INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1874-TRP, Addition of Roof Top Temperature Information to the Climatic Design Conditions chapter of the ASHRAE Handbook

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 4.2 Climatic Information

Co-sponsored by: TC 4.7 Energy Calculations & TC 4.10 Indoor Environmental Modeling

Budget Range: $75,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: **April 1, 2022** or later.

All proposals must be received at ASHRAE Headquarters by 8:00 AM, EST, December 15, 2021. 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: 1874-TRP, Addition of Roof Top Temperature Information to the Climatic Design Conditions chapter of the ASHRAE Handbook, 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
Technical Contact
Michael Roth
49 Winston Cres
Guelph, ON N1E 2K1
CANADA
E-Mail: michael.roth@klimaat.ca

For Administrative or Procedural Matters:
Manager of Research & Technical Services (MORTS)
Michael R. Vaughn
ASHRAE, Inc.
180 Technology Parkway, NW
Peachtree Corners, GA 30092
Phone: 404-636-8400
Fax: 678-539-2111
E-Mail: MORTS@ashrae.net

Contractors intending to submit a proposal should so notify, by mail or e-mail, the Manager of Research and Technical Services, (MORTS) by December 1, 2021 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 and mvaughn@ashrae.org. Hardcopy submissions are not permitted. **In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EST, December 15, 2021. 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)
There is a growing technical literature on microclimate variations within a city due to human-made changes to the local environment such as buildings, streets, and urban vegetation that have resulted in an "Urban Heat Island" (UHI) effect (Akbari et al. 1990; Erell et al. 2010; Williamson, Erell, and Soebarto 2009, Georgescu et al 2012). ASHRAE has sponsored two projects on this topic, one (RP-606, "Determination of Climate Variation within Metropolitan Areas", completed 1992) to characterize the UHI, and another (RP-1561, "Procedure to Adjust Observed Climatic Data for Regional or Mesoscale Climate Variations", completed 2015) to use meso-scale climate simulations to model the UHI effect. There have also been limited studies of the impact of a building itself on its own immediate environment, as when a hot roof elevates the temperature of the intake air of a Rooftop Unit (RTU). One study in London reported that the UHII (UHI Intensity) for an RTU was of the order of 7°C as compared to an UHII of 2.6°C for the city (Levermore, Vandaele, and Parkinson 2017).

A study comparing air temperatures at two locations (one near and the other far from the RTU) found a small increase of 0.3°C that was eliminated when the roof albedo was increased (Wray and Akbari 2008). Another recent study in Australia found that air temperatures within 1.5m (4.5 ft) of the roof surface were typically 0.5-4°C higher than the ambient air temperature during the middle of the day (Green et al. 2018). CFD simulations were also done in parallel with the measurements, but the RMS compared to the measured data was larger than the measured temperature rise. Lastly, there is also a large amount of measured data on air temperatures entering RTUs that can be made available to this project (Hayes 2018), although it's unclear whether these also contain concurrent measurements of ambient air temperatures away from the roofs.

There have also been CFD studies of the environmental conditions of outdoor split AC units that showed reductions in cooling system performance of 17% compared to a rural site (Gracik et al. 2015) and 10-22% compared to design conditions (Koh et al. 2008), but the benchmark conditions are not the same.

Justification and Value to ASHRAE
There are many challenges that the HVAC&R industry faces with respect to its impact on climate and the environment. One of the biggest challenges is reducing the use of chemicals that contribute to global warming. CO2 is a viable alternative to such chemicals in the commercial refrigeration sector, but its acceptance into the market has been slow outside of Europe. Some of the hesitancy to adopt CO2 is attributed to the challenges of its low critical temperature and high working pressures, which create difficulties in designing systems to operate to the same expectations of synthetic refrigerants. Customers (grocers) are disappointed when CO2 systems shut down in warm weather, which can occur when the temperatures that systems are being exposed to are well above the recommended design climate information currently found in the ASHRAE database.

The completion of this project will give more correct climate design information for RTUs and wall-mounted ACUs (via a simple algorithm or look-up table) to engineers and application designers, allowing systems and components to be designed and selected appropriately for the climate conditions they will actually be exposed to. These designs will include components that won't need to be needlessly over designed, causing the first cost of the equipment to be a detriment to the acceptance and adoption of a cleaner, more environmentally friendly technology.

Objectives
The Project Objectives include:

1. Identifying factors that influence the differences between ASHRAE design or measured ambient temperature data and urban commercial roof top temperatures (roof top surface characteristics including albedo and roughness, roof dimensions, solar radiation, wind speed, etc).

2. Observation of the temperature differences through testing and data collection. Although the temperature differences between the airport and the building site should be noted for informational purposes, it is beyond the scope of this project to develop a procedure for estimating this UHI effect.

3. The main objective of this project is to quantify the impact of the building, esp. the roof, on the psychrometric conditions of the entering air (humidity as well as temperature) to either a RTU or a wall-mounted ACU. CFD simulations can be used to simulate these effects, from which simple equations or tables are developed allowing design engineers to modify ASHRAE design data or simulation weather files.

4. Update ASHRAE literature and tools to include roof top temperature data with explanation for how andwhen to apply the data in real world application engineering.

Scope:

Check all that apply: □Lab testing ■ Computations □ Surveys ■ Field tests ■ Analyses and modeling □ Validation efforts □ Other (specify) ( )

The project is envisioned to have three tasks:

Task 1. Literature search to find and obtain, if possible, measured data on rooftop air temperatures that are ideally coupled with concurrent ambient air temperature measurements. If concurrent ambient air temperatures were not recorded, obtain the air temperatures from the nearest weather station. In either case, other meteorological data, including the relative humidity, solar radiation, and wind speed, should be obtained from the nearest available source for assessing their relationship to the temperature elevation.

Task 2. Review of the pre-existing reports, along with analysis of the available data together with first-principles calculations, to determine how significant is the effect of rooftops in elevating the temperature of the incoming air to RTUs. If deeded necessary, limited measurements of air temperatures over a roof can be done to verify the preliminary conclusions.

Task 3. Use computer simulations, e.g., Computation Fluid Dynamics (CFD), to understand the relationship between the ambient climatic conditions (i.e., temperature, humidity, solar gain, and wind speed), the physical characteristics of the roof and walls (e.g.., size, roughness, and albedo) to the amount of temperature and humidity change compared to that of the ambient air, and then validate those simulation results against measured data.

Task 4. Based on the detailed CFD simulations, develop a simplified method that standard engineers and building energy modelers can implement into their design calculations or annual simulations to account for the heating or humidification of air entering a RTU or an ACU mounted near an exterior wall. This can be either a simple reduced-order equation or a look-up table that can be added to the ASHRAE Handbook of Fundamentals or HVAC.

Deliverables:

a. Technical Deliverables

Tasks 1 & 2. Technical report describing the findings from the literature review and analysis of pre-existing measured data.

Tasks 3 & 4. Technical report describing the simulation modeling of rooftop air temperatures, validation of the results, and development of the simplified model(s) for use in standard design calculations and annual simulations of RTUs and split ACUs using standard weather files.

b. 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 three quarterly intervals; specifically on or before the beginning of the third, sixth, and ninth month of the contract period.
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.

c. 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. Unless otherwise specified, six copies of the final report shall be furnished for review by the Society's Project Monitoring Subcommittee (PMS). 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.
-One unbound copy, printed on one side only, suitable for reproduction.
-Two copies on CD-ROM; one in PDF format and one in Microsoft Word.

d. *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 presentation at a Society meeting. The Technical Paper(s) shall conform to the instructions posted in "Manuscript Central" for a technical paper. The technical paper title shall contain the research project number (1874-RP) at the end of the title in parentheses, e.g., (1874-RP).

e. Data
Data is defined in General Condition VI, "DATA"
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.

f. 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 is planned to have 12 month duration (spread over 2 society meetings) with an approximate budget of $75,000. It is expected that 3 person-months of Principle Investigator and 6 person-months of researcher effort are required to complete the project

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month
Task 1	Literature search and obtaining pre-existing data	2
Task 2	Analysis of literature findings and data	4
Task 3	Computer modeling of air conditions entering or around a RTU or ACU	7
Task 4	Simplified method to account for the interaction of the building roof and walls on the performance of a RTU or ACU	9

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	15%
2	Quality of methodology proposed for conducting research	25%
3	Contractor's capability in terms of facilities	15%
4	Qualifications of personnel for this project	15%
5	Student involvement	15%
6	Probability of meeting the objectives and schedule of the Work Statement	15%

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

References

1. Levermore,G. , S. Vandaele and J. Parkinson 2017. "Temperature adjustments for design data for urban air condition design", *Building Services Engineering Research & Technology* (UK), 0 (0), 1-8
2. Erell,E., I. Eliasson, S. Grimmond, B. Offerle and T. Williamson 2010. "The effect of stability on estimated variations of advected moisture In the Canyon Air Temperature (CAT) Model", *9th Symposium on Urban Environment,* J4C.4
3. Gracik, S., M. Heidarinejad, J.Y. Liu, and J. Srebec 2015. "Effect of urban neighborhoods on the performance of building cooling systems", *Building and Environment* 90 (2015) 15-29.
4. Green, A., R. Paolini, A. Synnefa et al. 2018. "Characterisation of the air temperature filed above large-footprint buildings – full-scale experiments and large eddy CFD simulations". *Proceedings of the 11th Australasian Heat and Mass Transfer Conference*, Melbourne Australia, July 9-10, 2018.
5. Koh, J.Y., H.G. Lee, and J. Zhai 2008. "System performance with variation of outdoor unit layouts at building re-entrants", *International Journal of Air-Conditioning and Refrigeration*, Vol. 16, No. 1.
6. Williamson, t., E. Erell, and V. Soebarto 2009. "Assessing the error from failure to account for urban microclimate in computer simulation of building energy performance", *Eleventh IBPSA Conference*, Glasgow, Scotland, 497-504.
7. Wray, C.P. and H. Akbari 2008. "The effect of roof reflectance on air temperatures surrounding a rooftop condensing unit". *Energy and Buildings*, Vol. 40, p. 11-28.