

# Worldwide Glass Trends

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# Worldwide Glass Trends - Summary from GPD 2017

- I have gone through 180 presentations and over 10 000 PowerPoint slides from the GPD 2017
- I have selected the most important trends from different areas.



**Ebook available at  
[www.gpd.fi](http://www.gpd.fi)**

Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Jorma Vitkala, GPD

# GPDs impressive record - 25 years



## GPD 1992 - 2017

- 14 600 delegates
- 1 180 speakers
- 3 100 presentations
- 10 000 pages of technical documents



# GPD FINLAND 2017



INDIA

UAE

CUBA

BRAZIL

CHINA

SINGAPORE

TURKEY

AZERBAIJAN

ENGLAND

## GPD 25 years

- 15 conference in Finland
- 20 regional conferences
- International knowledge,
- Local languages and markets



# GPD Finland Participant History



- Since 1992
  - Over 14 600 participants in GPD events worldwide since 1992
  - Over 1 200 speakers
  - Over 3 100 presentations
  - Over 10 000 pages of technical papers published

# Worldwide Glass Market Trends

Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Jorma Vitkala, GPD

# Our industry changed during these last 25 years



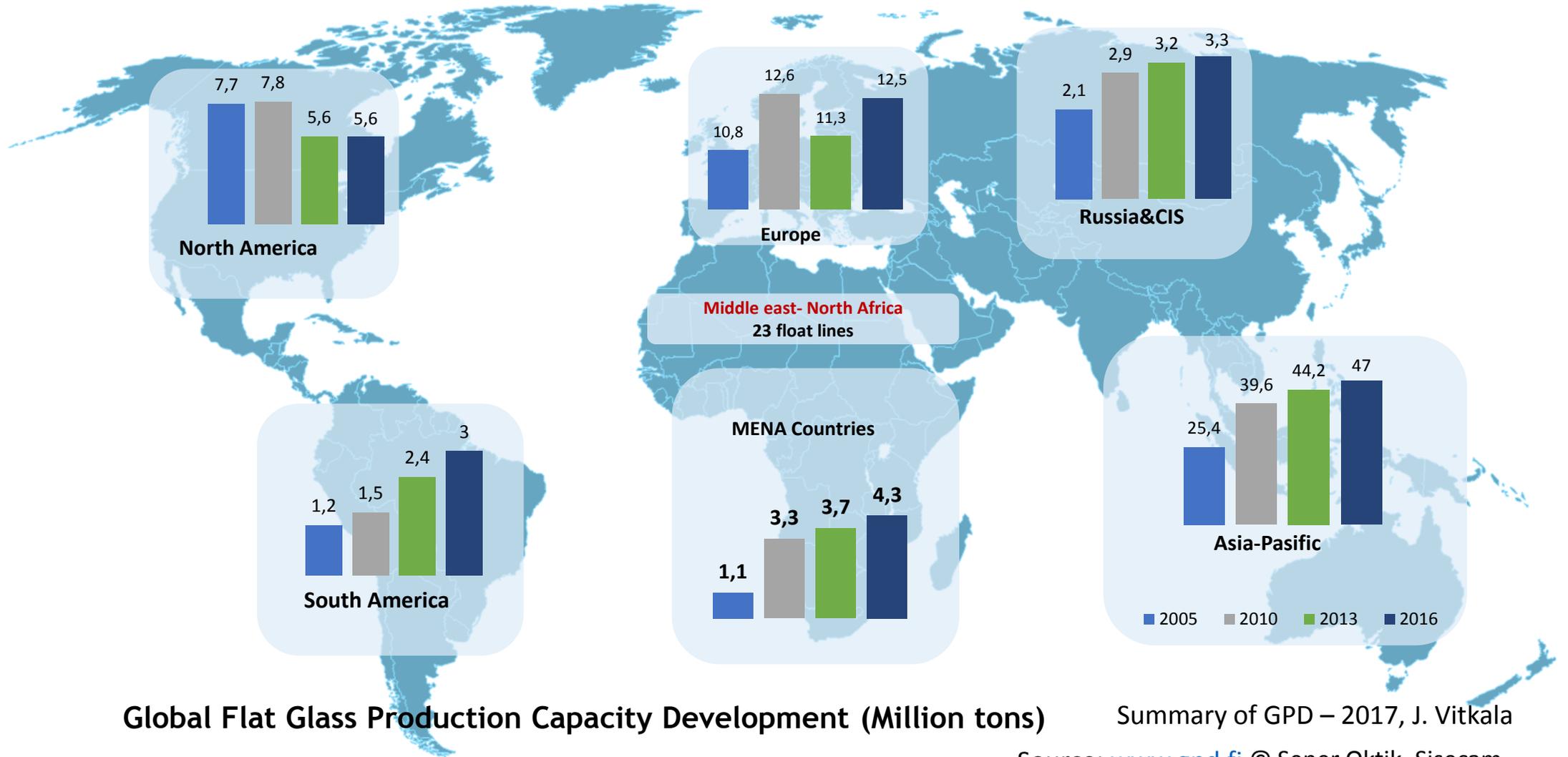
1992	2017
150 float lines	More than 500 lines
25 lines in China	More than 250 lines
60% of production in EU + USA + Japan	Less than 20 % in EU + USA + Japan
4 Dominant companies	New principals
322 Chinese patents on glass	More than 7000 Chinese patents on glass
80 Korean patents	More than 1000
Producers were dominant	Downstream business is more crucial than before
Selling prices decreased	

2016 The Global demand for flat glass: ~73 million tonnes (~ 9.2 billion m<sup>2</sup>)

The global market value of flat glass: \$90 billion



2005  
2010  
2013  
2016



Global Flat Glass Production Capacity Development (Million tons)

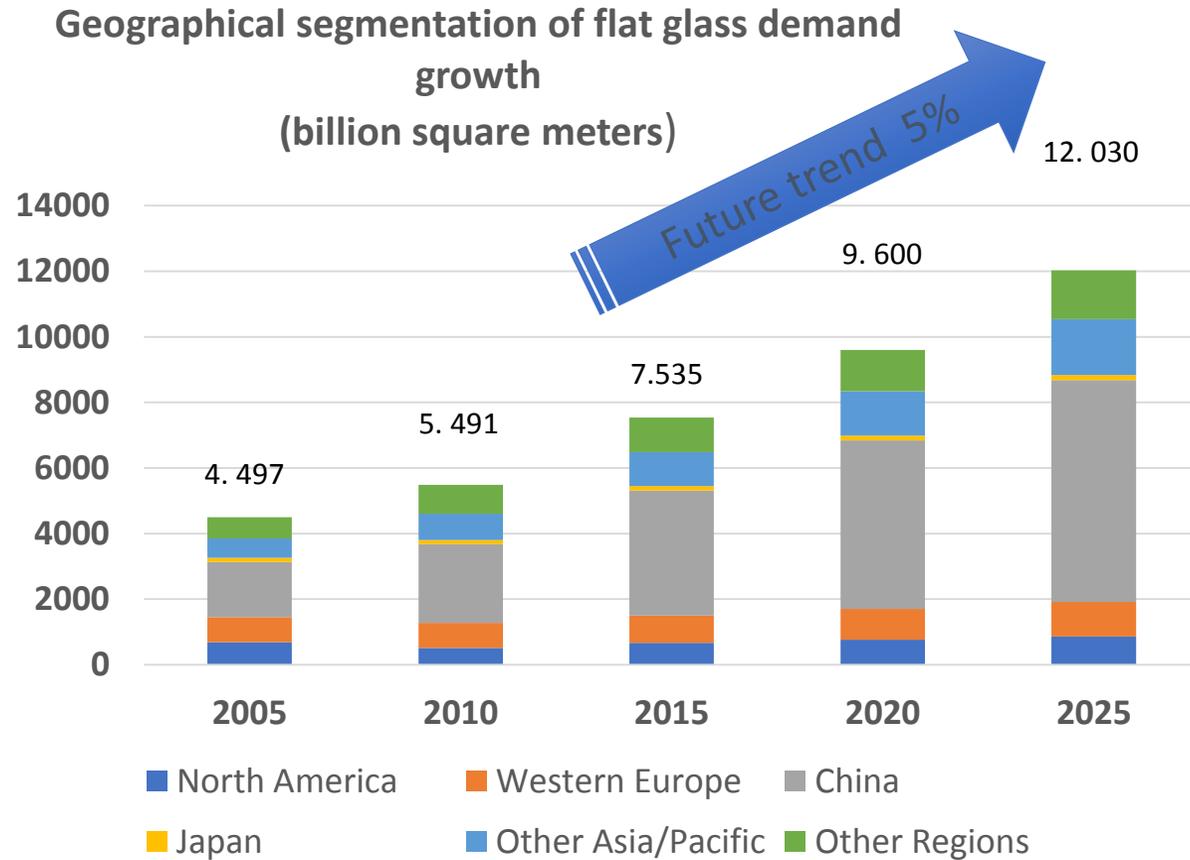
Summary of GPD – 2017, J. Vitkala

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# Growth of global demand for flat glass & geographical segmentation

**In 2016, Demand: ~73 million tons (~ 9.2 billion m<sup>2</sup>) (dominated by China 51%)**

2016 Geographical segmentation analysis (%) of global market for flat glass (~ 9,2 Billion m <sup>2</sup> )	
China	51
Europe	19
Southeast Asia	8
North America	7
South America	4
Russia	6
Others	5
<b>Total</b>	<b>100</b>



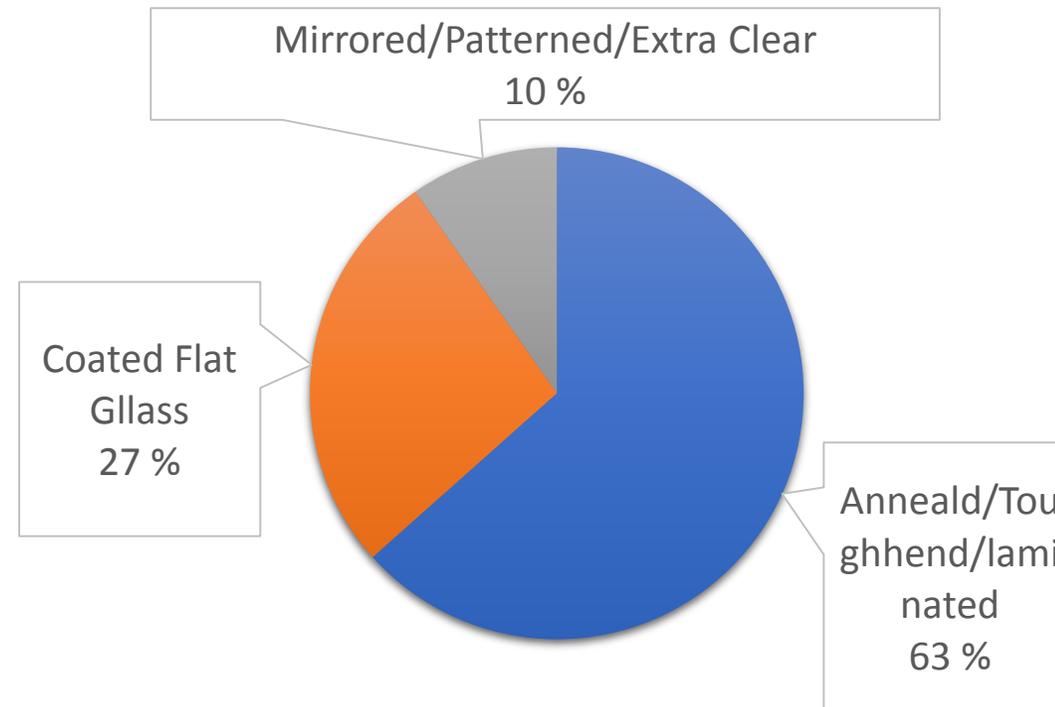
# Coated flat glass at a glance

2016 The Global demand for flat glass:

**~ 73 million tonnes**

*~ 9,2 billion m<sup>2</sup>\**

2016 The Global demand  
for coated flat glass:  
**~ 20 million tonnes**  
*~ 2,5 billion m<sup>2</sup>\**

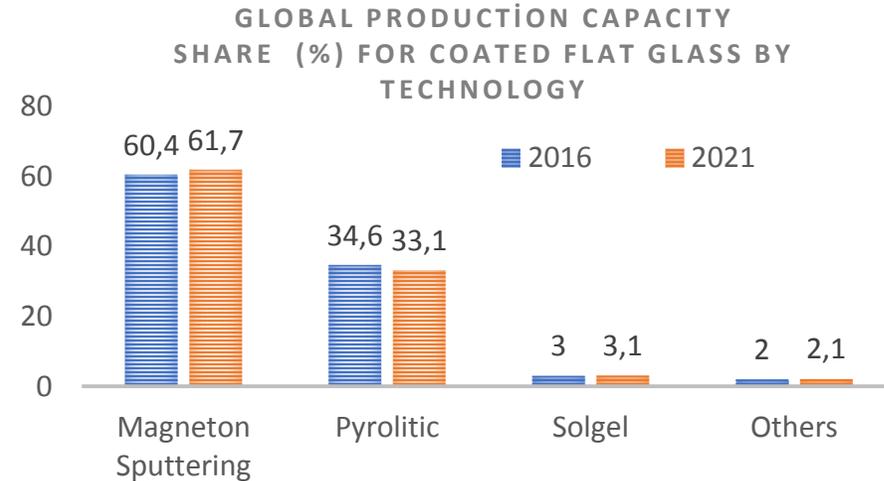
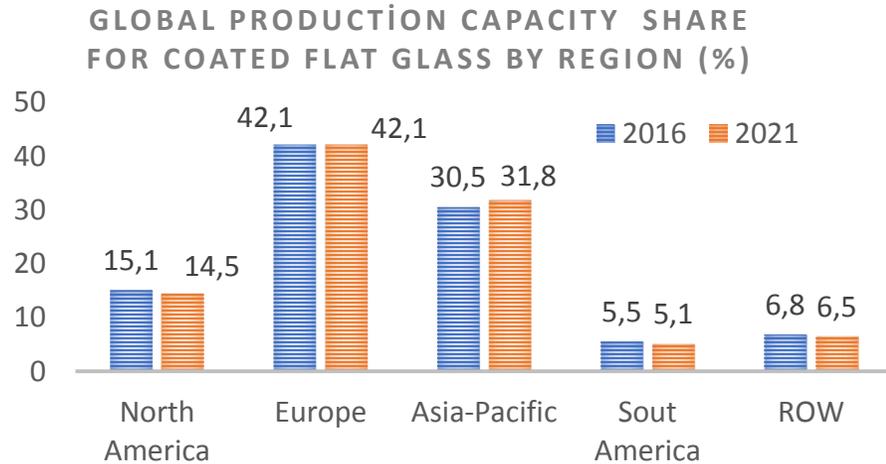


*( \*for a rough estimation; m<sup>2</sup> /metric ton ≈125)*

# GLOBAL PRODUCTION & MARKET VOLUME AND PROJECTION TO 2021 FOR COATED FLAT GLASS



Coated Flat glass Production	2015	2016					2021
Million Tons	~19	~20	CAGR~6.1%				~25
Billion m <sup>2</sup> (m <sup>2</sup> /metric ton ≈125)	~2,4	~2,5					~3,2
The Market (Billion US Dolars)	~24,4	~25,8	CAGR~5,9%				~34,4

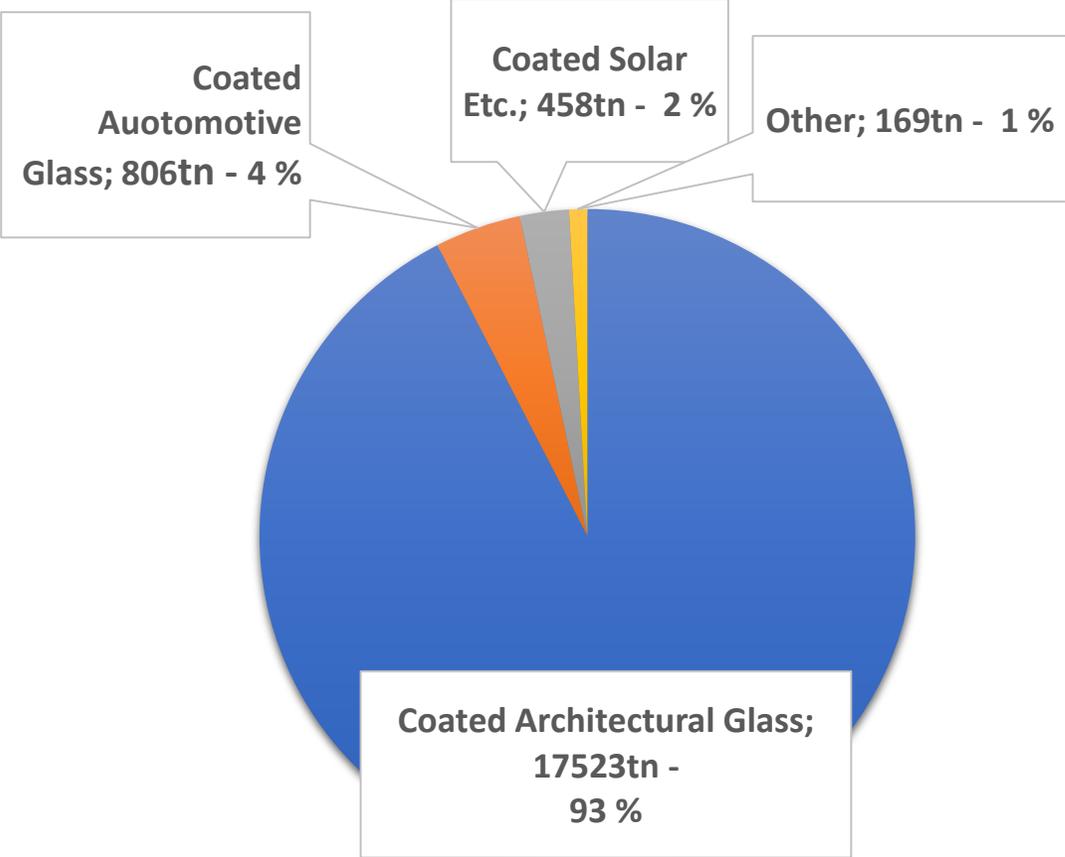


BCC Research, Wellesley MA USA, Website: [www.bccresearch.com](http://www.bccresearch.com)

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# 2016 Global market for coated falt glass by applications



*(Thousand tons - %)*

# 2016;The global demand for flat glass & application segments

**Demand: ~73 million tons** (~ 9.2 billion m<sup>2</sup>) (dominated by China 51%)

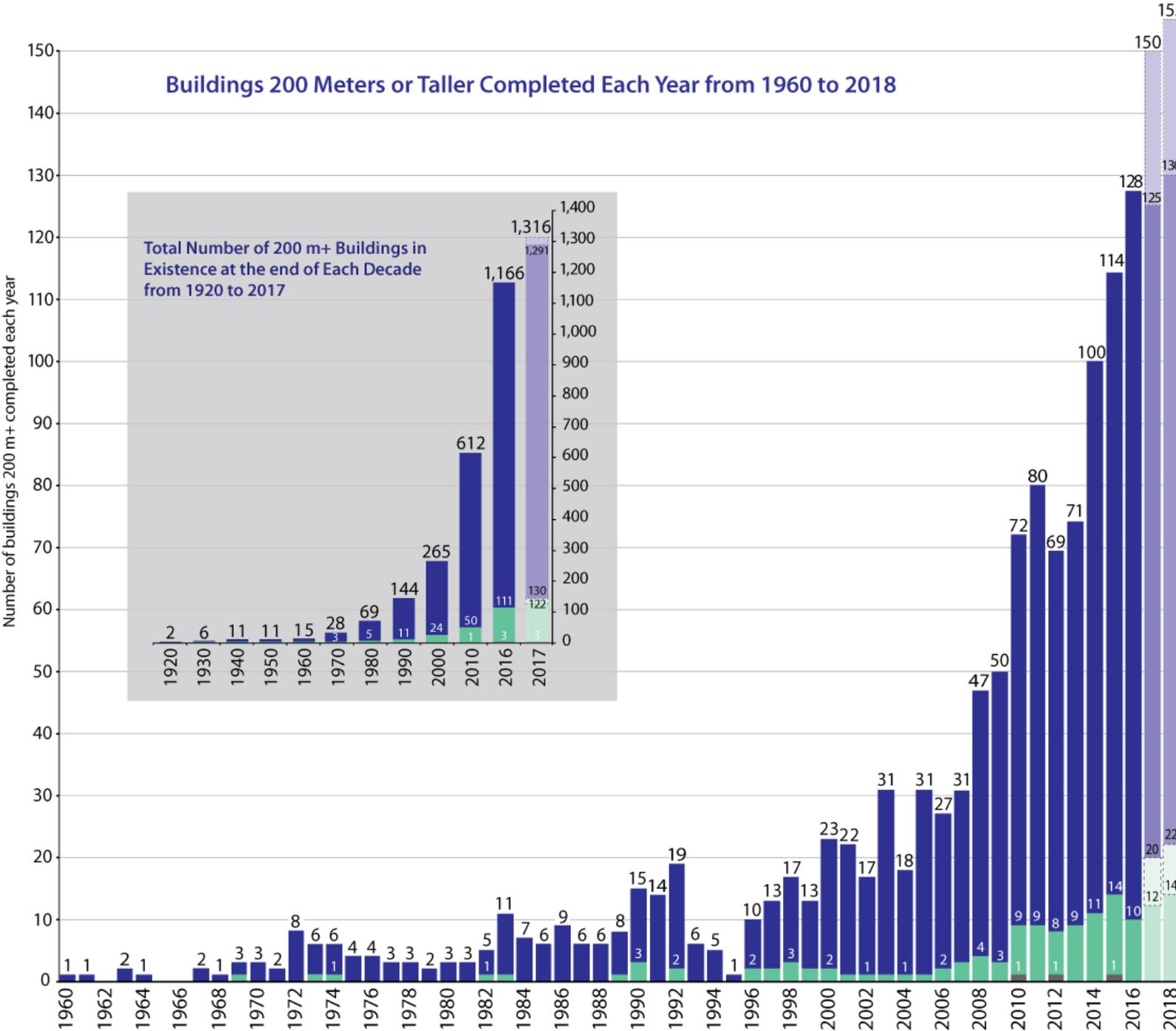
(m<sup>2</sup>/metric ton ≈125)

The global demand for flat glass & Application Segments (%)			
Architectural	80	New Buildings Façade	40
		New Building Interior	20
		Refurbishment	40
Automotive	10	Original equipment manufacturers (OEMs)	80
		Replacements	20
Special applications	10	Technical glass +displays + electronics equipment + solar glass	10

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Buildings 200 Meters or Taller Completed Each Year from 1960 to 2018



# High Rise Buildings Data Research

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Source: [www.gpd.fi](http://www.gpd.fi) © Dario Trabucco, CTBUH

# Industry 4.0 / IoT

# Industry 4.0 / IoT – what is it?



Industry 4.0 has been coined as the fourth industrial revolution.

It is a collective term for **IoT** devices coupled with systems that contain machine learning algorithms that control a process or factory with little human intervention

# DEVELOPMENT PHASES FROM INDUSTRY 1.0 TO INDUSTRY 4.0

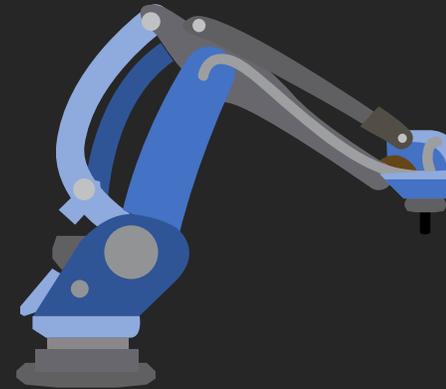
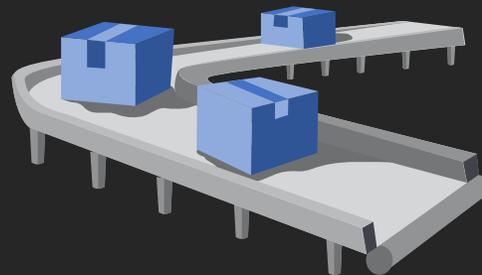


1.

**First Industrial Revolution:**  
**steam power** makes  
mechanical production  
possible  
(Late 18th century)

**Second Industrial Revolution:**  
**electric energy** makes mass  
production possible  
(Beginning of the 20th century)

2.



3.

**Third Industrial Revolution:** **IT and computer technology** allow  
for more manufacturing  
automation  
(Beginning of the 1970s)

**Fourth Industrial Revolution:** Internet of  
Things makes networked  
manufacturing possible  
(Since the 21st century)

4.



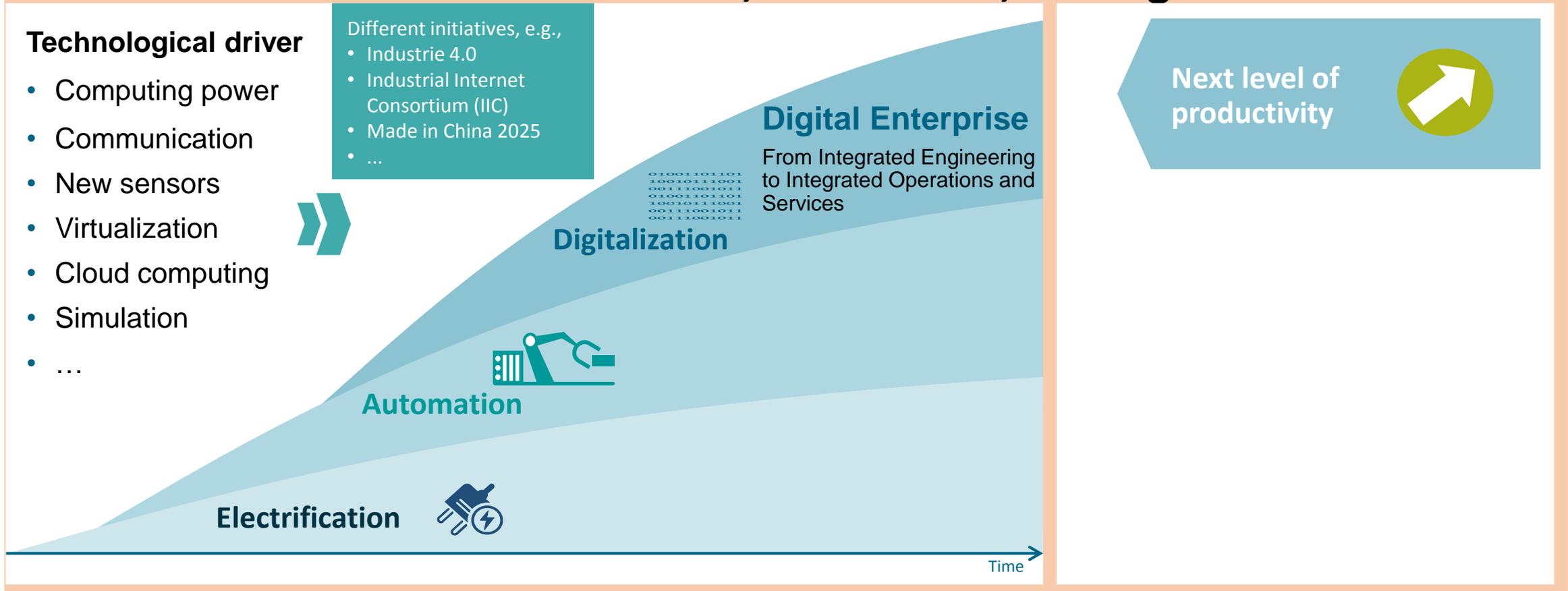
# Process industries → electrification, automation, and digitalization as drivers

## Technological driver

- Computing power
- Communication
- New sensors
- Virtualization
- Cloud computing
- Simulation
- ...

Different initiatives, e.g.,

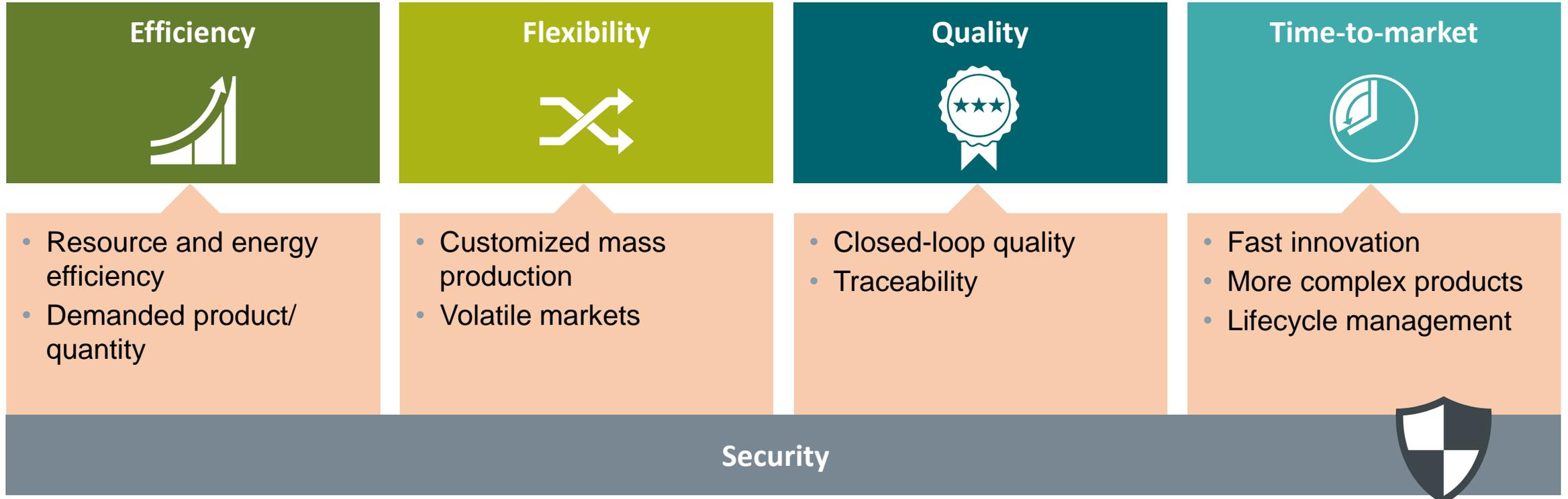
- Industrie 4.0
- Industrial Internet Consortium (IIC)
- Made in China 2025
- ...



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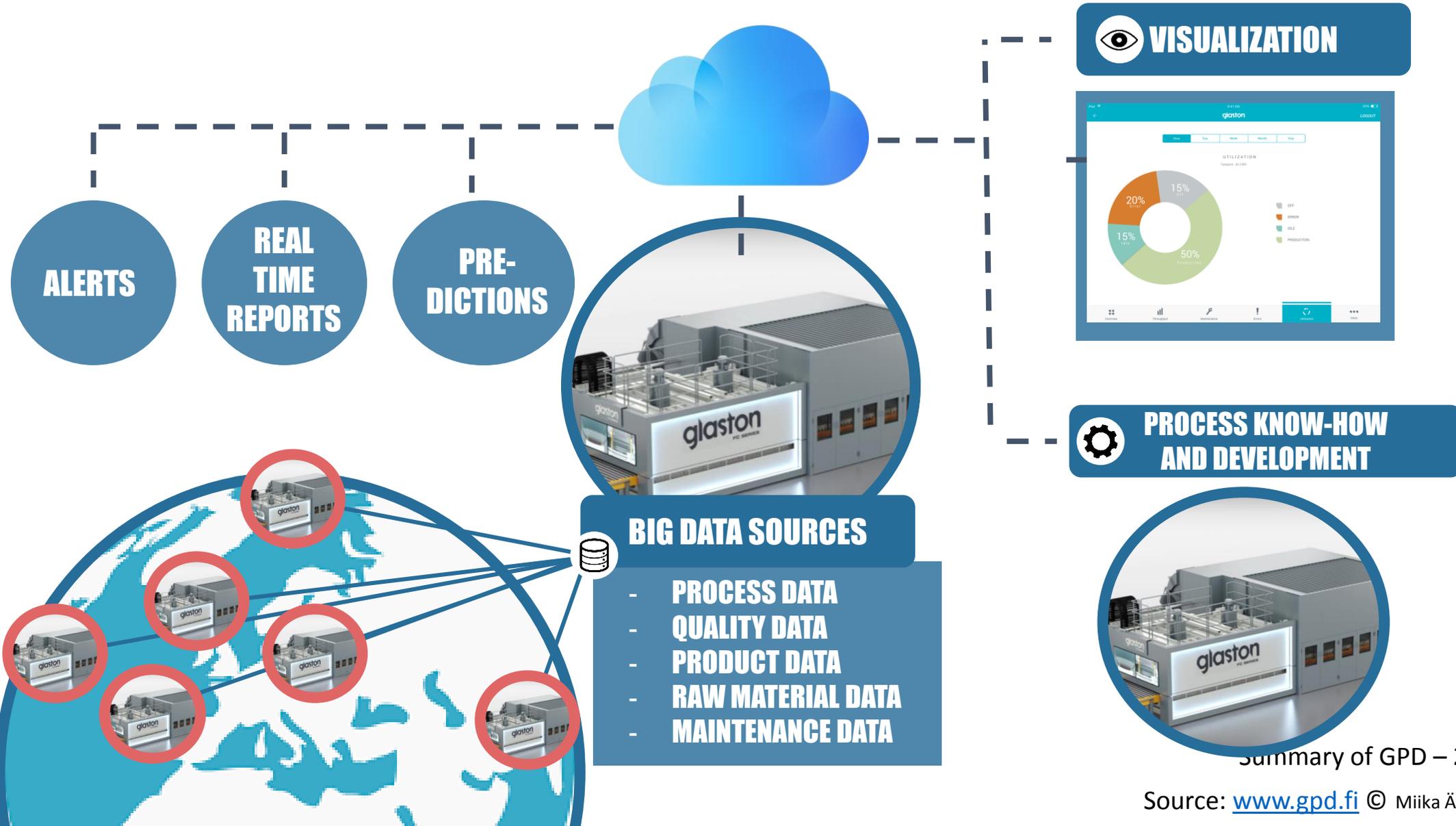
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# Industry trends



Health and safety | Environment | Regulations/standards | ...

# Use of big data



**VISUALIZATION**



**PROCESS KNOW-HOW AND DEVELOPMENT**



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# Worldwide Glass Design Trends

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(rendering; courtesy of BIG)

**A dream becomes real**  
**Multidisciplinary effort and success**

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(rendering; courtesy of BIG)

## Competition proposal Aspiration

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## Aspired transparency

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O'Callaghan





## Glass Bridge Zhang Jia Jie, China

**Architect:** HaimDotan

**Engineer:** He'nan Chengjian Decoration Engineer Co.,Ltd

**Laminator:** He'nan Fuxin Glass Co., Ltd

**Interlayer:** Ionoplast

It has been designed to accommodate up to 800 visitors so the glazing solution had to be incredibly robust.

# Lighting and Sound Show in Hong Kong



## The ICC Light & Music Show

This show on the tallest building in Hong Kong combines music and animated story themes. An advanced computer programme controls each LED on the facades to create truly breath-taking animated images. The show has set a Guinness World Record for the largest light and sound show on a single building.

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Source: [www.gpd.fi](http://www.gpd.fi) © Sammy Hui, Hong Kong Facade Association



## Louis Vuitton Paris, France

**Architect:** Frank Gehry

**Structural Engineer:** RFR

**Laminator:** Sunglass

**Interlayer:** 1.52 mm (60 mil) Ionoplast

Given the complexity of the sails and their multiple facets, all of which required unique geometries Ionoplast was the best choice.

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## Nardini Bolle Exhibition Centre, Italy

**Architect:** Massimiliano Fuksas

**Laminator:** Sunglass Srl, Villafranca Padovana, Italy

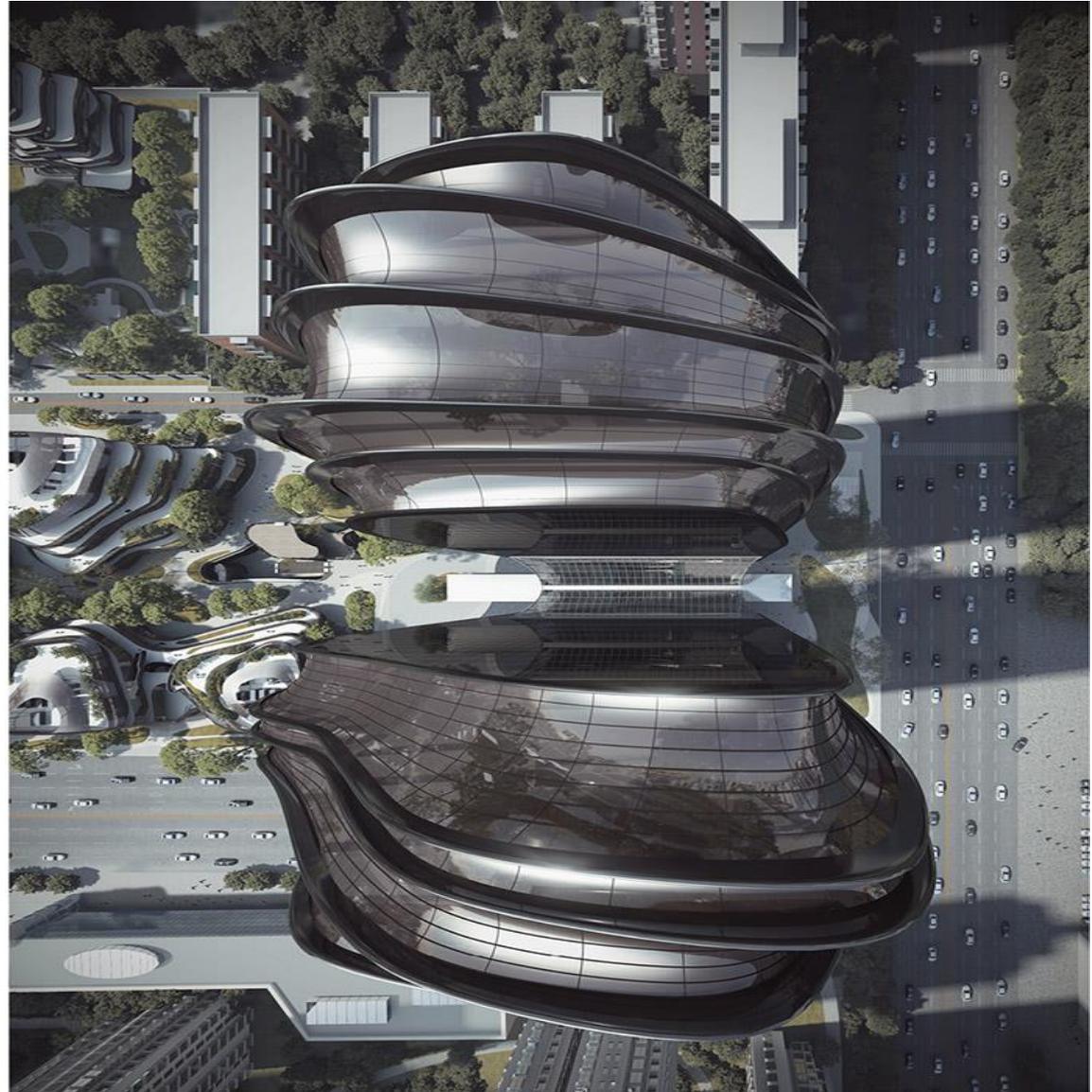
**Building Owner:** Ditta Bortolo Nardini S.p.a

**Interlayer:** 1.52 mm PVB UltraClear



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# Glass is a fantastic material...



Louis Vuitton, Paris



Marina Bay Sands, Singapore



Shanghai Tower

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# Enzo Ferrari Museum, Italy

**Architect:** Jan Kaplicky and Andrea Morgante, Future Systems

**Engineer:** Werner Sobek

**Construction:** Politecnica

**Interlayer:** 1.52 mm (60 mil) Ionoplast

The requirements of geometrical shape and transparency + reduction of glass thickness allowed the usage of Ionoplast.



# Parametric System Façade Examples

Science Park (project)  
Kopenhagen  
mvrdr



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# Parametric System 3D facade system



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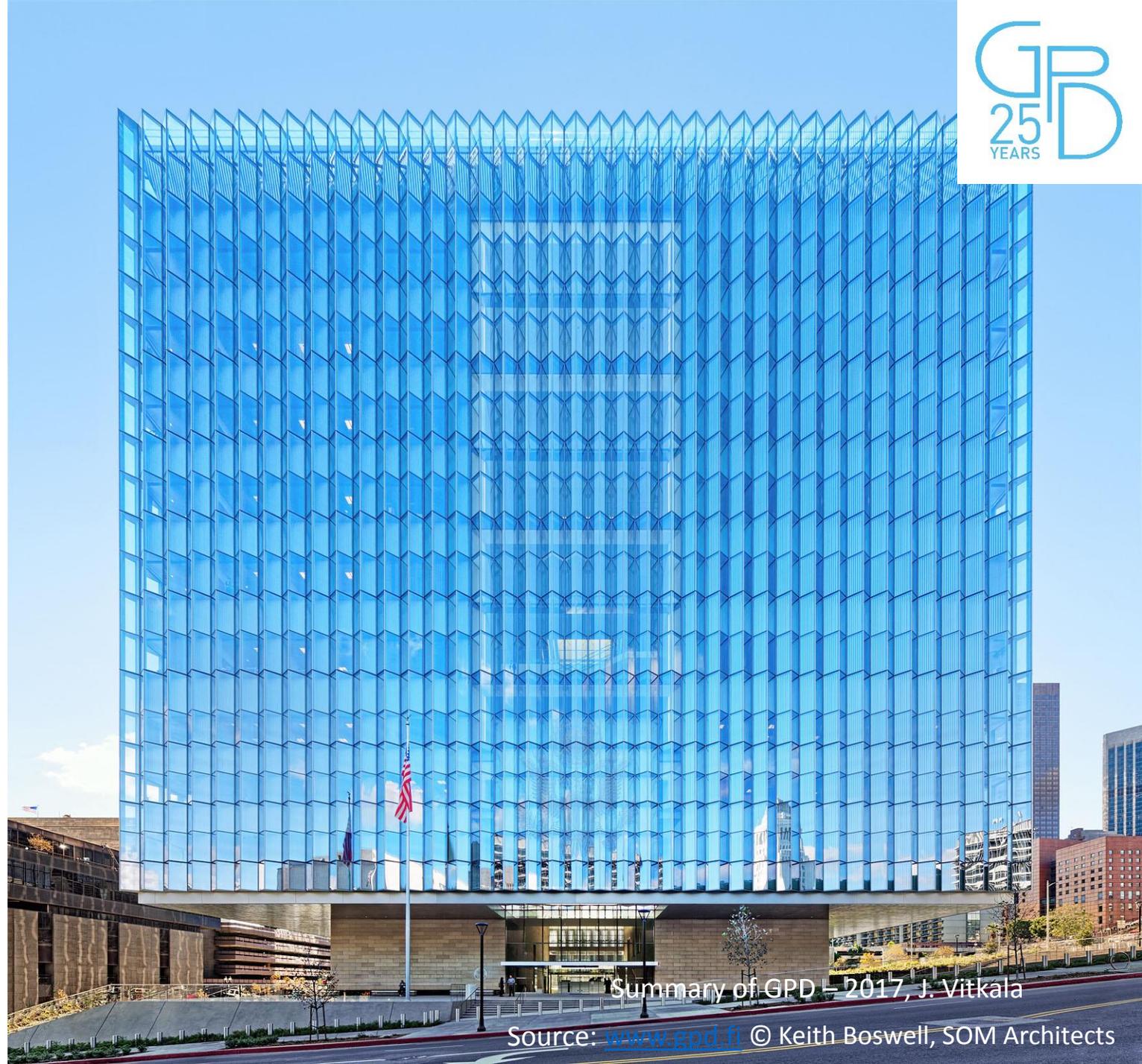
LOS ANGELES, CALIFORNIA



Engagement in the Urban Realm



LOS ANGELES, CALIFORNIA



SKIDMORE, OWINGS & MERRILL LLP

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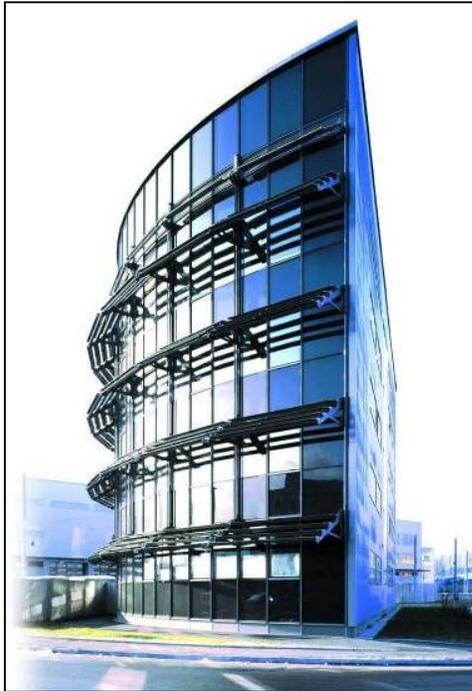
# Market Trends: Daylighting

- Studies have shown in spaces with improved daylight and/or views:
  - Increased real estate value, rental rates
  - 6% increased retail sales
  - 20% increased in office worker cognitive test rates
  - **39 additional work hours per year in office worker productivity**
  - 9-16% improved performance on visual memory tests (but glare decreased it by 17%)
  - 15% decreased absenteeism in office workers
  - Decreased office worker turnover
  - 21% increase in student test scores
  - 22% reduced development of surgical post-op delirium
  - **Reduced length of hospital stay by 2.6 days**
  - 22% less pain medication in post-spinal surgery patients
  - Reduced depression, improved sleep



# Energy Performance: Daylighting

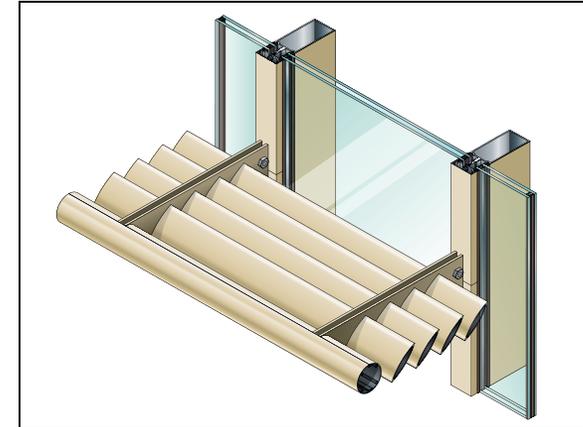
- Integrated approach to shading, glare control, daylighting, and even power production



photovoltaic sunshades



light shelves and/or  
light redirecting films



sunshades

Summary of GPD – 2017, J. Vitkala

Urmilla Sowell, GANA

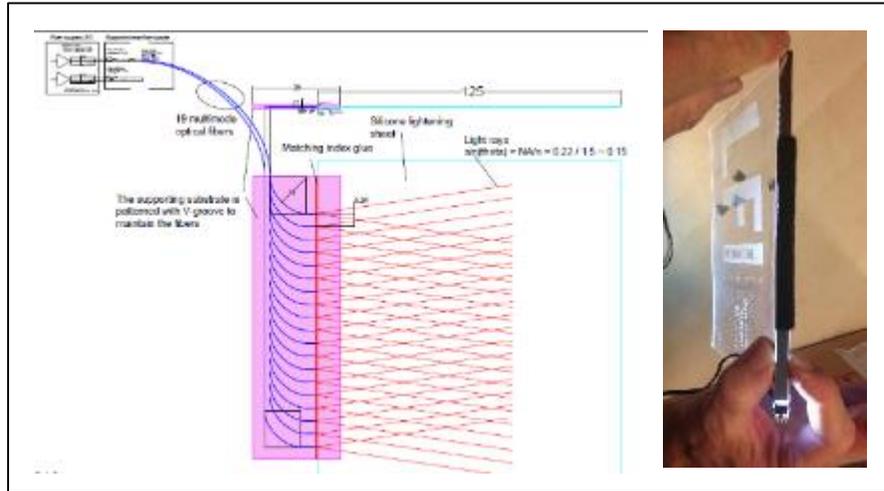
Source: [www.gpd.fi](http://www.gpd.fi) © Tom Culp, GANA Energy Code Consulting



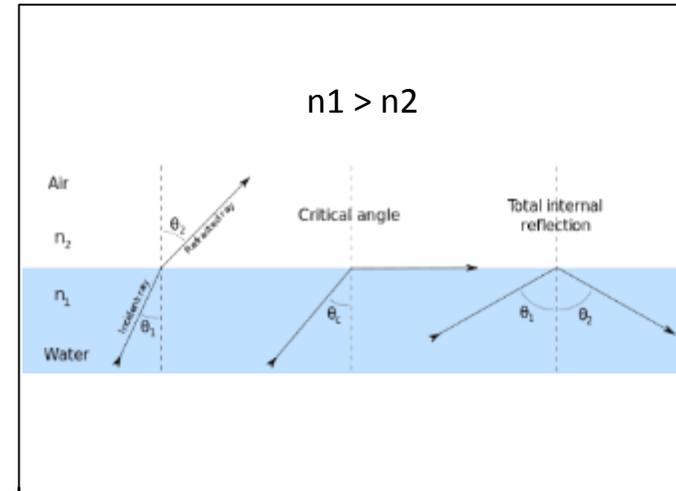
Summary of GPD – 2015, J.Vitkala  
Source: [www.gpd.fi](http://www.gpd.fi) ©Stig Mikkelsen,  
MIKKELSEN Architects

National Bank  
of Denmark

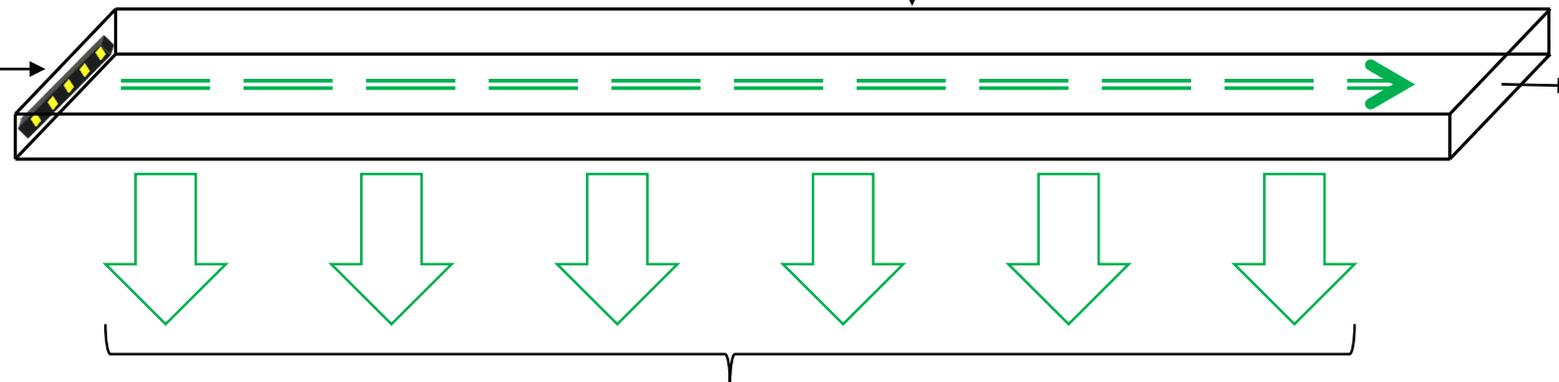
# Light Injection, Propagation and Extraction



Light injection

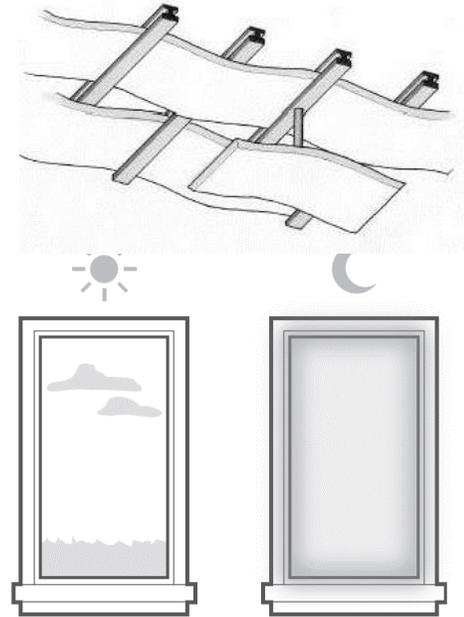
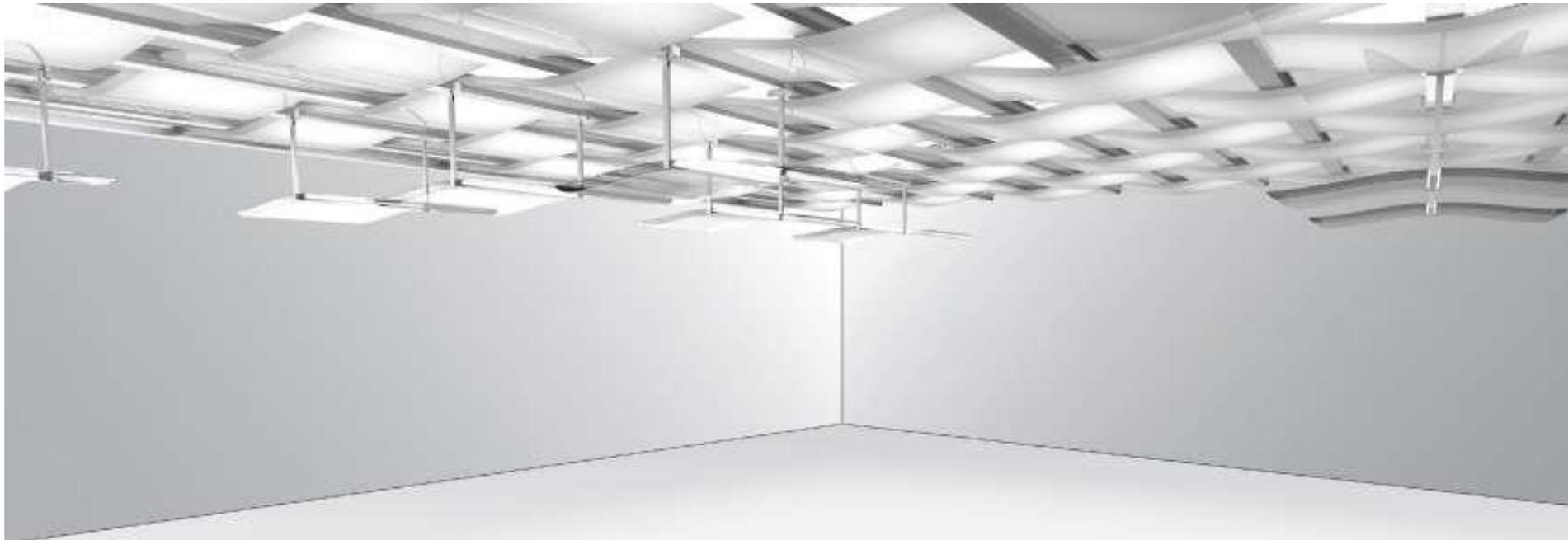


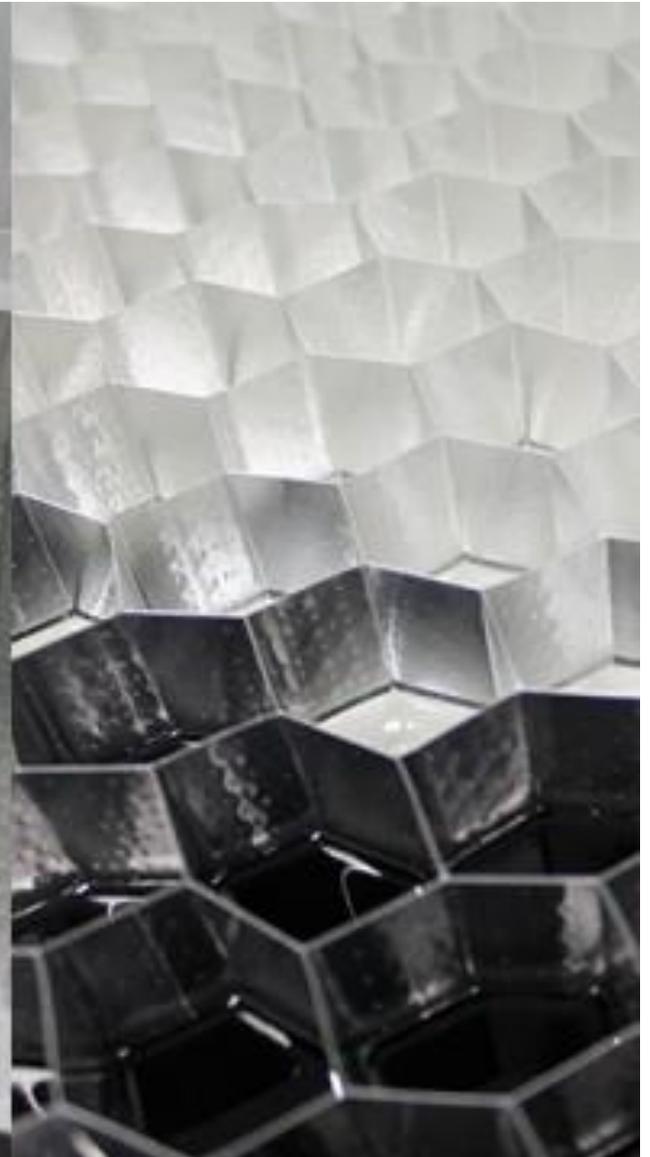
Light propagation



Uniform or Patterned light extraction

# Flat or Flexible illumination, interior or exterior





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Source: [www.gpd.fi](http://www.gpd.fi) © Graham Dodd, Arup

# Honeycomb structure



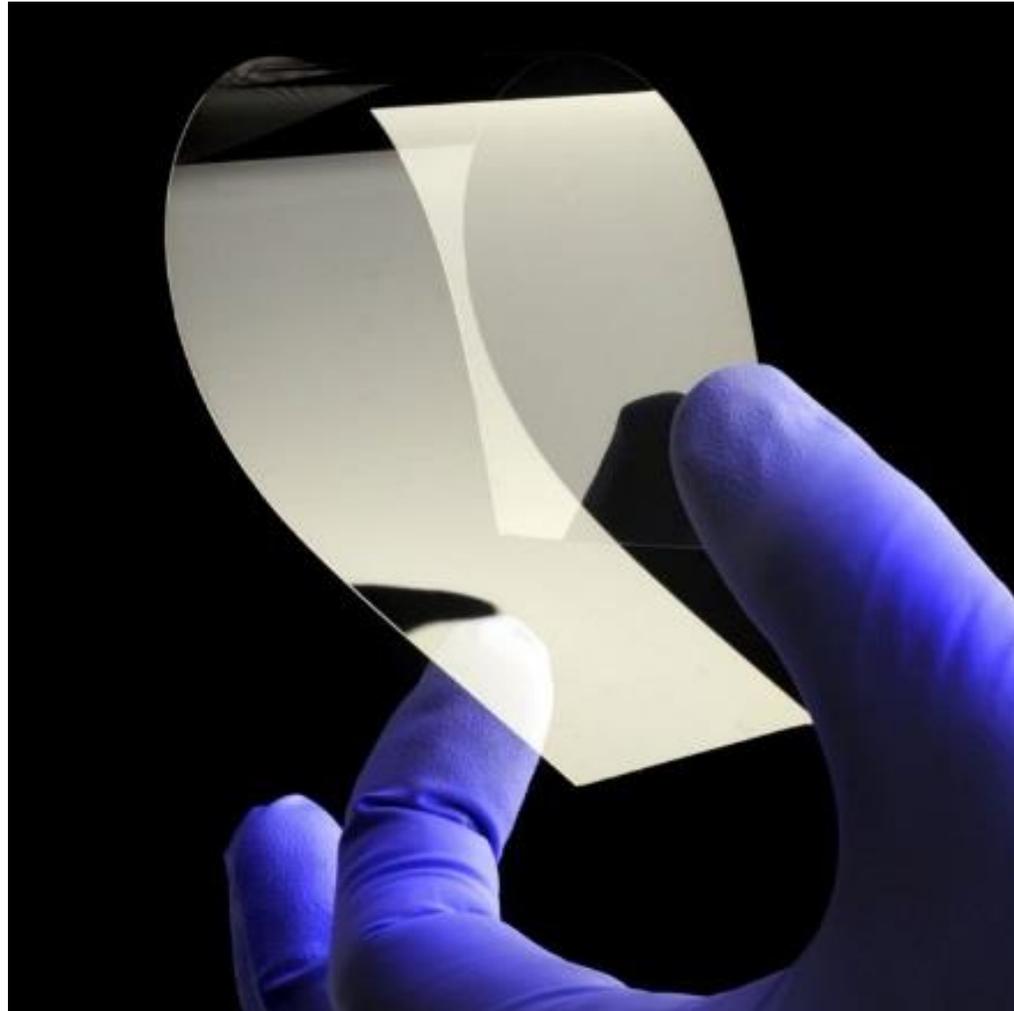


**1mm thin glass 'Leoflex' by  
AGC is strong and extremely  
light**

Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Mick Eekhout, Octatube

# Ultra-Thin Glass



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# Multi-Color Glass 3D Printing

# New ideas creates the new business



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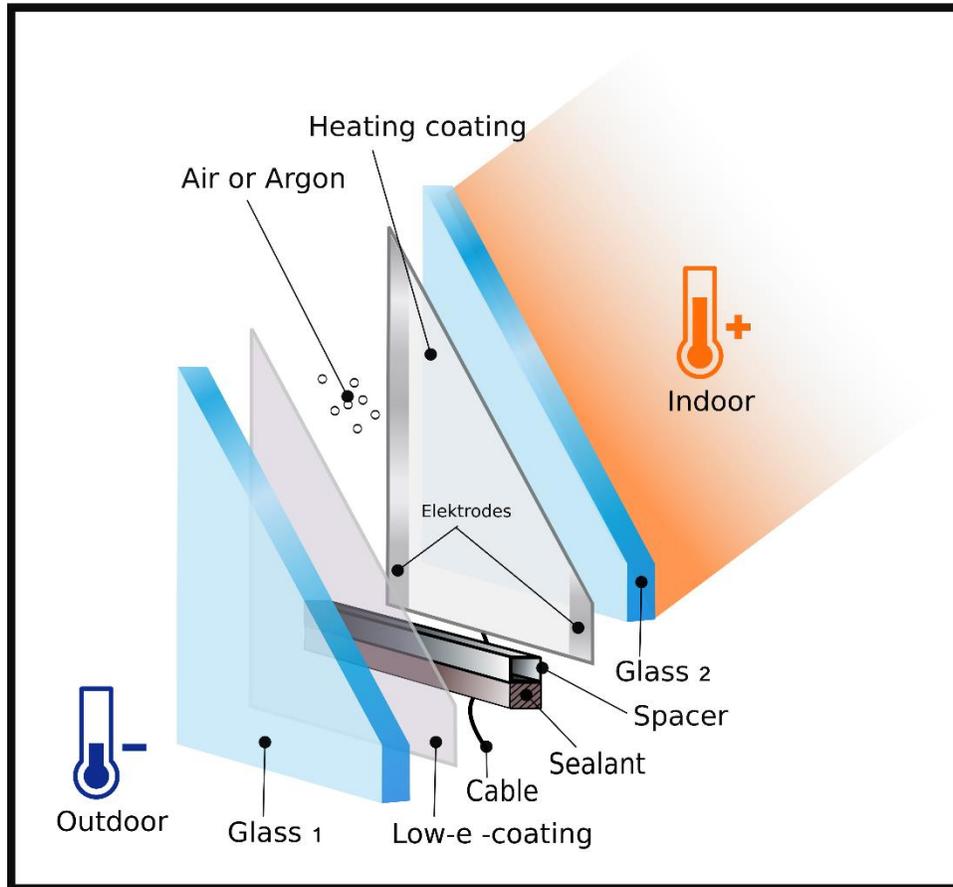
Source: [www.gpd.fi](http://www.gpd.fi) © Timo Saukko, Finnglass



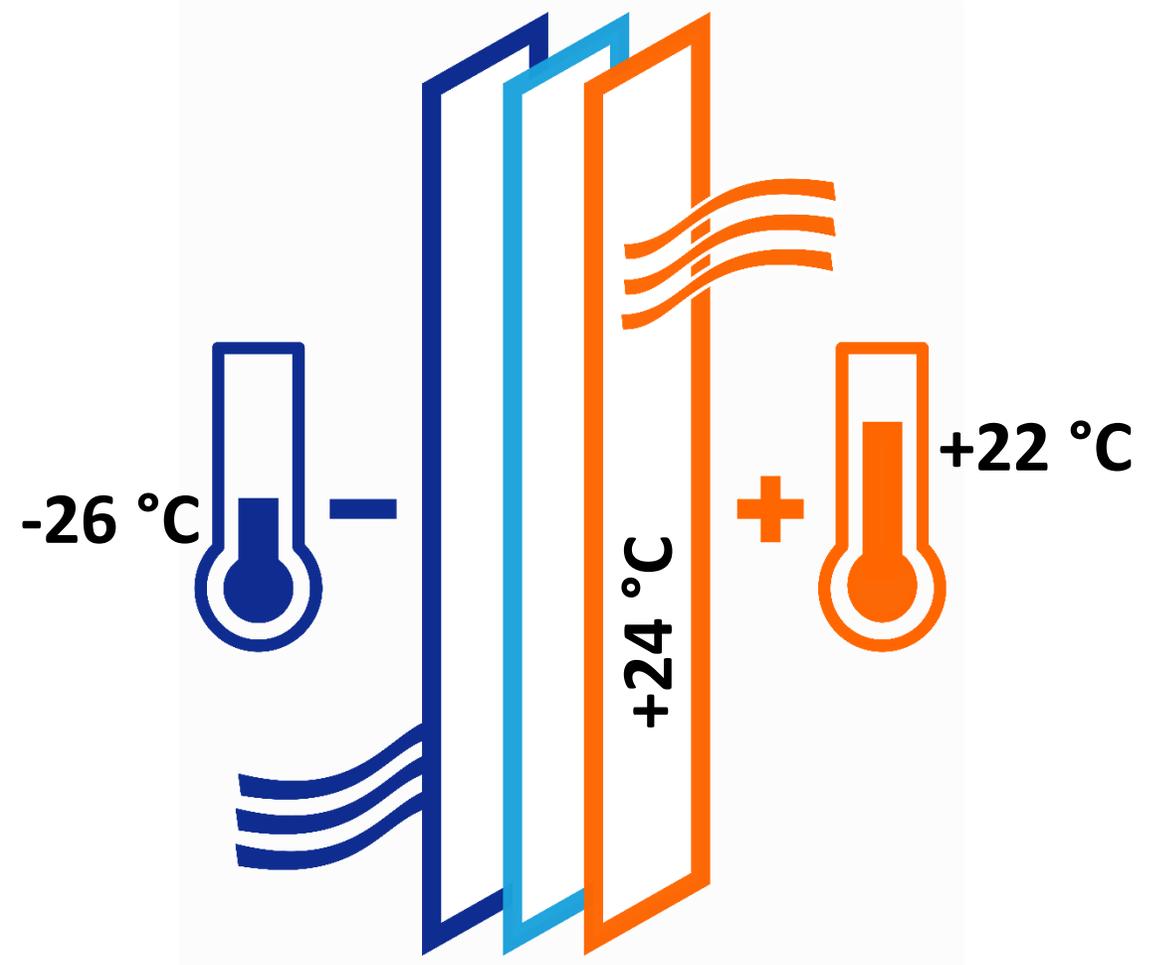
© Valtteri Hirvonen



© Kakslauttanen Arctic Resort



[www.finnglass.com](http://www.finnglass.com)



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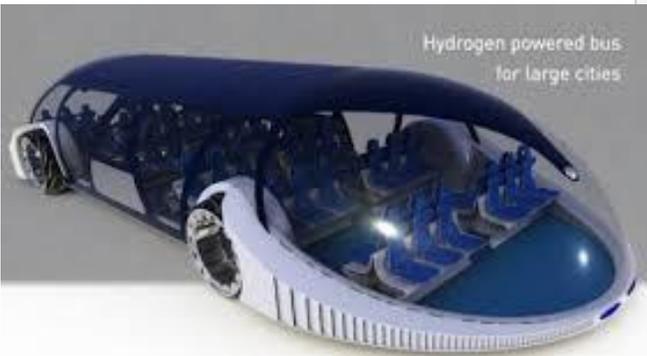
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# Automotive Design Trends

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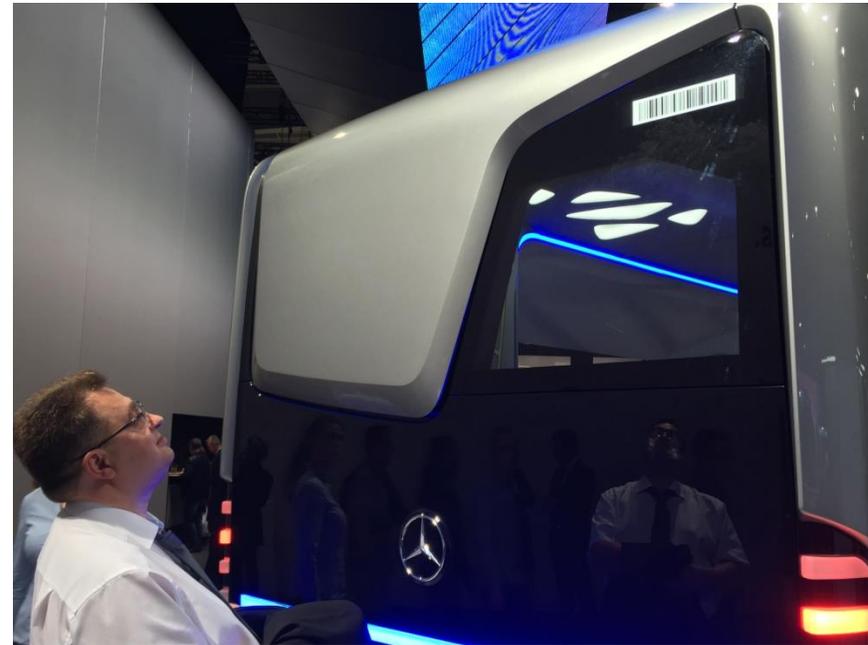
# Future Buses

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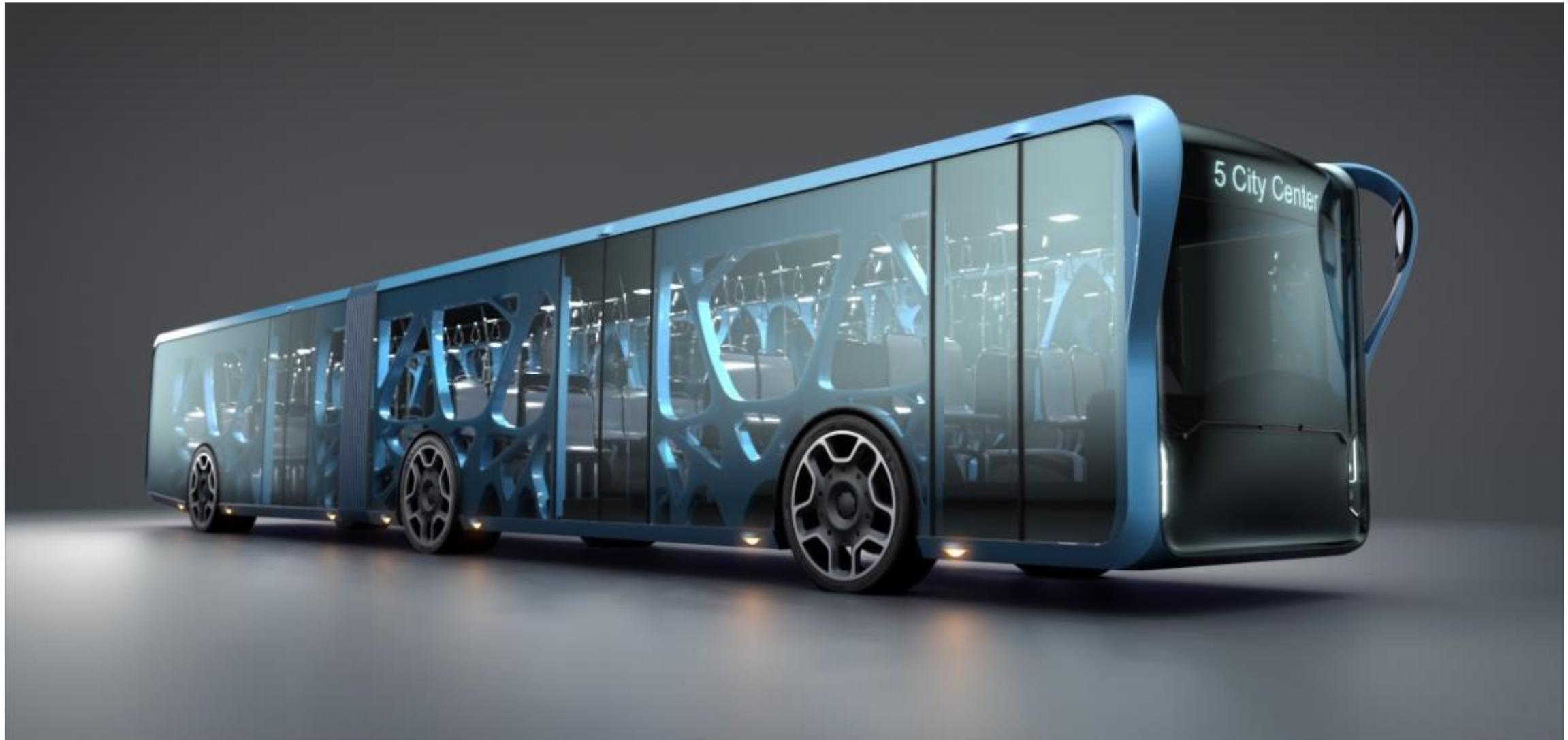
# Future Buses



Summary of GPD – 2017, J. Vitkala

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# Opportunities



Summary of GPD – 2017, J. Vitkala

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# Future Trucks

Summary of GPD – 2017, J. Vitkala

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# Future Trams



## – Projections and reflections

- CRT
- Laser
- VFD
- OLED
- etc.

## – Transparent displays?





# IAA 2016. LED-display in glass



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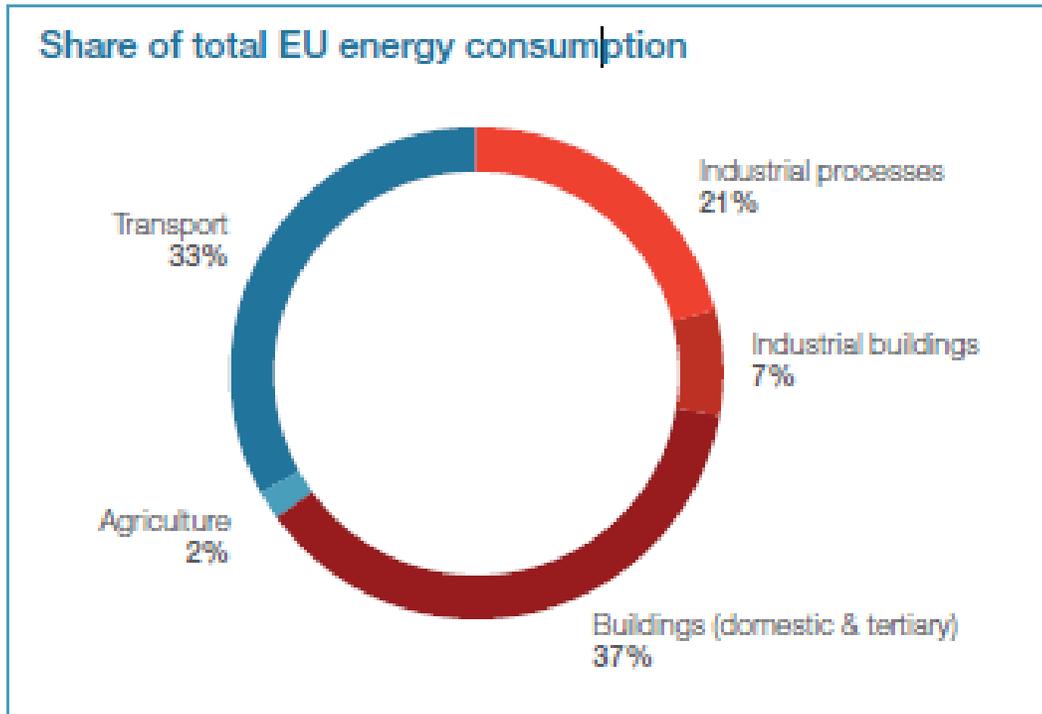
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# Worldwide Glass Energy Trends

Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Jorma Vitkala, GPD

# European legislation and minimum performance requirements in the 28 EU Member States



Over 40% of EU energy consumption  
from buildings



- European Union objective: energy savings target of 20% by 2020. New objective under discussion for 2030
- Windows considered responsible for 24% of the EU heating demand and 9% of the cooling demand
- Over 85% of glazed areas in EU buildings equipped either with single glazing or uncoated double glazing
- 1 billion of new windows to be sold by 2030

**Windows energy saving potential is substantial if energy efficient windows are equipped**

Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Cedric Janssens, Glass for Europe

Buildings have a HUGE impact on energy use, the natural environment, and bottom lines



**60%**

CONSUMPTION  
OF GENERATED  
ELECTRICITY

**>1/3**

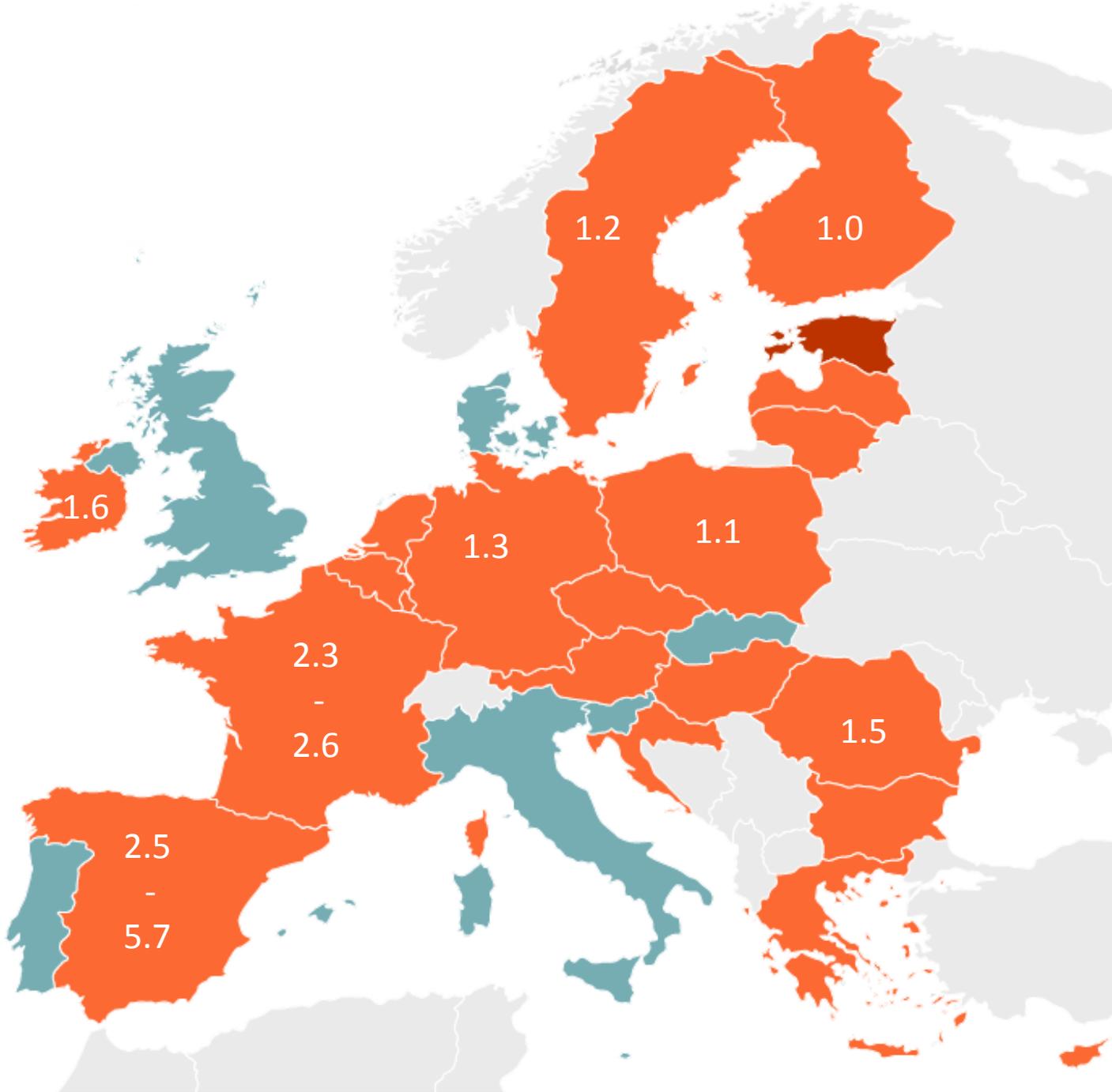
GLOBAL  
GREENHOUSE  
EMISSIONS

**25%**

ENERGY IS THE  
LARGEST  
OPEX FOR  
BUILDINGS

Summary of GPD – 2017, J. Vitkala

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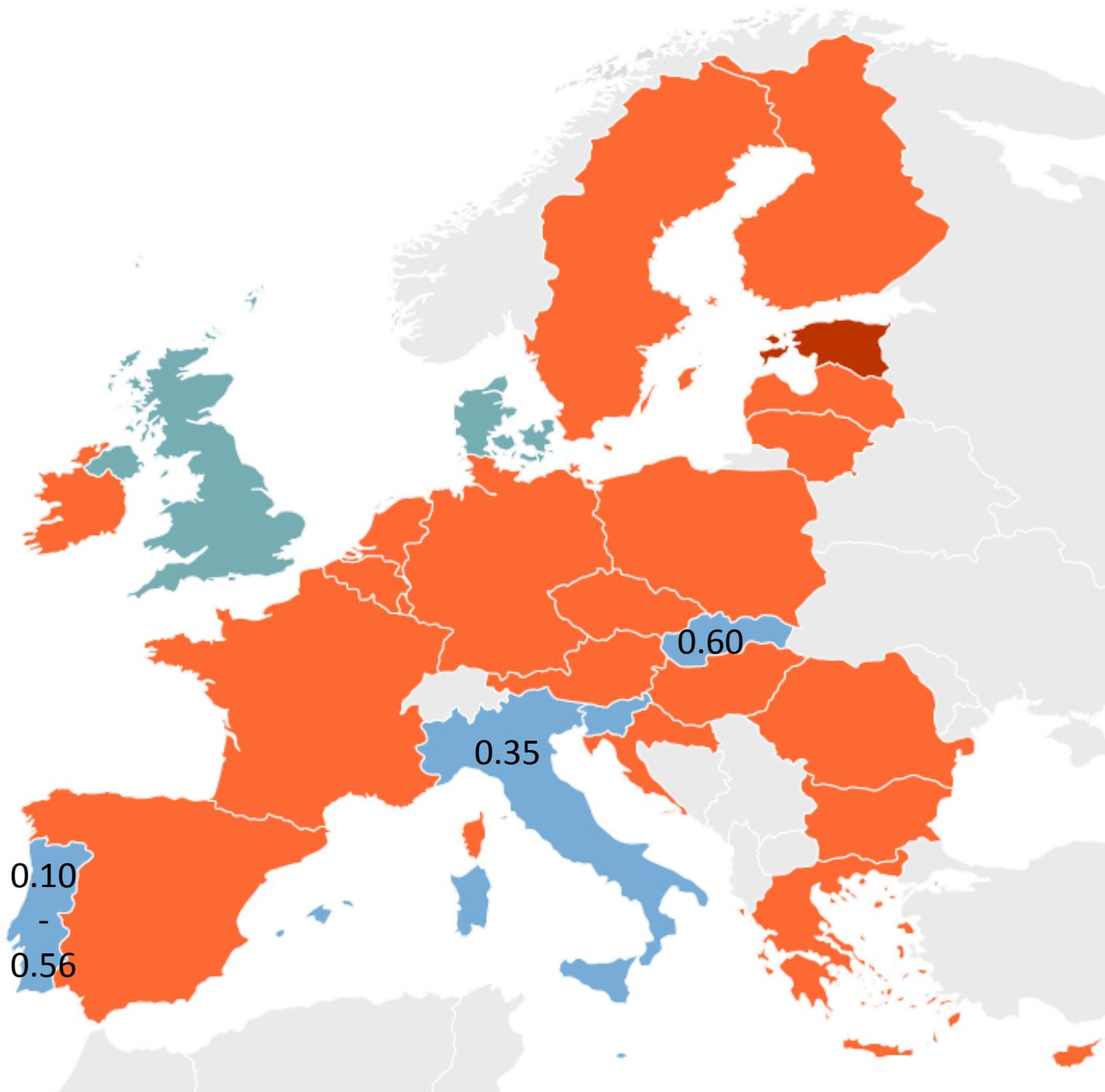
# Dominant: Uw-value solely

Often, sub-optimal and lack of updates

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Source: [www.gpd.fi](http://www.gpd.fi) © Cedric Janssens, Glass for Europe

## Separated g-value in 5 countries



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Source: [www.gpd.fi](http://www.gpd.fi) ©

# Smart Facades Convert Sunlight to Useful Energy

- **Electricity from the Sun:**
  - **Building Integrated Photovoltaics: BIPV**
  - **Options for view glazing**
    - Crystalline Cells
    - Expanded Cells
    - Amorphous
- **Solar Thermal**
  - Hot Air
  - Hot Water



Summary of GPD – 2017, J. Vitkala

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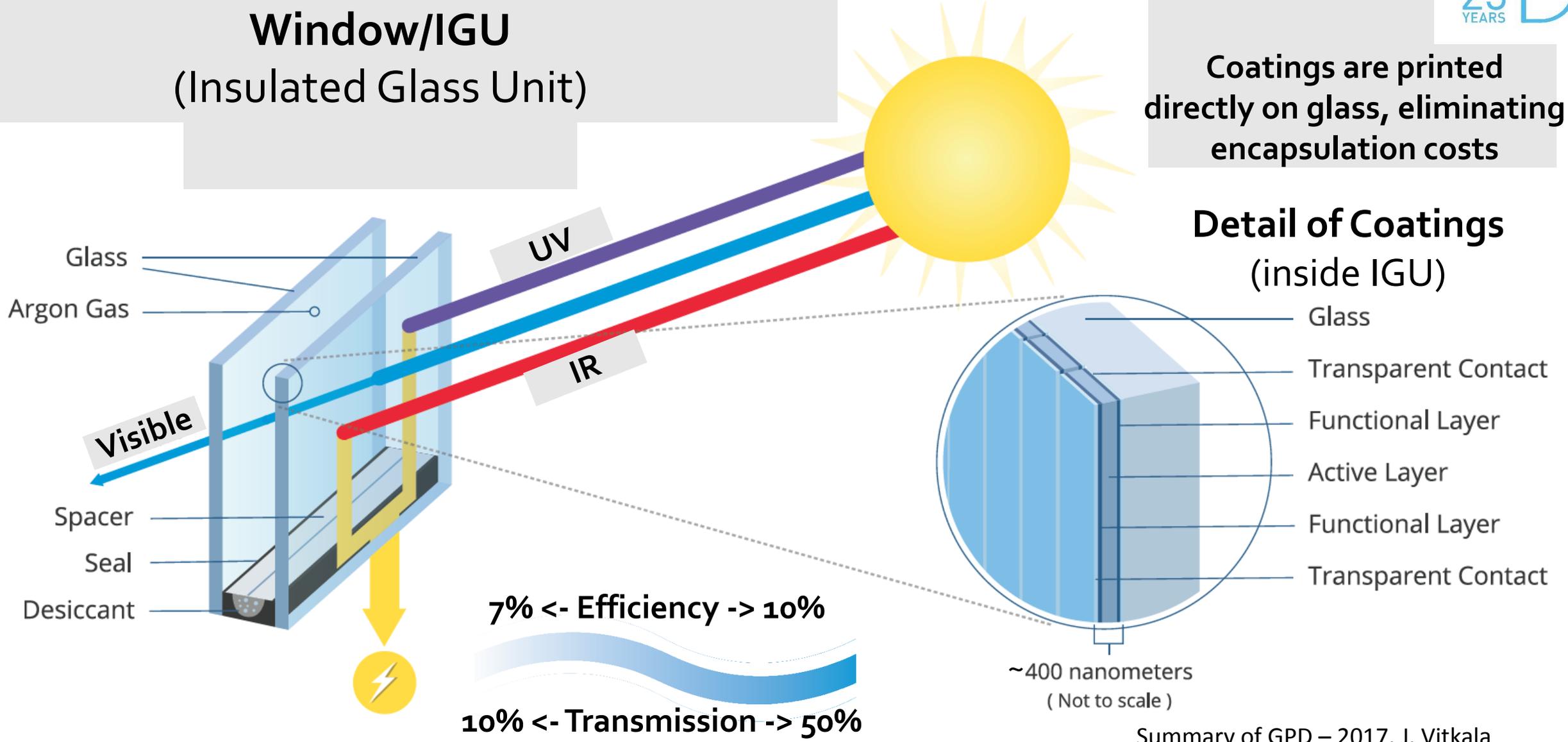
Summary of GPD – 2017, J. Vitkala  
Source: [www.gpd.fi](http://www.gpd.fi) © Erika Saretta, SUPSI

# SSM-OPV technology transforms windows into energy producing assets



## Window/IGU (Insulated Glass Unit)

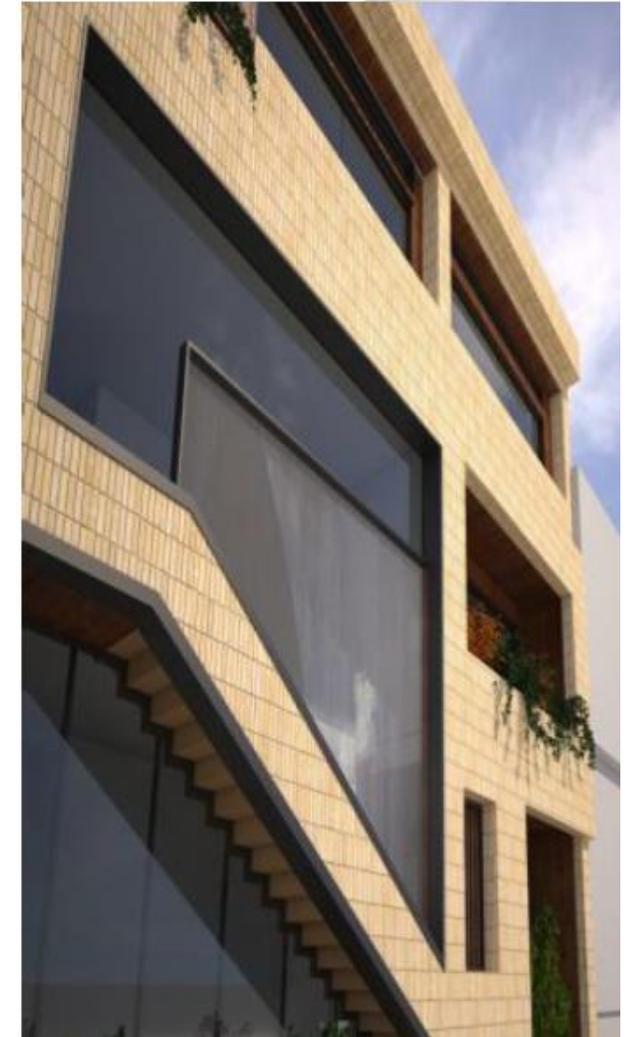
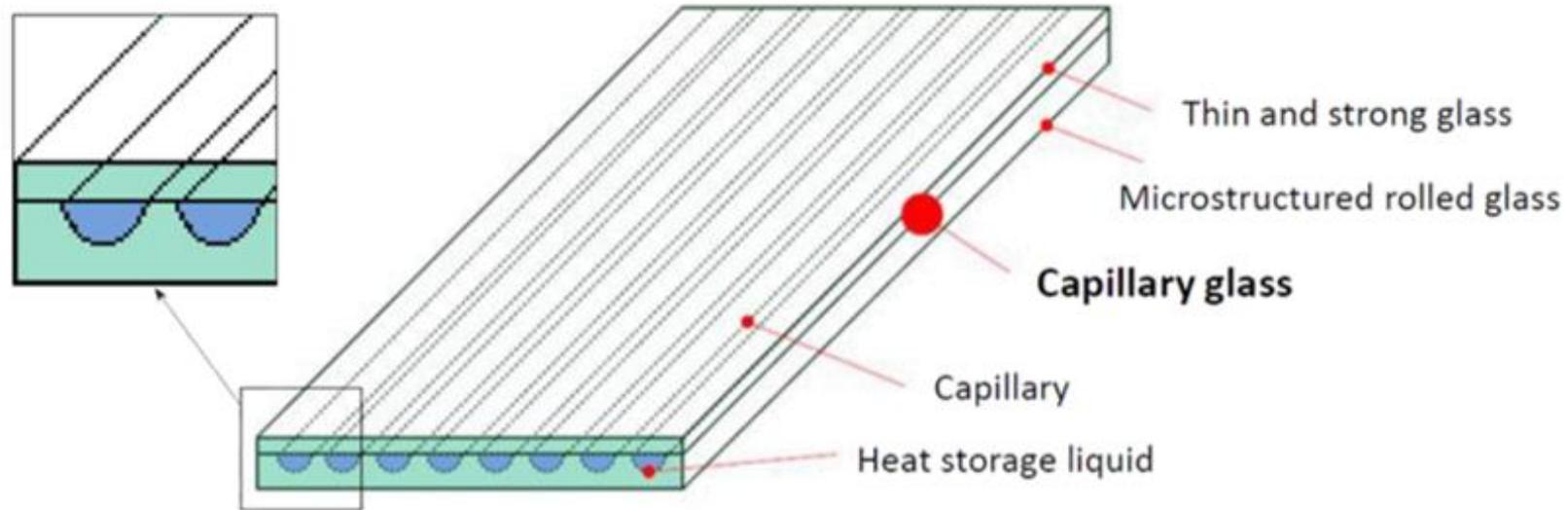
Coatings are printed directly on glass, eliminating encapsulation costs



Summary of GPD – 2017, J. Vitkala

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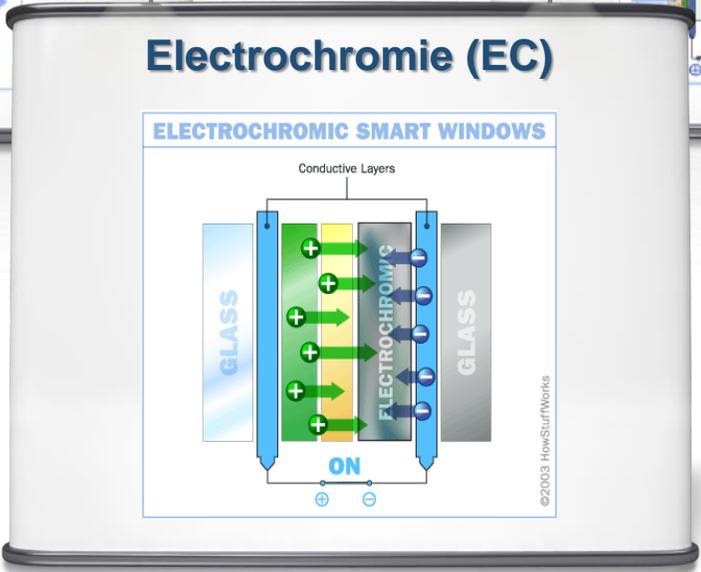
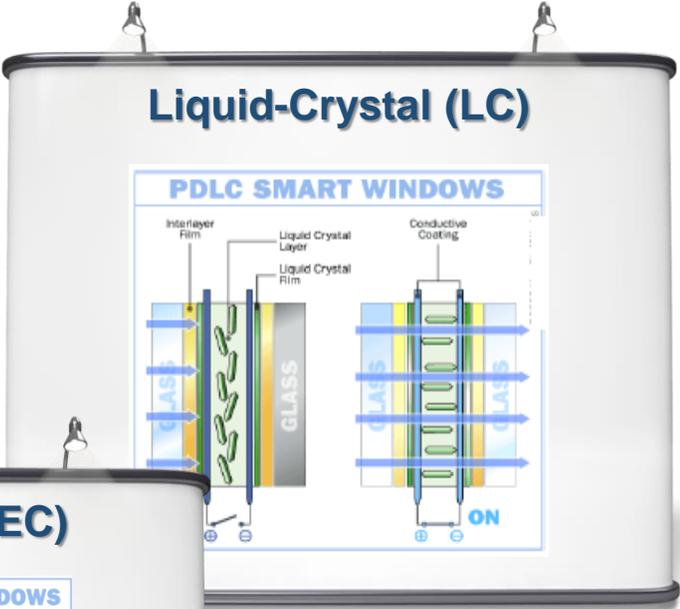
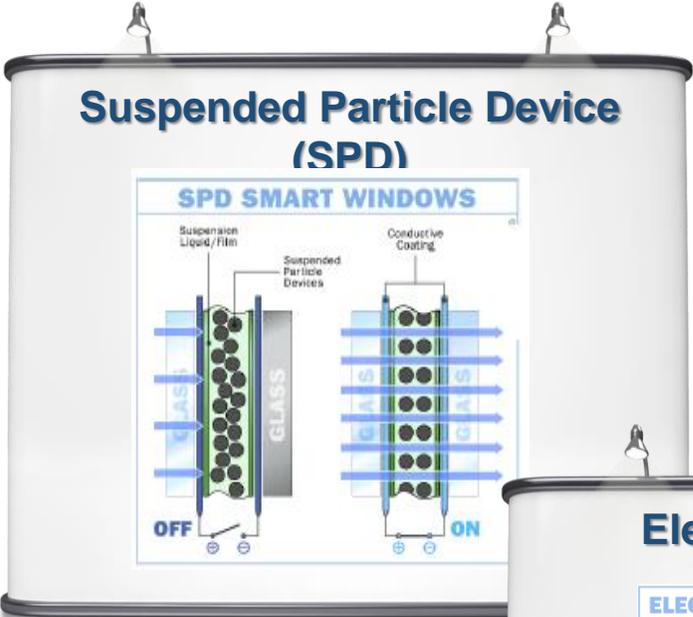
# LaWin: The concept



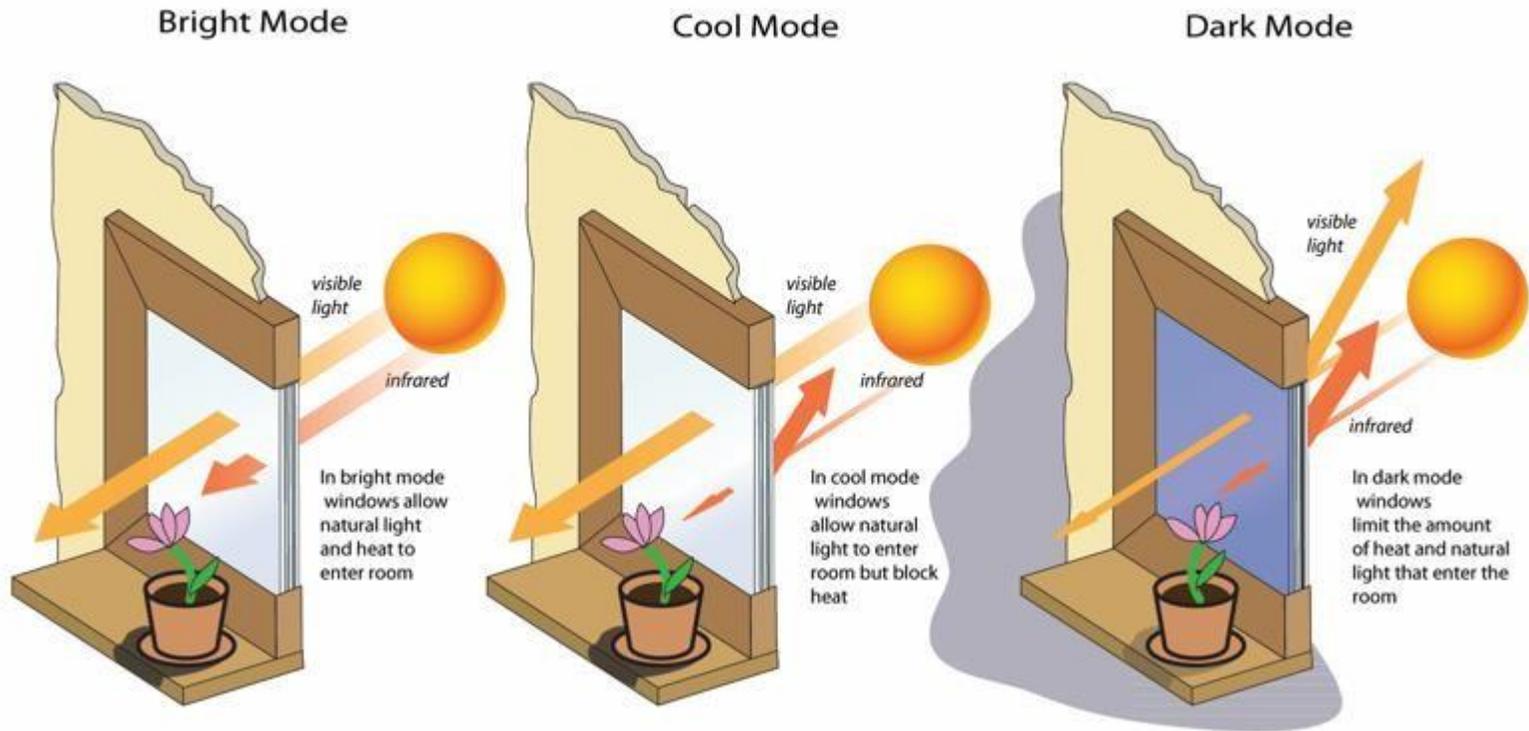
Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Steffen Bornemann, Folienwerk Wolfen

# Smart Window Technologies



# NanoEC is the Only Technology that Controls Both the Visible and Near-Infrared Spectrum



NanoEC Operating Mode	Eliminate Glare	Daylight Control	Reduce Heat Gain	Passive Heat Gain (Winter)
Bright - Dark	✓	✓	✓	
Cool			✓	✓
Bright - Cool - Dark	✓	✓	✓	✓

Summary of GPD – 2017, J. Vitkala

- Possible switching patterns | display performance



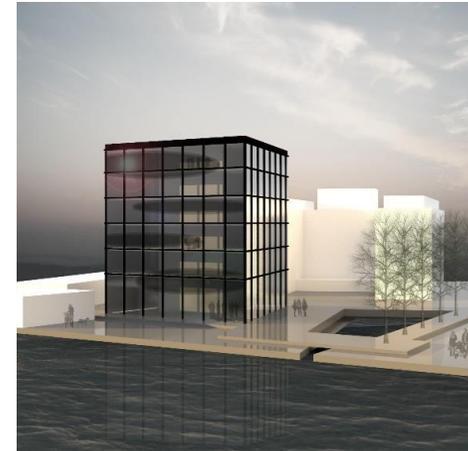
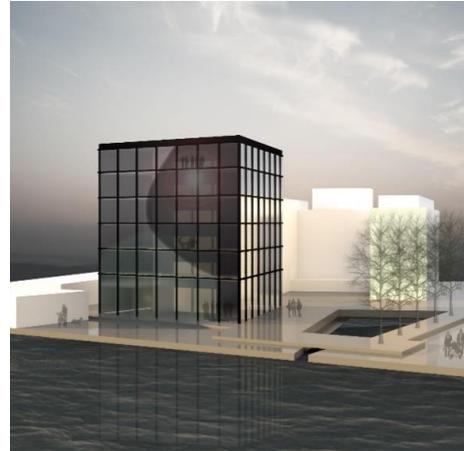
View from inside

Photos: ILEK

Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Walter Haase, Uni. Of Stuttgart

- Future vision



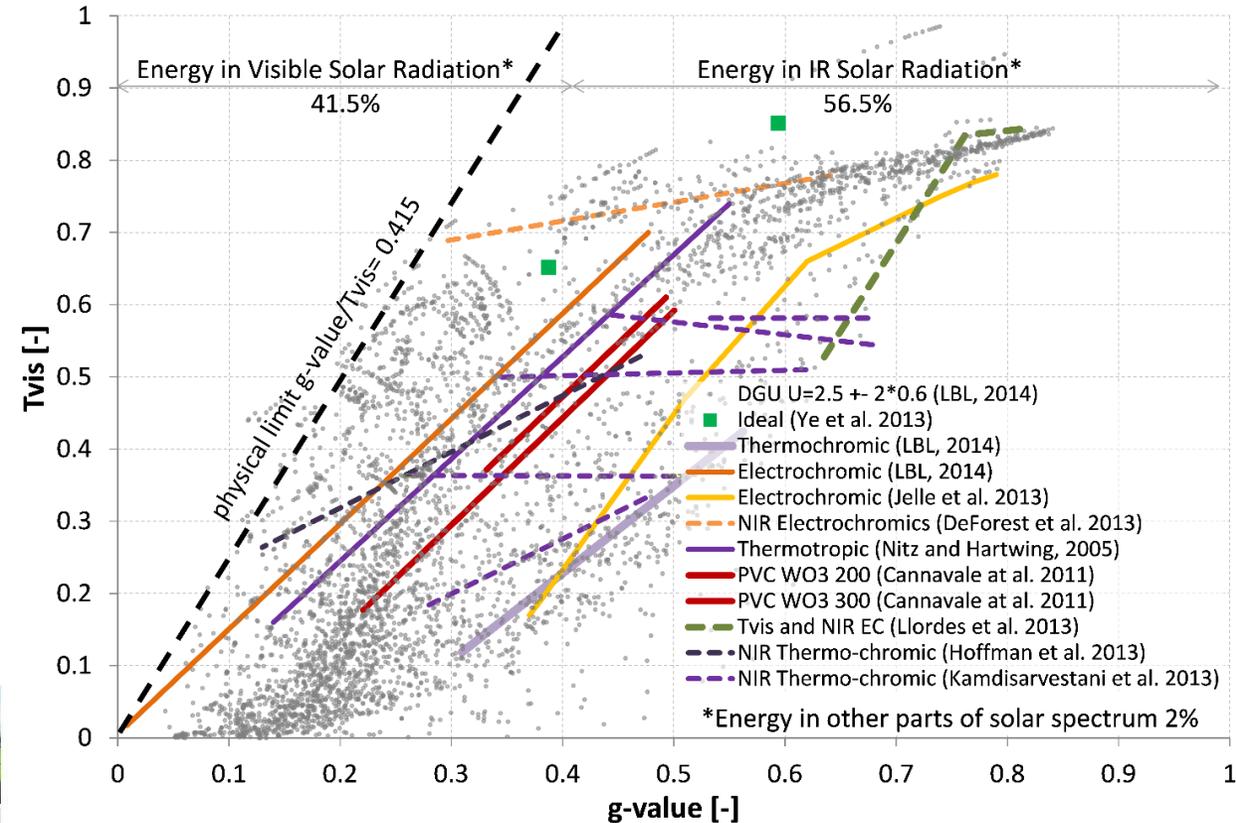
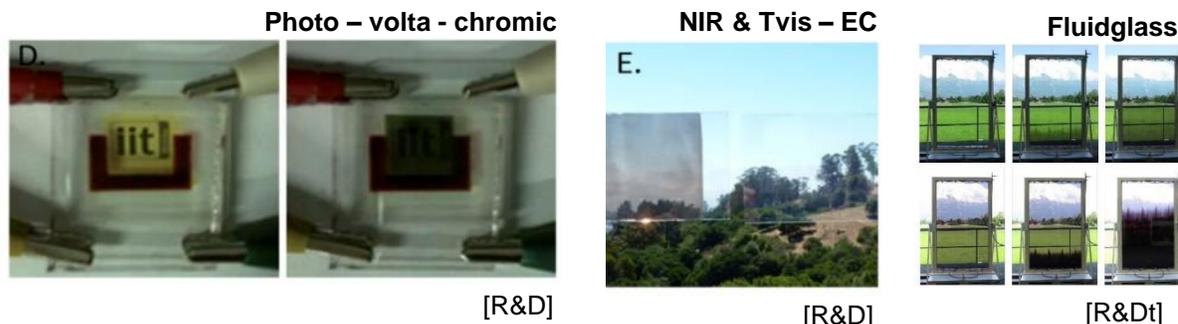
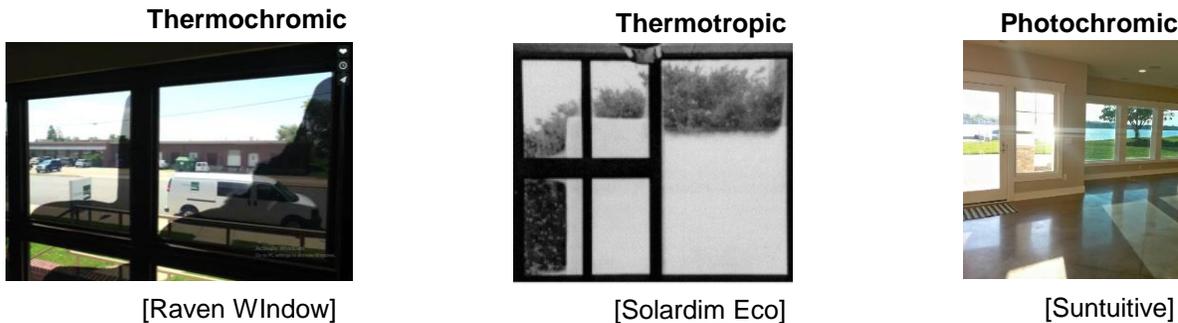
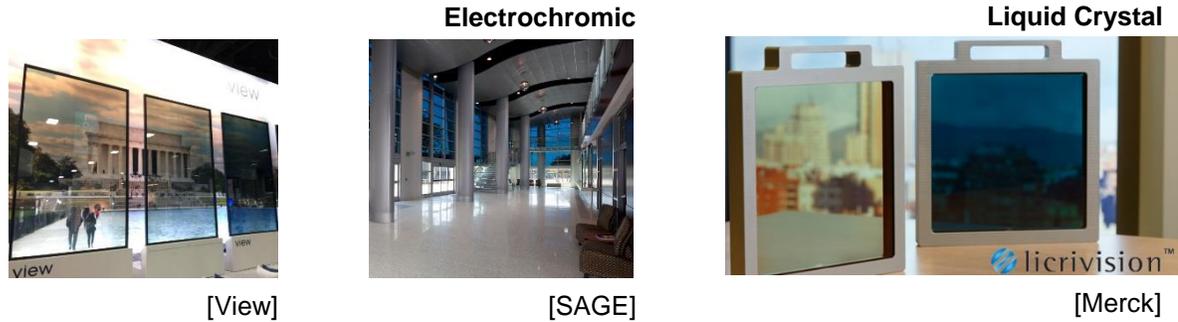
Rendering: ILEK

Summary of GPD – 2017, J. Vitkala

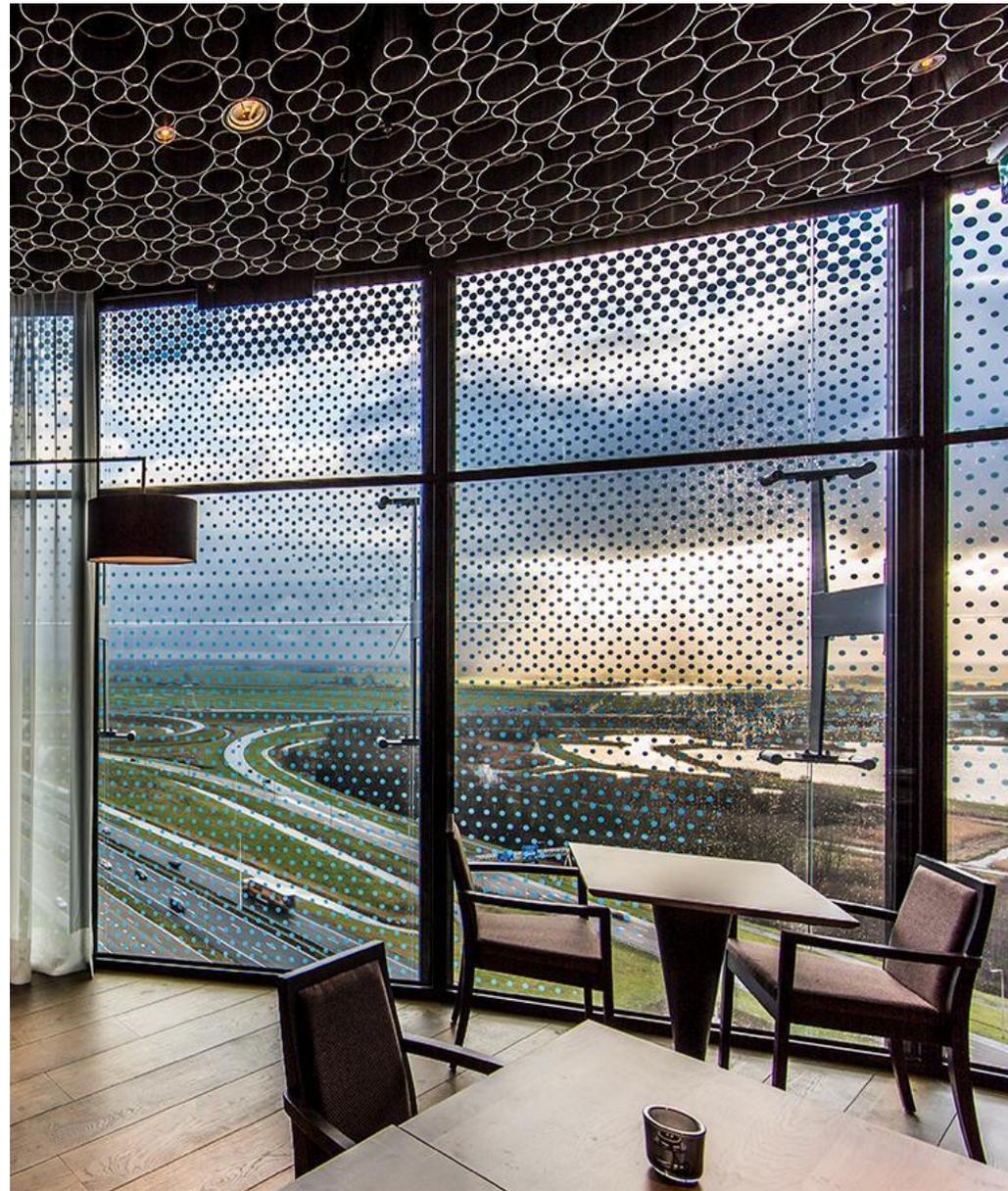
Source: [www.gpd.fi](http://www.gpd.fi) © Walter Haase, Uni. Of Stuttgart

# Smart glazings

“...able to reversibly and repeatedly **change** one or more of its **properties, functions, behaviour** during building operation to **react** in a controlled and holistic way to changing boundary conditions and/or performance requirements to improve building performance.”



Summary of GPD – 2017, J. Vitkala



## Characteristic exterior and interior view

Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Mick Eekhout, Octatube

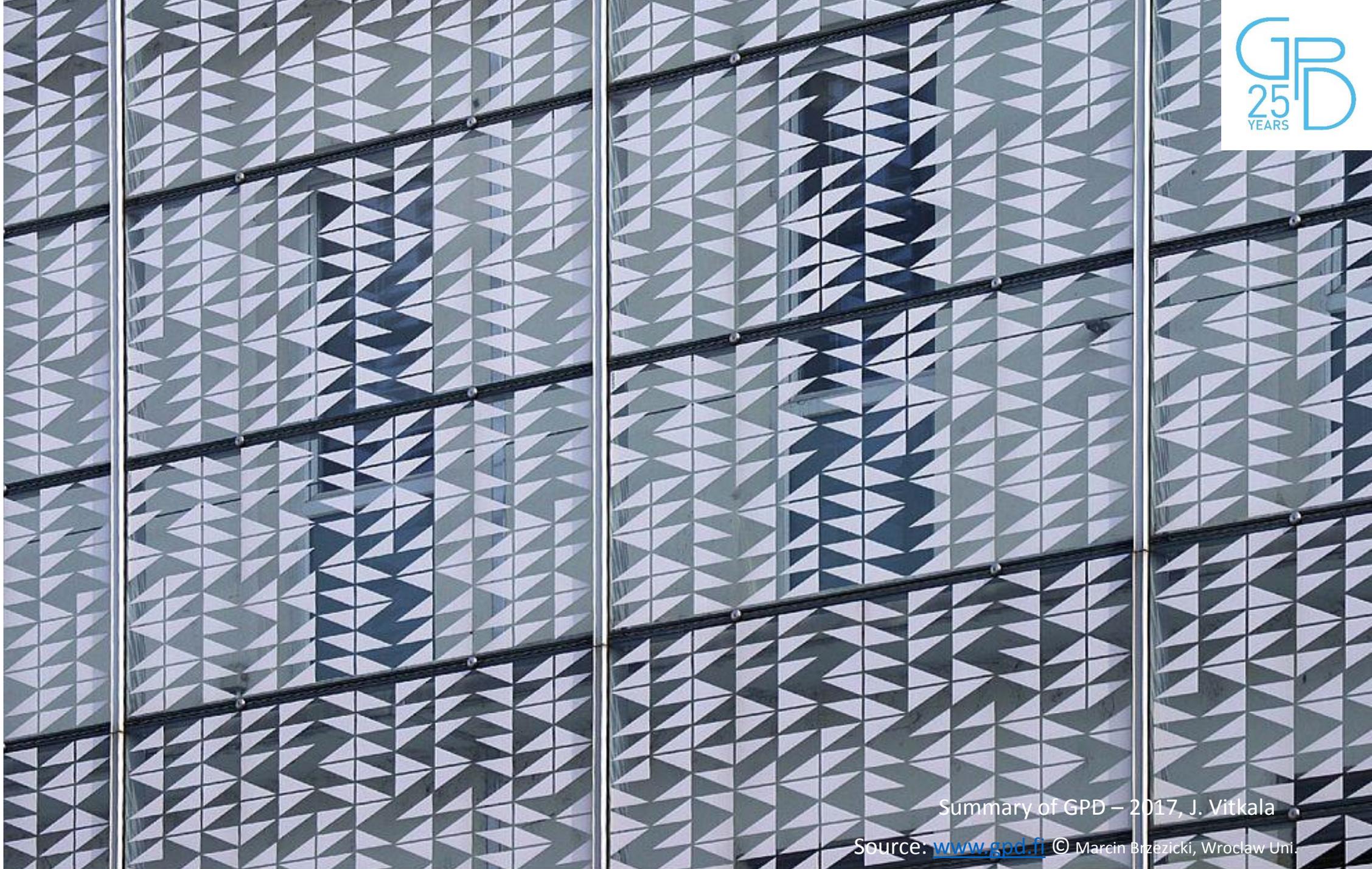
# Dutchess County Residence

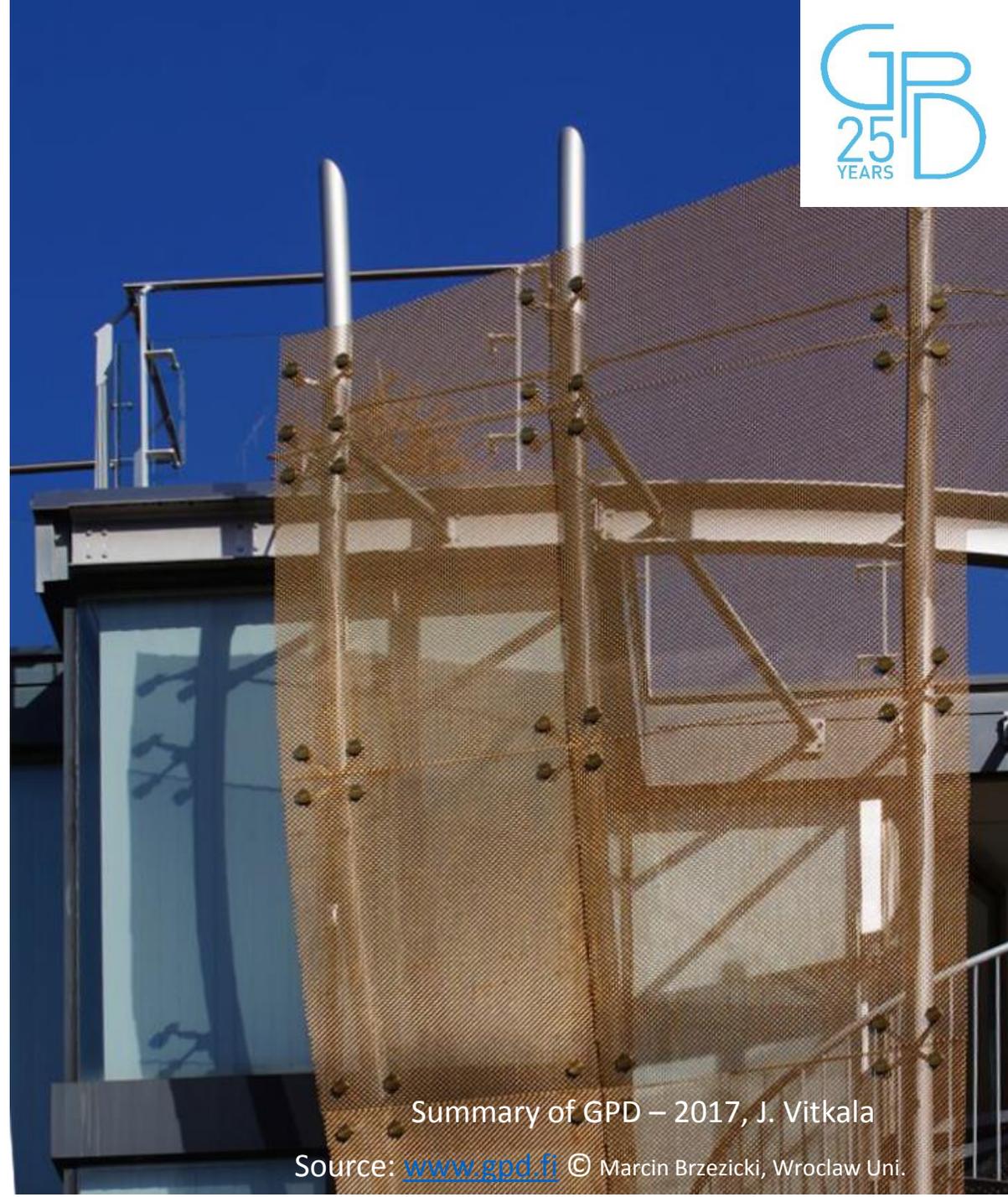


Summary of GPD – 2017, J. Vitkala

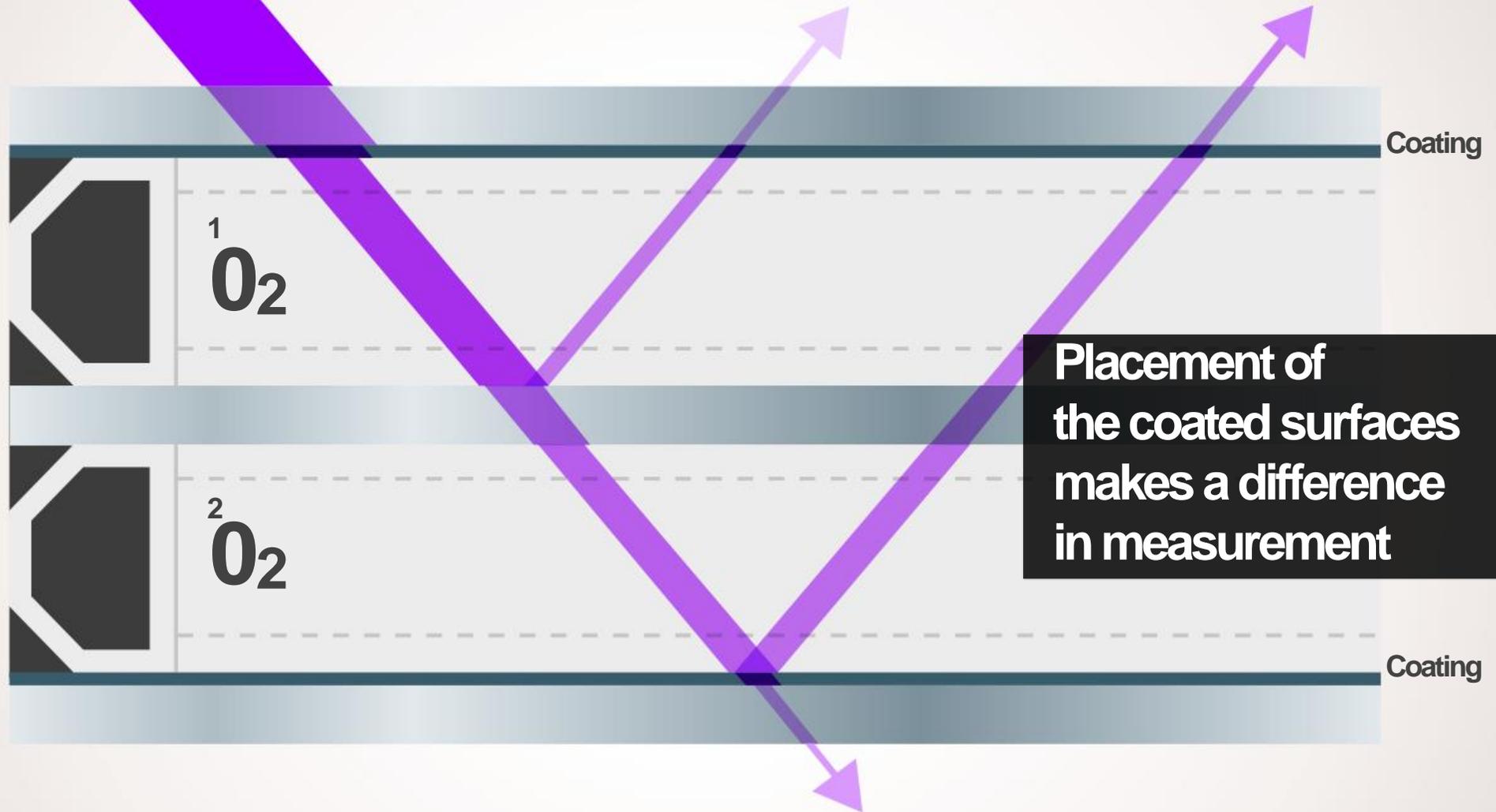
Source: [www.gpd.fi](http://www.gpd.fi) © Daniel Vos, Heintges & Associates

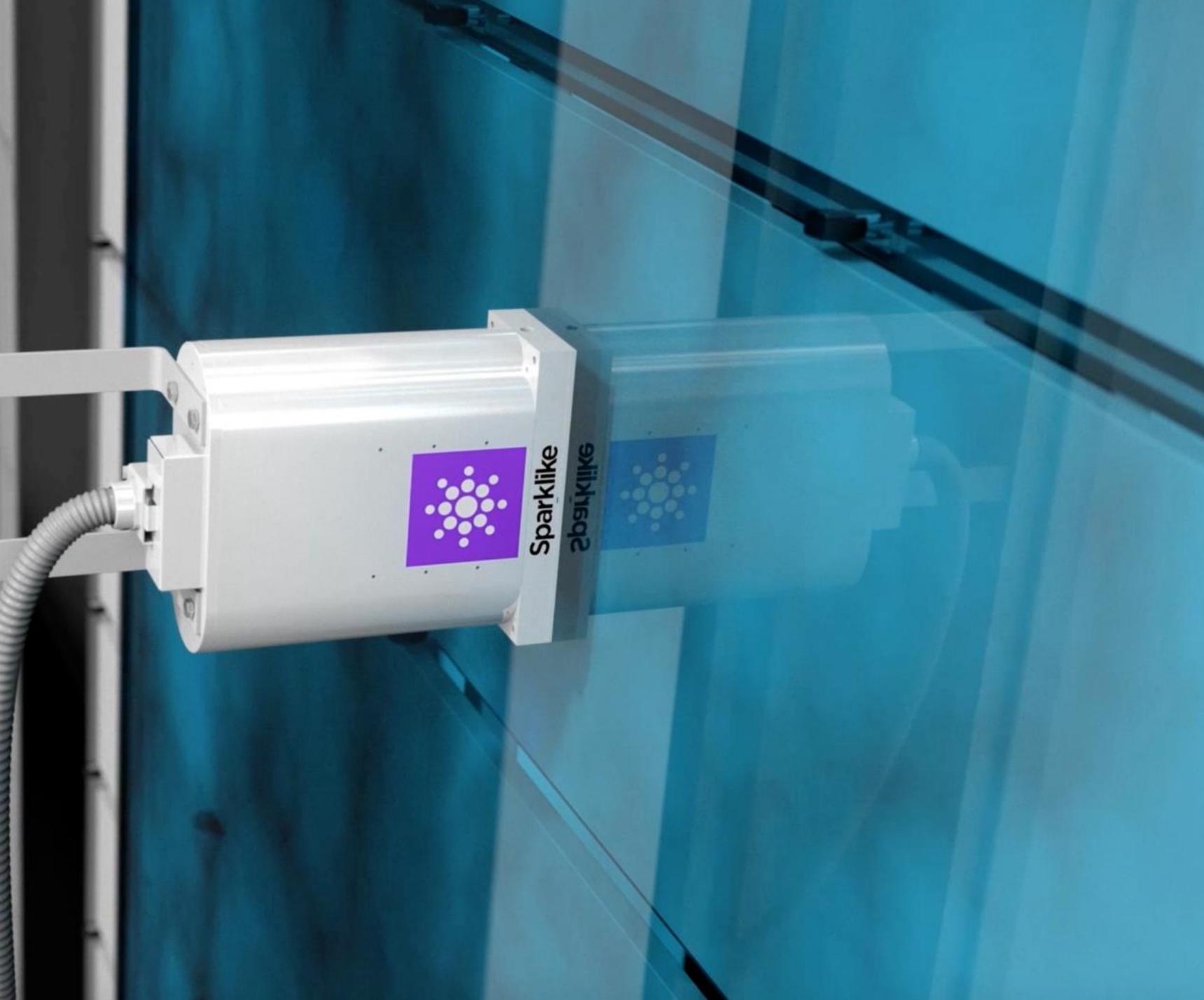






# Measuring gas concentration without breaking the IGU – even on triples





# Structural Glass Applications



Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Tim Macfarlane, GL&SS



Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Tim Macfarlane, GL&SS





Dewhurst Macfarlane and Partners

DMP20

Revision

Sheet No.

Job No.

Member/Location

Job Title

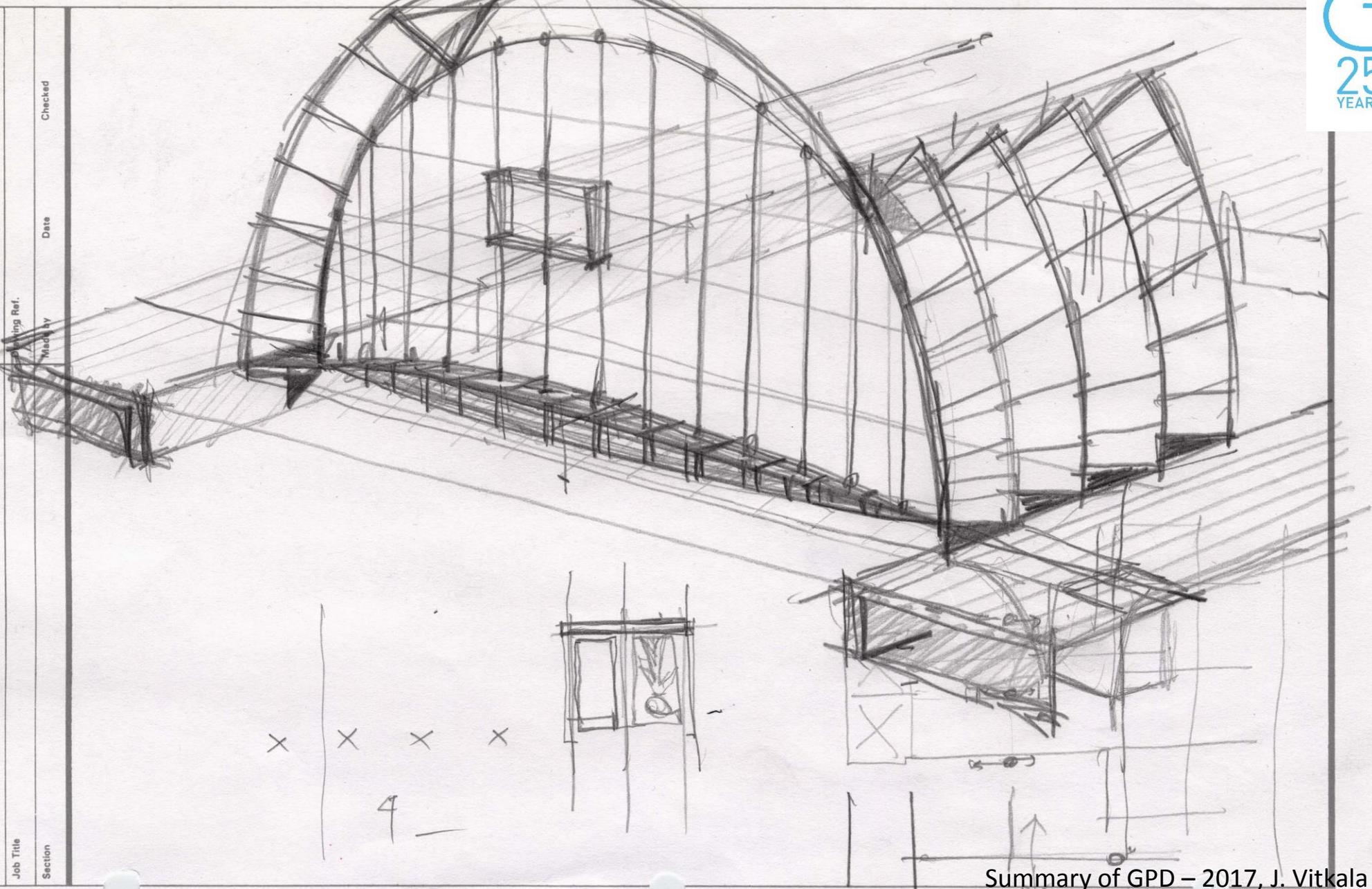
Drawing Ref.

Section

Date

Checked

Made by



Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Tim Macfarlane, GL&SS



# Loadbearing Glass Walls

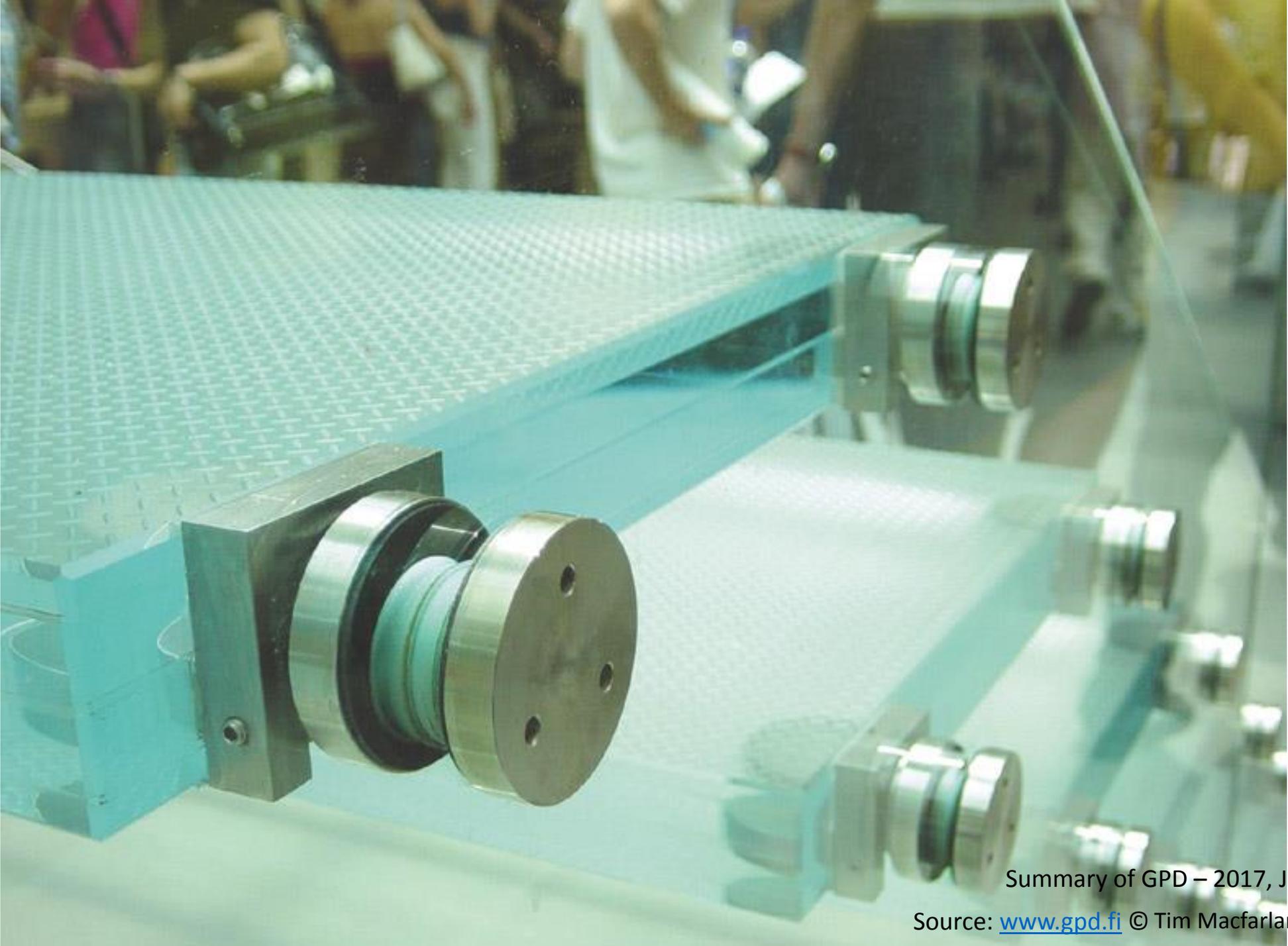


Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Tim Macfarlane, GL&SS



Summary of GPD – 2015, J.Vitkala  
Source: [www.gpd.fi](http://www.gpd.fi) ©James Ocallaghan, Eckersley  
O'Callaghan



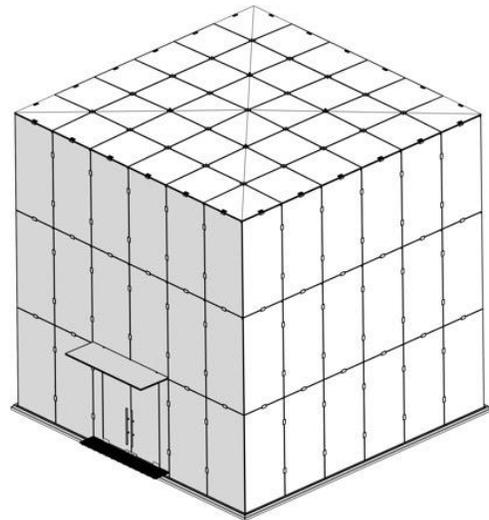
Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Tim Macfarlane, GL&SS

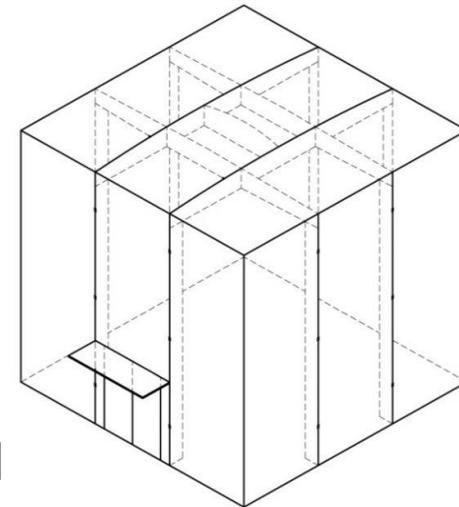




2006



2011



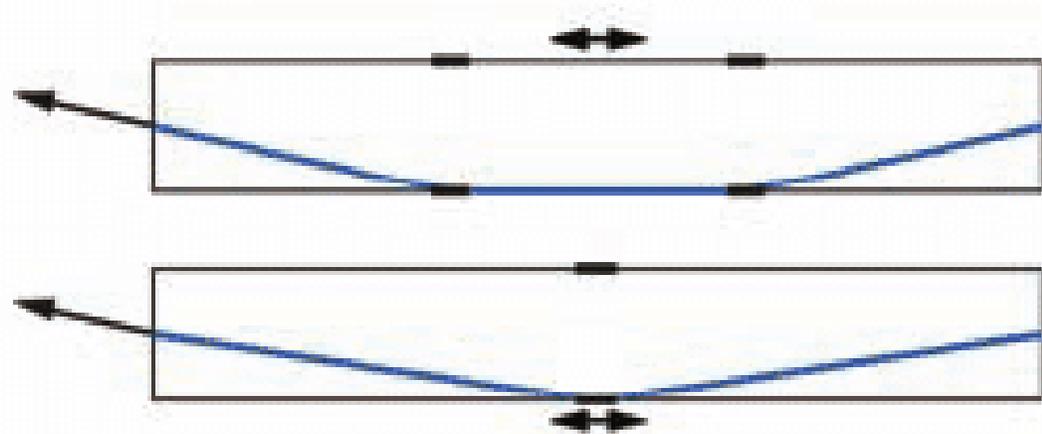
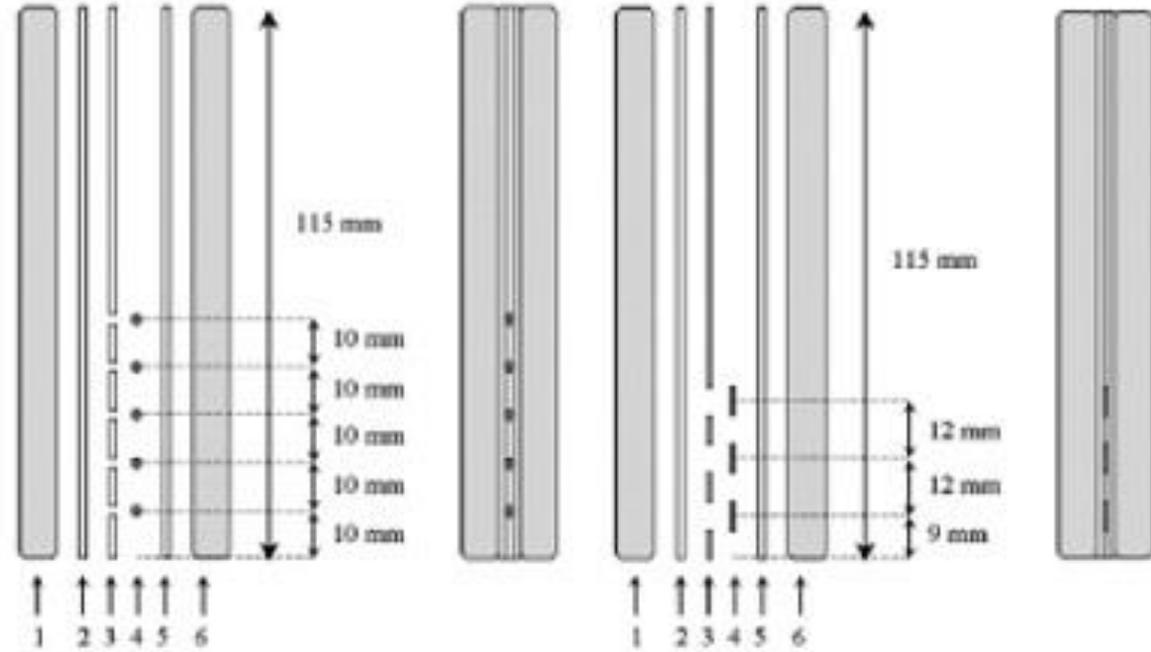
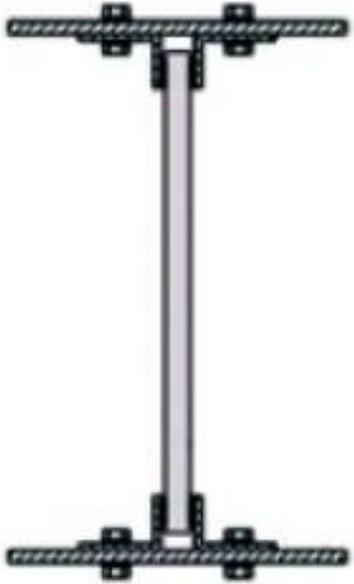


Summary of GPD – 2015, J.Vitkala  
Source: [www.gpd.fi](http://www.gpd.fi) ©James Ocallaghan, Eckersley O'Callaghan

# Large glass needs special handling equipment - Tvitec Spain



# Current research - Hybrid glass beams



**EVOLUTION OF DESIGN AND GEOMETRY**

**Glass beam evolution**

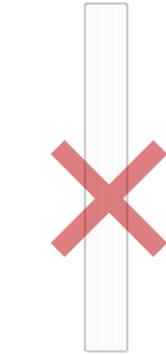
Calculation hypothesis

Analytic & F.E.M calculation

Physical test  
And results

Post-breakage analysis

Conclusions &  
Future research



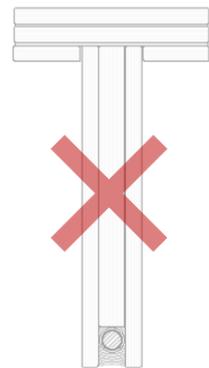
MONOLITHIC BEAM



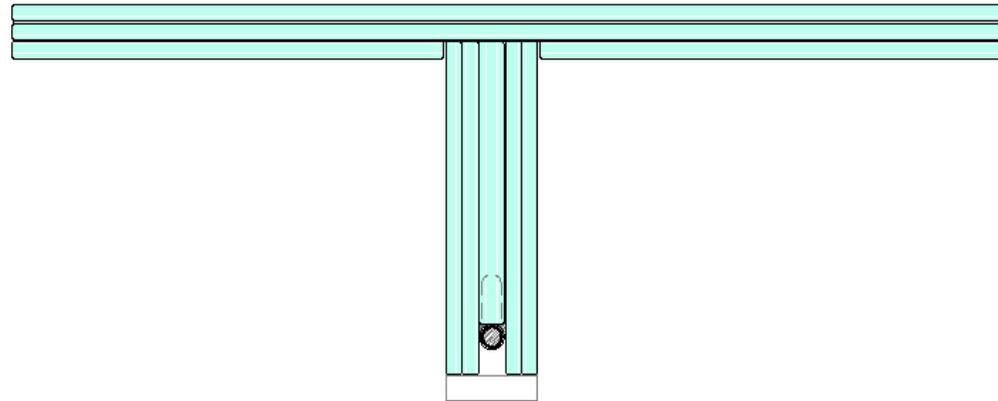
LAMINATED BEAM



PRESTRESSED LAMINATED BEAM



PRESTRESSED LAMINATED "T" SHAPED BEAM



PRESTRESSED LAMINATED "T" SHAPED BEAM

**STRENGTH**

**SAFE DESIGN**

**POST-BREAKAGE**

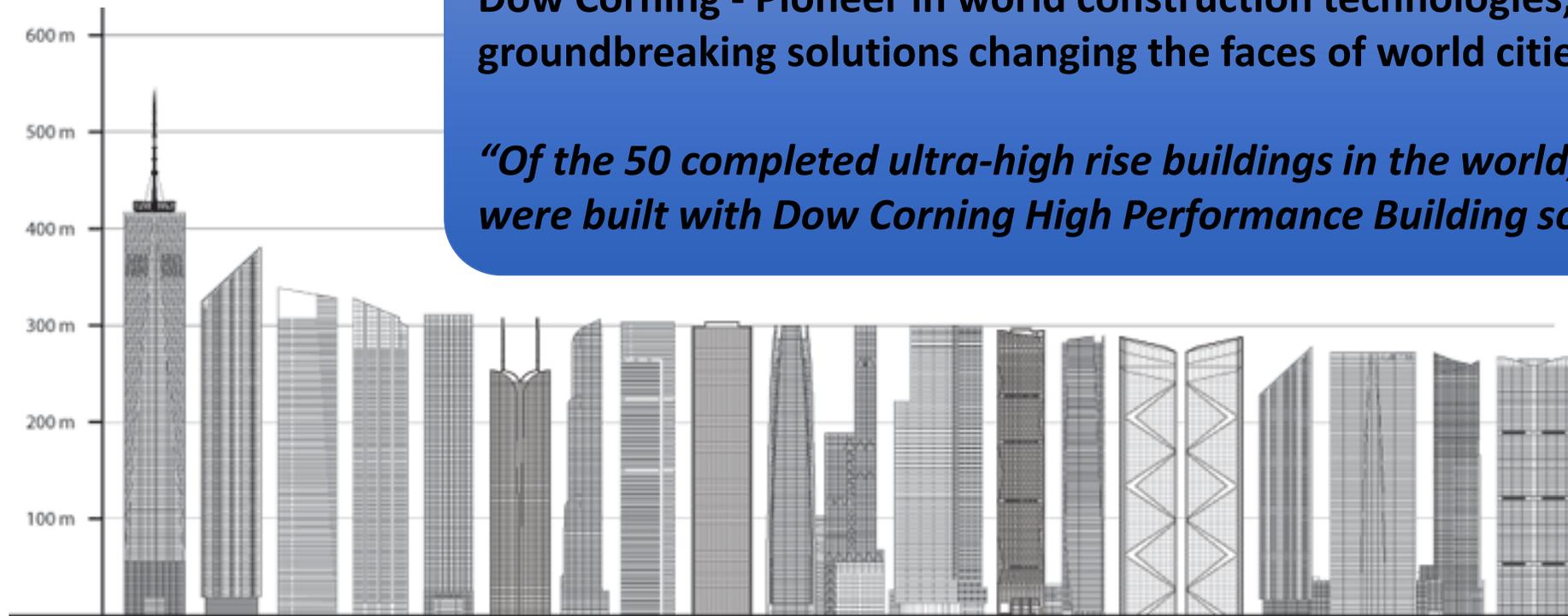
**SLENDERNESS**

**BUCKLING**

**USE ABILITY**

**STABILITY**

# Structural Glazing since 1964...



Tallest Buildings Completed in 2014

**Dow Corning - Pioneer in world construction technologies, groundbreaking solutions changing the faces of world cities.**

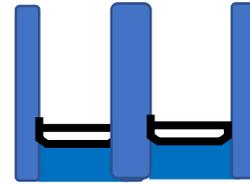
***“Of the 50 completed ultra-high rise buildings in the world, 35 of them were built with Dow Corning High Performance Building solutions.”***

# Smart Design: Thinner joints, Light & Energy Efficiency

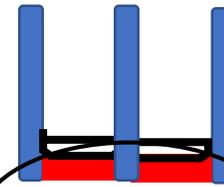
30% thinner & stronger joints:

- Durability (EN1279-4)
- More glass: 5% more light
- Lower U-value & Higher surface T°C

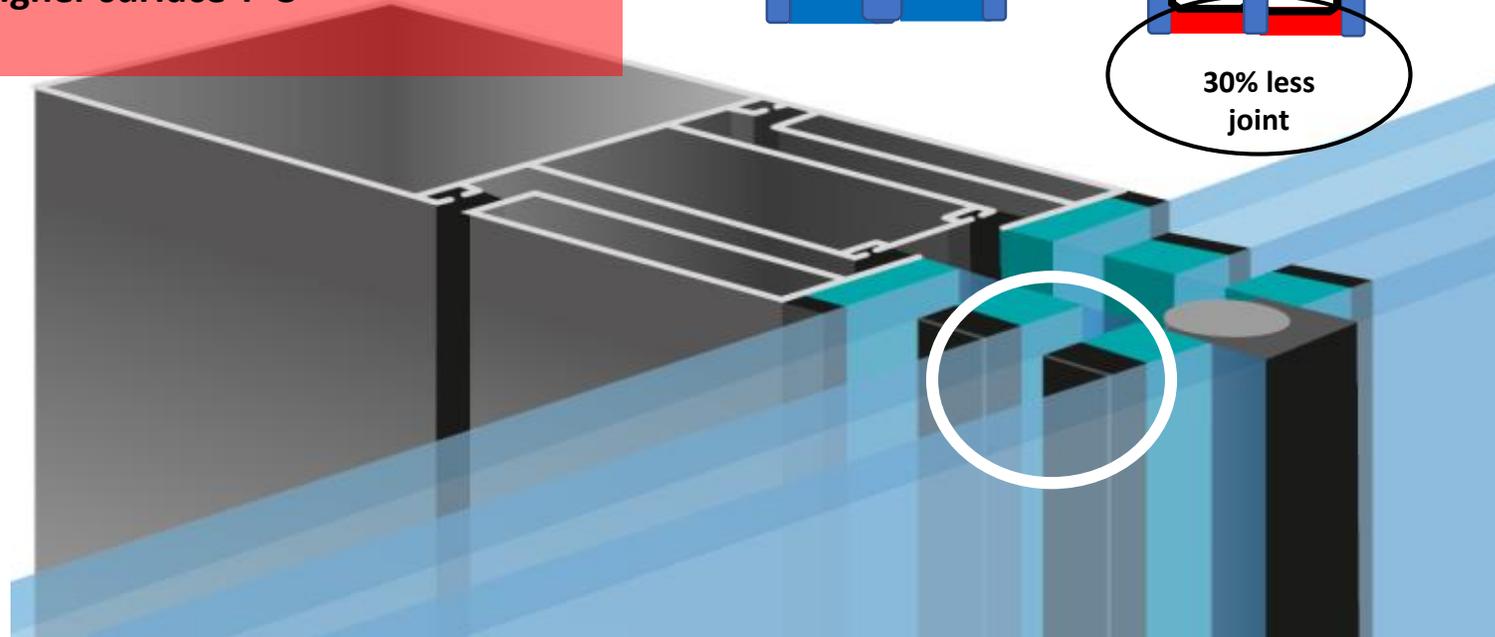
Standard triple IGU



High strength



30% less joint



Dow Corning® 3363 High strength silicone  
Design strength= 0.21MPa (ETAG002)

Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Valerie Hayez, Dow Corning Corp

# Transparent Structural Silicone Adhesive (TSSA)



- For exterior applications
- Point fixation
- Strength
  - 10x higher design strength \*
  - Strong adhesion performance
  - High performance silicone durability
- High transparency, crystal clear

\* Compared to regular 2-part structural silicone

# Application: Crystal Clear Structural Glass Connections



Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Valerie Hayez, Dow Corning Corp

# Strength, Aesthetics and Creativity



Vidre Slide,  
Cricursa and EOC



## Application



# Structural interlayers

## Application:

- 1-3 side supported glass + minimally supported
  - High post-breakage performance
  - Low glass thickness
- Structural balustrades
- Skylites , floor and canopies

## Primary Benefit:

- Glass thickness/weight reduction
- Glass size increase

## Other benefits:

- Enhance glass safety and security through fragment retention and penetration resistance
  - EN12600, ASTM Z93...
- UV Control
- Blast performance where need for a stiff interlayer is required

## Limitation:

- Acoustic performance



# Cold Bent Glass Applications

# Cold bent glass in architecture



IAC headquarters, New York City, Frank Gehry (2007)



Jinso Pavilion,  
Amsterdam, Cepezed  
(2009)

Main Train Station,  
Strasbourg, J.-M.  
Duthilleul, 2007



Summary of GPD – 2017, J. Vitkala

# COLD-BENT UNITS

## «STATE-OF-THE-ART» ???



Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Viviana Nardini, Sika services AG

# Complex Geometry - Panelization Options

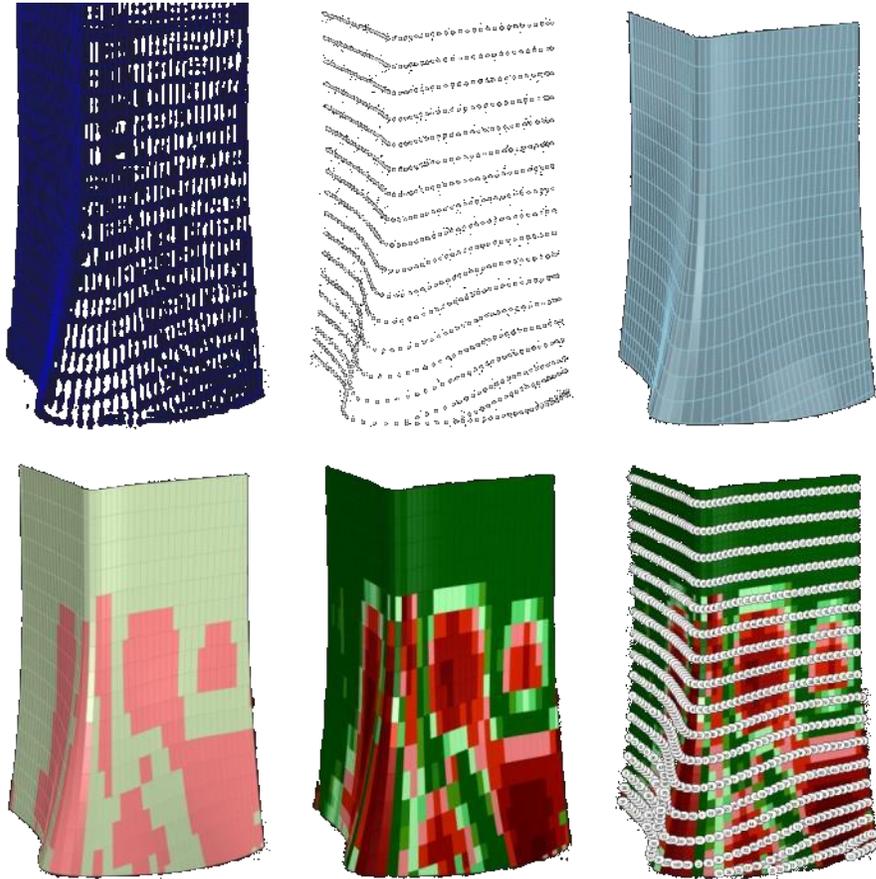


Recent complex geometry façade projects in Dubai  
Meinhardt Façade Technology

Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Benjamin Beer, Meinhardt Façade

# Complex Geometry – Cold-Bending Options



# Cold Bending



Summary of GPD – 2015, J.Vitkala  
Source: [www.gpd.fi](http://www.gpd.fi) © Lutz Schöne, LEICHT  
Structural Engineering & Specialist Consulting

Summary of GPD – 2017, J. Vitkala  
Source: [www.gpd.fi](http://www.gpd.fi) © Lutz Schöne, LEICHT

# Gravity Glass Bending



## Bending Process:

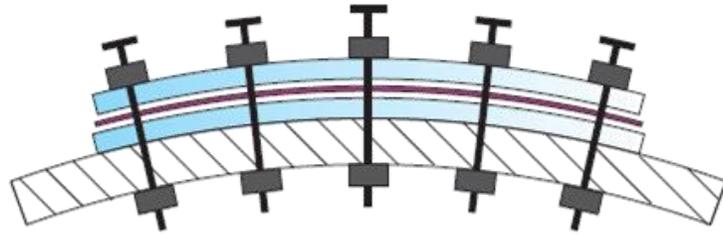
- Coated and uncoated glass in package
- Definition of Bending Parameter
- Discussion Productivity: Prior – During – Afterwards

Summary of GPD – 2017, J. Vitkala

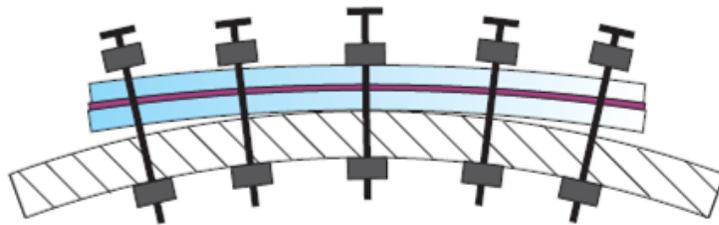


Summary of GPD – 2017, J. Vitkala

# Warm-Bending inside autoclave



Phase I- **Distortion** of the yet-not-coupled glass-interlayer package and **lamination** in deformed configuration



Phase II – **Release** of the element from the mould...springing back and relaxation due to the viscoelastic response of the interlayer!



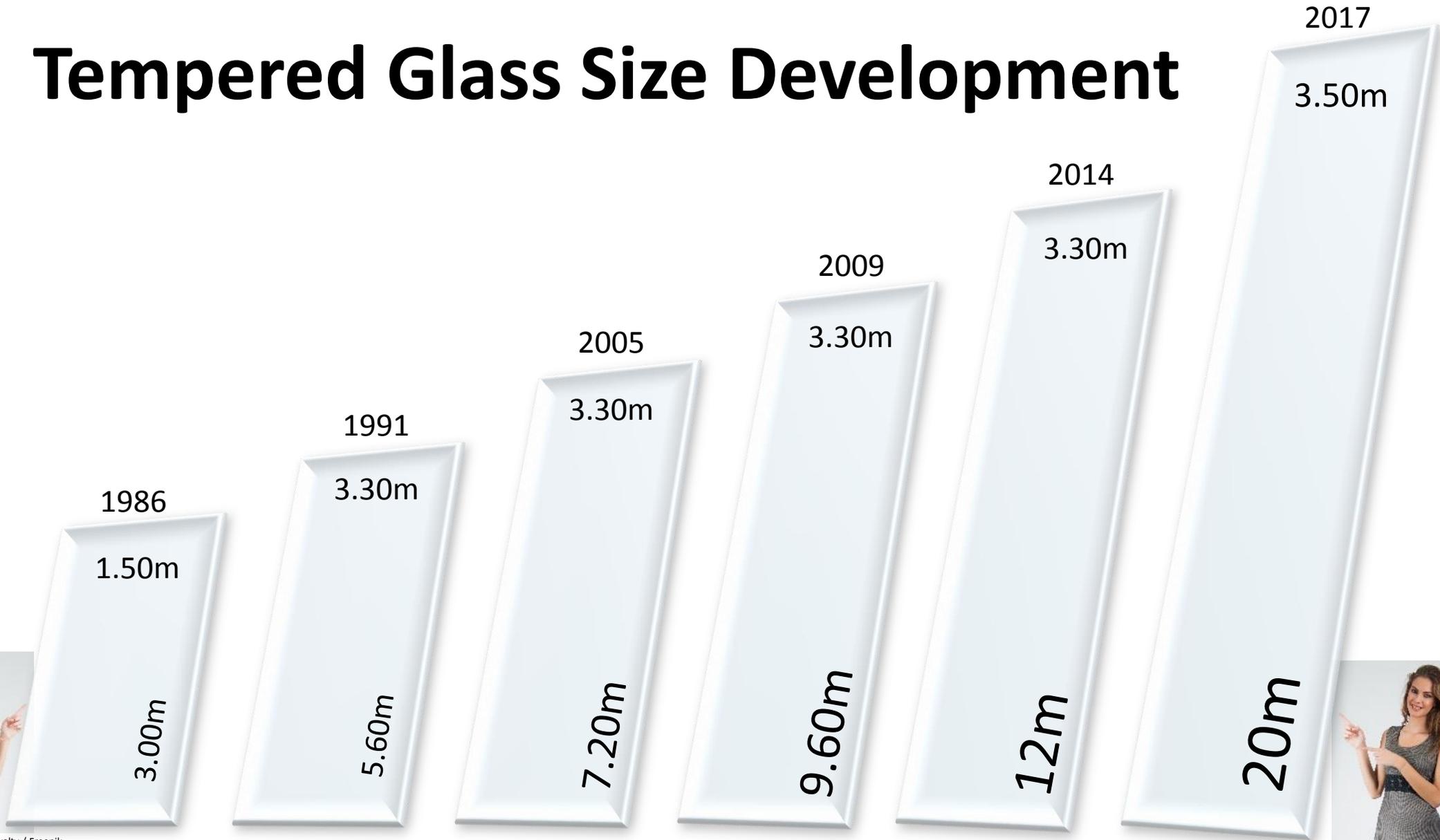
Phase III - **final placement** in the desired position

# World Wide Glass Quality and processing Trends

Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Jorma Vitkala, GPD

# Tempered Glass Size Development



Designed by photoroyalty / Freepik

Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Jorma Vitkala, GPD

# Large glass needs special handling equipment - Tvitec Spain

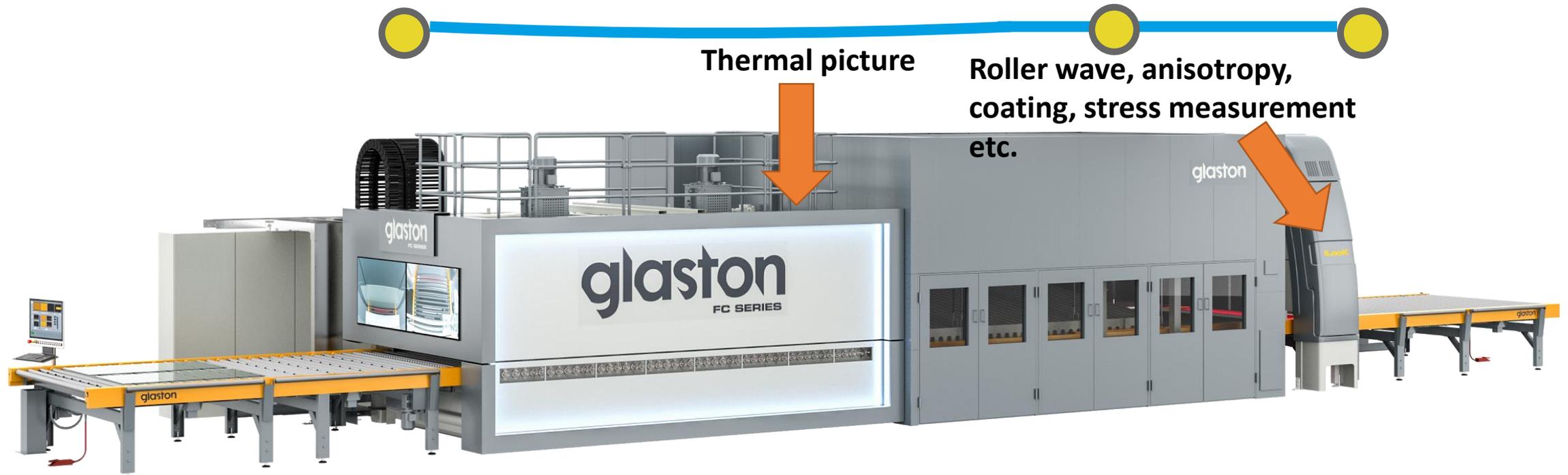


Summary of GPD – 2015, J.Vitkala  
Source: [www.gpd.fi](http://www.gpd.fi) ©Tvitec

## Glass types recognition

(thickness, size, coating/  
emissivity measurement, holes,  
cut offs, etc.)

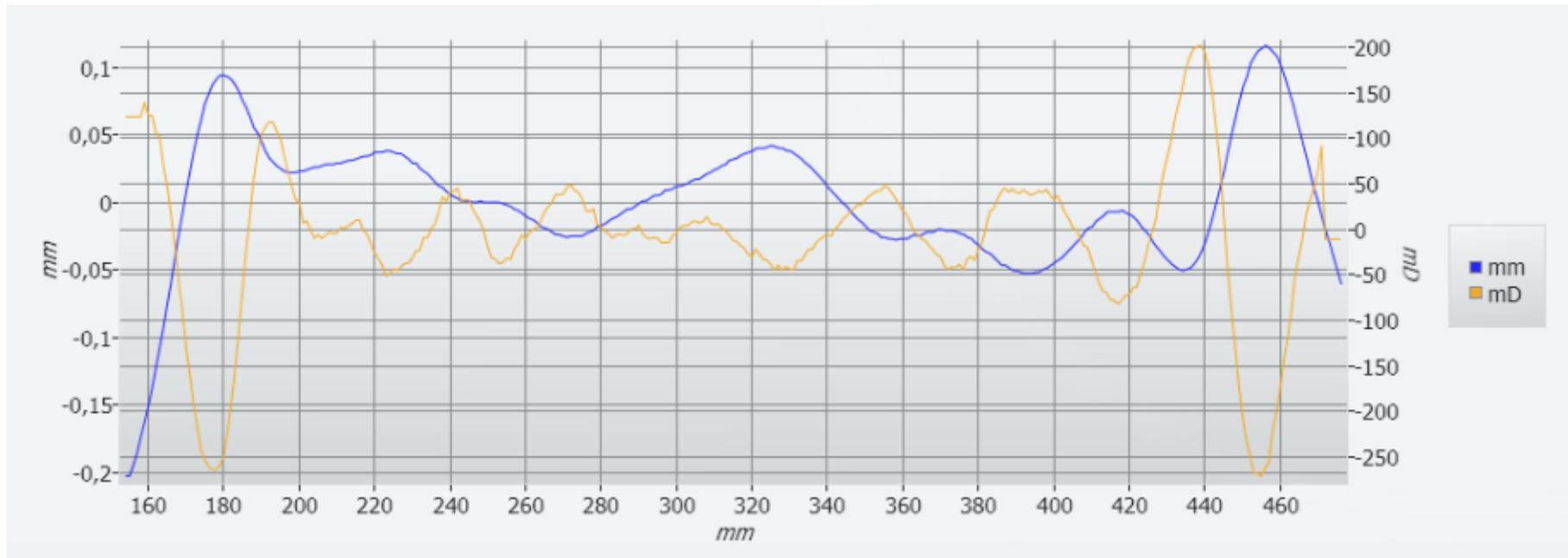
Overall bow measurement  
in horizontal process



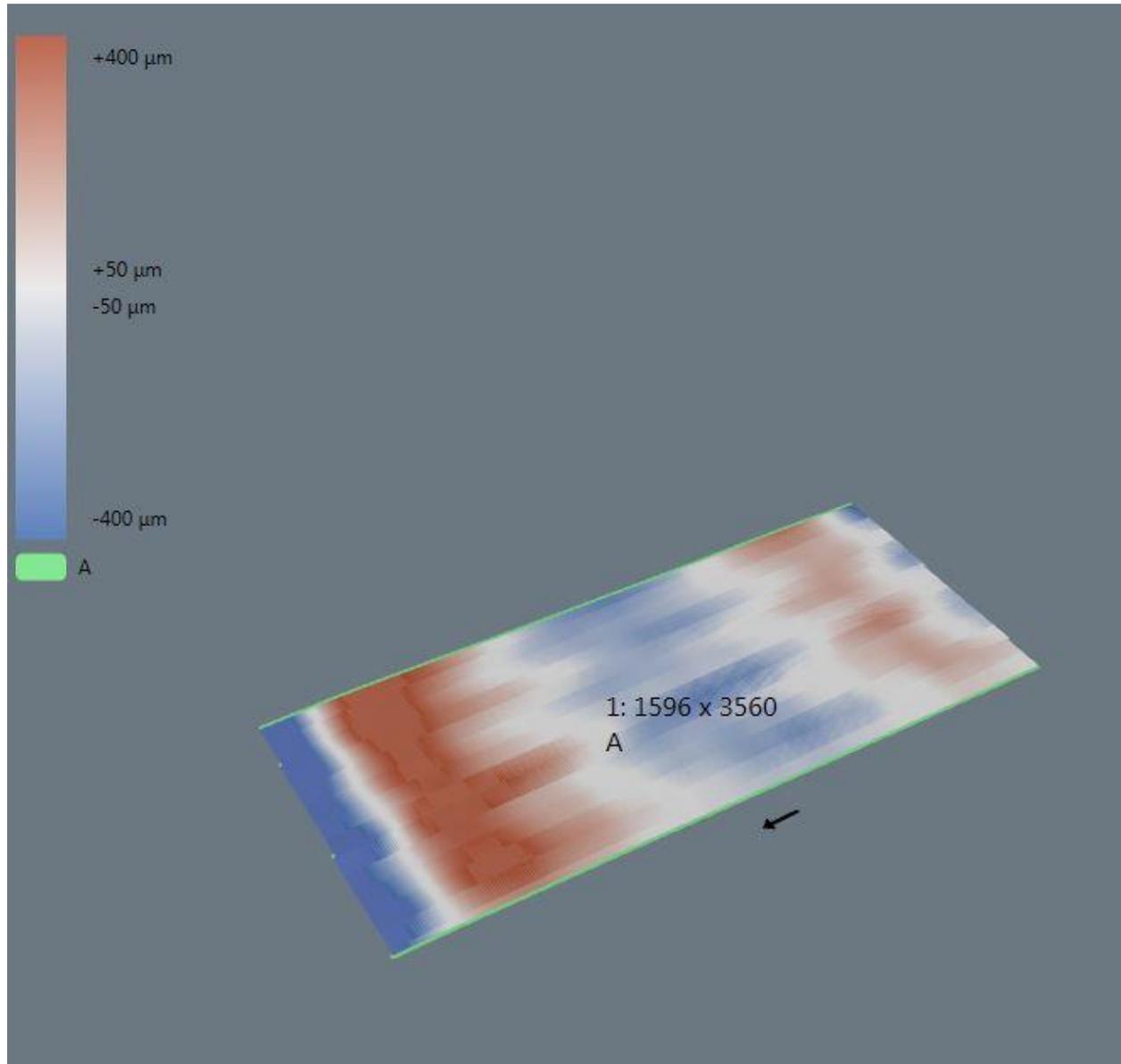
Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Miika Äppelqvist, Glaston Finland Oy  
Jorma Vitkala, GPD

# Roller wave measurements



# Roller wave measurements



Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Jorma Vitkala, GPD

# Reasons

Quench marks

Heating

Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Riku Färm, Glaston Finland Oy

# Towards better anisotropy – measurement becomes online



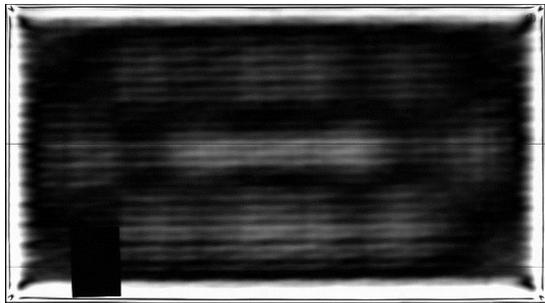
Summary of GPD – 2017, J. Vitkala

Source: [www.gpd.fi](http://www.gpd.fi) © Riku Färm, Glaston Finland Oy

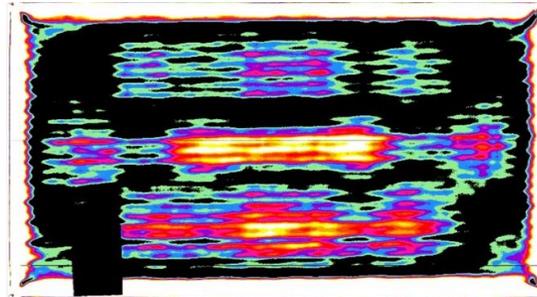
# Isotropy visualization

Alternative visualization of measurement results

**Operator can switch between 3 result visualizations options!**

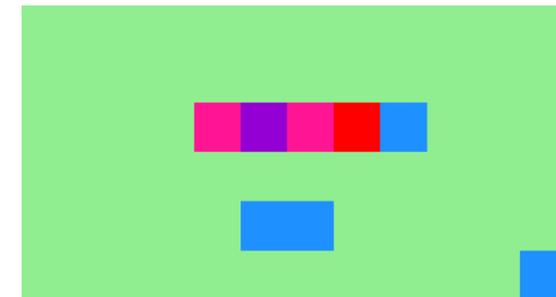


**Real camera image**



**Intensity image**

**Representing the  
optical retardation**



**Segmented areas**

**Detecting critical areas of  
Anisotropy effects**

“Treat each and every project as if it the last one you will ever do.  
The project should achieve the highest level of craft possible,  
utilize innovative and appropriate technology and  
reflect how you want to be remembered”

C. Keith Boswell

# Thank you!

**Jorma Vitkala, GPD Chairman**

**[Jorma.vitkala@gpd.fi](mailto:Jorma.vitkala@gpd.fi)**

**+358 40 5532042**

**GPD 2017 Ebook: [www.gpd.fi](http://www.gpd.fi)**

**GPD Turkey – 7-10.3.2018**

**GPD China – 17.4.2018**

**GPD Finland – June 2019**