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Regulations and certification systems on Daylighting performance metrics in workspaces

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Abstract. This study examines the inconsistencies between scientific advances in daylight metrics and their implementation in the regulations and certification standards governing workplace design. Over the last decades, climate-based daylight metrics (CBDMs) have become prevalent in research, since this measure provides a more realistic representation of annual daylight variations. Added to CBDMs, novel metrics including perceptual metrics and indicators of the non-visual effects of daylight have been developed. However, the implementation of advanced metrics in building regulations and standards is still limited and inconsistent with advanced approaches. A structured comparative study was conducted to assess the alignment of lighting regulations and certification standards with scientific evidence. Our analysis was focused on the type, temporal dimension and role of metrics in laws, standards and certification standards. Our results demonstrate a structural mismatch: whereas dynamic, perceptual and circadian metrics are increasingly used in studies, their implementation in regulations and standards is still limited. Certification standards serve as a stepping stone to the incorporation of advanced metrics into regulations. We need to advance towards a more consistent and integrative use of daylight performance metrics combining the visual, perceptual and physiological dimensions of natural light to align building regulations and design practice with scientific knowledge.

Keywords: Daylight metrics, climate-based daylighting, workspaces, building lighting standards, building certification systems.

1. Introduction

The evidence currently available on the impact of daylighting performance on visual comfort, occupant well-being [1] and energy efficiency [2] in workspaces has led daylighting performance assessment to become a crucial factor in architectural design.

Over the last decades, research studies have consistently underscored the limitations of traditional static metrics while supporting the alternative use of CBDMs for a more realistic representation of annual natural light variations [3]. In parallel, daylight evaluation approaches have extended beyond merely photometric criteria to progressively include novel perceptual, user-centered metrics and indicators of the non-visual effects of daylight.

However, the consolidation of advanced approaches in recent research has not fully translated into their consistent integration in regulations and certification standards. These findings raise concerns about the alignment between scientific evidence and regulatory and design practices.

Taking the findings of Entrena-Martínez et al. [4] as a reference, we conducted a comparative study of widely accepted daylighting performance metrics in the recent literature and the metrics implemented in the regulations and certification standards currently in force.

2. Methods

A structured comparative study was carried out to assess the alignment of the criteria adopted in building lighting regulations and certification standards with the evidence provided in the scientific literature. This study does not provide new estimations or quantifications, but it takes the results of the systematic review conducted by Entrena-Martínez et al. [4] as the scientific framework of reference.

A. *Scientific framework of reference*

This study is based on the results reported by Entrena-Martínez et al. [4]. The authors identified and classified the metrics used in the recent literature to assess daylighting performance in workspaces into four categories: static metrics; climate-based daylighting metrics (CBDMs); occupant-centered perceptual metrics; and metrics for the non-visual effects of light. The systematic review by Entrena-Martínez et al. [4] revealed that annualized CBDMs have become predominant in the literature, whereas perceptual and circadian metrics still demonstrate limited integration. For the purposes of our study, these conclusions were assumed to outline the

state of affairs in this field and were not reconsidered in our study.
Table 1 summarizes the relevant metrics identified and defines acronyms, categories and relevant literature references. New evaluations or reinterpretations are not provided.

Table I. - Summary and classification of daylight performance evaluation metrics in workspaces, as identified by Entrena-Martínez et al. [4].

METRIC		REFERENCES
STATIC METRICS		
Em	Mean horizontal illuminance at the workplane	[2],[5]-[17]
U□	Illuminance uniformity	[2],[6],[8],[10],[13],[17]
DF	Daylight Factor	[1],[6],[10],[18]
CLIMATE-BASED DAYLIGHT METRICS		
DA	Daylight Autonomy	[5]-[6],[19]-[22]
DAo.con	Continuous Overcast Daylight Autonomy	[20]
sDA	Spatial Daylight Autonomy	[1]-[2],[5],[9],[12]-[13],[20]-[33]
UDI	Useful Daylight Illuminance	[1]-[2],[6],[8],[10]-[11],[18]-[24],[27],[29]-[31],[34]-[44]
sUDI	Spatial Useful Daylight Illuminance	[17],[21]
ASE	Annual Sunlight Exposure	[9]-[10],[13],[19]-[20],[22]-[23],[26]-[28],[30]-[31]
DGP	Daylight Glare Probability	[2],[6],[8],[11]-[12],[17],[19],[29],[32]-[34],[40]
DGPs	Simplified Daylight Glare Probability	[42]
GA	Glare Autonomy	[19]
sGA	Spatial Glare Autonomy	[12],[17]-[19],[29],[33]-[34]
UOD	Uniformity of Daylight	[32]
VF	Visual-effective Frequency	[7]
PERCEPTUAL METRICS		
pDA	Perceptual Daylight Autonomy	[6]
spDA	Spatial Perceptual Daylight Autonomy	[6]
EVQ	Exterior View Quality	[1],[16],[42],[45]
NON-VISUAL METRICS		
Ev	Vertical illuminance at eye level	[1],[14],[16]
EML	Equivalent Melanopic Lux	[11]
m-EDI	Melanopic Equivalent Daylight Illuminance	[1],[7],[11], [46]
CF	Circadian Frequency	[1],[7]
CSA	Circadian Stimulus Autonomy	[20],[31]
DVIA	Daylight Vertical Illuminance Availability	[33]

These metrics constitute the scientific framework of reference for our comparative analysis of building lighting regulations, standards and certification systems.

B. Scope and comparative criteria

This study examines the consistency between predominant metrics in the literature and their level of integration into prescriptive building regulations and non-mandatory certification systems that respectively govern and guide daylighting design in workplaces. We selected the most relevant regulatory policies and certification standards in professional practice that include natural lighting requirements.
The aspects considered included the type, temporal dimension and role of metrics in laws, standards and certification systems, with special attention paid to the level of integration of CBDMs and non-visual metrics. The objective of this study was to identify consistencies, inconsistencies and underlying discrepancies between the latest scientific evidence and its integration into regulatory policies and certification schemes.

3. Regulatory framework for daylighting performance evaluation metrics for workspaces

Daylighting performance evaluation is governed by a set of national and international laws, codes and non-mandatory standards regulating indoor lighting design and evaluation in workspaces. This Section analyses the metrics implemented in regulatory documents for assessing natural lighting in workplaces.

A. Spanish and European regulatory framework governing lighting in workspaces

The UNE-EN 12464-1:2022 [47], which entirely adopts EN 12464-1:2021 [48], establishes indoor illuminance thresholds for workplaces. This standard of reference is used to demonstrate compliance with the lighting requirements established in Spanish Royal Decree 486/1997 [49]. This document sets Minimum Maintained Average Illuminance ($\bar{E}m$) thresholds for each type of visual task, along with Minimum Illuminance Thresholds for surrounding and background areas. In the two cases, overall uniformity (U□) thresholds are provided to avoid excessive lighting contrast across areas and ensure even light distribution on the workspace. Additionally, UNE-EN 12464-1:2022 incorporates Maintained Average Cylindrical Illuminance ($\bar{E}m,z$), relevant to facial expression visibility and three-dimensional perception. Minimum thresholds are additionally established for Vertical Wall Illuminance ($\bar{E}m,wall$) and Horizontal Ceiling Illuminance ($\bar{E}m,ceiling$). These parameters are included in the formulas for evaluating average environment illuminance, which is crucial for spatial perception.
It is worth noting that only a part of these metrics can be directly applied to daylighting or mixed lighting performance evaluation. Strictly photometric parameters; including Average Illuminance; Cylindrical Illuminance; Wall and Ceiling Illuminance; and Surrounding Illuminance, can be implemented regardless of the type of light source. Additionally, metrics such as Overall Uniformity (U□); Unified Glare Rating (UGR); Color Rendering Index (Ra); Special Color Rendering Index (Ri); and Correlated Color Temperature (Tcp) are primarily applied to artificial lighting. These metrics are calculated assuming a stable, controllable illuminance

distribution, whereas natural light distribution varies across time and space.

Along with the Spanish Technical Building Code (CTE) [50], UNE-EN 12464-1 is one of the most widely adopted standards for indoor illuminance design and evaluation in workspaces. However, these documents do not define specific daylighting performance evaluation metrics. In the CTE, lighting performance is mostly addressed in terms of energy efficiency. This Code sets minimum energy efficiency thresholds for lighting installations (VEEI_lim) and maximum thresholds for the total installed power of lamps and auxiliary equipment per unit of illuminated area (PTOT/STOT). Moreover, the use of artificial lighting control and modulation systems is compulsory, which is applicable to mixed lighting conditions. The CTE requires the installation of adjustable daylight harvesting systems that adjust to the available natural light to ensure adequate illumination levels under the conditions defined by law.

B. Spanish and European regulatory framework for daylight performance evaluation

UNE-EN 17037:2020+A1 [51], which adopts EN 17037:2018+A1:2021 [52], defines a standardized methodology for evaluating natural light performance in built spaces.

This standard establishes the Target Illuminance (ET) and Minimum Target Illuminance (ETM) levels that should be achieved for at least 50% of the daylight hours in a year across a specified percentage of the working plane area. Certainly, ET and ETM illuminance criteria introduce spatio-temporal conditions comparable to those considered in some sDA thresholds; however, ET and ETM differ conceptually and methodologically from CBDMs and cannot be considered to be equivalent.

UNE-EN 17037:2020+A1 also includes Daylight Glare Probability (DGP) for evaluating glare from sunlight. Additionally, this standard establishes criteria for assessing exterior view quality based on horizontal view angle, distance from external view, and number of layers visible. Sunlight exposure is also evaluated on the basis of a minimum time of sunlight exposure on a given date in uncovered sky conditions.

In Spain, the non-mandatory standard UNE-EN 17037 is commonly applied as a complementary reference to the Technical Building Code (CTE) [50].

C. International regulatory framework for daylighting performance evaluation

A variety of international regulatory documents establish procedures for assessing performance in daylighting based on the latest scientific evidence. The American National Standard ANSI/IES LM-83-23 [53], a national ANSI-approved standard released by the Illuminating Engineering Society (IES), is the standard of reference in USA. This standard explicitly incorporates CBDMs, more specifically sDA and ASE, into annualized hourly models and probabilistic criteria.

The ISO/CIE 8995-1:2025 standard [54] establishes lighting requirements for indoor workspaces that are applicable to artificial, mixed or natural lighting. Moreover, the standard integrates the Melanopic Equivalent Daylight Illuminance (m-EDI) metric, an indicator of non-visual light effects.

In China, the GB/T 5699-2025 [55] standard, which replaces GB/T 5699-2017, contemplates static daylighting metrics as DF and introduces Uniformity Ratio of Daylighting, as well as non-visual indicators and exterior view quality requirements.

4. Environmental and occupant well-being certification systems: Integration of daylight metrics

Daylight availability and performance evaluation metrics have recently been incorporated into diverse environmental and occupant well-being certification standards. The variety of methods and approaches adopted highlight differences in daylighting techniques and performance thresholds. These non-mandatory certifications have contributed to the progressive incorporation of advanced metrics into professional practice.

In the field of energy efficiency and sustainability, LEED v5 certification (Leadership in Energy and Environmental Design) [56] is the most consolidated example of CBDMs integration. This certification standard explicitly makes reference to the provisions set forth in IES LM-83-23 as guidance for evaluating daylighting performance. Moreover, this standard defines sDA and ASE as quantitative indicators in credit EQc2: *Occupant Experience.* In addition, it establishes the distance between regularly occupied areas and envelope glazing. By adopting hourly daylighting modeling and probabilistic criteria, LEED v5 certification directly translates CBDMs from the scientific literature into daylighting performance evaluation practice.

Credit Hea-01: *Natural Light* of BREEAM New Construction v7 (Building Research Establishment Environmental Assessment Method) certification system [57] established a variety of methods for evaluating daylighting performance, including verification approaches based on daylight illuminance thresholds, EN 17037 requirements, and IES LM-83-23 climate-based daylight metrics, as specified in guidance note GN50 0.0.

The WELL Building Standard v2 [58] relies on IES LM-83 indoor daylighting evaluation metrics along with EN 17037 requirements. This standard additionally considers the circadian effects of daylight and includes quantitative metrics such as Equivalent Melanopic Lux (EML) and m-EDI based equivalent formulations. Moreover, this standard includes prescriptive spatial and façade design requirements to optimize daylighting performance in occupied spaces.

In other certification systems, a combined approach is adopted. An example is Fitwel v3, Section 07: *Workspaces-Daylighting Access* [59], which defines two alternative methods to verify daylight availability: based on compliance with defined design requirements or through modeling-based assessment methods; in the latter, sDA is used as an objective way to verify the percentage of an area that receives sufficient daylight.

Living Building Challenge 4.1 [60] establishes daylight availability and visual comfort requirements according to daylighting design and geometrical verification criteria. A comparable approach is adopted by Green Globes (United States and Canada) [61] and Ascent (outside the US and Canada) [62], which additionally define the use of DF as a quantitative daylight performance indicator.

5. Discussion

This study assesses consistency between the most commonly-used daylighting performance metrics in the recent literature and their selective incorporation into building regulatory frameworks. The results highlight that building laws and standards are not systematically updated on the basis of the latest scientific evidence.
The study conducted by Entrena-Martínez et al. [4] revealed that CBDMs have become essential for annualized daylight performance evaluation. The use of UDI, sDA, ASE and DGP is widespread in the literature; however, the implementation of these indicators in building regulations and standards is still partial and inconsistent.
Our findings indicate that current regulations partially incorporate advanced metrics and rely on evaluation approaches that differ from those commonly used in research. Whereas a dynamic, probabilistic, annual approach is adopted in research, regulations priorizite prescriptive, static, threshold-based criteria. As summarized in Figure 1, certification standards lie at an intermediate point.

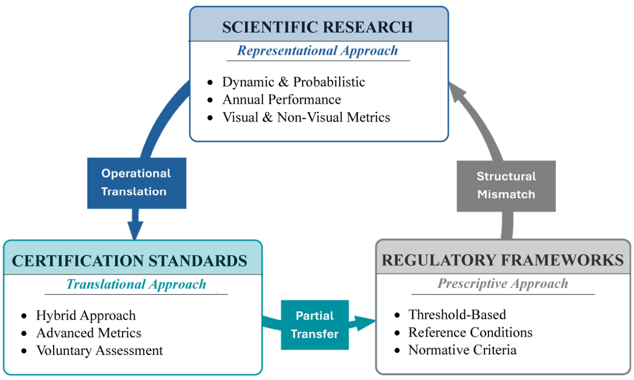

Fig. 1. Structural relationships between approaches to daylight performance assessment

These discrepancies do not stem from a lack of robust evidence supporting the usefulness of CBDMs; rather, the limited incorporation of advanced metrics in laws and regulations is due to the fact that regulatory norms prioritize stable, simple and universally-applicable criteria over multi-parametric modeling of variable phenomena such as daylight. In consequence, mandatory building regulations adopt a prescriptive approach based on thresholds and standard situations, rather than on an integrative and continuous evaluation of daylighting performance thorough a year.
This rigid approach partially explains the limited implementation of such widely-used metrics in the literature as UDI. Translating this metric into unequivocal prescriptive criteria is hindered by its multi-parametric nature, added to its reliance on evaluator's interpretation.
By integrating advanced metrics into daylighting performance evaluation guidelines, certification systems provide the intermediate step towards the transfer of scientific evidence into mandatory regulations. LEED and BREEAM, among others, have contributed to the integration of CBDMs, primarily sDA and ASE, into daylighting practice, albeit with disparate scopes, levels of enforceability and verification methods. Unlike other certification systems, the WELL Building Standard incorporates EML-based α-opic indicators, thereby integrating physiological dimensions into daylighting evaluation.
This comparative study reveals an inconsistent usage of CBDMs across research studies, building regulatory frameworks and certification systems. This finding highlights the necessity of developing a theoretical framework that ensures a consistent use of daylighting performance evaluation metrics across their different levels of application. The partial and inconsistent use of visual, non-visual and perceptual metrics hinders cross-study comparability and limits the effective transfer of scientific knowledge into practice and regulatory and certification procedures.

6. Conclusion

This study assesses the level of consistency between the most widely-used daylighting performance evaluation metrics for workspaces in recent research studies and the metrics adopted in relevant regulatory frameworks and certification systems. Taking the study of Entrena-Martínez et al. [4] as a reference, we concluded that although CBDMs are widely applied in research studies, their incorporation into daylighting regulations, standards and certification systems has been partial and inconsistent. This finding underscores the lack of a fully structured theoretical framework for a consistent transfer of scientific evidence into regulatory and certification schemes.
This state of affairs is not due to the lack of solid evidence on the effectiveness of CBDMs, but to their challenging transferability to regulatory and certification procedures, which seek to establish clear, verifiable and universally-applicable criteria. Certification standards operate as an intermediate step for the evidence-based integration of advanced metrics in daylighting design practice, although the use of non-visual metrics is still limited.
It is necessary to advance towards a more integrative theoretical framework that ensures the consistent implementation of visual, perceptual and physiological daylighting performance metrics across research studies, professional practice, regulatory frameworks and certification standards.
Reducing this gap is crucial to improve methodological consistency and ensure the alignment of design practices with scientific knowledge on daylight variations and effects on human well-being.

References

[1] J. Xu, Y. Gao, Y. Wu, “The visual and non-visual effects of annual daylighting performance on middle school students: A longitudinal field survey of classrooms in

Eastern China", Energy and Buildings (2025). Vol. 331, no. 115364.
[2] A. Mesloub, M.M. Alnaim, G. Albaqawy, K. Elkhayat, R. Hafnaoui, A. Ghosh, M.S. Mayhoub, "The Daylighting Optimization of Integrated Suspended Particle Devices Glazing in Different School Typologies", Buildings (2024). Vol. 14, no. 2574.
[3] J. Mardaljevic, "Examples of climate-based daylight Modelling", CIBSE National Conference 2006: Engineering the Future (2006). No. 67.
[4] I. Entrena-Martínez, A. Castillo-Martínez, A. Peña-García. "Metrics for assessing daylight performance in workspaces: A systematic review of research approaches", 24th International Conference on Renewable Energies and Power Quality (ICREPQ'26) (2026). In press.
[5] L. Arango-Diaz, N.G. Vasquez, B.P. Moreno, "Advancing on a dynamic metric to assess daylight sufficiency based on people's perception of daylight availability in the tropics" Building and Environment (2025). Vol. 282, no. 113209.
[6] E.A.M.S. AL-Mowallad, X. Huang, Z. Lu, X. Li, K. Wu, Z. Zhu, G. Liu, "Assessment and Improvement of Daylighting Quality in Classrooms with Double-Side Windows", Buildings (2024). Vol. 14. no. 3501.
[7] H. Hao, J. Xu, L.J.M. Schlangen, "Evaluation and optimization of annual light variations for visual and non-visual effects within a ground-floor middle school classroom", Journal of Building Engineering (2024). Vol. 98, no. 111293.
[8] A. Ibrahim, M. Alsukkar, Y. Dong, P. Hu, "Investigations for the daylighting performance of trapezoid profile shadings using multi-objective optimization", Journal of Building Engineering (2025). Vol. 99, no. 111645.
[9] H. Li, J. Jia, H. Yu, X. Wang, "Research on the daylighting metrics of college classrooms based on visual comfort in China", Journal of Building Engineering (2024). Vol. 98, no. 111178.
[10] X. Mo, O. Pons-Valladares, S.I. Ortega Donoso, "Model to Improve Classrooms' Visual Comfort Using Waste-Based Shading and Its Validation in Mediterranean Schools", Sustainability (2024). Vol. 16, no. 10176.
[11] M.C. Noor, F.M. Saradj, S.A. Yazdanfar, "Optimal daylighting design for standard photopic and melanopic equivalent daylight illuminance, and glare minimization in Tehran classrooms", Journal of Building Engineering (2025). Vol. 105, no. 112104.
[12] L. Qi, J. Yang, L. Gong, W. Wu, C. Wu, "The impact of orientation changes in kindergarten activity rooms in different light climate zones of China on indoor daylighting environment", Scientific Reports (2024). Vol. 14, no. 28369.
[13] S. Sebayang, O.C. Dewi, T. Panjaitan, K. Rahmasari, M.R. Darmawiredja, R. Irwansyah, A.D. Ismoyo, A.M. Dugar, "Investigating perforated egg crates as dynamic shading systems for open-plan offices in tropical climates", Journal of Building Engineering (2024). Vol. 96, no. 110462.
[14] M. Tabatabaei Manesh, M. Rajaian Hoonejani, S. Ghafari Gousheh, A. Abdolmaleki, A. Nikkhah Dehnavi, A. Shahrashoob, "AI-driven control algorithm using machine learning and genetic optimization for enhancing visual comfort in adaptive façades", Automation in Construction (2025). Vol. 179, no. 106474.
[15] M.S. Tagueu, L.A. Madjou Tanekou, B. Ndzana, "Contribution of Daylighting to Saving Electrical Energy in Cameroon: Case Study of a Classroom in a Public School", Journal of Engineering (2025). No. 8196538.
[16] H. Xu, L. Zhang, Y. Zeng, L. Bergefurt, J. Xu, "Untangle the Effects of Classroom Environmental Features on Middle-School Students' Mood Perception with Machine Learning and XAI", Sustainability (2025). Vol. 17, no. 9459.
[17] W. Zhang, Z. Ma, H. Qiu, Y. Pan, Y. Shi, L. Zhang, "Machine learning-boosted multi-objective optimization of integrated shading systems: Enhancing daylight availability, glare protection, and energy savings", Building and Environment (2025). Vol. 280, no. 113124.
[18] Y. Song, H. Wang, "Optimization Potential of Side-Lit Windows for Energy and Daylight Performance of University Classrooms in Shanghai", Buildings (2024). Vol. 14, no. 3947.
[19] A. Alafchi, H. Sanaieian, M. Faizi, M. Mousaeipour, S.M.A. Hosseini, "Multi-objective optimization of parametric shading devices for atrium in libraries: Enhancing daylight and thermal performance in semi-arid climates", Case Studies in Thermal Engineering (2025). Vol. 76, no. 107288.
[20] G. García-Martín, M.Á. Campano, I. Acosta, P. Bustamante, "New Approaches in Dynamic Metrics for Lighting Control Systems: A Critical Review", Applied Sciences (2025). Vol. 15, no. 8243.
[21] J.M. Monteoliva, A. Villalba, S.M. Donato, A.E. Pattini, "Decision tree-based modeling of daylight availability for perimeter offices in the Southern Hemisphere", Journal of Building Engineering (2025). Vol. 114, no. 114287.
[22] E. Ukpong, F.O. Uzuegbunam, E.O. Ibem, E. Udomiaye, "Daylighting performance evaluation in tropical lecture rooms: A comparative analysis of static and climate-based metrics", Journal of Building Engineering (2025). Vol. 103, no. 112044.
[23] S.R. Aritonang, R.A. Mangkuto, Atthaillah, I. Prasetiyo, "Daylighting Design Optimization of Complex Fenestration Systems with External Shading and Horizontal Slats in Tropical Elementary School Classrooms", Journal of Architectural Engineering (2025). Vol. 31(1), no. 04025001.
[24] W. Bai, W. Guo, Y. He, Y. Wu, S. Liang, S. Zhang, "Research on the Optimization Design of the Atrium Space Form in University Libraries Based on the Coupling of Daylighting and Energy Consumption", Buildings (2024). Vol. 14, no. 2715.
[25] Y. Bian, Y. Zhou, S. Yang, D. Lin, Y. Ma, "Using machine learning algorithm to predict lighting energy consumption of daylight-linked lighting systems from spatial daylight autonomy", Energy and Buildings (2025). Vol. 341, no. 115847.
[26] N. de Queiroz, F.S. Westphal, "Graphic tool for thermal and daylight performance analysis of façades and definition of glazing type and horizontal shading devices in air-conditioned offices across three Brazilian climates", Ambiente Construído (2025). Vol. 25, no. e146292.
[27] J. Jayaram, L. Sundaram, "Evaluating the Effects of Vegetation on Daylight Performance: A Simulation-Based Study of Government School Buildings in the Hot–Humid Climate of Chennai, India", Buildings (2025). Vol. 15, no. 3231.
[28] T. Jebril, Y. Chen, S. Hamed, A. Hajjaj, "Lecture Notes in Civil Engineering - The Effect of Geometry Parameters on Daylighting of School Buildings in the Gaza Strip", Springer Nature Singapore (2024). Vol. 389, pp.553-561.
[29] S. Masoud, Z. Zamani, S.M. Hosseini, M. Mahdavinejad, J. Wang, "Enhancing Classroom Lighting Quality in Tehran Through the Integration of a Dynamic Light Shelf and Solar Panels", Buildings (2025). Vol. 15, no. 2215.
[30] T.K. Mukti, R.A. Mangkuto, N.P.A. Nitidara, "Assessing the future impact of climate change on daylighting performance in tropical school classrooms with various opening sizes and positions", Sustainable Energy Technologies and Assessments (2025). Vol. 82, no. 104515.
[31] C. Muñoz-Viveros, C. Rubio Bellido, A. Pérez-Fargallo, "Evaluation of energy and lighting in schools considering

solar protections", Energy Reports (2024), Vol. 12, pp. 1157-1177.
[32] H. Song, Y. Liu, Q. Deng, "A Two-Stage Generative Optimization Framework for "Daylighting Schools": A Case Study in the Lingnan Region of China", Buildings (2025). Vol.15, no. 3821.
[33] M. Wang, X. Peng, Y. Cai, "A multi-metric evaluation of classroom daylighting: Integrating myopia prevention and visual comfort", Journal of Building Engineering (2025). Vol. 99, no. 111616.
[34] S. Cai, L. Li, Z. Gou, "Optimizing open-plan office passive retrofits: A human-centric, climate-adaptive approach to lighting, thermal comfort, and energy savings", Building and Environment (2026). Vol. 287, no. 113894.
[35] T. Chen, L. Tan, "Multiobjective optimization of external shading for west facing university dormitories in Kunming considering solar radiation and daylighting", Scientific Reports (2025). Vol. 15, no. 21876.
[36] X. Du, X. Liu, F. Gao, Z. Zhou, "Energy saving and low carbon oriented renovation framework for educational buildings with Tianjin University case study", Scientific Reports (2025). Vol. 15. no. 28822.
[37] Y. Gao, S. Zhao, Y. Huang, H. Pan, "Multi-Objective Optimization of Daylighting–Thermal Performance in Cold-Region University Library Atriums: A Parametric Design Approach", Energies (2025). Vol. 18, no. 1184.
[38] F. Garzia, S. Verbeke, C. Pozza, A. Audenaert, "Lecture Notes in Civil Engineering - Quantifying Co-benefits of Building Automation: Effects of Shading Control on Visual Comfort, Well-Being, and Productivity in Office Buildings", Springer Nature Singapore (2025). Vol. 555, pp. 285–291.
[39] M.F. Islam, "Lecture Notes in Civil Engineering - Transforming Downtown Vancouver: Smart Glass Solutions for Energy-Efficient Office Building Envelopes and Well-Being", Springer Nature Singapore (2025). Vol. 553, pp. 550–557.
[40] J. Liu, Z. Li, Q. Zhong, J. Wu, L. Xie, "Multi-objective optimization of daylighting performance and energy consumption of educational buildings in different climatic zones of China", Journal of Building Engineering (2024). Vol. 95, no. 110322.
[41] A. Mesloub, R. Hafnaoui, M.H. Hassan Abdelhafez, T.E. Seghier, L. Kolsi, N. Ben Ali, A. Ghosh, "Multi-objective optimization of switchable suspended particle device vacuum glazing for comfort and energy efficiency in school typologies under hot climate", Case Studies in Thermal Engineering (2024). Vol. 61, no. 105039.
[42] S. Vanage, H. Dong, P. Guillante, N. Kunwar, K. Cetin, "Parametric model development for building input variables for lighting and shading controls for different building form factors", Science and Technology for the Built Environment (2025). Vol. 31, pp. 806–839.
[43] S. Xu, Y. Chen, J. Liu, J. Kang, J.F. Gao, Y. Qin, W. Tan, G. Li, "Comprehensive improvement of energy efficiency and indoor environmental quality for university library atrium—A multi-objective fast optimization framework", Frontiers of Architectural Research (2025). Vol. 14, pp. 449-470.
[44] W. Hao, J. Xu, F. Zhao, D.W. Sohn, X. Shi, "Integration of Photovoltaic Shading Device and Vertical Farming on School Buildings to Improving Indoor Daylight, Thermal Comfort and Energy Performance in Three Different Cities in China", Buildings (2024). Vol. 14, no. 3502.
[45] F. Binarti, N. Sekarlangi, M.K.V. Brilianto, B.R. Hakim, "EEG-Based Neurophysiological Responses to Classroom Window Views in Green Campus Settings", Journal of Daylighting (2025). Vol. 12, pp. 359-374.
[46] S.W. de Vries, M. Gkaintatzi-Masouti, J. van Duijnhovena, J. Mardaljevicb, M.P.J. Aarts, "Recommendations for light-dosimetry field studies based on a meta-analysis of personal light levels of office workers", Lighting Research and Technology (2025). Vol. 57, pp. 47-70.
[47] Asociación Española de Normalización (UNE), "UNE-EN 12464-1:2022. Luz e iluminación. Iluminación de los lugares de trabajo. Parte 1: Lugares de trabajo en interiores", UNE (2022).
[48] European Committee for Standardization (CEN), "EN 12464-1:2021. Light and lighting - Lighting of work places - Part 1: Indoor work places", CEN (2021).
[49] Gobierno de España, "Real Decreto 486/1997, de 14 de abril, por el que se establecen las disposiciones mínimas de seguridad y salud en los lugares de trabajo", Boletín Oficial del Estado (1997). Núm. 97.
[50] Gobierno de España, "Real Decreto 314/2006, de 17 de marzo, por el que se aprueba el Código Técnico de la Edificación", Boletín Oficial del Estado (2006). Núm. 74.
[51] Asociación Española de Normalización (UNE), "UNE-EN 17037:2020+A1. Iluminación natural de los edificios", UNE (2022).
[52] European Committee for Standardization (CEN), "EN 17037:2018+A1:2021. Daylight in buildings", CEN (2021).
[53] Illuminating Engineering Society (IES), "ANSI/IES LM-83-23. Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE). An American National Standard", IES (2023).
[54] International Organization for Standardization (ISO), International Commission on Illumination (CIE), "ISO/CIE 8995-1. Light and lighting- Lighting of work places- Part 1: Indoor", ISO/CIE (2025).
[55] State Administration For Market Regulation, National Standardization Management Committee, "GB/T 5699-2025. Method of daylighting measurements", National Standardization Management Committee (2025).
[56] US Green Building Council (USGBC), "LEED v5 Reference Guide. Building design and construction", USGBC (2025).
[57] BRE Global Ltd., "Guidance Note 50. Natural light calculation methodology", BRE Global Ltd. (2024).
[58] International WELL Building Institute (IWBI), "WELL v2", IWBI (2025).
[59] Center for Active Design (CfAD), "Fiwell v3", CfAD (2024).
[60] International Living Future Institute, "Living Building Challenge 4.1. Program Manual. A Visionary Path to a Regenerative Future", International Living Future Institute (2025).
[61] Green Building Initiative (GBI), "Green Globes Building Certification. Existing buildings 2025. Technical reference manual", GBI (2025).
[62] Green Building Initiative (GBI), "Ascent for existing buildings 2025. Technical reference manual", GBI (2025).