

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

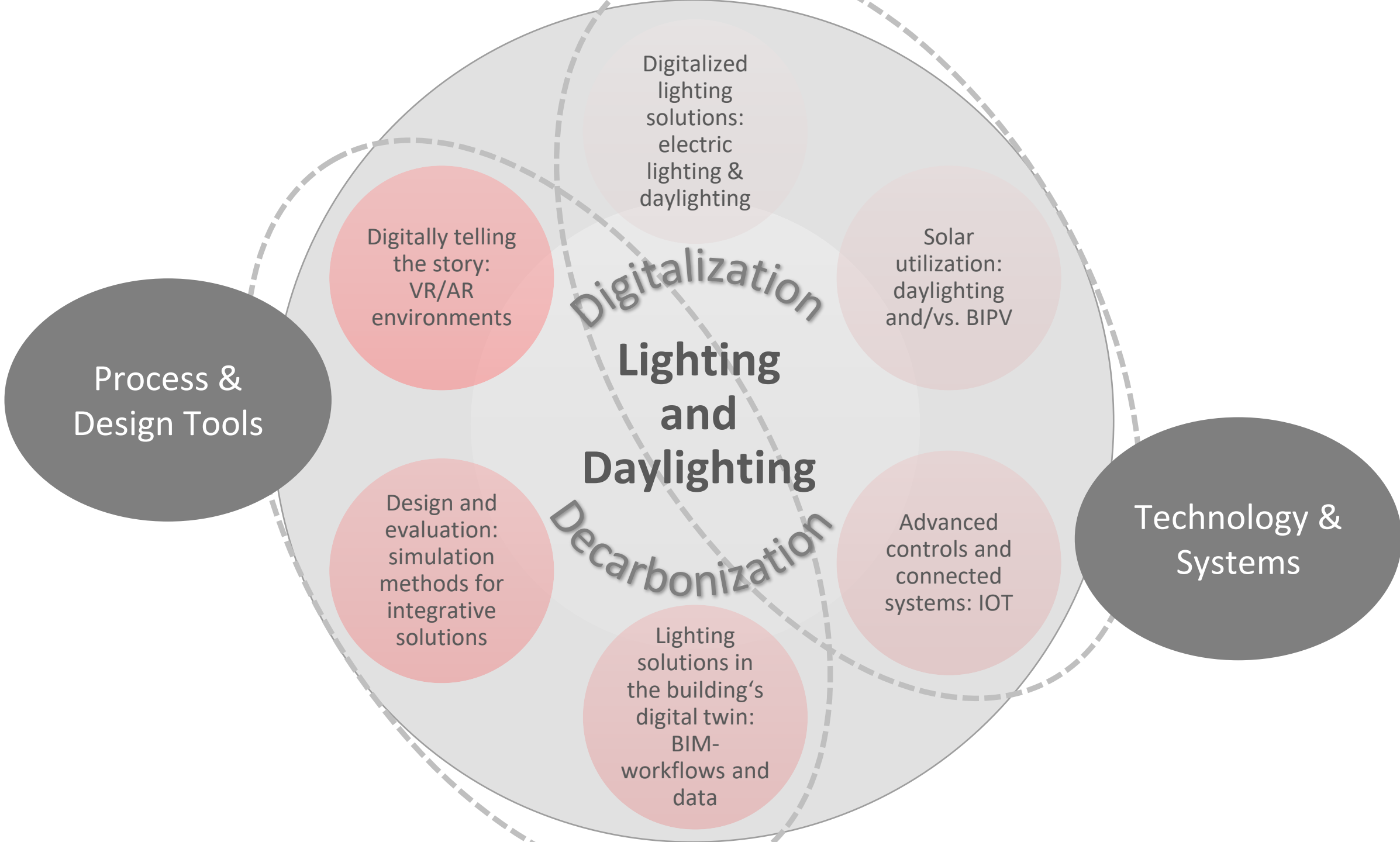
TASK 70

Low Carbon, High Comfort Integrated Lighting

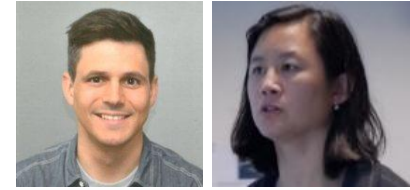
Digitalized Lighting Solutions – State of the Art in Technologies and Design Workflows

David Geisler-Moroder
IEA SHC Solar Academy | 19 May 2026 & 21 May 2026

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Digitalized Lighting Solutions (Technology & Design Tools / Process)



Coordination: David Geisler-Moroder, University Innsbruck, Austria and Eleanor S. Lee, LBNL, U.S.A.

Technology

- System concepts for digitalized lighting solutions and combined daylight and solar utilization
- IOT and control systems



Design Tools / Process

- BIM - continuous workflow for integrated lighting solutions and underlying data
- Simulation methods for integrative lighting design and VR possibilities

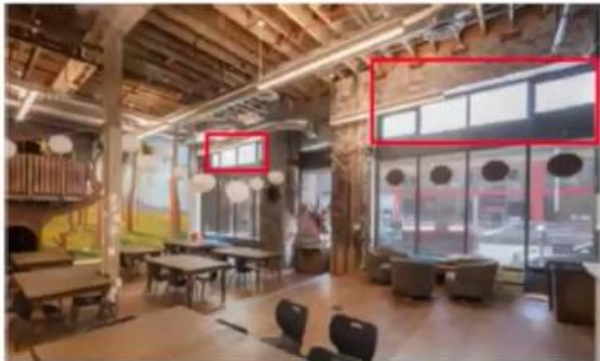


Micro-prismatic materials for Complex Fenestration Systems

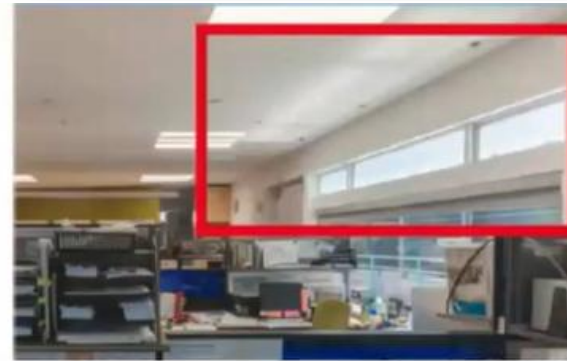
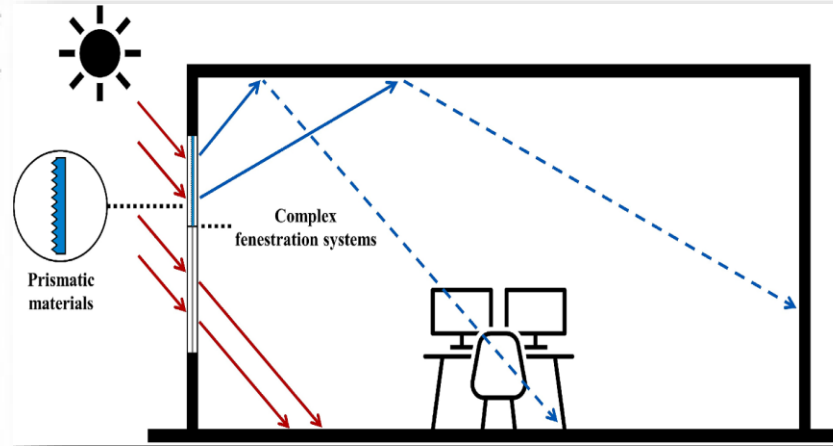
On-site images



[113]



[114]



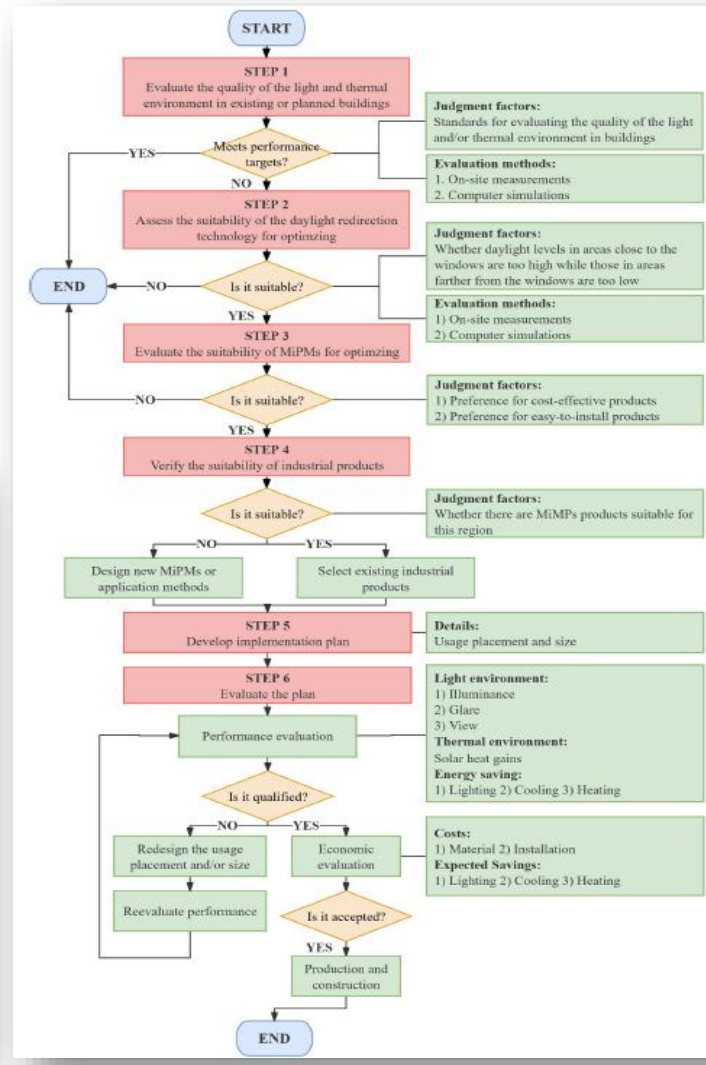
[115]

Highlights

- MiPMs can effectively enhance the quality of light and thermal environments in buildings.
- Optimization algorithms and new materials improve MiPMs design and performance.
- Ultra-precision machining is essential for high-quality MiPMs production.
- A roadmap for MiPMs implementation in building fenestrations is provided.
- High-quality products, standardized evaluations, and integration with other technologies are the keys to MiPMs improvement.

Table 3
Existing literature on the impact of MiPMs on indoor illumination.

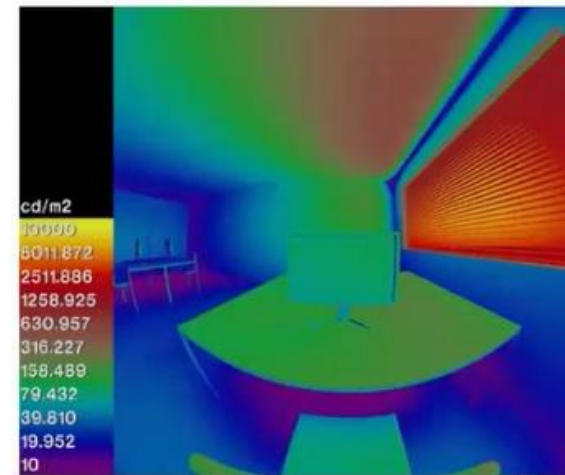
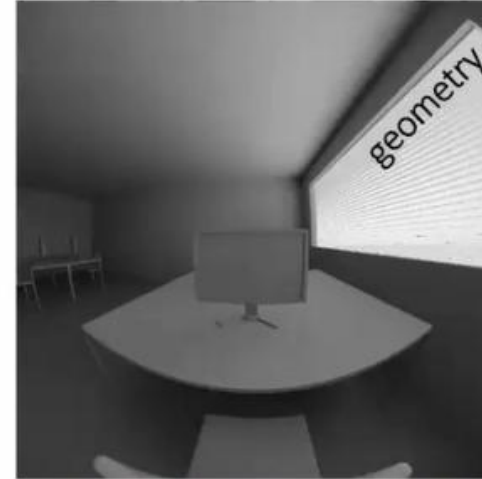
Reference	Features of CFS with MiPMs	Types of MiPMs	Location	Evaluation methods	Evaluation metrics	Results
Mashaly <i>et al.</i> [34]	Full window coverage	Single-sided	Cairo	Computer simulations	sDA	Increased sDA from 67 % to 78 %, compared to plain glass
Tian <i>et al.</i> [77]	Full window coverage	Single-sided	Suzhou	On-site tests & computer simulation	Horizontal illuminance	Improved illuminance levels and uniformity in sunny days, compared to conventional glazing
Tian <i>et al.</i> [78]	Full window coverage	Single-sided	Suzhou, Harbin, and Beijing	On-site tests & computer simulations	Horizontal illuminance, illuminance uniformity (U_0) and Glare index	Increased U_0 and reduced glare index, compared to conventional glazing
Dávila [107]	Upper window coverage	Single-sided	Central-north Mexico	Computer simulations	UDI	Improved illuminance compared to standard glass
Kazanmaz <i>et al.</i> [44]	Upper window coverage	Single-sided	Lucerne	Computer simulations	sDA	Increased sDA from 60.2 % to 80.2 %, compared to typical double-glazing
Lin <i>et al.</i> [108]	Upper window coverage	Single-sided	Shanghai	Computer simulations	Work plane illuminance (WPI)	Increased WPI by 5.4 %, 26.9 %, and 34.6 % at different solar altitudes, compared to conventional glazing
Mashaly <i>et al.</i> [37]	Full and upper window coverage	Single-sided and double-sided	Brisbane	Computer simulations	Arithmetic mean illuminance (E_{area}), standard deviation of illuminance (SD(E)), and the ratio between SD(E) and E_{area}	Most redirecting panels performed better at solar altitude angles higher than 20°, compared to normal window
Mashaly <i>et al.</i> [31]	Upper window coverage (optimized)	Single-sided	Brisbane	Computer simulations	SD(E), and modified UDI (mUDI)	Reduced SD(E) from 0.9 % to 7.4 % and improved mUDI from 45 % to 66.9 %, compared to the best existing CFS
Grobe [73]	Coating for venetian blinds	/	The sun in the South at an elevation of 50°	Computer simulations	Illuminance	Better illuminance distribution, compared to other coatings
Salamati <i>et al.</i> [90]	Combining with horizontal skylight system	Single-sided	New York, Raleigh, San Francisco, and Phoenix	Computer simulations	UDI	Improved UDI from 9 % to 16 %, ideal daylight for 95 % of working hours annually, compared to other skylight configurations
Haghani and Place [52]	Combining with vertical louvers	Single-sided	Raleigh	Computer simulations	Uniformity Index (UI)	Minimum UI value of 0.41 under various conditions
Do and Chen [46]	Combining with automated roller shades	Single-sided	Taipei	Computer simulations	cDA and sDA	Enhanced daylight availability with appropriate scheme selection
Fang <i>et al.</i> [45]	Combining with dynamic louvers	Single-sided	Shanghai	Computer simulations	UDI	Reduced excessive daylight of 17 % in the front zone and improved useful daylight of 10 % in the back zone, compared to conventional double glazing



BSDF Data Generation

BSDF: Bidirectional Scattering Distribution Function

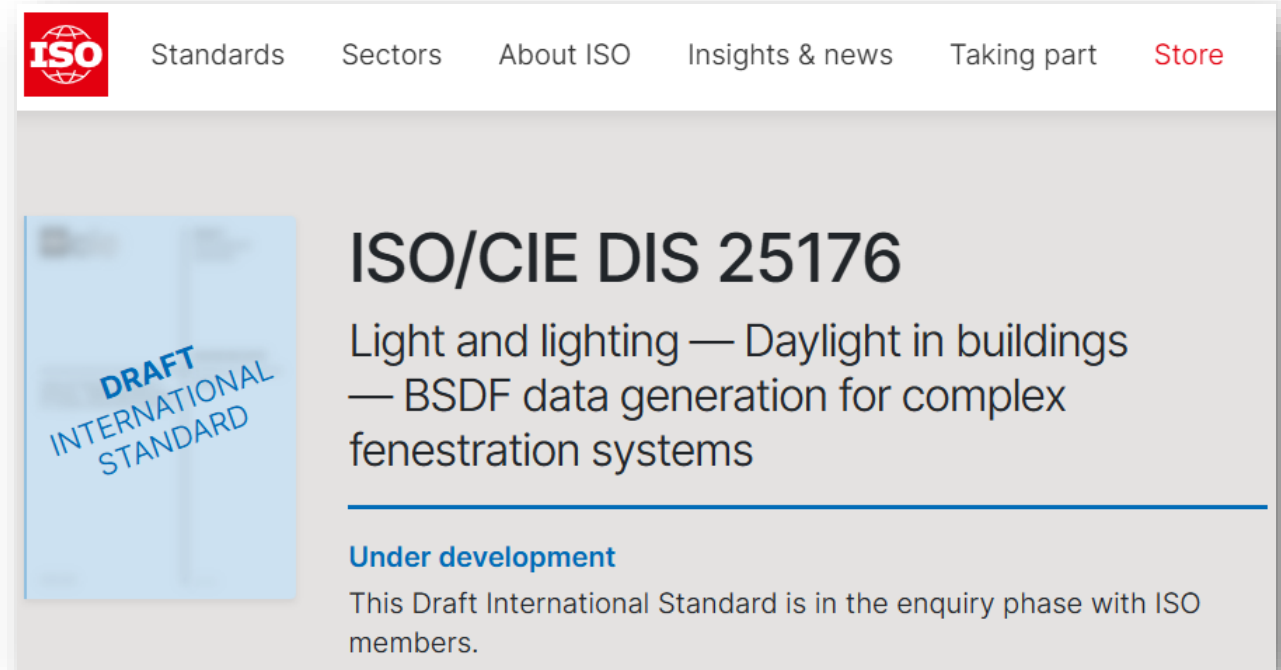
- Photometry of window / shading / daylighting systems
- Analogon to luminous intensity distributions for daylighting systems
- Distribution on the interior side as function of the exterior



BSDF Data Generation: ISO/CIE Standardization

ISO/CIE DIS 25176: “BSDF data generation for complex fenestration systems”

- Draft International Standard (DIS)
- DIS ballot: starting soon
- Publication of standard: target date: 20.06.2027



ISO Standards Sectors About ISO Insights & news Taking part Store

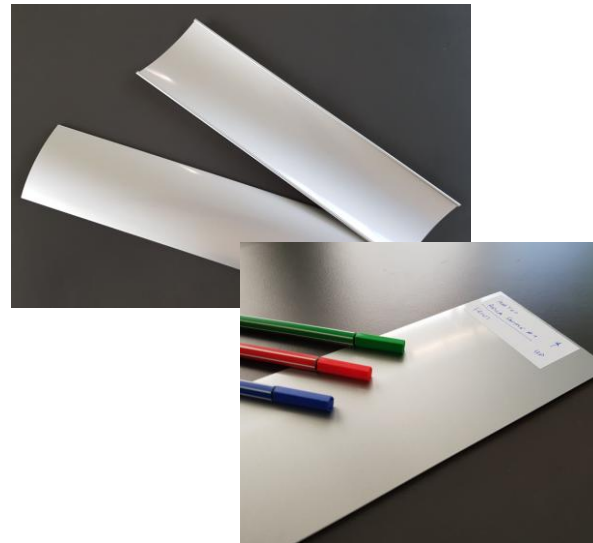
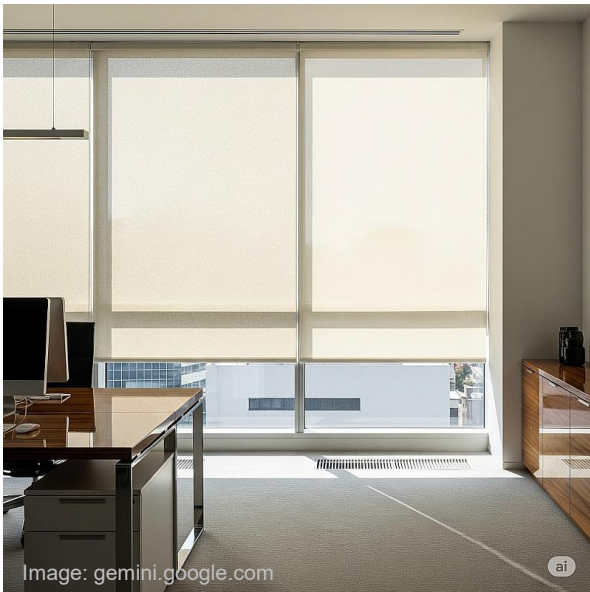
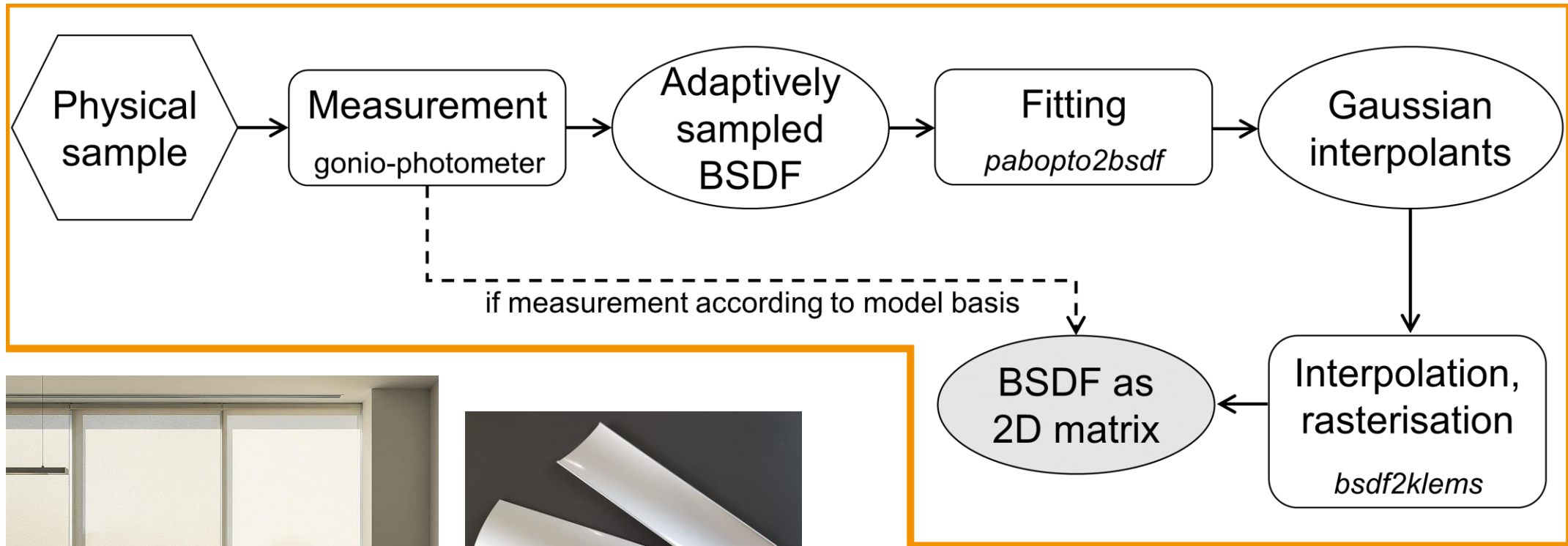
ISO/CIE DIS 25176

Light and lighting — Daylight in buildings
— BSDF data generation for complex
fenestration systems

Under development

This Draft International Standard is in the enquiry phase with ISO members.

BSDF Data Generation: ISO/CIE Standardization



Measurement-based | Microscopic systems

BSDF Data Generation: ISO/CIE Standardization

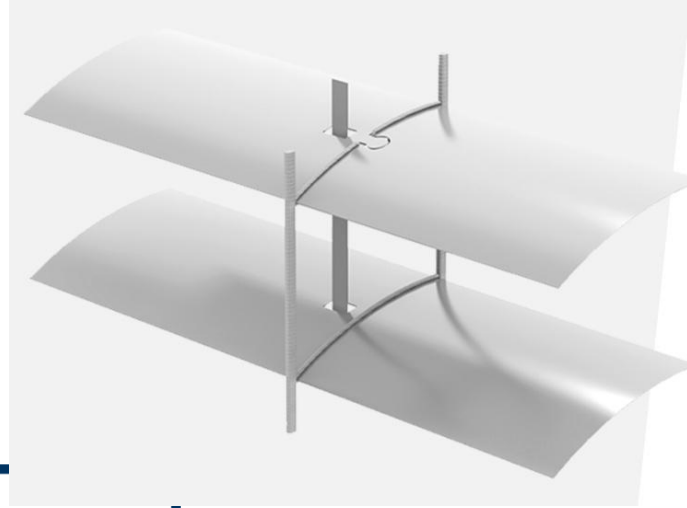
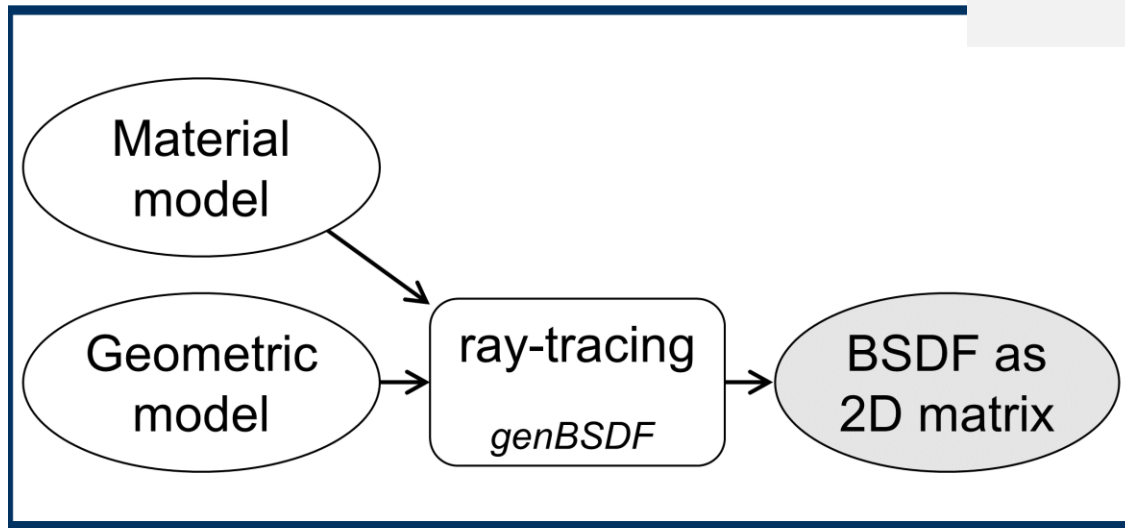
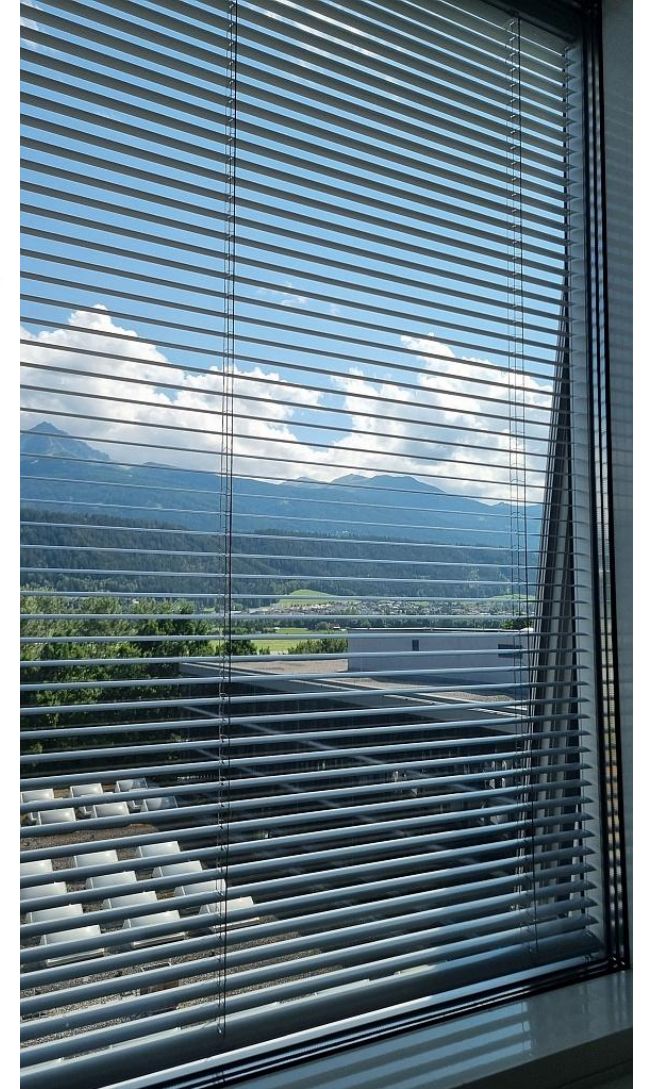
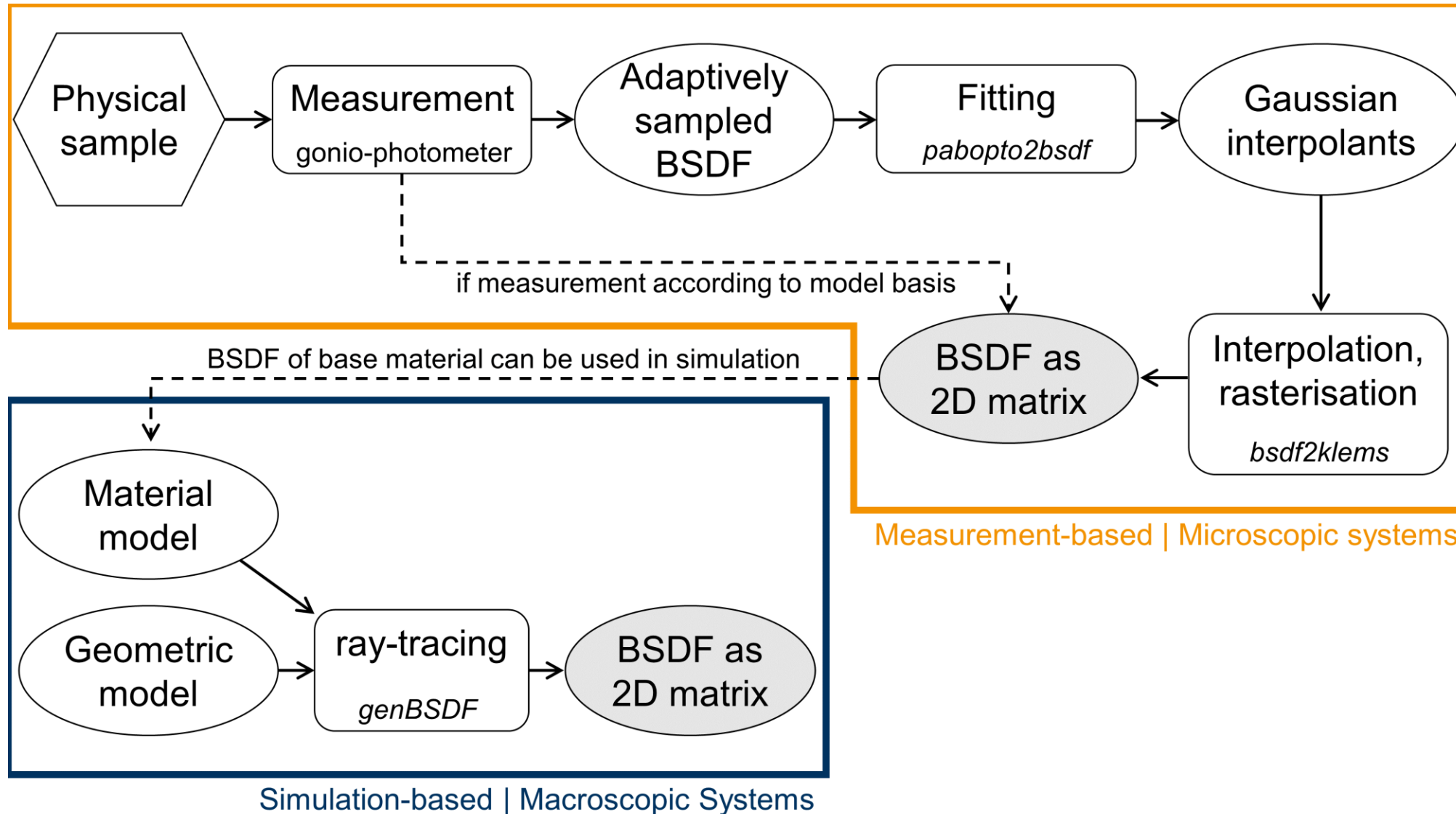


Image: www.hella.info

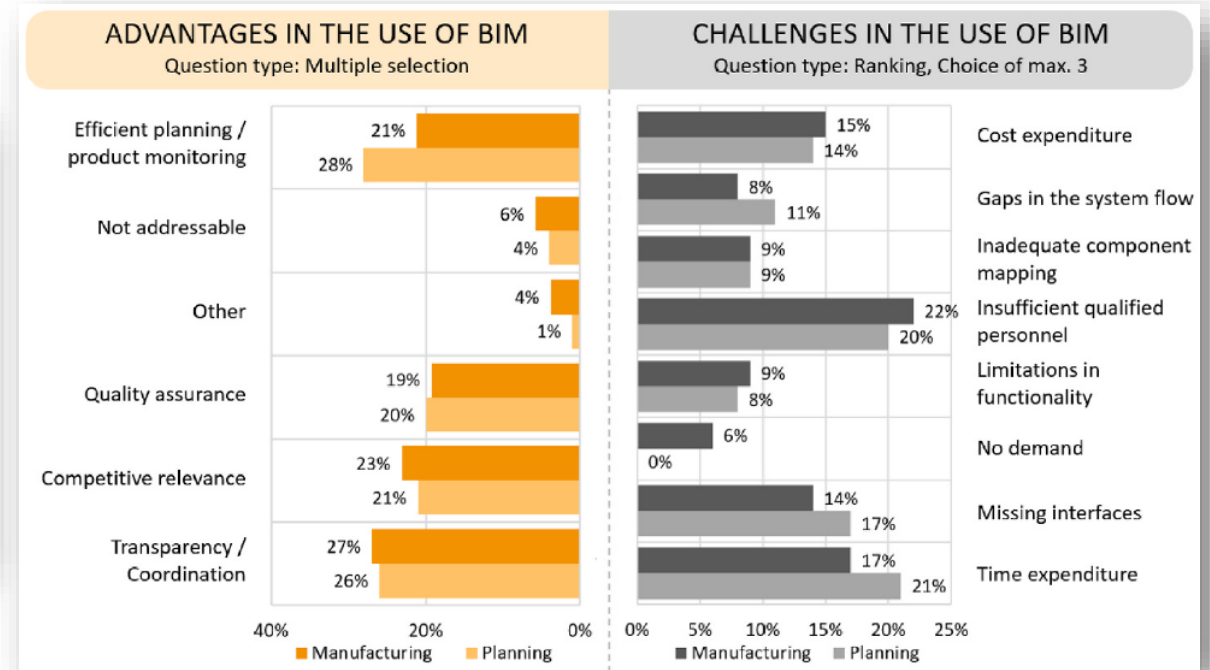
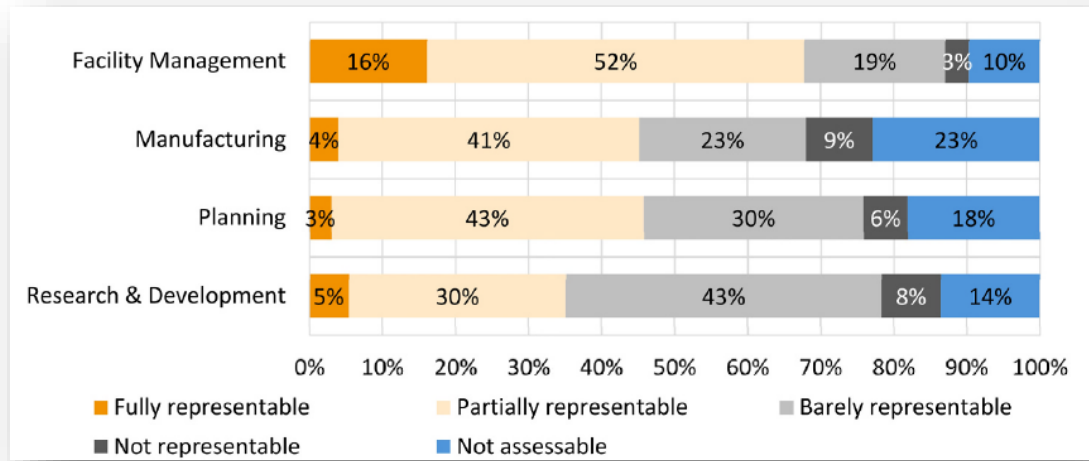


Simulation-based | Macroscopic Systems

BSDF Data Generation: ISO/CIE Standardization



BIM-based and user-centred lighting control

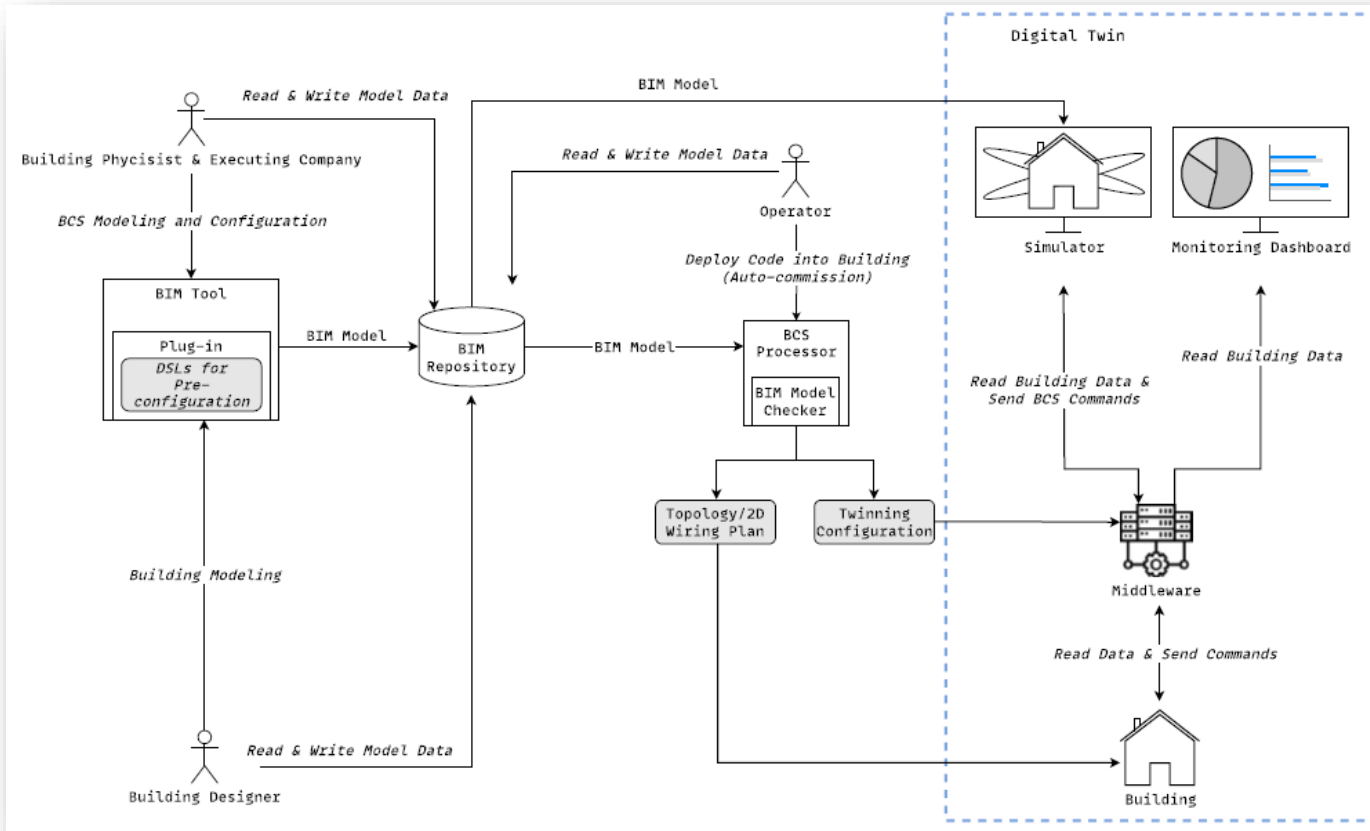


Highlights

- Solution concepts from two literature reviews compared to market demands.
- Survey results on Building Information Modelling and controls from 165 responses.
- Identification of methods for more user-centricity and greater energy efficiency.
- Necessary tools, interfaces, and systems for more efficient building operation.
- Evaluation of the influence of interest groups on the design of building controls.

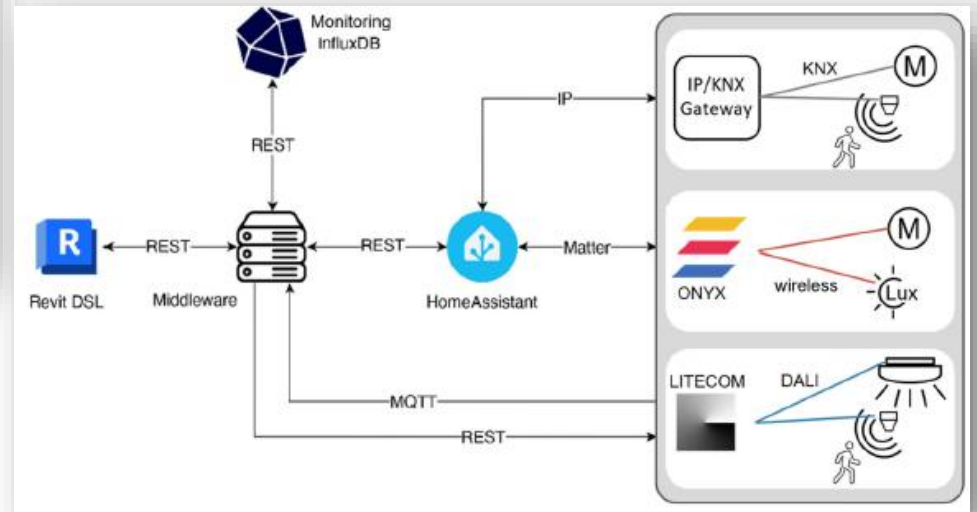
Hammes S, Geisler-Moroder D, Weninger J, Zech P, Pfluger R, **Market demands vs. scientific realities: A comparative analysis in the context of BIM-based and user-centred lighting control**, Developments in the Built Environment, Volume 19, 2024, 100526, <https://doi.org/10.1016/j.dibe.2024.100526>.

From BIM to Digital Twin




Highlights

- Graphical DSL for building control system preconfiguration in the BIM planning process.
- Simulation-based assessment of building control systems.
- Auto-commissioning of building control systems from BIM models.
- Auto-commissioning of an IT infrastructure for digital twinning for data-driven simulation.



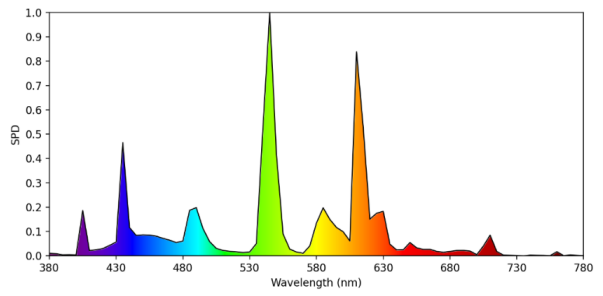
Zech P, Hammes S, Goldin E, Geisler-Moroder D, Breu R, Pfluger R, **From BIM to Digital Twin: A transformation process through advanced control modeling and automated commissioning using daylight and artificial lighting as examples**, Energy & Buildings 329, 115184, 2025. <https://doi.org/10.1016/j.enbuild.2024.115184>

Hyperspectral lighting simulations in Radiance



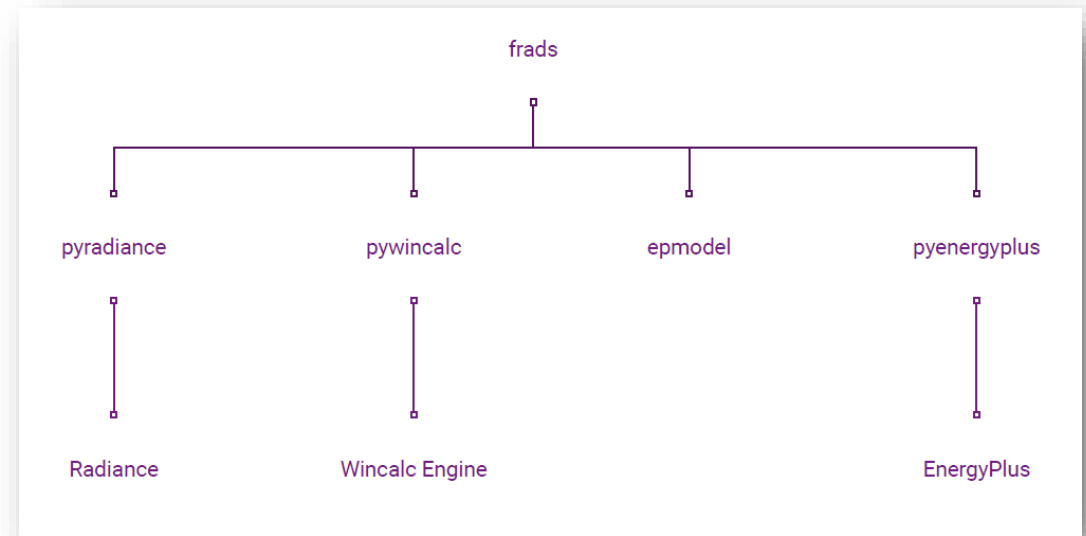
Hyperspectral Rendering in Radiance

Greg Ward, Anywhere Software



Highlights

- Hyperspectral rendering capability
- C++ class hierarchy
- pyradiance & frads Python interfaces



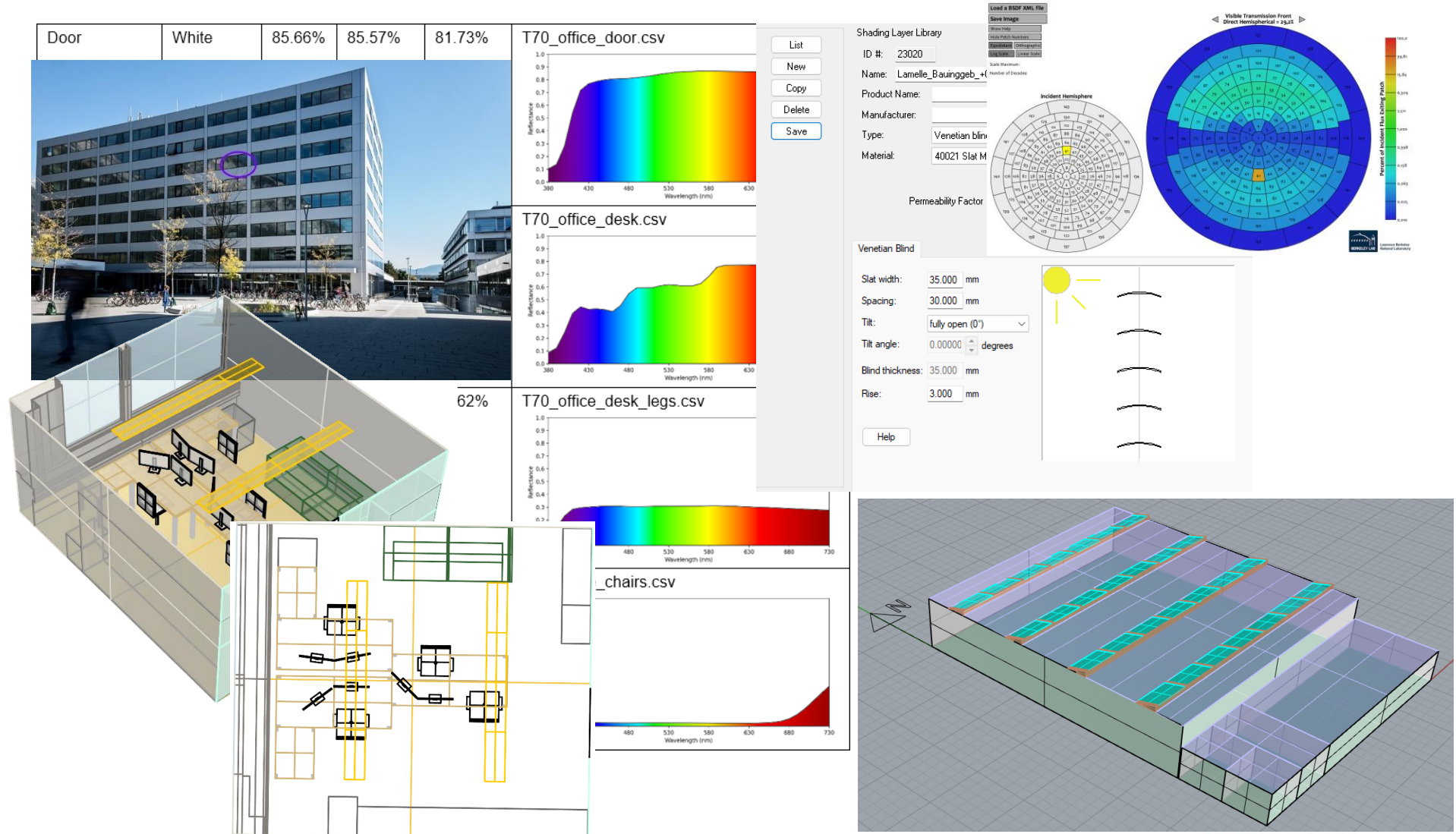
Ward G, Ward T, *Hyperspectral Rendering in Radiance*, 22nd Int. Radiance Workshop, Salt Lake City, Utah, August 26-28, 2024, https://www.radiance-online.org/community/workshops/2024-salt-lake-city-presentations-1/M01_HyperSpecRadTutorial.pdf

Reference Rooms for Integrative Lighting Simulations

2 Rooms (Office, factory hall)

Full spectral definition

Dataset available on Zenodo and presented in Data In Brief article (under review)



Virtual reality in lighting design

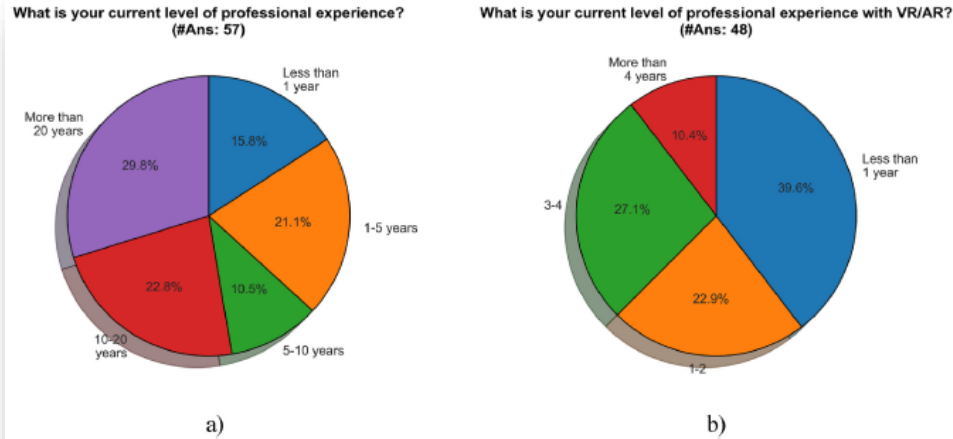


Fig. 2. Demographics and general VR use results: a) level of professional experience and b) level of professional experience with VR/AR. The difference in the number of answers in the two graphs is due to the fact that 9 people learnt or acknowledged VR but did not use VR in practice.

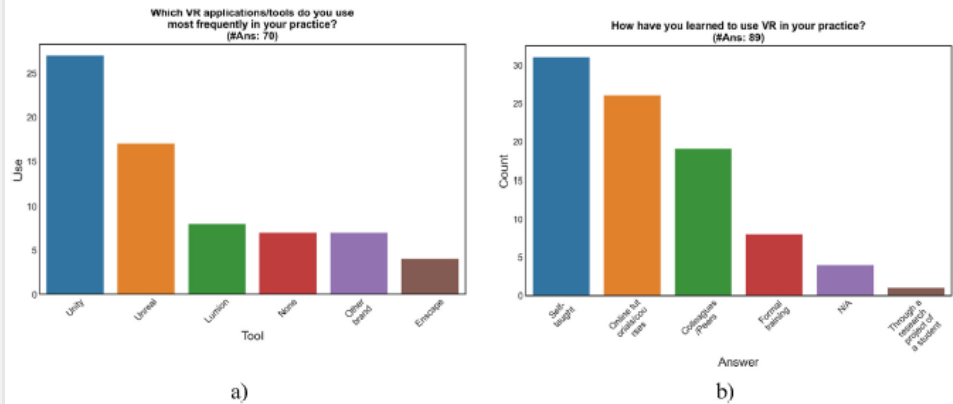


Fig. 3. a) Used VR tools and b) how VR was learned.

Scorpio M, Bladowski A, Geisler-Moroder D, Martyniuk-Pęczek J, Sibilio S, Pfluger R, Sokół N, **Virtual reality in lighting design: Insights from academia and an international survey among professionals**, Journal of Building Engineering 102, 112036, 2025. <https://doi.org/10.1016/j.jobe.2025.112036>

Highlights

- Virtual Reality for lighting: status in academia vs. professionals' use.
- International survey to investigate the views of professionals.

- Virtual reality as promising tool for lighting designers but rarely adopted.
- Accuracy of light distribution in virtual reality expected by professionals.
- Simple, intuitive, and open-source virtual reality tools required.

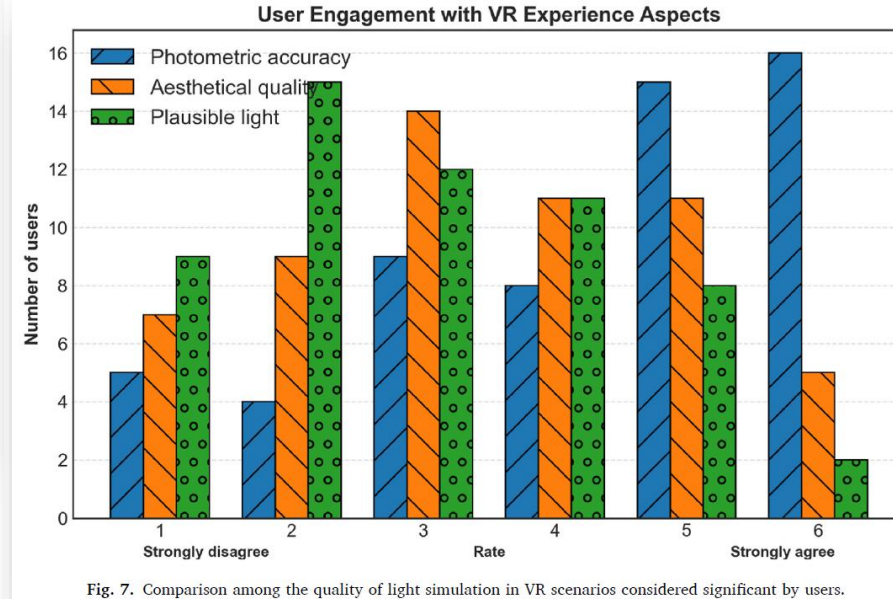


Fig. 7. Comparison among the quality of light simulation in VR scenarios considered significant by users.

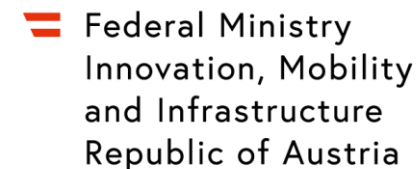
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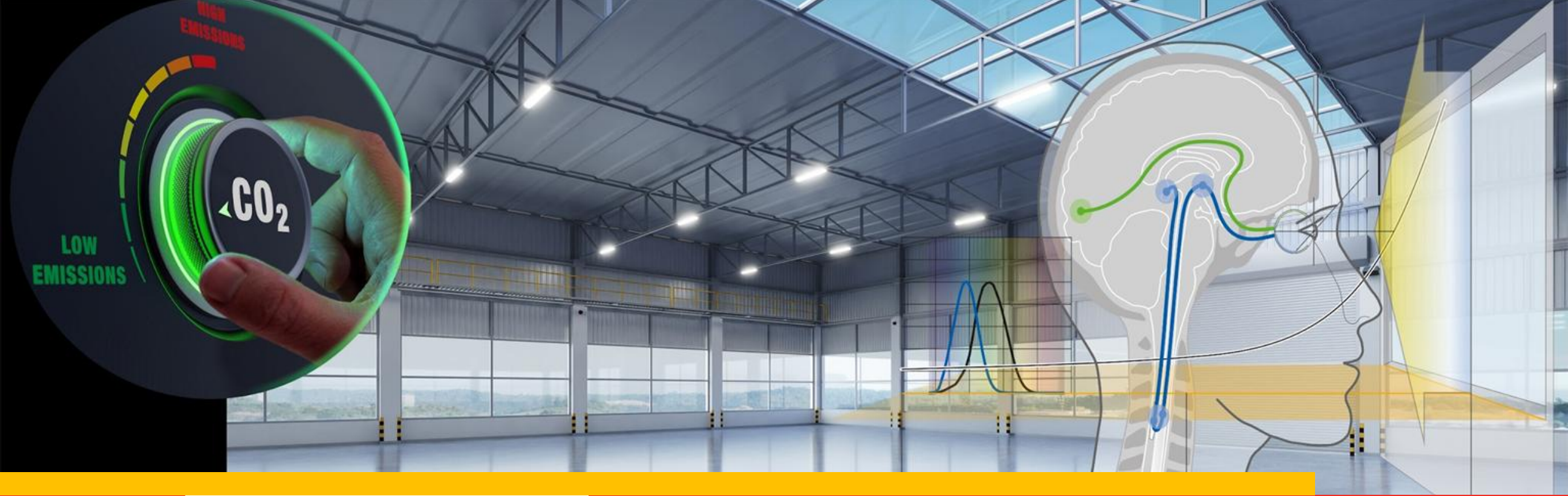
Funding

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