High Performance Roof Daylighting

The Passive House standard is part of the solution

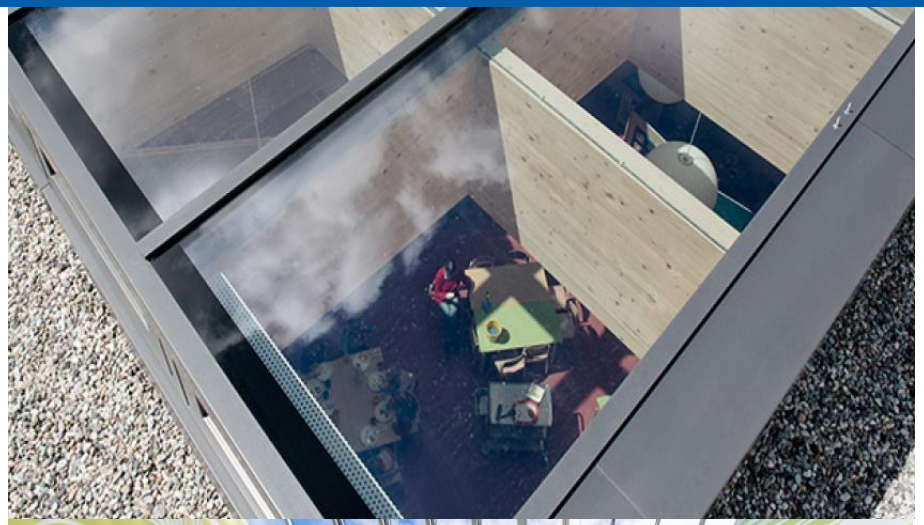
Credit: burohappold

Credit: Nick Grant

Credit: zigersnead.com

Why Daylighting?

- We are all more healthy and productive
  - We all sleep better at night
  - Increase productivity
  - Students perform better
  - Stores sell more products



Why Daylighting?

Aesthetics

Kimball Art Museum, Louis Kahn

Other Benefits?

Natural Ventilation

Exterior Access

Energy Positive Potential

Extend Benefits Deep To Interior

IECC daylight requirement on top floor (C402.4.2)

Johnson Wax Administration Building, Frank Lloyd Wright

More Energy Better Balance

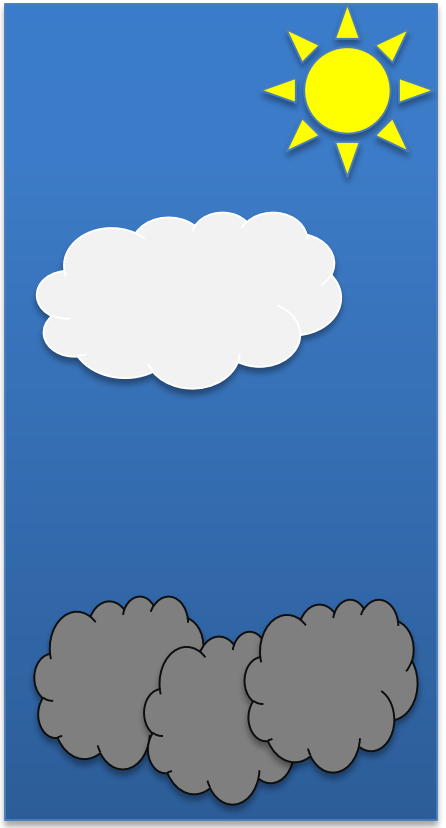
- Windows mostly provide indirect daylight from the sky
- Skylights can combine direct sunlight in addition to diffuse daylight
- Skylights can easily be 3-10 times smaller than a window to collect the same amount of light

Direct Sun
5,000 – 10,000 fc

Bright, sunlit clouds
3,000 – 5,000 fc

Blue Sky
1,000 – 3,000 fc

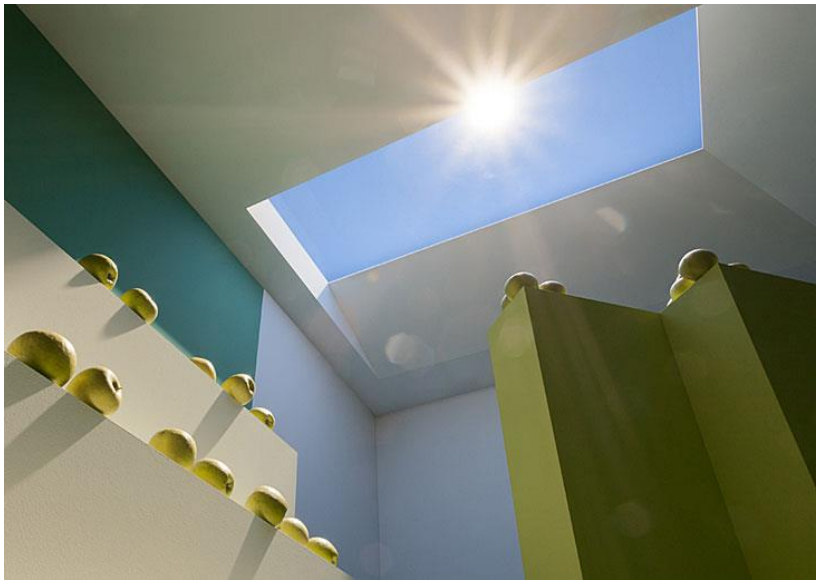
Dark, heavy clouds
1,000 fc



fc = foot candles – a measure of illumination from a light source

Challenges for roof daylighting?

- Glare
- Winter heat losses
- Summer over-heating
- Condensation

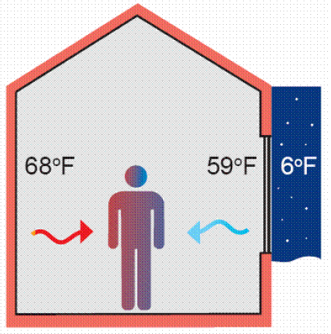


Discover Magazine

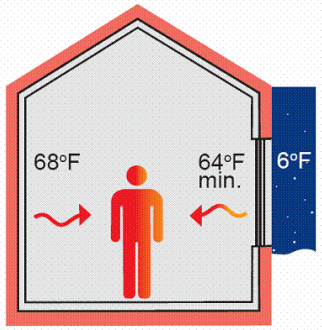
Building enclosure consulting

Comfort Drivers

- Even light distribution
- Uniform surface temperatures



discomfort

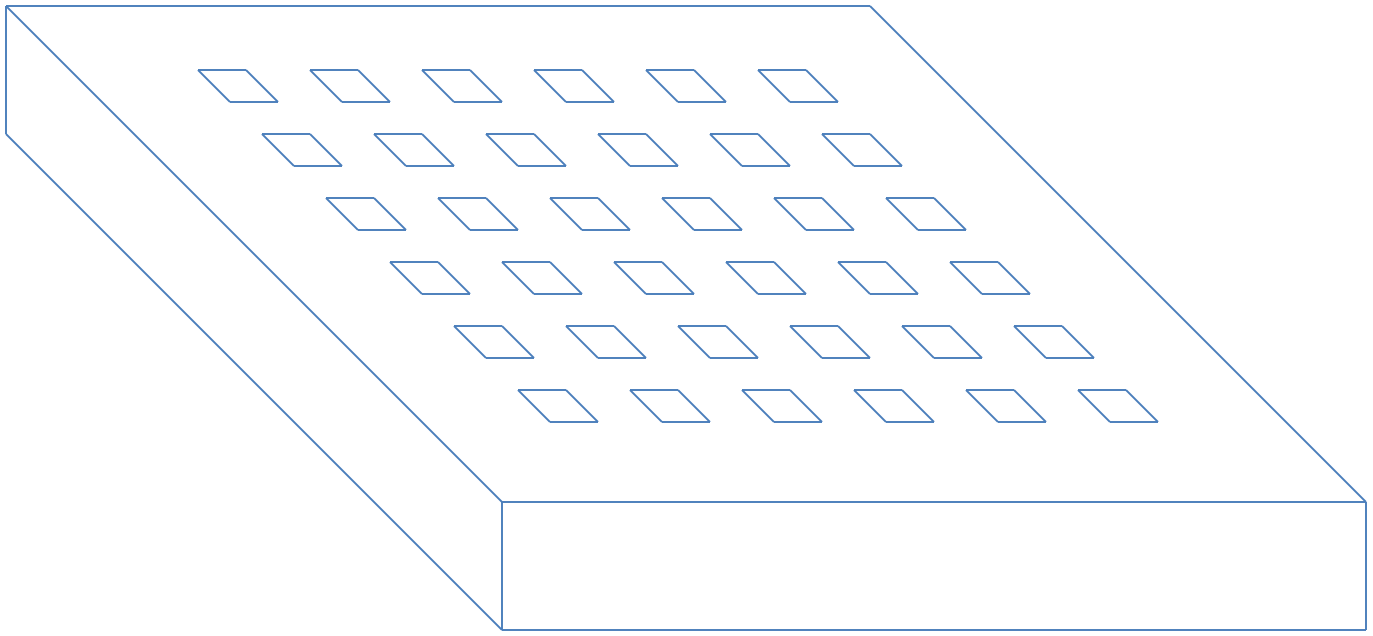


comfort

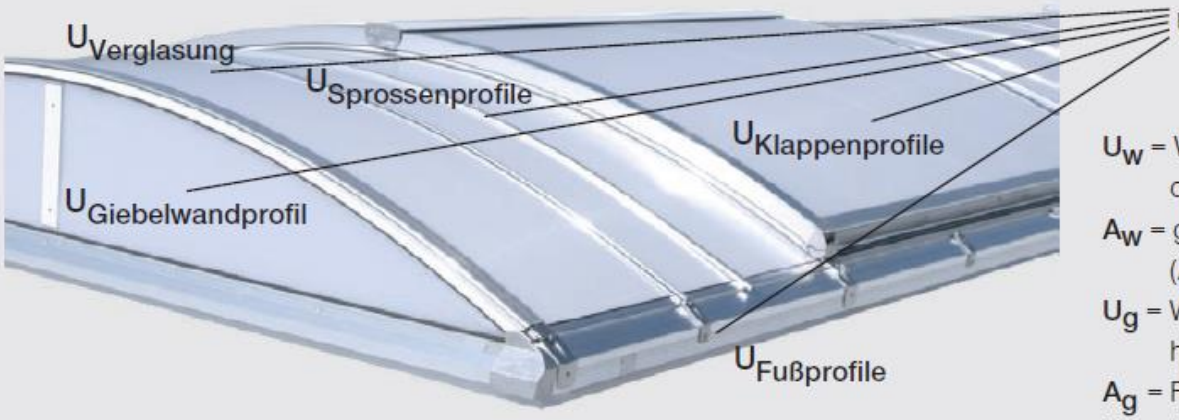
Aaron Leitz Photography

Energy Balance

Building Footprint: 200ft x 200ft
Skylights: 36 (38”x38” each)
Total glass area: 323 SF



Thermal Values



Nur unter dieser Betrachtung ist ersichtlich, wie sich der Wärmedurchgangskoeffizient der einzelnen Bauteile direkt auf die Energiebilanz eines Gebäudes auswirkt.

Unsere Ingenieure übernehmen für Sie die Berechnung:

$$U_W = \frac{U_g \times A_g + \Sigma (U_{fi} \times A_{fi}) + \psi_i \times l_i + \chi_i}{A_g + \Sigma A_{fi}}$$

U_W = Wärmedurchgangswert des gesamten Lichtbandes ohne Zarge

A_W = gesamte wärmeabstrahlende Fläche des Lichtbandes ($A_W = A_g + \Sigma A_{fi}$)

U_g = Wärmedurchgangskoeffizient der Verglasung in horizontaler Einbaulage

A_g = Flächenanteil der Verglasung

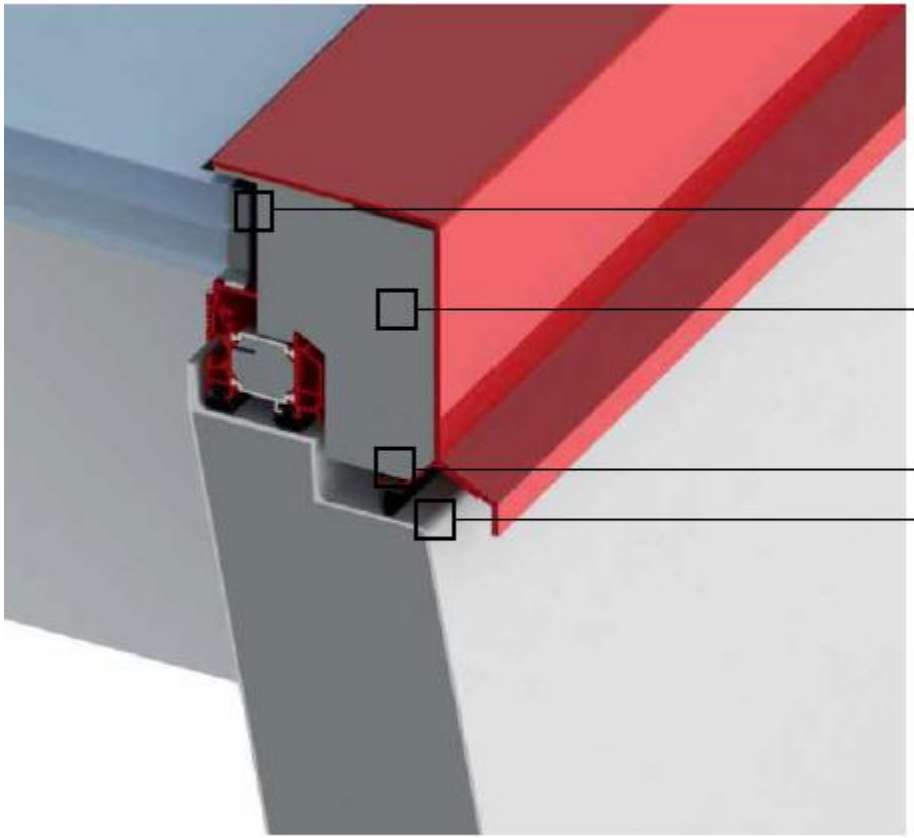
U_f = Wärmedurchgangskoeffizient der Rahmenbauteile

A_f = Flächenanteil der Rahmenprofile

ψ = längenbezogener Wärmebrückenverlustkoeffizient

χ = punktförmiger Wärmbrückenverlustkoeffizient (Wird für Klappen und Lastkonverter angesetzt)

Thermally optimized



NEW: "warm edge" with Super Spacer in serial-production triple glazing

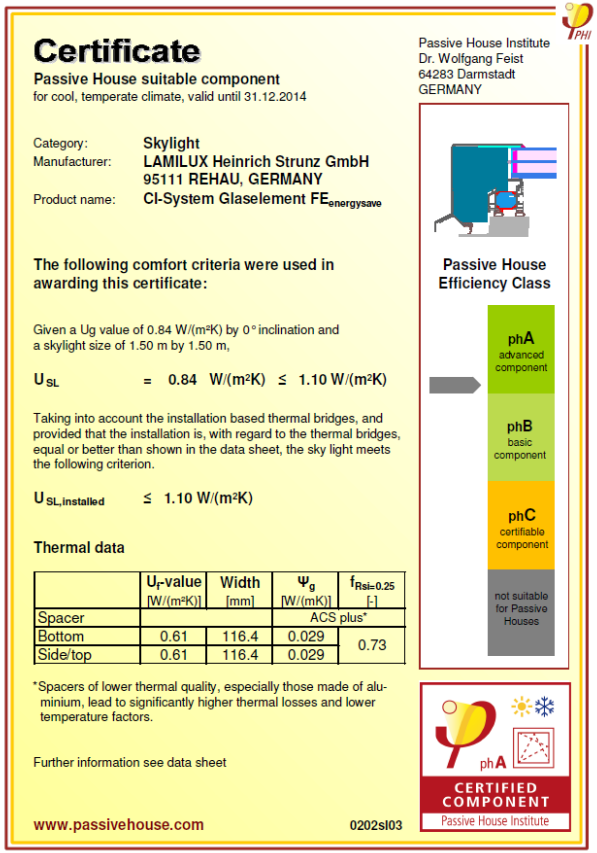
NEW: optimised impermeable core

NEW: triple layered seal system

Upstand with layered geometry to hold layered seal

Thermal Values

Unit Skylights with insulated curbs



Certificate

Passive House suitable component
for cool, temperate climate, valid until 31.12.2014

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
GERMANY

Category: Skylight
Manufacturer: LAMILUX Heinrich Strunz GmbH
95111 REHAU, GERMANY
Product name: CI-System Glaselement FE$_{energysave}$

The following comfort criteria were used in awarding this certificate:

Given a Ug value of 0.84 W/(m²K) by 0° inclination and a skylight size of 1.50 m by 1.50 m,

U_{SL} = 0.84 W/(m²K) ≤ 1.10 W/(m²K)

Taking into account the installation based thermal bridges, and provided that the installation is, with regard to the thermal bridges, equal or better than shown in the data sheet, the sky light meets the following criterion.

$U_{SL,installed}$ ≤ 1.10 W/(m²K)

Thermal data

	U_f-value [W/(m²K)]	Width [mm]	Ψ_g [W/(mK)]	$f_{Rsi=0.25}$ [-]
Spacer			ACS plus*	
Bottom	0.61	116.4	0.029	0.73
Side/top	0.61	116.4	0.029	

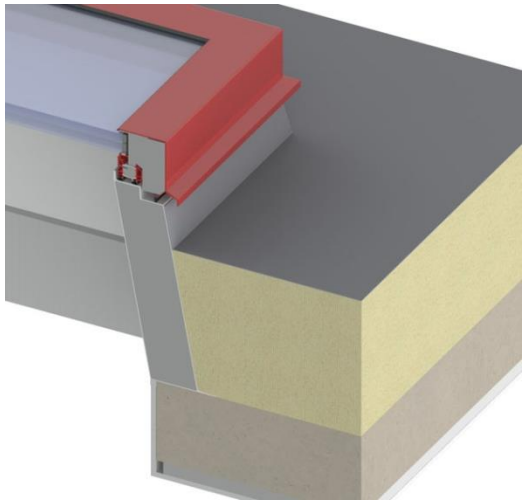
*Spacers of lower thermal quality, especially those made of aluminium, lead to significantly higher thermal losses and lower temperature factors.

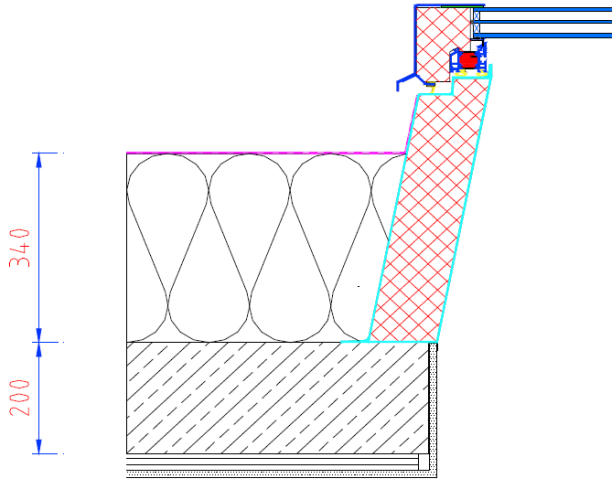
Further information see data sheet

Passive House Efficiency Class
phA advanced component
phB basic component
phC certifiable component
not suitable for Passive Houses

phA CERTIFIED COMPONENT Passive House Institute

www.passivehouse.com 0202sl03





Installed skylight U-value: 0.15 (R-7)

Glass U-value: 0.11 (vert) = 0.13 (hor)
Frame U-value: 0.11
Spacer psi value: 0.017

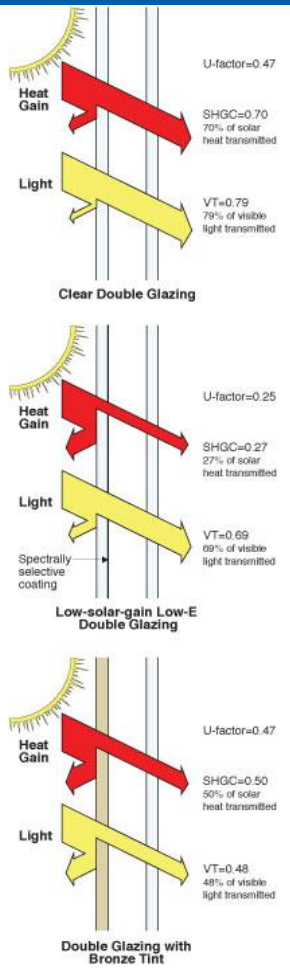
All in IP units

Light Transmission /SHGC

Light transmission to Solar Heat gain coefficient ratio
- Sunglasses (bronze tint) between 1 and 1.2
- Better 2
- Maximum theoretically possible 2.5

Optimize diffuse daylight - high VT with orientation and shading devices

Einkaufcenter Rhein-Galerie, Ludwigshafen



Energy Balance (heating)

Building Footprint: 200ft x 200ft
Skylights: 36 (38”x38” each)
Total glass area: 323 SF

Skylight	Thermal Bridge Free	Curb Insulation	Uglass BTU/hr.ft2°F	SHGC	Losses kBTU/yr	Solar Gains	Total Heat Gain or Loss	Total of heat loss/gain for building (%)
Double pane	No	None	0.24	30%	25935	11687	14248	212748 **(7%)**
Triple pane - conventional spacer	No	Non-Continuous	0.18	30%	23907	11053	12854	210114 **(6%)**
Triple pane - better spacer	Yes	Non-Continuous	0.18	30%	21907	11053	10854	208898 **(5%)**
Advanced component – low SHGC	Yes	4" Continuous	0.13	30%	10835	11032	**-197**	198079 **(0%)**
Advanced component – high SHGC	Yes	4" Continuous	0.13	**50%**	10835	18332	**-7497**	198079 **(-4%)**
Advanced component – high SHGC, shaded in summer	Yes	4" Continuous	0.13	**50%**	10835	18387	**-7552**	**191389 (-4%)**

Total reduction of heat demand of **21359** kBTU/yr **– 11% improvement** (excluding lighting energy savings)

Energy Balance (cooling)

Building Footprint: 200ft x 200ft
Skylights: 36 (38”x38” each)
Total glass area: 323 SF

Skylight	Thermal Bridge Free	Curb Insulation	R-skylight installed	Area	Cooling Gt F*day/yr	Summer heat Gains kBTU/sf*yr)
Double pane	No	None	0.24	400	2863	14111
Triple pane - conventional spacer	No	Non-Continuous	0.18	400	2863	12664
Triple pane - better spacer	Yes	Non-Continuous	0.18	400	2863	11994
Advanced component – low SHGC	Yes	4" Continuous	0.13	400	2863	5988
Advanced component – high SHGC	Yes	4" Continuous	0.13	400	2863	5988
Advanced component – high SHGC, shaded in summer	Yes	4" Continuous	0.13	400	2863	**5988**

Total reduction of heat gain by transmission – **8123** kBTU/yr (Reduction of **57%)**

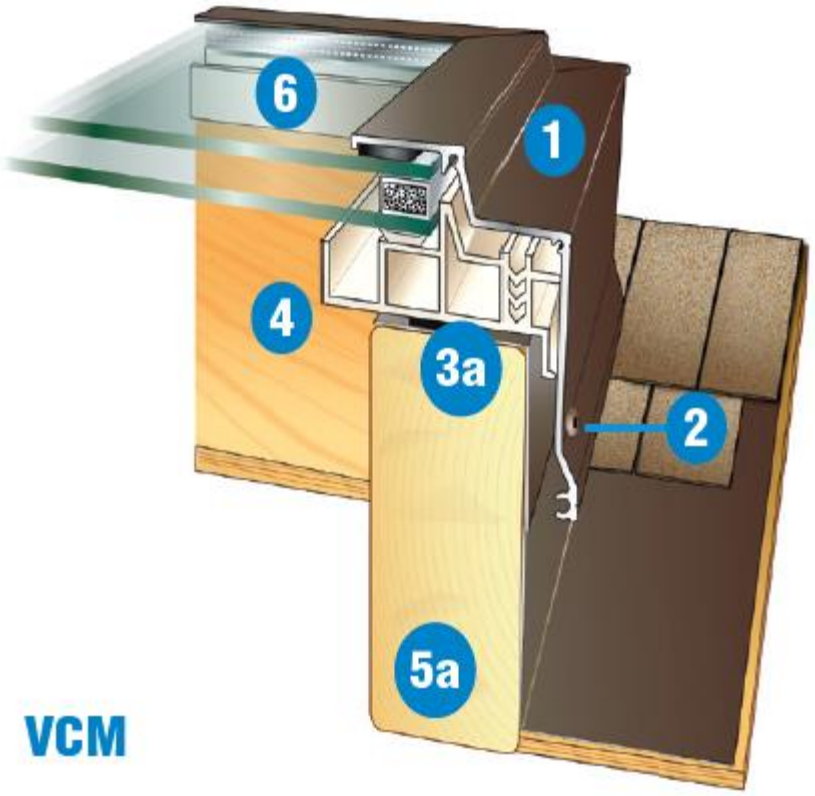
Energy Balance (cooling)

Building Footprint: 200ft x 200ft
Skylights: 36 (38”x38” each)
Total glass area: 323 SF

Skylight	Thermal Bridge Free	Curb Insulation	Uglass BTU/hr.ft2°F	SHGC		Summer solar Gains kBTU/sf*yr)
Double pane	No	None	0.24	30%		28364
Triple pane - conventional spacer	No	Non-Continuous	0.18	30%		28364
Triple pane - better spacer	Yes	Non-Continuous	0.18	30%		28364
Advanced component – low SHGC	Yes	4" Continuous	0.13	30%		28311
Advanced component – high SHGC	Yes	4" Continuous	0.13	50%		47185
Advanced component – high SHGC, shaded in summer	Yes	4" Continuous	0.13	50%		**18874**

Total reduction of cooling load by shading 50% SHGC compared to 30% SHGC glass – app **10,000** kBTU/yr **(-33%)**

Condensation



1 Durable Aluminum Cap: Baked brown enamel finish*

2 Installation: Outside fastening as standard. Inside fastening also available.

3 Base Frame:

- **a** Thermally broken white PVC base frame
- **b** Thermally broken aluminum base frame

4 Condensation channel: 4 sided channel with weep holes in each corner

5 Curb:

- **a** Can be installed on a 2 x 4, 2 x 6 or 2 x 8 curb
- **b** Can be installed on a 2 x 4, 2 x 6 or 2 x 8 curb - Requires a full 2" wide curb

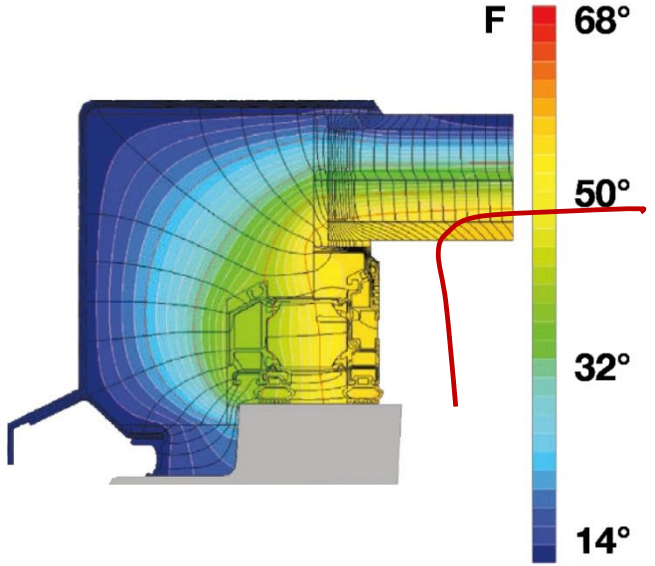
6 Glazing: 7 glass & 6 acrylic or polycarbonate glazing options *(See page 18)*

Columbia skylights

Airtight?

Condensation

Thermo active design:
Increase surface temperature at critical junction



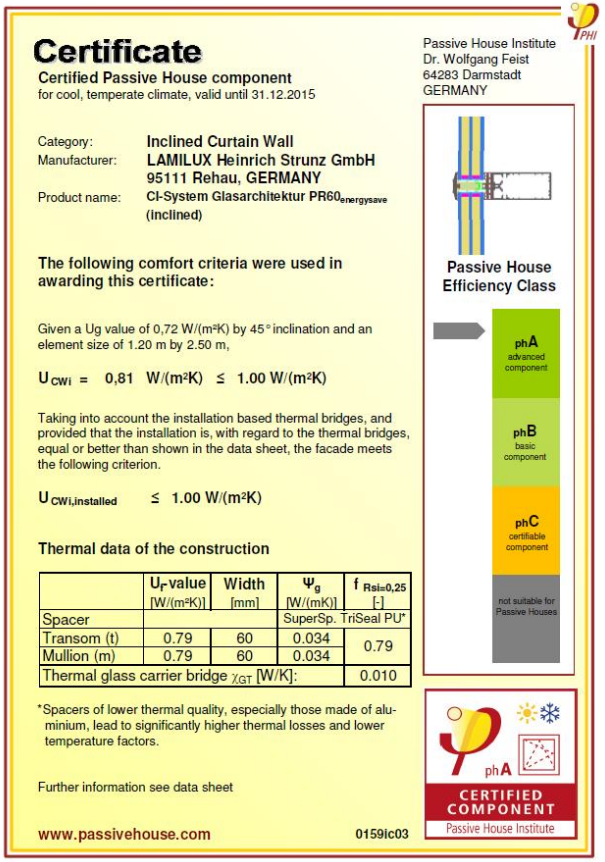
Surface temperature stays far above ‘dew point’ of 50F/10C (red line)

Offers protection with higher relative humidities (climate dependant)

Completely airtight (class 4)

Advanced Components

Glass Roofs



Certificate

Certified Passive House component
for cool, temperate climate, valid until 31.12.2015

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
GERMANY

Category: **Inclined Curtain Wall**
Manufacturer: **LAMILUX Heinrich Strunz GmbH**
95111 Rehau, GERMANY
Product name: **CI-System Glasarchitektur PR60$_{energysave}$ (inclined)**

The following comfort criteria were used in awarding this certificate:

Given a Ug value of 0,72 W/(m²K) by 45° inclination and an element size of 1.20 m by 2.50 m,

U_{CWI} = 0,81 W/(m²K) ≤ 1.00 W/(m²K)

Taking into account the installation based thermal bridges, and provided that the installation is, with regard to the thermal bridges, equal or better than shown in the data sheet, the facade meets the following criterion.

$U_{CWI,installed}$ ≤ 1.00 W/(m²K)

Thermal data of the construction

	U_f value [W/(m²K)]	Width [mm]	Ψ_g [W/(mK)]	$f_{Rsi=0,25}$ [-]
Spacer			SuperSp. TriSeal PU*	
Transom (t)	0.79	60	0.034	0.79
Mullion (m)	0.79	60	0.034	
Thermal glass carrier bridge χ_{GT} [W/K]:				0.010

*Spacers of lower thermal quality, especially those made of aluminium, lead to significantly higher thermal losses and lower temperature factors.

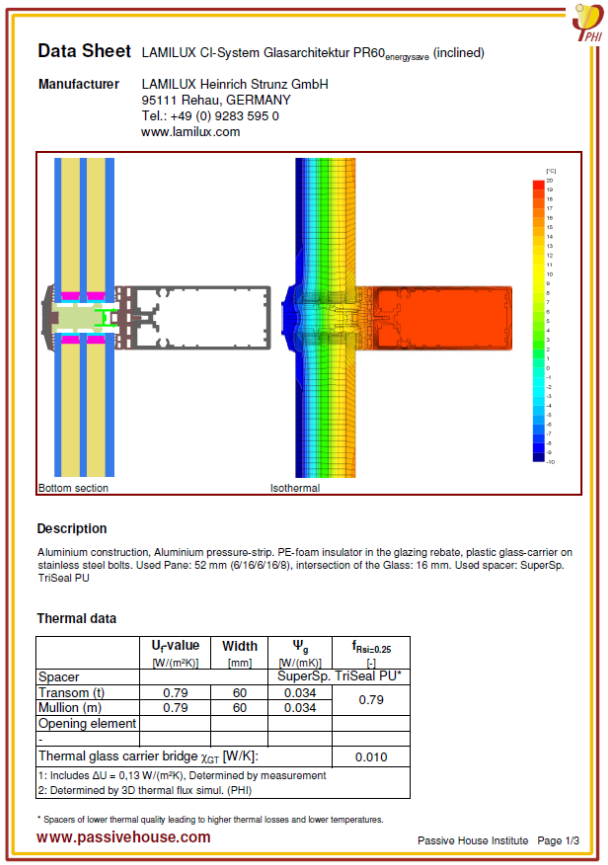
Further information see data sheet

Passive House Efficiency Class

phA advanced component
phB basic component
phC certifiable component
not suitable for Passive Houses

phA CERTIFIED COMPONENT Passive House Institute

www.passivehouse.com 0159ic03



Data Sheet LAMILUX CI-System Glasarchitektur PR60$_{energysave}$ (inclined)

Manufacturer LAMILUX Heinrich Strunz GmbH
95111 Rehau, GERMANY
Tel.: +49 (0) 9283 595 0
www.lamilux.com

Bottom section Isothermal

Description

Aluminium construction, Aluminium pressure-strip. PE-foam insulator in the glazing rebate, plastic glass-carrier on stainless steel bolts. Used Pane: 52 mm (6/16/6/16/8), intersection of the Glass: 16 mm. Used spacer: SuperSp. TriSeal PU

Thermal data

	U_f value [W/(m²K)]	Width [mm]	Ψ_g [W/(mK)]	$f_{Rsi=0.25}$ [-]
Spacer			SuperSp. TriSeal PU*	
Transom (t)	0.79	60	0.034	0.79
Mullion (m)	0.79	60	0.034	
Opening element				
-				
Thermal glass carrier bridge χ_{GT} [W/K]:				0.010

1: Includes ΔU = 0,13 W/(m²K), Determined by measurement
2: Determined by 3D thermal flux simul. (PHI)

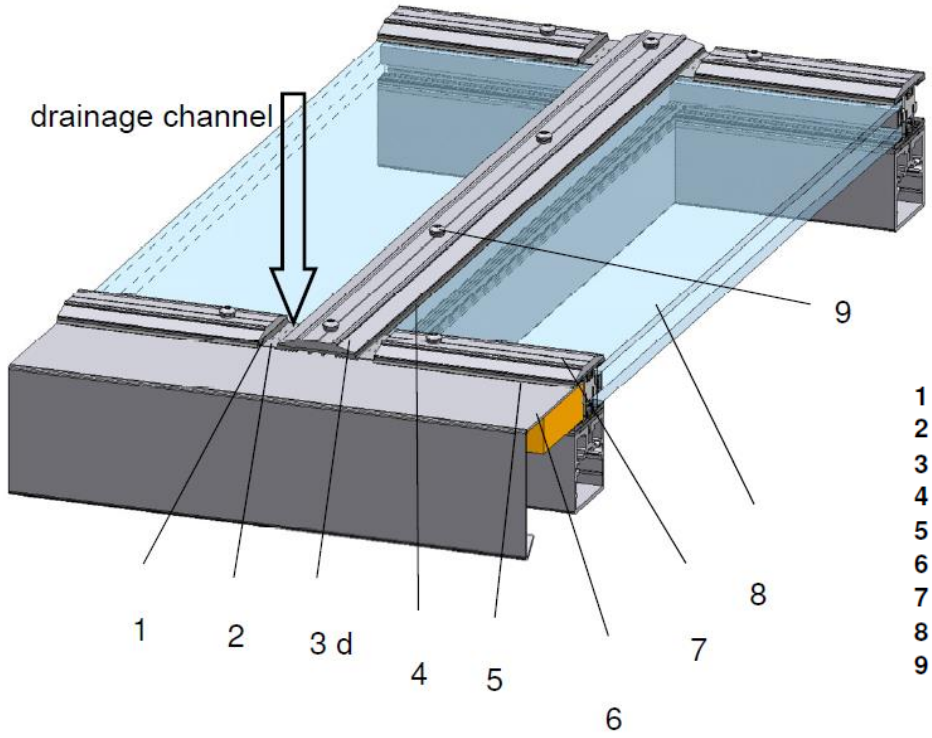
* Spacers of lower thermal quality leading to higher thermal losses and lower temperatures.

www.passivehouse.com Passive House Institute Page 1/3

Advanced Components

Glass Roofs

Detailing of a glass roof



1 Sealed horizontal mullon-cover joint
2 Self adhering stainless steel cover plate for traverse gasket joint
3 Veritcal mullon
4 Exterior vert. mullon gasket
5 Exterior hor. mullon gasket
6 Flashing
7 Horizontal mullon
8 Glass
9 Stainless steel screw connection with epdm seal

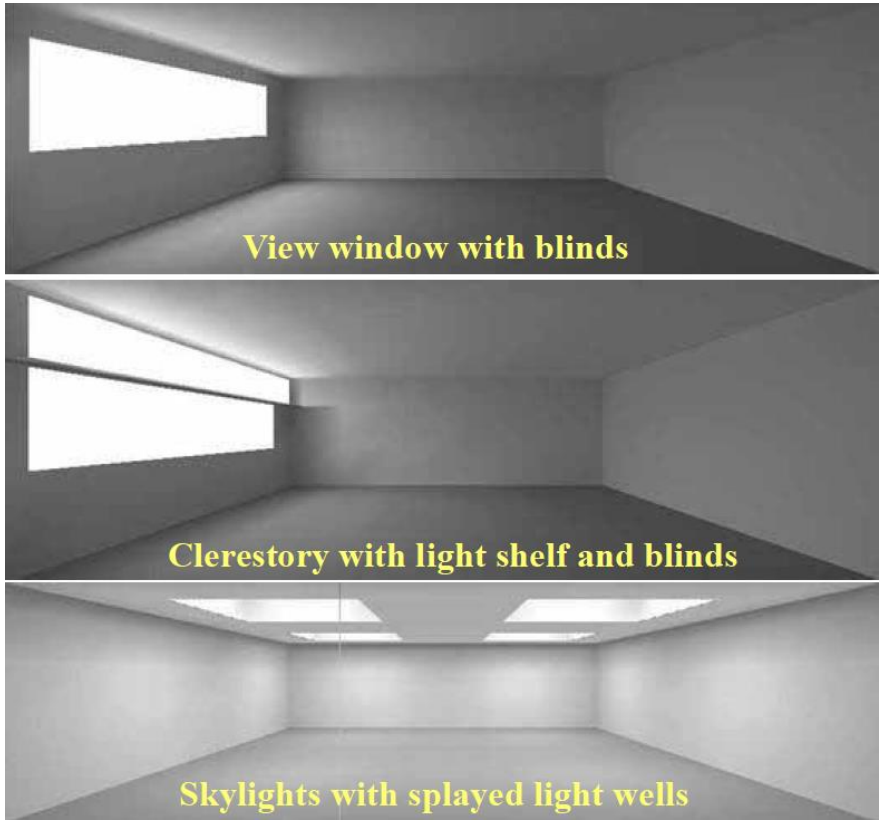
Big Design Strategies

- Orientation
- Spacing
- Diffuse the Light
- Ventilation
- Renewables (BIPV)
- Controls/BMS

Orientation

- Daylight from windows limited
- Lightshelf can increase penetration

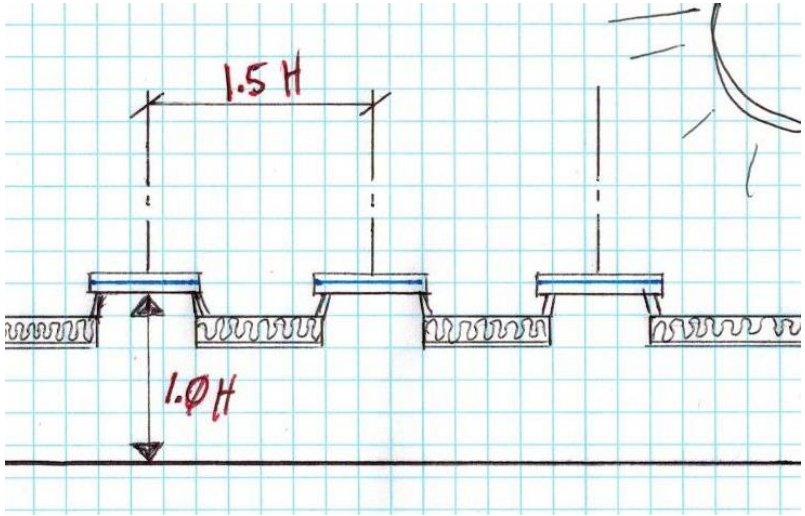
- Unit skylights with splayed light wells provide the most uniform light



AAMA Skylight Council

Spacing

- The general rule of thumb is to space skylights at 1.0 to 1.5 times the ceiling height (center-to-center in both directions)
- Actual designs can vary considerably based upon:
  - Skylight type
  - Light well depth and splays
  - Furniture or shelves



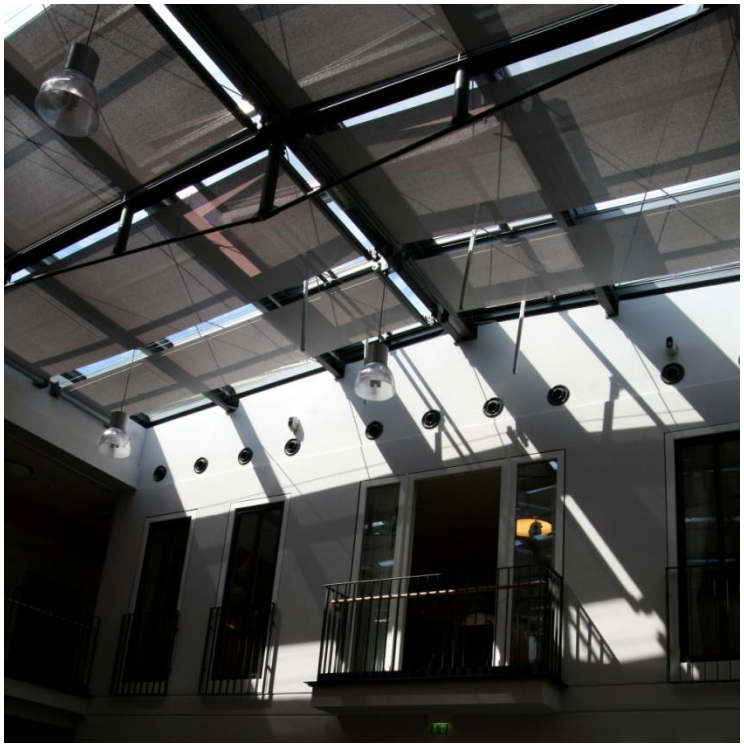
Cross-section

Diffuse the Light

- External shading
- Internal treatments

Glare/solar control

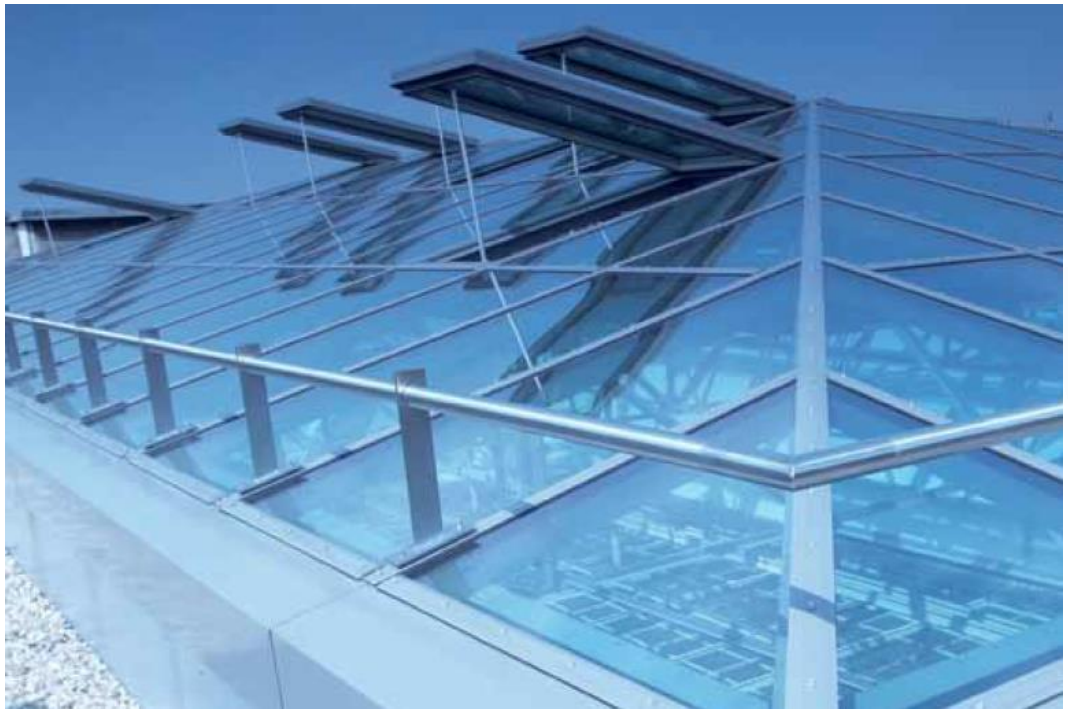
Glass Roofs - shading



Renewable Integration

Ventilation Integration

In sholder seasons (night time cooling)



Also for heat / smoke venting

BMS Controls

Office building Nurnberg

Smoke
Ventilation
Fire Protection
Sun Protection
Access Systems

Find out more…

floris@foursevenfive.com

twitter: @475floris