a return-on-investment analysis for only one company. In addition, Caprio's work analysis was only on one specific project using a single supplier's smart glass. Due to the limited amount of data, this became this author's basis for comparison on competing suppliers' return-on-investments. Another article written by Amy Cortese of the New Buildings Institute, described the percentage of carbon emissions by construction and provided strategies on how to lower this number. In another publication, Alex Fitzpatrick of Axios detailed the advantages of utilizing smart glass in reducing energy consumption in buildings and the practical application of the technology. From the leading manufacturer of smart glass, Sage Glass, the article I reviewed provided a plethora of information on the specifics of smart glass technology in application. Lastly, an article by Dmitri Maxim of Smart Glass Country provided valuable information on the range of smart glass costs for different sized applications. All the literature reviewed provided useful information and built a foundation for performing a return-on-investment comparison between electrochromic smart glass suppliers, which has not been conducted before.

About Electrochromic Technology

This report focuses on three major suppliers of electrochromic products. These suppliers are Halio, Smart Glass Technologies, and Smart Glass Country. In addition to their advanced sustainable design, electrochromic systems additionally allow building designers more design freedom. They essentially eliminate the need for shade structures in a building, therefore opening endless possibilities of attractive exterior glazing systems.

Electrochromic technology has many advantages to the typical standard glazing systems used by most buildings. These advantages include, but are not limited to, overall energy savings, ability to control the indoor environment, increased aesthetic appeal and ease of design, and higher level of comfort for occupants of buildings. Although smart glass units are more expensive than standard glazing, they provide many long-term benefits that are more difficult to obtain without substantial building design implications. The electrochromic technology devices vary depending on the company as their designs are slightly different, but all are some variations of an Insulating Glass Unit (IGU). For example, as shown in Figure 1, Sage Glass technology, the leading smart-glass global manufacturer, includes a double pane IGU that contains five layers of ceramic material coated onto a thin piece of glass

(SageGlass, 2022). By applying a small electrical charge, lithium ions transfer layers which cause the glass to tint, and reversing this process results in the glass clearing.

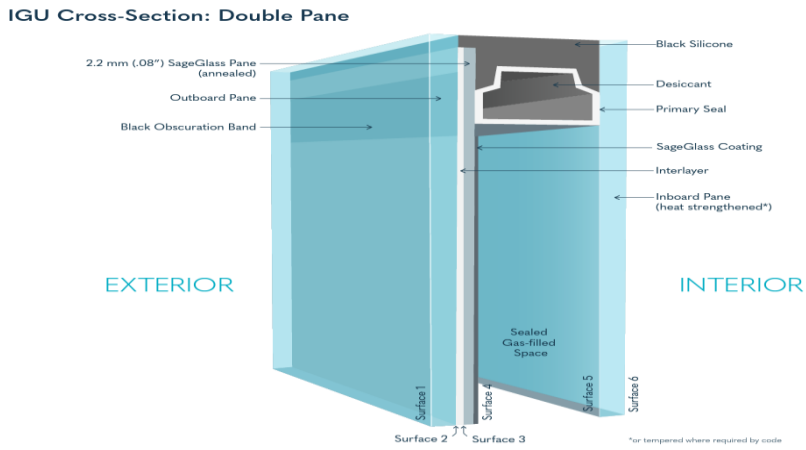

Figure 1: Sage Glass IGU (SageGlass, 2022)

This however must be connected to an overall electrochromic building system to work effectively. The system includes both a communications hub and a system intelligence that works together to effectively create an active electrochromic system for the building envelope. The system intelligence considers external and internal temperatures, building orientation, occupancy, and time of day among other factors to communicate with the communications hub what process should take place within each IGU. This ensures the comfort of all occupants of the building, and this method of an electrochromic system is consistent for all the companies I have picked to highlight.

Methodology

The primary methodology used for this report consists of interviews conducted with material suppliers to obtain quantitative data on their respective products. It also includes several interviews with construction management professionals that have used one or more of these products on commercial construction projects. The return on investment analysis includes an evaluation of cost implications associated with smart glass, as well as disadvantages and advantages of utilizing this technology. The steps to repeat this report are as followed:

1. Gather general information about electrochromic technology and its applications via literature review.
2. Interview industry professional(s) who have worked on projects with electrochromic technology.
3. Obtain prices of smart glass applications through interview(s) with smart glass suppliers or further research.
4. Perform return on investment analysis for each supplier.
5. Compare each supplier return on investment for its product to determine which is the most profitable.

Results

Sustainability's Influence on The Construction Market

In recent years, sustainability in construction has been a primary goal for most commercial construction general contractors and related project owners. This sustainable design utilizing sleek materials and technology not only increases the aesthetic of the building, but it more importantly increases the value of the building. As aforementioned, LEED buildings and their credits are becoming increasingly sought after as these structures successfully address the triple bottom line of people, planet, and profit which motivates the market. According to USGBC, "LEED-certified Class A urban office sales generated a 25.3% price per square foot premium over noncertified buildings" (Benjamin, 2022). In different categories, the premiums range from this 25.3% to an astronomic 77.5% premium per square foot for class B offices. Utilizing electrochromic technology is not only sleek from a design perspective but affords owners a competitive advantage in the commercial construction market. Additionally, carbon emissions from construction are a constant battle for the industry as according to the New Buildings Institute, "Buildings account for 39% of global energy-related carbon emissions" (Cortese, 2022). As shown in the figure below (see figure 2), 28% of the total global emissions of CO2 can be attributed to building operations. The heating and cooling of buildings is a large part of their CO2 emissions from building operations, and the implementation of an electrochromic system would drastically reduce those emissions. According to the U.S. Department of Energy, smart glass can reduce a building's heating or cooling energy needs by about 20% (Fitzpatrick, 2022).

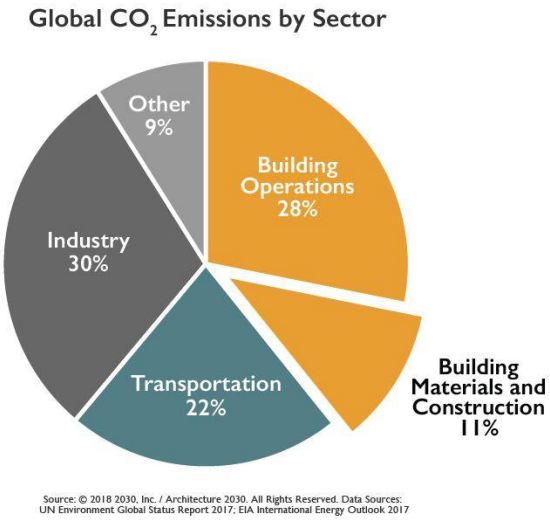

Figure 2: Global CO2 Emissions by Sector (Cortese, 2022)

Financial Implications of Electrochromic Technology

The use of Electrochromic Technology certainly has financial implications that a project owner should be aware of. Though new devices and technology in general are more expensive than their standard counterparts, there are certainly many objective benefits to investing a little more upfront. However, it is important to acknowledge that higher upfront costs of electrochromic technology can

be a deterrent, which makes the utilization of this technology less feasible. Electrochromic windows are also electrical units, which may require a higher cost for the associated electrical subcontractor on the project. Additionally, after interviewing members of the construction industry who used an early version of this product, they described difficulties with delivery of the units and on-site installation.

Cost of Standard Glazing

Contained in Table 1 is the cost of standard glazing for a hypothetical commercial construction project based in Southern California, which includes 5,000 SF of glazing and 30,000 SF of building floor plate. The estimates received by each company reflects this type of project roughly based on building size and square footage of smart glass. The "Standard Glazing" figure in Table 1 refers to the costs typically associated with a standard window system. The "minimum" column represents the cost of a standard window system for the hypothetical building that does not include any additional add-ons to the glazing units. The items in the left column represent additions that can be implemented to the typical standard glass unit (Caprio, 2022). This cost is broken down by square feet, linear feet or kilowatt hours depending on the line item. The "maximum" column represents the most expensive cost of a standard glazing system with all of the additional modifications denoted in the left column to increase indoor environmental quality and functionality.

Table 1

Cost of Standard Glazing + Additional Fees for Modifications

Standard Glazing + Additional Fees for Modifications	Minimum	Maximum
Low-E Glass Cost @ $15 - $25 (per SF)	$75,000.00	$125,000.00
Low-Iron Glass [Ultra Clear] @ $3 (per SF)	$0.00	$15,000.00
Acoustic Rating STC 45 [Add Lamination] @ $5 (per SF)	$0.00	$25,000.00
Interior Blinds or Shades @$12 - $35 (per SF)	$60,000.00	$175,000.00
Safety Glass - HT or FT @ $5 (per SF)	$0.00	$25,000.00
Exterior Window Treatments / Shade @ $0 - $80 (per SF)	$0.00	$400,000.00
Dry Wall Pockets for Electric Shade @ $85 (per LF)	$0.00	$41,055.00
HVAC Right-sizing @ $45 (per SF Floor Plate)	$0.00	$135,000.00
10 Year Energy Savings 2kWh - 4KWh @ $0.18 (per kWh)	$106,344.00	$212,688.00
Totals	$241,344.00	$1,153,743.00

ROI by Company

Halio ROI

The table below (see table 2) compare the cost of using Halio's electrochromic product to a standard glazing system. As described earlier, the minimum side of the standard glazing total represents window systems with standard grade rating, and the maximum category denotes the cost of a standard system with the most expensive possible modifications. As noted, for a building with 5,000 SF of glazing, the Halio product upcharge is $108,656. That means that the Halio Product is $108,656 more

expensive than the cheapest standard glazing window system total. However, the product is $803,743 less expensive than the most expensive standard glazing window system. Considering average annual energy savings of $11,800 (Caprio, 2022) the breakeven point for the glazing cost will be achieved in 9 years and 2 months after the completion of the project.

Table 2

Comparison of Halio Costs to Standard Glazing Costs

Net Halio Upcharge vs. Standard Glazing			
Halio Budgetary Price Total			$350,000.00
Standard Glazing System Total			
(Minimum)			$241,344.00
(Maximum)			$1,153,743.00
HALIO Upcharge			
(Minimum)			$108,656.00
(Maximum)			-$803,743.00

The breakeven point for the return on investment depends on the square footage of the building floor plate and the square footage of the glazing included in the building design. The ROI for Halio's product is determined from the cost of the product for a building that is 30,000 SF, and 5,000 SF of glass and its annual energy savings data provided by Halio. Halio has reported an average $11,800 of energy costs saved annually on projects where their product is used. For the $350,000 Halio total system cost, a return on investment will be achieved in 29.7 years.

Smart Glass Technologies ROI

The table shown below (see table 3) compares the cost of using Smart Glass Technologies' electrochromic product to the standard glazing system. As aforementioned, the minimum side of the standard glazing total represents window systems with standard grate rating, and the maximum category denotes the cost of a standard system with the most expensive possible modifications. The table below includes the same 30,000 SF building with 5000 SF of glazing. For a building of this size the Smart Glass Technologies product upcharge is $433,656. This means the Smart Glass Technologies product is $433,656 more expensive than the cheapest standard glazing window system total. However, as shown with the Halio product previously, the Smart Glass Technologies product is $478,743 less expensive than the most expensive standard glazing system. Using the constant average energy savings of $11,800 annually the breakeven point for the glazing cost with Smart Glass Technologies will be achieved in 36 years and 9 months.

Table 3

Comparison of Smart Glass Technologies Costs to Standard Glazing Costs

Smart Glass Technologies Upcharge vs. Standard Glazing			

Smart Glass Technologies Budgetary Price Total	$675,000.00
Standard Glazing System Total	
(Minimum)	$241,344.00
(Maximum)	$1,153,743.00
Smart Glass Technologies Upcharge	
(Minimum)	$433,656.00
(Maximum)	-$478,743.00

Smart Glass Technologies was unable to provide me with an average energy annual savings cost, so I used the average provided by Halio. Utilizing this average, it is calculated that eventually over the building's lifetime, the Smart Glass Technologies electrochromic system will pay for itself in energy savings. For the $675,000 Smart Glass Technologies system cost, a return on investment will be achieved in 57.2 years and any subsequent time elapsed will turn a profit.

Smart Glass Country ROI

Table 4 below compares the cost of using Smart Glass Country's electrochromic product to the cost of the standard glazing system. The minimum side of the standard glazing total represents window systems with the standard grate rating, and the maximum category denotes the cost of a standard system with the most expensive possible modifications. For a building with 5,000 SF of glazing with Smart Glass Country's electrochromic product, the upcharge is $233,656. This means that the Smart Glass Country product is $233,656 initially more expensive than the least expensive standard glazing window system. However, the product is $678,743 less expensive than the most lucrative standard glazing window system. Considering the previously established average annual savings of $11,800 the breakeven point for the Smart Glass Country glazing cost will be achieved in 19 years and 10 months after the completion of the project.

Table 4

Comparison of Smart Glass Country Costs to Standard Glazing Costs

Net Smart Glass Country Upcharge vs. Standard Glazing			
Smart Glass Country Total			$475,000.00
Standard Glazing System Total			
(Minimum)			$241,344.00
(Maximum)			$1,153,743.00
SMART GLASS COUNTRY Upcharge			
(Minimum)			$233,656.00
(Maximum)			-$678,743.00

Smart Glass Country was also unable to provide an average energy annual savings cost, so I also used the same average provided by Halio. Utilizing this average, it is calculated that eventually over the building's lifetime the Smart Glass Country photovoltaic system will pay for itself in energy savings

over time. For the $475,000 Smart Glass Country system cost, a complete return on investment will be achieved in 40.25 years and any subsequent time elapsed will turn a profit (Maxim, 2018).

Conclusion

After a thorough analysis of three electrochromic technology suppliers, it is easy to see why many commercial projects are shifting to use smart glass instead of normal glazing. Of the three companies analyzed, Halio would have the highest return on investment, followed by Smart Glass Country, and Smart Glass Technologies. However, as noted in the individual analysis of each company, all three would require steeper upfront costs followed by a large return on investment that pays for itself over time. If a commercial general contractor were to choose a glazing system with an owner, all three of these suppliers would make more sense financially long-term than a standard glazing system if affordable.

Best Practices and Feasibility

The extensive review of aspects of electrochromic technology and the feasibility of this technology has yielded several key conclusions. Foremost, electrochromic technology is extremely novel and complex which means the units require a higher level of financial investment and expertise to be utilized successfully. Additionally, the numbers provided by these companies were rough estimates as the exact estimate would depend on many other factors that would only be addressed on a specific project. The technology, however, is advancing at an exponential rate and with this comes more industry knowledge on the subject. As shown in the return on investment analysis, at peak effectiveness this technology has the ability to transform the way the construction industry controls the indoor environmental quality. All three of the companies analyzed had higher upfront costs than the cheapest standard glazing system. However, each one was much less expensive than the most expensive standard glazing system. Considering the return on investment periods of 9 years and 2 months for Halio, 36 years and 9 months for Smart Glass Technologies, and 19 years and 10 months for Smart Glass Country, all three manufacturers' systems paid for themselves in energy costs saved over time. If you can afford it as an owner, all three manufacturers would be a fantastic choice to increase building value while lowering energy costs, and ultimately increasing building comfort.

Future Research

As demand for sustainability increases in construction, the industry will further utilize electrochromic technology as it advances. As the technology advances, the steeper upfront costs will be driven down by an increase in suppliers, which will increase the accessibility of smart glass systems. Data described in this report shows the value of building green with increasing property values while decreasing energy costs, which will likely yield to more usage of electrochromic technology. Future research on this matter could include monitoring the market value of buildings with electrochromic technology implemented, expanding the sample of suppliers to determine a more realistic electromatic technology price range, and tracking the success in revenue of these smart glass suppliers. However, the most compelling direction to take an electrochromic study would be an in-depth case study on commercial projects that have this technology in place. Electrochromic technology is set to expand greatly in the construction market in the near future, which leaves lots of room for future research on the topic.

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