Worldwide Glass Trends

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Summary of GPD – 2017, J. Vitkala

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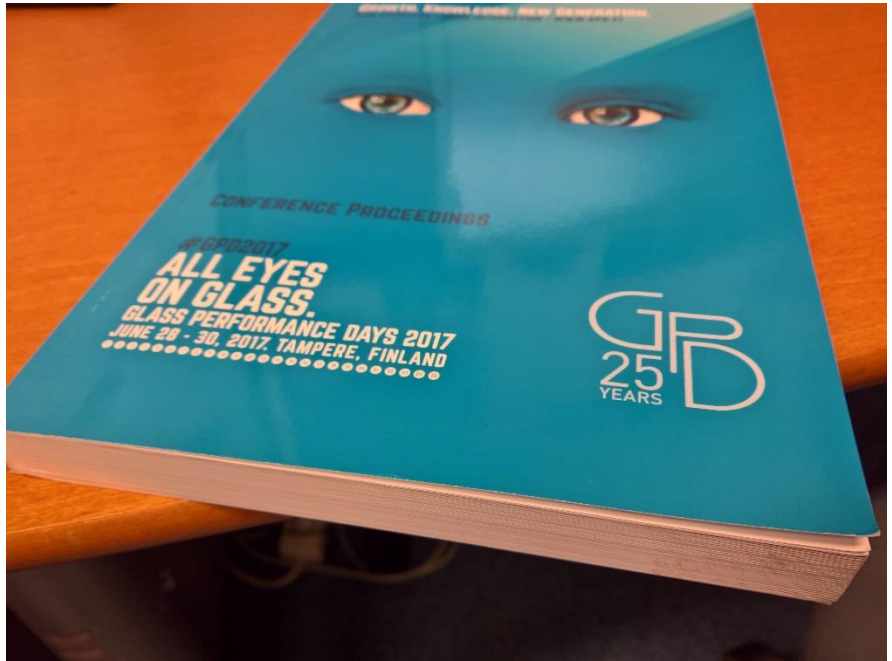
Worldwide Glass Trends -

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

GPDs impressive record - 25 years

GPD 1992 - 2017

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

GPD 2017 - 25 years

- GPD 2017 registered a total of 657 participants in Tampere
  Top of that 160 specialists at the high-rise seminar in Helsinki.
- Total over 817 participants
- 16 focused workshops with all together 402 specialists attending were organized preceding the GPD.

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”Knowledge grows when knowledge is shared”

- - The Indian poet Bhartrihari
c.670 CE

Architect speakers during the GPD history

- Thomas Herzog
- Herzog & de Meuron - Stefan Goedderte
- SOM – K. Boswell, L. Follman, C. Timm, N. Holt, E. Tomich
- UN studio – A. Piper, R. Henderson
- BIG – Kai-Uwe Bergman, Claus Hermansen
- SHoP architects – Kumar
- Wener Sobek
- Ian Ritchie
- Foster + Partners – S. Behlin, R. Partington, Corti, Kolkhoven
- James Carpenter, D. Norris, L. Lowengs
- Henn architects – Gunter Henn
- A. Compagno
- Dominique Perrault
- Klaus Daniels
- Octatube – M. Eekhout
- Snohetta – Peter French
- AKKA –architects – Stephanie Akkaoui Hughes
- Mikkelsen Architects - Stig Mikkelsen
- Bohlin Cywinski Jackson architect – K. Backus
- Rafael Vinoly Architects
- Heintges Architects – Robert Heintges
- Goettsch Partners – Patrick Loughran

Finnish speakers:

- Pallasmaa
- Nousjoki
- Gronholm
- Mahlamäki
- Rautiola

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Automotive speakers during the GPD history

- Pininfarina - Lorentz Ramaciotti
- General Motors – D.Ablesson, D.Ruzzin
- Renault – M. Jordin
- PSA Peugeot Citroen – E.Even, G.Lozach
- Lancia Fiat / ED Design – M. Robinson
- Toyota – M. Kawase
- Ford – M.Massara, V.Henry

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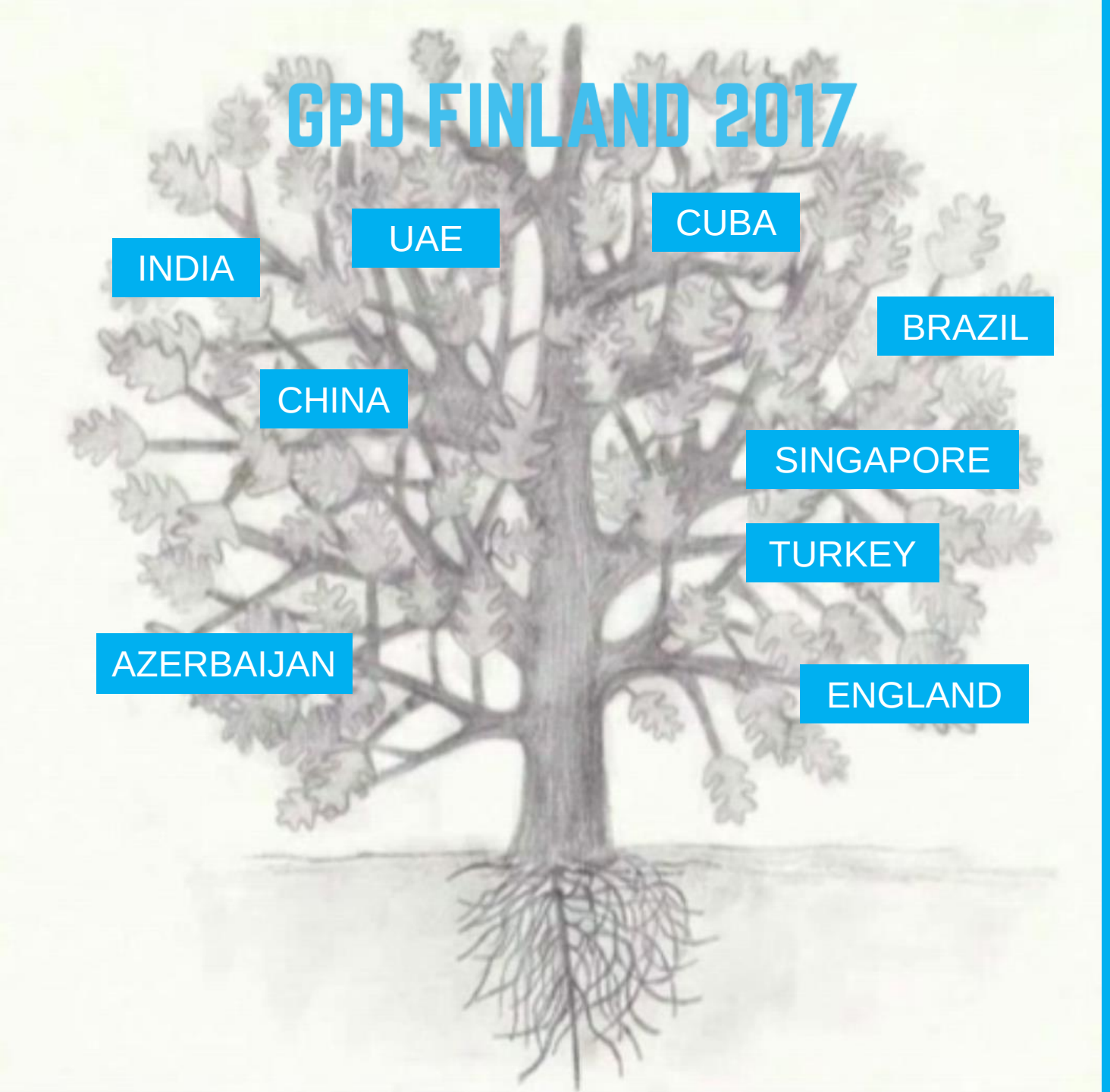
From a little acorn,
grows a mighty oak

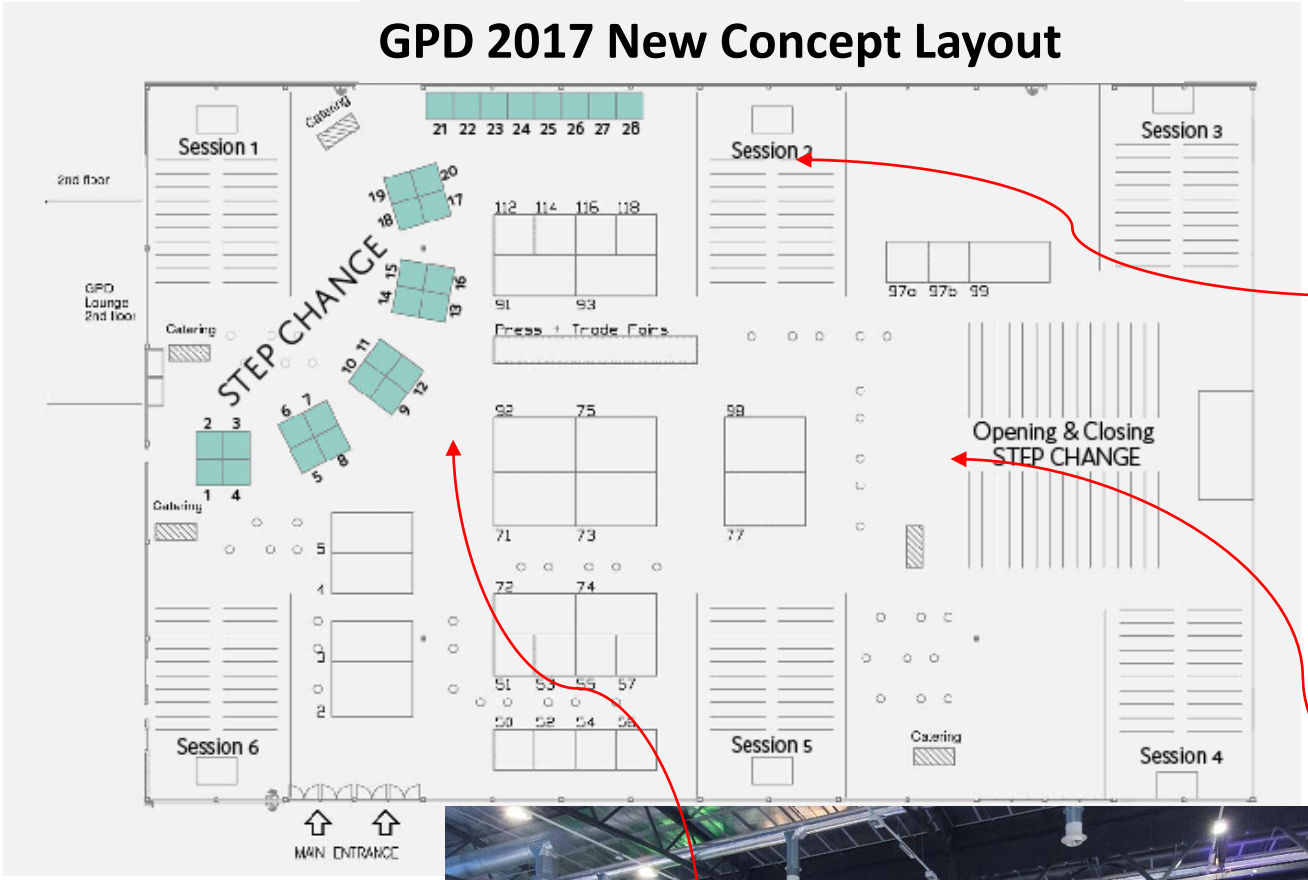


GPD 25 years

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

GPD 25 YEARS

GPD 2017 New Concept Layout



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Source: www.gpd.fi ©

Step Change Program

Increase the clock speed of the industry

- Scott Thomsen & Russell Ebeid

Step Change brings together:

- New technologies
- Startups
- Innovation teams
- Business angels

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 © Jorma Vitkala, GPD

The world drastically changed during these last 25 years:

- Internet
  - Linkedin
  - Google
  - Facebook
  - Twitter
- Portable telephone
- Renewable energies
- Planet climate change
- Terrorism
- 2008 financial crisis

Summary of GPD – 2017, J. Vitkala

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	

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Bernard Savaëte, BJS.Différences

During these 25 years float glass processes have evolved:

- float lines nominal tonnage
- furnace campaign life
- oxy-combustion
- extra-thin glass
- special compositions

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Source: www.gpd.fi © Bernard Savaëte, BJS.Différences

During these 25 years we have observed several improvements in the fabrication processes:

- tempering line able to temper down to 2 mm
- complex bending for building & automobile
- lamination with or without autoclave
- digital printing on glass
- cold bending
- processing of XXL sizes.
- machinery able to process soft coatings
- automatic assembling of insulating glass units
- quality control on line during fabrication
- more automatization
- ….

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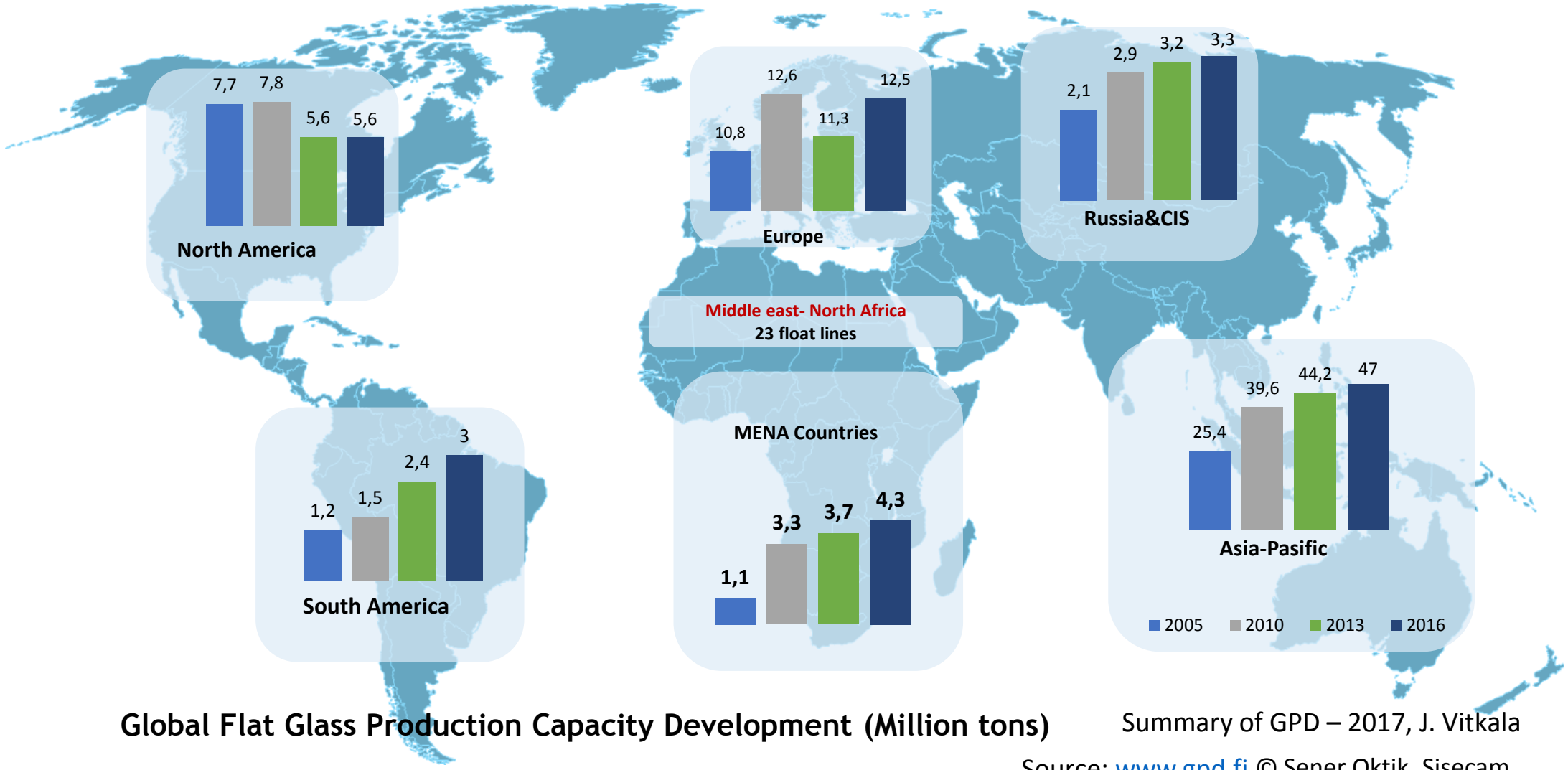
Source: www.gpd.fi

2016 The Global demand for flat glass: ~73 million tonnes (~ 9.2 billion m²)

The global market value of flat glass: $90 billion



Global Flat Glass Production Capacity Development (Million tons)

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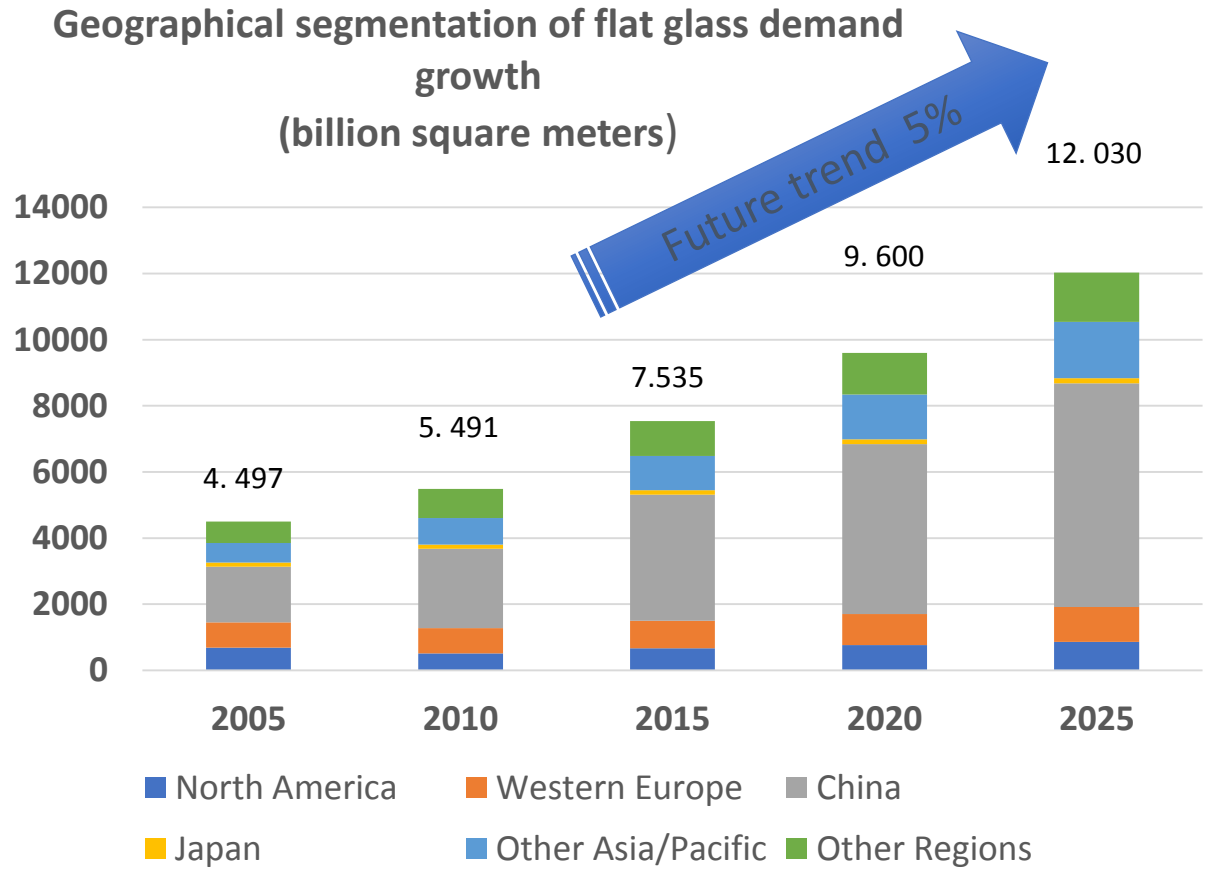
Growth of global demand for flat glass & geographical segmentation

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

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



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Coated flat glass at a glance

2016 The Global demand for flat glass:

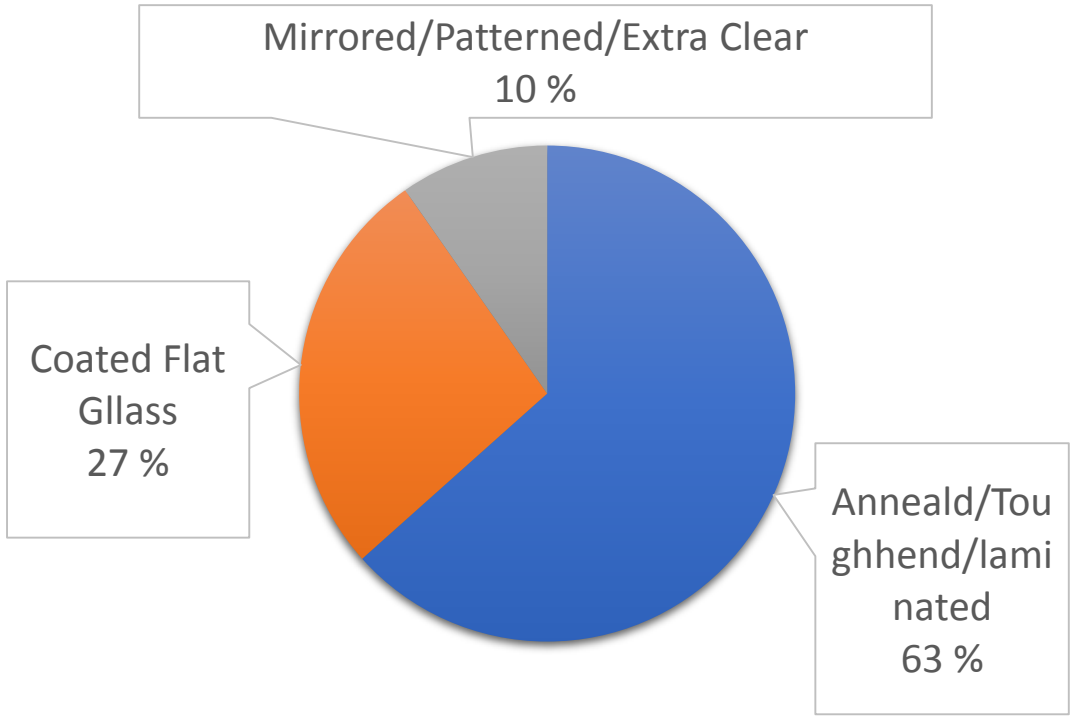
~ 73 million tonnes

~ 9,2 billion m²*

2016 The Global demand for coated flat glass:

~ 20 million tonnes

~ 2,5 billion m²*



*(*for a rough estimation; m² /metric ton ≈125)*

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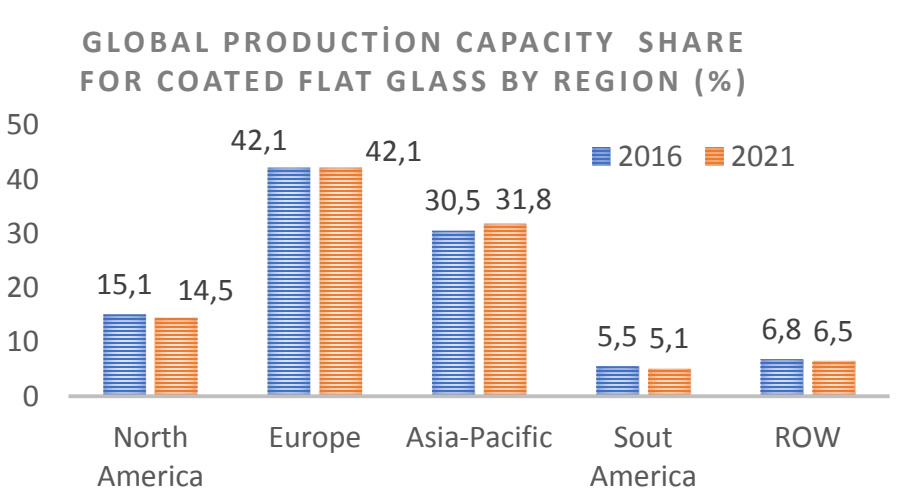
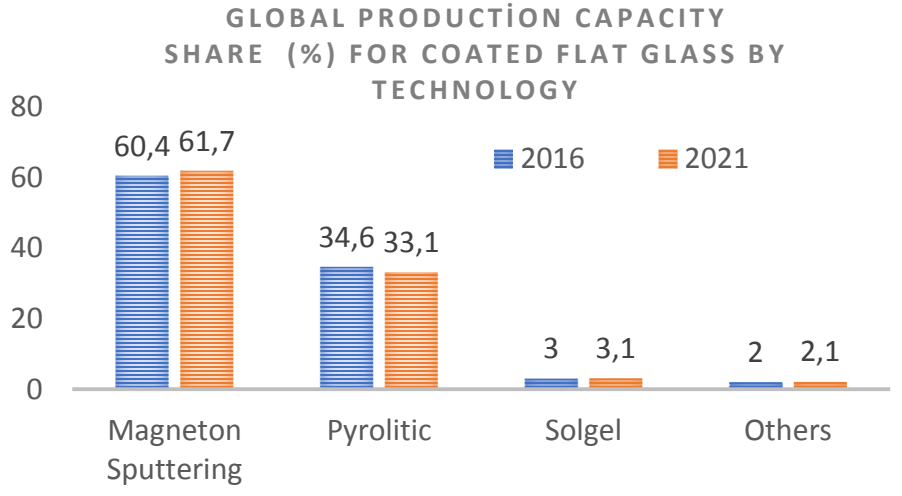
GLOBAL PRODUCTION & MARKET VOLUME AND PROJECTION TO 2021 FOR COATED FLAT GLASS

Coated Flat glass Production	2015	2016		2021
Million Tons	~19	~20	CAGR~6.1%	~25
Billion m^2 *(m^2/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

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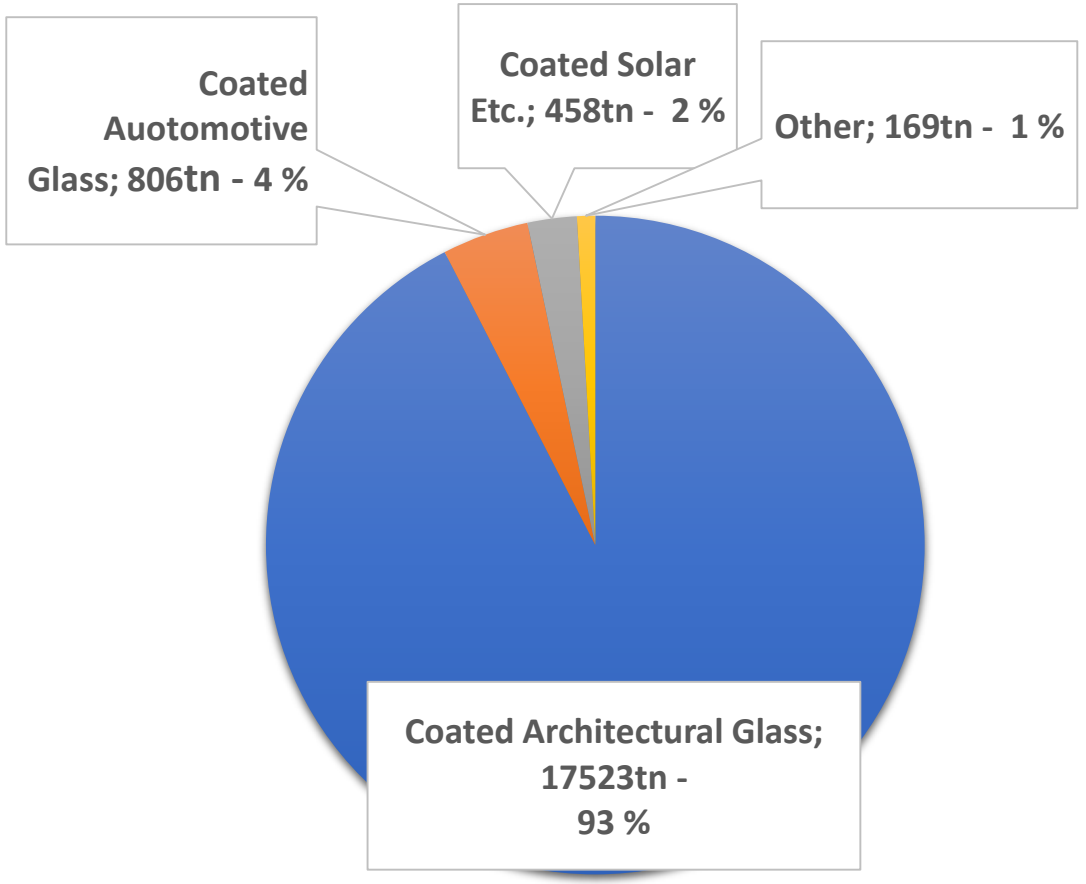
2016 Global market for coated falt glass by applications



(Thousand tons - %)

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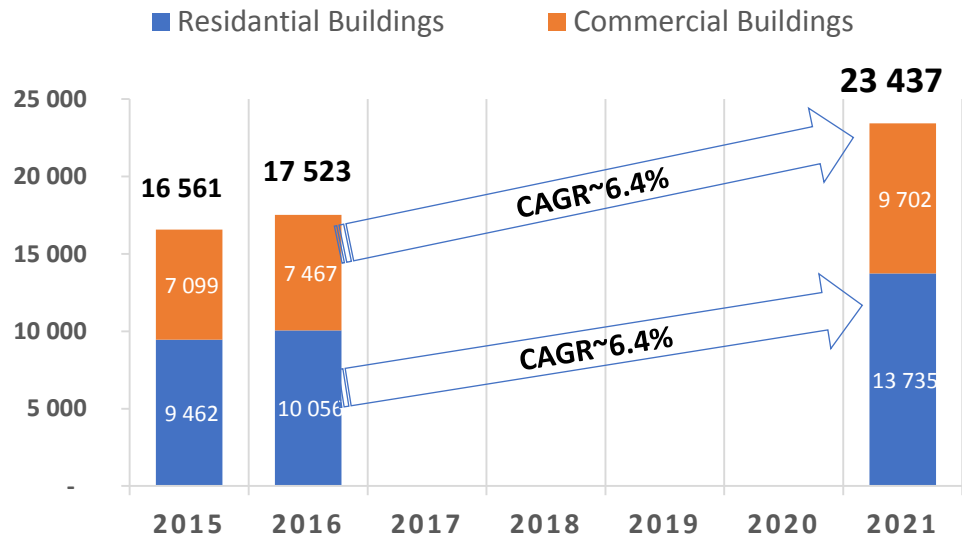
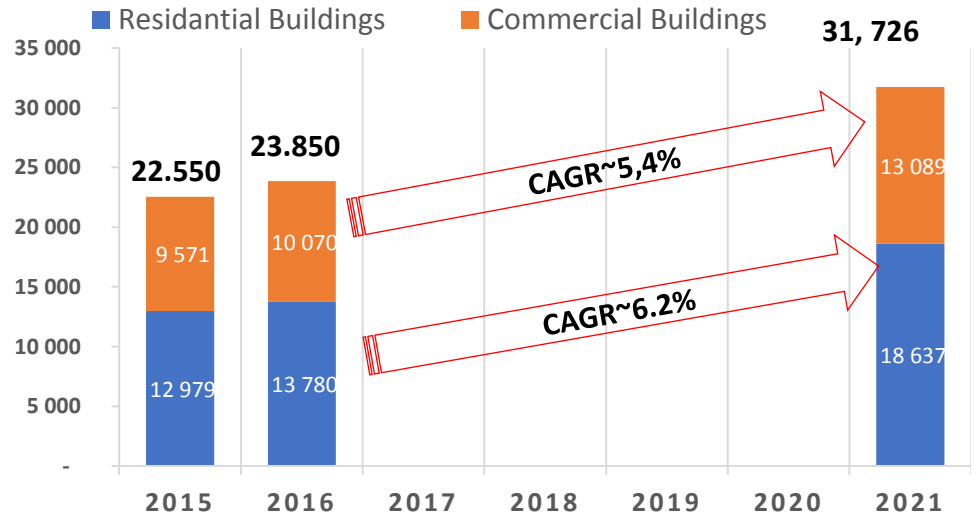
GLOBAL OUTLOOK OF COATED FLAT GLASS FOR ARCHITECTURAL APPLICATION AND PROJECTION TO 2021

PRODUCTION CAPACITY (Thousand Tons)



GLOBAL MARKET (Billion US Dolars)



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2016;The global demand for flat glass & application segments

Demand: ~73 million tons *(~ 9.2 billion m^2) (dominated by China 51%)*

(m^2/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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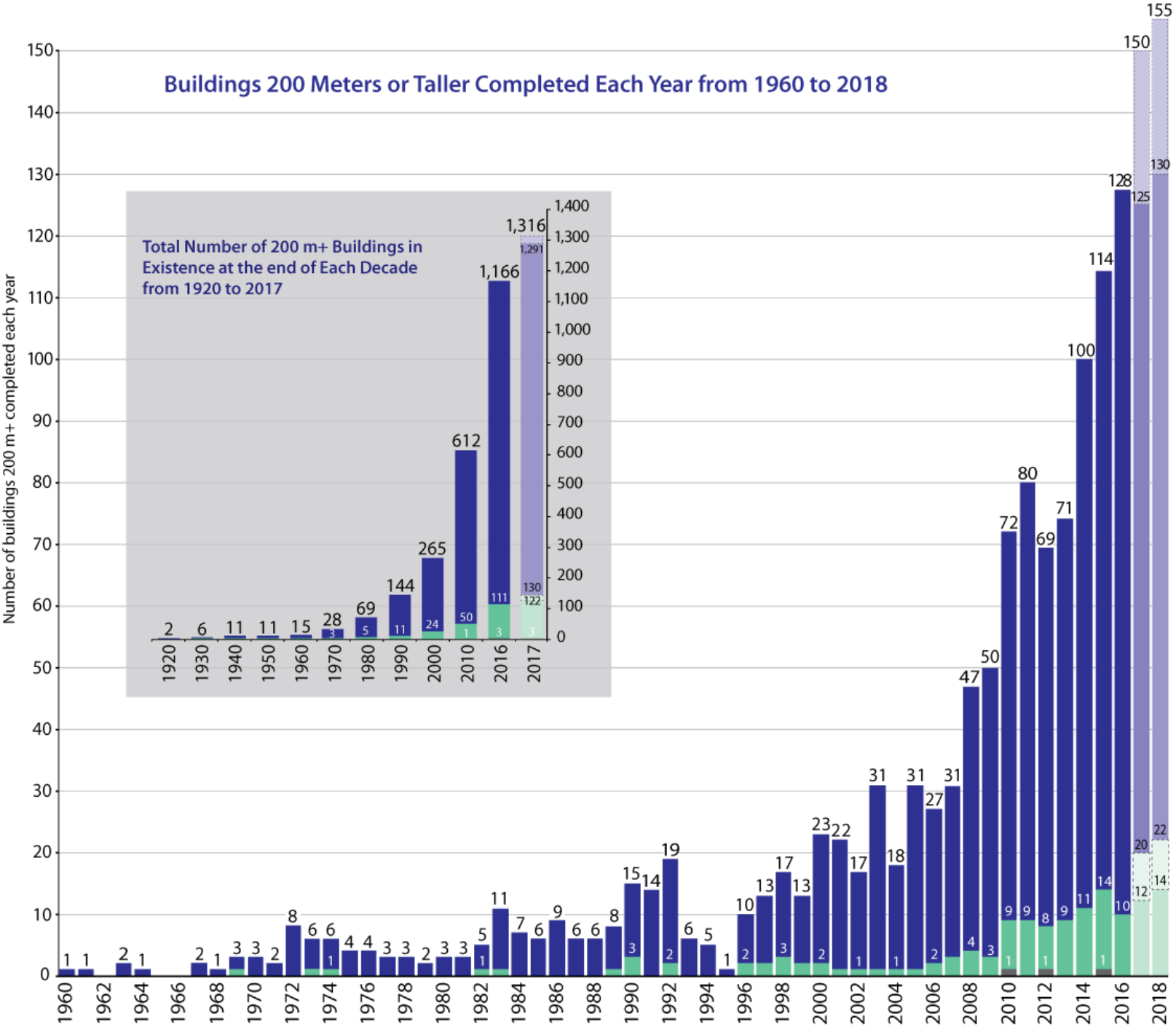

High Rise Buildings Data Research

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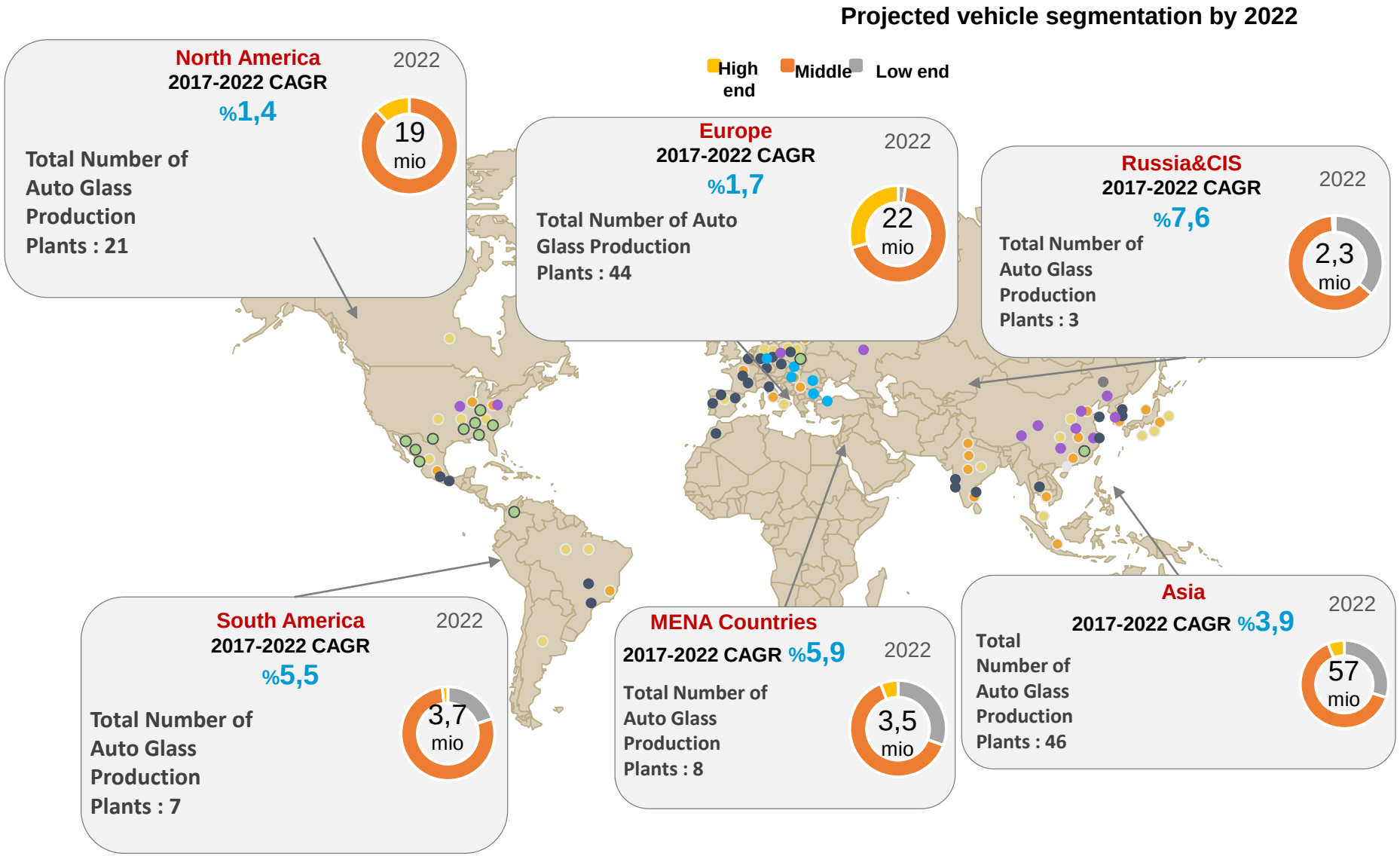
Regional Number of Automotive Glass Plants (2017) and Expected Vehicle Sales by 2022



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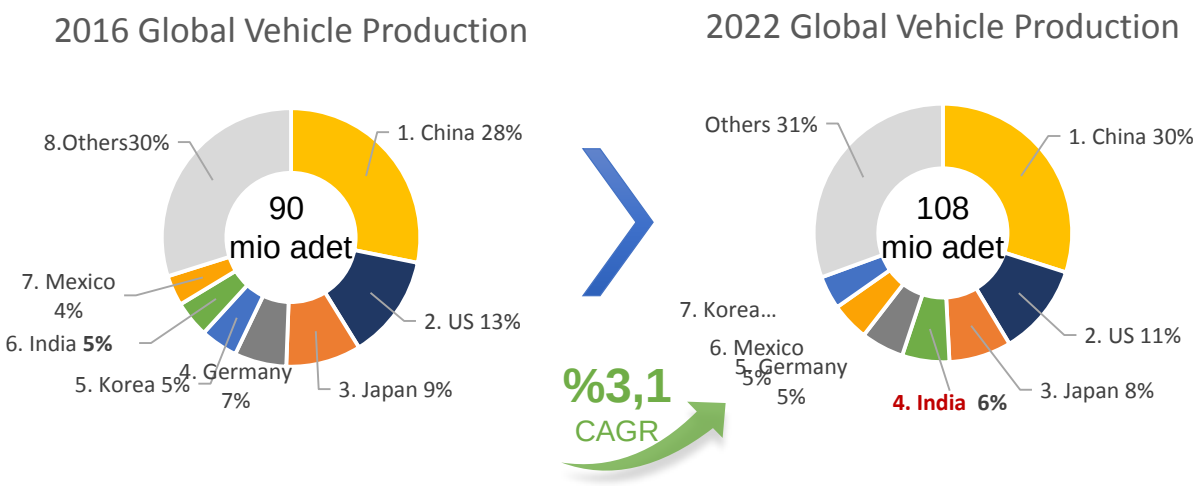
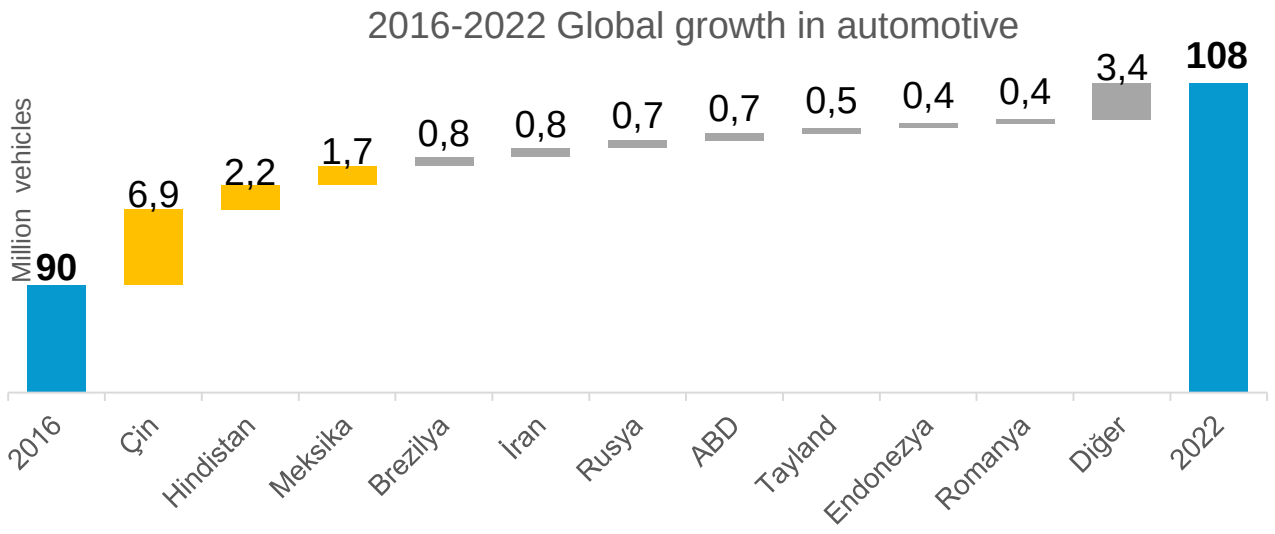
Global Vehicle Manufacturing at a Glance and Projection to 2022





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Industry 4.0 / IoT

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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

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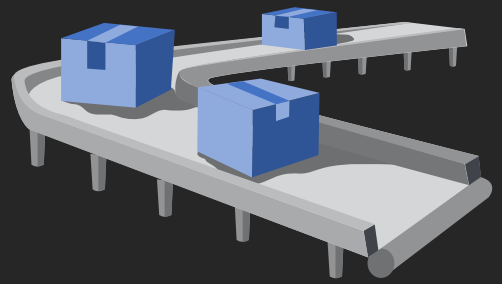
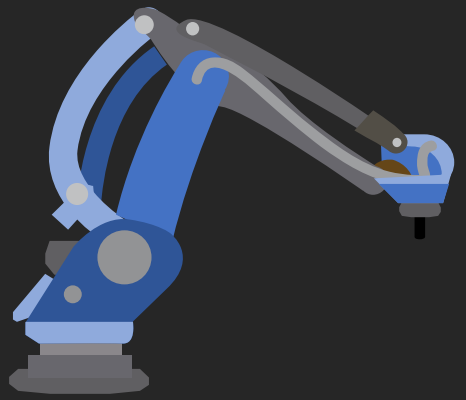
Source: www.gpd.fi © Alex Ochoa, FeneTech Inc

DEVELOPMENT PHASES FROM INDUSTRY 1.0 TO INDUSTRY 4.0

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



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



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

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

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Industry 4.0 – what is it?

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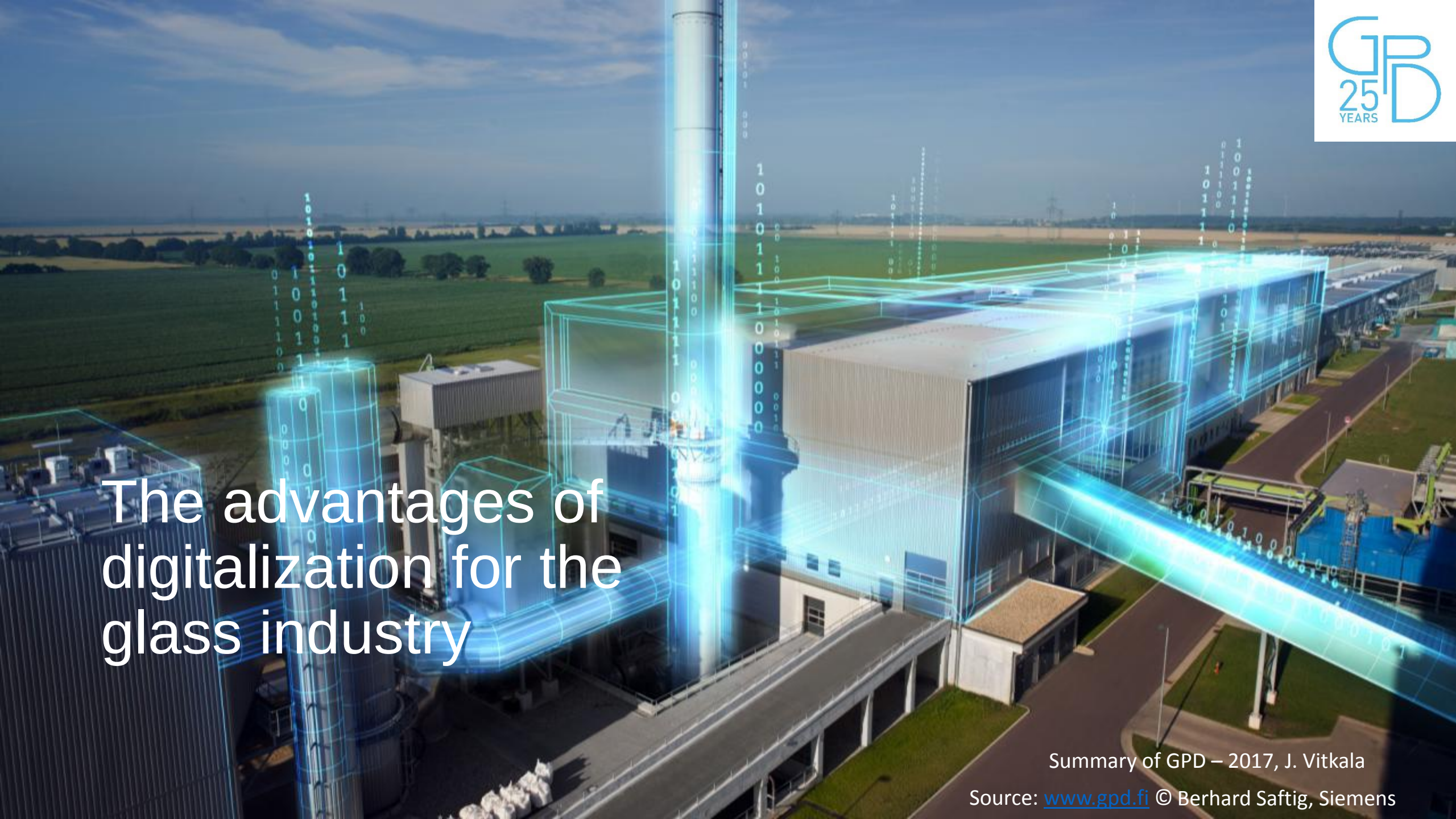

The advantages of digitalization for the glass industry

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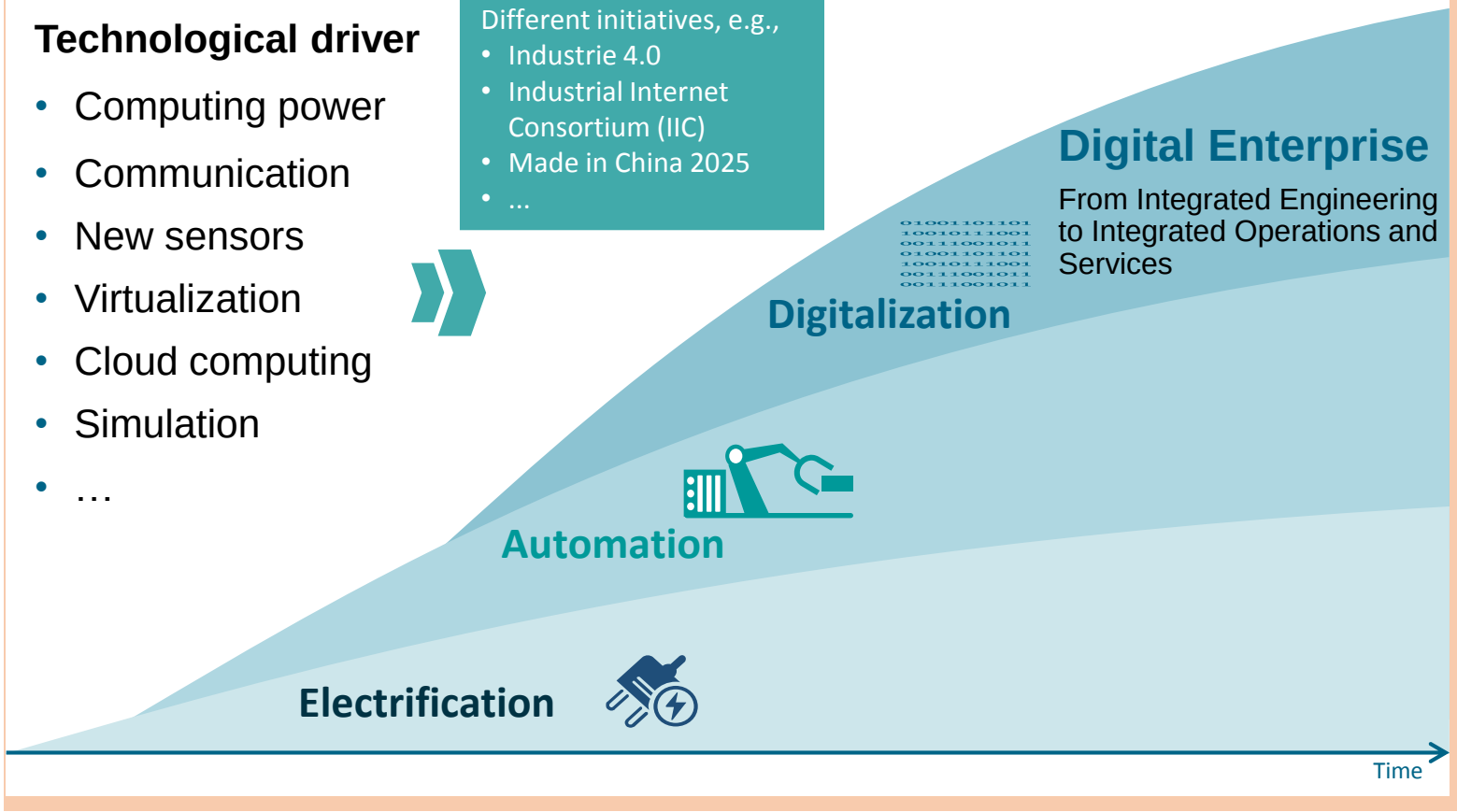
Process industries → electrification, automation, and digitalization as drivers

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
- …



Next level of productivity

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Industry trends

Efficiency	Flexibility	Quality	Time-to-market
• Resource and energy efficiency • Demanded product/ quantity	• Customized mass production • Volatile markets	• Closed-loop quality • Traceability	• Fast innovation • More complex products • Lifecycle management

Security

Health and safety | Environment | Regulations/standards | …

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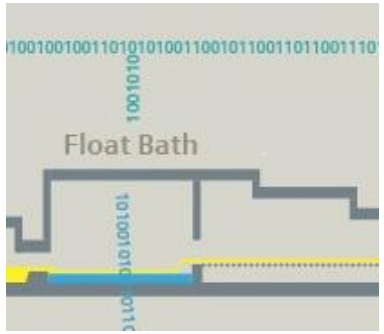
Digital Enterprise is the portfolio of solutions for the digital transformation – for both the discrete and process industries

Digital Enterprise

Process industries — **Discrete industries**

Process industries					Discrete industries				
Product design	Process and plant design	Engineering	Operation	Services	Product design	Production planning	Production engineering	Production execution	Services

Industrial software and automation for process industry

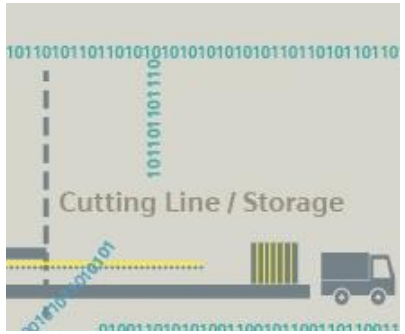


+ **Industrial communication**

+ **Industrial security**

+ **Industrial services**

Industrial software and automation for discrete industry



Digitalization of the field level

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Use of big data

ALERTS

REAL TIME REPORTS

PRE-DICTIONS

BIG DATA SOURCES

- PROCESS DATA
- QUALITY DATA
- PRODUCT DATA
- RAW MATERIAL DATA
- MAINTENANCE DATA

VISUALIZATION

PROCESS KNOW-HOW AND DEVELOPMENT

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Worldwide Glass Design Trends

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A dream becomes real

Multidisciplinary effort and success

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Competition proposal

Aspiration

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Aspired transparency

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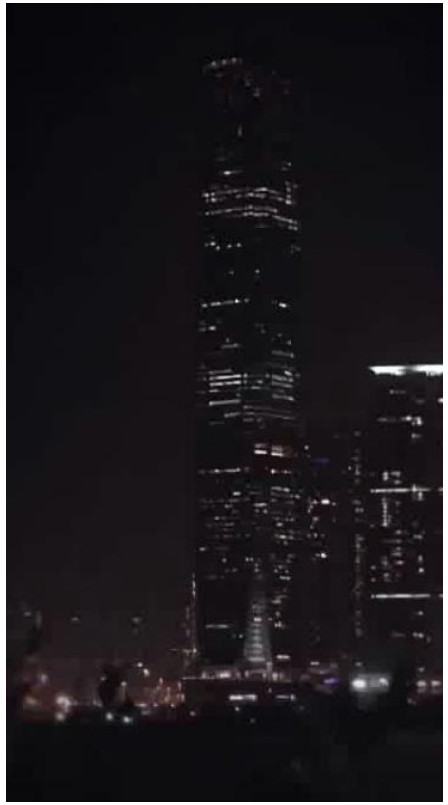
Glass Bridge Zhang Jia Jie, China

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.

Source: www.gpd.fi © Sandro Casaccio, Kuraray

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 © 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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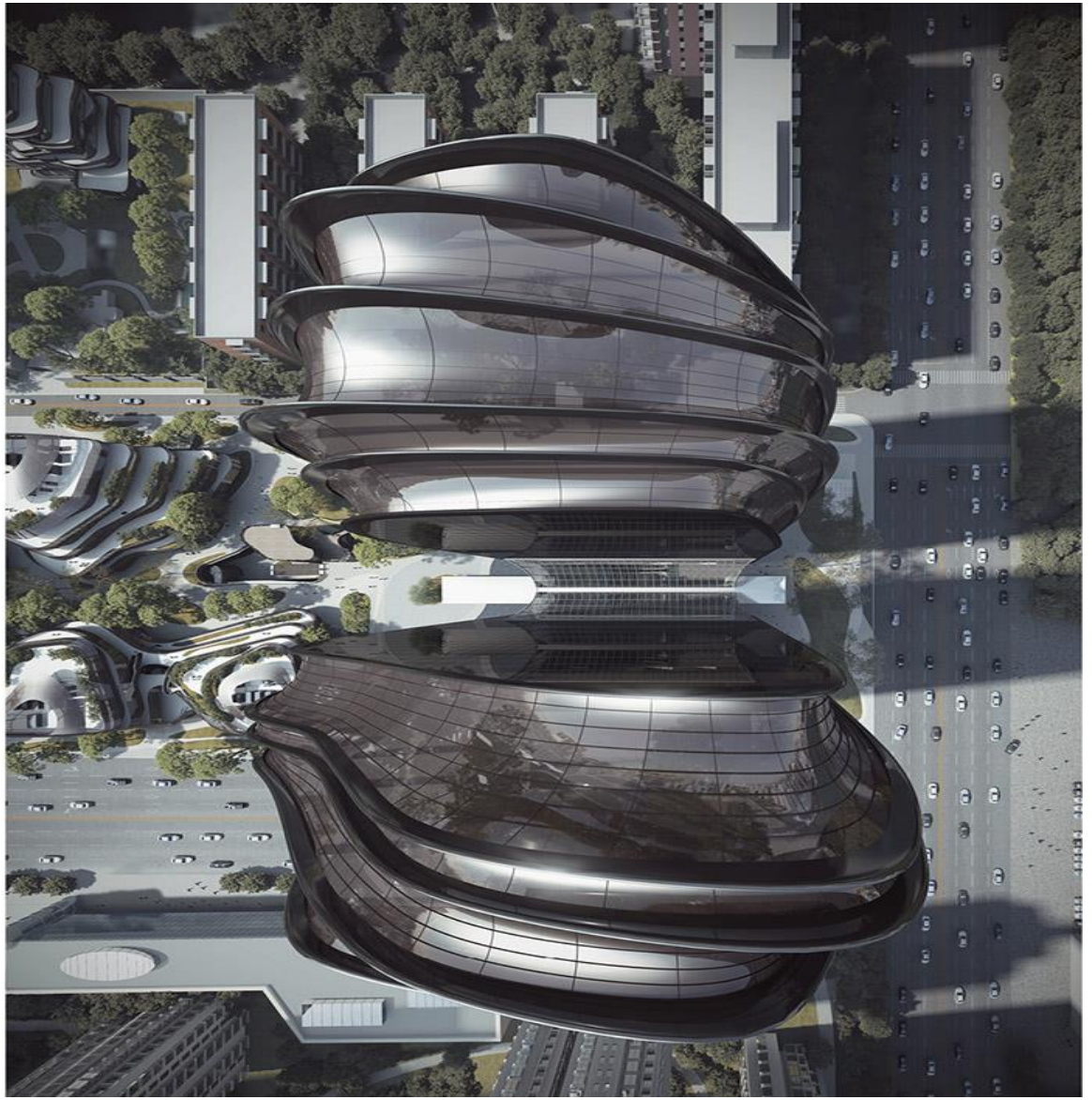

CHAOYANG PARK PLAZA, BEIJING – MAD Architects

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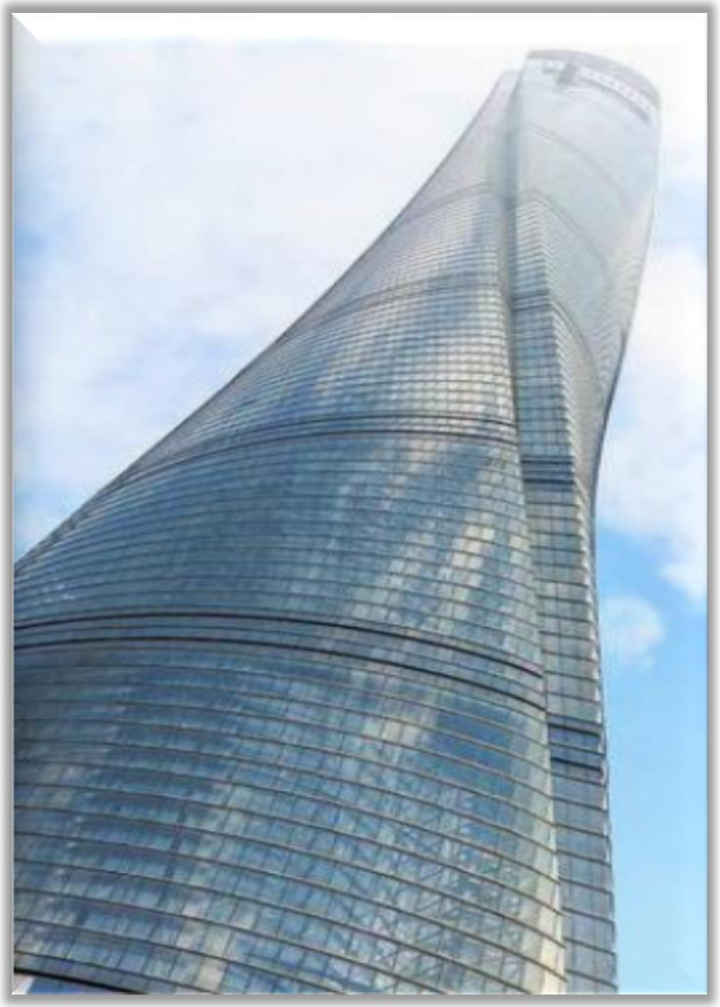
Glass is a fantastic material…

Louis Vuitton, Paris

Marina Bay Sands, Singapore



Shanghai Tower

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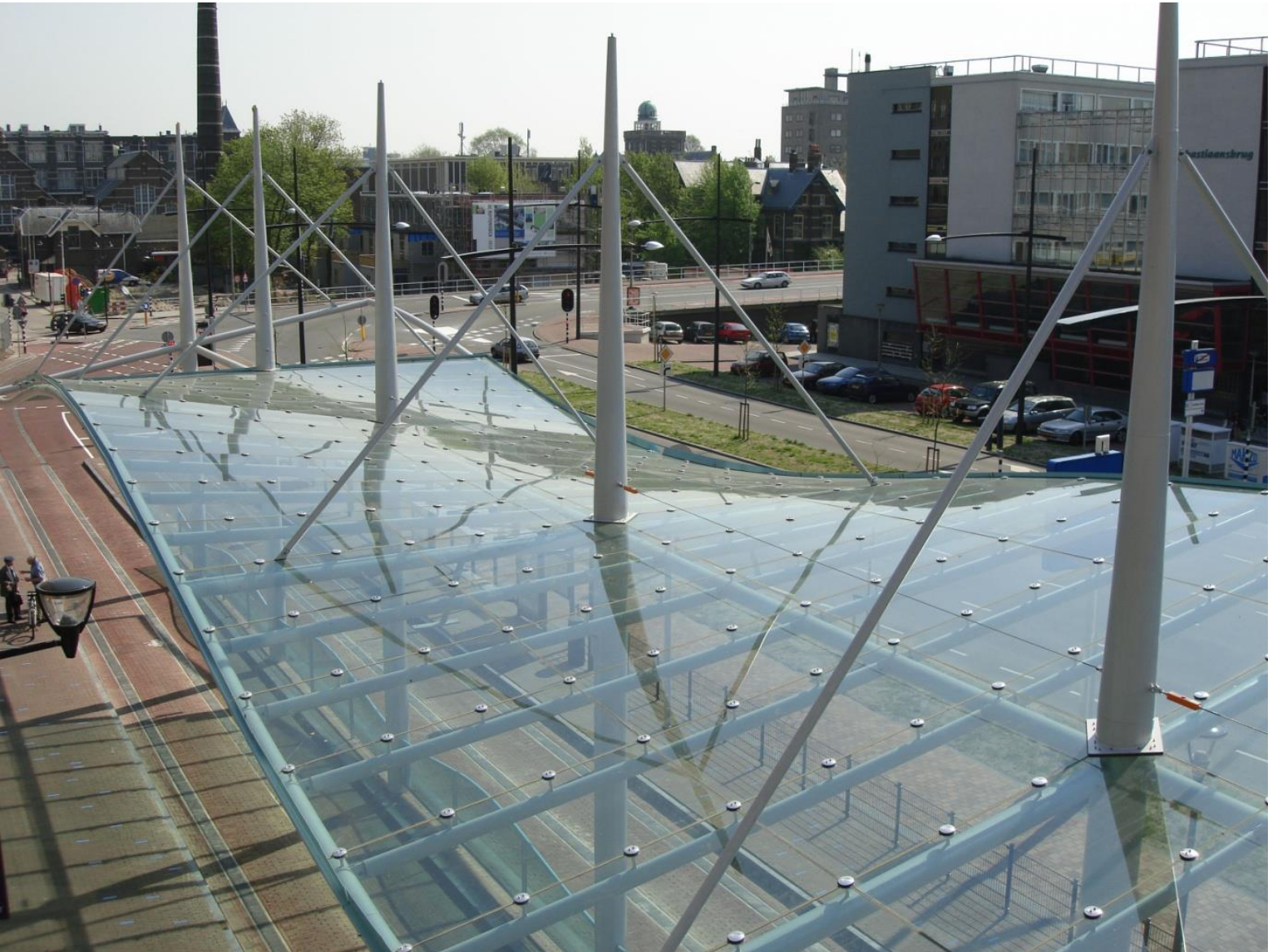

Tram station roof with warped glass, Delft. 2005

Arch. Mick Eekhout

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Source: www.gpd.fi © Mick Eekhout, Octatube

Parametric System

3D facade system

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LOS ANGELES, CALIFORNIA

Engagement in the Urban Realm

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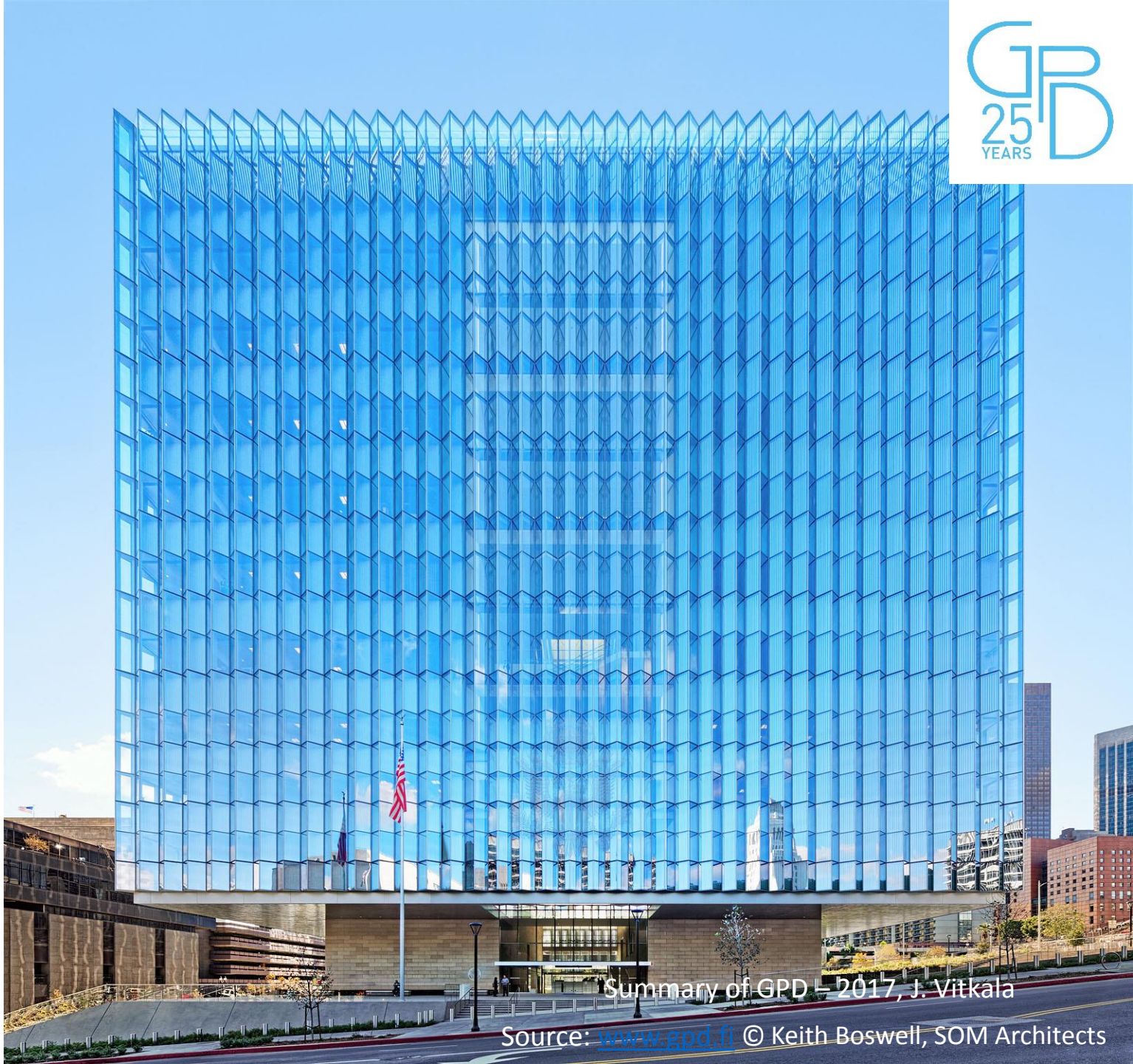
LOS ANGELES, CALIFORNIA



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Source: www.gpd.fi © Keith Boswell, SOM Architects

Establish a clear and memorable idea

You are only as good as what you do today

Specific Solution to a Specific Opportunity

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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

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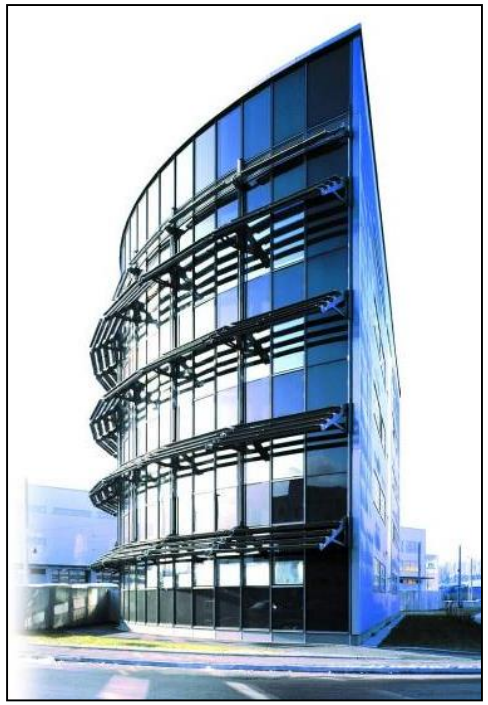
Urmilla Sowell, GANA
Source: www.gpd.fi © Tom Culp, GANA Energy Code Consulting

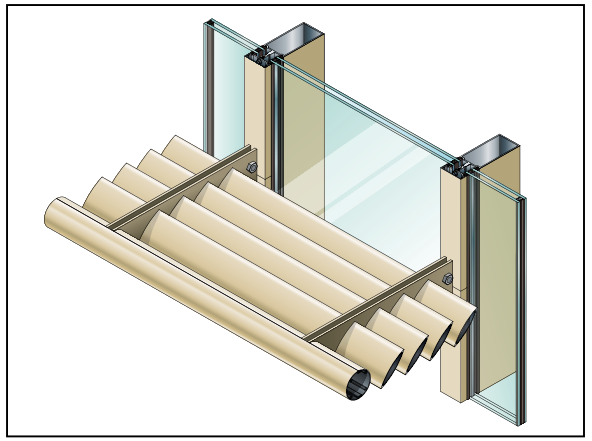
Energy Performance: Daylighting

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



photovoltaic sunshades

light shelves and/or
light redirecting films



sunshades

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Urmilla Sowell, GANA
Source: www.gpd.fi © Tom Culp, GANA Energy Code Consulting

Summary of GPD – 2015, J.Vitkala
Source: www.gpd.fi ©Stig Mikkelsen, MIKKELSEN Architects

National Bank of Denmark

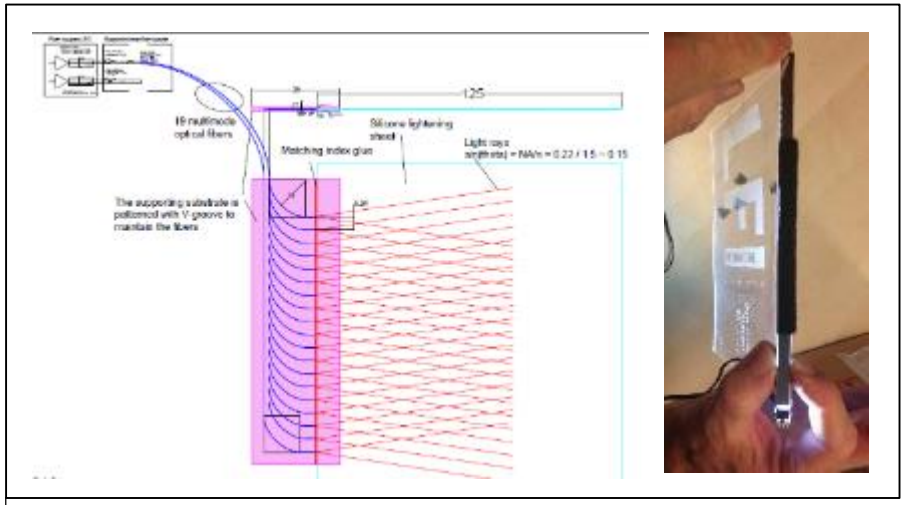
The technology easily meets customer needs

- **Aesthetics**
  - 100% transparency
  - Sophisticated and attractive architecture
- **Sustainability and well being**
  - Save energy
  - Use natural daylight spectrum
- **Innovative features**
  - Instantly change the atmosphere
  - Interactive façade
- **Investment and Life cycle costing**
  - Reduce cooling, lighting and maintenance costs
  - Easy installation

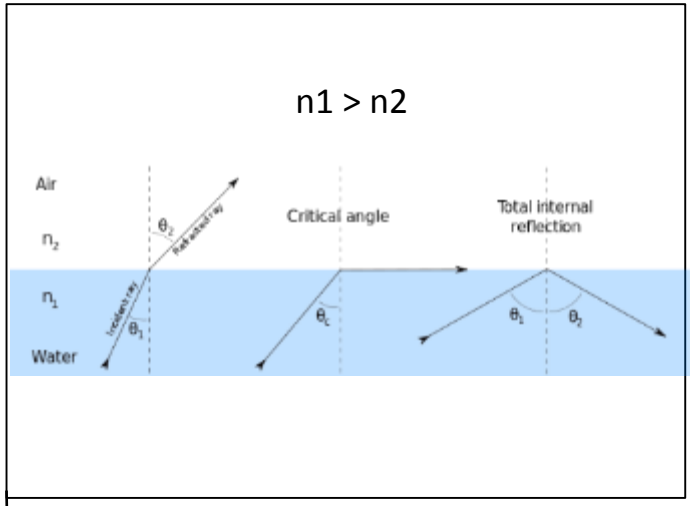
Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Martin Zitto, Merck KGaA

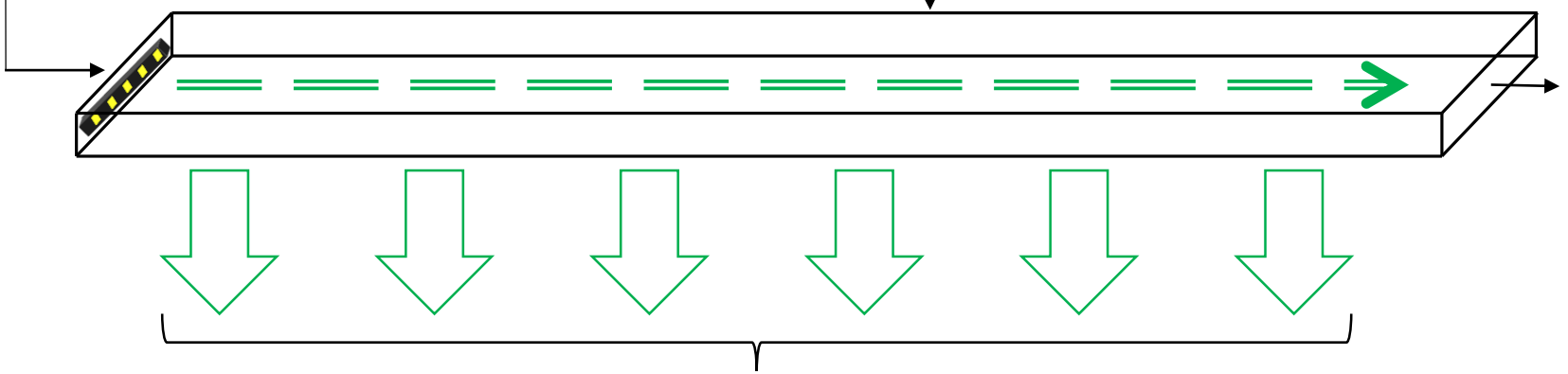
Light Injection, Propagation and Extraction



Light injection



Light propagation



Uniform or Patterned light extraction

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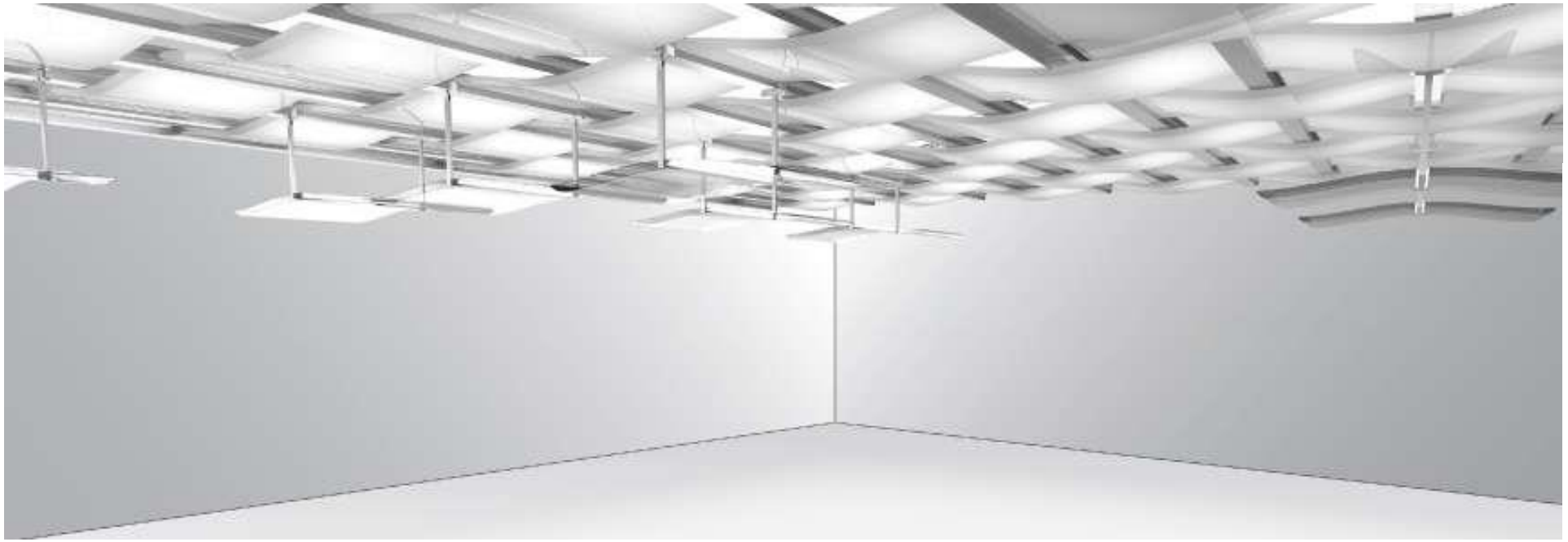
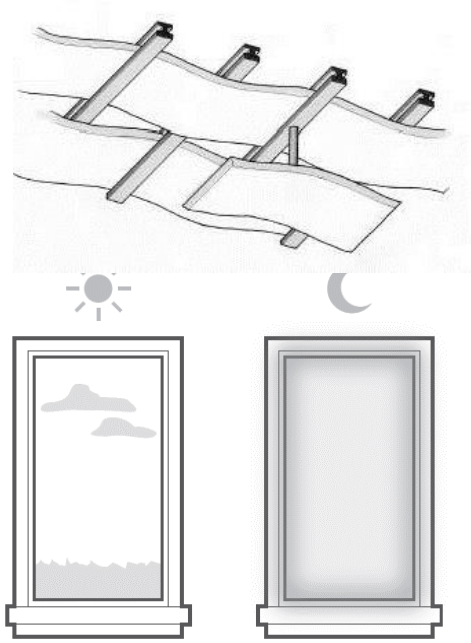
Source: www.gpd.fi © Valerie Hayez, Dow Corning Corp

Flat or Flexible illumination, interior or exterior





Summary of GPD – 2017, J. Vitkala

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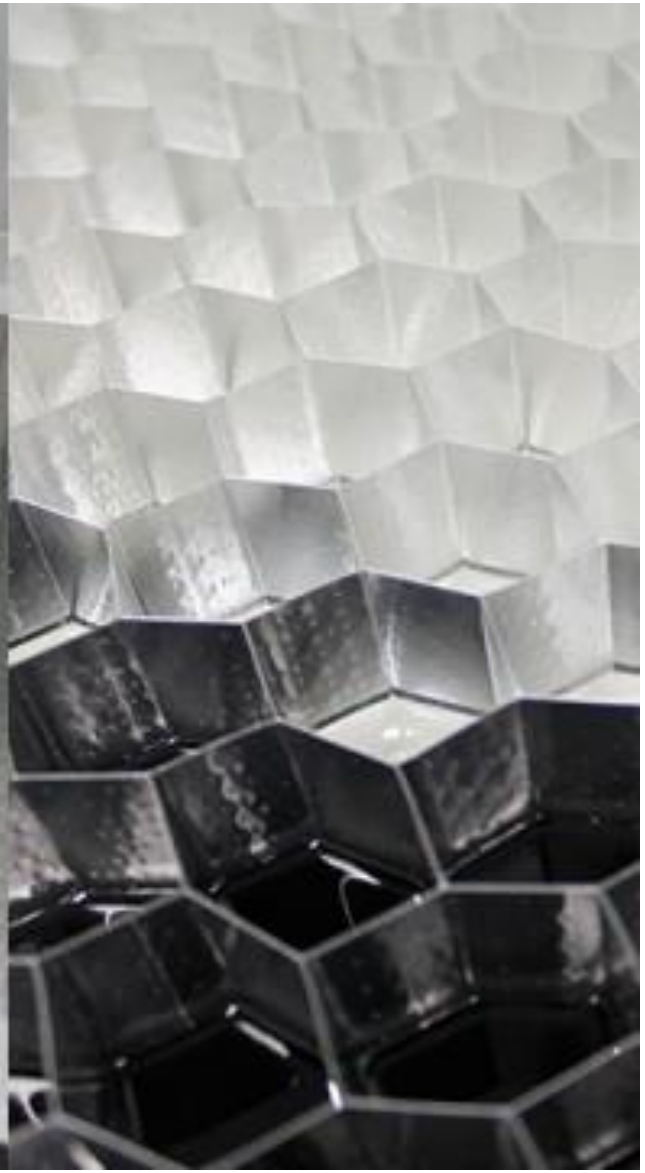

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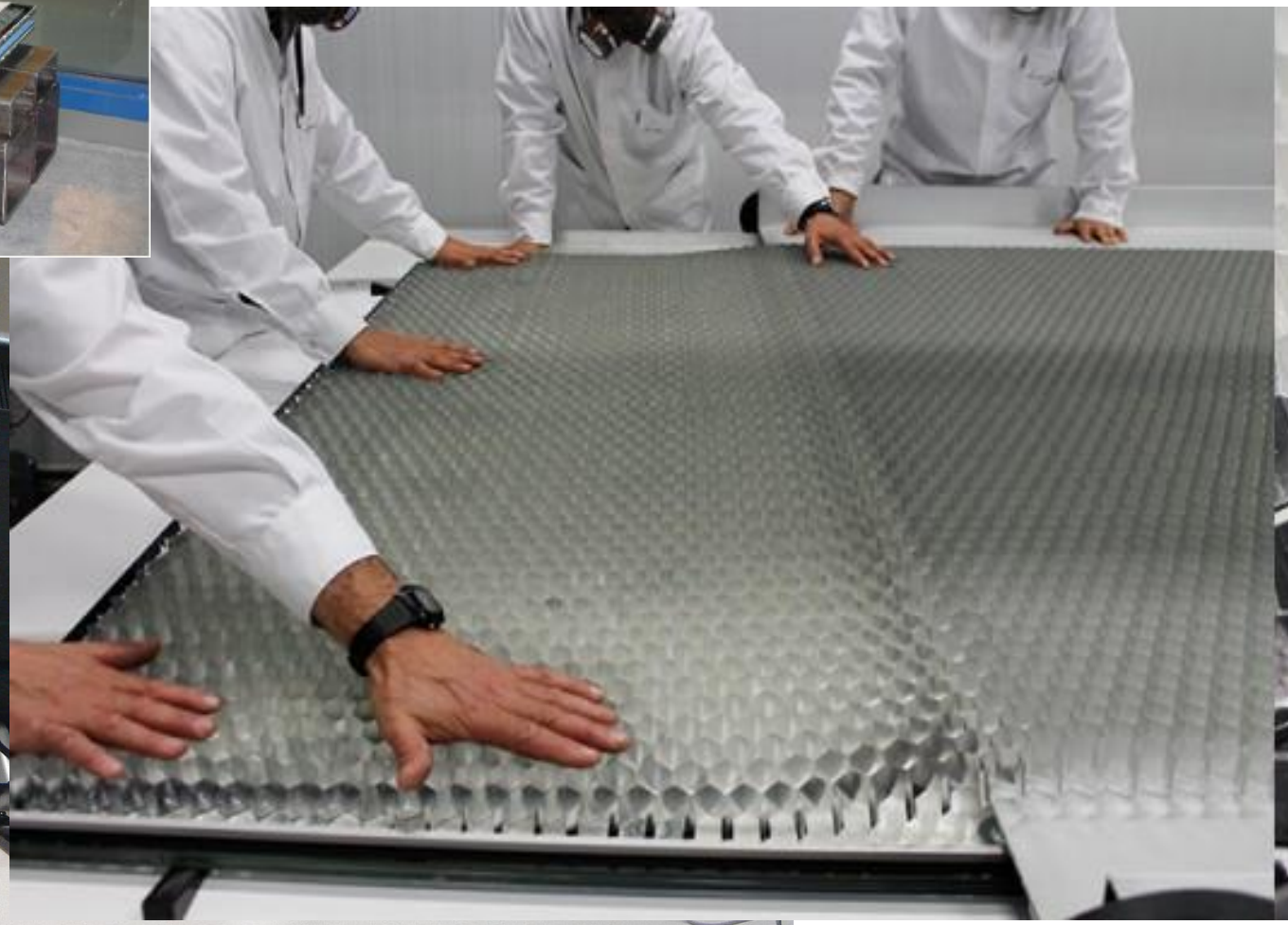
Honeycomb structure



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1mm thin glass ‘Leoflex’by AGC is strong and extremely light

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Multi-Color Glass 3D Printing

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New ideas creates the new business

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Source: www.gpd.fi © Timo Saukko, Finnglass

© Valtteri Hirvonen

© Kakslauttanen Arctic Resort

Summary of GPD – 2017, J. Vitkala

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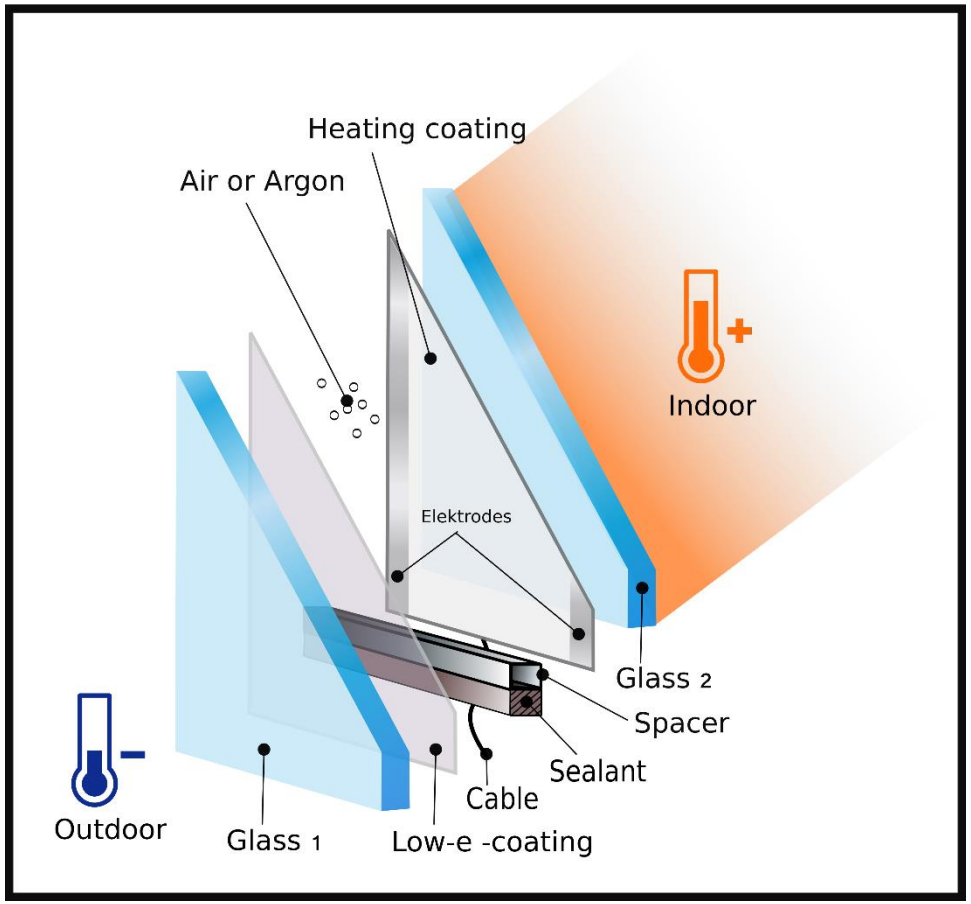
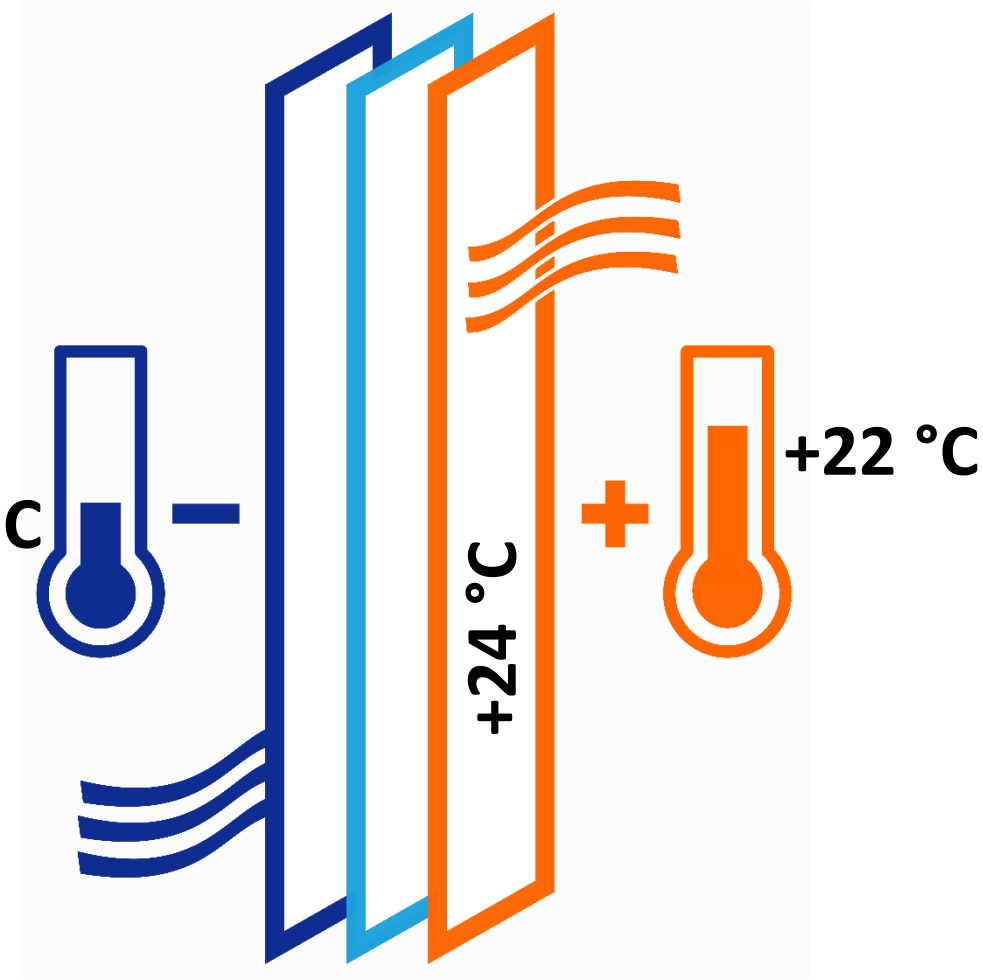


www.finnglass.com



Summary of GPD – 2017, J. Vitkala

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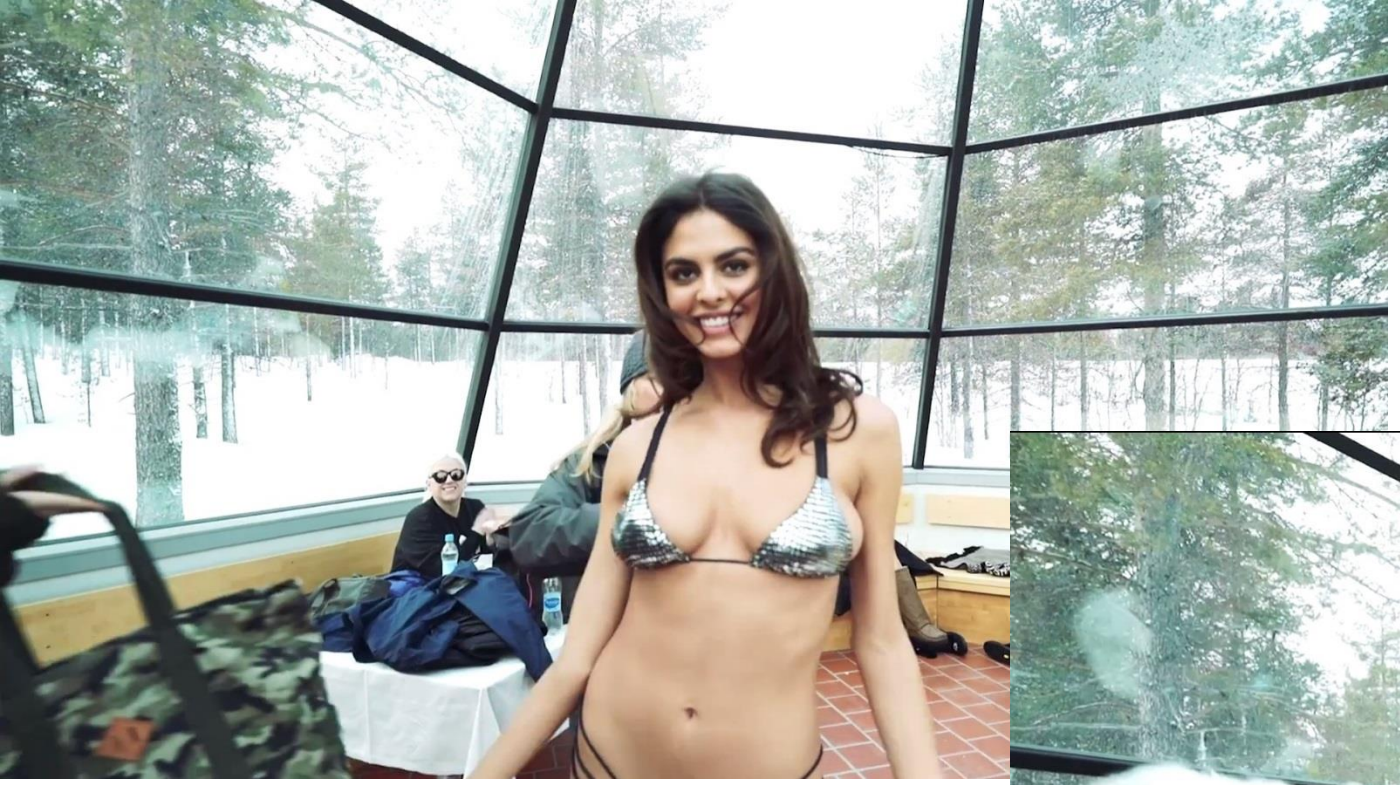

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Automotive Design Trends

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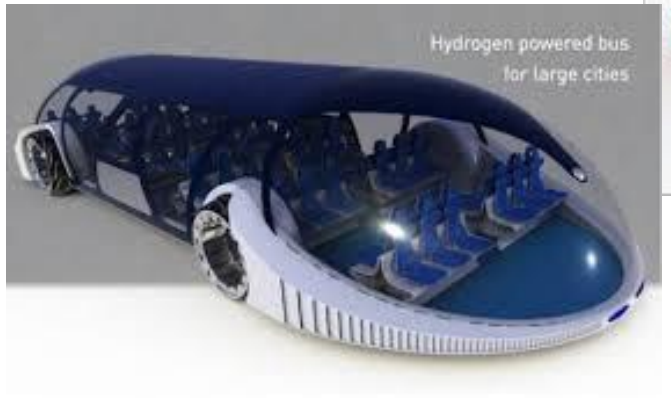
Future Buses



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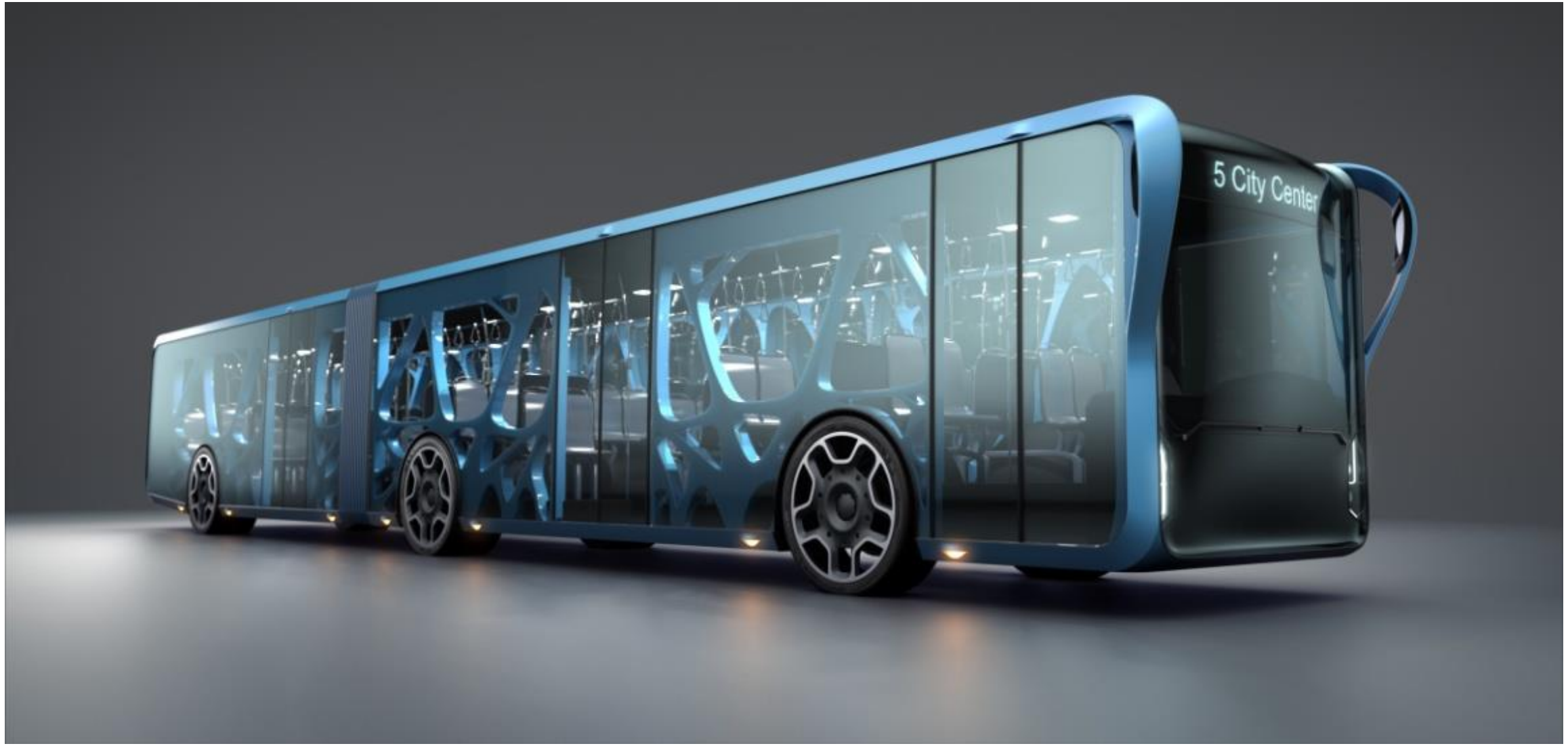
Future Buses

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Juha Artama, NSG Group

Opportunities



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Future Trucks

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Juha Artama, NSG Group

Future Trams

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Source: www.gpd.fi © Juha Artama, NSG Group

- **Projections and reflections**
  - CRT
  - Laser
  - VFD
  - OLED
  - etc.
- **Transparent displays?**

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Source: www.gpd.fi © Joe Pimenoff, Beneq

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IAA 2016. LED-display in glass

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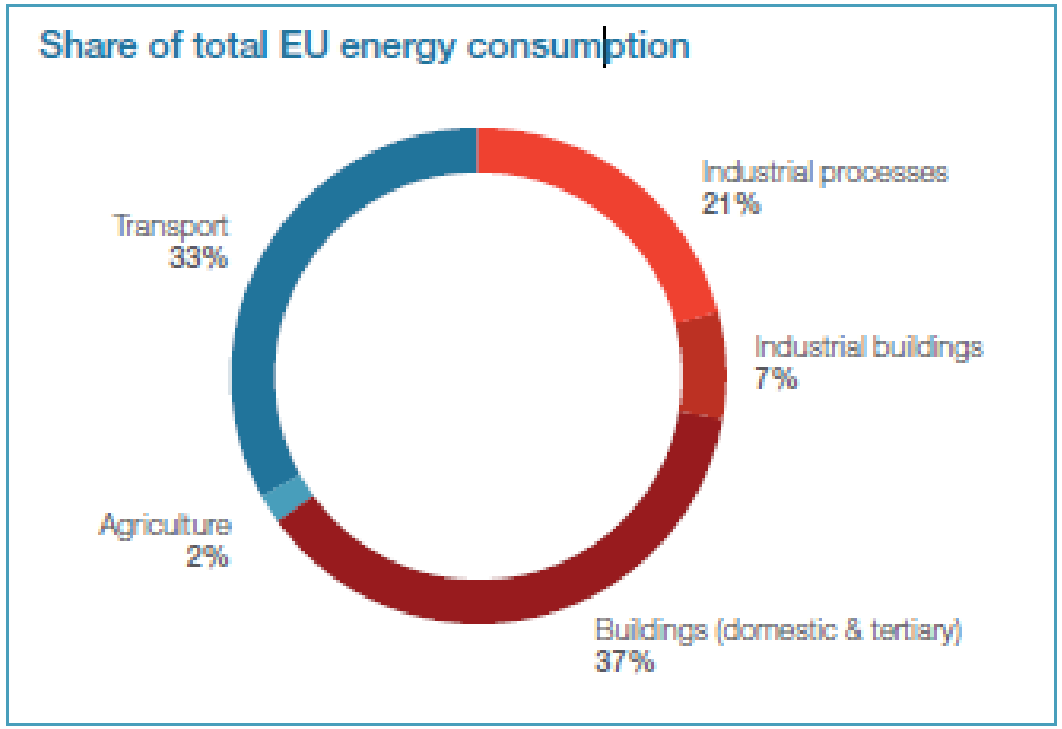
Worldwide Glass Energy Trends

Summary of GPD – 2017, J. Vitkala

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



Over 40% of EU energy consumption from buildings

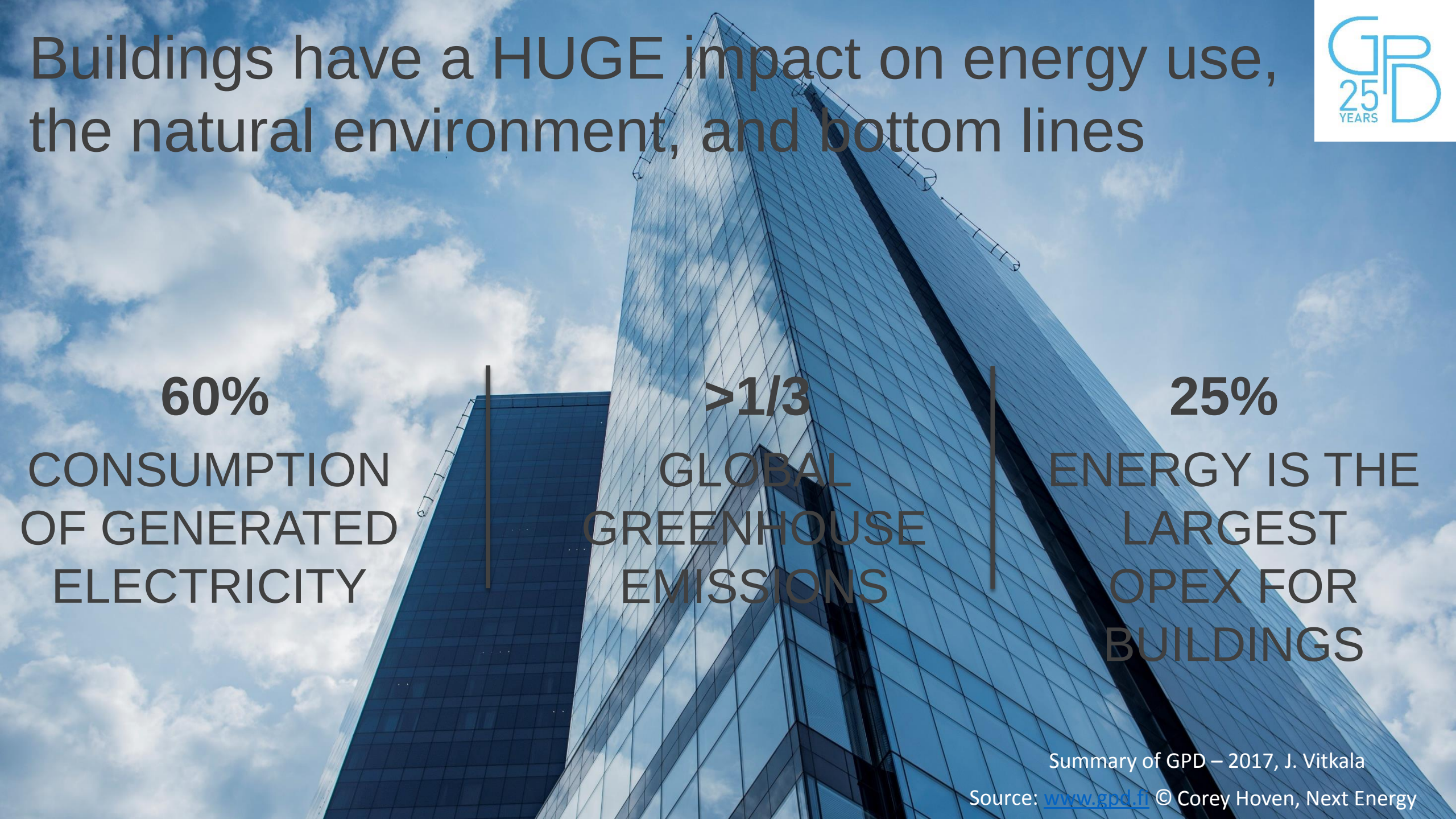
- European Union objective: energy savings target of 20% by 2020. New objective under discussion for 2030
- Windows considered responsible for 24% of the EU heating demand and 9% of the cooling demand
- Over 85% of glazed areas in EU buildings equipped either with single glazing or uncoated double glazing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

Source: www.gpd.fi © Corey Hoven, Next Energy

What is the Most Costly "Building Component"?

Occupancy Costs = 100 x Energy Cost

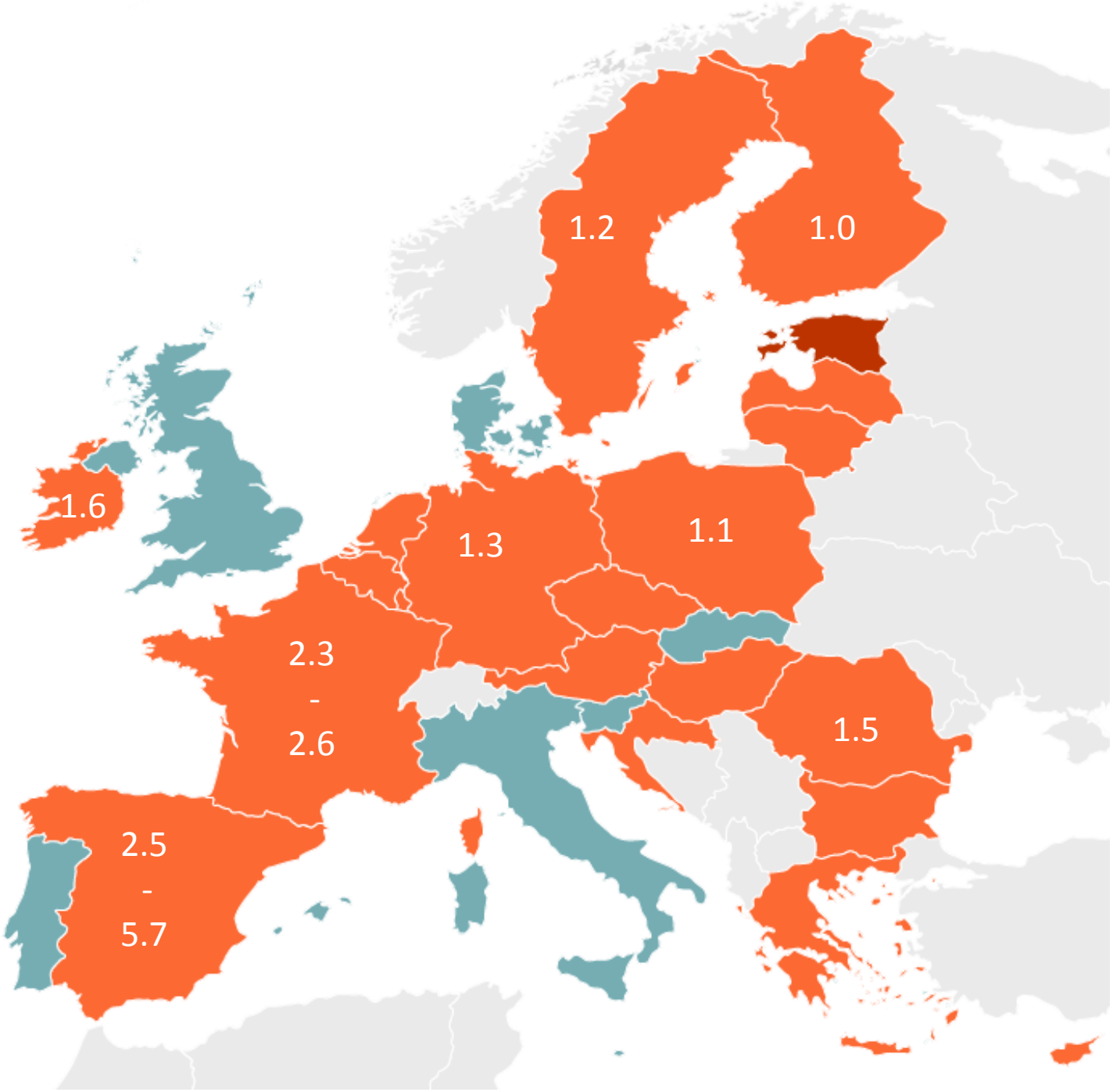
Smart Integrated Systems will Improve Satisfaction, Comfort and Productivity

Cost / Sq. M. Floor -Year

- Energy Cost: $40.00
- Rent: $400.00
- "Productivity" $4000.00+

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Stephen Selkowitz, LBNL



Dominant: Uw-value solely

Often, sub-optimal and lack of updates

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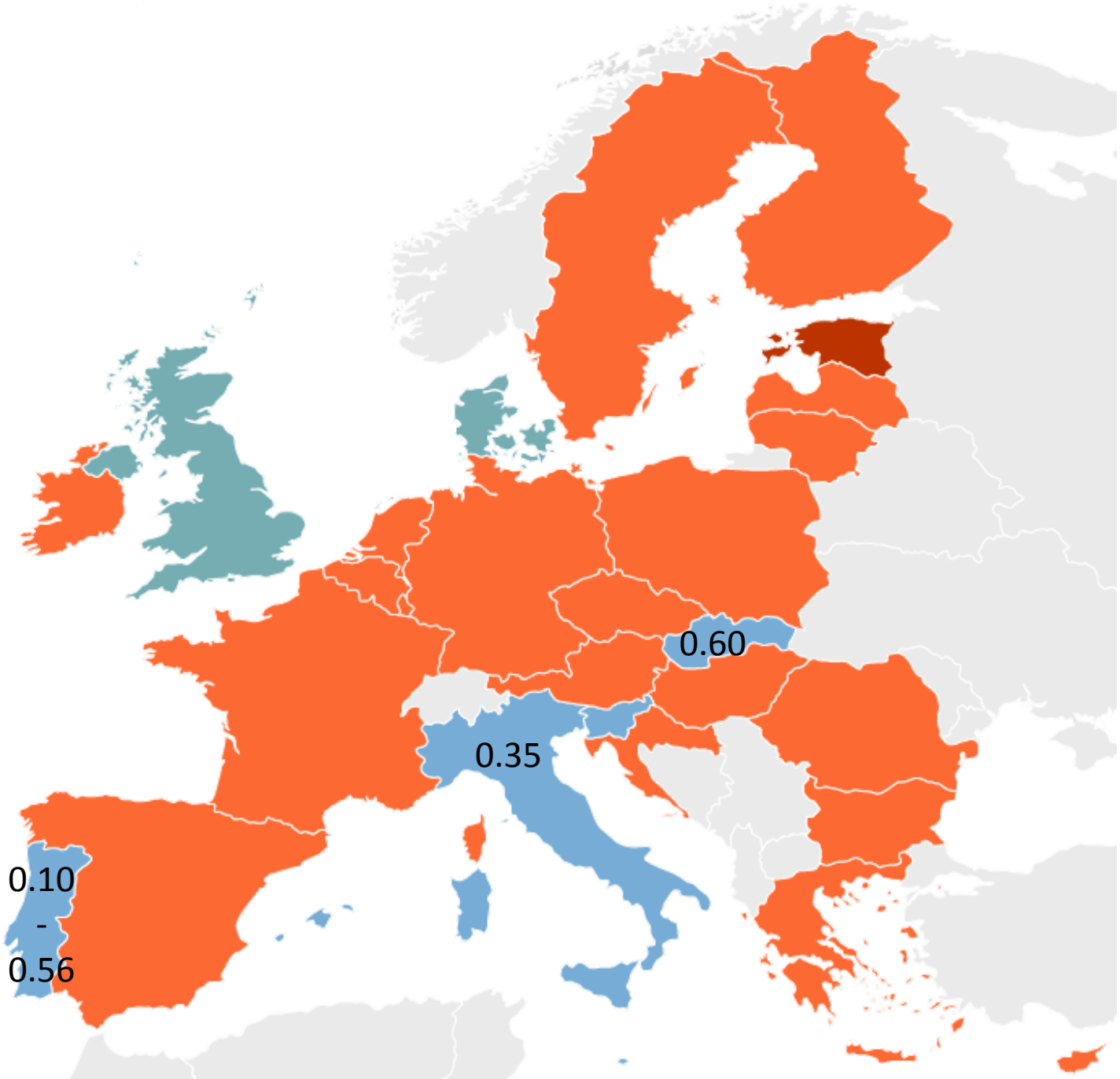

Separated g-value in 5 countries

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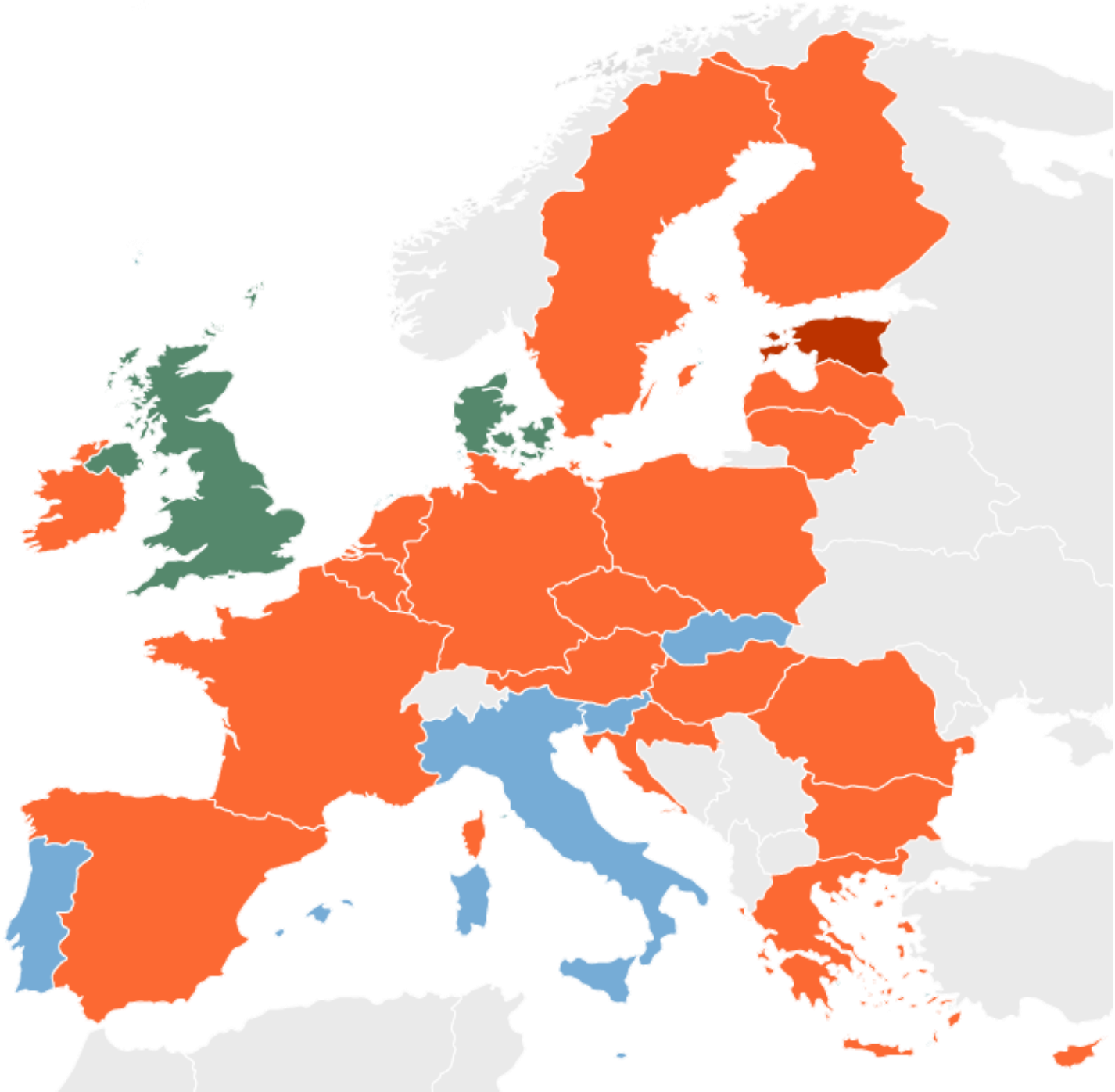
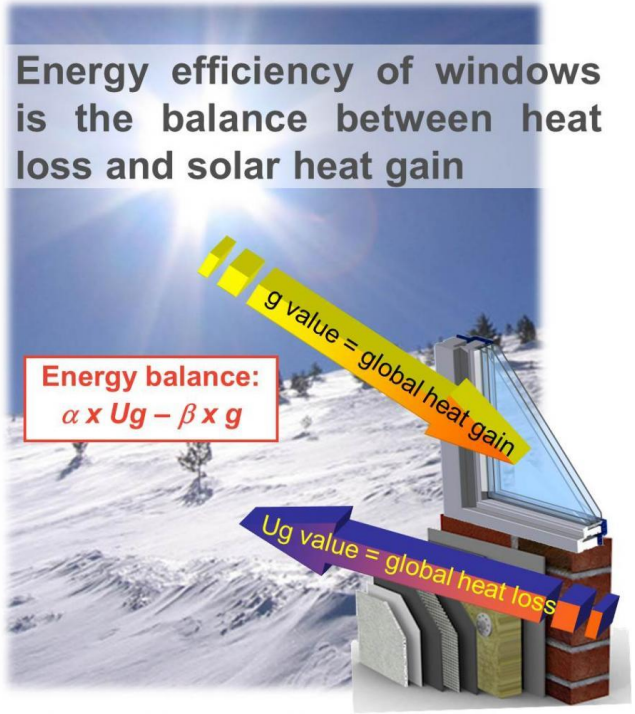


Energy balance in two countries



Summary of GPD – 2017, J. Vitkala

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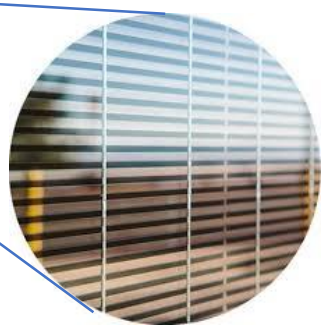
Smart Facades Convert Sunlight to Useful Energy

- **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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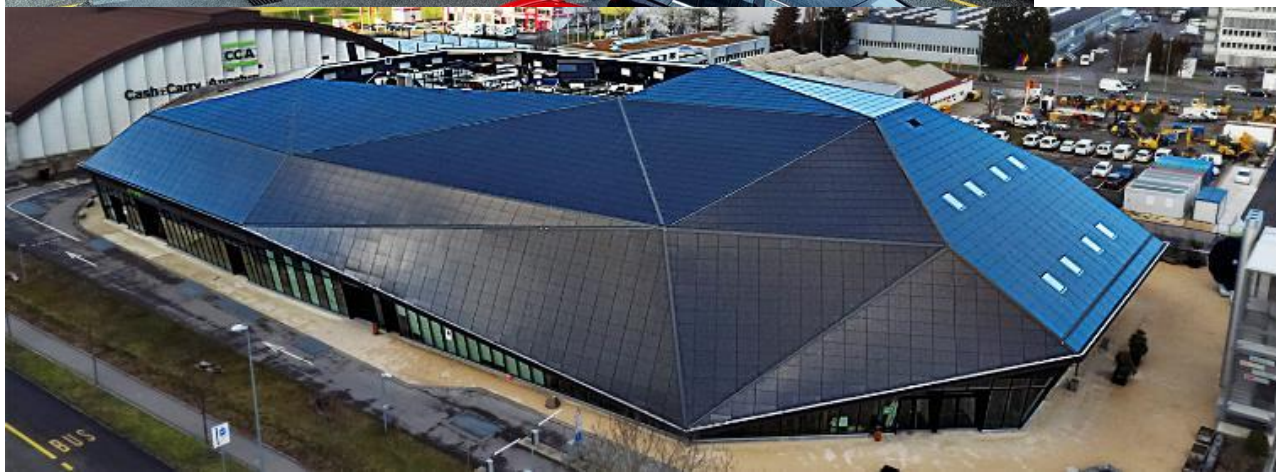

Summary of GPD – 2017, J. Vitkala

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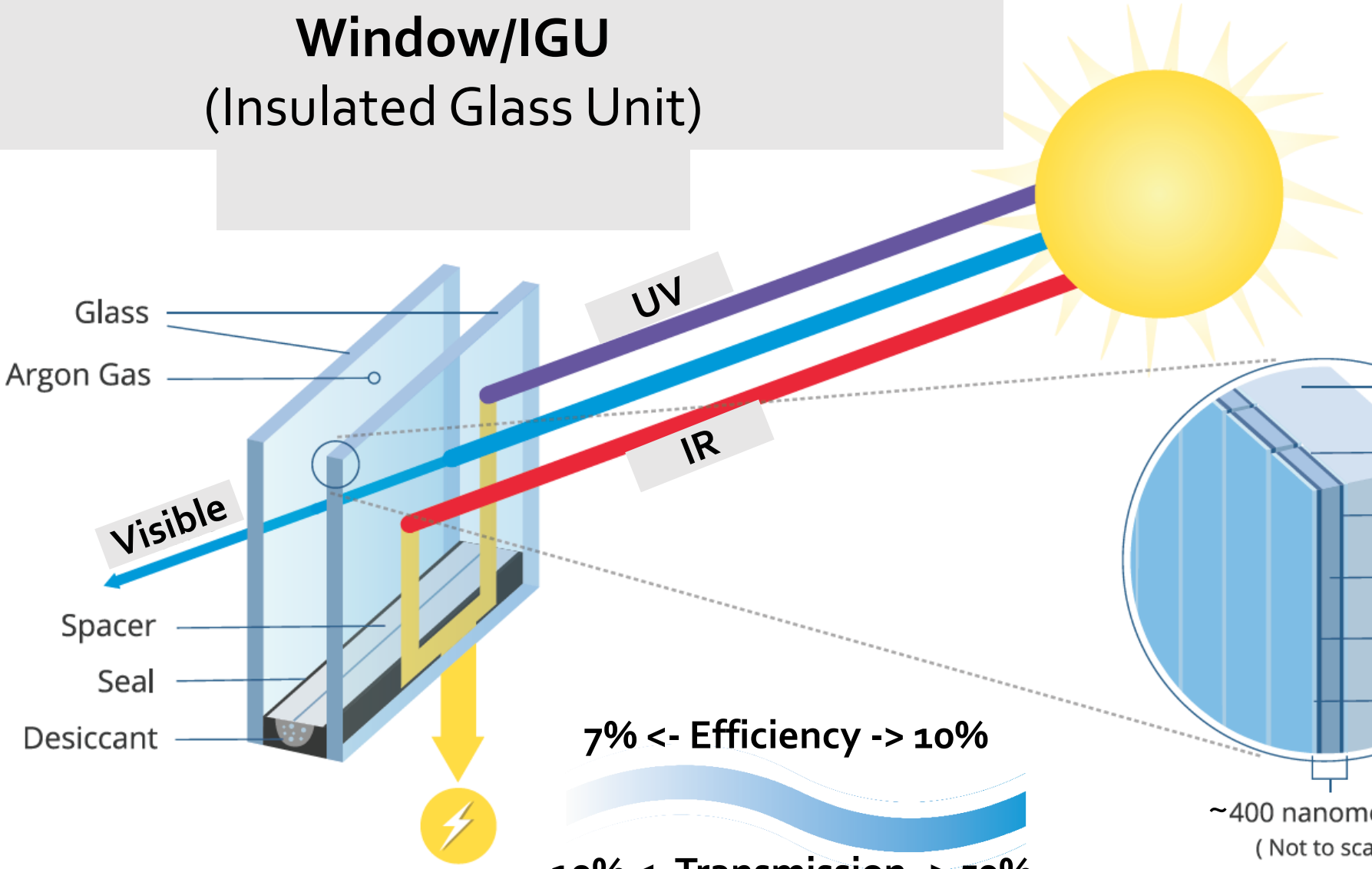
SSM-OPV technology transforms windows into energy producing assets

Window/IGU
(Insulated Glass Unit)

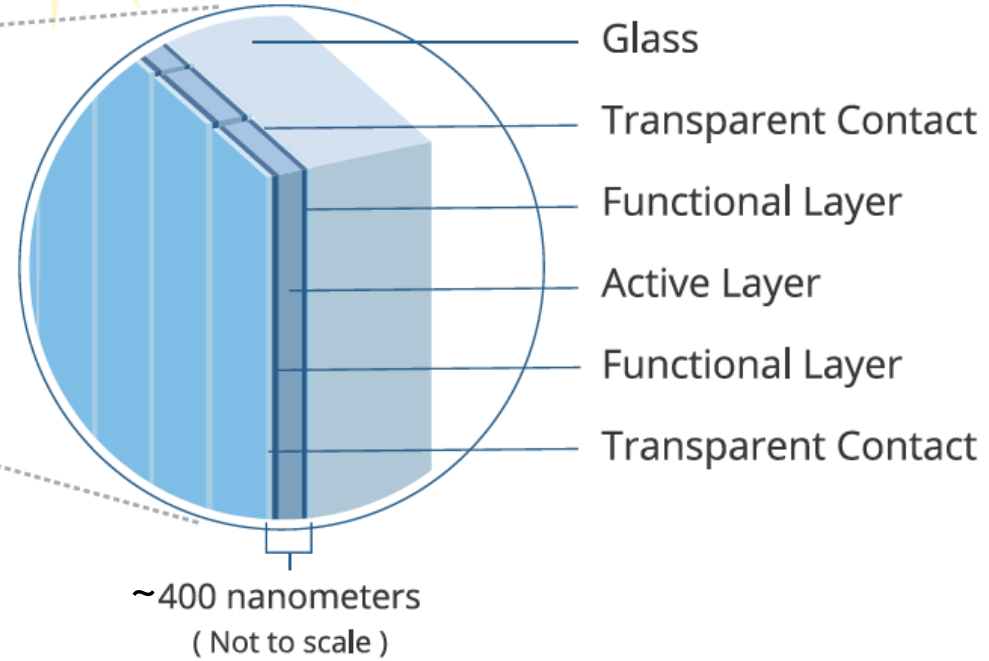
Coatings are printed directly on glass, eliminating encapsulation costs



7% <- Efficiency -> 10%

10% <- Transmission -> 50%

Detail of Coatings
(inside IGU)



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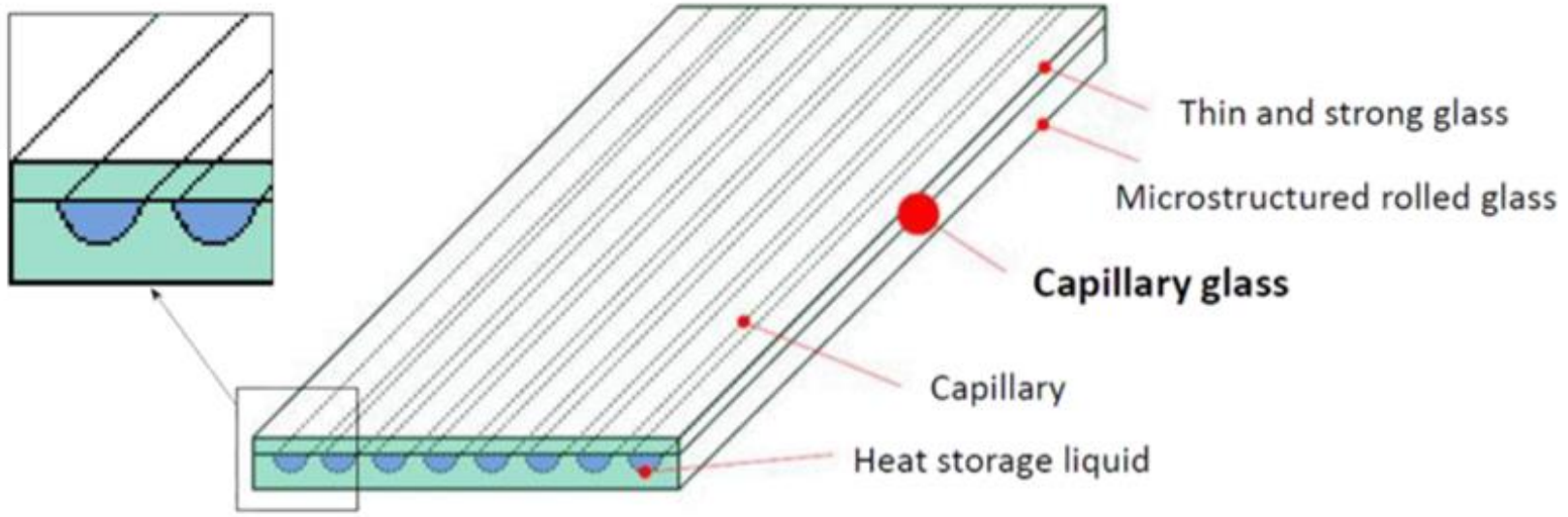
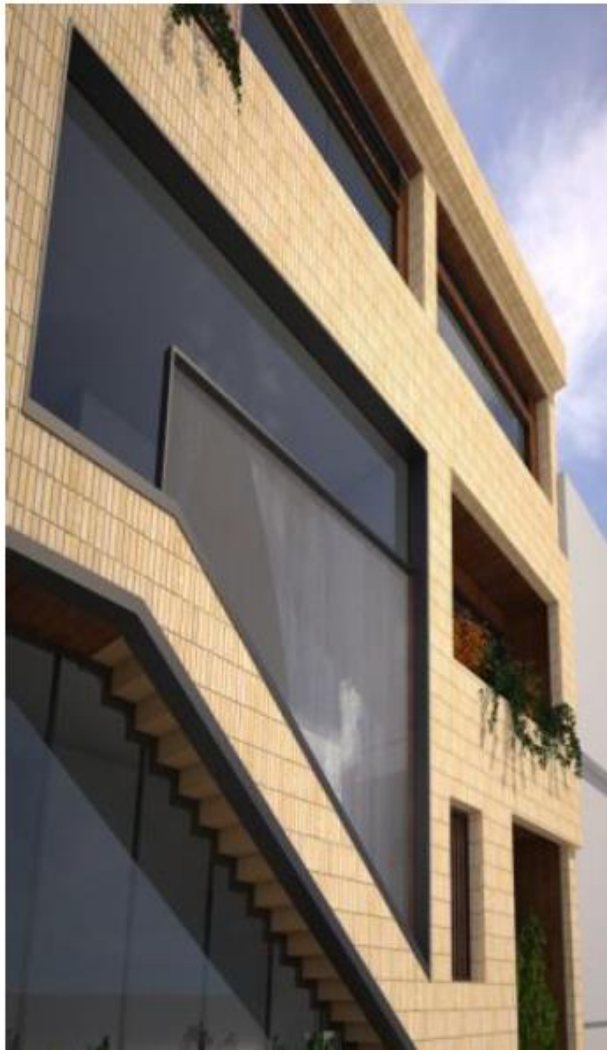
LaWin: The concept





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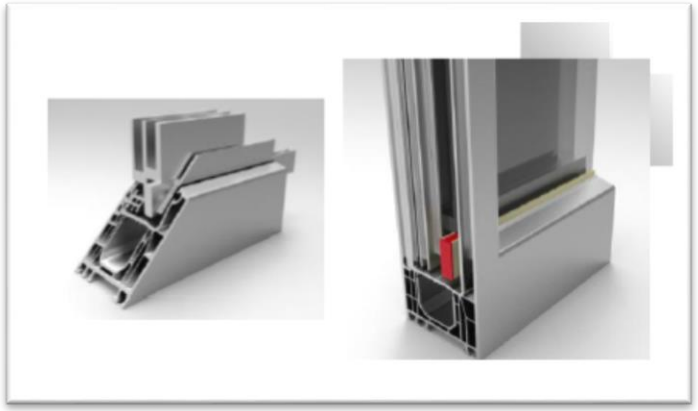
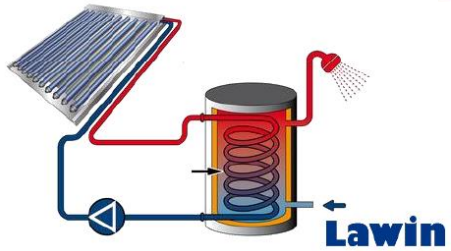
LaWin: Application possibilities

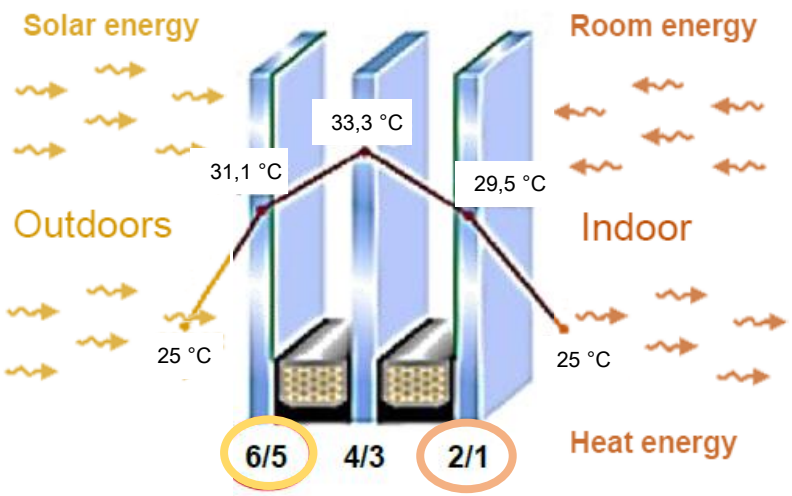
outdoor



→ function as a heat exchanger
to collect natural energy

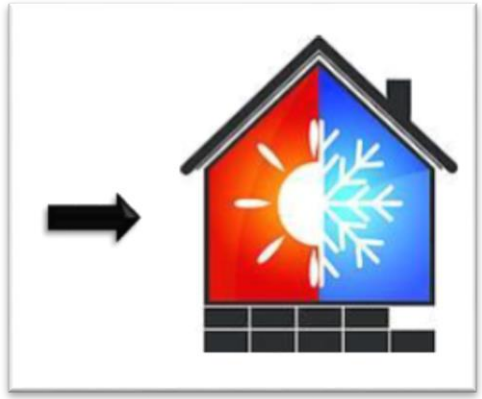


3-fold insulated glass



Position for
Lawin glas

indoor



Heating and cooling system

→ function as a heat exchanger
for heat pumps for heating and cooling

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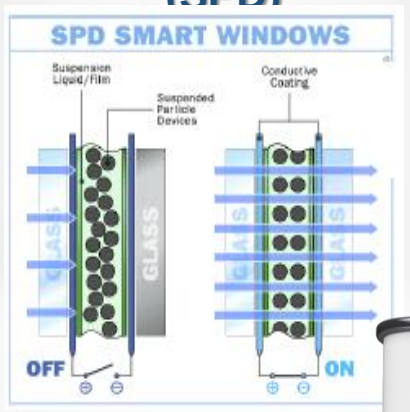
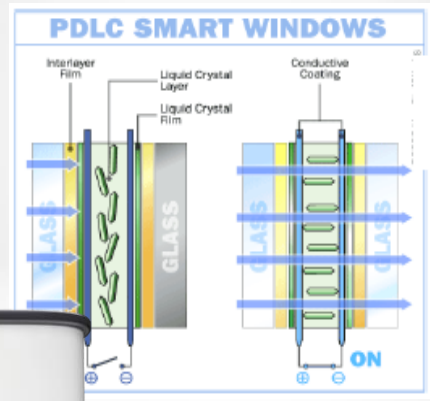
Smart Window Technologies

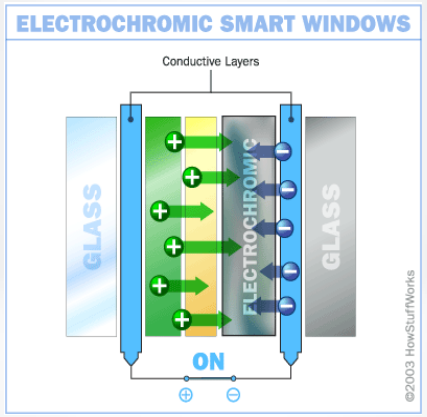
Suspended Particle Device (SPD)



Liquid-Crystal (LC)

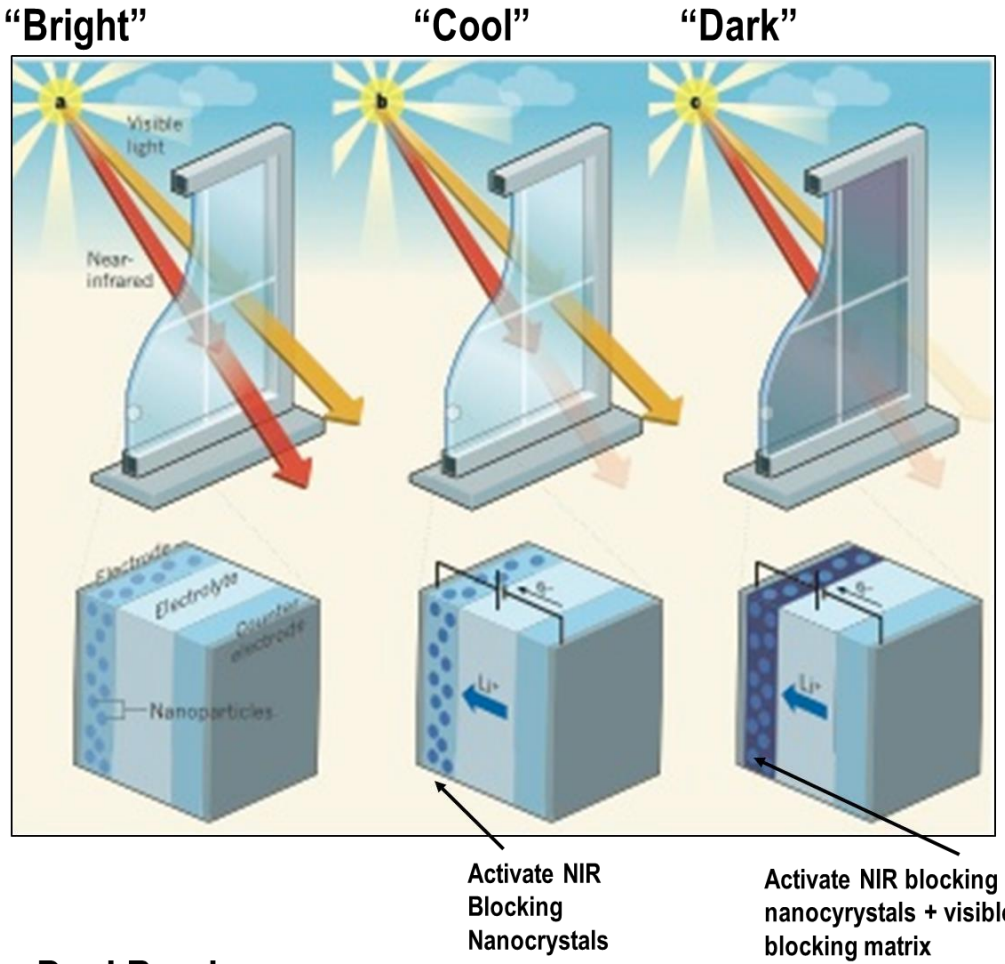


Electrochromie (EC)



Summary of GPD – 2015, J.Vitkala
Source: www.gpd.fi © Damoder Reddy, Argil, Inc

NanoEC™ Dual Band Electrochromic SPU



Bright Mode

Cool Mode

Dark Mode

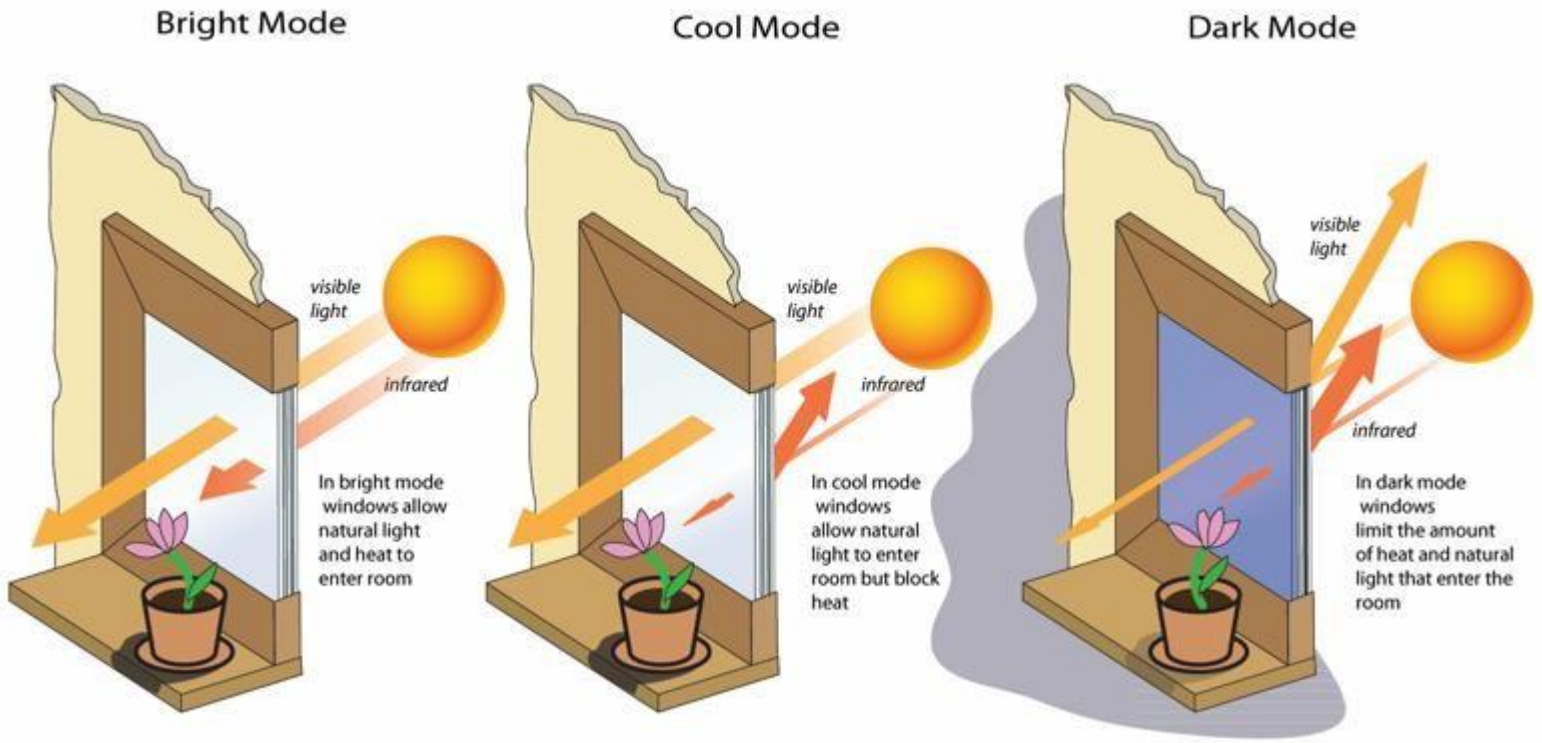
- Dual Band
  - Bright: Transmit both visible and near infrared
  - Cool: Transmit visible but block near infrared
  - Dark: Block both visible and near infrared

Power consumption insignificant < 1W/m^2

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Amir Bayati, Helitrope Tech Inc.

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

Source: www.gpd.fi © Amir Bayati, Helitrope Tech Inc.

- Possible switching patterns | display performance

View from inside

Photos: ILEK

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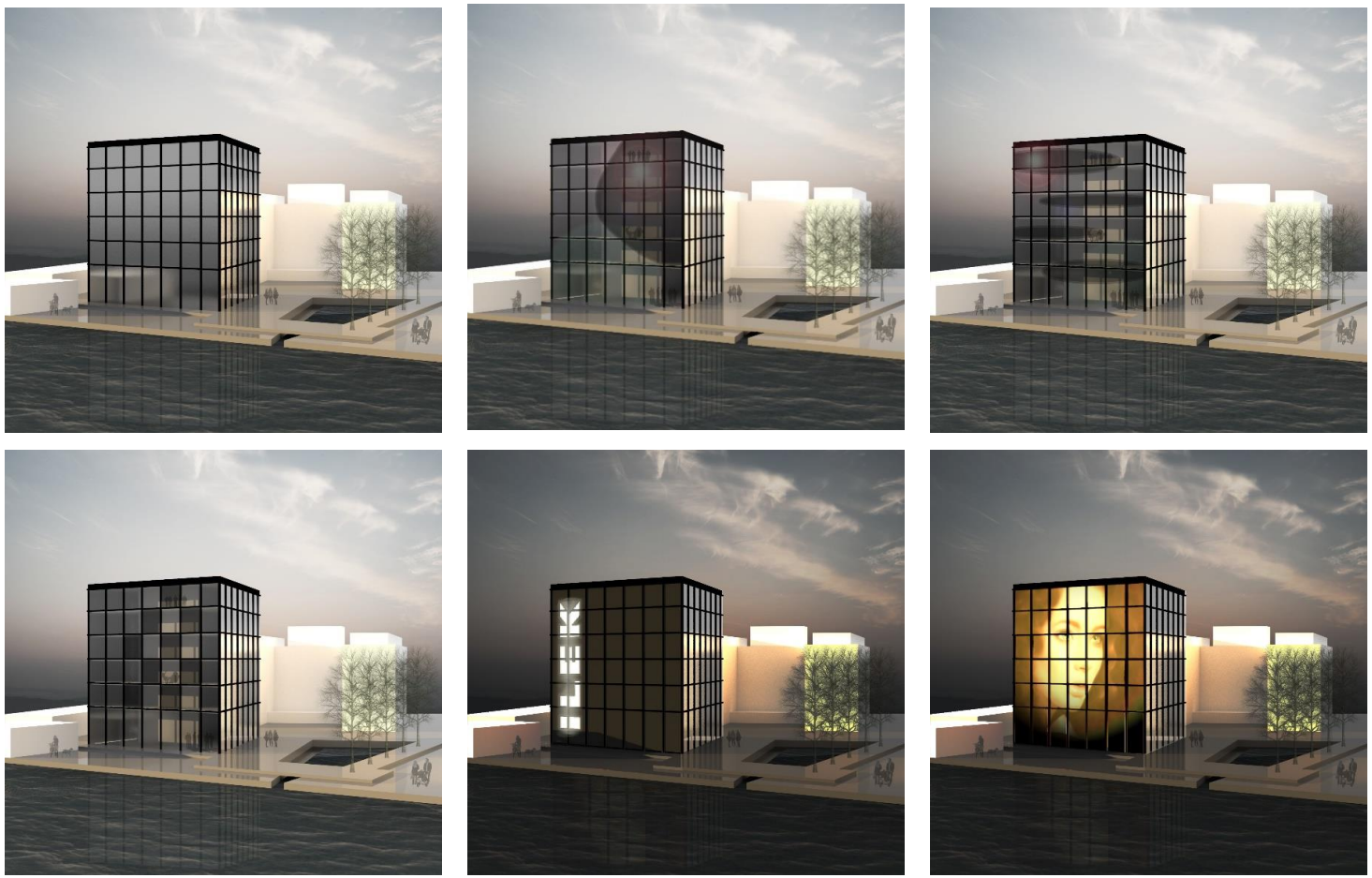
Source: www.gpd.fi © Walter Haase, Uni. Of Stuttgart

- Future vision



Rendering: ILEK

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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."

[View]

Electrochromic

[SAGE]

Liquid Crystal

[Merck]

Thermochromic

[Raven WIndow]

Thermotropic

[Solardim Eco]

Photochromic

[Suntuitive]

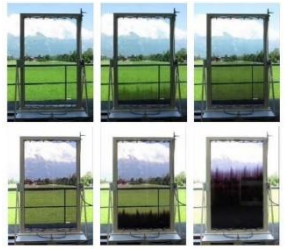
Photo – volta - chromic

[R&D]

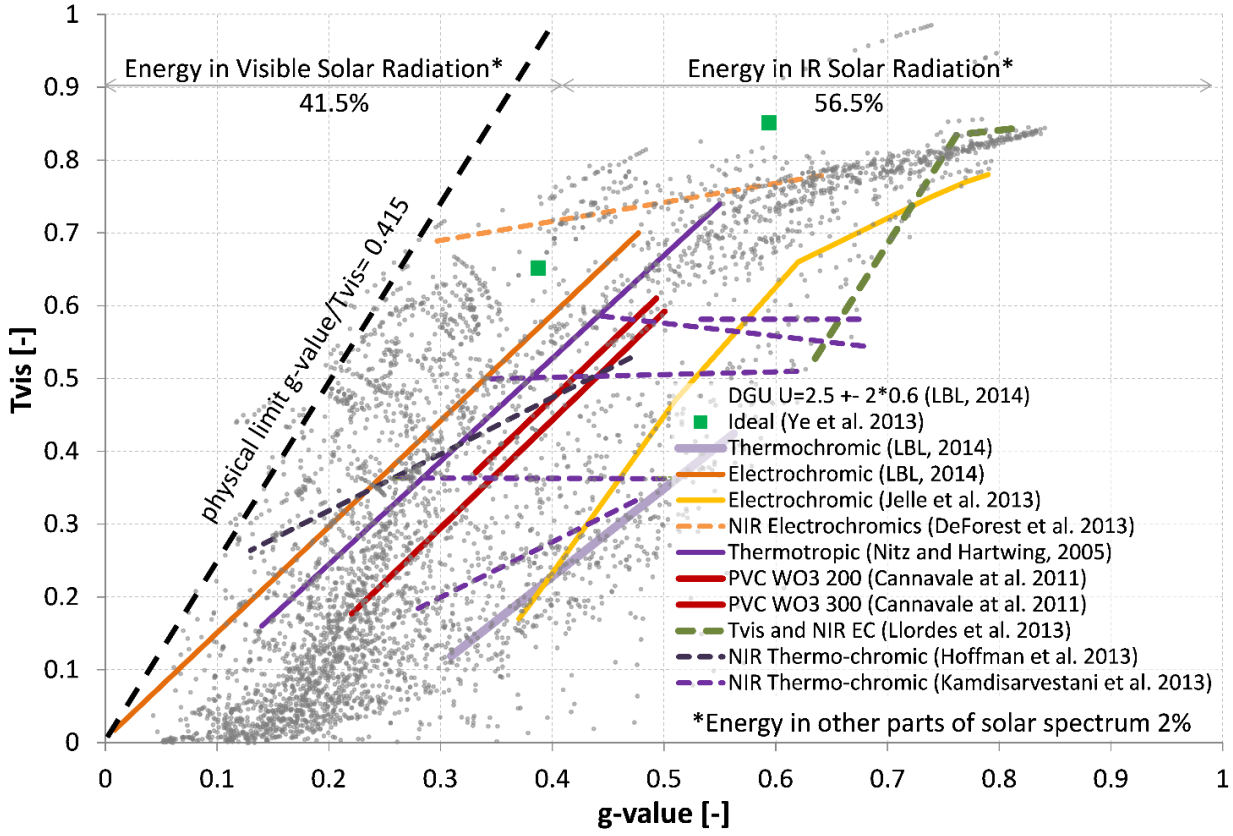
NIR & Tvis – EC

[R&D]

Fluidglass



[R&Dt]



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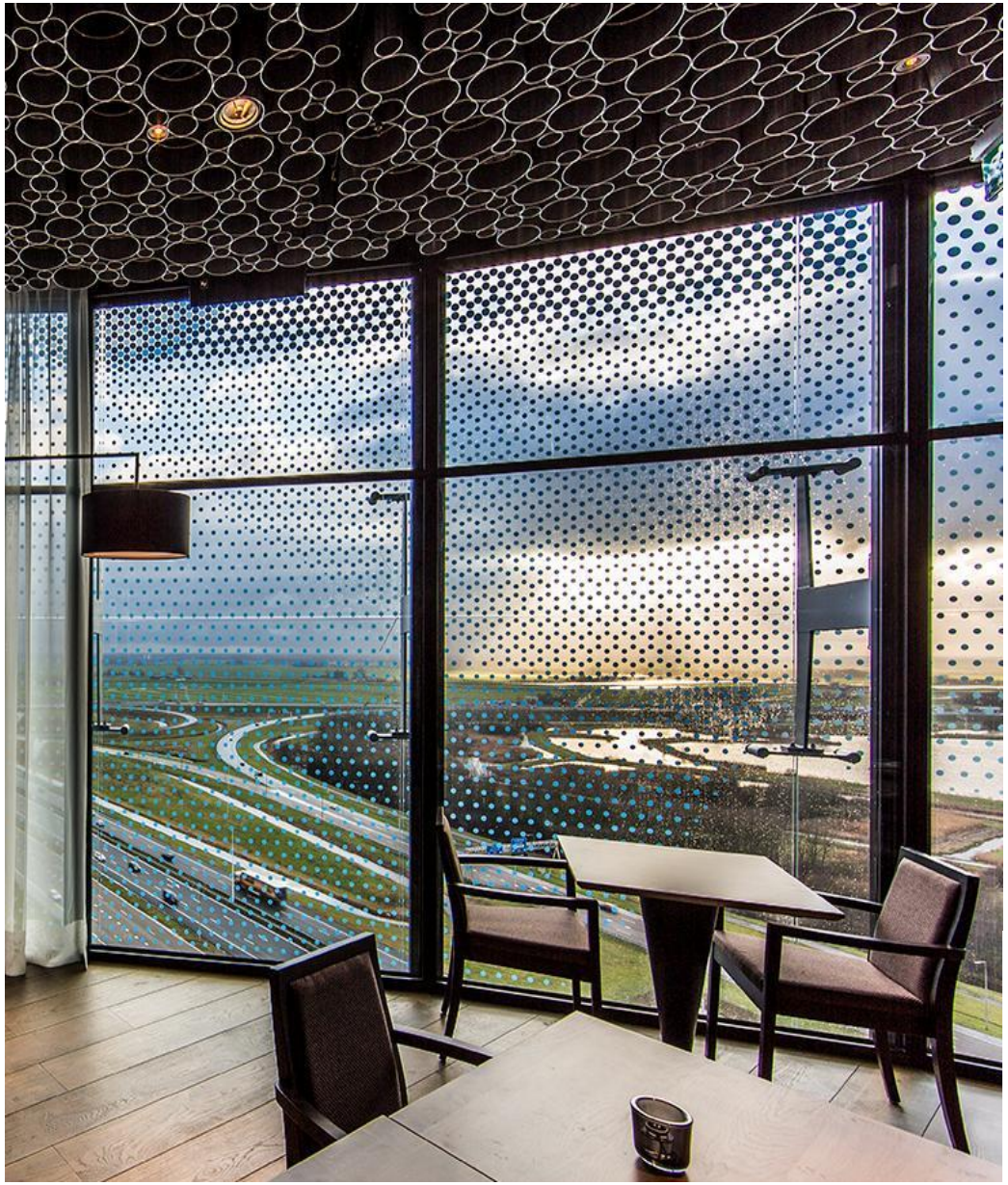

Characteristic exterior and interior view

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Dutchess County Residence

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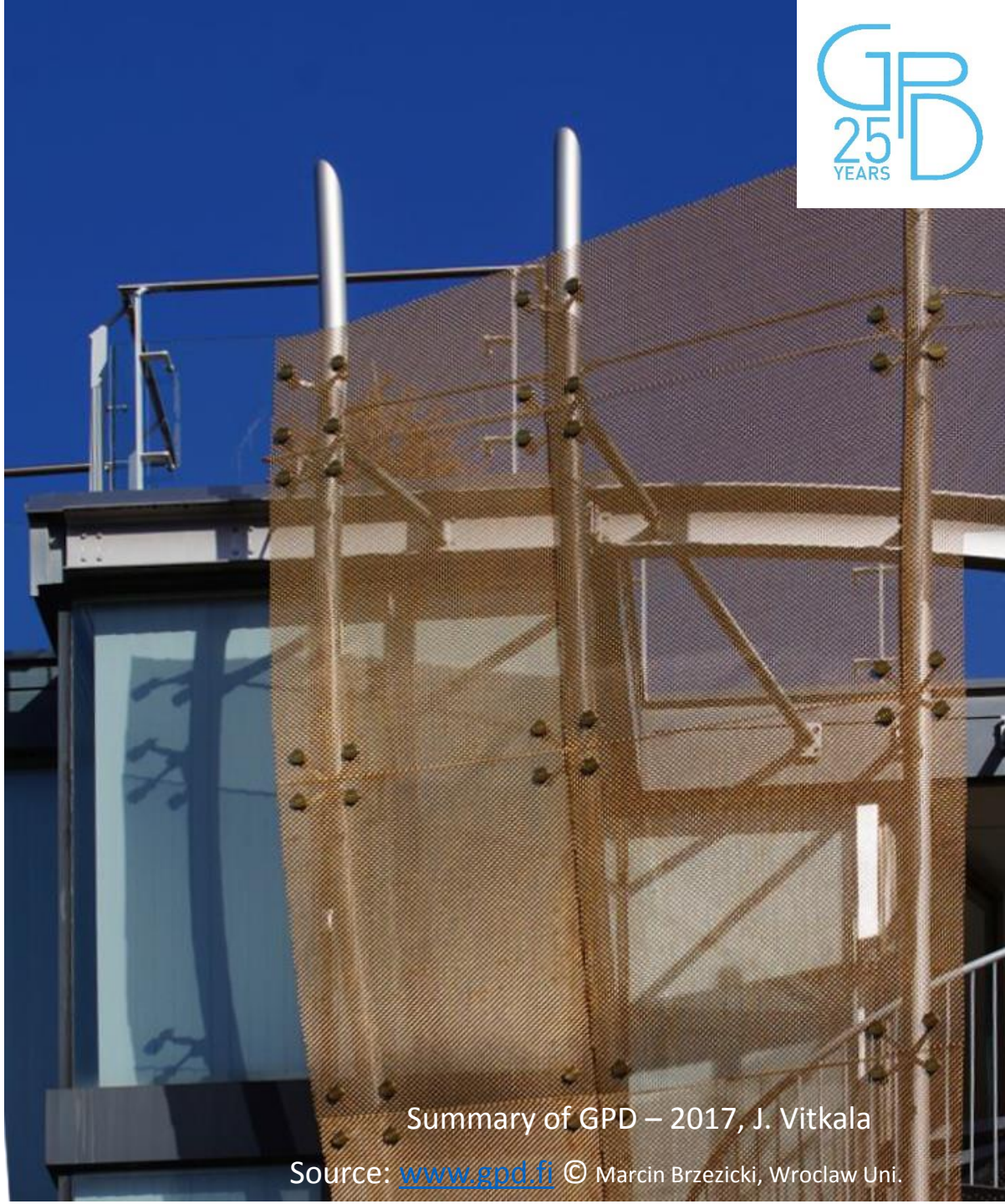

Summary of GPD – 2017, J. Vitkala

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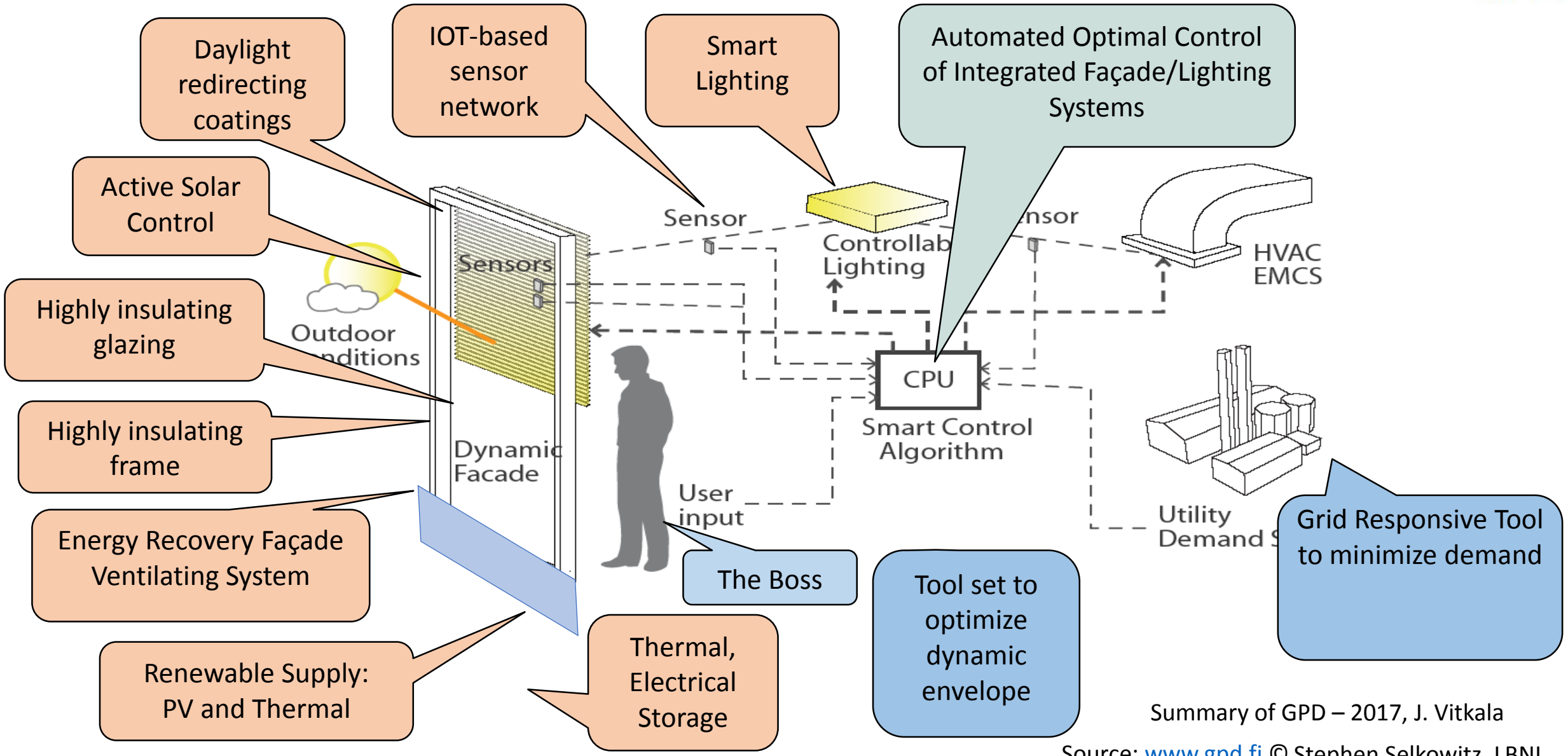
Facades are intrinsically “integrated systems” –

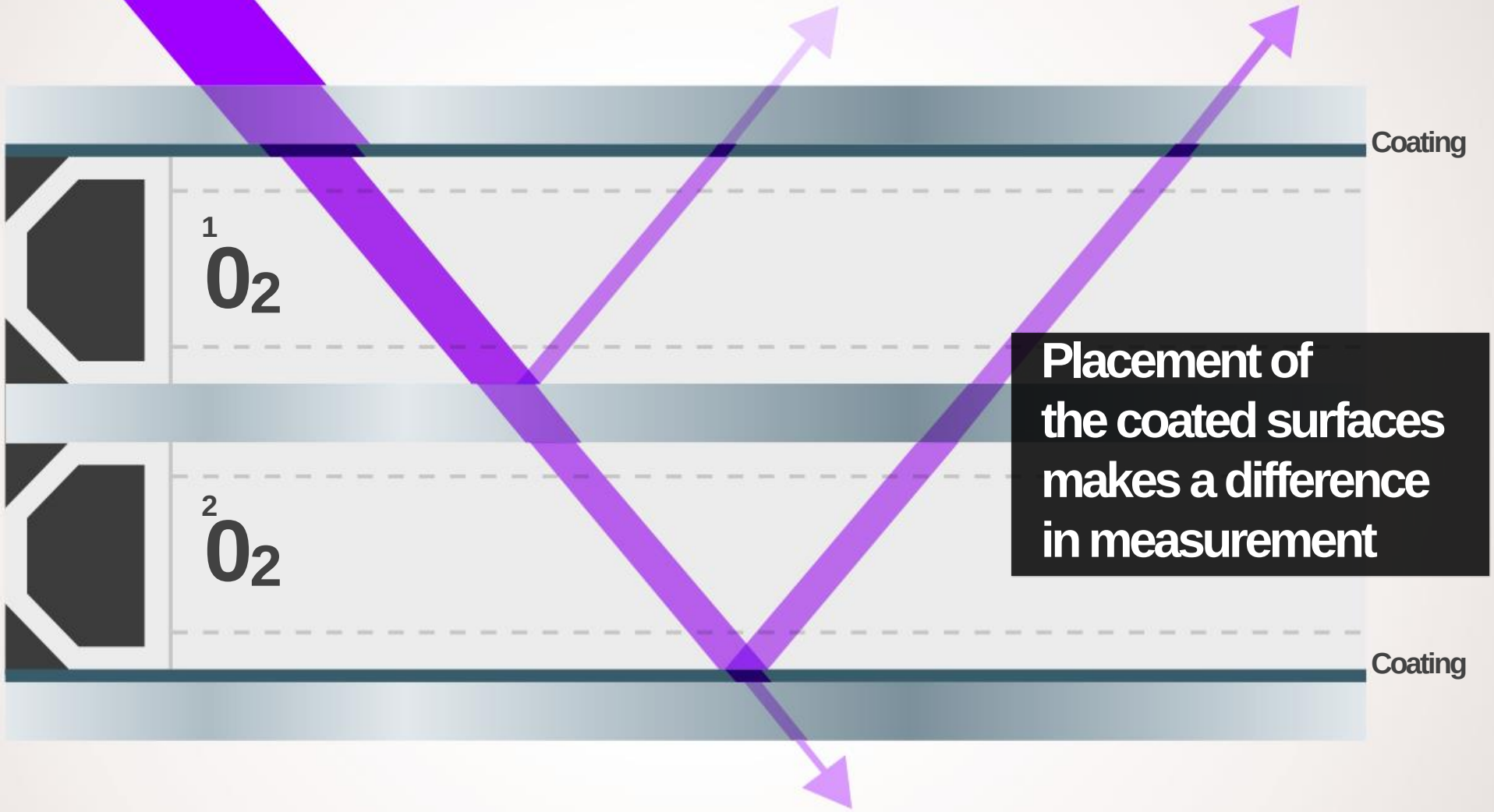
managing light, glare, solar gain, heat transfer, ventilation, power generation, energy storage,



Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Stephen Selkowitz, LBNL

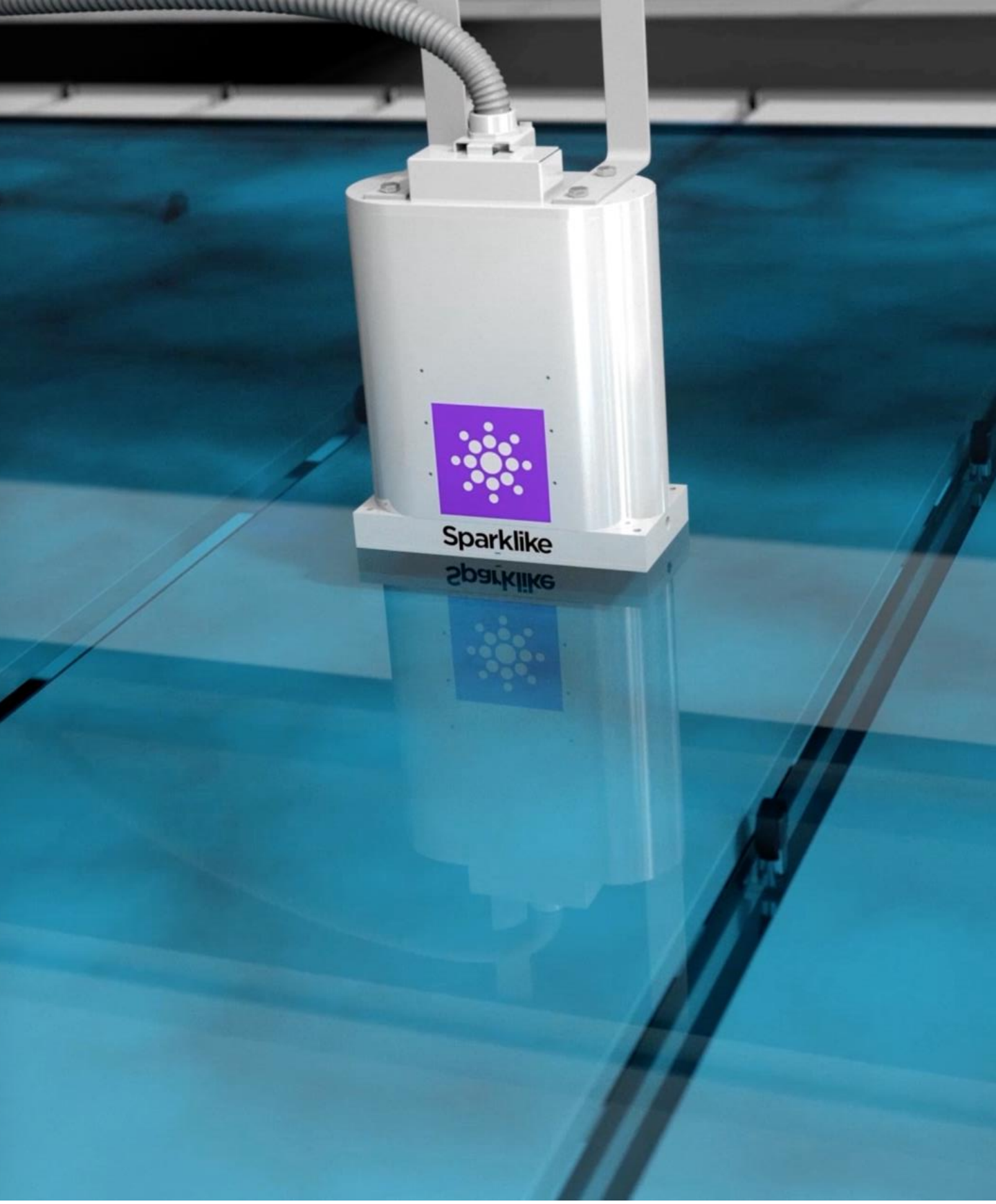
Measuring gas concentration without breaking the IGU – even on triples



Placement of the coated surfaces makes a difference in measurement

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Miikkael Niemi, Sparklike



Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Miikkael Niemi, Sparklike

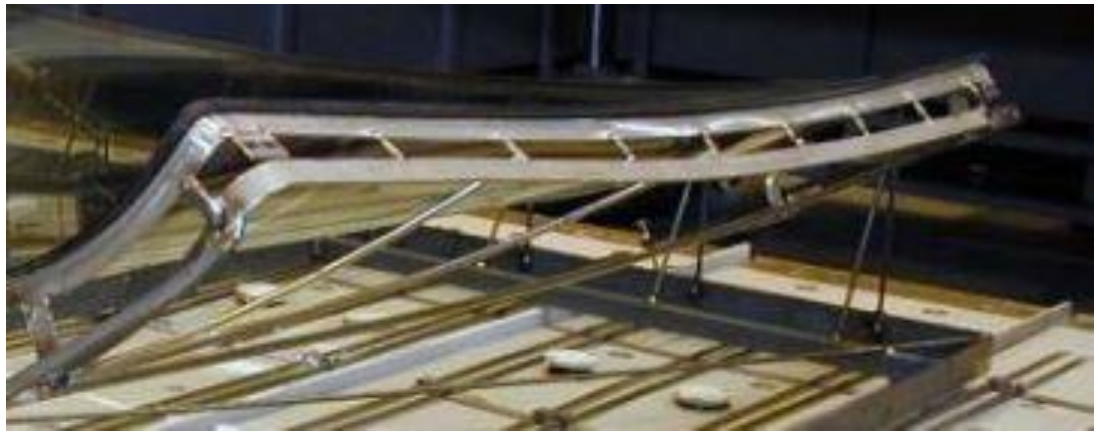
Mold

- Traditional vs. Light, optimized mold
- 48 kg vs. 18 kg

$$dE=mcdT$$

$30kg*500J/(kgK)*500°C/3,6*10^{6=}$

2,08 kWh

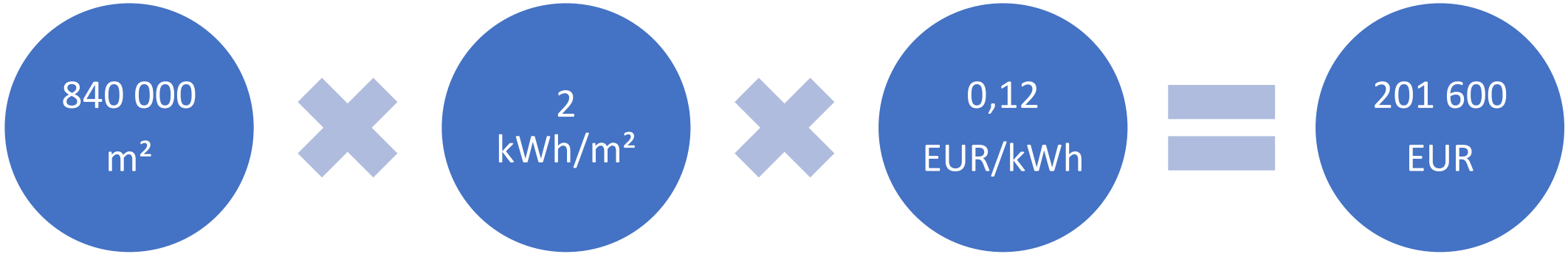


Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Juha Karisola, Glaston Oy

Why do we speak about energy saving? How much you could actually save?

- Annual production 700 000 windscreens
- Average size 1,2 m²/ windscreen
- Annual output 840 000 m²
- Energy price 0,12 EUR/kWh
- Energy consumption of an old type of furnace 9 kWh/m²
- Matrix™ energy consumption 7 kWh/m² → saving 2 kWh/m²



Potential saving 10 year's of operation over 2 million euros!

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Source: www.gpd.fi © Juha Karisola, Glaston Oy

Practical energy consumption of different types of equipment

Box type

(Bus WS furnace)

12-25 kWh/m²

Single level furnace (U-type)

9-13 kWh/m²

Basic double level furnace

6,5 – 10 kWh/m²

Matrix

Smart double level furnace

5,3 – 8,7 kWh/m²

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Structual Glass Applications

Summary of GPD – 2017, J. Vitkala

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Tim Macfarlane, GL&SS

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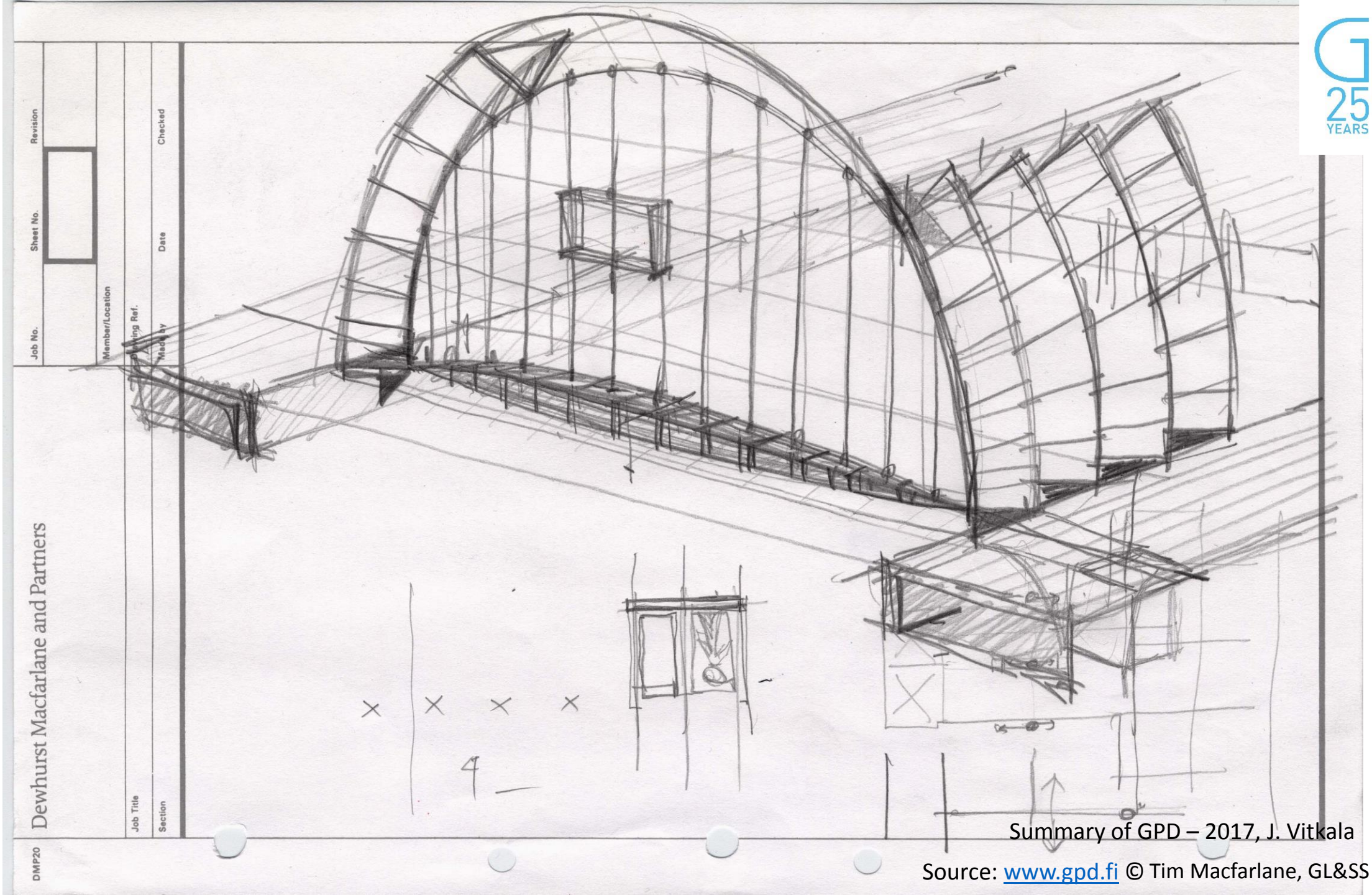
Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Tim Macfarlane, GL&SS



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Source: www.gpd.fi © Tim Macfarlane, GL&SS

Loadbearing Glass Walls

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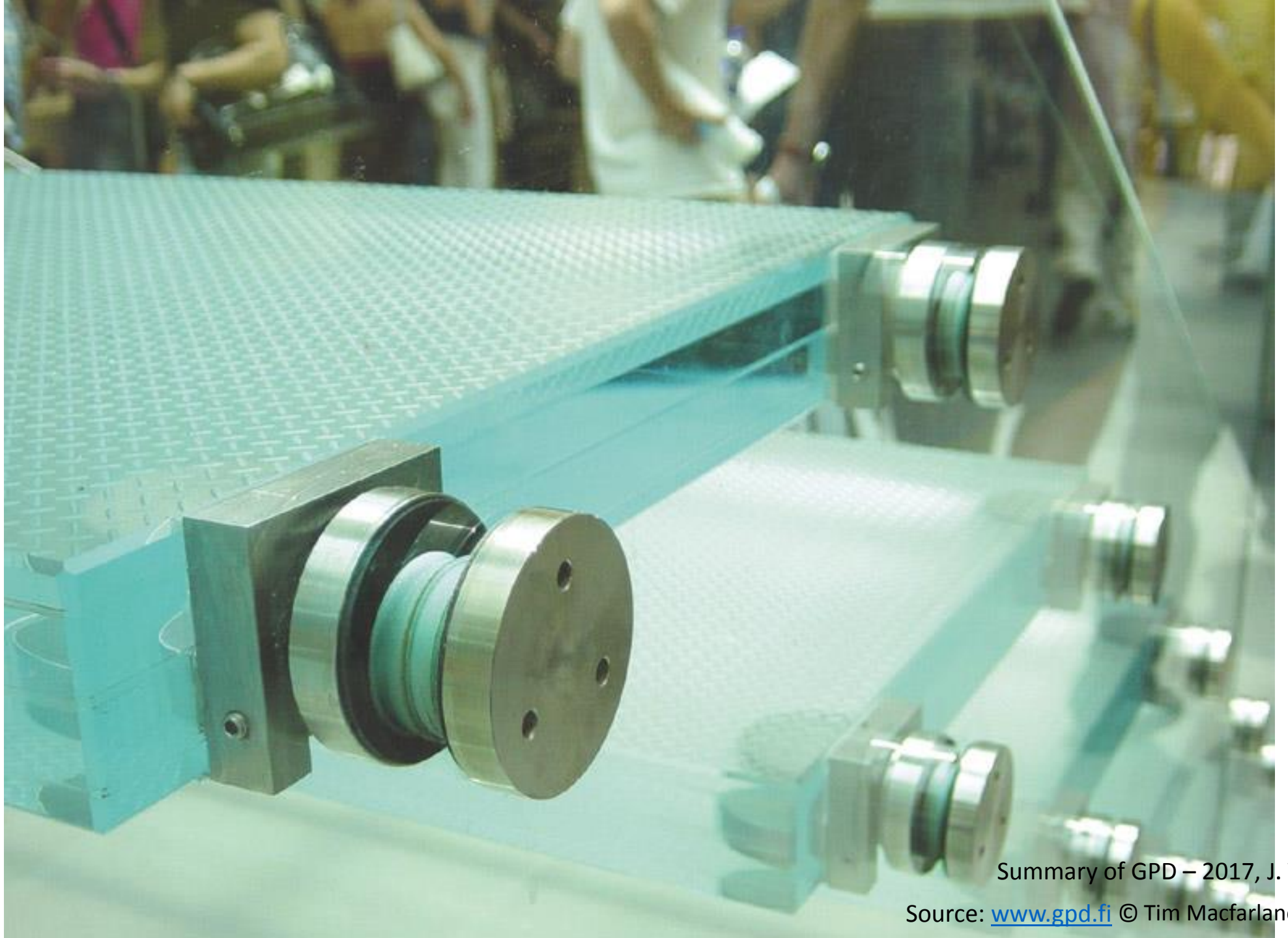
Summary of GPD – 2015, J.Vitkala
Source: www.gpd.fi ©James Ocallaghan, Eckersley O'Callaghan



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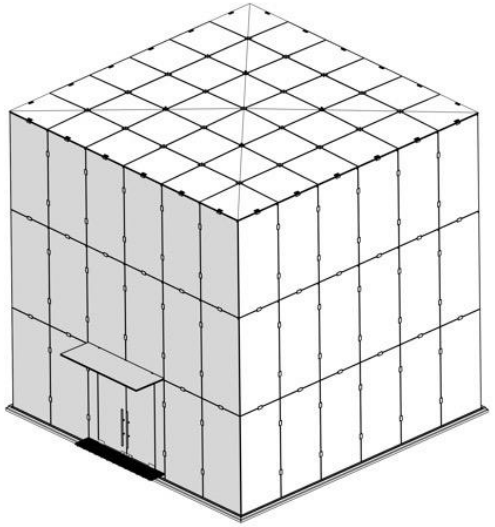
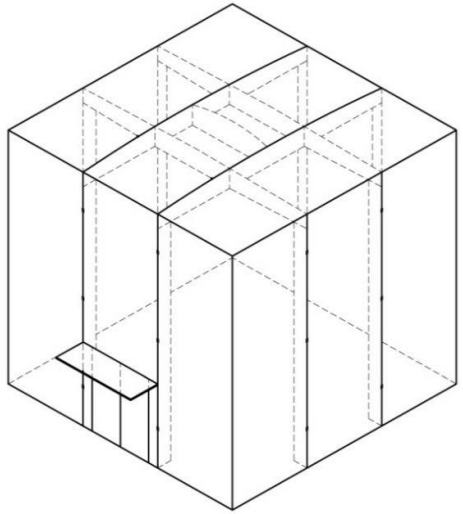
Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Tim Macfarlane, GL&SS

2006



2011



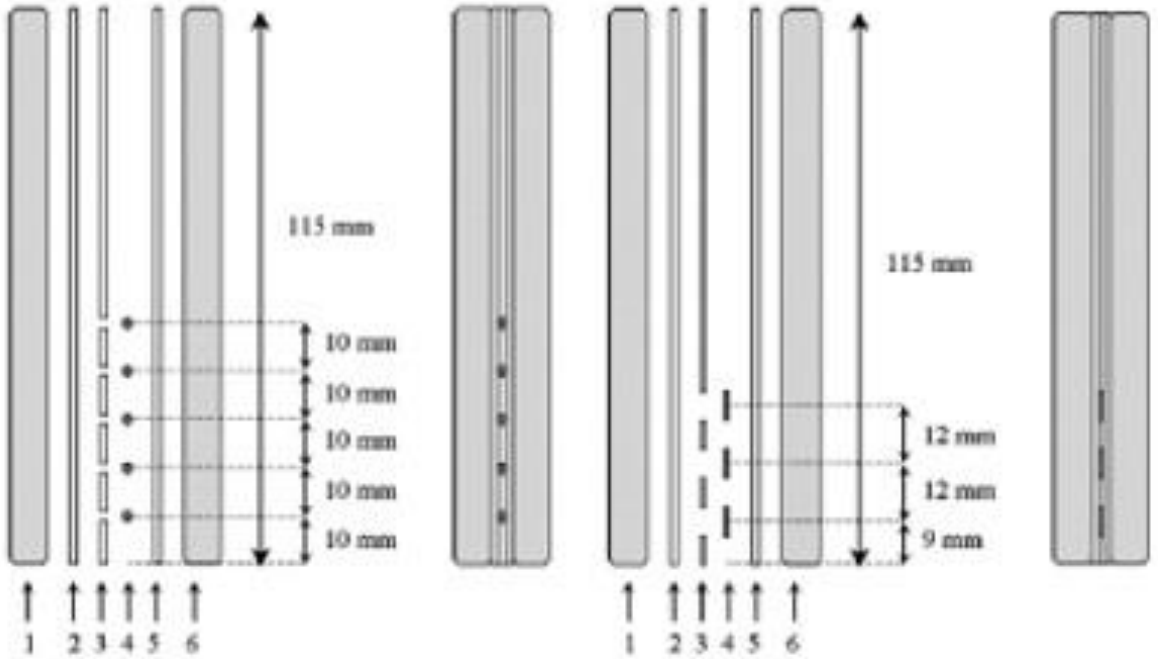
Summary of GPD – 2015, J.Vitkala
Source: www.gpd.fi ©James Ocallaghan, Eckersley O'Callaghan

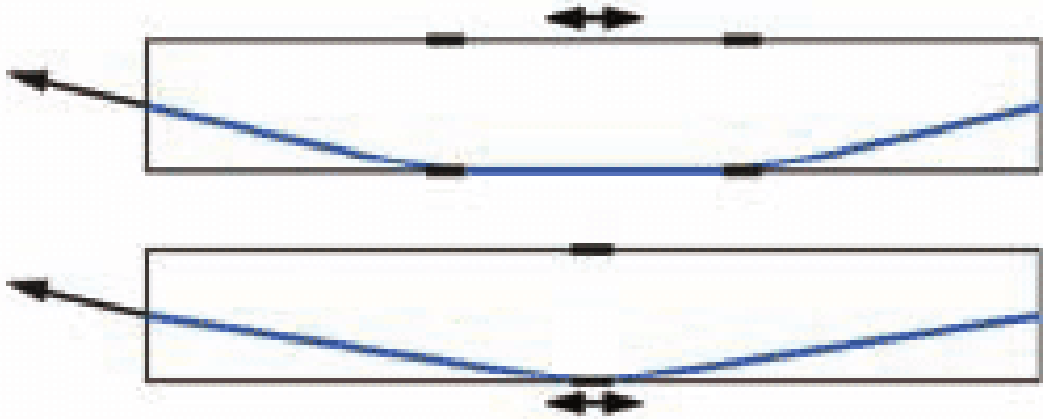
Summary of GPD – 2015, J.Vitkala
Source: www.gpd.fi ©James Ocallaghan, Eckersley O'Callaghan

Large glass needs special handling equipment - Tvitec Spain

Summary of GPD – 2015, J.Vitkala
Source: www.gpd.fi ©Tvitec

Current research - Hybrid glass beams





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EVOLUTION OF DESIGN AND GEOMETRY

Calculation hypothesis

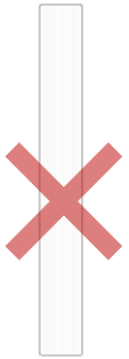
Analytic & F.E.M calculation

Physical test And results

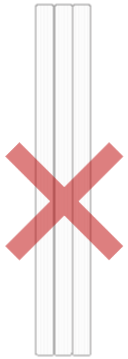
Post-breakage analysis

Conclusions & Future research

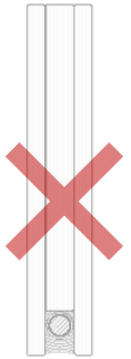
Glass beam evolution



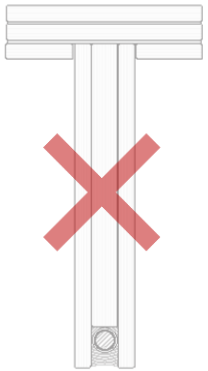
MONOLYTHIC BEAM



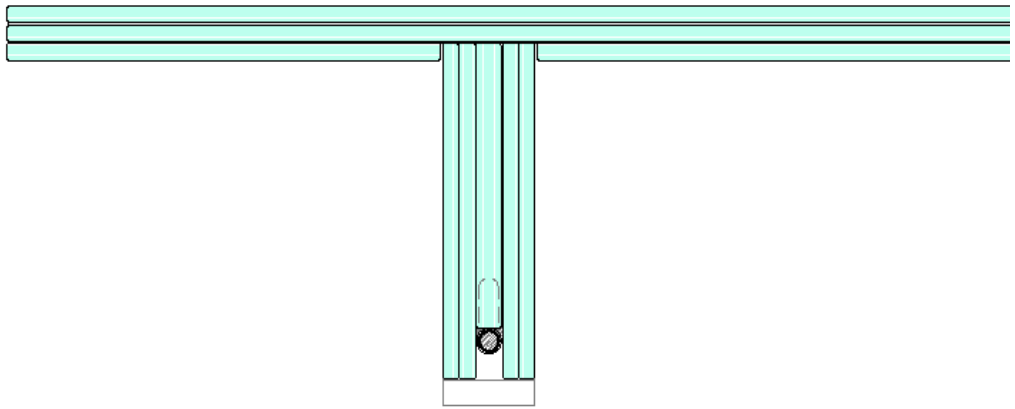
LAMINATED BEAM



PRESTRESSED LAMINATED BEAM



PRESTRESSED LAMINATED "T" SHAPED BEAM



PRESTRESSED LAMINATED "T" SHAPED BEAM

STRENGHT

SAFE DESIGN

POST-BREAKAGE

SLENDERNESS

BUCKLING

USE ABILITY

~~STABILITY~~

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Jesús M. Cerezo, ENAR

EVOLUTION OF DESIGN AND GEOMETRY

Calculation hypothesis

Analytic & F.E.M calculation

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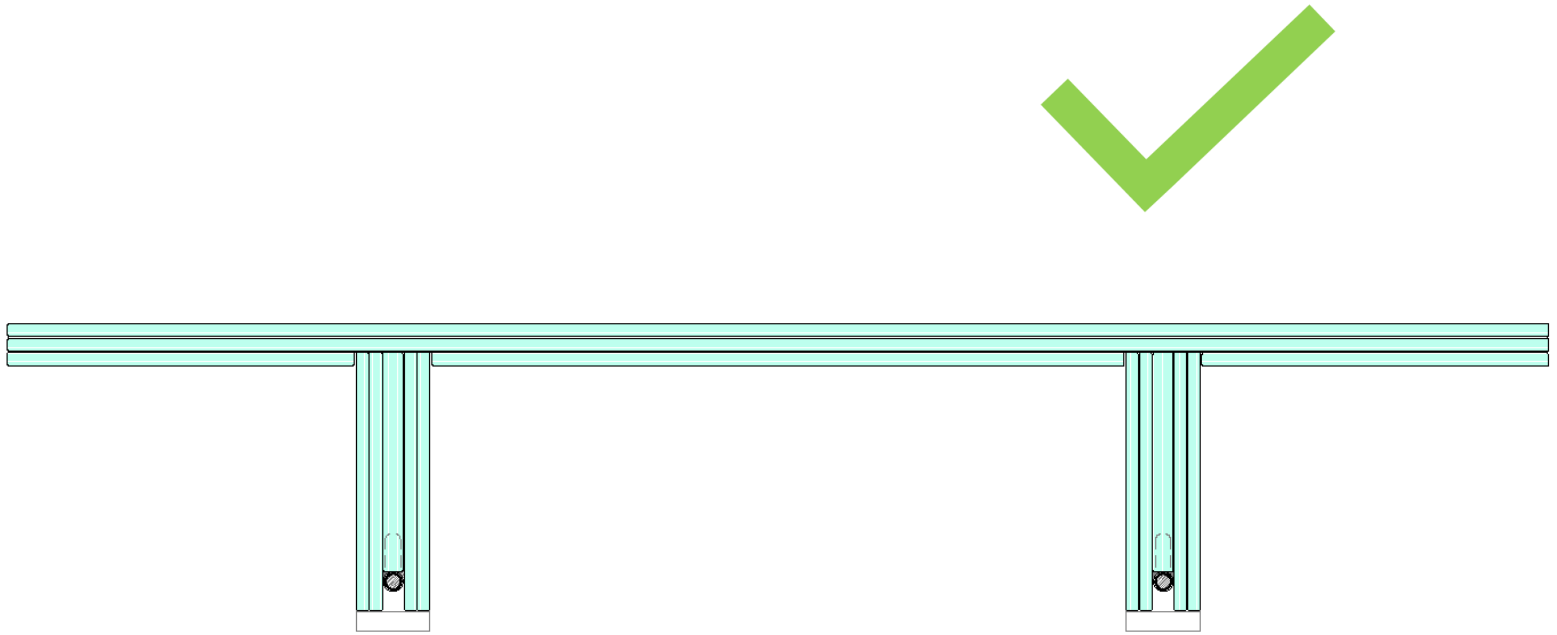

PRESTRESSED LAMINATED "TT" SHAPED BEAM

STRENGHT

SAFE DESIGN

POST-BREAKAGE

SLENDERNESS

BUCKLING

USE ABILITY

STABILITY

Summary of GPD – 2017, J. Vitkala

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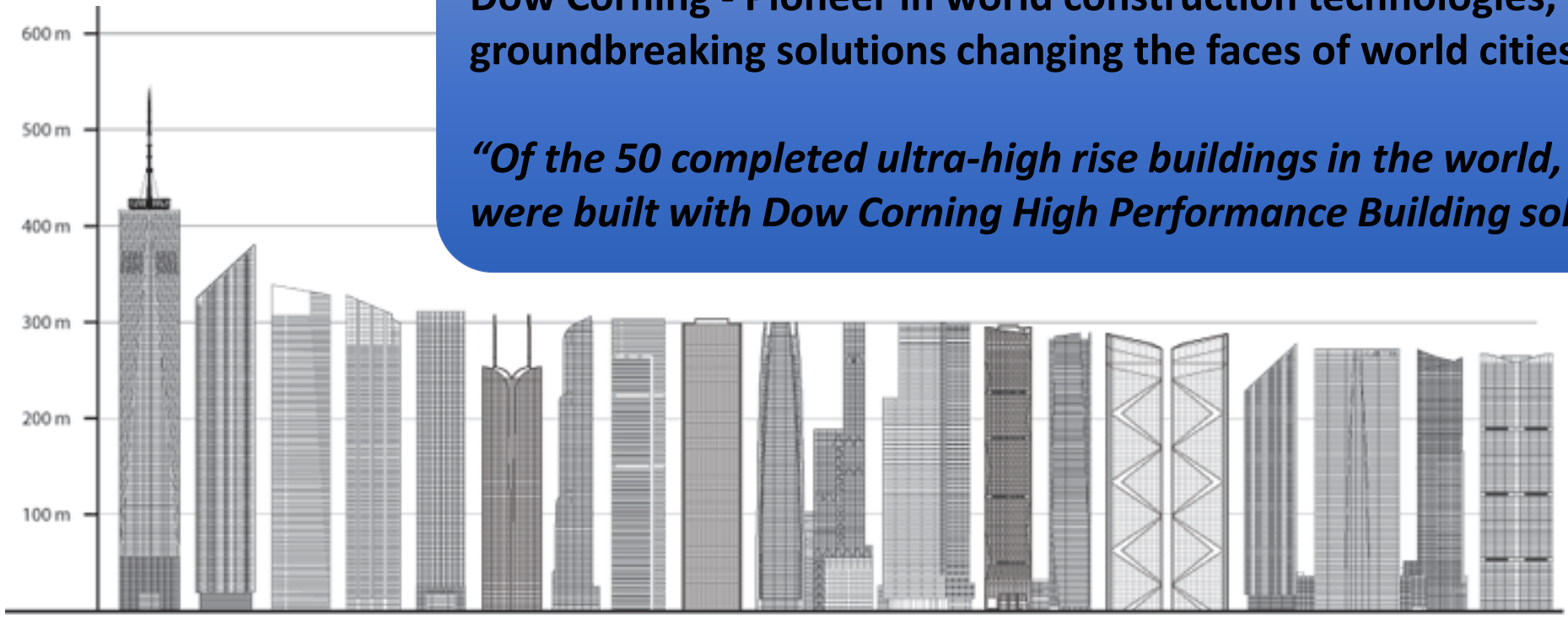
Structural Glazing since 1964...

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."



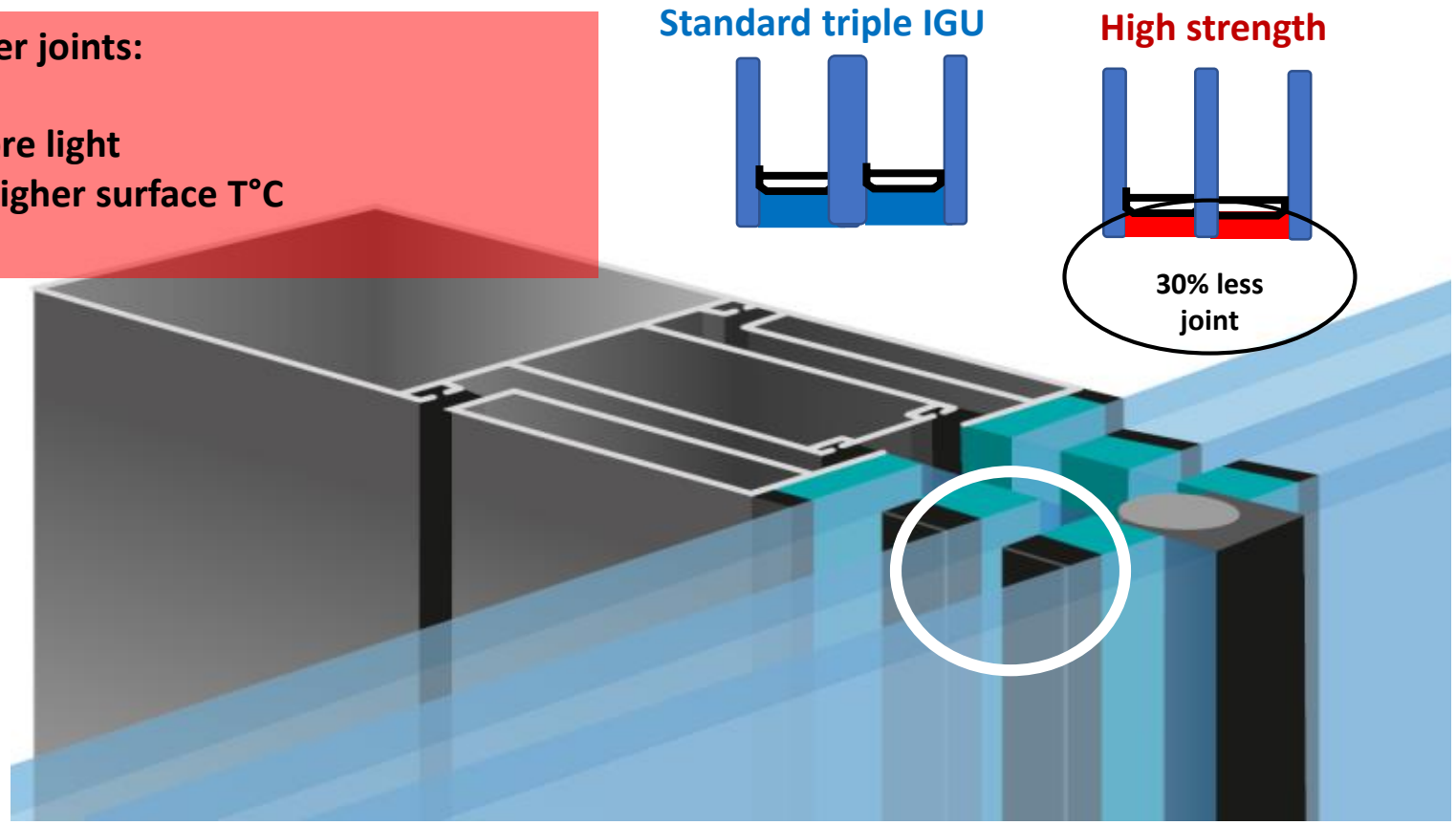
Tallest Buildings Completed in 2014

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Valerie Hayez, Dow Corning Corp

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



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

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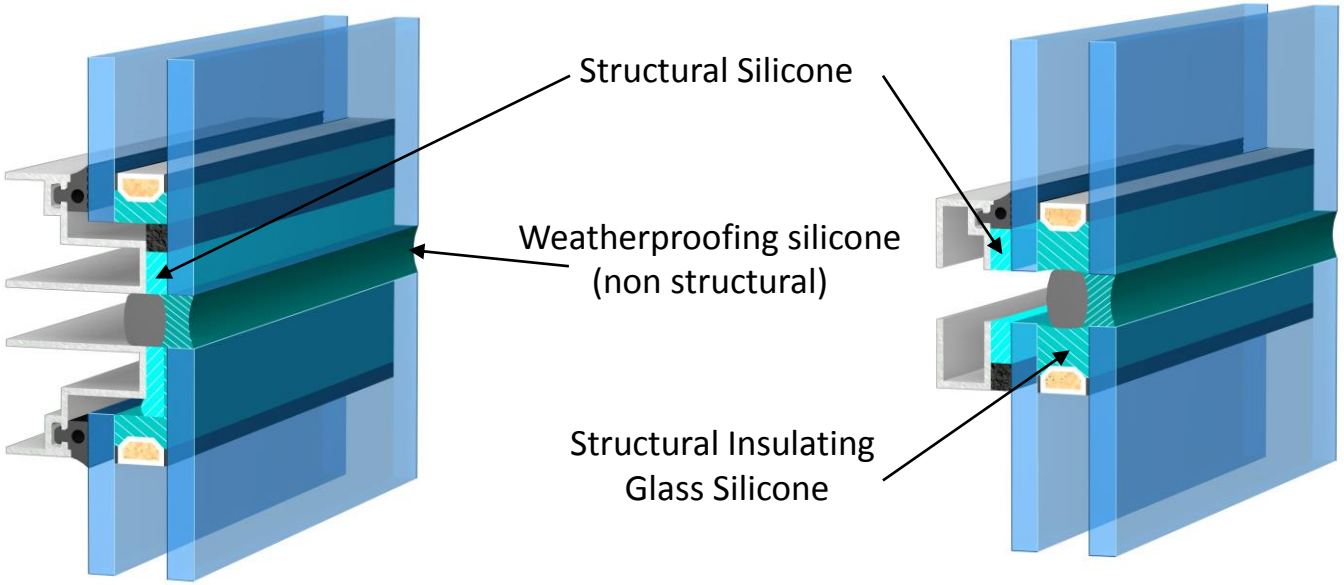
Source: www.gpd.fi © Valerie Hayez, Dow Corning Corp

What is Structural Silicone Glazing (SSG) ?



2-sided SSG

4-sided SSG

- Structural silicones are applied in facades, roofs, windows, doors, solar collectors, photovoltaic modules and internal partition walls to fix glass elements to metallic frames
- Only certified silicones are proven to
  - take over dynamic loads from wind and impact
  - take over permanent load components from glass weight
  - resist thermal cycles and sun radiation
  - stay durable over a long time

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Source: www.gpd.fi © Sigurd Sitte, Dow Corning

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

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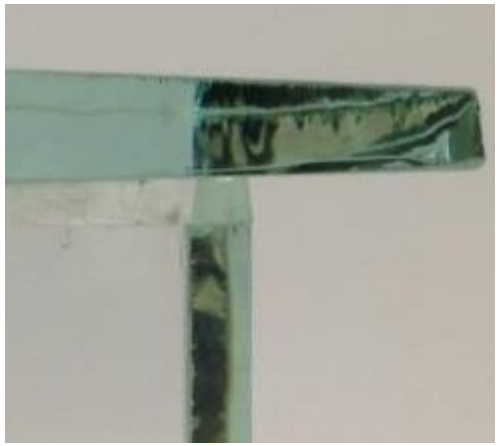
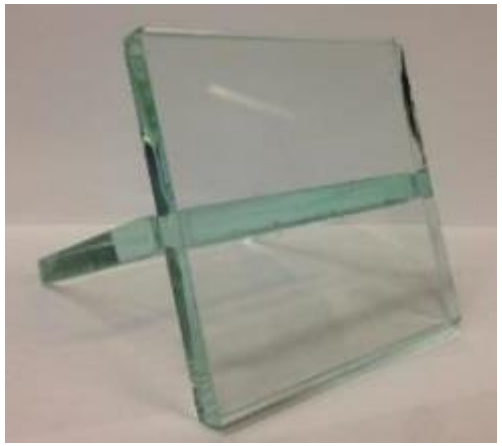
Application: Crystal Clear Structural Glass Connections





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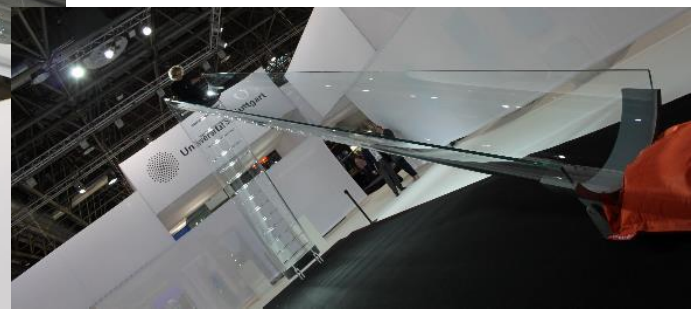
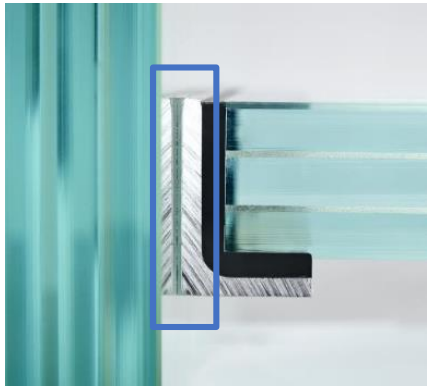
Source: www.gpd.fi © Valerie Hayez, Dow Corning Corp

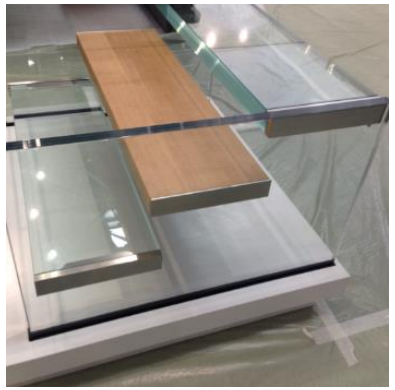
Strength, Aesthetics and Creativity

Vidre Slide,
Cricursa and EOC



Application





Summary of GPD – 2017, J. Vitkala

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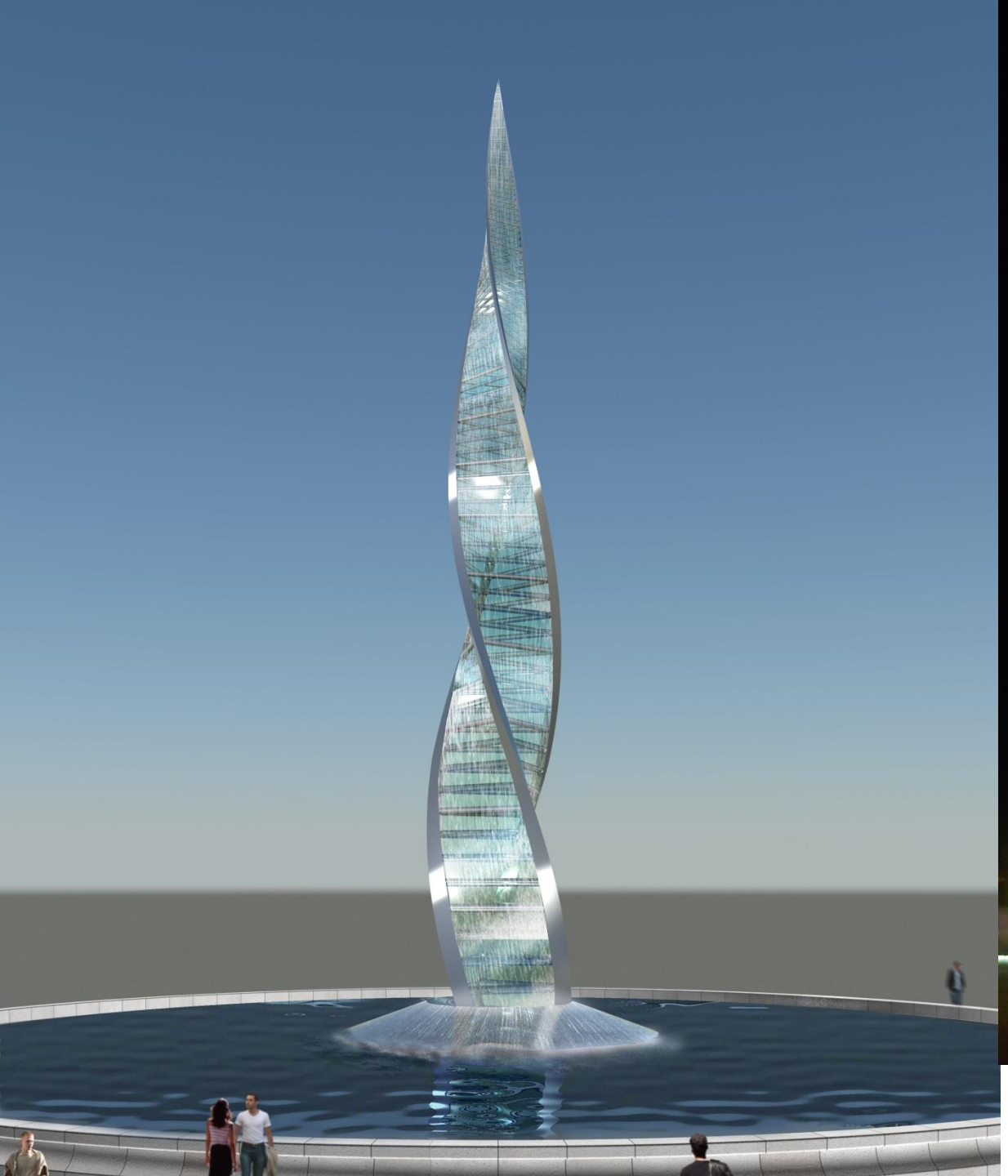

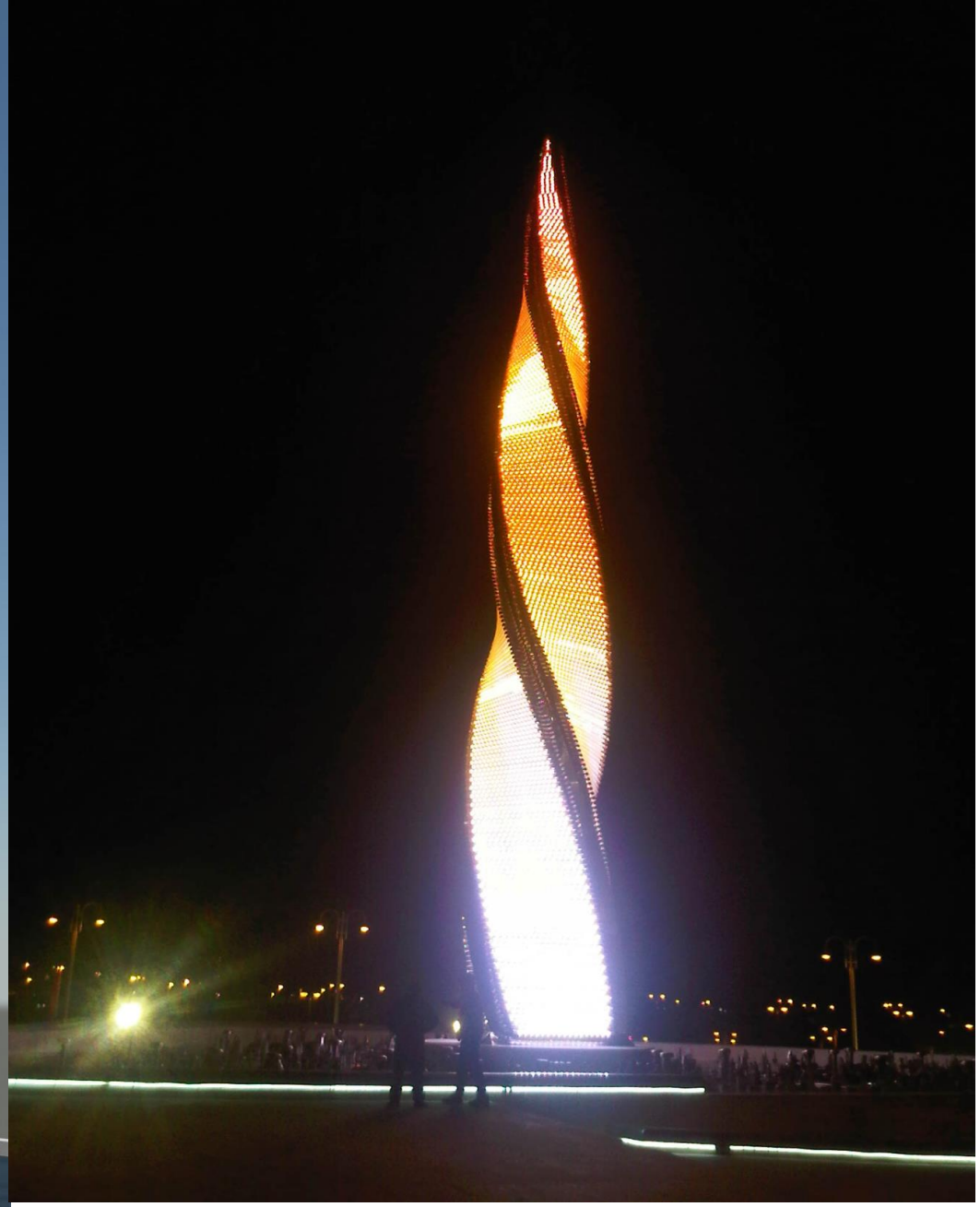

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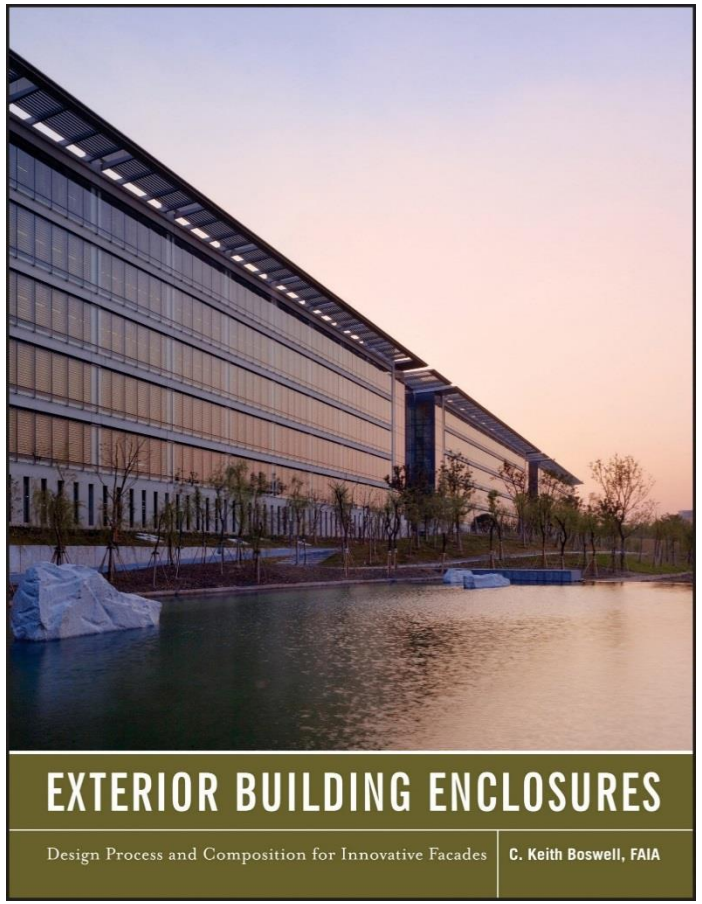

HOLISTIC BALANCED DESIGN

Design is more than visual appearance. Holistic–or complete - design consists of equal parts visual composition and performance. This integration of composition and performance is achieved through a collaborative, sometimes elusive, and always iterative process.

High performance design is the application and careful balance of performance principles and the art of composition. It is the integration of physics and the science of materials. It requires a basic understanding of building and construction sequencing. It is in this intersection of science, art, materials, and construction where design and technology, art, and science become architecture. Beauty is more than skin deep.

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Source: www.gpd.fi © Keith Boswell, SOM Architects

Cold Bent Glass Applications

Summary of GPD – 2017, J. Vitkala

Cold bent glass in architecture

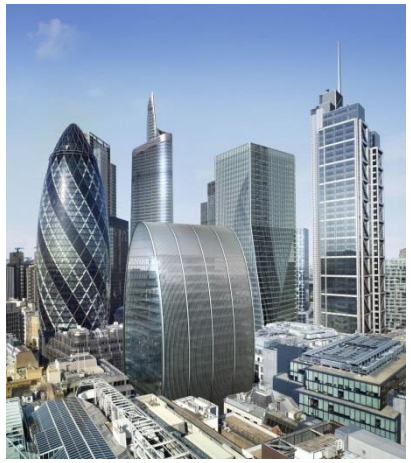
IAC headquarters, New York City, Frank Gehry (2007)

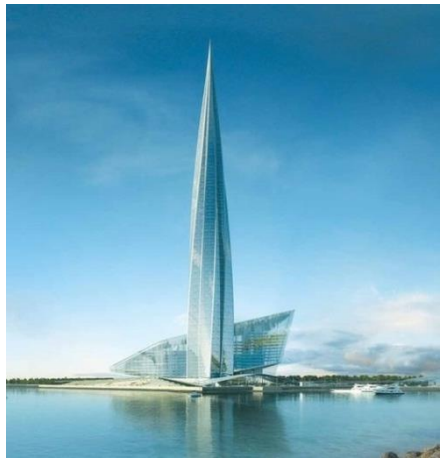
Jinso Pavilion, Amsterdam, Cepezed (2009)

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

COLD-BENT UNITS

«STATE-OF-THE-ART» ???



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Source: www.gpd.fi © Viviana Nardini, Sika services AG

Complex Geometry - Panelization Options

Recent complex geometry façade projects in Dubai
Meinhardt Façade Technology

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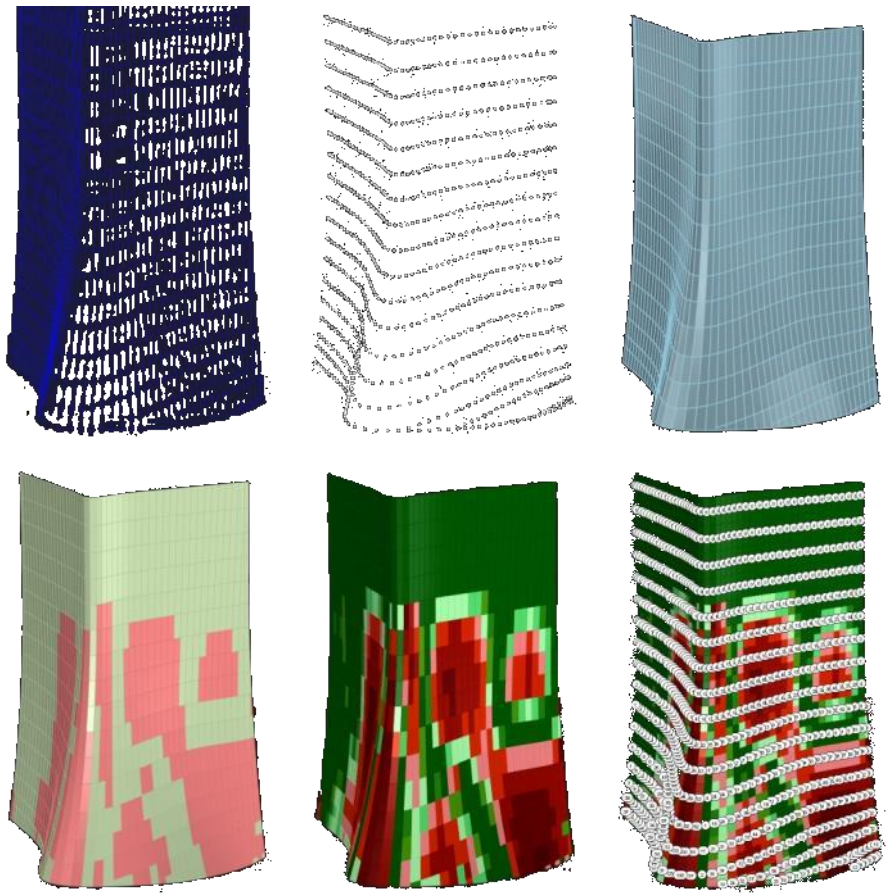
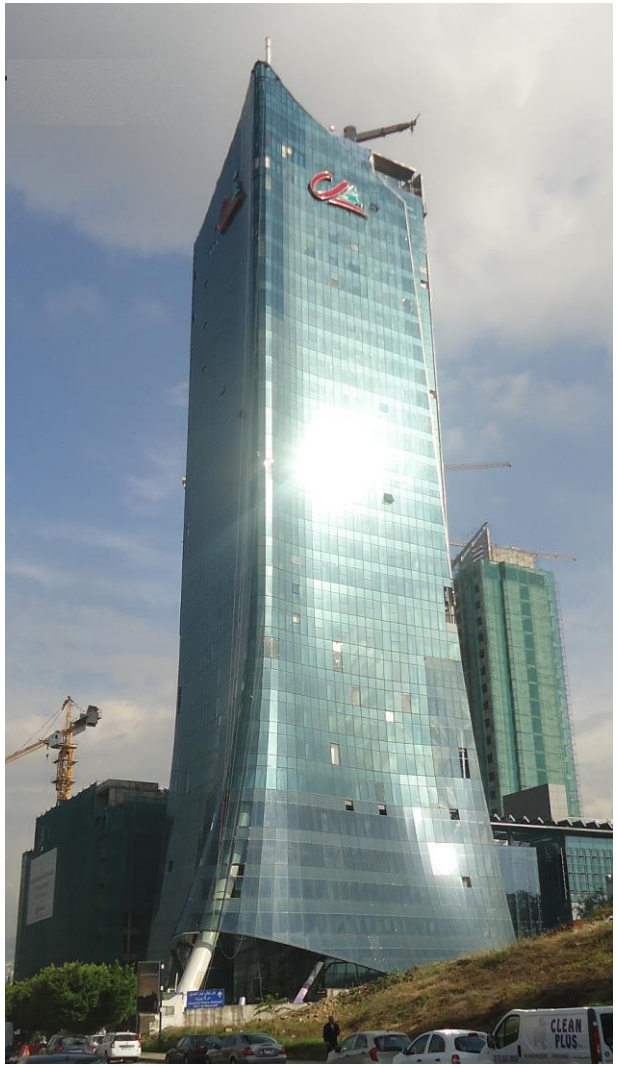
Source: www.gpd.fi © Benjamin Beer, Meinhardt Facade

Complex Geometry – Cold-Bending Options





Credit Libanais project
Meinhardt Façade Technology

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Source: www.gpd.fi © Benjamin Beer, Meinhardt Facade

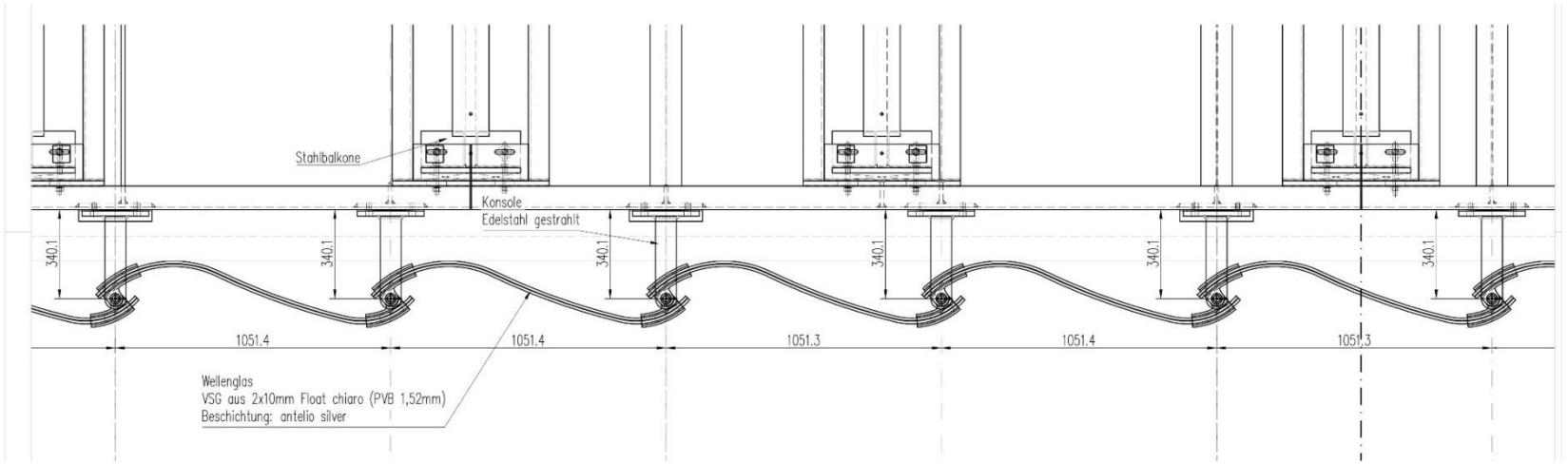
Cold Bending

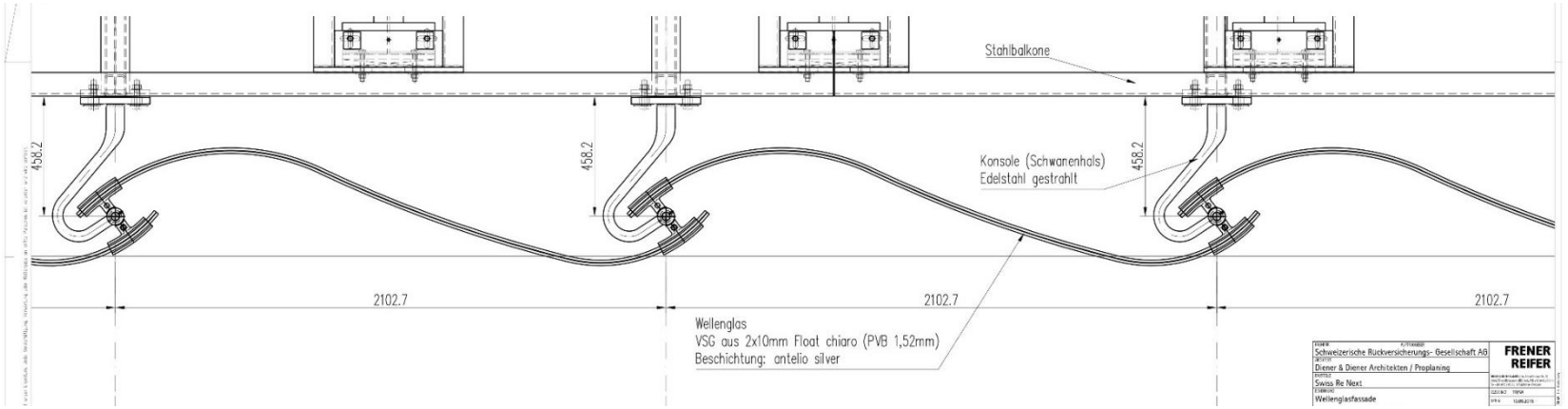
Summary of GPD – 2015, J.Vitkala
Source: www.gpd.fi © Lutz Schöne, LEICHT
Structural Engineering & Specialist Consulting

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Lutz Schöne, LEICHT

Horizontal Details – Hot Bent Glasses





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Gravity Glass Bending

Bending Process:

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

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Source: www.gpd.fi © Marc Zimmer, Frener & Reifer GmbH

Swiss Re Next. Zürich, Schweiz | Diener & Diener Architekten

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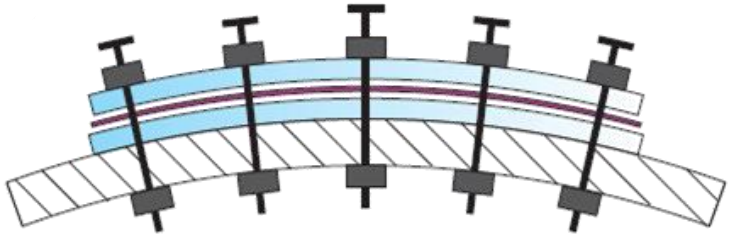
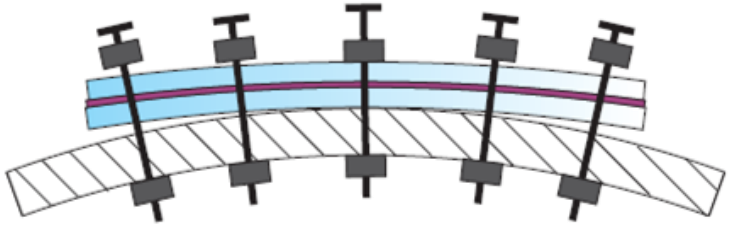
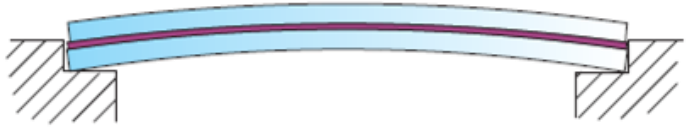
Warm-Bending inside autoclave



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

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Source: www.gpd.fi © Gabriele Pisano, Uni. Of Parma

World Wide Glass Quality and processing Trends

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Tempered Glass Size Development

Designed by photoroyalty / Freepik

1986
1.50m
3.00m

1991
3.30m
5.60m

2005
3.30m
7.20m

2009
3.30m
9.60m

2014
3.30m
12m

2017
3.50m
20m

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Jorma Vitkala, GPD

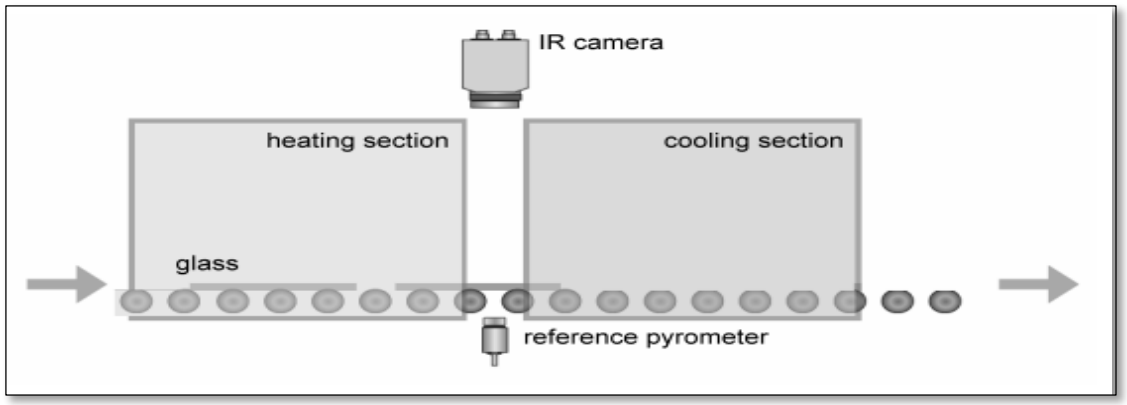
Large glass needs special handling equipment - **Tvitec Spain**

Summary of GPD – 2015, J.Vitkala
Source: www.gpd.fi ©Tvitec

Coated glass – temperature measurement

Measurement from below

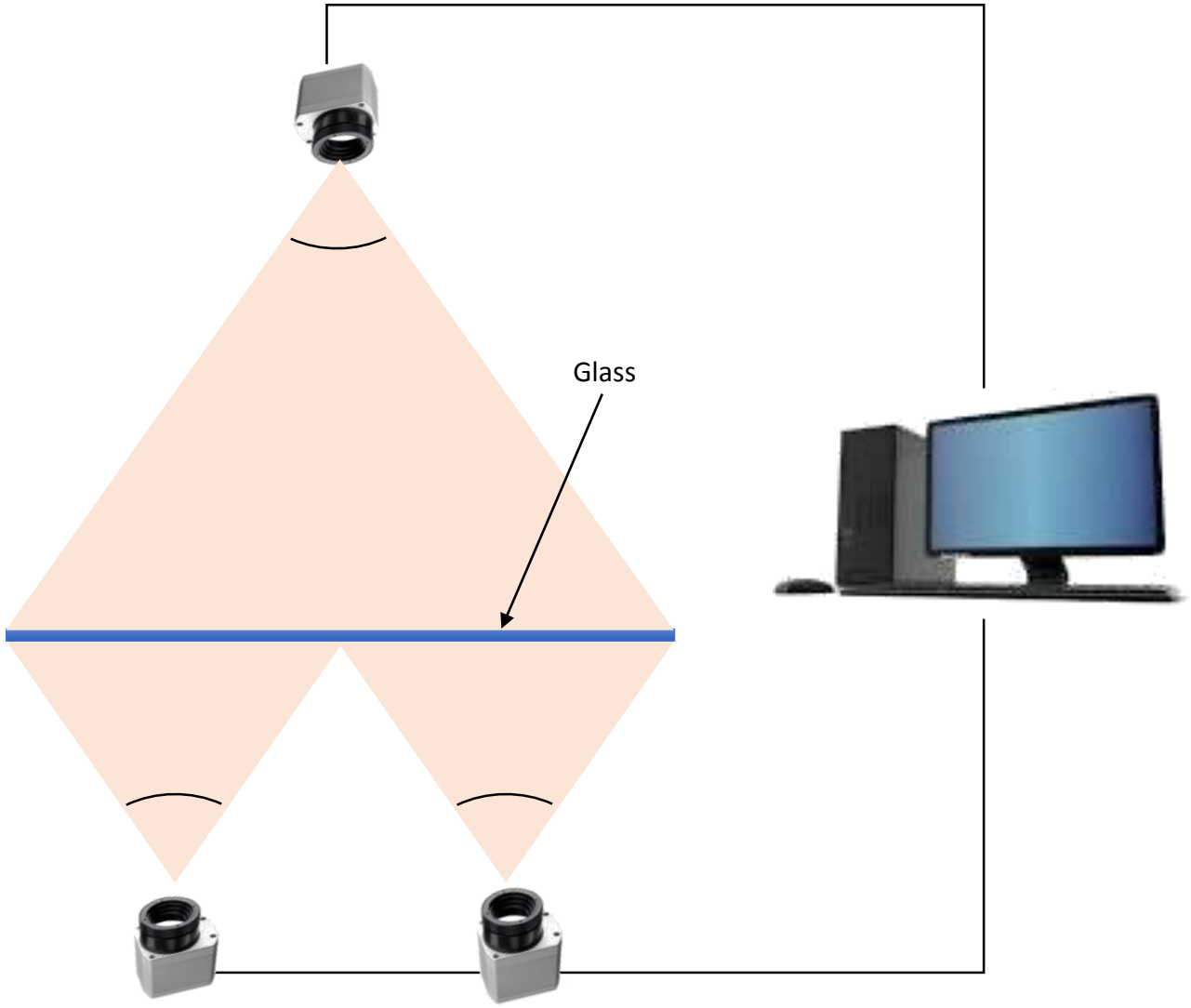
- Indirect by reference pyrometer
  - Measurement with small head sensor from below connected to main device



Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Ingo Stahlkopf, Optris GmbH

Approaches for coated glass



1 one from above

2 from below - connected

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Ingo Stahlkopf, Optris GmbH

Non-Contact Technology

How Eddy Current Works

I. A primary magnetic field is created when alternating current is injected into an induction coil

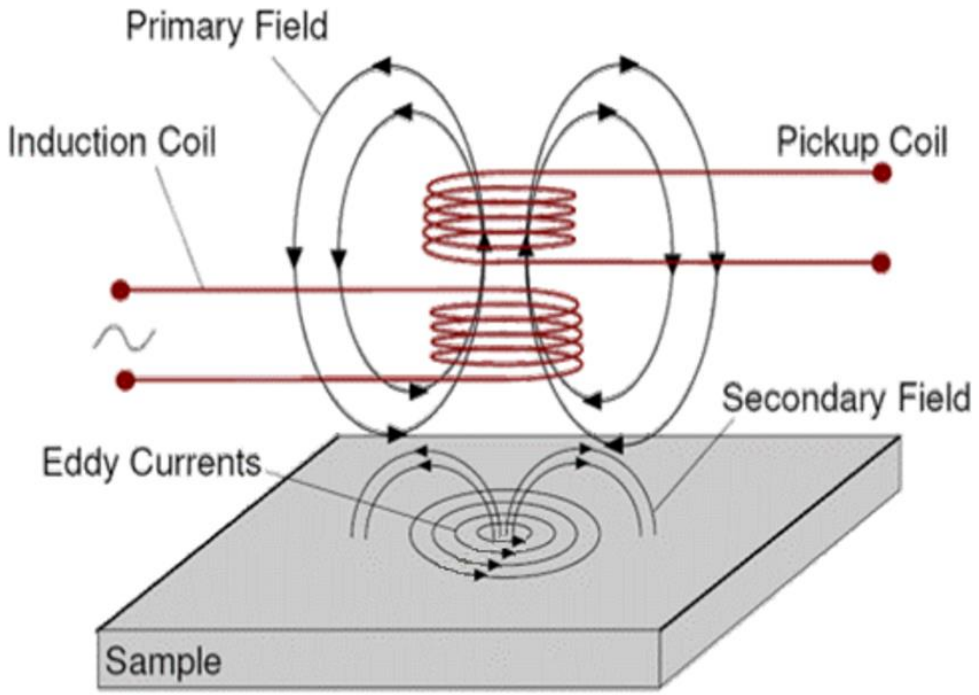
II. Eddy Currents are generated when the coil is placed over a conductive sample

III. The characteristics of the Eddy Currents are determined by material characteristics

IV. The Eddy Currents generate a secondary magnetic field opposed towards the primary field

V. The impedance of the coil is affected by material differences that influence conductivity

VI. This influence is measured by a pick up coil



\+ High sample rate
\+ High sensitivity
\+ Non-contact solutions
– Limited to conductive materials

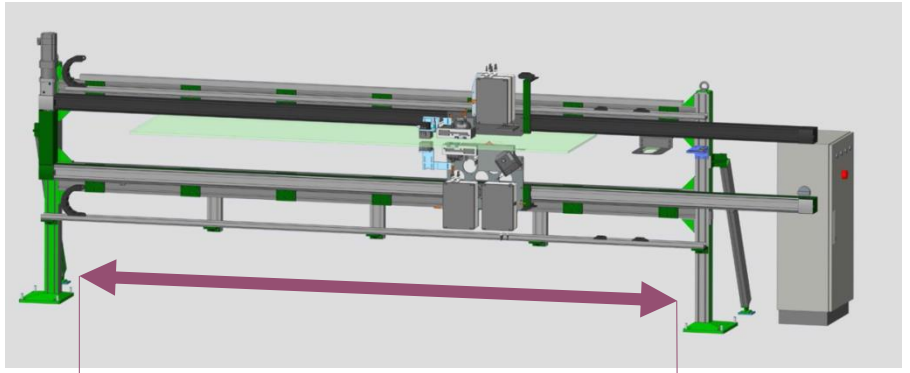
Summary of GPD – 2017, J. Vitkala

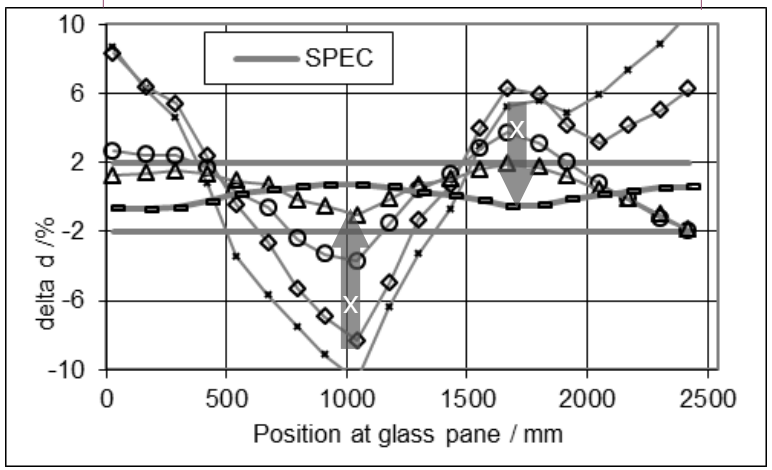
Source: www.gpd.fi © Marcus Klein, SURAGUS GmbH

Color as Thickness Indicator: Result

- The example shown demonstrates the tuning of the coating process to bring the layer to specified thickness.

- Cross section plots of coating thickness variation





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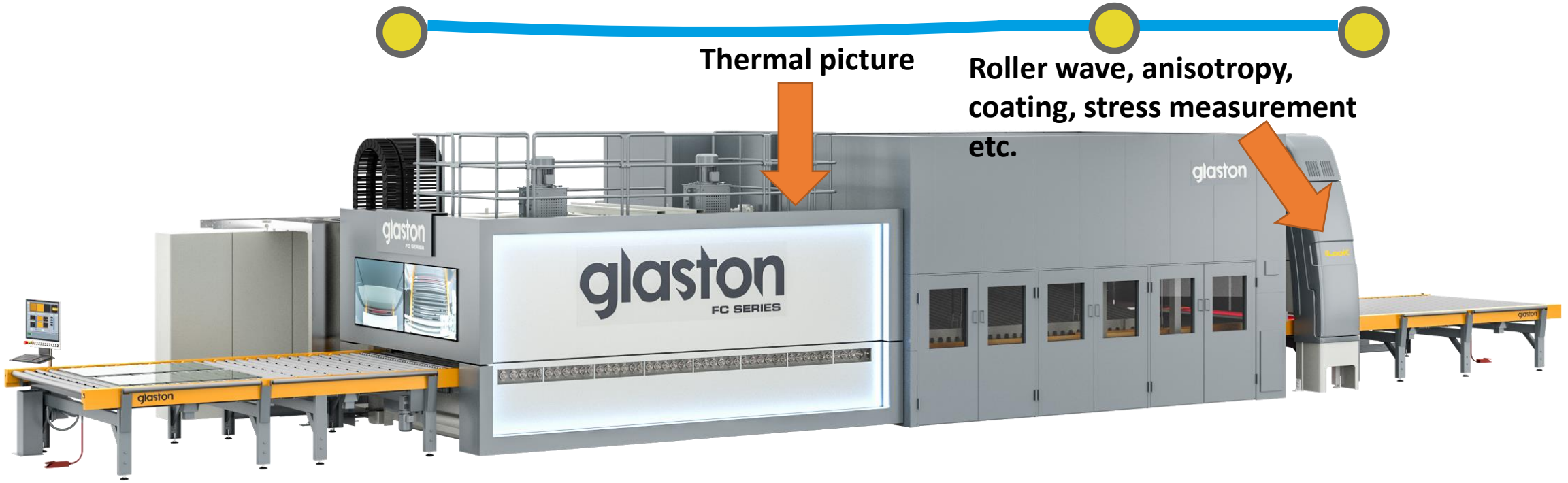
Source: www.gpd.fi © Chris Hellwig, Carl Zeiss Spectroscopy

AUTOMATION / QUALITY CONTROL

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

Overall bow measurement in horizontal process



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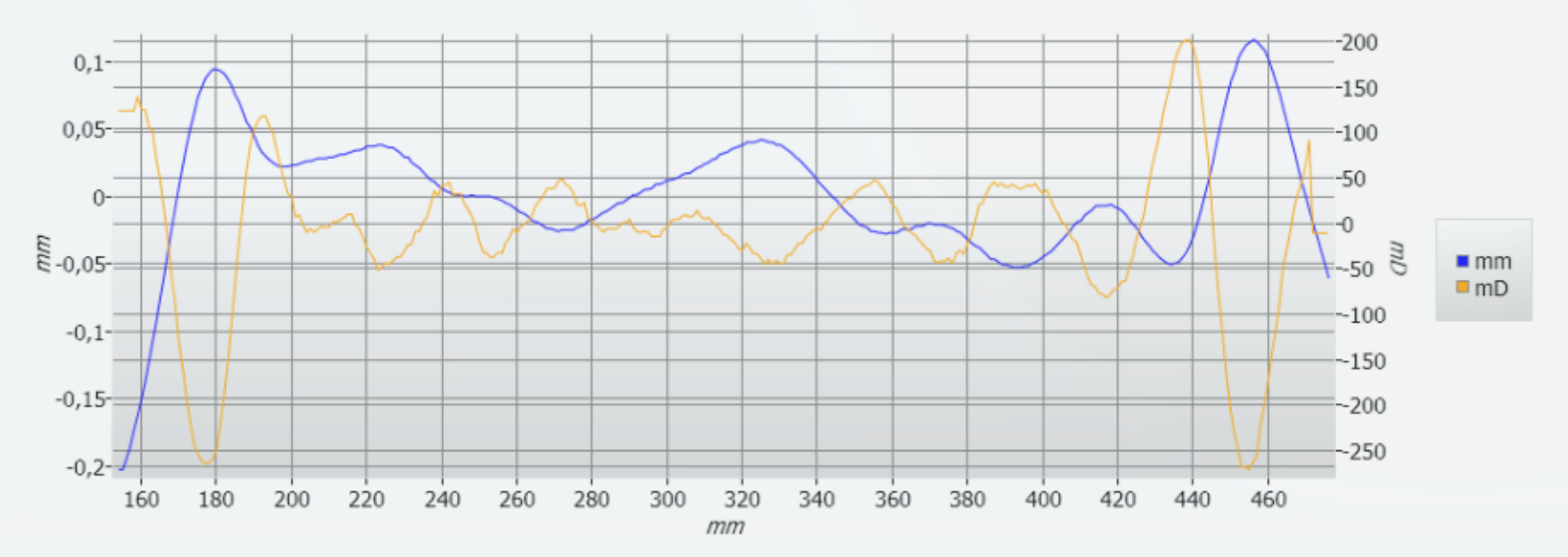
Jorma Vitkala, GPD

Roller wave measurements



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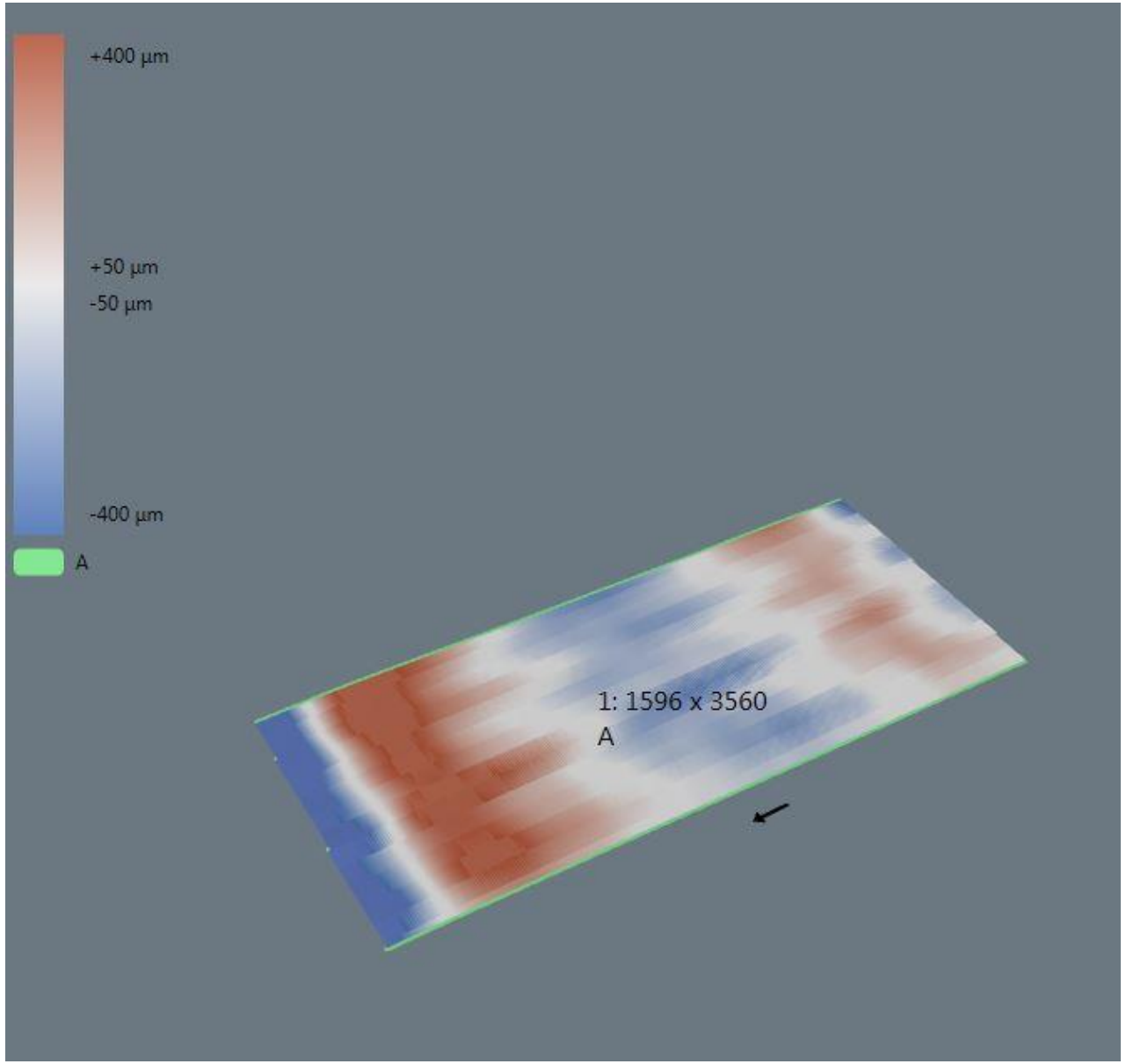
Roller wave measurements



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A Masterpiece of Intelligence

Built-in **Process Know-how**

Assistant
Assistant Pro

Built-in **Production development** tools

Reporting Pro

Built-in **Online-Process Feedback**

iLooK Distortion
iLooK Anisotropy
Bottom Scanner

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Source: www.gpd.fi © Miika Äppelqvist, Glaston

A Masterpiece of Intelligence

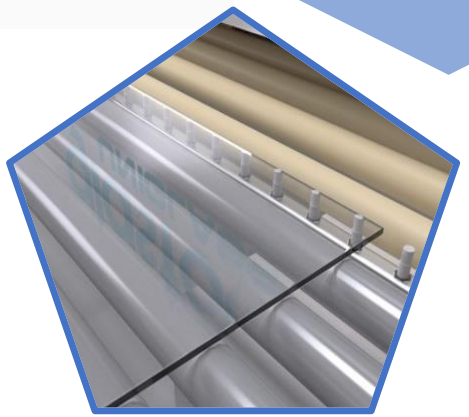
The Assistant family will lead you to victory and success

Built-in Process Know-How

Assistant

Assistant Pro*

- Standard with all FC-Furnaces
- DLP - Load recognitions and automatic heating profile
- Air balance adjustment based on glass size



- Automatic adjustment for heating and cooling parameters based on loading pattern
- Operator selects only the thickness and glass type

*Requires bottom scanner for reliable measurements

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Miika Äppelqvist, Glaston

A Masterpiece of Intelligence

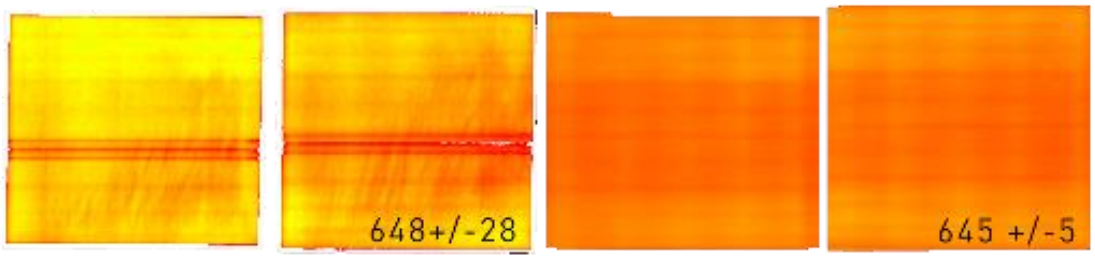
Reliable measurement is a key factor in further automation

Built-in

On-Line Process

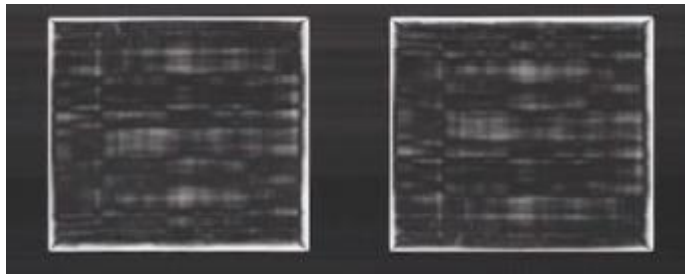
Feedback

- Reliable lowE feedback (BSCA)
- iLook – Distortion & Anisotropy
- Quality measurement and traceability for each glass. All measurement are saved in QMS report for each load

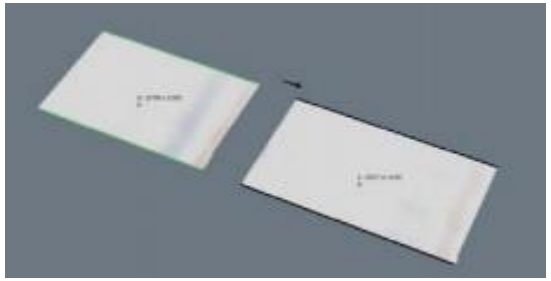


Normal scanner measurement with lowE glass

Bottom Scanner measurement from same glasses.



Online Anisotropy scan for each glass coming our from the tempering line.



Distortion (rollerwave and edge lift) online measurement with iLooK distortion.

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Source: www.gpd.fi © Miika Äppelqvist, Glaston

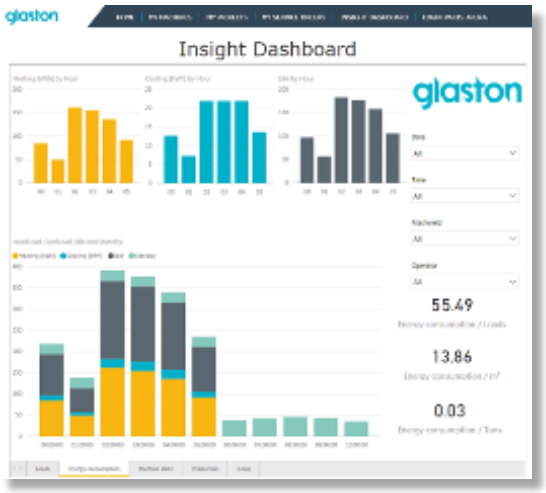
A Masterpiece of Intelligence

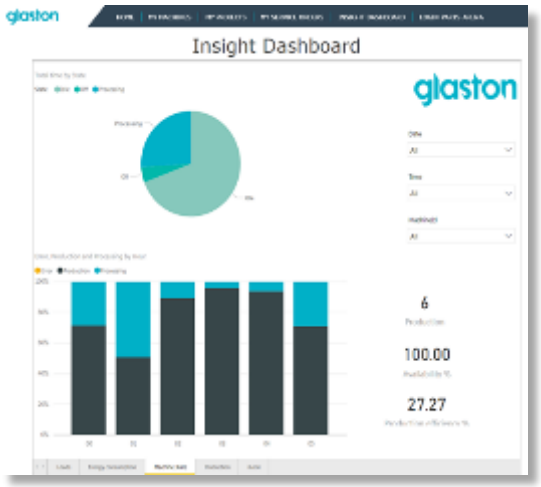
Peace of mind and real time analytics on any device

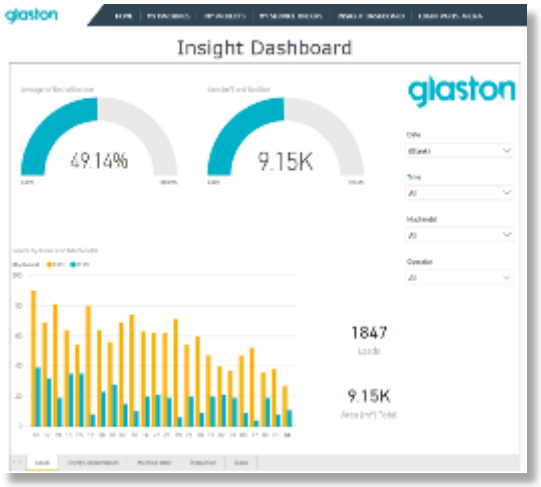
Built-in Production Development Tools

- Production reports
- Automated maintenance alerts
- Energy reports
- Quality reports
- Capacity reporting
- Gap-analysis

Also available on mobile or desktop







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Our definition of quality

Quality is built in. Quality is the basis of everything we do. From the way we design, manufacture and test our products, to the services, parts and people who support them.

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Taking control of anisotropy

New tempering solutions

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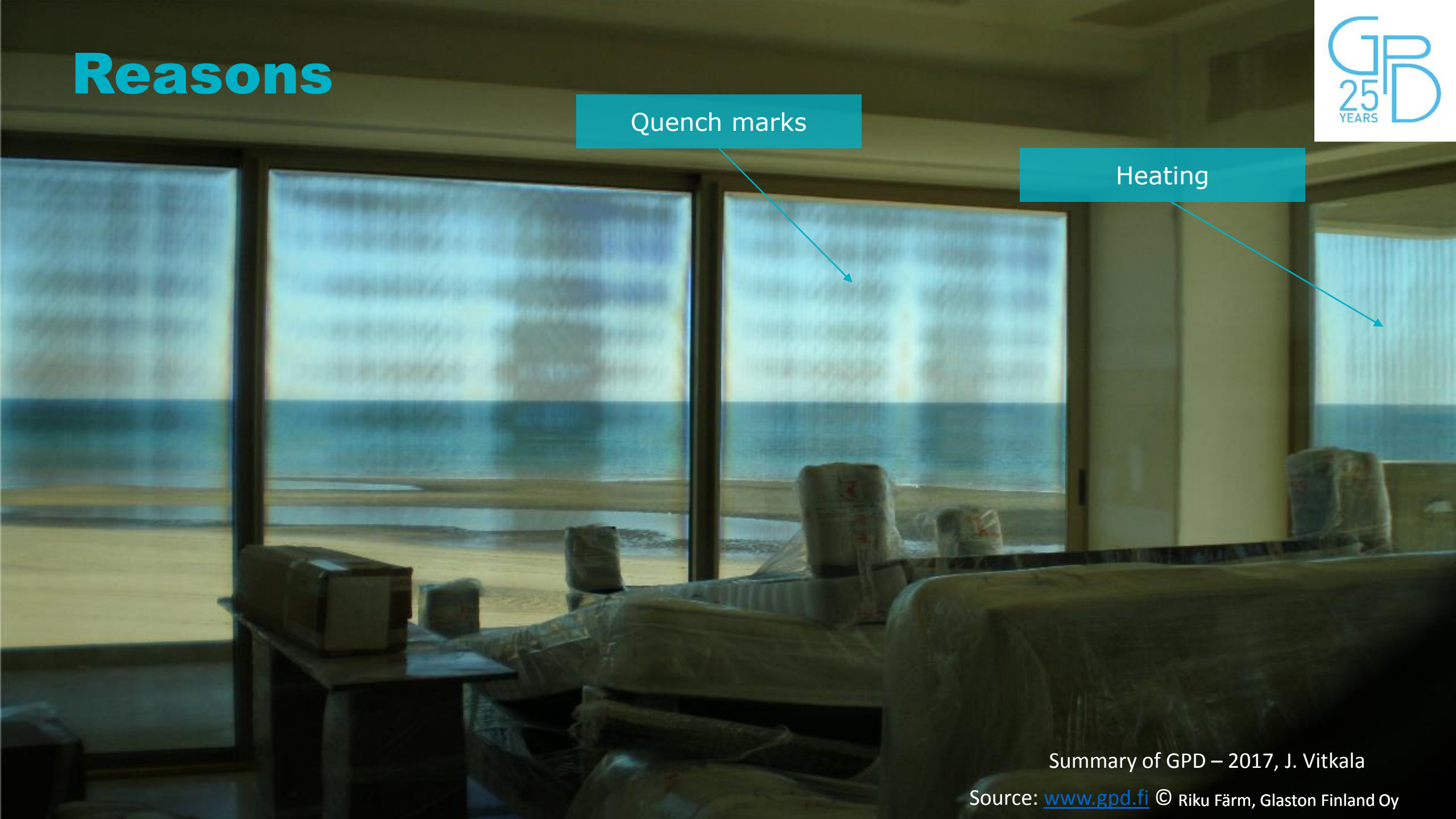
Source: www.gpd.fi © Riku Färm, Glaston Finland Oy

Reasons



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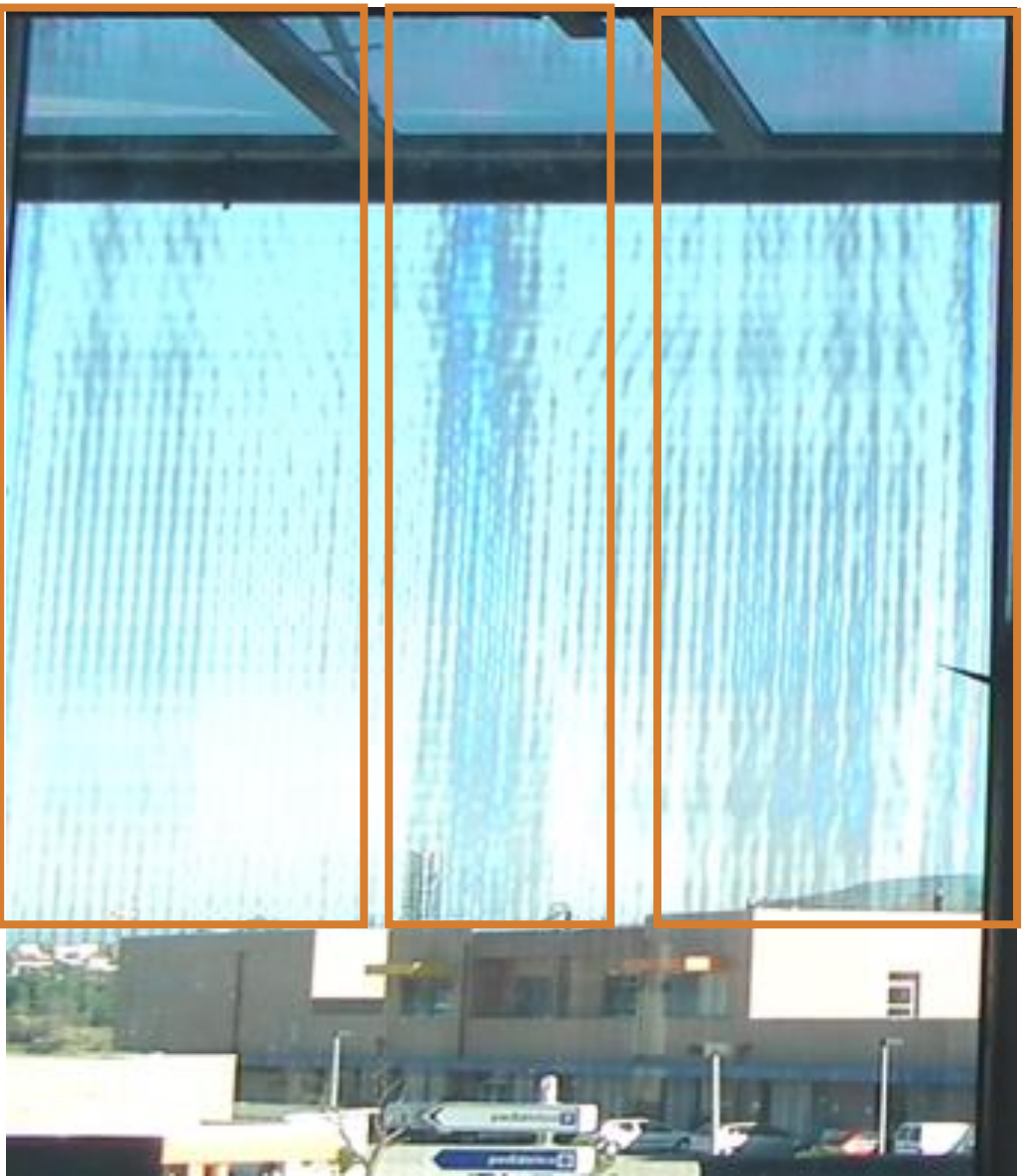
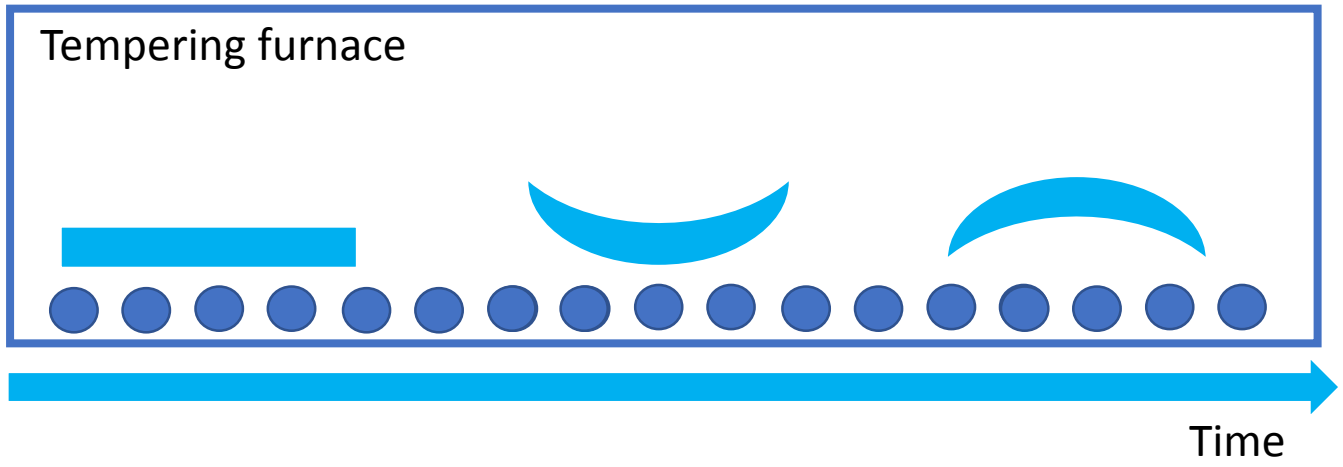


Reasons - heating

1. Beginning of heating period
2. End of heating period



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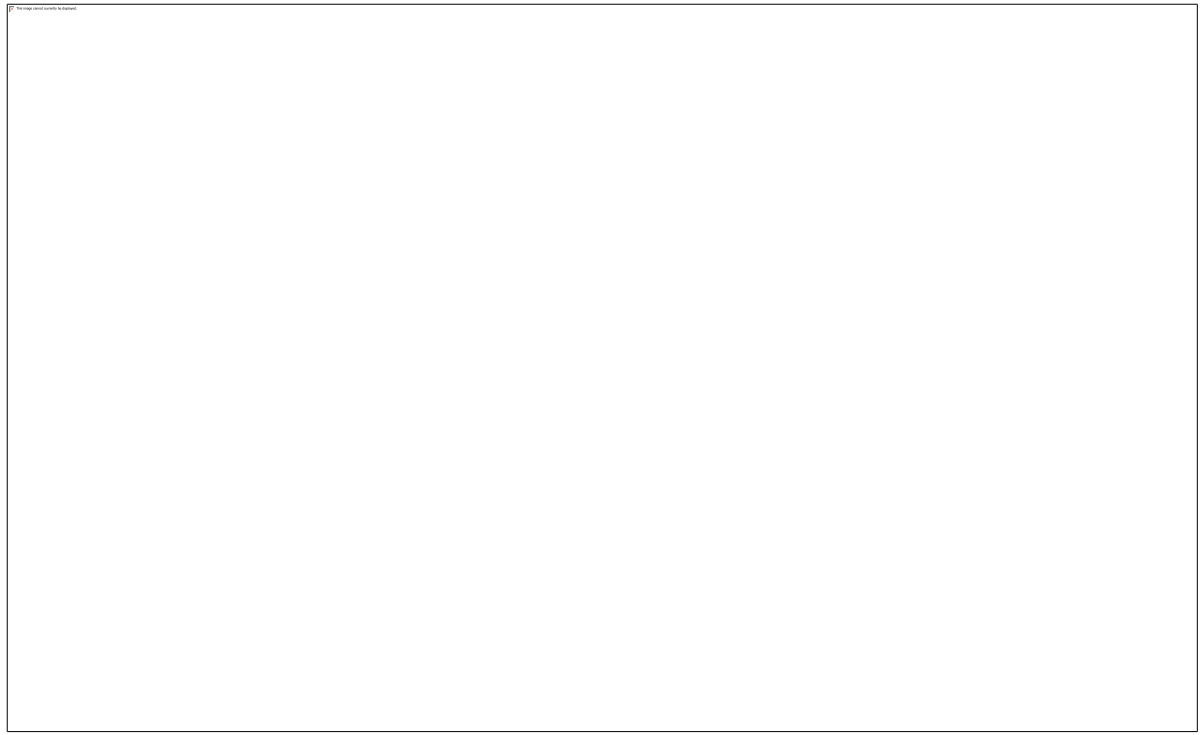
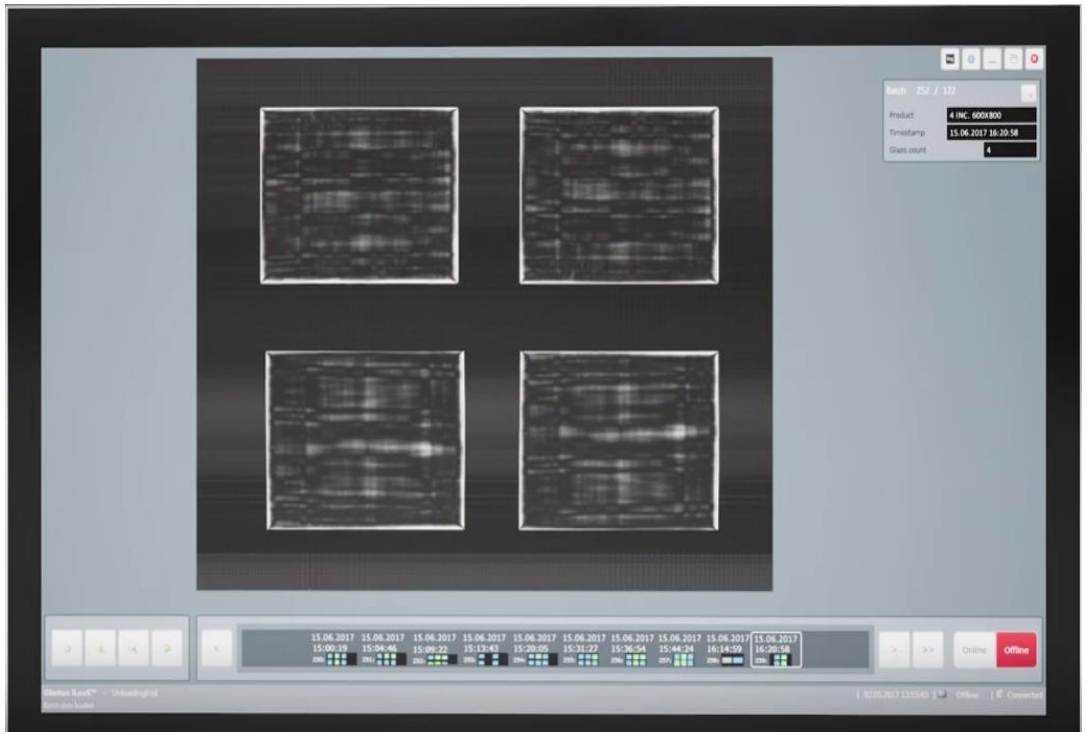
Towards better anisotropy – measurement becomes online





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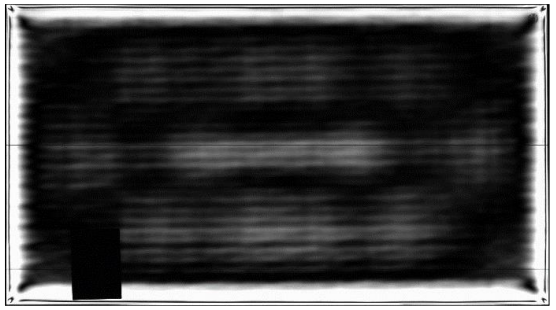
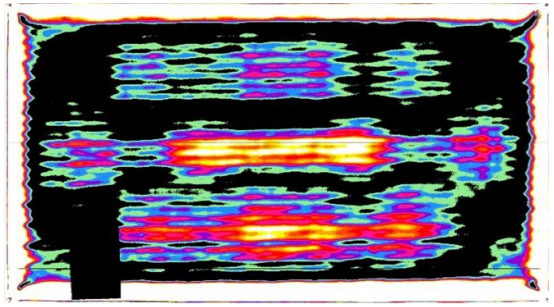
Isotropy visualization

Alternative visualization of measurement results

Operator can switch between 3 result visualizations options!

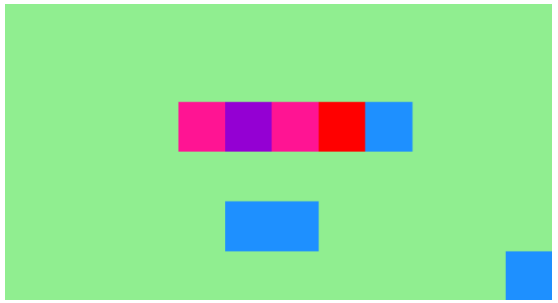


Real camera image



Intensity image

Representing the optical retardation

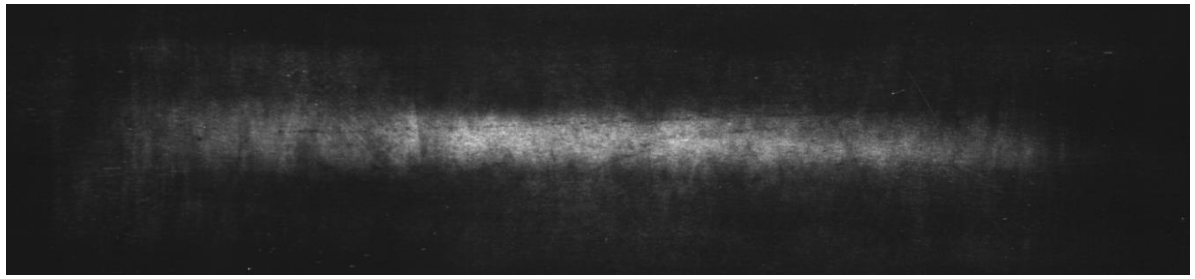


Segmented areas

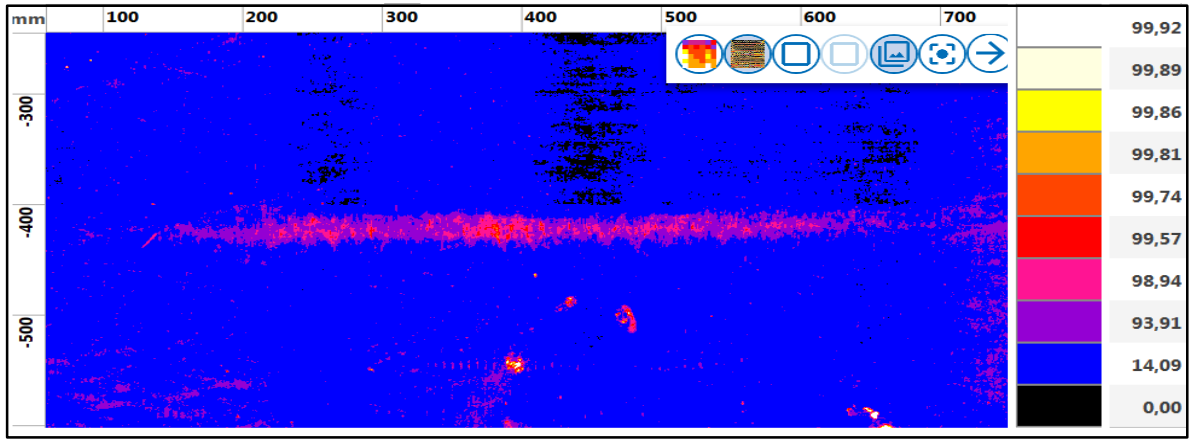
Detecting critical areas of Anisotropy effects

White Haze Option

Detecting White Haze



Real camera image



Intensity image of a White Haze example

Source: www.gpd.fi © Kai Vogel, Viprotron

Worldwide Glass Processing Trends

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FULL AUTOMATION DOES NOT MAGICALLY APPEAR

IT'S A RESULT OF SYSTEMATIC DEVELOPMENT STEPS

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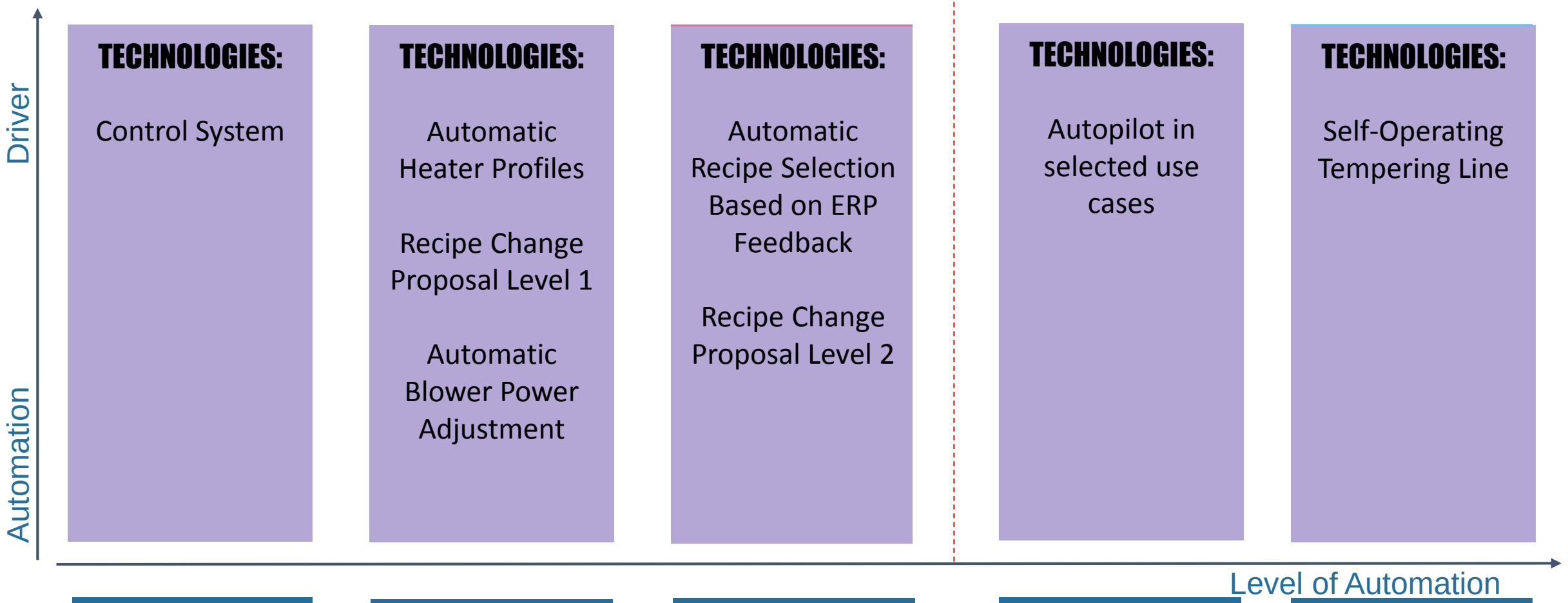
ROAD TO AUTOMATION – TEMPERING LINE



Source: www.gpd.fi © Miika Äppelqvist, Glaston Finland Oy

Use of big data

ALERTS

REAL TIME REPORTS

PRE-DICTIONS

BIG DATA SOURCES

- PROCESS DATA
- QUALITY DATA
- PRODUCT DATA
- RAW MATERIAL DATA
- MAINTENANCE DATA

VISUALIZATION

PROCESS KNOW-HOW AND DEVELOPMENT

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“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

Summary of GPD – 2017, J. Vitkala

Source: www.gpd.fi © Keith Boswell, SOM Architects

Thank you!

Jorma Vitkala, GPD Chairman

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GPD 2017 Ebook: www.gpd.fi

GPD Turkey – 7-10.3.2018

GPD China – 17.4.2018

GPD Finland – June 2019