INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1925-TRP, Development of view clarity metrics for fenestration systems

Attached is a Request-for-Proposal (RFP) for a project dealing with a subject in which you, or your institution have expressed interest. Should you decide not to submit a proposal, please circulate it to any colleague who might have interest in this subject.

Sponsoring Committee: TC 4.5 Fenestration

Budget Range: $200,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: **September 1, 2025** or later.

All proposals must be received at ASHRAE Headquarters by 8:00 AM, EDT, May 30, 2025. NO EXCEPTIONS, NO EXTENSIONS. Electronic copies must be sent to rpbids@ashrae.org. Electronic signatures must be scanned and added to the file before submitting. The submission title line should read: 1925-TRP, *Development of view clarity metrics for fenestration systems*, and *"Bidding Institutions Name"* (electronic pdf format, ASHRAE's server will accept up to 10MB)

If you have questions concerning the Project, we suggest you contact one of the individuals listed below:

For Technical Matters
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Contractors intending to submit a proposal should notify, by mail or e-mail, the Research Administrator by May 1st, 2025 in order that any late or additional information on the RFP may be furnished to them prior to the bid due date.

All proposals must be submitted electronically. Electronic submissions require a PDF file containing the complete proposal preceded by signed copies of the two forms listed below in the order listed below. **ALL electronic proposals are to be sent to rpbids@ashrae.org.**

All other correspondence must be sent to ddaniel@ashrae.org. Hardcopy submissions are not permitted. **In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EDT, May 30, 2025.**
NO EXCEPTIONS, NO EXTENSIONS.

The following forms (Application for Grant of Funds and the Additional Information form have been combined) must accompany the proposal:

(1) ASHRAE Application for Grant of Funds (electronic signature required) and
(2) Additional Information for Contractors (electronic signature required) ASHRAE Application for Grant of Funds (signed) and

ASHRAE reserves the right to reject any or all bids.

State of the Art (Background)

With the advances in envelope materials and shading systems, various fenestration designs are increasingly common. Although these are designed to reduce the risks of glare, overheating [1,2] or privacy issues [3,4], they also block or distort the view to the outside [5,6]. To date, fenestration research has mostly focused on the development of metrics to assess its energy, thermal and visual comfort performance, but the outside view aspect was under-studied despite its effect on human satisfaction [7], improved health and well-being [8], emotion [9], cognitive performance [9–11], and stress recovery

[12]. Among the three primary variables that determine window view quality (i.e., content, access, clarity) [13], clarity is directly influenced by fenestration system (glazing and shading attachment) properties. Clarity addresses how clearly the visual content in the view can be seen by the occupant. It encompasses the visual obstructions present at the window – before, after, or inside the glazing layer(s) and its temporal characteristics impacted by, or responding to, external stimuli (e.g., direct sun) [14]. These include the changes in the optical properties and occlusion patterns of a dynamic glazing or shading system.

Even though there is a direct relationship between fenestration design and clarity, only few approximate guidelines exist. Most daylighting standards and green certification systems, such as European Daylighting Standard EN17037 and LEED v4, are developed assuming the glazing material of a window provides a view that is clear, neutrally colored, and undistorted by frits, fibers, patterned glazing, or added tints [15,16]. Similarly, ASHRAE 189.1 [17] requires undiffused glazing with a haze value [18] less than 3 % for view fenestration. European standard EN 14501 [19] specifies a method for evaluating the effect of blinds and shutters on exterior view based on two transmittance parameters of the solar protection device. However, it is not applicable for various fenestration materials in assessing the diverse visual effects on the occupants.

The type, material and optical properties of fenestration systems affect view clarity, and this can lead to different view perceptions. So far, only view clarity through specific types of fabric roller shades has been studied, leading to the development of the View Clarity Index [20, 21]. Other studies compared its effect on glare and color perception [22,23] or daylight availability [24]. The results showed that darker colored fabrics can lead to higher clarity of view and better color perception, and shade openness factor also affect the results. In contrast, the shading type that creates fractured views, such as venetian blinds, affects the clarity differently [25,26, 32]. The photometric contrast created by the shades can 4 affect view perception [27,28], which depends on the scale, patterns, and their relationship to the content of the window view. Semi-transparent materials (e.g., semi-transparent photovoltaic), silk-screened (i.e., frit) glass, and external shades with a pattern would fall in this type. Lastly, specular materials, such as tints, films, and electrochromic glass, are also commonly used and its effect on view perception require further investigation [22]. These mainly shift the brightness, reflectivity, and color perception while keeping the transparency through the materials [29,30].

As noted above, various aspects of glazing and shading properties and design parameters influence its impact on view clarity and there are no systemic metrics that can be applied to a wide range of fenestration materials. Therefore, it is important to develop a metric that can assess the view clarity performance of different fenestration systems in a consistent way

Justification and Value to ASHRAE

This project will develop the first of its kind unified view clarity metric, a novelty that will benefit fenestration design and control guidelines towards human-centered building design. Together with energy and comfort-related metrics, this index will contribute to a more integrated assessment of IEQ in perimeter building spaces, a priority for ASHRAE. Moreover, this research will strengthen ASHRAE's position as a leader in assessing IEQ holistically and influence related national and international Standards and product rating schemes.

Except for TC. 4.5 (Fenestration), NFRC, AERC, glazing and shading manufacturers would benefit from this research and should be contributing to this work, at least in-kind, when the project is awarded.

Objectives

The objectives of the proposed project are:

a) to develop an experimental protocol and conduct experimental studies with human participants to assess outside view clarity through a wide range of fenestration products (e.g., coated and uncoated glazing systems, dynamic windows, roller shades, venetian blinds, frit panels) as well as combinations of the above.
b) to statistically analyze the experimental findings and develop a systematic approach to obtain a widely applicable scoring metric that will evaluate the view clarity performance of either individual or combinations of fenestration products.
c) to use this information to update Ch. 15 of the ASHRAE Handbook of Fundamentals, and coordinate with newer versions of Standards and window/attachment rating schemes (e.g., AERC) for the assessment of view clarity through fenestration systems.

Scope:
The technical approach for the proposed project and expectations are described below. This description provides the general framework of required experimental methodology and analysis. Proposers may modify this approach if they feel that they can offer more efficient methods to serve the project objectives.

Task 1. Configuration of experimental facility and approved testing protocol (3-6 months) Configure, design or modify the experimental space according to required specifications (see below), to be able to test the view clarity through various fenestration products. Develop a plan for flexible installation and replacement of glazing and/or shading products and configure space instrumentation. Conduct a literature review of previous studies, survey and select initial fenestration systems for testing. Initiate IRB approval for including test subjects and develop a testing protocol. Provide a detailed plan on measured quantities and collected variables. The deliverable for Task 1 will be a literature review on existing clarity metrics for glazing and fenestration attachments to be published in Science and Technology for the Built Environment or other related major journals.

Task 2. Experimental assessment of view clarity though various fenestration systems (6-12 months) Develop and conduct a detailed and consistent experimental procedure for testing view clarity through various window systems. The systems should be placed at a position where the participants will be able to look outside with their line of sight being horizontal, and this should remain consistent throughout all treatments.

2.1. Human subjects recruiting and development of view clarity assessment tests Develop carefully designed surveys (questionnaires) that will be used to evaluate view clarity through windows, considering different aspects (visual acuity, color perception, target size, shape, distance, etc.). Recruit human subjects who will perform a series of consistent visual tests with different fenestration options that include both objective (directly quantifiable) measurements and subjective evaluations. Take measures (e.g., randomize tasks and product testing) to avoid bias in the experiments. Determine the test subject size required for this work using a power analysis or similar method. Subjects eligible for the study should not be reporting health issues that affect their visual acuity.

2.2. Fenestration systems selection Different fenestration options must be tested to address the diverse nature of view clarity. These should include glazing systems with various films/optical properties, window attachments that through their structure (e.g., perforation) or color produce distortion (e.g., roller shades, screens) as well as attachments that introduce opaque portions (e.g., venetian blinds, frit glass) that block outside view -as well as combinations of the above. Examples of recommended products are:

- Glazing: Clear glass (baseline), coated glass with different films/coatings or EC glass (with varying visible transmittance), ceramic frit glass, etc.
- Internal shading: venetian blinds (slat angle increments and different materials), roller shades (openness factor varying from 1% to 20%)
- Other systems such as exterior louvers, perforated metal panels, semi-transparent photovoltaic glass, etc

A reasonable and inclusive selection of glazing and shading products should be made considering: (i) their availability in the market today and in the near future

(ii) a wide range of optical properties that can be defining for clarity (direct transmission patterns, color, density, opaque portion designs, etc.).

For all the products participating in the project, an accurate documentation of all relevant properties is required; if this is not included in the manufacturer's specifications, measurements should be performed using state-of-the-art practices that will be described in the proposal. The cost of the testing and products may be part of the total proposed budget. Bidders may propose a selection of products of their choice with proper justification for their decision; however, this needs to cover at least three main categories (glazing, roller shades and venetian blinds) in reasonable ranges. To that end, they need to include at least 16 fabrics covering the required span of OF and Tv mentioned above, at least 4 types (dark and light colored – matt or reflective slats) of venetian blinds tested in a wide range of slat angles, and at least 2 types of glass (tinted and frit) with at least 4 options each covering different ranges of transmittance and pattern densities. Clear glass should be also used as a baseline.

The mechanism of interfering with the perception of the visual content through distortion or omission can be different depending on the fenestration system; therefore, different properties should be included in the developed metrics. In such cases, a meta-analysis should be conducted to establish equivalent metrics that will allow consistent comparison between products.

Testing should be repeated for sunny and overcast conditions to account for high luminance effects as well as potential glare, which can impact view perception and therefore should be measured during the experiments in compliance with state-of-the-art practices [31]. Literature has suggested that viewing distance can also affect clarity perception [20].

The deliverable of Task 2 should be an organized dataset including subjects' codes, clarity grading, and measured indoor environmental variables. The dataset should be well structured and labeled so it may become usable in future research studies

Task 3. Development of view clarity metrics and a clarity rating scheme (4-6 months) Collect, organize and report all raw data. Develop new widely applicable metric(s) that can characterize view clarity through different fenestration options by statistically analyzing the experimental objective (e.g., measured physical variables, fenestration properties) and subjective data (view clarity rating of products). Describe the proposed methods and models that will be used. Develop a view clarity rating scheme using properties of individual fenestration systems and their combinations. The deliverable of
Task 3 will be a comprehensive clarity rating scheme based on the developed metrics, that will be utilizing commonly available properties of the involved products.

Task 4: ASHRAE Handbook information and Final Report (1-2 months) Provide useful results (useful data sets, correlations, view clarity metrics, rating schemes, etc.) to be included in the ASHRAE Handbook of Fundamental's Fenestration Chapter as well as in other subsections of other Chapters (such as Chapter 10), along with related design guidelines for product ratings. Submit the Final Report to the Manager of Research and Technical Services that contains the complete details of all research carried out in the project. The deliverable for Task 4 will be the aforementioned additions to the Handbook clearly outlined in the final report.

Required Facility for Testing This project requires a full-scale experimental space (ideally, real office spaces) where human subjects will perform a set of tests facing the exterior through different fenestration options (glazing, shading, and combinations). Real window products must be used. The experimental facility should be able to host a variety of fenestration products in multiple identical occupied testing sections. The latter have to be

isolated from each other regarding visual environmental conditions (e.g. different rooms, or rooms separated by floor-to-ceiling opaque partitions). Multiple simultaneous testing options are recommended to make the process more efficient. Multi-modal sensing infrastructure should be able to capture basic visual environmental variables (included but not limited to horizontal and vertical illuminance, luminance in the field of view and exterior vertical illuminance incident on the façade). In the spirit of the recommendations of EN 17037 [15], at least two layers of view (including the sky) should be accessible through the windows.

Deliverables:
Progress, Financial and Final Reports, Technical Paper(s), and Data shall constitute the deliverables ("Deliverables") under this Agreement and shall be provided as follows:

a. Progress and Financial Reports

Progress and Financial Reports, in a form approved by the Society, shall be made to the Society through its Manager of Research and Technical Services at quarterly intervals; specifically on or before each January 1, April 1, June 10, and October 1 of the contract period.

The following deliverables shall be provided to the Project Monitoring Subcommittee (PMS) as described in the Scope/Technical Approach section above, as they are available:

Furthermore, the Institution's Principal Investigator, subject to the Society's approval, shall, during the period of performance and after the Final Report has been submitted, report in person to the sponsoring Technical Committee/Task Group (TC/TG) at the annual and winter meetings, and be available to answer such questions regarding the research as may arise.

b. Final Report

A written report, design guide, or manual, (collectively, "Final Report"), in a form approved by the Society, shall be prepared by the Institution and submitted to the Society's Manager of Research and Technical Services by the end of the Agreement term, containing complete details of all research carried out under this Agreement, including a summary of the control strategy and savings guidelines. Unless otherwise specified, the final draft report shall be furnished, electronically for review by the Society's Project Monitoring Subcommittee (PMS).

Tabulated values for all measurements shall be provided as an appendix to the final report (for measurements which are adjusted by correction factors, also tabulate the corrected results and clearly show the method used for correction).

Following approval by the PMS and the TC/TG, in their sole discretion, final copies of the Final Report will be furnished by the Institution as follows:

-An executive summary in a form suitable for wide distribution to the industry and to the public.
-Two copies; one in PDF format and one in Microsoft Word.

c. *Science & Technology for the Built Environment* or ASHRAE Transactions Technical Papers

One or more papers shall be submitted first to the ASHRAE Manager of Research and Technical Services (MORTS) and then to the "ASHRAE Manuscript Central" website-based manuscript review system in a form and containing such information as designated by the Society suitable for publication. Papers specified as deliverables should be submitted as either Research Papers for HVAC&R Research or Technical Paper(s) for ASHRAE Transactions. Research papers contain generalized results of long-term archival value, whereas technical papers are appropriate for applied research of shorter-term value, ASHRAE Conference papers are not acceptable as deliverables from ASHRAE research projects. The paper(s) shall conform to the instructions posted in "Manuscript Central" for an ASHRAE Transactions Technical or HVAC&R Research papers. The paper title shall contain the research project number (1925-RP) at the end of the title in parentheses, e.g., (1925-RP).

All papers or articles prepared in connection with an ASHRAE research project, which are being submitted for inclusion in any ASHRAE publication, shall be submitted through the Manager of Research and Technical Services first and not to the publication's editor or Program Committee.

d. Data

Data is defined in General Condition VI, "DATA"

e. Project Synopsis

A written synopsis totaling approximately 100 words in length and written for a broad technical audience, which documents 1. Main findings of research project, 2. Why findings are significant, and 3. How the findings benefit ASHRAE membership and/or society in general shall be submitted to the Manager of Research and Technical Services by the end of the Agreement term for publication in ASHRAE Insights

The Society may request the Institution submit a technical article suitable for publication in the Society's ASHRAE JOURNAL. This is considered a voluntary submission and not a Deliverable. Technical articles shall be prepared using dual units; e.g., rational inch-pound with equivalent SI units shown parenthetically. SI usage shall be in accordance with IEEE/ASTM Standard SI-10.

Level of Effort

The project anticipates 4 professional months for the principal investigator and 18-20 professional months for a researcher or graduate student. The estimated cost is $200,000 and the project is expected to take up to 24 months. A typical graduate student cost for two years is anticipated at the order of $130,000. Depending on the level of cost share by the bidder regarding the PI's time, $50,000-70,000 can be dedicated to the experiment itself. Within this budget, the cost of 20 human subjects at $13 per hour, for approximately 20 hours each would be at the order of $5,000, leaving approximately $45,000-65,000 for the necessary fenestration products, installations, sensing equipment, space, etc. In-kind support by fenestration industry is encouraged to achieve an as wide as possible products range for the experiment

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month
1	Configuration of experimental facility and approved testing protocol	6
2	Human subjects recruiting and development of view clarity assessment tests	8
3	Experimental assessment of view clarity though various fenestration systems	16
4	Development of view clarity metrics and a clarity rating scheme	22
5	ASHRAE Handbook information and Final Report	24

Proposal Evaluation Criteria

Proposals submitted to ASHRAE for this project should include the following minimum information:

No.	Proposal Review Criterion	Weighting Factor
1	Contractor's understanding of Work Statement as revealed in proposal a) Logistical problems associated b) Technical problems associated	15%
2	Quality of methodology proposed for conducting research a) Organization of project b) Management plan	25%
3	Contractor's capability in terms of facilities a) Managerial support b) Data collection c) Technical expertise	20%
4	Qualifications of personnel for this project a) Project team 'well rounded' in terms of qualifications and experience in related work b) Project manager person directly responsible, experience and corporate position c) Team members' qualifications and experience d) Time commitment of Principal Investigator	20%
5	Student involvement a) Extent of student participation on contractor's team b) Likelihood that involvement in project will encourage entry into HVAC&R industry	5%
6	Probability of contractor's research plan meeting the objectives of the Work Statement a) Detailed and logical work plan with major tasks and key milestones b) All technical and logistic factors considered c) Reasonableness of project schedule	15%

References

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