Research Topic Acceptance Request Cover Sheet

Date: **January 15, 2019**

(Please Check to Insure the Following Information is in the RTAR)

A. Title	x
B Executive Summary	x
C. Background	x
D. Research Need	x
E. Project Objectives	x
F. Expected Approach	x
G. Relevance and Benefits to ASHRAE	x
H. Anticipated Funding Level and Duration	x
I. References	x

Title:

Solar PV Design Guide for the Building Professional: Including HVAC and Building Interactions

RTAR #

(To be assigned by MORTS)

Results of this Project will affect the following Handbook Chapters, Special Publications, etc.:

This RTAR / project involves solar PV, not solar thermal, but it could potentially impact Chapter 37, Solar Energy Equipment

Research Classification:

Basic/Applied Research	
Advanced Concepts	
Technology Transfer	X

Responsible Committee: **TC 6.7**

Date of Vote:

For		6
Against	*	0
Abstaining	*	0
Absent or not returning Ballot	*	1
Total Voting Members		7

RTAR Authors

Lead: **James Leidel**

Others:

Co-sponsoring TC/TG/MTG/SSPCs (give vote and date)

Expected Work Statement Authors

Lead: James Leidel and TC6.7 members

Others:

Potential Co-funders (organization, contact person information):

	Yes	No
Has an electronic copy been furnished to the MORTS?		x
Has the Research Liaison reviewed the RTAR?		x

* Reasons for negative vote(s) and abstentions

RTAR # _____________

Title:

Solar PV Design Guide for the Building Professional: Including HVAC and Building Interactions

Executive Summary

This RTAR proposes to develop and publish a guidebook for building professionals for the design, optimization and operation of photovoltaic systems. Currently, there is no publication that looks comprehensively at photovoltaics from the perspective of building design professionals. Additionally, this guidebook will align with, and support, ASHRAE's NZEB goals, specifically 1, 2 & 3 as described below.

Background

To meet NZEB goals, building designer and operations professionals must fully understand how alternative energy systems, and in particular, photovoltaic (PV) systems, can most effectively be installed and most efficiently operated.

For low energy and NZEB designs, we need to minimize carbon based energy usage. Solar PV electricity generated at the building site is zero carbon and available globally in various amounts for all buildings. In general, solar PV design is a well established and mature technology. However, in the building design community, PV is often an afterthought, implemented on a completed building design by the electrical engineer or electrical contractor. There is a need to look at building integrated PV, parking area PV, integration with energy storage (both electrical and thermal), building energy demand, as well as safety and code issues, early in an integrated design process.

The cost of PV, and hence solar PV electricity, has been falling to parity or below that of conventional grid electricity. At some point in the future, PV will be a common and/or required element of all buildings. ASHRAE should provide a comprehensive HVAC, electrical and BIPV guide reference for this crititcal component of all NZEB facilities.

Research Need

Building design professionals presently lack a comprehensive reference on how PV systems are designed, installed and integrated into today's low energy facilities or NZEB's. To reach NZEB goals, we need to maximize the amount of PV energy produced on a building site using as much of the roof surface, and potentially vertical facades and parking lot surfaces. Interactive effects of PV system are not often viewed in a comprehensive fashion. Peak electrical demand, energy storage, roof shade effects and other HVAC interactions are not broadly understood or considered during the building design process.

Project Objectives

This project will research and collect information for compilation into a guidebook format for a comprehensive resource for PV design and operation. The following topics will be utilized as a starting point for the guidebook contents. The editor will further develop topics under TC6.7 supervision.

- System components: panels, inverters, racking
- System sizing methodology
- Location, orientation and mounting
- Roofing types and racking methods
- Building integrated PV
- Parking deck and surface lot shade structures.
- Ground mount systems
- System commissioning
- Safety considerations: grounding, fire safety, code issues
- Battery storage
- Electric heat pumps and thermal storage interactions
- Micro-grids, including PV/CHP optimization
- PV and electric to thermal coupling for electric demand management
- Roof shading effects on HVAC loads
- Thermal effects on PV panels and considerations for panel ventilation
- Carbon and source energy accounting for NZEB design
- Embedded energy content and "life cycle analysis"

Expected Approach

Check all that apply: Lab testing [ ], Computations [ ], Surveys [ ], Field tests [ ], Analyses and modeling [ ], Validation efforts [X], Other

This project involves the research, collection and editing of a information and design guidance for compilation into an ASHRAE guidebook. The expectation will be to create a work more detailed work scope for solicitation of an experienced and qualified editor. TC6.7 will then oversee, assist and manage this guidebook development.

Relevance and Benefits to ASHRAE

This PV design guide for building professionals is central to ASHRAE's Mission and Vision, Strategic Plan and its Research Strategic Plan.

It furthers ASHRAE's vision of positioning ASHRAE as an essential knowledge resource to promote a sustainable built environment. The proper design of PV systems is critical to providing clean, renewable electricity to buildings.

One of ASHRAE's main goals within the Strategic Plan is to disseminate essential information and knowledge for a sustainable, high performance built environment. This is the core purpose of this project to create and publish a PV Design Guide. The specific goals within the ASHRAE Research Strategic Plan applicable to this RTAR are Goals 1, 2 & 3.

Goal Number 1: Maximize the actual operational energy performance of buildings and facilities.

A properly designed PV system is required to supply the necessary renewable energy to any future NZEB. To maximize the energy output and performance of a PV system, designers must understand the potential HVAC, peak load management, and thermal interactions.

Goal Number 2 (second part): Progress toward Advanced Energy Design Guides (AEDG) and cost effective net zero energy buildings (NZEB).

The first cost and lifecycle cost of PV systems are presently lower than comparable costs for solar thermal systems. It is now more economical and efficient to use solar PV over solar thermal to heat water, and of course solar PV provides electricity for any other need in the facility.

Goal Number 3: Support development of tools, procedures and methods suitable for designing low energy buildings.

The proposed design guide will educate and direct design and facilities professionals in the "procedures and methods suitable for designing low energy buildings". Without the use of solar energy, designers will be unable to reach NZEB or Plus-Energy building design goals.

Anticipated Funding Level and Duration

Funding Amount Range: $149,500 Duration in Months: 24 months

References

PV Guide Books

"Planning and Installing Photovoltaic Systems: A Guide for Installers, Architects and Engineers" 3rd Edition, German Energy Society, Earthscan Publications (July 2013).

"Photovoltaics: Design and Installation Manual", Solar Energy International, New Society Publishers (Sept 2004).

Related ASHRAE Handbook Chapters

- ASHRAE Handbook, 2016 HVAC Systems and Equipment, Chapter 37. Solar Energy Equipment,
- ASHRAE Handbook, 2016 HVAC Systems and Equipment, Chapter 51. Thermal Storage,
- ASHRAE Handbook, 2016 HVAC Systems and Equipment, Chapter 9. Applied Heat Pump and Heat Recovery Systems,
- ASHRAE Handbook, 2015 HVAC Applications, Chapter 35. Solar Energy Use.

PV Roof Cooling Effects

J. Kleissl, J. Luvall and A. Dominguez, "Effects of solar photovoltaic panels on roof heat transfer", **Solar Energy**, Volume 85, Issue 9, Pages 2244-2255 (Sept 2011).

A. Dehwah and M. Asif, "Assessment of net energy contribution to buildings by rooftop photovoltaic systems in hot-humid climates", **Renewable Energy**, Volume 131, Pages 1288-1299 (Feb 2019).

C. Peng and J. Yang, "The Effect of Photovoltaic Panels on the Rooftop Temperature in the EnergyPlus Simulation Environment", **International Journal of Photoenergy**, Article ID 9020567, 12 pages (2016).

Demand Response

G. Lorenziab, C. Augusto and S. Silva, "Comparing demand response and battery storage to optimize self-consumption in PV systems", **Applied Energy**, Volume 180, Pages 524-535, (Oct 2016).

S. Comell and A. Sahoo, "The Road Ahead for Solar PV Power", **Renewable and Sustainable Energy Reviews**, Volume 92, Pages 744-756, (Sept 2018).

Safety Standards

International Electrotechnical Commission, TR 63226, "Managing fire risk related to photovoltaic (PV) systems on buildings", https://www.iec.ch/dyn/www/f?p=103:38:9254899702586::::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:1276,23,102641

References, Continued…

Building Integrated PV

T. Yang, and A.K. Athienitis, "A review of research and developments of building-integrated photovoltaic/thermal (BIPV/T) systems", **Renewable and Sustainable Energy Reviews,** Volume 66, Pages 886-912 (Dec 2016).

International Electrotechnical Commission, IEC 63092–1 – "Photovoltaics in buildings – Part 1: Building integrated photovoltaic modules", https://www.iec.ch/dyn/www/f?p=103:38:8299336743964::::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:1276,23,23167

International Electrotechnical Commission, IEC 63092–2 – "Photovoltaics in buildings – Part 2: Building integrated photovoltaic systems", https://www.iec.ch/dyn/www/f?p=103:38:8299336743964::::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:1276,23,22310

ISO/TS 18178:2018: "Glass in building – Laminated solar photovoltaic glass for use in buildings", https://www.iso.org/standard/74652.html

ISO 19467:2017: "Thermal performance of windows and doors – Determination of solar heat gain coefficient using solar simulator", https://www.iso.org/standard/64989.html

General Solar Energy in Buildings

J. Leidel, "Maximum Solar Energy Utilization in the Built Environment: Evaluation of Energy Capture and Conversion Technologies for Maximum Practical Use in Buildings (CH-15-C029)", ASHRAE Conference Paper, Chicago, IL (Winter 2015).

D. Brearley, "Designing and Deploying Carport Mounted PV Systems", SolarPro (Issue 7.1), (Dec./Jan. 2014).

"A Common Definition for Zero Energy Buildings", US Department of Energy, DOE/EE-1247, (Sept 2015).

US Department of Energy, Better Buildings, "On - Site Commercial Solar PV Decision Guide", (Sept 2014)

"Guidelines for Roof Mounted Photovoltaic System Installations", National Roofing Contractors Association, (2009).

Feedback to RAC and Suggested Improvements to RTAR Process

It would be helpful to have this form offered in a plain MS Word format without the text boxes. Alternatively, if the word count per section is critical, an online web form that calculates the word count for you automatically would be nice as well. Thank you.