

# Novel Encapsulation Technology

European Smart Windows Conference

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# AGENDA

- 1. Welcome and Company Presentation**
- 2. Thin glass (handling & advantages)**
- 3. Laminating process for glass-glass-laminates**
- 4. Selection of the Encapsulation foil**
- 5. Quadruple IG-unit (application examples)**



CREATING VISIONS. PROVIDING SOLUTIONS.



## Machinery

- Stand-alone machines
- High-tech plants
- Integrated system solutions



## Software / Automation

- Comprehensive, highly automated solutions
- Dynamic production planning
- Production control systems
- Modular structure of software components



## Services

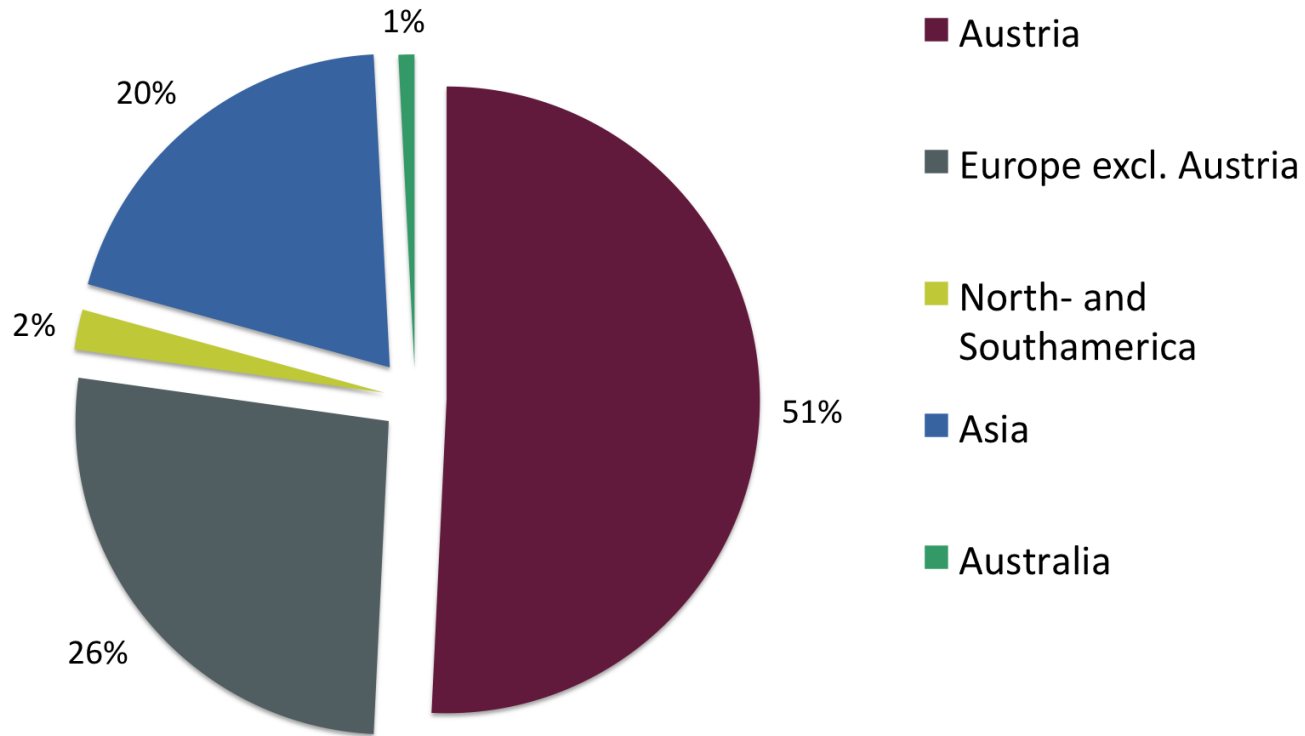
- Largest and broadest service net
- Extensive support
- Online service
- 150 service engineers worldwide
- Service contracts



## Operational know-how

- IG glass production
- Tempered glass
- Laminated glass production & processing
- Thin glass production & processing
- Floatglass processing

# Employees by Region



Status: July 2013

# Thermal Tempering

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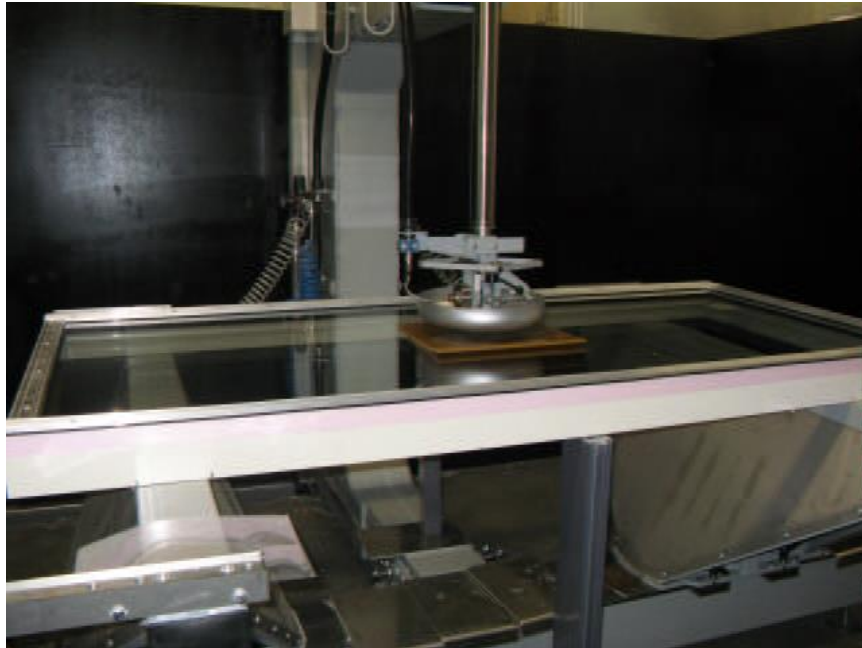
- 0.9mm till 8mm, 3-times increased bending tension
- no touching of glass surface
- no roller waves
- high convection, ideal for coated glass
- significant enhanced energy balance



# Load test

## Advantages thin glass

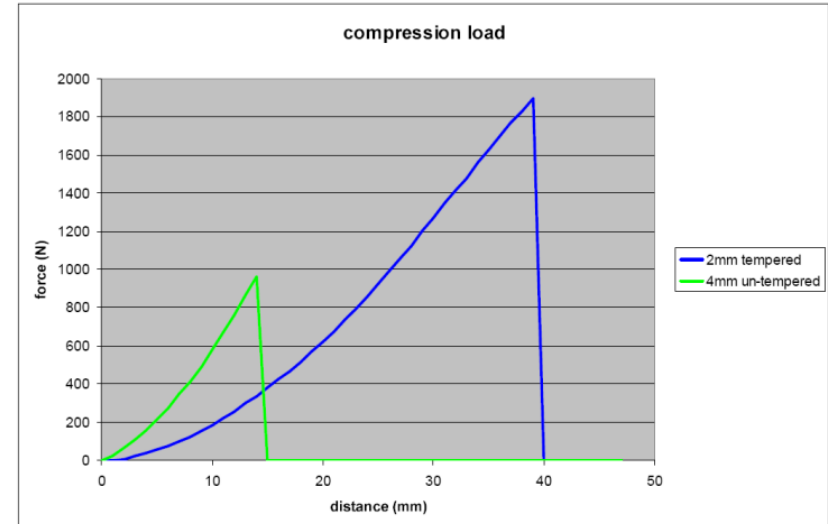
comparing 2mm tempered to 4mm untempered glass



### 2. force/way table from Compression load test

Also created from a test-series of each 10 sheets.

2,0 mm float tempered	Lisec tempered	1894N	39mm distance
4mm float un-tempered		961N	14mm distance

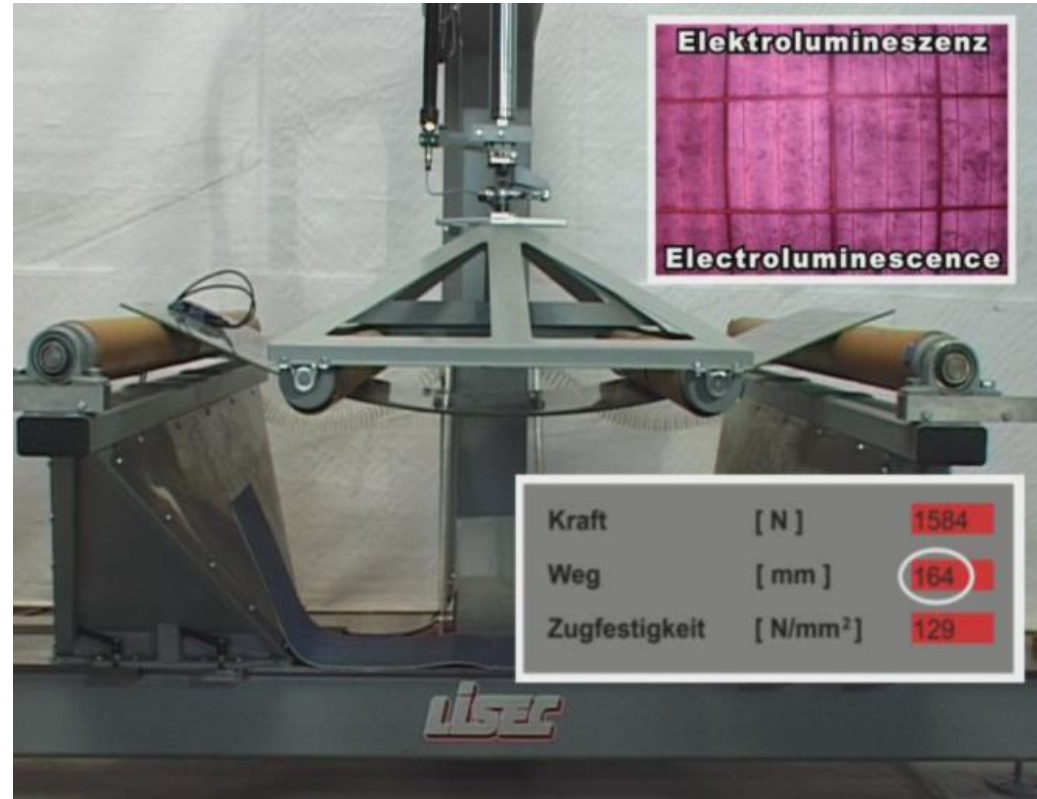
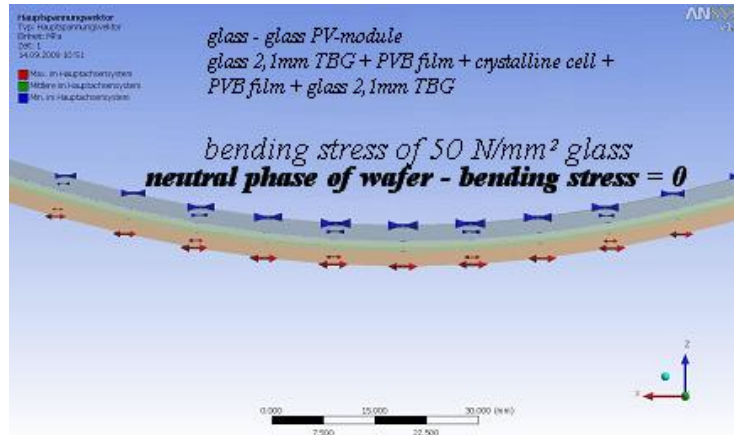


\* 50% un-tempered 4mm glass was breaking on this result

# Glass-Glass Module

## Advantages thin glass in a solar module

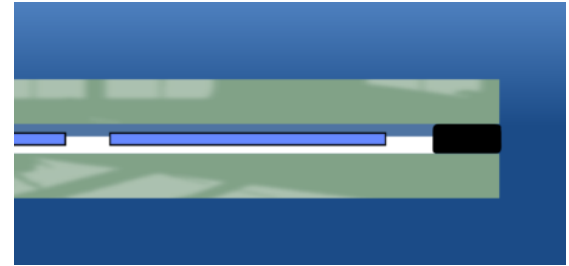
- higher flexibility
- glass-glass module, cells are in the neutral phase of bending tension
- diffusion tight edge sealing



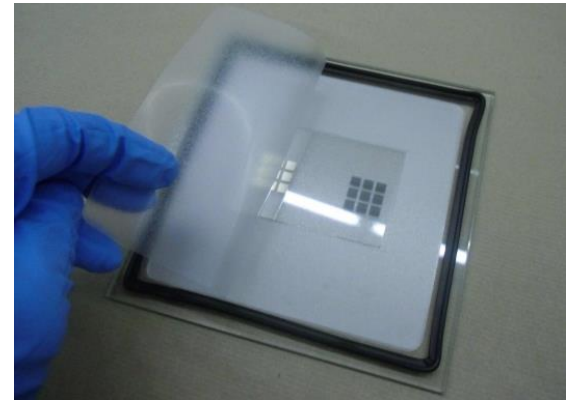
# Butyl Applicator

VHA Butyl Applicator for automatic application of edge sealing

***LiSEC***



Calcium Pads for moisture determination





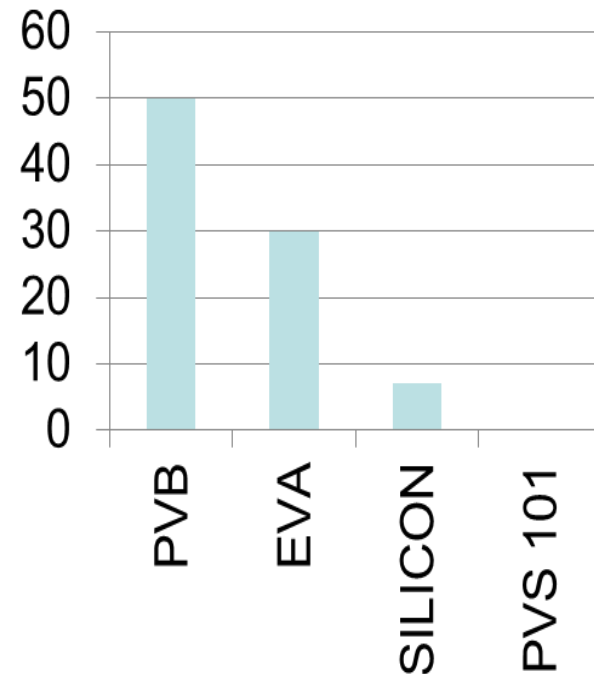
# Water vapor diffusion

## Edge Sealing

▪ <b>PVB</b>	Encapsulation foil	~ <b>50 g/m<sup>2</sup>day</b>
▪ <b>EVA</b>	Encapsulation foil	~ <b>30 g/m<sup>2</sup>day</b>
▪ <b>Tectosil / Silicon</b>	Encapsulation foil	~ <b>7 g/m<sup>2</sup>day</b>
▪ <b>PVS 101</b>	Edge sealing	<b>0,01 g/m<sup>2</sup>day</b>

Due to the additional edge sealing, the module is 700 times more water vapor diffusion tight as the best encapsulation foil.

The cells are best protected against moisture and environmental influences.



# Laminator

## LiSEC Vacuum Laminator compared to Membran Laminator

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	LiSEC Laminator	Competitors
encapsulation foil	PVB	EVA
uniform temperature	not so important PVB = thermoplastic material = no cross linking	< +/- 2K Required an expensive electric or thermal oil heating
temperature level	constant	different temperature between bottom and top side and cooling process
lamination time	< 5 minutes	10 – 15 minutes
wear parts	no critical parts	membranes / diaphragma are changed all ~5000 cycles
edge delamination	flat metal plates – no overpress	membrane caused an overpress of glass edges – delamination! additional subframe or devices necessary



# Bake Test with different vacuum lamination parameter

## Vacuum Laminator



pos.	VPL Vacuumlaminator			autoclave	other	picture	Kuraray	
	temperature	vacuum	heating time				baketest	humidity
1	80 °C	1 mbar	60 sec	3bar / 140°C / 45min			140°C / 2 bubbles	0,37
2	110 °C	1 mbar	60 sec	3bar / 140°C / 45min			150°C / ok	0,35-0,36
3	140 °C	1 mbar	60 sec	3bar / 140°C / 45min			150°C / ok	0,27-0,31
4	110 °C	0,1 mbar	120 sec	3bar / 140°C / 45min			150°C / ok	0,23-0,29
5	110 °C	10 mbar	60 sec	3bar / 140°C / 45min			150°C / 1 bubble	0,33-0,37
6	110 °C	50 mbar	60 sec	3bar / 140°C / 45min	small bubbles		110°C / 1 bubble    150°C / 7 bubbles	0,41-0,47
7	110 °C	100 mbar	60 sec	3bar / 140°C / 45min	many long bubbles		100°C / 10 new additional bubbles	0,41-0,43
8	110 °C	1 mbar	60 sec	3bar / 140°C / 45min	PVB predrying		150°C / ok	0,11-0,16
9	roll laminator			3bar / 140°C / 45min	without edge sealing		120°C / 12 bubbles 130°C / additional 30 bubbles	0,43-0,44

Bake Test: Bubbles are allowed  $\geq 130^{\circ}\text{C}$

Result: The LiSEC Vacuumlaminator allows a wide process window.

When the vacuum is lower than 10mbar and the temperature is higher than  $80^{\circ}\text{C}$  then the Bake Test is well.

These test results are experience from LiSEC but no guarantee for the final product.

The customer is responsible to determine the correct process parameters and to perform a final quality check!

# Encapsulation foils

## Vacuum Laminator



Samples with different encapsulation foils produced on the LiSEC Vacuum Laminator with low process temperature ( $\leq 130^\circ \text{C}$ ) for OLED applications to determine bubbles and transmission

Folienart		VaccumLaminator		foil melted and bubbles		transmission	furthermore	skill
producer	type	temperature	time	130°C/30min	150°C/30min			
		[°C]	[sek]					
Isovoltaic	TPO F2G	110	60	2	2	5		-
Isovoltaic	TPO F2G	130	360	1	1	5		-
Isovoltaic	TPO F1G	110	60	3	3	4	foil adhesion and flow rating	-
Isovoltaic	TPO F1G	130	360	2	2	4		-
Novopolymers	Novovellum FC3	110	60	3	5	1		~
Novopolymers	Novovellum FC3	130	360	2	4	1		~
Evasa	FC1 Fast Cure	110	60	3	3	1	material compatibility yellowing cross connectors	~
Evasa	FC1 Fast Cure	130	360	2	2	1		~
Evasa	FC3 PID Free	110	60	3	5	1	small bubbles next to cross connectors	~
Evasa	FC3 PID Free	130	360	2	2	1		~
Dupont	PV 5414	110	60	4	5	2		~
Dupont	PV 5414	130	360	2	2	2		~
Dupont	PV 5316 plates	110	60	5	4	1	high static charge clean room	+
Dupont	PV 5316 plates	130	360	2	2	1		+
Dow Chemical	Polyolefin ENLIGHT	110	60	5	5	4		-
Dow Chemical	Polyolefin ENLIGHT	130	360	1	1	4		-
Wacker Chemie	Tectosil	110	60	5	1	2		+
Wacker Chemie	Tectosil	130	360	5	1	2		+
Trosifol	Solar R40	110	60	2	1	1		+
Trosifol	Solar R40	130	360	2	1	1		+

### caption:

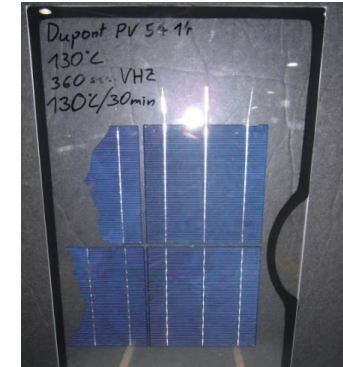
foil melted and bubbles:

1 = without bubbles ..... 5 = many small bubbles

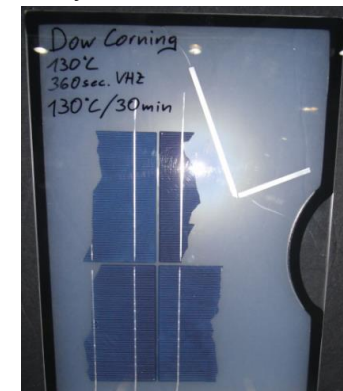
transmission:

1 = high transmission, completely clear ..... 5 = opaque

clear



hazy



# Test report

## Encapsulation of OPV module with SGP 5000 and Krystalflex



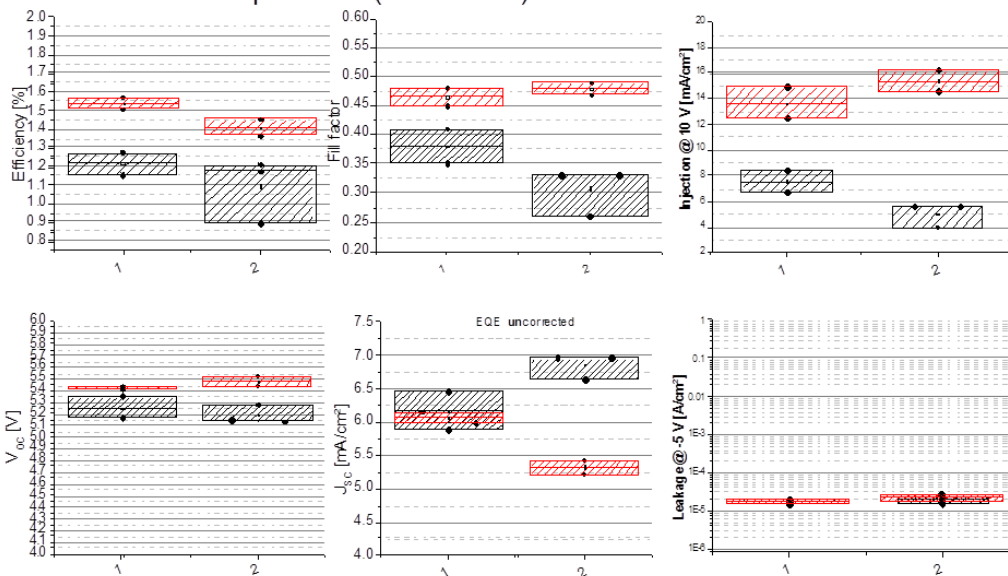
Sample 1) Laminated with Krystalflex TPU PE 429

Sample 2) Laminated with DuPont SGP 5000

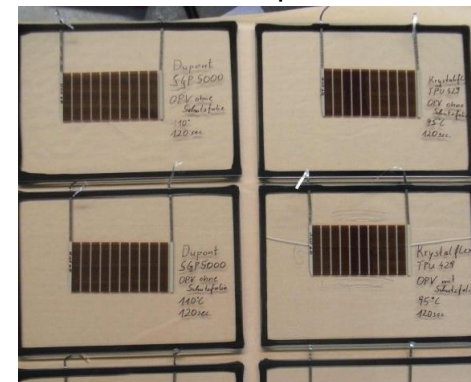
Result: OPV sample laminated with the encapsulation foil Krystalflex shows no current losses through Light Soaking. Probably there is no water and oxygen between the glasses in the laminate. (Figure 7)

MW104 - Modules for glass encapsulation  
after encapsulation (MEM4WIN)

1 Krystalflex x TPU 429  
2 Dupont SGP5000



OPV samples



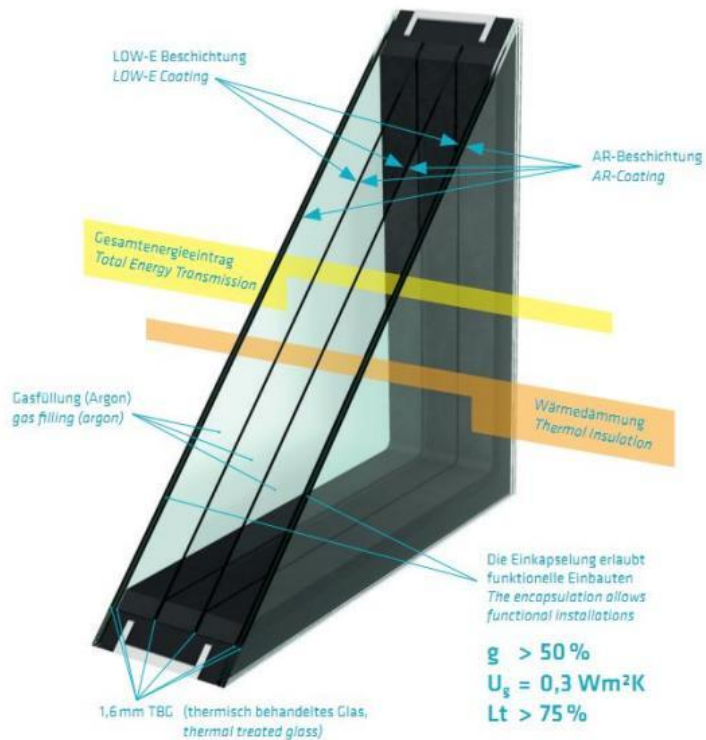
Lamination parameter for Krystalflex foil

stage 1	Laminator, 95 °C at 1 mbar for 5 min
stage 2	Autoclave, 95 °C at 3 bar for 2 hrs

# MEM4WIN facade mock up

## Quadruple IG-Unit

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Thank you for your attention!