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Research Article

Optimising ADASY Components for Daylight Enhancement in Public Residential Building Retrofits

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Abstract

In many dormitory-style and communal residential buildings across Bangladesh, rooms are arranged along long corridors, making it difficult to open windows facing shared spaces due to privacy concerns. This results in insufficient daylight penetration, causing visual discomfort and adversely affecting occupants' physical and psychological well-being. Moreover, increased reliance on artificial lighting during daytime leads to higher energy consumption, contributing to the global energy crisis. Addressing these challenges in resource-constrained retrofit scenarios demands passive, low-intervention solutions. This study explores the effectiveness of the Active Daylighting System (ADASY), a modular, facade-integrated daylighting strategy for bringing natural light into deeper parts of buildings in the context of Bangladesh. Using Rhino-Grasshopper, Climate Studio, and the Octopus optimization tool, a parametric workflow is developed to optimize the geometry of ADASY's components- collector and ceiling-panel geometry for improved daylight penetration and reduced energy load. Results show substantial gains relative to the base case: spatial daylight autonomy increased from 44.44% to 100%, mean illuminance from 408 to 773 lux, and EUI decreased from 176 to 154.2 kWh/m^2·yr, with ASE remaining below threshold. A balanced solution was consistently found around a –15° collector truncation, 40° tilt, and –15° ceiling panels positioned ~0.7 m below the lintel. Two contributions emerge: extending ADASY from commercial to privacy-constrained residences, and optimizing ceiling geometry, which is pivotal for daylight distribution and energy trade-offs. Despite a single-room, short-window limitation, the workflow offers actionable parameters for low-intervention retrofits. Broader adoption could enhance occupant well-being, reduce grid demand, and support affordable, climate-responsive design across diverse building types.

Keywords: Daylighting; Anidolic systems; ADASY; Residential retrofit; Multi-objective optimization; Energy efficiency

Highlights

- Optimized ADASY lifts sDA to 100% and cuts EUI ~12% with no glare.
- Ceiling geometry matters: tuned panel tilt and height improve light spread.
- Transferable workflow enables low-cost, low-disruption daylight upgrades.

1 Introduction

Daylighting is central to sustainable design, reducing electric-lighting demand while improving visual comfort, health, and cognitive performance (Edwards & Torcellini, 2002). In dormitory and communal housing, deep plans and privacy along shared corridors restrict façade openings and daylight penetration, making low-intervention retrofits especially relevant in resource-constrained contexts (Edwards & Torcellini, 2002). Façade-integrated daylight-guiding systems—light shelves, ducts, and non-imaging anidolic devices—collect and redistribute light to deeper zones (Scartezzini & Courret, 2002; EPFL LESO-PB, n.d.). Within this family, ADASY combines exterior anidolic collectors with a ceiling light guide and extractors; its first built prototype was reported in Spain in 2012 (El-saggan et al., 2023).

Two gaps remain: limited evidence for residential, privacy-constrained South Asian typologies, and scarce multi-objective optimization to balance sufficiency, over-exposure, and energy (IES, 2012; Carlucci et al., 2015). Accordingly, a Rhino–Grasshopper workflow was developed coupling ClimateStudio with Octopus to optimize ADASY parameters under local climate, and Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE), Mean Illuminance with energy implications via EUI (IES, 2012; Solemma, 2023; Vierlinger, 2018) were evaluated.

To guide the analysis, two research questions were addressed

RQ1: How do ADASY geometries affect daylight sufficiency and spatial uniformity in corridor-side rooms?

RQ2: To what extent can optimized ADASY reduce electric-lighting demand (EUI) versus baseline?

By answering these questions, the paper aims to demonstrate that low-intervention, façade-integrated ADASY can be contextually optimized to improve daylight access and reduce energy use in public residential retrofits, offering a scalable pathway for healthier, more efficient living environments.

2 Literature Review

This study situates ADASY within current work on low-intervention daylight-guiding retrofits for privacy-constrained residences and dormitories. It synthesizes: (i) climate-based sDA/ASE metrics, (ii) non-imaging optics underpinning anidolic collectors/light ducts, and (iii) multi-objective optimization to balance daylight quality and energy. Building on recent standards and reviews (ANSI/IES, 2023; Sepúlveda et al., 2022; Wu et al., 2024; Zocchi et al., 2024), it motivates a context-specific conceptual model for Bangladesh.

2.1 Key Concepts

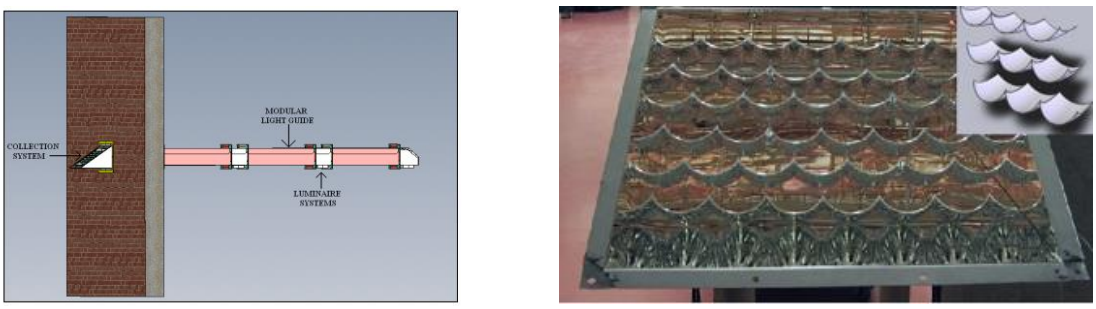
Daylighting sufficiency and over-exposure Spatial Daylight Autonomy (sDA300,50%) expresses the fraction of floor area achieving ≥300 lux for ≥50% of annual occupied hours (daylight sufficiency) while Annual Sunlight Exposure, ASE1000,250, following LM-83 conventions (IES, 2012; ANSI/IES, 2023) indicates the fraction of floor area exceeding 1000 lux for >250 h/year (potential over-exposure/glare risk) (IES, 2012). LEED v4/v4.1 recognizes sDA thresholds (e.g., 55%, 75%, 90%) with an ASE safeguard (≤10% area), which was adopted as interpretive benchmarks rather than compliance objectives (USGBC, 2024). Simulations were executed with a Radiance-based engine via ClimateStudio, which implements LM-83 and LEED daylight workflows (Solemma, 2025). Mean work-plane illuminance, is the average light level over a surface (CIE, 2010) was additionally used to assess distribution uniformity and complement area-based metrics during optimization process (Solemma, 2025)What to include.

Energy Use Intensity (EUI) is widely applied as a normalized indicator of whole-building energy performance, calculated by dividing total annual energy use by gross floor area (Borgstein, Lamberts, & Hensen, 2016; Energy Star, 2016). It is influenced by factors such as climate, heating and cooling loads, and occupancy schedules (Lakhdari, Sriti, & Painter, 2021). As EUI accounts for all major energy uses—including heating, cooling, and artificial lighting—it was adopted in this study as the primary optimization metric for energy consumption.

European daylight standard. EN 17037:2018 is the first Europe-wide daylight standard; it defines four aspects—daylight provision, view out, sunlight exposure, and glare—shifting practice beyond static daylight-factor checks. Recent assessments explore applicability and thresholds across climates and room types. (CEN/BSI, 2021; Sepúlveda et al., 2022; ClimateStudio Docs, 2024).

Anidolic daylighting and light-transport ducts. Anidolic systems are non-imaging optical devices that collect and redirect daylight using shaped reflectors (edge-ray/compound-parabolic principles) to improve back-of-room illuminance and uniformity while controlling glare. Recent work refines collector/curve design and integrates ducts, diffusers, and extractors; allied tubular daylight devices (TDDs) offer compact roof apertures with highly reflective guides. (Sorooshnia et al., 2023; Sreelakshmi et al., 2024; Fernandes & Regnier, 2023; Wu et al., 2024).

ADASY (Active Daylighting System). ADASY denotes a modular façade-integrated anidolic collector array feeding a horizontal ceiling duct with distributed extractors to deliver uniform, glare-controlled daylight deeper into plans with minimal structural intervention (Fig. 1a). The collector uses a truncated compound parabolic concentrator (T-CPC) structure, directing captured light through a highly reflective duct (*D. Vázquez-Moliní et al., 2013)*. The first built prototype was reported in Spain in 2012 within the EUREKA-3575 project led by the Lledó Group, in collaboration with Universidad Complutense de Madrid (El-saggan et al., 2023) (Fig. 1b). While the system lineage traces to prior anidolic and light-duct prototypes, its modular retrofit orientation distinguishes it for privacy-constrained housing. (El-Saggan et al., 2023; Wu et al., 2024).



(a) (b)

Figure 1. (a) ADASY's components scheme; (b) Prototype array collectors (Source: D. Vázquez-Moliní et al., 2013)

Privacy-constrained corridors. Long, enclosed corridors and shared-space façades limit conventional window openings in dormitory/public residential types, pushing daytime electric lighting. “Borrowed-light” corridor studies underscore the challenge and potential of optical guidance to penetrate deeper zones. (Abuzarifa et al., 2021).

2.2 Existing Theories and Frameworks

Non-imaging optics for architectural daylighting. Contemporary anidolic design leverages edge-ray theory to craft collectors/ducts with angular selectivity that harvest diffuse and low-altitude sun while limiting high-angle glare. Parametric and curve-optimization methods have been proposed to minimize reflections and losses and to tailor acceptance angles by climate/latitude. (Sorooshnia et al., 2023; Wu et al., 2024).

Performance standards and climate-based metrics. LM-83’s sDA/ASE and EN 17037 together form a dual lens—sufficiency/over-exposure and broader quality factors (view, glare, sunlight)—increasingly operationalized in simulation platforms (e.g., Radiance-based engines in ClimateStudio). The 2023 LM-83 update reaffirms hourly climate-based si

Daylight-guiding systems in retrofits. Recent reviews report strong potential of light pipes/TDDs and hybrid anidolic-duct systems to improve back-of-room illuminance and reduce lighting electricity when properly integrated with controls; however, performance varies with sky conditions, collector/diffuser combinations, and maintenance. (Wu et al., 2024; Sreelakshmi et al., 2024; Fernandes & Regnier, 2023). mulation as the reference for design evaluation. (ANSI/IES, 2023; IES, 2012; ClimateStudio Docs, 2024; CEN/BSI, 2021)

Parametric optimization and decision-support. Optimization is widely adopted in architecture to tackle complex design challenges (Lakhdari et al., 2021). It is the systematic search for extrema by adjusting variables within constraints (Machairas et al., 2014). Performance-based optimization combines parametric modeling, building-performance simulation, and genetic algorithms (Fang, 2017; Machairas et al., 2014). In parametric design, inputs are varied within a defined space to generate alternatives and enable evidence-based selection (Qingsong & Fukuda, 2016). These methods are increasingly applied to environmental design and are often read against thermal-comfort criteria such as ANSI/ASHRAE 55 (Lakhdari et al., 2021; ANSI/ASHRAE, 2010). An optimization framework comprises design variables and objective functions—geometric/physical parameters and simulation-derived performance indicators (Fang, 2017; Machairas et al., 2014). When optimization process targets mutiple design objectives, it is called multi-objective optimization,

Evidence in tropical/Global South contexts A 2024 Building and Environment study optimized an anidolic ceiling for tropical offices, demonstrating combined daylight-energy gains—indicative for similar optics-based strategies in South Asian retrofits. Related regional work explores daylight access in dense Dhaka housing and corridor-type learning spaces, underscoring constraints that ADASY targets. (Shoeb & Joarder, 2024; Sumaiya et al., 2021; Abuzarifa et al., 2021).

2.3 Knowledge Gaps and Research Opportunities

Context-specific adaptation for privacy-constrained housing. Most recent optimization studies target offices or generic deep-plan rooms; few address dormitory/public residential layouts where windows toward shared corridors are restricted by privacy norms—precisely where ceiling-integrated guidance (e.g., ADASY) could unlock daylight penetration without façade transparency. Field-validated frameworks for these typologies remain scarce. (Shoeb & Joarder, 2024; Abuzarifa et al., 2021; Wu et al., 2024). Analyse inconsistencies, contradictions, or underexplored aspects in existing research.

Integrated objectives (sDA–ASE–EUI) and controls. Reviews note fragmented practice: projects optimize daylight or energy in isolation, and often not co-simulated, limiting reliable EUI gains. There is opportunity for joint optimization of optical geometry and control logic under local climate/occupancy assumptions. (Zocchi et al., 2024; Sreelakshmi et al., 2024; Fernandes & Regnier, 2023).

Robust methods for hot-humid/tropical skies. Performance sensitivity to sky luminance distributions and solar altitude is under-reported for anidolic systems in monsoon/tropical climates; more studies should parameterize acceptance angles, duct aspect ratios, and extractor spacing against measured climate data. (Wu et al., 2024; Shoeb & Joarder, 2024).

Human-centric metrics. Emerging research on non-visual effects (e.g., melanopic EDI) suggests new evaluation axes for residences, yet robust workflows alongside sDA/ASE are still nascent—an avenue for future expansion. (Chen et al., 2024).

Thes gaps were addressed by (i) targeting public residential/dormitory rooms constrained by corridor-side privacy in Bangladesh, (ii) developing a parametric ADASY optimization to jointly improve sDA, limit ASE, and reduce lighting energy (EUI), and (iii) reporting sensitivity to geometry and climate factors to guide retrofit practice. (Shoeb & Joarder, 2024; Alexakis et al., 2024; ENERGY STAR, 2024).

3 Methodology

This study adopted a quantitative, simulation-based approach supported by targeted field measurements. A parametric workflow was developed to optimize the ADASY collector and ceiling geometry, with the aim of improving daylight penetration and reducing energy use. The case study focused on a university dormitory room designed for faculty housing. The room model was built in Rhinoceros, while optimization was performed using the Octopus plugin in Grasshopper. Performance was assessed with climate-based daylight metrics consistent with LEED credit criteria and Energy Use Intensity (EUI) as a normalized energy indicator (USGBC, 2024; EPA, 2024).

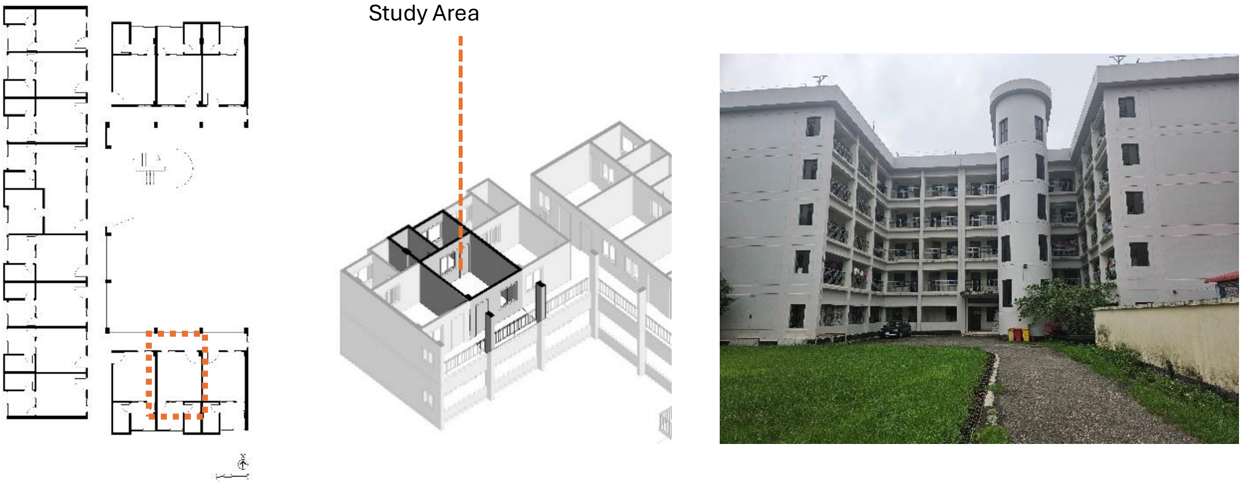
The research process was structured into four phases: (1) field measurements to document existing daylighting conditions, (2) development of base case models from field data and typical construction details to establish a baseline, (3) daylight and energy performance analysis of the base case, and (4) parametric optimization to identify balanced design solutions that enhance both visual and energy performance. This methodology combines empirical data collection, validated simulation tools, and algorithmic design exploration, ensuring a rigorous and reproducible approach to performance-driven design.

3.1 Case Study Description

The case study is a single room within a five-storey public residential dormitory in Gazipur, Bangladesh. The room is interior-locked—an entrance corridor to the north, service spaces to the south, and adjacent rooms east/west—typical of privacy-constrained layouts where conventional façade openings toward shared corridors are limited. The usable floor area is ≈ 10.2 m^2 (≈110 ft^2). Table I presents the key parameters of the case study room, including dimensions, window size, sill and lintel levels, and material specifications. The floor plan along with the exterior and interior views of the room are illustrated in Figure 2.

Table I. Parameters of the case study.

Parameters	Attributes
Room shape	Square
Room dimension	3.48m X 3.9m
Window width	1 m
Window height	1.34m
Window type	Sliding glass window
Sill level	0.1m
Lintel level	2.1m
Wall	150mm brick plaster wall, off-white colour
Ceiling	Concrete slab, white colour
Floor	Mosaic floor, off-white colour



(a) (b) (c)

Figure 2. (a) Floor plan of the building; (b) Casy study area; (c) Exterior view of the building

3.2 Experimental Protocol for Field Measurements

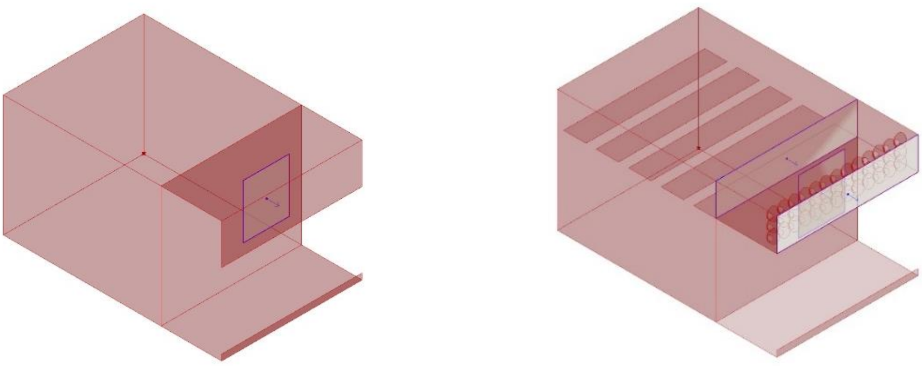
To ground the simulations, spot illuminance measurements were conducted on 23 July 2025, under clear, sunny conditions between 14:00–15:00 local time, with electric lighting off and windows closed. Readings were taken along the work plane (0.75 m height) from the opening centerline at 0.6 m intervals (Fig. 3a). The instrument was a HOBO Pendant MX2202 (Bluetooth) data logger (Fig. 3b)with a light sensor range of 0–167,731 lux and typical ±10% accuracy in direct sunlight; logging rates and device characteristics followed the manufacturer's datasheet (Onset, 2024). Measurement layout was informed by good-practice guidance for on-site photometric measurements and CIE references on assessing lighting program accuracy, used here to frame expectations for model-to-field comparisons (CIE, 2006).

(a) (b)

Figure 3. (a) Sensor placements during field measurments; (b) Instrument used for light measurements

3.3 Base Case Model

A base digital model of the room was created in Rhinoceros 3D (v7) with parametric control via Grasshopper. ClimateStudio (v2.1) performed climate-based daylight simulations; lighting/thermal energy estimation was produced within the Grasshopper workflow using the Dhaka EPW and standard schedules. The base model reflects as-found dimensions, constructions, and interior finishes. Occupancy and infiltration assumptions followed typical residential practice; heating/cooling setpoints were 18 °C and 26 °C, respectively, consistent with the project brief. For context, EN 16798-1:2019 supersedes EN 15251 and provides category-based indoor environmental recommendations (CEN, 2019). Simulations used TMY EPW climate files for the Dhaka region from the OneBuilding repository to ensure standardized annual inputs for daylight and energy modeling (OneBuilding, 2025). All annual runs used the same TMY input to allow direct comparison across design variants (OneBuilding, 2025; Solemma, 2025). This base case model was developed with ADASY collector and ceiling components to perform the optimization (Fig. 4).



(a) (b)

Figure 4. (a) Base case model; (b) Test case model with ADASY

3.4 Multi-objective Optimization

A multi-objective evolutionary optimization was carried out in Octopus (Grasshopper) to maximize daylight sufficiency (sDA300,50%) and mean illuminance, while minimizing EUI. and. In this process, Pareto fronts of non-dominated solutions are generated (Vierlinger, 2018) to balance competing objectives—an approach that has been widely adopted in building-performance optimization and retrofit studies (Deb, Pratap, Agarwal, & Meyarivan, 2002; Alexakis et al., 2024).

3.5 Optimization Parameters

This Four decision variables of ADASY in retrofit are: 1) Collector truncation angle (α°), 2) Collector tilt angle (β°), 3) Ceiling-duct elevation relative to lintel (m), and 4) Ceiling panel angle (°) no need to acting as an internal extractor/redirector. Parameter ranges were bounded by constructability and headroom constraints (Table I). Each candidate was simulated under identical boundary conditions to ensure comparability across the design space (Sorooshnia, Ahmadi, & Kheybari, 2023; Wu et al., 2024). Table II shows the parameters adjusted during the optimization process.

Table II. Parameters adjusted during the optimization process

Parameteres	Max Value	Min value
Collector truncation angle (α°)	+35	-20
Collector tilt angle (β°)	45	0
Ceiling-duct elevation relative to lintel (m)	0.75	0
Ceiling panel angle (ϴ°)	+15	-15

3.6 Optimization Process

Within Octopus, the genomes (design variables) and fitness objectives (maximising sDA and mean illuminance, minimising EUI) were specified, and the solver evolved populations toward a Pareto front. Runs used a population size of 30 with a maximum of 10 Pareto segments, balancing diversity with tractable computation (Vierlinger, 2018). The best-performing individuals (extreme and "knee" points) were exported alongside the full non-dominated set. For post-processing, Design Explorer enabled interactive filtering, parallel-coordinates analysis, and inspection of variable–objective trade-offs to select solutions balancing daylight sufficiency, over-exposure control, and energy (Thornton Tomasetti, n.d.; Alexakis et al., 2024). Finally the optimal genome was compared with the base case to identify the achivement of the objectives.

3.7 Data Analysis, Validity, Ethics, and Limitations

sDA, ASE, and mean illuminance were computed from annual simulations, and lighting, heating, and cooling were combined to estimate site EUI. LM-83 workflows with Dhaka TMY were used, and short checks were made on site with a HOBO MX2202 meter (±10%). Measurements were taken in an empty room with permission; no human data were involved. Limits were a single clear-sky day, meter accuracy, a single-zone model, assumed schedules, and fixed setpoints. In future work, longer measurements, model calibration, and co-simulated lighting controls will be included.

4 Results- Key Findings

4.1 Field Measurement

The field measurements explored a significant variation in daylight penetration. At point E6, which is nearest to the window, the highest illuminance reached approximately 106 lux. At point E1, which is the most distant point, the values decreased to around 8 lux (Fig. 5). This difference indicates that daylight levels diminish quickly with distance from the window. The more interior points of the room (E3–E1) were consistently recorded very low illuminance levels at all time intervals. This confirms that both the quantity and distribution of daylight are inadequate. These results suggest that the current daylighting conditions are insufficient for visual comfort and supporting the need for a system like ADASY to improve daylight penetration and uniformity.

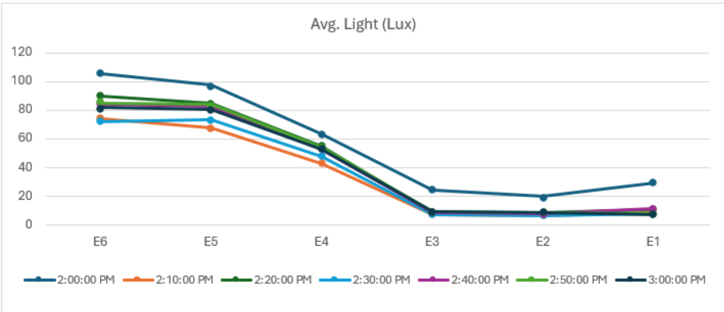


Figure 5. Lighting level (Average lux) at different points in the room across measurement period

4.2 Base Case Performance

In the base case, the daylight performance achieved an sDA of 44.44% and one LEED daylight credit. The ASE value of 0% shows that no areas in the room experienced excessive sunlight. It also indicates the absence of glare, which is favorable for visual comfort. However, the average illuminance level of 408 lux illustrates limited daylight penetration. It reveals an uneven light distribution within the space. The annual EUI was determined to be 174 kWh/m^2 which indicates a relatively high energy usage. These results express that although glare is not an issue, the overall state of daylighting is weak. It also shows that enhancements in daylight access could significantly lessen dependence on artificial lighting and consequently reduce energy consumption.

4.3 Optimization Solutions for the Case Study

With ASE below the threshold, optimization focused on maximizing sDA and mean illuminance while minimizing EUI to achieve a balanced design. The simulation results from Octopus were generated in .xlsx format and exported to Design Explorer in .csv format for analysis. Figure 6 illustrates all the simulation results plotted in Design Explorer

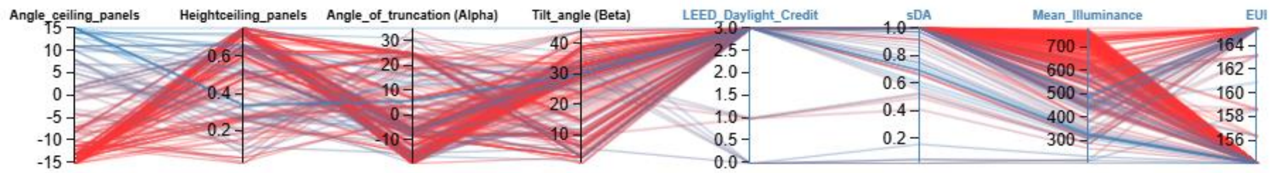


Figure 6. All the simulation results plotted in Design Explorer

4.4 Best Daylight Performance Solutions

The best daylight performance, achieving three LEED credits (sDA > 75%), was found with collector truncation angles of –5° to –15°, tilt angles of 30°–40°, and ceiling panels at –15° placed over 0.65 m below the lintel (Fig. 7). While these settings improved daylight penetration and mean illuminance, they produced a range of EUI values, showing that energy performance varied from poor to strong across solutions.

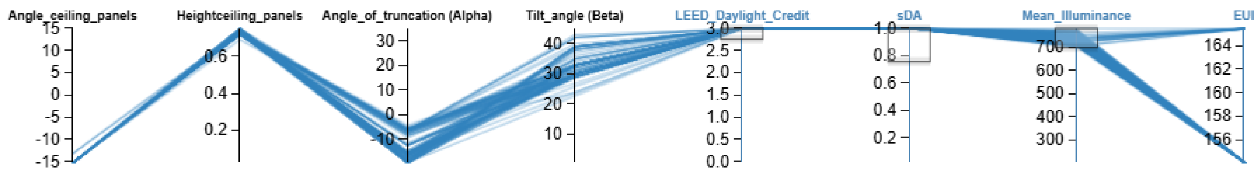


Figure 7. Best solutions in terms of Daylight Performance

4.5 Best Energy Performance Solutions

The lowest EUI of 154.2 kWh/m^2 was mainly achieved with collector truncation angles between 0° and –15°, tilt angles of 30° to 40°, and ceiling panels tilted at –15° positioned between 0.6 and 0.7 m below the lintel (Fig. 8). Although these settings provided the most energy-efficient solutions, the daylight performance metrics varied considerably, with some even falling below the base case values, suggesting that specific configurations decreased the available daylight in the room compared to its original state.

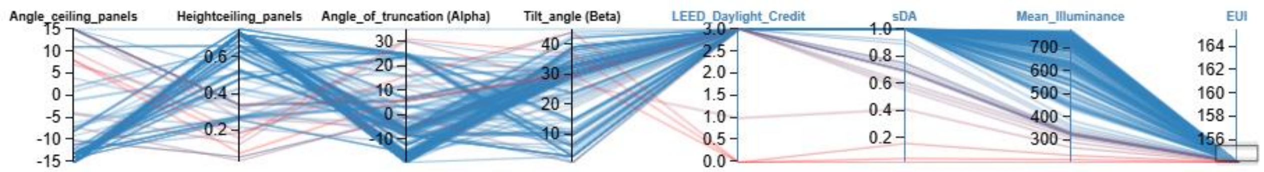


Figure 8. Best solution in terms of Daylight Performance

If daylight performance or energy performance is maximized in isolation, one objective is achieved at the expense of the other. This trade-off highlights the necessity of identifying a solution that balances both daylight and energy goals, ensuring improved lighting quality while maintaining energy efficiency.

4.6 Balanced Design Choices

To derive an optimal solution that addresses the conflicting performance objectives, designs with an sDA above 80% were first shortlisted, ensuring attainment of the maximum LEED daylight credit (Fig. 9, 10). To limit energy use, configurations with the lowest EUI were then considered (Fig. 11), while those with the highest mean illuminance were selected to support more uniform daylight distribution (Fig. 12). The analysis indicates that a collector array truncated at –15° and tilted at 40°, combined with ceiling panels tilted at –15° and positioned 0.7 m below the lintel, offers the most balanced design, effectively reconciling both daylighting and energy performance goals.

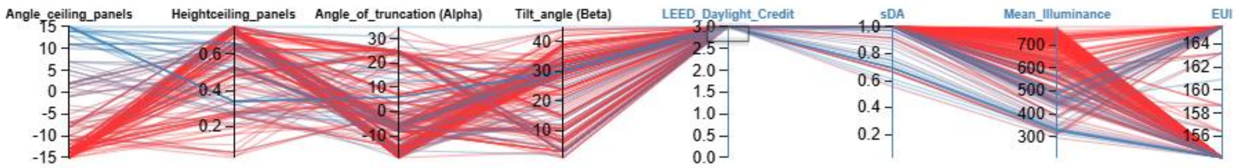


Figure 9. Solutions with maximum LEED credits

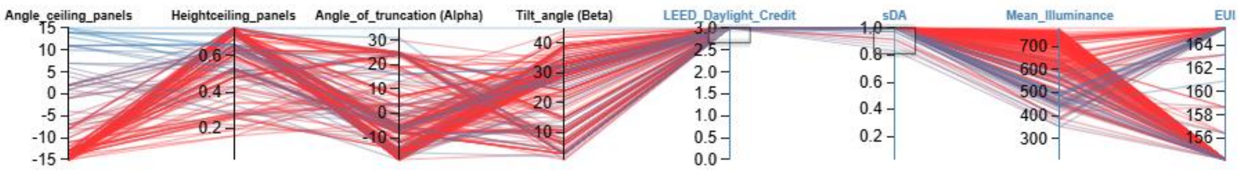


Figure 10. Solutions with maximum LEED credit and sDA above 80%

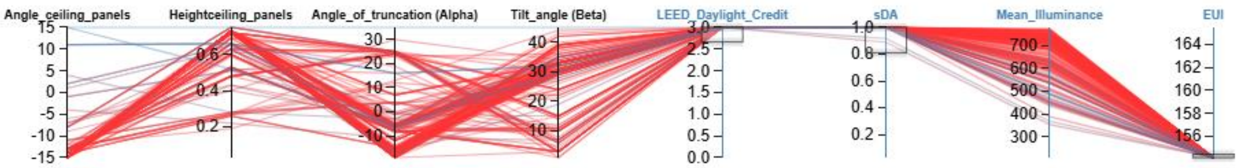


Figure 11. Solutions with maximum LEED credit, sDA above 80% and minimum EUI

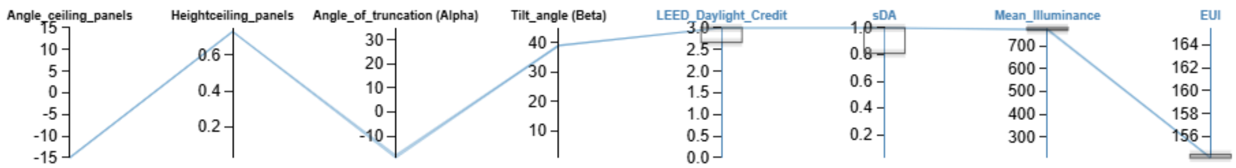
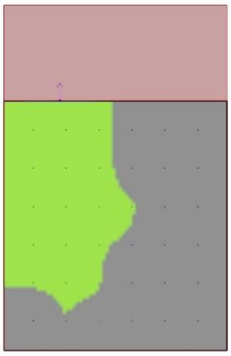
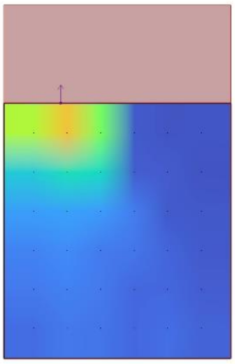
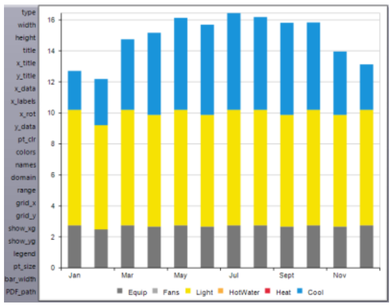
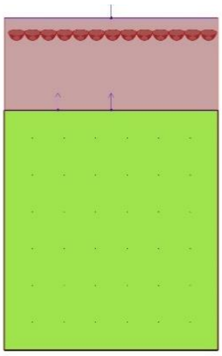
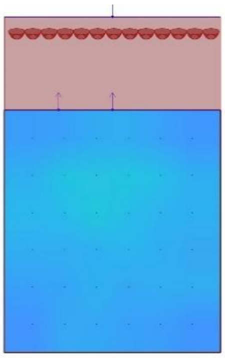
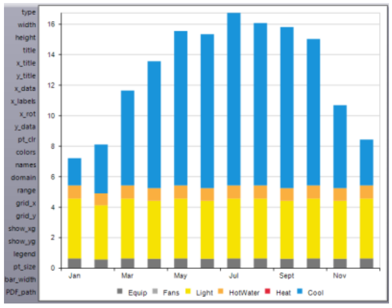


Figure 12. Solutions with maximum LEED credit, sDA above 80%, minimum EUI and maximum mean illuminance

4.7 Comparative Analysis

The optimization results demonstrate significant improvements in daylight and energy performance compared to the base case. The spatial daylight autonomy (sDA) increased from 44.44% to 100%, representing an improvement of approximately 125%, which indicates a substantial enhancement in daylight sufficiency across the space. Similarly, the mean illuminance rose from 408 lux to 773 lux, an increase of about 90%, reflecting both greater daylight availability and improved distribution within the interior. In terms of energy performance, the EUI was reduced from 176 kWh/m^2·yr to 154.2 kWh/m^2·yr, a reduction of around 12%, highlighting the potential of the optimized design to decrease reliance on artificial lighting and improve overall energy efficiency. Table III presents the improvements of lighting and energy performance across these key metrics.

Table III. Comparison of Base Case and Optimized Case Performance Metrics

Case	sDA (%)	Mean Illumimance (lux)	EUI (kWh/m^2)
Base Model			
	44.4	408	176
Test Model			
	100	773	154.2
Remarks	125% improved	89.5% improved	12.4% improved

5 Discussion

This study aimed to enhance daylight access and reduce energy consumption in a residential room constrained by privacy using an anidolic façade integrated system and a multi objective optimization process. The results clearly indicate significant improvements: sDA improved from 44.44% to 100%, average illuminance increased from 408 to 773 lux, and EUI decreased from 176 to 154.2 kWh/m^2·yr. Glare risk, as measured by ASE, remained below the threshold. This indicates it was not a constraining factor. Collectively, these findings address the research questions by demonstrating (i) how ADASY geometry can enhance daylight adequacy and distribution, and (ii) how to reduce energy demand related to lighting.

Patterns in the solutions are instructive. Daylight-leading designs clustered around collector truncation –5° to –15° and tilt 30°–40°, with ceiling panels at –15° and ≈0.65–0.7 m below the lintel; energy-leading designs overlapped these ranges but, when pushed too far, sometimes reduced daylight below the base case. The final balanced configuration—–15° truncation, 40° tilt, –15° panels at 0.7 m—demonstrates that a practical middle ground exists: strong daylight with a meaningful energy reduction. This trade-off aligns with broader findings in architectural daylighting and retrofits optimization, where single-objective “winners” often underperform on a second objective. ADASY has mostly been investigated in commercial settings; its applicability to privacy-constrained residential/dormitory rooms is demonstrated here. Optimization of ceiling geometry (panel tilt and elevation), largely omitted previously, was incorporated, and daylight–EUI trade-offs were quantified via multi-objective analysis.

For retrofit practice in corridor-facing rooms, the parameter ranges above offer a useful starting point. Because structural interventions are minimal, this approach is feasible in occupied buildings. To translate daylight gains into reliable energy savings, pairing the system with appropriate electric-lighting controls is recommended. The work supports the value of climate-based metrics and multi-objective optimization in early-stage design, and highlights the sensitivity of anidolic components to small geometric changes. It also underscores the importance of context-specific tuning for hot-humid climates.

The study is based on a single room and uses a short field check under clear sky; the energy model assumes a single zone, fixed schedules, and setpoints. These choices simplify analysis but may narrow generalizability. Longer field measurements across seasons and sky types, calibrated models, and explicit co-simulation of lighting controls would strengthen the evidence. Extending the study to multiple rooms, orientations, and floors, and adding human-centric and EN 17037 view/glare criteria, would broaden applicability. A basic cost–benefit or maintenance assessment would also help decision-makers. To sum up, a carefully tuned ADASY configuration can substantially improve daylight while reducing energy use in privacy-constrained residential retrofits. The reported workflow and parameter ranges are offered as practical guidance for balancing visual comfort and energy efficiency in comparable settings and can be readily adapted to other building types and contexts.

6 Conclusions

This study demonstrated that the Active Daylighting System (ADASY), when optimized through a parametric and multi-objective workflow, can significantly enhance daylighting performance in privacy-constrained residential settings. The results showed a marked improvement in sDA (44.44% to 100%) and mean illuminance (408 to 773 lux), alongside a reduction in EUI (176 to 154.2 kWh/m^2·yr), while maintaining ASE below threshold. These findings directly address the research objectives, confirming that ADASY can improve daylight sufficiency, limit glare, and reduce energy demand in dormitory-style buildings—areas often overlooked in previous studies. Importantly, this research extends the application of ADASY beyond commercial buildings and incorporates ceiling geometry optimization, offering a novel contribution to the field.

The broader implication of this work lies in providing designers with actionable parameters and a replicable workflow to balance daylight quality and energy efficiency in dense urban housing. While the study was limited to a single room and short measurement periods, it highlights clear opportunities for broader applications. Future research should validate results across multiple spaces, seasons, and sky conditions, integrating lighting control simulations for more accurate energy savings. Overall, the study reinforces the potential of context-specific daylighting strategies to advance sustainable architectural design and improve occupant well-being.

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Data Availability Statement

The data supporting the findings of this study are not publicly available due to privacy and ethical restrictions.

Conflicts of Interest

The authors declare no conflict of interest.

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