ENVIRONMENTAL PRODUCT DECLARATION

SAGEGLASS®: ELECTROCHROMIC GLASS

PROCESSED GLASS

(Photo © Jeffrey Totaro, 2015, SageGlass installed at Saint-Gobain's Platinum LEED© certified headquarters, Malvern, PA)

SageGlass Electrochromic Insulating Glass provides dynamic control of the admission of the sun's light and heat into buildings while maintaining the view to the outside.

At Saint-Gobain we are committed to providing sustainable building products and to limiting our impacts on the environment while doing so. (See our CSR at https://www.saint-gobain.com/en/commitments/saint-gobains-csr-commitments.)

We are also committed to market transparency through third party verified EPDs. In 2016, Saint-Gobain became the group with the most EPDs registered in the International EPD® System. This third party verified EPD for SageGlass continues that commitment.

SageGlass® electronically tintable glass (or electrochromic (EC) glass) has been shown to significantly reduce energy use and peak demand in buildings and it is a key component of the US DOE's road map for net zero energy façade systems.

And because SageGlass® insulating glass eliminates the needs for additional mechanical shading systems, it can help reduce the overall environmental impact of buildings.

ENVIRONMENTAL PRODUCT DECLARATION

SageGlass

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

This declaration is an environmental product declaration (EPD) in accordance with ISO 14025. EPDs rely on Life Cycle Assessment (LCA) to provide information on a number of environmental impacts of products over their life cycle. Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc. Accuracy of Results: EPDs regularly rely on estimations of impacts, and the level of accuracy in estimation of effect differs for any particular product line and reported impact. Comparability: EPDs are not comparative assertions and are either not comparable or have limited comparability when they cover different life cycle stages, are based on different product category rules or are missing relevant environmental impacts. EPDs from different programs may not be comparable.

PROGRAM OPERATOR	UL Environment
DECLARATION HOLDER	SageGlass, Saint-Gobain
DECLARATION NUMBER	4787287780.101.1
DECLARED PRODUCT	SageGlass Electrochromic Glass
REFERENCE PCR	UL PCR Part B: Processed Glass EPD Requirements v1.0, 2016
DATE OF ISSUE	September 20, 2016
PERIOD OF VALIDITY	5 Years
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications

The PCR review was conducted by:	PCR Review Panel Chair: t.gloria@industrial-ecology.com epd@ul.com
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL	Wade Stout, UL
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas Gloria, Industrial Ecology Consultants

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

Comparability

As instructed by the PCR, comparison of the environmental performance of processed glass using EPD information shall be based on the product's use and impacts at the building level, and therefore EPDs may not be used for comparability purposes when not considering the building energy use phase. Full conformance with the PCR for North American Processed Glass allows EPD comparability only when all stages of the processed glass life cycle have been considered, which is not permitted under this PCR. However, variations and deviations are possible.

Product Documentation

Product Description

SageGlass electrochromic (EC) insulating glass (IG) is a type of dynamic glazing for use in buildings which tints automatically or on demand to control sunlight admission, controlling heat and glare, maintaining a view to the outdoors and reducing energy consumption. The dynamic functionality is provided by the SageGlass® EC coating which is located on the cavity facing surface of the exterior lite of the insulating glass unit (see figure 1). The SageGlass coating comprises multiple layers of ceramic materials of less than a micron thick (the EC coating stack), that together, and upon application of a low voltage direct current, provide the ability to reversibly tint the glass to dynamically control the admission of the sun's heat and light. SageGlass electrochromic insulating glass is available in a range of product configurations according to customer specifications. A typical IG configuration is shown in figure 1. Each configuration comprises (i) 2.2mm thick float glass lite on which the EC coating stack is deposited, (ii) a second lite of float glass to which the 2.2mm lite is laminated (called a support lite), the thickness of which depends on the application, (iii) a third lite of float glass which is the inboard lite of the insulating glass unit, the thickness and type of which depends on the application, and (iv) associated insulating glass materials which comprise metallic spacer, dessicant, sealants, laminating interlayer materials, and wiring.

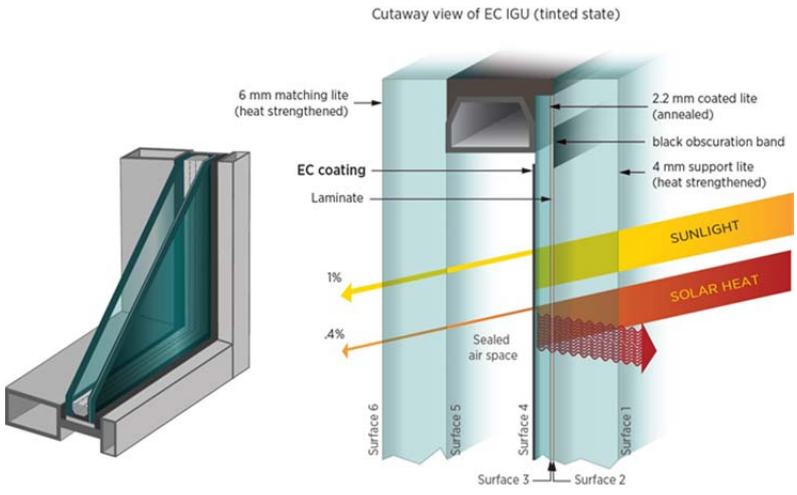

Figure 1: Schematic of a SageGlass electrochromic insulating glass unit

SageGlass electrochomic insulating glass is packaged in a crate made of a combination of lumber and plywood crate.

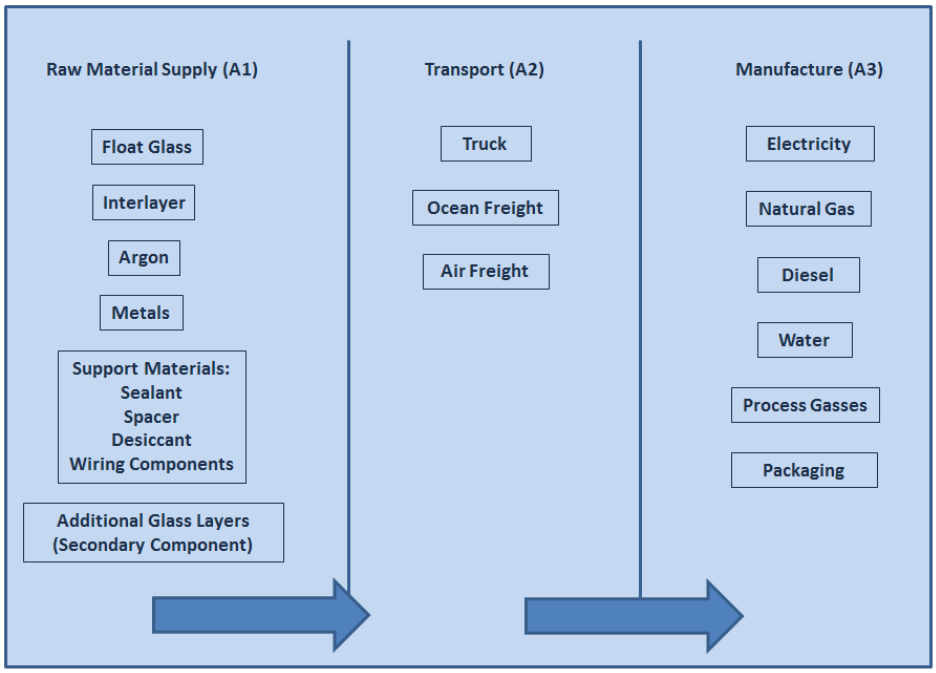

Figure 2: Main Production Process and Material Flow Diagram

SageGlass electrochomic glass is certified by the Insulating Glass Certification Council and the Insulating Glass Manufacturers' Alliance IG Certification Program which certifies compliance to ASTM E2190. SageGlass EC coatings also meet the requirements of ASTM E2953 Standard Specification for Evaluating Accelerated Aging Performance of Electrochromic Devices in Sealed Insulating Glass Units.

SageGlass EC glass also meets the CE performance standards for heat treated, laminated, coated glass and insulating glass (EN1096, EN1279, EN1863, EN12150, EN12600).

SageGlass EC glass also has achieved China's Compulsory Certificate (CCC) Mark for insulating and laminated glass.

Application

SageGlass electrochromic glass can be used in any window, skylight, or curtain wall system in commercial, institutional or residential buildings.

SageGlass

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

Technical Data

Typical SageGlass Insulating Glass Unit Performance for North America Using NFRC 100-2010 Environmental Conditions (based on 1" insulating glass unit with a 12.2mm argon filled cavity)								
SageGlass Clear w/SR2.0	**Visible light transmission, %**	**Exterior reflection, %**	**Interior reflection, %**	**Solar transmission, %**	**Solar Heat Gain Coefficient**	**U-factor, btu/°F.hr.ft²**	**UV transmission, %**	**Fading protection, % T_{dw-ISO}**
Clear State	60	16	14	33	0.41	0.28	0	35
Intermediate State (tint) 1	18	10	9	7	0.15	0.28	0	12
Intermediate State (tint) 2	6	10	9	2	0.10	0.28	0	5
Fully Tinted	1	11	9	0.4	0.09	0.28	0	1
Typical SageGlass Insulating Glass Unit Performance for Europe Using EN410-2011 and EN673-2011 (based on a 25mm thick insulating glass unit with a 12.2mm krypton filled cavity and a low-e coating on the cavity facing side of the inboard lite)								
SageGlass Clear w/SR2.0	**Visible light transmission, %**	**Exterior reflection, %**	**Interior reflection, %**	**Solar transmission, %**	**Solar Heat Gain Coefficient (g-value)**	**U-factor, W/m²K**	**UV transmission, %**	**Fading protection, % T_{dw-ISO}**
Clear State	59	16	15	34	0.40	1.1	0.1	33
Intermediate State (tint) 1	17	10	10	8	0.12	1.1	0.1	11
Intermediate State (tint) 2	6	10	10	2	0.07	1.1	0	4
Fully Tinted	1	11	10	0.4	0.04	1.1	0	1

Table 1: Technical Data for Typical SageGlass Insulating Glass Unit

SageGlass

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

Delivery Status

SageGlass insulating glass units are available in sizes up to 1.5m x 3.0m (5ft x 10ft) with a range of overall unit thicknesses up to 50mm (2in). Both double pane and triple pane insulating glass units are also available.

Base Materials/Ancillary Materials

The insulating glass configuration is comprised of 2.2mm float glass and additional layers of glass of varying thicknesses according to the application. The scope of this study covered the entire production of SageGlass insulating glass for 2014, the weighted average of which was 4.6mm for the support lite, and 7.1mm for the cover lite, for a total average glass thickness of the additional glass layers of 11.7mm.

The standard component of the product consists of 2.2mm float glass, a ionomer interlayer, sealant materials, argon gas, spacer materials (including desiccant), wiring components, and metals, that comprise a total of 19.1% of the average final product. The 2.2mm float glass and the ionomer interlayer account for 87.5% of the standard component and 16.7% of the average final product composition. The remaining 12.5% of the standard composition (2.4% of the average final product) includes the sealant materials, argon gas, spacer materials (including desiccant), wiring components, and metals.

The secondary component of the product consists of the additional layers of glass that vary according to the customer specified configuration. The secondary component includes the support lite, cover lite (laminated or non-laminated), and the PVB found in the laminated cover lite. In the average final product configuration, the secondary component comprises 80.9%.

A breakdown of the components for the average final product with a 2.2mm standard float glass component, 4.6mm support lite, and 7.1mm cover lite, for a total nominal average thickness of 13.9mm is shown in Table 2 and Figures 3 and 4.

Product Components				
Component	**Composition**		**Percent of Component**	**Percent of Average Final Product**
Standard Component	Glass	2.2mm float glass	75.8%	14.5%
	Interlayer	Ionomer interlayer	11.7%	2.2%
	Gases	Argon	0.2%	0.03%
	Support Materials	Sealant	7.2%	1.4%
		Spacer (including desiccant)	2.2%	0.4%
		Wiring Components	0.4%	0.08%
	Metals	Metals	2.5%	0.5%
	Percent of Standard Component in Average Final Product:			**19.1%**
Secondary Component (thickness varies according to configuration)	Glass	Support lite	44%	35.6%
		Cover lite (non -laminated)	44%	35.6%
		Laminated Cover lite	11%	8.7%
	Interlayer	PVB in laminated cover lite	1%	1%
	Percent of Secondary Component in Average Final Product:			**80.9%**

Table 2: Product Component by Weight Percentage

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

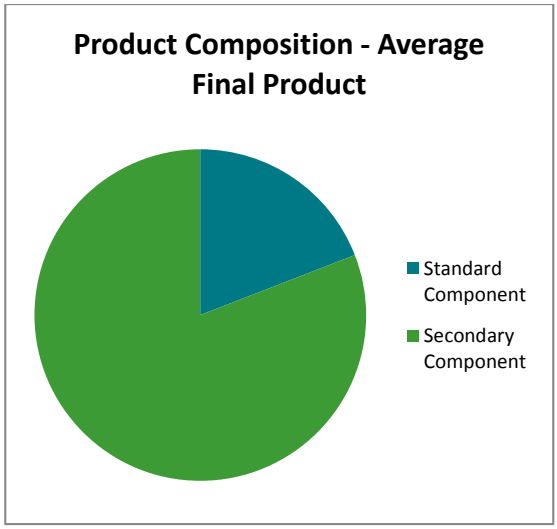

Figure 3: Product Component by Weight Percentage for Average Final Product

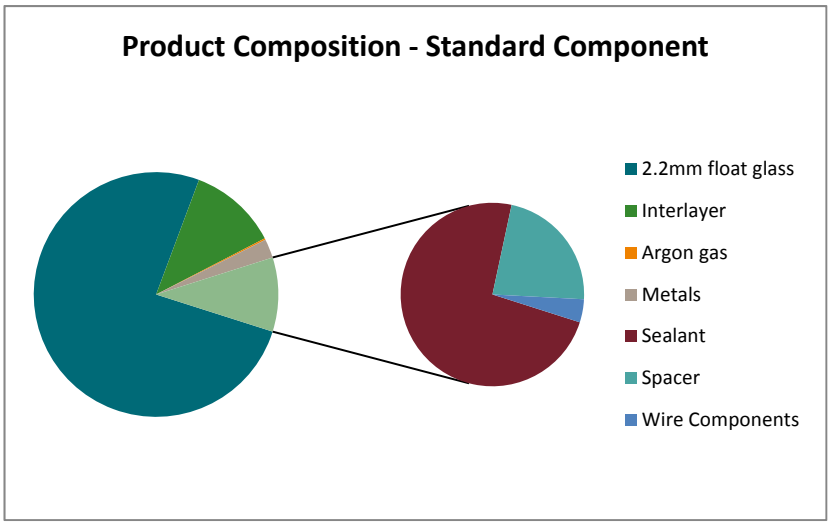

Figure 4: Product Component by Weight Percentage for the Standard Component

Manufacture

SageGlass electrochromic glass is manufactured in Faribault, MN. The production process begins with the trimming and washing of the 2.2mm float glass. Coatings are then applied by vacuum sputtering, and undergo various heat treatments, frit application, and laser processing. The glass is then cut to fit specified customer size. The 2.2mm glass is laminated to the support lite, combined with the cover lite and spacer, and sealed to form the insulating glass unit. Wiring componenets are added to the unit during the insulating glass fabrication process. The unit is then tested before packaging.

Environment and Health During Manufacture

SageGlass and Saint-Gobain have well-established Environmental, Health, and Safety (EHS) and product stewardship programs, which help to enforce proper evaluation and monitoring of chemicals and raw materials chosen to manufacture prodcuts. These programs ensure that all environmental and OSHA requirements are met or exceeded to ensure the health and safety of all employees and contractors.

Packaging

Electrochromic glass is packaged when leaving the manufacturing facility in Faribault, MN using a shipping crate made of lumber and plywood.

SageGlass

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

Product Processing/Installation

SageGlass electrochromic insulating glass is installed by glazing contractors into windows, skylights, and curtain walls in a similar manner to conventional insulating glass (see figure 5 below). The only additional requirement is to connect the wire pigtail exiting the IGU to the frame cables that are routed through the hollow framing system and connects each insulating glass unit to the control system (see image in figure 5 below). There are no requirements for industrial or environmental protections since there are no dust or other airborne emissions producted as a result of the installation process. Personal protective equipment should be used such as gloves and fall protection appropriate to the installation conditions.

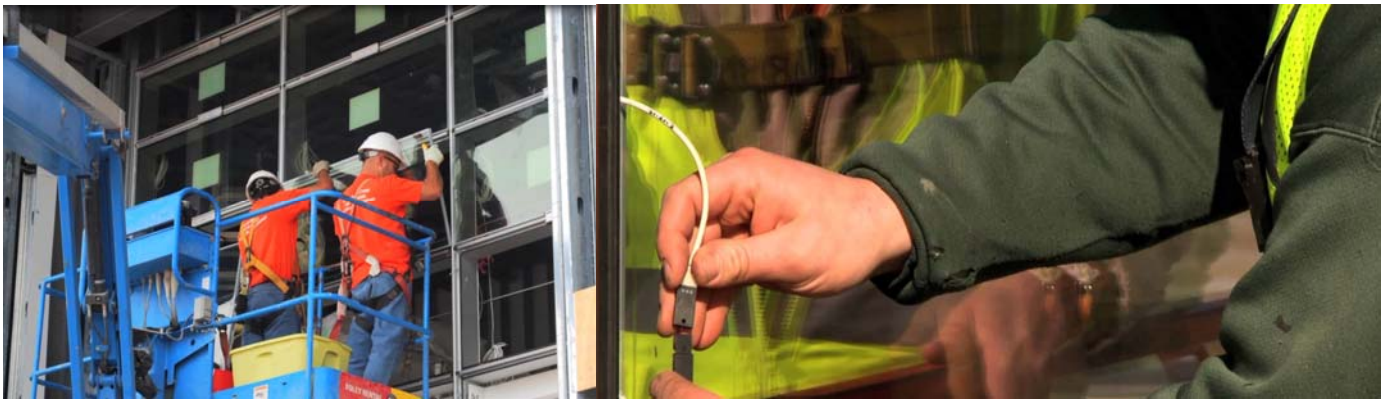

Figure 5: Images of the installation of SageGlass Electrochromic glazing in a curtain wall system. (Left image) Installation of the glass pane. (Right image) Connection between the pigtail and the frame cable.

Condition of Use

SageGlass electrochromic glass allows for control of visible light transmission and solar heat gain over a wide range, to provide a balance of light and heat entering a building. The various levels of tinting block glare producing light, effectively darken the space while still maintaining a view to the outdoors.

Environment and Health During Use

SageGlass electrochromic glass has no known emissions during use that could affect the enivronment or human health.

No additional maintenance is required during the use of SageGlass electrochromic glass. Cleaning can be done with typical glass cleaning solutions as needed, in the same way as for conventional glazing.

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

Extraordinary Effects

SageGlass electrochromic glass has no extraordinary effects concerning fire, water, or mechanical destruction.

Re-Use/Recycling/Disposal

In the same way as conventional insulating glass, SageGlass electrochromic glass is typically deglazed from the window opening and loaded onto a truck or dumpster at the decommissioning of a building and disposed in a landfill. There are currently no known re-use, recycling, or energy recovery programs for electrochromic glass, although just like conventional insulating glass, recycling of the glass is possible by removing this component from the edge sealant materials.

Further Information

http://sageglass.com/

LCA Calculation Rules

Declared Unit

Declared Unit		
Name	**Value**	**Unit**
Declared Unit	1	m^2
Mass per piece	38.06	kg/m^2
Standard Component Thickness	2.2	mm
Standard Component Weight	7.26	kg/m^2
Standard Component Weight per mm	3.30	kg/mm
Secondary Component Average Thickness	11.7	mm
Secondary Component Average Weight	30.8	kg/m^2
Secondary Component Average Weight per mm	2.63	kg/mm
Final Product Total Average Thickness	13.9	mm
Interlayer percent mass	2.2	%
Spacer percent mass (including desiccant)	0.4	%
Sealant percent mass	1.4	%

Table 3: Declared Unit Information

Scaling Factor

SageGlass electrochromic glass is available in various product configurations depending on customer needs. Each configuration includes a 2.2mm layer of float glass and two layers of varying thicknesses of support lite glass and cover lite glass. Depending on the application for the product, the cover lite glass may also be laminated. The processing of the glass for any configuration is done on the 2.2mm layer of float glass; therefore the impacts of the 2.2mm float glass layer do not change with the configurations. The support lite glass and cover lite glass, including the laminated cover lites, is the only portion of the product with varying thickness. This study examined impacts of an overall weighted average of the support and cover lites according to production volumes separately from the standard components in order to create a scaling factor that can be used to determine the impacts for any configuration.

The weighted average of the support lite glass is 4.6mm and the weighted average of the cover lite glass, including the laminated cover lites is 7.1mm, for a total average thickness of the additional layers of 11.7mm. The impacts for the selected impact categories per millimeter of the combined support and cover lites was then determined by dividing the total by 11.7mm, as shown in Table 4.

Impacts for specific configurations of the Electrochromic Glass product can be calculated by adding the impacts for the standard components to the total sum of the support lite and cover lite glass layers that has been multiplied by the per millimeter impact for the support and cover lites. The calculation of the scaling factor is shown below in Figure 6.

Impact category	Unit	Impact Total for Weighted Average of Combined Support & Cover Lites (11.7mm)	Impact per mm of Combined Support & Cover Lites
Traci 2.1 Impact Assessment, October 2013 – North America Environmental Impact Potentials			
GWP (Global warming potential)	kg CO_2 eq	7.43E+01	6.35E+00
ODP (Stratospheric ozone layer depletion potential)	kg CFC-11 eq	8.92E-06	7.62E-07
AP Air (Acidification potential)	kg SO_2 eq	6.82E-01	5.83E-02
EP (Eutrophication potentials)	kg N eq	1.08E-01	9.22E-03
POCP (Photochemical ozone creation potential)	kg O_3 eq	7.61E+00	6.51E-01
ADP (Abiotic resource depletion potential – fossil fuels)	MJ	1.16E+02	9.91E+00
Impact category	**Unit**	**Impact Total for Weighted Average of Combined Support & Cover Lites (11.7mm)**	**Impact per mm of Combined Support & Cover Lites**
CML 4.1 Impact Assessment, per EN 15804:2012 + A1:2013 – Europe and Rest of World Environmental Impact Potentials			
GWP (Global warming potential)	kg CO_2 eq	7.43E+01	6.35E+00
ODP (Depletion potential of the stratospheric ozone layer)	kg CFC-11 eq	6.81E-06	5.82E-07
AP Air (Acidification potentials for air emissions)	kg SO_2 eq	6.93E-01	5.92E-02
EP (Eutrophication potentials)	kg $(PO_4)^3$ eq	8.11E-02	6.94E-03
POCP (Formation potential of tropospheric ozone)	Kg ethene eq	2.51E-02	2.15E-03
ADP Elements (Abiotic depletion potential for non-fossil resources)	kg Sb eq	3.24E-04	2.77E-05
ADP Fossil Fuels (Abiotic depletion potential for fossil resources)	MJ	9.02E+02	7.71E+01

Table 4: Environmental Impact Potentials for Secondary Components, weighted average and per mm

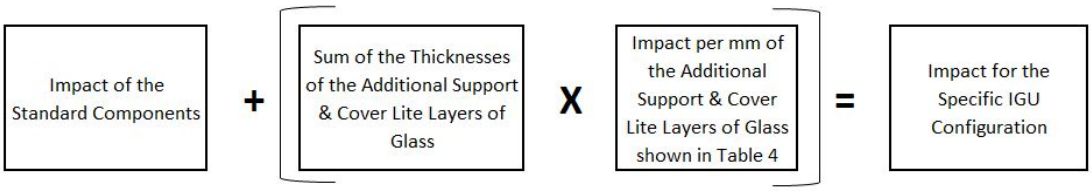

Figure 6: Scaling Factor Calculation for Various Product Configurations

System Boundary

The life cycle analysis performed for this EPD includes “cradle-to-gate” life cycle stages. The system boundary includes the raw material supply, manufacture, and transport; the Electrochromic Glass manufacture in Faribault, MN, and the packaging. Transport from manufacture to customer installation, installation, use, and end-of-life, are excluded from this study as required by the PCR.

Description of the System Boundary (x = Included in LCA; MND = Module not declared)																
Product Stage			Construction Process Stage		Use Stage							End of Life Stage				Benefits and Loads Beyond the System Boundary
Raw Material Supply	Transport	Manufacturing	Transport from gate to site	Assembly/ Install	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	Deconstruction	Transport	Waste Processing	Disposal	Reuse, Recovery, Recycling Potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

Table 5: System Boundary

Estimates and Assumptions

A proxy material was used in place of two metals used in the SageGlass electrochromic glass product because the two metals are not listed in the Ecoinvent v3 database. The proxy material was selected based on its similarity in melting point, density, thermal conductivity, electric resistivity, and hardness.

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

Cut-Off Criteria

The cut-off criteria established for the study inlcude materials, energy, and emissions data. For the purposes of this study, the criteria are as follows:

- Mass – Chemicals with a combined weight less than 1% of the mass of the modeled product may be excluded, providing its environmental relevance is not a concern.
- Human activity factors were not included in the scope of this study.
- Captial equipment factors were not included in the scope of this study.
- Data deemed proprietary to SageGlass (such as the specific metals used) were made available for the analysis and the peer review; however that information has not been disclosed in this declaration.

Background Data

SimaPro v8 software system was used for modeling the life cycle of the SageGlass electrochromic glass. Each background dataset used was taken from the SimaPro databases, Ecoinvent v3 and US LCI.

Data Quality

Wherever secondary data is used, the study adopts critically reviewed data for consistency, precision, and reproducibility to limit uncertainty. The data sources used are complete and representative of Europe and North America (depending on the material source) in terms of the geographic and technological coverage and are less than ten years old. Any deviations from these initial data quality requirements for secondary data are documented in the report. Overall, the primary data from the manufacturing location is of very high quality, being directly tracked and measured by facility personnel. Secondary data sets are of fair-to-good quality.

Period Under Review

Data for this LCA was collected for the 2014 calendar year.

Allocation

The Faribault, MN plant is the only Saint-Gobain location that produces SageGlass electrochromic glass and SageGlass electrochromic glass is the only product made at the facility at this time. All flows and impacts are allocated to the SageGlass electrochromic glass product and can be scaled to specific configurations.

LCA Results and Interpretation

Environmental Impact Potentials: North America

The tables and charts below present the environmental impact potentials for the system boundary modules A1-A3, raw material supply, transport, and manufacturing, as specified for North America: global warming potential, stratospheric ozone layer depletion potential, acidification potential, eutrophication potential, photochemical ozone creation potential, and abiotic resource depletion potential – fossil fuels. The impacts shown are respresentative of the embodied environmental impacts for 1 square meter of SageGlass electrochromic glass over the raw material and manufacturing stages of its life cycle, shown for the standard components, the weighted average configuration (2.2mm standard component + 11.7mm weighted average secondary component) and the two most common configurations ((i) 2.2mm standard component + 4mm support lite/6mm cover lite secondary component and (ii) 2.2mm standard component + 6mm support lite, 3mm/1.5mm PVB/3mm cover lite secondary component) calculated using the scaling factor calculation outlined above.

TRACI 2.1 Impact Assessment, October 2013 for 1 square meter of Electrochromic glass, for system boundary modules A1-A3 (raw material supply, transport, and manufacture)						
Parameter	**Parameter**	**Unit**	**Standard Components**	**w/ Weighted Average Secondary Component (11.7mm nominal thickness)**	**w/4mm Support Lite & 6mm Cover Lite Secondary Component (9.6mm nominal thickness)**	**w/ 6mm Support Lite & 3mm/1.5mm PVB/3mm Cover Lite Secondary Component (11.9mm nominal thickness)**
GWP	Global warming potential	kg CO_2-Eq.	1.86E+03	1.94E+03	1.93E+03	1.94E+03
ODP	Stratospheric ozone layer depletion potential	kg CFC-11 Eq.	5.48E-05	6.37E-05	6.21E-05	6.39E-05
AP	Acidification potential	kg SO_2-Eq.	1.55E+01	1.62E+01	1.60E+01	1.62E+01
EP	Eutrophication potential	kg N-Eq.	8.34E-01	9.42E-01	9.23E-01	9.44E-01
POCP	Photochemical ozone creation potential	kg O_3-Eq.	1.28E+02	1.35E+02	1.34E+02	1.35E+02
ADP	Abiotic resource depletion potential – fossil fuels	MJ	1.16E+03	1.28E+03	1.26E+03	1.28E+03

Table 6: TRACI 2.1 Impact Assessment – Environmental Impact Potentials

SageGlass

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

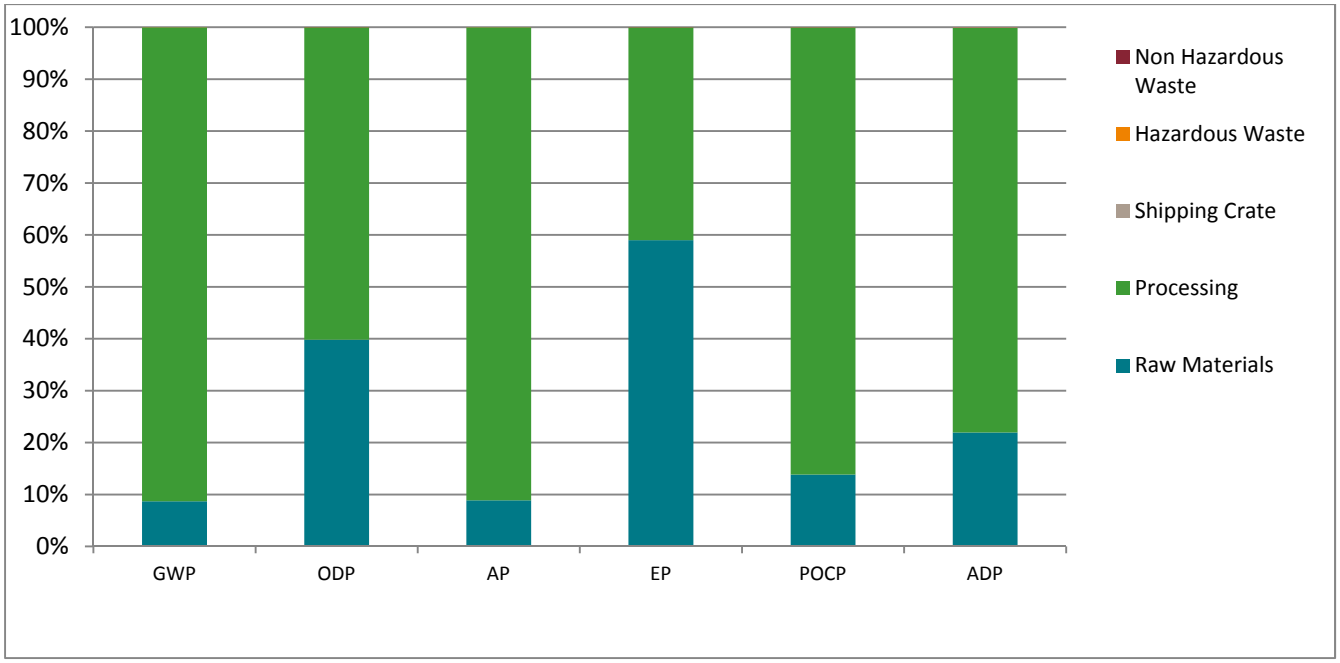

Figure 7: TRACI 2.1 Impact Assessment – Environmental Impact Potentials (Standard Components)

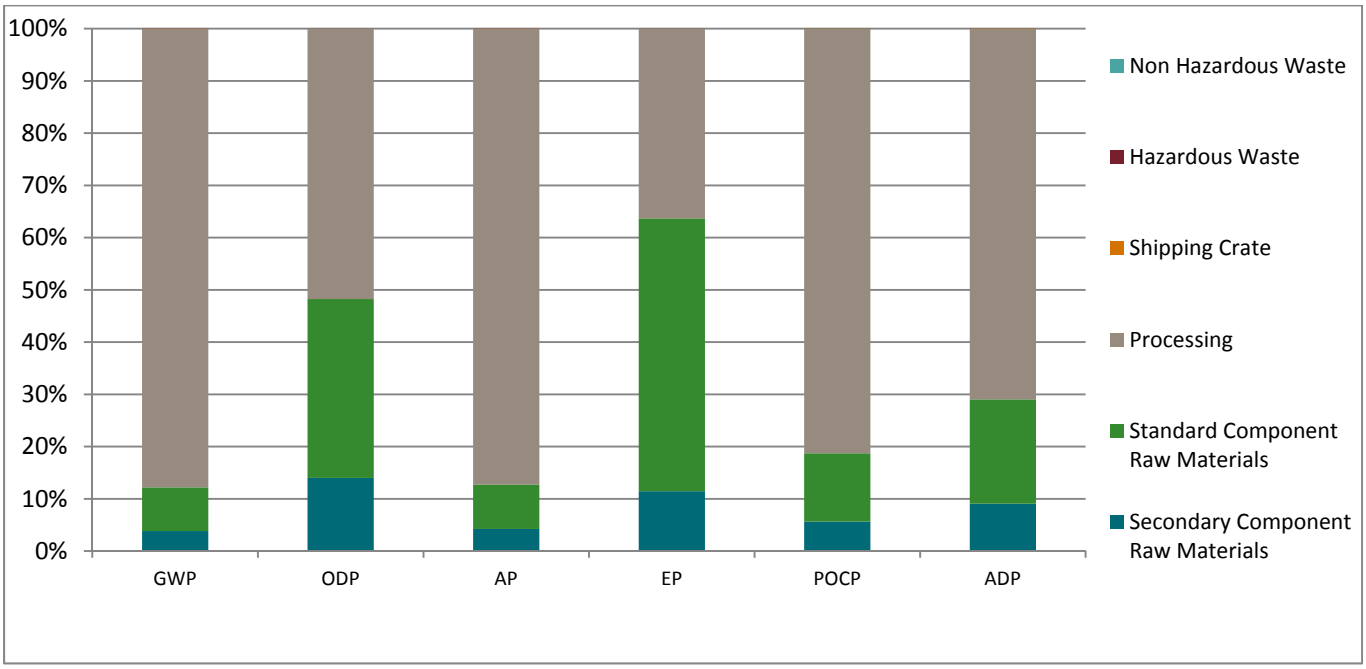

Figure 8: TRACI 2.1 Impact Assessment – Environmental Impact Potentials (Standard Components + Weighted Average Secondary Component – 11.7mm nominal thickness)

SageGlass

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

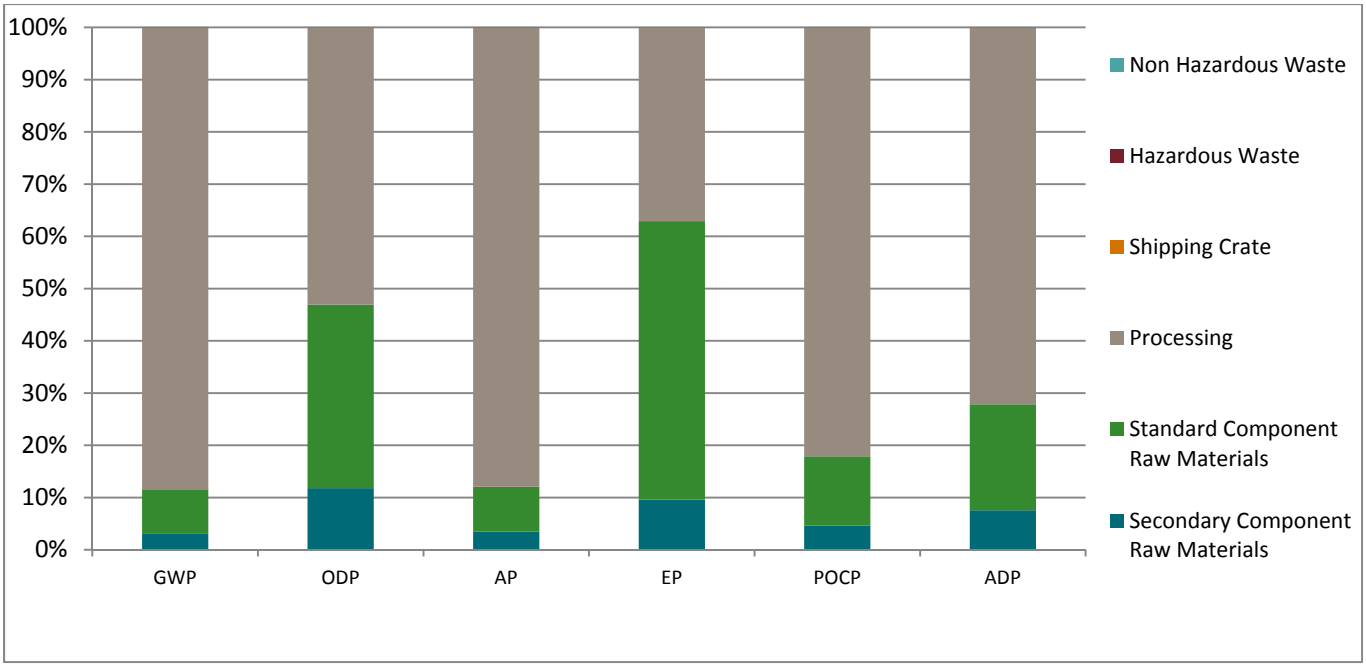

Figure 9: TRACI 2.1 Impact Assessment – Environmental Impact Potentials (Standard Components + 4mm Support Lite, 6mm Cover Lite Secondary Component – 9.6mm nominal thickness)

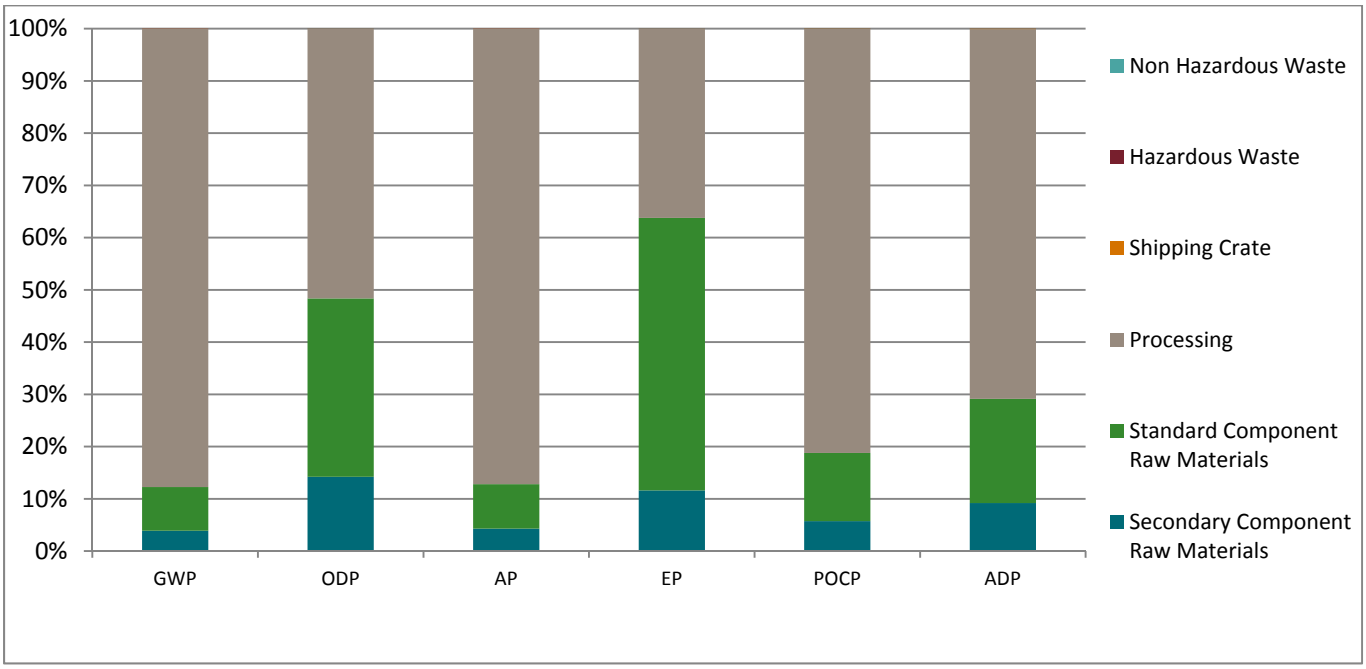

Figure 10: TRACI 2.1 Impact Assessment – Environmental Impact Potentials (Standard Components + 6mm Support Lite, 3mm/1.5mm PVB/3mm Cover Lite Secondary Component – 11.9mm nominal thickness)

Environmental Impact Potentials: Europe and Rest of World

The tables and charts below present the environmental impact potentials for the system boundary modules A1-A3, raw material supply, transport, and manufacturing, as specified for Europe and the Rest of World: global warming potential, depletion potential of the stratospheric ozone layer, acidification potentials for air emissions, eutrophication potentials, formation potential of tropospheric ozone, abiotic depletion potential for non-fossil resources, and abiotic depletion potenial for fossil resources. The impacts shown are respresentative of the embodied environmental impacts for 1 square meter of SageGlass electrochromic glass over the raw material and manufacturing stages of its life cycle, shown for the standard components, the weighted average configuration(2.2mm standard component + 11.7mm weighted average secondary component) and the two most common configurations ((i) 2.2mm standard component + 4mm support lite/6mm cover lite secondary component and (ii) 2.2mm standard component + 6mm support lite, 3mm/1.5mm PVB/3mm cover lite secondary component) calculated using the scaling factor calculation outlined above.

CML 4.1 Impact Assessment, per EN 15804:2012 + A1:2013 for 1 square meter of electrochromic glass, for system boundary modules A1-A3 (raw material supply, transport, and manufacture)						
Parameter	**Parameter**	**Unit**	**Standard Components**	**w/ Weighted Average Secondary Component (11.7mm nominal thickness)**	**w/4mm Support Lite & 6mm Cover Lite Secondary Component (9.6mm nominal thickness)**	**w/ 6mm Support Lite & 3mm/1.5mm PVB/3mm Cover Lite Secondary Component (11.9mm nominal thickness)**
GWP	Global warming potential	kg CO2 eq	1.86E+03	1.94E+03	1.93E+03	1.94E+03
ODP	Depletion potential of the stratospheric ozone layer	kg CFC-11 eq	4.50E-05	5.18E-05	5.06E-05	5.19E-05
AP Air	Acidification potentials for air emissions	kg SO2 eq	1.63E+01	1.70E+01	1.69E+01	1.70E+01
EP	Eutrophication potentials	kg (PO4)3 eq	9.17E-01	9.99E-01	9.84E-01	1.00E+00
POCP	Formation potential of tropospheric ozone	Kg ethene eq	7.68E-01	7.93E-01	7.88E-01	7.93E-01
ADP Elements	Abiotic depletion potential for non-fossil resources	kg Sb eq	4.90E-03	5.23E-03	5.17E-03	5.23E-03
ADP Fossil Fuels	Abiotic depletion potential for fossil resources	MJ	2.68E+04	2.77E+04	2.75E+04	2.77E+04

Table 7: CML 4.1 Impact Assessment – Environmental Impact Potentials

SageGlass

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

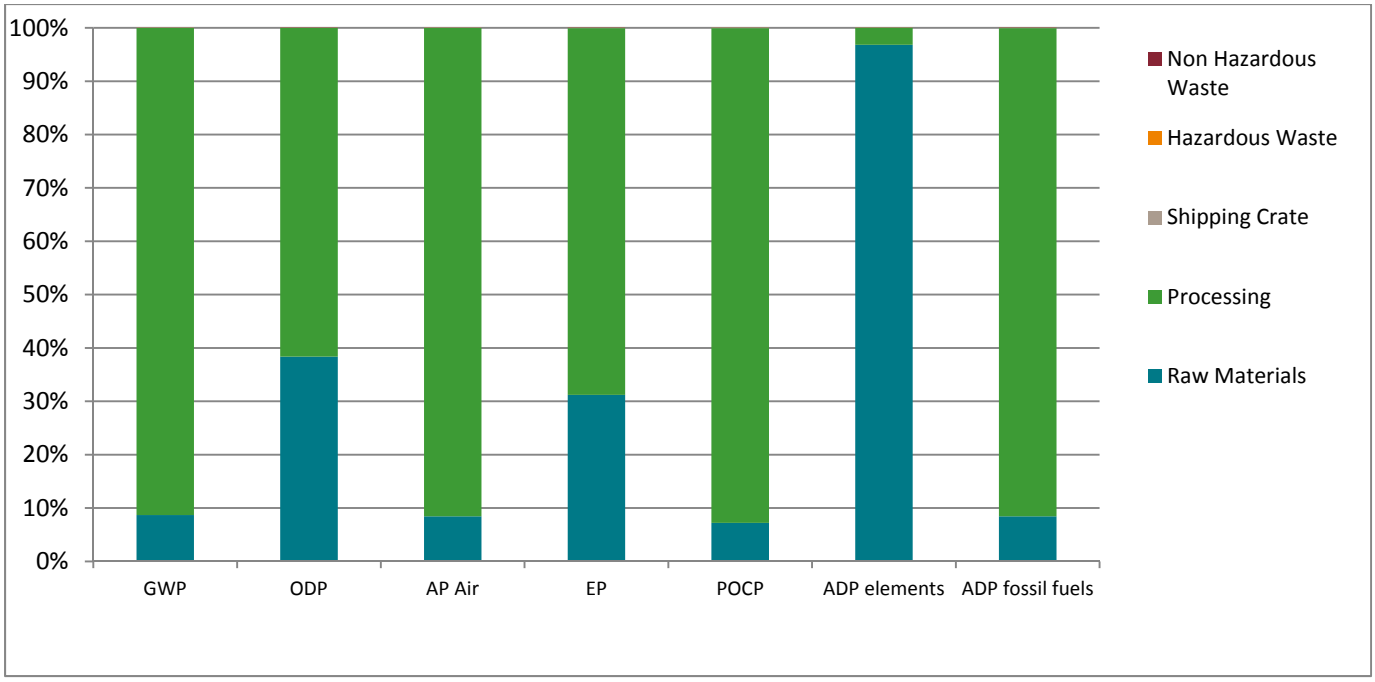

Figure 11: CML 4.1 Impact Assessment – Environmental Impact Potentials (Standard Components)

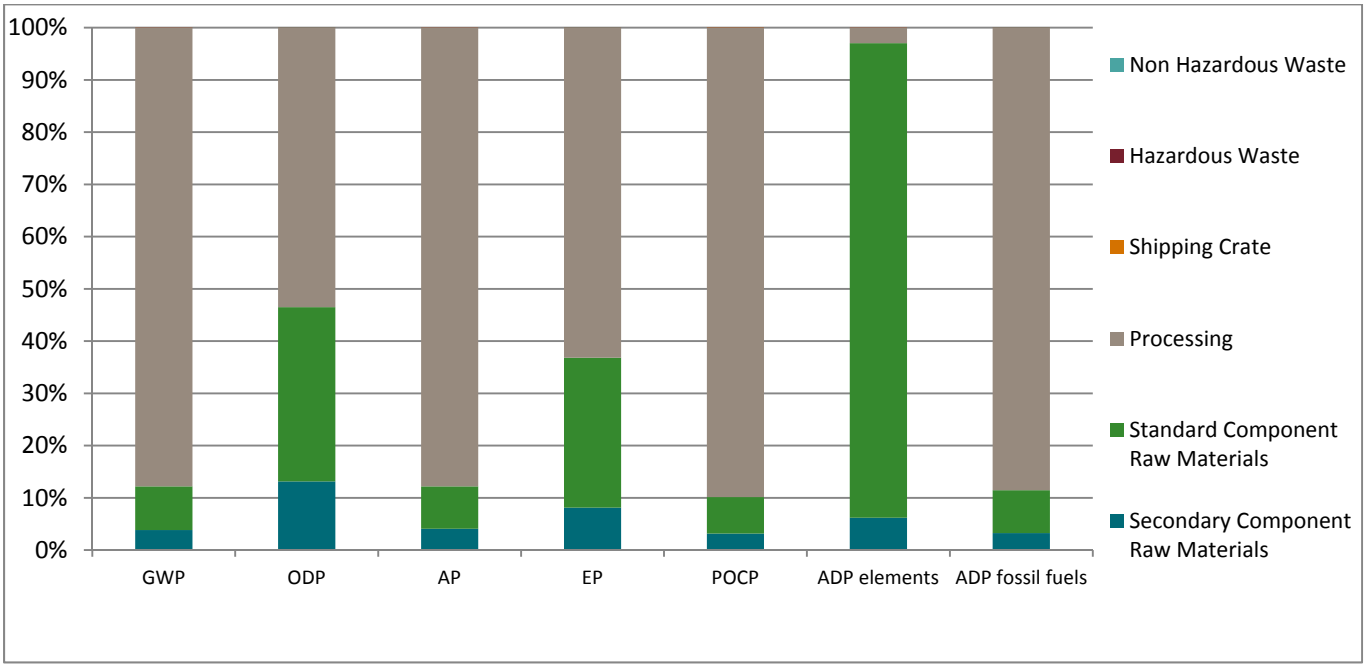

Figure 12: CML 4.1 Impact Assessment – Environmental Impact Potentials (Standard Components + Weighted Average Secondary Component – 11.7mm nominal thickness)

SageGlass

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

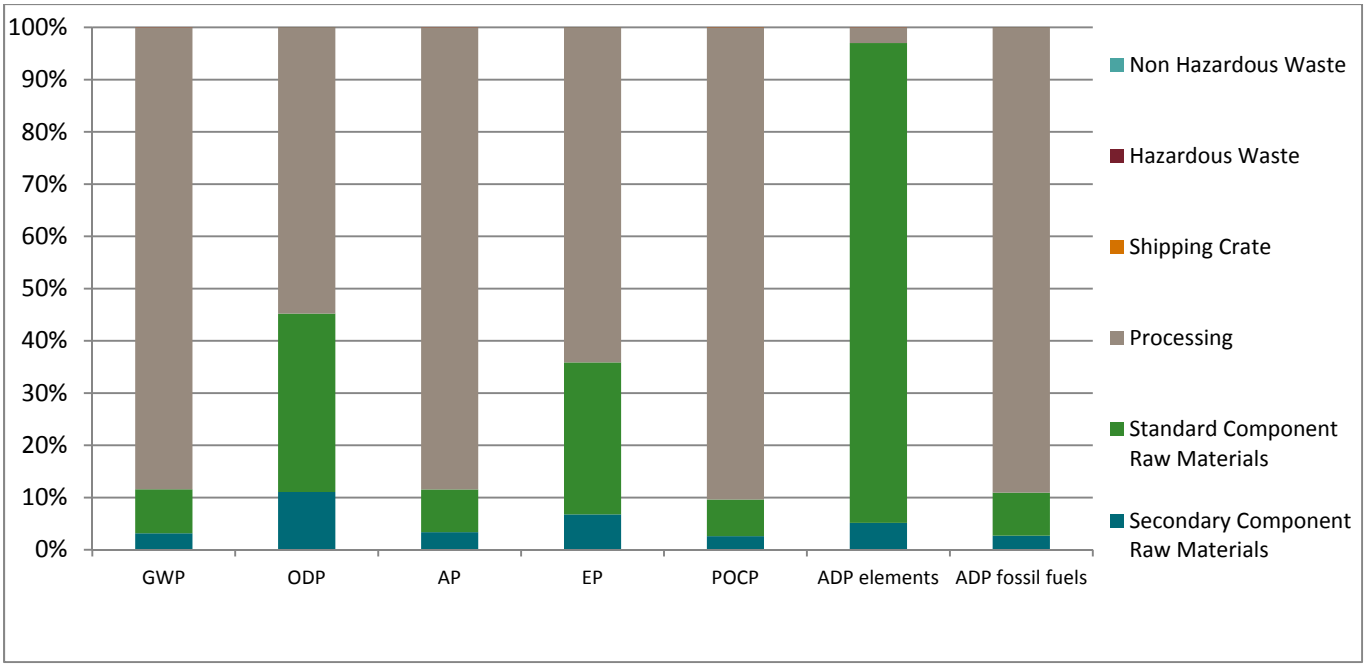

Figure 13: CML 4.1 Impact Assessment – Environmental Impact Potentials (Standard Components + 4mm Support Lite, 6mm Cover Lite Secondary Component – 9.6mm nominal thickness)

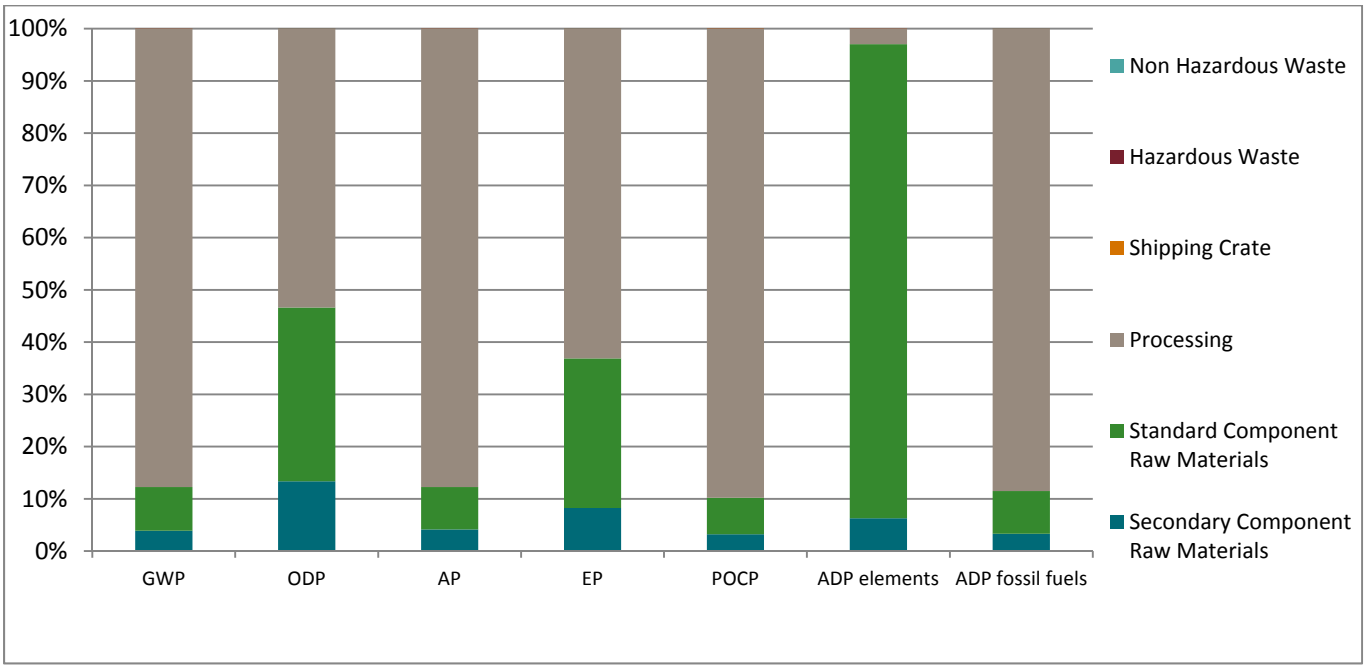

Figure 14: CML 4.1 Impact Assessment – Environmental Impact Potentials (Standard Components + 6mm Support Lite, 3mm/1.5mm PVB/3mm Cover Lite Secondary Component – 11.9mm nominal thickness)

SageGlass

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

Resource Use

LCA Results: Resource Use for 1 square meter of electrochromic glass						
Parameter	**Parameter**	**Unit**	**Standard Components**	**w/ Weighted Average Secondary Component (11.7mm nominal thickness)**	**w/4mm Support Lite & 6mm Cover Lite Secondary Component (9.6mm nominal thickness)**	**w/ 6mm Support Lite & 3mm/1.5mm PVB/3mm Cover Lite Secondary Component (11.9mm nominal thickness)**
PERE	Renewable primary energy as energy carrier	MJ	2.70E+04	2.79E+04	2.78E+04	2.79E+04
PERM	Renewable primary energy resources as material utilization	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	Total use of renewable primary energy resources	MJ	2.70E+04	2.79E+04	2.78E+04	2.79E+04
PENRE	Non-renewable primary energy as energy carrier	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRM	Non-renewable primary energy as material utilization	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	Total use of non-renewable primary energy resources	MJ	1.67E+02	2.06E+02	1.99E+02	2.07E+02
SM	Use of secondary material	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	Use of renewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	Use of non-renewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	Use of new fresh water	M^3	6.99E+00	7.16E+00	7.13E+00	7.17E+00

Table 8: Resource Use

SageGlass

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

Output Flows and Waste Categories

LCA Results: Output Flows and Waste Categories for 1 square meter of electrochromic glass						
Parameter	**Parameter**	**Unit**	**Standard Components**	**w/ Weighted Average Secondary Component (11.7mm nominal thickness)**	**w/4mm Support Lite & 6mm Cover Lite Secondary Component (9.6mm nominal thickness)**	**w/ 6mm Support Lite & 3mm/1.5mm PVB/3mm Cover Lite Secondary Component (11.9mm nominal thickness)**
HWD	Hazardous Waste Disposed	kg	5.61E-03	6.48E-03	6.32E-03	6.49E-03
NHWD	Non-hazardous Waste Disposed	kg	5.75E+01	6.74E+01	6.57E+01	6.76E+01
RWD	Radioactive Waste Disposed	kg	1.05E-02	1.39E-02	1.33E-02	1.39E-02
CRU	Components for re-use	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	Materials for recycling	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER	Materials for energy recovery	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE	Exported energy	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 9: Output Flows and Waste Categories

Electrochromic Glass
Weighted Average, 4.6mm Support Lite with 7.1mm Cover Lite

According to ISO 14025

References

UL Environment

UL Environment General Program Instructions April 2015, version 2

Relevant PCRs

PCR Part A: UL Environment and Institute of Construction and Environment e.V., Königswinter (pub.): Product Category Rules for Construction Products from the range of Environmental Product Declarations of Institut Bauen und Umwelt (IBU), Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report. July 2014, version 1.3

PCR Part B: UL Environment and Institute of Construction and Environment: Product Category Rule Guidance for Building-Related Products and Services from the range of Environmental Product Declarations of UL Environment, Part B: Processed Glass EPD Requirements

Sustainability Reporting Standards

EN 15804: 2012-04 - Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction product.

ISO 14025: 2006 - Environmental labels and declarations — Type III environmental declarations — Principles and procedures

ISO 14040: 2006 - Environmental management – Life cycle assessment – Principles and framework

ISO 14044:2006 - Environmental management – Life cycle assessment – Requirements and guidelines