



DRAFT MINUTES
(THESE DRAFT MINUTES ARE NOT THE OFFICIAL MINUTES UNTIL APPROVED BY THIS COMMITTEE.)
ASHRAE TC 4.7 ENERGY CALCULATIONS – MAIN MEETING
WINTER 2022 VIRTUAL LAS VEGAS CONFERENCE
TUE. FEB 1, 2022, 3:30 PM – 5:30 PM PST

[MOTION]

1. Kruis moves to approve agenda and 2021 Winter and Annual meeting minutes. Haberl seconds. 5-0-0 CV
2. Kruis moves to maintain the current Title and Scope and revisit again in Toronto. Haberl seconds. 5-0-0 CV
3. H Kim moves to approve co-sponsorship of 1815-WS Integrating Occupant Behavior Data with Building Information Modeling for Performance Simulation. Haberl seconds. Haberl volunteered to be PMS. 5-0-0 CV
4. Kruis moves to adjourn. Haberl seconds. No objections!

[ACTION]

1. Muehleisen to post the roster before the Toronto meeting after deleting personal information such as email addresses.
2. Muehleisen to follow up with Wang regarding her seminar idea.
3. Muehleisen to follow up with Residential Building Committee to appoint Fontanini as 4.7 liaison.

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Connection Instructions

- Enter name and email address and then click Join as Guest at the prompt you get from the link below:
<https://ashrae.webex.com/ashrae/j.php?MTID=m8eff709c84315409dba9de4daa2c1aa7>

Call to Order and Introduction of Members (5 min, Muehleisen)

- Ralph Muehleisen, Chair
- Neal Kruis, Vice-Chair
- Hyojin Kim, Secretary
- Brian Ball, Simulation and Component Models Subcommittee Chair
- Jeff Haberl, Honors, Awards, and History Subcommittee Chair
- Ron Judkoff, Multi-scale Building Modeling Subcommittee Chair
- Brian Kastl, Program Subcommittee Chair
- Jeannie Kim, Webmaster
- Tim McDowell, Research Subcommittee Chair
- Joel Neymark, Standards Subcommittee Chair
- John Pruett, Handbook Subcommittee Chair
- Amanda Smith, Data-driven Modeling Subcommittee Chair

Attendance Form

- Neal distributed the [attendance form](#) in zoom chat.

Reciting of Code of Ethics Commitment (2 min, Muehleisen)

- Commitment to the ASHRAE Code of Ethics: In this and all other ASHRAE meetings, we will act with honesty, fairness, courtesy, competence, integrity and respect for others, and we shall avoid all real or perceived conflicts of interest.

Call of Voting Members (5 min, Kruis)

Present?	Last Name	First Name	Term Ends	Company	Email
	Miller	Clayton	2025	Nat. U. of Singapore	clayton@nus.edu.sg
	Crawley	Dru	2024	Bentley	dru.crawley@bentley.com
X	Haberl	Jeff	2024	Texas A&M	jhaberl@tamu.edu
X - Arrived late	Judkoff	Ron	2024	NREL	ron.judkoff@nrel.gov
X	Kim	Hyojin	2022	NJIT	hyojin.kim@njit.edu
X	Kruis	Neal	2024	Big Ladder	neal.kruis@bigladdersoftware.com
X	Muehleisen	Ralph	2022	Argonne	rmuehleisen@anl.gov
X - Left early	Rao	Sagar	2023	AEI	sagar.rao@outlook.com
	Wang	Liping	2025	U. of Wyoming	

5 VM: Quorum achieved.

Accept Agenda & Approve Minutes of 2021 Annual Meeting (2 min, Muehleisen)

[MOTION 1] Kruis moves to approve agenda and 2021 Winter and Annual meeting minutes. Haberl seconds. 5-0-0 CV

Review TC 4.7 Scope (5 min, Muehleisen)

- Title:** TC 4.7 Energy Calculations
- Scope:** TC 4.7 identifies, evaluates, develops, and recommends procedures for calculating energy performance of the built environment.

We updated this 2 years ago to be consistent with some of the changes of our sister committees. Does anyone see any needed changes?

Chair willing to entertain a motion to vote to maintain the current Title and Scope and revisit again in Toronto.

[MOTION 2] Kruis moves to maintain the current Title and Scope and revisit again in Toronto. Haberl seconds. 5-0-0 CV

Ron Judkoff joins as a VM after vote.

Membership (15 min, Muehleisen)

- Changes in TC 4.7 Leadership
 - Hyojin Kim is replacing Alamelu Brooks as Secretary and VC in waiting. After the Annual meeting in June, Neal Kruis to take over as Chair and Hyojin to take over as VC, so we will need a new Secretary.

Thank you for your service, Alamelu !!!

- Clayton Miller is replacing Malcolm Cook as a non-quorum voting member.

Thank you for your service, Malcolm !!!

- Brian Ball is replacing Edwin Lee as Chair of the Simulation and Component Modeling (SCM) subcommittee.

Thank you for your service, Edwin !!!

- Jeannie Kim is replacing Joshua New as Webmaster.

Thank you for your *long* time service, Joshua !!!

- We are actively looking for a new person to take over as Secretary starting in July. By agreeing to become Secretary you are agreeing, in principle, for a 6-year job moving from Secretary (2 years) to Vice Chair (2 years) to Chair (2 years). The idea of succession is to improve continuity. But, the expectation is that you will be available and active in helping lead the TC over the next several years and are expected to attend both the Annual and Winter meetings when they go back to being in person.

The role of the Secretary is to be the primary minute taker in various committee meetings (subcommittees, executive meetings, main TC meetings) and final minute assembler (which means making as many of the subcommittee meetings as possible), work with the vice-chair in reviewing the roster and work with chair and vice-chair in planning committee activities, recruiting new members and new leadership, and generally help provide input to the various subcommittees.

Anyone who has been reasonably active in the committee and has an interest in a longer-term role in TC leadership should contact Ralph, Neal, or Hyojin to express their interest.

- Voting Members: (Currently at 9)
 - The following people rolled off as VM: Joel Neymark and John Pruett. They should be off for a year before rejoining as VM if they wish to be considered again.

Thank you Joel and John for your service as VM and let Neal know next year if you want to be considered again !!!

- Liping Wang was added as a VM. Thanks for stepping up Liping !!!

- We are now at only 9 VM with 1 (RM) to roll off if we renew Hyojin through 2028, so we should add at least 1 VM and could add 2 or 3 (3 preferred). You cannot be considered if someone at your company is already a VM.

- Roster changes of PCM to CM were submitted on time to ASHRAE before the Annual Meeting in June but it seems that yet again, they didn't all take (i.e., change of Anthony Fontanini to Amanda Smith). Please contact Muehleisen if you had thought you should be converted and were not or were supposed.

Fontanini requested to post the roster before each meeting. Haberl asked to remove email addresses from the roster before posting. Ralph agreed.

[ACTION 1] Muehleisen to post the roster before the Toronto meeting after deleting personal information such as email addresses.

- Reminder that we have moved from the onebuilding.org listserv to Basecamp as per ASHRAE's request that TCs start doing all business through Basecamp. We announced the transition 2 years ago and last year kept official announcements through both. We have moved to Basecamp now full time. Anyone who wants to be added please contact TC 4.7 executive committee (Ralph, Neal, Hyojin) or VM or anyone currently in the TC 4.7 Basecamp. Any current member of the Basecamp project can add a new member. You do not need to be a listed member of TC 4.7 (CM, PCM, etc.) to join the Basecamp group.

Announcements/Liaisons (20 min, Muehleisen)

- Vance Payne (Section 4 Liaison)

Payne asked to make any roster changes and send them to him for his review. ASHRAE's deadline is February 15.

- Natascha Milesi-Ferretti (Research Liaison)

ASHRAE has developed training for RTAR and PTAR development and PMS. Research funding has been down to \$1.8M from \$2.5M. (Discretionary/unsolicited are on hold).

RTAR/WS deadline reminder: MMAD 15

- Bass Abushakra (Handbook Liaison)

New Liaison is Jeff Boldt.

- All FG are being asked to develop a "Vision" and a set of "Measurable Objectives" (MOBs). I'll need to clarify how/why the Title, Purpose, Scope, isn't clear enough.
- TAC is no longer requesting we start Management by Objective so if our committee works we are not being asked to change. I don't think we need to change so I'm going to leave this to the next chair to decide to implement if he wants

Note: Ralph was going to create an ad hoc committee to start developing a Vision and MOB but put that off given online meeting burnout with Covid. With the updated information from TAC, he decided not to create one at all.

Subcommittee Reports (60 min, Various)

(Rearranged to move standards to top of this part of agenda)

- Standards (A summary of activities are attached to this meeting minutes.)

Neymark

140, 205P, 209, 229P, 232P are standards within TC 4.7.

140-2020: Method of Test for Evaluating Building Performance Simulation Software.

140-2020 just came out last year. 90.1 has a new reference to 140-2020, 90.2 updates to reference 140-2017. There will be 140 stakeholder meetings in spring or summer - contact Muehleisen if you are interested in attending that.

205P: Standard Representation of Performance Data for HVAC&R and Other Facility Equipment.

PC just approved final responses to comments for PPR3 and is almost ready to submit an independent substantial change rather than a full PPR4 to address the final changes to resolve comments.

209-2018: Energy Simulation Aided Design for Buildings Except Low-Rise Residential Buildings.

209-2018 is published. Reopened for revision. 20 VMs. 15 Working groups. IBPSA is in process of being a co-sponsor. Trying to be SSPC. Public review perhaps later next year (2023).

229P: Protocols for Evaluating Ruleset Implementation in Building Performance Modeling Software.

Full committee meeting every 2 months. Working groups for schema ruleset model report, ruleset checking, and terminology of the standard. Targeting public review draft by the end of this year, but likely 2023.

232P: Schema-Based Building Data Model Protocols.

This standard defines conventions that define data models. It's the front matter of 205 that is more general than the 205 representations. It will be referenced by 229 and 205, and IBPSA USA Building Data Exchange will reference it as well. Call for members. Tim McDowell is chair.

- Honors, Awards, and History

Haberl

Two papers are in preparation:

Ahn, J., Haberl, J. 2022. "Origins of Whole-building Energy Simulation Programs Used for High Performance Commercial Buildings: Contributions of the NATEOUS, SHEP, TACS, CP-26, CP-33 and RESPTK programs", in preparation.
 Ahn, J., Haberl, J. 2022. "Origins of Whole-building Energy Simulation Programs Used for High Performance Commercial Buildings: Contributions of the ASHRAE TGER Committee", in preparation.

Joe Huang became a Fellow at this meeting.

- Web Site (<https://tc0407.ashraetcs.org/>)

J. Kim

Website is up to date.

- Handbook

Pruett

Note: John Pruett was due to step down as Handbook SC Chair but because of the screwups at ASHRAE for HOF 2021 he wants to stay on through the next revision to help ensure it goes correctly. Thank you John!

We had a 19-page increase in the last cycle, so a fairly substantial increase. 10 attendees in the Handbook SC meeting. Splitting/reorganizing the chapter into two is under discussion. To-do-list will be on Basecamp - need volunteers.

- Program

Kastl

TC 4.7 did not sponsor any programs at this meeting. One was not accepted. For Toronto, there are 4 proposed seminars, and Tianzhen will resubmit (thereby, 5 seminars for Toronto).

- Research

McDowell

Currently 2 RPs in progress:

4.7 Cognizant TC: RP-1661 Development and Validation of Dynamic Models for the Evaluation of Chilled-Water Systems Control Strategies in the ASHRAE Handbook (PI Wangda Zuo) - planned to be completed by April 2022.

4.7 Co-sponsoring TC: RP-1816 Load Profiles for Hospital Imaging Equipment

1 WS conditionally accepted (1730-WS) & 2 accepted RTARs (1921-RTAR and 1920-RTAR).

Sagar Rao left the meeting as a VM.

1815-WS Integrating Occupant Behavior Data with Building Information Modeling for Performance Simulation: Tianzhen asked for co-sponsorship.

[MOTION 3] H. Kim moves to approve co-sponsorship of 1815-WS Integrating Occupant Behavior Data with Building Information Modeling for Performance Simulation. Haberl seconds. Haberl volunteered to be PMS. 5-0-0 CV

- Multiscale Building Energy Modeling

Judkoff

31 in attendance. There is a report on the survey of MBEM practitioners by Haberl. Peter Ellis commented the survey focused on academia. Haberl said this document is a living document and will include industry.

- Simulation and Component Models

Ball

25 in attendance. 2 program ideas for Atlanta (no action needed at this meeting).

- Data-Driven Modeling (DDM)

Smith

20 in attendance. Need more research! One program idea (machine-learning-based approach for building energy simulation) by Wang - we need to follow up later.

[ACTION 2] Muehleisen to follow up with Wang regarding her seminar idea.

Related Activities Reports (10 min, Various)

- 90.1: No report
- TC 4.1: No report
- TC 4.2: No report
- TC 4.4: No report
- TC 7.6

Report on 1836-RP *Developing a Standardized Categorization System for Energy Efficiency Measures* is coming from the U. of Cincinnati.

New GPC 45P *Measurement of Whole Building Performance for Occupied Buildings except Low-Rise Residential Buildings*: Measure various things in buildings (energy, water, IEQ, occupancy, etc). Performance Measurement Protocols now becoming a full ASHRAE Guideline.

- MTGs: No report
- IBPSA-USA

BPAC/SIMBUILD 2022 in Chicago for this fall. Call for seminars soon. There will be a Hackathon at the conference. Starting a certification committee to look at various potential certifications related to simulation. IBPSA USA Building Data Exchange is continuing to develop data models.

- IBPSA-World

Building Simulation 2021 in Belgium was hybrid. 2023 conference in Shanghai in Sept 2023. IPBSA Project 1 to finish/close this year.

- Others

179D Certification: Still, contact Ron Judkoff if you want your software certified.

New Business (Muehleisen)

ASHRAE Residential Building Committee was looking for liaisons. Fontanini volunteered. MTG Resiliency was also looking for liaisons.

[ACTION 3] Muehleisen to follow up with Residential Building Committee to appoint Fontanini as 4.7 liaison.

Adjourn (Muehleisen)

[MOTION 4] Kruis moves to adjourn. Haberl seconds. No objections!

Upcoming Meetings

- June 25-29, 2022 – Toronto, ON
- Feb. 4-8, 2023 – Atlanta, GA
- June 24-28, 2023 – Tampa, FL
- Jan. 20-24, 2024 – Chicago, IL
- June 22-26, 2024 – Indianapolis, IN
- Feb. 8-12, 2025 – Orlando, FL
- June 21-25, 2025 – Phoenix, AZ

Appendix A: Resources

- ASHRAE's Research Proposal Process:
 - <https://www.ashrae.org/file%20library/technical%20resources/research/ashrae-research-flowchart-r6.pdf>
- 4.7 Committee Home Page:
 - <http://tc0407.ashraetcs.org/>
- 4.7 BaseCamp Page:
 - <https://3.basecamp.com/3106353/projects/8174587>

Appendix B: 2022 Winter (Las Vegas) Program Tracks

1. **HVAC&R Systems and Equipment:** HVAC&R systems and equipment are constantly evolving to address the changing requirements of the built environment. Papers and programs in this track focus on the development of new systems and equipment, improvements to existing systems and equipment and the proper application and operation of systems and equipment.
2. **Fundamentals and Applications:** Fundamentals are the foundation for understanding applications in engineering. Key components of ASHRAE fundamentals include thermodynamics, psychometrics, fluid and mass flow. This track provides opportunities for papers and presentations of varying levels across a large topic base. Concepts, design elements and shared experiences for theoretical and applied concepts of HVAC&R design are included.
3. **Refrigerants and Refrigeration:** Refrigeration systems generate and use cold for a range of processes, from food preparation and conservation, to vaccine preservation, to long-term protection of fragile ancient inks of historic documents and others. Differences in technologies and equipment, performances, refrigerants, etc., may hide synergies from which both industrial and commercial systems might benefit, also, but not only, from the points of view of reducing direct and indirect GHG emissions.
4. **Buildings at 360°:** Buildings use a large share of a country's final energy, in particular for heating, cooling and various services. Papers and presentations explaining methods, equipment, systems and solutions to satisfy occupants' needs, to guarantee buildings' performances and resilience, and to save resources (energy, water, etc.) will fit this track.
5. **Energy System Integration:** Energy is the omnipresent reality of our daily lives (e.g., electricity for appliances and equipment, heat and cold for industrial processes and commercial purposes). Once used, part of the input the energy is wasted as heat/cold or as exhaust byproducts, thus contributing to the pollution of soil, water and air. The integration of various energy sources/grids with buildings, processes and transportation allows to better exploit the available energy (renewables, in particular) while reducing the said waste through a circular approach to energy usage. Papers on renewables, fossil fuels, grid integration, aggregation, demand-side flexibility, smart devices, IoT, synthetic hydrogen and synthetic fuels, CCUS, electrification would fit this track.
6. **Environmental Health and IEQ in the International Arena:** We spend a large part of our days indoors to live, work, practice gym, etc. Indoor environment is essential for our comfort, well-being, health, productivity, but is often treated and regulated differently in various parts of the world due to local conditions, circumstances, history, traditions. Presentations that explain local norms and trends are welcome to increase the knowledge on such an important topic, with an eye also on energy usage.
7. **HVAC for Industrial and Commercial Purposes - Challenges and Opportunities:** How to guarantee a set point within the required tolerances in a large industrial facility? How to increase the overall energy efficiency of a commercial facility through HVAC systems? What are the lessons that can be learnt from in terms of equipment, installation, commissioning, etc. and that can be transferred to other types of facilities; and vice versa? This is the track where such topics can find suitable space.

Appendix C: 2022 Annual (Toronto) Program Tracks

The 2022 ASHRAE Annual Conference technical program is comprised of eight tracks, selected to represent areas of focus common among ASHRAE membership.

Track	Description
1	<p>Fundamentals and Applications: Fundamentals and Applications: Fundamentals are the foundation for understanding applications in engineering. Key components of ASHRAE fundamentals include thermodynamics, psychometrics, fluid and mass flow. This track provides opportunities for papers and presentations of varying levels across a large topic base. Concepts, design elements and shared experiences for theoretical and applied concepts of HVAC&R design are included.</p> <p>Track Chair: Erik D Sanchez esanchez@prmech.com</p>
2	<p>HVAC&R Systems and Equipment: HVAC&R Systems and Equipment: HVAC&R systems and equipment are constantly evolving to address the changing requirements of the built environment. Papers and programs in this track focus on the development of new systems and equipment, improvements to existing systems and equipment and the proper application and operation of systems and equipment.</p> <p>Track Chair: Marites Calad mcalad@norman-wright.com</p>
3	<p>Research Summit: Active research, and the exchange of those research findings, are critical to the development of our HVAC&R industry and built environment. The 9th annual research summit invites researchers to share those results, including ASHRAE-sponsored research and research of interest to the ASHRAE community. Researchers are invited to present papers, extended abstracts, seminars, forums or participate in panel discussions. The Research Summit includes a partnership with ASHRAE's archival journal, <i>Science and Technology for the Built Environment</i>.</p> <p>Track Chair: Brian Fronk brian.fronk@oregonstate.eduEnvironment</p>
4	<p>Connected Buildings, Connected Communities: As buildings become smarter, and as sensor systems, internet connectivity and data collection become more ubiquitous, there are substantial opportunities to improve the performance and efficiency of buildings. Similarly, as renewable energy resources, including wind and solar energy and energy storage, becoming increasingly common, buildings can be used as electric grid assets, to strategically support energy efficiency and demand flexibility. To accomplish this requires many stakeholders, coordinated efforts and a diversity of buildings and buildings systems components and controls.</p> <p>Track Chair: Ahmed Abdel Salam ahmed.abdel-salam@usask.ca</p>
5	<p>Cold Climate Building System Design, Operation and Resilience: The design, construction and operation of buildings in cold climate regions which experience extreme winter conditions require specific considerations for the building envelope and HVAC&R systems and resulting thermal and hygrothermal performance. Resilience in the face of extreme temperature shifts, and in some cases remoteness and permafrost, should be considered to ensure building maintain interior design conditions. This track covers efforts and topics specifically focused on buildings, building systems and equipment in cold, arctic and subarctic climates.</p> <p>Track Chair: Davide Ziviani dziviani@purdue.edu</p>
6	<p>IAQ, Energy Use, Comfort and Health of Sustainable Buildings: Indoor environmental quality, energy use and efficiency and occupant comfort and health are all priorities buildings must balance. Sustainability priorities in buildings continue to increase, requiring careful consideration of how to achieve sustainability goals without sacrificing other building functions and owner/operator priorities. This track covers each of these topics, and how they interact and impact one another.</p> <p>Track Chair: Rafi Karim rkarim@aeieng.com</p>
7	<p>Professional Development and Education: As members of a professional organization, we not only participate for the great value of technical exchange, but also the interpersonal exchange. We recognize that the single greatest strength of our organization is its membership. This track is designed to allow those professionals and educators an opportunity to develop and share knowledge in the areas of presentation skills, leadership, team-building, understanding various business operations, lean collaboration strategies, interpersonal skills, etc., and an opportunity for educators to</p>

	<p>share knowledge in the teaching and education of current and future generations of professionals. Submissions to this track may lend themselves to interactive session types such as workshops, panels and forums.</p> <p>Track Chair: Maggie Moninski maggie.moninski@gmail.com</p>
8	<p>Buildings in the Aftermath of COVID-19: The pandemic has had significant impacts on how buildings are used, and the priorities associated with building operations to ensure a healthy environment for occupants. More people are working remotely; commercial building interior design and functionality and occupant use of these buildings, ventilation and system needs and building owner, operator and occupant priorities have been impacted. This track covers these topics as our buildings transition to design and operation in the aftermath of the pandemic.</p> <p>Track Chair: Andy Cochrane acochrane@industrialairinc.com</p>

Appendix D: List of Attendees

- Total = 34
- VM = 6
- CM = 15
- PCM = 1
- G = 12
- YEA = 9

Virtual (LV) 2022	Virtual (Phoenix) 2022	Virtual (Chicago) 2021	Last Name	First Name	Affiliation	E-mail	Voting Status	YEA
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Abdel Salam	Ahmed	Nortek	ahaabdel salam@gmail.com		<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Abdelsalam	Mohammed R. H.	Enbridge	mohamed_rany2008@yahoo.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Abushakra	Bass	U.S. Military Academy	datadigm-analytics@outlook.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Adair	Daric	Henderson Engineers Inc	daric.adair@gmail.com	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Adams	Christopher	Insight Partners	cadams@pace-adams.com	CTTC Chair	<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Adams	Mark	ORNL	adamsmb@ornl.gov	CM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Ali Younes	Hassan		hassan@griffin-consultants.com		<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Alkhailil	Rami	Inteleqa Energy Solutions	rami.alkhalil@gmail.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Alkhalil	Rami	Intelaqa Energy Solutions	rami.alkhalil@gmail.com	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Ananthachar	Vinay	Green Banyan Consulting	vinay.ananthachar@gmail.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Anderson	JR	Anderson Engineering	JRHazel@BellSouth.net		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Archibald	A.	Alabama Solar Association	archi42@gmail.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Armstrong	Peter	Masdar Institute	parmstr@mit.edu		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Asaee	S. Rasoul	Carleton Universityq	asaee@dal.ca	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Ashukov	Artem	Remak a.s	green.ashukov@gmail.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Axley	James	Yale School of Architecture	james.axley@yale.edu	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Azizi Yeganeh	Amirmahyar	SC Engineers, Inc.	mahyar.yeganeh@gmail.com	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Babriya	Vipulkumar	Steven Winter Associates	vbabriya@swinter.com	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bae	Nuri	Univ. of Michigan	nuri@umich.edu		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bahnfleth	William	Penn State Univ	wbahnfleth@psu.edu	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Baines	Mark	UL	mark.baines@ul.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Baker	Chris	The Weidt Group	chrisb@twgi.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bakos	Panagiotis		bakospan@gmail.com		<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Balaras	Constantinos	NOA	costas@noa.gr	CM	<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Balbach	Chris	PSD	cbalbach@psdconsulting.com		<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Ball	Brian	NREL	brian.ball@nrel.gov		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Baltazar	Juan-Carlos	TAMU	jcbaltazar@tamu.edu	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bannister	Carsen	National Research Council, Canada	carsen.bannister@nrc-carc.gc.ca		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Barnaby	Chip		chipbarnaby@gmail.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Basarkar	Mangesh	LBNL	mangesh.basarkar@pge.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Basso	Darlan	Fluar Engenharia	darlan.basso@yahoo.com.br	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bauman	Fred	UC Berkeley	fbauman@berkeley.edu	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bdawi	Shahed	Seapal Trading & Investment	shahdsalah94@gmail.com	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Beausoleil-Morrison	Ian	Carleton Univers.	ian_Beausoleil-Morrison@carleton.ca	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Bennet	James	NIOSH	jbennett@cdc.gov		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bhandari	Biraj	EMA Engineering and Consulting	biraj.bhandari@hotmail.com	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bhandari	Mahabir	ORNL	bhandarims@ornl.gov		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bhargava	Akshay	TRC Worldwide Engineering MEP	abhargava@trcww.com	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bilderbeck	Mike	Pickering Firm	mbilderbeck@pickeringfirm.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bist	Nikhilesh	CEPT University	nikhilesh241192@gmail.com	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Black III	Albert	McClure Engineering	ablack@mcclureeng.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bosworth	David	BuildLab	bosworth@buildlab.net		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bourassa	Norman	LBNL	njbourassa@lbl.gov	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Brandemuehl	Michael	Colorado	michael.brandemuehl@colorado.edu	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Brink	Holly	Arup	holly.brink@arup.com	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Briscoe	Casey	Ingersoll Rand	Casey.Briscoe@trane.com	CM	<input checked="" type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Brophy	Andy	SSR	abrophy89@gmail.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bruning	Steven	Newcomb & Boyd	sbruning@newcomb-boyd.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Bucking	Scott	Carleton Univers.	scott.bucking@carlton.ca		<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Buckley	Liam	IES Ltd.	liam.buckley@iesve.com	CM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Butler	Trevor		butler.engineer@gmail.com	PCM	<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Carling	Par	EQUA	par.carling@equa.se		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Carpenter	Patrick	Fac Perf Engr	facperfeng@comcast.net	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Caton	Nick	Schneider Electric	nicholas.caton@se.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Chandler	Julie	DNV GL	julie.chandler@dnvgl.com		<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Chigullapalli	Sruti	Intel	sruti.chigullapalli@intel.com	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Cho	Heejin	Mississippi State Univ	cho@me.msstate.edu	CM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Cho	Soolyeon	NC State U.	scho3@ncsu.edu		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Christian	Jeff	ORNL	christianje@ornl.gov	CM	<input type="checkbox"/>

Virtual (LV) 2022	Virtual (Phoenix) 2022	Virtual (Chicago) 2021	Last Name	First Name	Affiliation	E-mail	Voting Status	YEA
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Chude	Ricson		ricson.chude@sce.com	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Claridge	David	Texas A&M University	dclaridge@tamu.edu	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Clark	Jordan	UT-Austin	jdclark@utexas.edu		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Cockerham	Keith	Loring Engineers	kcockerham@DLBassociates.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Coffey	Brian		brian.edward.coffey@gmail.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Colliver	Donald	University of Kentucky	dcolliver@uky.edu	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Collyer	Breesa	PG&E	brk8@pge.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Cook	Malcolm	Loughborough Univ	malcolm.cook@lboro.ac.uk	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Cornick	Steve	Nat'l Research Council Canada	Steve.Cornick@nrc.ca		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Correa	Jose	AME Group	josecorrea@amegroup.ca		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Cox	Bryce	Jacobs/Oregon State	brycecox@colebreit.com	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Crawley	Dru	Bentley	dru.crawley@bentley.com	VM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Cumali	Zulfi	Energy System	zulfi@cumali.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Curcija	Charlie	LBNL	dcurcija@lbl.gov	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Dahdolan	Mohd-Eslam	U. of Nebraska	mdahdolan@unomaha.edu		<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Davidovic	Branko		branko.davidovic@yandex.com	PCM	<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Degelman	Larry	TAMU	ldegelman@suddenlink.net	CM	<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Errett	Jessica	Energy Studio, Inc	errett.jessica@gmail.com	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Fallahi	Ali	Fraunhofer CSE	afallahi@fraunhofer.org		<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Feng	Jingjuan	Taylor Engineering	dovefeng@gmail.com	PCM	<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Fine	Jamie	U. of Toronto	jamie.fine@ryerson.ca		<input checked="" type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Fu	Yangyang	University of Colorado - Boulder	yangyang.fu@colorado.edu		<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Gallagher	John		j.gallagher@tcd.ie		<input checked="" type="checkbox"/>
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Virtual (LV) 2022	Virtual (Phoenix) 2022	Virtual (Chicago) 2021	Last Name	First Name	Affiliation	E-mail	Voting Status	YEA
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Griffin	David	Etc Group, LLC	eldergriffin@gmail.com		<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Gu	Lixing	FSEC	gu@fsec.ucf.edu		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Gudeman	Sarah	Morrissey Engineering	sgudeman@morrisseyengineering.com	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Gundavelli	Radhika	Southland Industries	rgundavelli@southlandind.com	CM	<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Han	Guiyuan	PSU	GOH5067@psu.edu		<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Hartley	Doug	Working Buildings	DEHartley@workingbuildings.com		<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Hensen	Jan	Technische Universiteit Eindhoven	j.hensen@tue.nl	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Hoffman	Michael	University of Arizona	hoffmanm@email.arizona.edu	PCM	<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Ingram	Jonathan		jonathan.ingram@pec1.com	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Jain	Swapnil	Design2Occupancy	swapniljain2050@gmail.com	PCM	<input checked="" type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Jarnagin	Ronald		ron.jarnagin@att.net	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Javed	Hassan	Masdar, Abu Dhabi	hjaved@masdar.ac.ae		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Jia	Yiyun	AEI	yjia@aeieng.com	PCM	<input checked="" type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Kamel	Ehsan	New York Inst. Of Technology	ekamel01@nyit.edu	PCM	<input checked="" type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Kingsley	Michael	OBG	michael.kingsley@obg.com		<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Koran	Bill	SBW Consulting	bill.koran@sbwconsulting.com	CM	<input type="checkbox"/>

Virtual (LV) 2022	Virtual (Phoenix) 2022	Virtual (Chicago) 2021	Last Name	First Name	Affiliation	E-mail	Voting Status	YEA
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Kosny	Jan	Fraunhofer CSE	jkosny@fraunhofer.org	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Kota	Sandeep	Texas A&M University	radhakrishn10@yahoo.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Koupriyanov	Mike	Price Industries	Mikek@priceindustries.com		<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Krarti	Moncef	U. of Colorado	krarti@colorado.edu	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Kreider	Jan	Kreider & Associates	jfk@well.com	CM	<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Kruis	Neal	Big Ladder Software	neal.kruis@bigladdersoftware.com	VM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Kummert	Michael	Polytech Montreal	michael.kummert@polymtl.ca		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Lau	Josephine	U. of Nebraska	jlau3@unl.edu		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Laughman	Christopher	Mitsubishi Electric Research Lab	crlaugh@gmail.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Lebrun	Jean	U. De Liege	j.lebrun@ulg.ac.be	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Ledezma Unzueta	Olman	Valenzuela & Asociados SRL	olman.jlu@outlook.com	PCM	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Lee	Edwin	NREL	edwin.lee@nrel.gov	CM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Lee	Sang Hoon	LBNL	sanghlee@lbl.gov		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Li	Yanfei	NREL	yanfei.tide@gmail.com	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Li	Siwei	Daikin North America	fiona.lee.0911@gmail.com		<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Li	Zhaoura	UTSA	jlk469@myutsa.edu		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Li	Qi	ANL	qi.li@anl.gov		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Li	Qinho	Texas AMU			<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Liesen	Richard	US Army Corps of Engineers	rliesen@gmail.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Lin	Cheng-Xian	Florida Int. University	linx@fiu.edu		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Lisenbee	Larry		lrbee@bellsouth.net	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Liu	Shichao	UT-Austin	liu.shichao@utexas.edu	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Liu	Mingsheng	Building Energy Solutions & Technology	mliu@bes-tech.net	CM	<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Longbrake	Kyle	Wiley Wilson	klongbrake@wileywilson.com	CM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Lou	Dong	UTRC	luod@utrc.utc.edu	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Lou	Yinqi	CU Boulder	yinquil.lou@colorado.edu		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Lu	Xing	U. of Miami	terranceluxing@gmail.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Luflok	Peter	7ACTech			<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Lyons	Peter	Peter Lyons & Asso.	peter.lyons@fenestralia.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	MacCormac	Patrick	Baskervill	pmaccormac@baskervill.com	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	MacDonald	Iain	NRC Canada	iain.macdonald@nrc.gc.ca	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Macumber	Daniel	NREL	daniel.macumber@nrel.gov	PCM	<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Malherek	Elyse	Weidt Group	elysem@twgi.com		<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	McFadden	Galen	UTSA	srj874@gmyutsa.edu		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	McHugh	Jonathan	MEC	jon@nchughenergy.com		<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	McNeill	James	Affiliated Engineers	jmcneill@afieng.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mellen	Christopher		Chrismellen@gmail.com	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mendon	Vrushali	Resource Refocus LLC	Resource Refocus LLC	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Meyer	Jeffrey	Honeywell		CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Meyers	Marcus	WSP	mmyers.us@gmail.com	PCM	<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Milesi Ferretti	Natascha	NIST		Research Liason	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Miller	Clayton	NUS	clayton@nus.edu.sg	VM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mitchell	John		mitchell@enr.wisc.edu	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Miura	Mayumi	Azbil Co.	m.miura.pe@azbil.com		<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Muehleisen	Ralph	Argonne	rmuehleisen@anl.gov	VM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mukhopadhyay	Jaya	U. of Montana	jaya.mukhopadhyay@montana.edu	CM	<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Nall	Daniel		dannall@mindspring.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Nelson	Ron	IMT	ron@imt.org		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	New	Joshua	ORNL	newjr@ornl.gov		<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Neymark	Joel	J. Neymark & Asso	neymarkj@msn.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Ng	Lisa	NIST	lisa.ng@nist.gov		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Nino	Victor	Modine Manufacturing Company	v.g.nino@na.modine.com	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Norford	Leslie	MIT	lnorford@mit.edu	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	O'Brien	Liam	Carleton University	liam.obrien@carleton.ca		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	O'Keefe	Michael	Big Ladder Software	michael.okeefe@bigladdersoftware.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	O'Neill	Zheng	Univ. of Alabama	zhengoneill@gmail.com	CM	<input type="checkbox"/>
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Virtual (LV) 2022	Virtual (Phoenix) 2022	Virtual (Chicago) 2021	Last Name	First Name	Affiliation	E-mail	Voting Status	YEA
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Oh	Sukjoon	TAMU			<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Oladeji	Oladayo	Montana State University	oladejioladayo@yahoo.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Omar	Aiman	mchugheng	aomar@mchugheng.com		<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Omere	Emmanuel				<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Pahade	Akshay	Design2Occupancy	apahade@outlook.com	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Pamoukov	Stoil		spamoukov@msa-phx.com		<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Pang	Xiufeng	LBNL	xpang@lbl.gov	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Panicker	Balakrishnan	CBRE Singapore Pte Ltd	balakrishnan.panicker@cbre.com	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Paulus	Mitch	MSOE	paulusm@msoe.edu	CM	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Payne	W. Vance	NIST	vance_payne@yahoo.com	Section 4 Head	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Pegu	Bishakha	Arizona State Univ	bpegu@asu.edu	PCM	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Pegues	Jim	Carrier	james.f.pegues@carrier.utc.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Pérez Cortines	Rafael	Daikin Europe NV	rafael.perez.cortines@gmail.com		<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Roth	Amir	DOE	amir.roth@ee.doe.gov		<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sahlin	Per	EQUA	per.sahlin@equa.se		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sanchez	Jamie		jaimesanchez@gmail.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sanyal	Jibo	ORNL	sanyal@ornl.gov	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Selin	Markus	EQUA	markus.selin@equa.se		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Seymour	Mark	Future Facilities	mark.seymour@futurefacilities.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Shah	Dipak		dshah2k@hotmail.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Shah	Archan	U. of Colorado	archan.shah@colorado.edu		<input checked="" type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sharma	Chandan	FSEC	csharma@fsec.ucf.edu		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sheinman	Harris	CTT Liaison	hsheinma@heety.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Shirey	Don	EPRI	don.shirey@epri.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Shoorideh	Taraneh	P2S inc	taraneh.shoorideh@p2sinc.com	PCM	<input checked="" type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Siddiqui	Abdullah	Council Engineers	asiddiqui@counsellengineers.com	PCM	<input checked="" type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Singh	Ravindra		rsingh@baltimoreaircoil.com		<input checked="" type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sommer	Klaus		klaus.sommer@fh-koeln.de	CM	<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sowell	Edward	Ayers Sowell Assoc.	ed_c1@efsowell.us	CM	<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Stovall	Therese	ORNL	stovaltk@ornl.gov		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Strand	Richard	U of I	rkstrand@illinois.edu	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Studer	Eric	TNZ EnergyConsulting	studer@TNZEnergy.com		<input type="checkbox"/>

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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Subbarao	Kris	PNNL	kris.subbarao@pnnl.gov	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sun	Kaiyu	LBNL	ksun@lbl.gov		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Suslov	Vladimir	Armstrong	vsuslov@armstrongfluidtechnology.com	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Swartz	Keith	Energy Center of Wi	kswartz@ecw.org		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Swenka	Matt	The Weidt Group	matts@twgi.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Syed	Imran		imransyed85@gmail.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Tabares	Paulo	Colorado School of Mines	tabares@mines.edu		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Takahashi	Ken		ktakahashi@integralgroup.com		<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Taylor	Russ	UTRC	taylorrd@utrc.urc.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Theron	Sumayyah	Cyclone Energy Group	sumayyah.theron@gmail.com	PCM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Tinkler	Greg		greg@tinkler.us		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Traboulsi	Samir	Thermotrade	traboulsi.samir@gmail.com	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Trcka	Marija	UTRC	trckam@utrc.uncf.co		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Ullah	Tania	NIST	tania.ullah@nist.gov		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Van Belle	Louis	Millies Engineering	louis@megce.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Varela	Ignacio	Heatcraft	ignacio.chaparro@heatcraftcpd.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Vawter	Kathryn		kvawter@gmail.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Villa	Daniel	Sandia National Lab	dlvilla@sandia.gov		<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Wen	Jin	Drexel	jinwen@drexel.edu	CM	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Werner	Luke	ERI	luke@ERIpacific.com		<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Wessel	Dennis	Section Head			<input type="checkbox"/>
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Appendix E: Subcommittee Meeting Minutes

- Standards Subcommittee
- Multiscale Building Energy Modeling Subcommittee
- Simulation and Component Models Subcommittee
- Data Driven Modeling Subcommittee
- Handbook Subcommittee

TC 4.7 Standards Subcommittee Report – 2022Feb01 (submitted to TC 4.7 Feb 01, 2022)

The TC 4.7 Standards SubC did not hold a conference call this cycle. Notes below summarize activities based on communications with relevant PC chairs.

General

TC 4.7 is cognizant TC for the following five Standards:

- 140 that is on continuous maintenance
- 209 that is published, and recently reopen for revisions
- 205P and 229P that are in later and earlier stages of development, respectively
- 232P that is recently approved by ASHRAE StdsC and is just forming
- These will be described by their respective officers below.

140-2020: Method of Test for Evaluating Building Performance Simulation Software (Neymark/McDowell)

- Standard 140 is widely referenced (ASHRAE 90.1, 90.2, 189.1; IECC; and others)
- **New: 90.1-2019, Addendum BE, published Jan 2002, refs 140-2020** (except Secs. 7,8)
 - Adds the updated Building Thermal Fabric tests to 90.1's requirements
- **ASHRAE 90.2-2018 Addendum A** (published 2021) updates to 140-2017
 - Adds Airside HVAC Eqpt analytical verification tests to 90.2's requirements
- **Weather Drivers Test Suite led by Tim McDowell**
 - Test models' ability to accurately process weather data
 - Simulation trials are complete. Proposed addendum circulated to SSPC 140 for comments. Letter-ballot to go to public review planned for lateFeb/earlyMarch.
- **90.1 ECB/140 Acceptance Criteria WG led by Jason Glazer and Tim McDowell**
 - This attaches normative acceptance criteria to Standard 140
 - Specific 140 test cases to be applied and ranges of acceptable results are prepared
 - Addendum language is making good progress
 - Letter ballot for public review expected this year.
- **Airside HVAC BESTEST Volume 2 test suite led by Neymark**
 - Airside 2 builds more realistic annual hourly software-to-software comparative tests off of Airside 1 steady-state tests that compare software to analytical solutions.
 - Test spec development in progress.
- **DOE empirical validation test suites**
 - Work by Argonne Lab, LBNL, NREL, and ORNL
 - The labs are making good progress on empirical data generation and empirical validation test specifications intended for Standard 140.
- **90.1 Performance Rating Method (PRM) test suite**
 - This would address building types applied in Standard 90.1 and is a different testing paradigm than the more diagnostic isolated-physics test suites applied so far for Std 140.
- **Other test suites for consideration** within Standard 140 are included in a "Prioritization Roadmap" document posted at: <http://data.ashrae.org/standard140/>
- Other items we are working on include Automation of the standard and a User's Manual – both intended to facilitate use of the Standard and led by Jason Glazer.
- **140 Stakeholder meeting to happen Spring or Summer.**
 - DOE seeks to gather feedback from beyond the SSPC 140 membership on how to further improve Standard 140
 - Contact Ralph Muehleisen if you are interested in attending that

229P: *Protocols for Evaluating Ruleset Implementation in Building Performance Modeling Software* (Goel/Glazer) – Goel reporting

This item moved up on StdsC agenda so that Supriya could report at this meeting. *[Note: Consider for next meeting to begin with 229, then 140, etc.]*

- Protocols are for evaluating models from defined rule sets, e.g., for baseline and proposed models.
- Committee meetings every two months with SubCs meeting weekly or bi-weekly
- Working groups for:
 - schema ruleset model report (RMR);
 - ruleset checking
 - terminology of the standard
- Good progress
- Public review likely 2023

205P: *Standard Representation of Performance Simulation Data for HVAC&R and Other Facility Equipment* (Barnaby/Kruis) – Kruis reporting


- 205 is developing a scheme for adapting machine readable schema information from a common base source; this promotes consistency of data content/format.
- PC approved final responses to comments on public review
- Will enter 4th ISC public review (review open only on sections that had comments) that is minor changes, hoping for final publication in 2023
- First pub will have data models standardized for air-cooled chillers, DX refrigeration, electric motors and drives, etc (there are 7 equipment types total)

209-2018: *Energy Simulation Aided Design for Buildings Except Low-Rise Residential Buildings* (Glazer/Kolderup) – Kolderup reporting

- Initial meetings in 2021 – a lot of interest
- 20 VMs, 17 NVMs
- 15 different Working Groups
- IBPSA-World in process of becoming a co-sponsor of the standard
- PC voted to become an SSPC, continuous maintenance
- Public review perhaps later next year (2023)

232P: *Schema-Based Building Data Model Protocols* (McDowell)

- Approved for going forward in December 2021 with McDowell as Chair
- Defines data structures and conventions that would be used for BPS models, but not defining data models themselves
- 229 needs data structures and IBPSA building data exchange committee needs to agree on data structures
- Call for members has been issued, applications due 2/21; go to ashrae web site under standards and guidelines, then the committee link
- First meeting planned after membership is formed, has to go through SPLS for membership approval.

	<p style="text-align: center;">Agenda and Minutes TC 4.7 MBEM Subcommittee 1/31/2022: Las Vegas Winter Mtng 6-7pm PST, 7-8pm MST, 8-9pm CST, 9-10pm EST Virtual Chair: Ron Judkoff ron.judkoff@nrel.gov</p>
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[New Research Topics](#)

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[Appendix B: 2021 Winter \(Chicago\) Program Tracks](#)

Connection Instructions

Microsoft Teams meeting

Join on your computer or mobile app

[Click here to join the meeting](#)

Or call in (audio only)

[+1 630-556-7958,,385301237#](#) United States, Big Rock

Phone Conference ID: 385 301 237#

[Find a local number](#) | [Reset PIN](#)

[Learn More](#) | [Meeting options](#)

Call to Order & Introductions

- Ralph Muehleisen, TC-4.7 Committee Chair
- Neal Kruis, Committee Vice-Chair
- Hyojin Kim, Incoming Secretary
- Brian Kastl, Committee Program Chair
- Jeannie Kim, Committee Webmaster

- John Pruett, Committee Handbook Chair
- Tim McDowell, Committee Research Chair
- Joel Neymark, Committee Standards Chair
- Ron Judkoff, Multi-scale Building Modeling Subcommittee Chair
- Amanda Smith, Data-driven Modeling Subcommittee Chair
- Brian Ball, Simulation and Component Models Subcommittee Chair

Research

Ongoing Research Projects

1816-RP: Load Profiles for Hospital Imaging Equipment (TC 4.1 cognizant, TC 4.7 co-sponsor). Jeff Haberl is PMS. This has been awarded and is getting started. Siemens is partnering. Who are other contractors? What are contractors names. Who were authors? What is status? Haberl to find out from RAC. **Haberl reports they are having trouble gaining access to hospitals, so project is going slowly.**

Work Statements

1857-WS: Improved simplified methodology for describing and calculating heat conduction between buildings and the ground. Kruis and McDowell authors. WS Has been accepted. TC-4.4 will co-sponsor. 90.1 and 4.1 are other potential co-sponsors. Info sent out to full TC for comments. RAC and 4.1 had minor comments. Neal and Tim updated the WS and responded to comments. TC-4.7 voted to move this forward with an email ballot in Nov. 2020. Tim and Neil working to make changes requested by RAC. What is the current status?

Having a hard time getting responses from research Liaison. Tim says she'll review and get comments back to him soon. Ralph to mark down problems with RAC again on activity form.

Draft RTARs

<See Latest Research Spreadsheet and filter on MBEM>

New Research Topics

Report on Survey of MBEM practitioners Needs. Jeff Haberl and Xi Zhao: Conducted a survey on what research is needed for community/urban scale modeling and who is performing such modeling. Jeff and Xi conducted 3 survey phone meetings. Report was posted on BASECAMP by Judkoff on 1/26/22. Jeff mentioned that one of the top issues involved the need to validate stock models because there are so many assumptions and approximations built-in. How well can reference buildings represent a group of buildings? How well can Google Earth aerial photos plus extruded vertical form represent the buildings? An annotated bibliography of existing and ongoing research is needed. Tianzhen: Annex 70 did a survey about data sources and methods and is writing up a report.

- 5min: Jeff and Xi present highest priority findings.

Some big findings: More intercommunication between modelers - methods vary widely.

It's a potential seminar/program topic on this?? (What topic? Is it communication or general MBEM?)
Peter Ellis observed that there wasn't enough representation from private sector practitioners and wondered if there was a design to focus on university/lab researchers? Jeff said it was an omission and the document is a living document. Jeff and Xi will interview Peter and add to the document.

Validating Morning Warmup in Simulation. Erik Kolderup organized several calls and started an RTAR with several others.

- 5 min: Erik give status and current participants.

Not much has happened since July online meeting. Topic has interest, but how to do research on this topic is unclear to Erik.

Google doc link: https://docs.google.com/document/d/1NXz_0NYgQPv-yiwpoq1JCCrzyRfbVyuq2sh2jNRnf88/edit?usp=sharing

Model Calibration for future weather change. Daniel Villa. RTAR part written. Action: Ralph to check on status with Villa.

- Ralph or Daniel give status.

No new updates - keep it on the list.

Tianzhen: Interbuilding effects (especially in a dense urban context) Shading, interbuilding radiation coupling. When do these get strong enough that we need to consider? Ron: Urban canyons can radiate infrared radiation to surrounding buildings and light-colored pavements could reflect short wave radiation into windows of surrounding buildings. Tianzhen to put together a short presentation/review to help committee determine need.

- Tianzhen give status.

Seminar proposal was rejected for Las Vegas. Ron suggested resubmitting to the Toronto meeting. Toronto may be difficult for Lab staff to attend.

Ron: Grid Interactive Buildings (Energy Modeling Aspects). Keep our eye on the topic. Maybe a seminar. Maybe the BTO Roadmap people. Action Tianzhen will talk to BTO Roadmap people to give seminar.

- Tianzhen give status.

Will look at Toronto for a seminar.

Ron: Passive House (Haus) standard design was developed in Europe where heating load dominates. How does that really apply/work here in the US where cooling loads are larger? Purpose is to inform designers. Tianzhen, PNNL is looking at this from the lens of resilience. This is also related to over insulating data centers (90.1 minimums are way too high for high internal load buildings/processes). Tim: overtightening buildings can increase cooling loads in certain climates and building types. Co-sponsor between 4.7 and others 9.9 (data intensive), TC 2.10 (resilience). Ralph: Maybe pose this more generally than Passive Haus, but as a general problem of determining under what conditions additional insulation becomes detrimental.

- What is next action on this?

This item should look at other aspects such as embodied carbon and operational carbon beyond what we normally focus (i.e., energy use). Ron wondered if there are any ASHRAE documents to convert energy to operational carbon. Ralph mentioned EPA's efforts: eGrid. One effort made by NREL is Cambium data set: <https://www.nrel.gov/analysis/cambium.html>.

Nick Long mentioned EMS measure being added to URBANopt for use in LadyBug Tools:

https://github.com/NREL/openstudio-common-measures-gem/tree/develop/lib/measures/add_ems_emissions_reporting

Wangda has two papers on this topic and would be happy to speak at the seminar.

Wangda volunteers to chair a session. Need speakers - interested people should email Wangda at wangda.zuo@psu.edu.

Haberl: Need research on mixed use buildings (eg. Atria, Shopping Centers, etc.).

Program Submissions

Program Ideas

Ralph submit V&U session for Phoenix? (LBNL, ORNL, NREL, ANL). Is it ready yet? Maybe Annual 2022. **Now to be Winter 2023.**

Joshua: (idea only – someone should lead) Empirical validation of multiscale buildings but put focus on calibration. Ralph contact End Use Load Profile project about potential discussion of calibration/uncertainty.

- Ralph: status? **Now to be Winter 2023.**

Tianzhen thinking of submitting something on “Performance Gap”. Ron: Maybe the seminar should be about realigning expectations of what simulation tells us? Jeff: States/cities have started looking at using simulation to predict carbon reductions for above code buildings (and stretch codes). How is this working? Is it accurate enough? Tianzhen to contact his colleague Jerry about helping put together a seminar on GEB modeling. Status? **(See above)**

MBEM in Practice session for 2022 Annual: (Idea from Joshua New who can help find speakers but can't lead) Peter Ellis or someone else from Big Ladder to lead.

Program on 229 rule-set checking (i.e. appendix G rules to create a reference building) end-to-end when it is ready. Status?

Keep it on the list. Supriya or Jason may lead this effort.

Other Topics for Discussion

Standard 209, **BEM Aided Design**, is starting an update. Next meeting is June 15th. Status? **Monthly meetings are happening. Maybe we can start with updates after that. Committee looking at possibly trying to become SSPC**

Wangda wants to maybe do something on Air Quality. They have a paper. Tim will introduce to CONTAM people at NIST and the 1.x group working on that.

Related Topics:

229P, Rulesets for correctly generating BEM reference buildings.

205P, Data for HVAC Equipment.

232P, Schema based Data Model Protocols. Looking for memebers.

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Ball, Brian	Brian.Ball@nrel.gov
Brian Kastl (Guest)	
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Upcoming Meetings

- June 25-29, 2022 – Toronto, ON
- Feb. 4-8, 2023 – Atlanta, GA
- June 24-28, 2023 – Tampa, FL
- Jan. 20-24, 2024 – Chicago, IL
- June 22-26, 2024 – Indianapolis, IN
- Feb. 8-12, 2025 – Orlando, FL
- June 21-25, 2025 – Phoenix, AZ

Appendix A: Resources

- ASHRAE's Research Proposal Process:
 - <https://www.ashrae.org/file%20library/technical%20resources/research/ashrae-research-flowchart-r6.pdf>
- 4.7 Committee Home Page:
 - <http://tc0407.ashraetcs.org/>
- 4.7 BaseCamp Page:
 - <https://3.basecamp.com/3106353/projects/8174587>

2022 Annual (Toronto) Program Tracks

The 2022 ASHRAE Annual Conference technical program is comprised of eight tracks, selected to represent areas of focus common among ASHRAE membership.

Track	Description
1	Fundamentals and Applications: Fundamentals and Applications: Fundamentals are the foundation for understanding applications in engineering. Key components of ASHRAE fundamentals include thermodynamics, psychometrics, fluid and mass flow. This track provides opportunities for papers and presentations of varying levels across a large topic base. Concepts, design elements and shared experiences for theoretical and applied concepts of HVAC&R design are included. Track Chair: Erik D Sanchez esanchez@prmech.com
2	HVAC&R Systems and Equipment: HVAC&R Systems and Equipment: HVAC&R systems and equipment are constantly evolving to address the changing requirements of the built environment. Papers and programs in this track focus on the development of new systems and equipment, improvements to existing systems and equipment and the proper application and operation of systems and equipment. Track Chair: Marites Calad mcalad@norman-wright.com
3	Research Summit: Active research, and the exchange of those research findings, are critical to the development of our HVAC&R industry and built environment. The 9th annual research summit invites researchers to share those results, including ASHRAE-sponsored research and research of interest to the ASHRAE community. Researchers are invited to present papers, extended abstracts, seminars, forums or participate in panel discussions. The Research Summit includes a partnership with ASHRAE's archival journal, <i>Science and Technology for the Built Environment</i> . Track Chair: Brian Fronk brian.fronk@oregonstate.edu Environment
4	Connected Buildings, Connected Communities: As buildings become smarter, and as sensor systems, internet connectivity and data collection become more ubiquitous, there are substantial opportunities to improve the performance and efficiency of buildings. Similarly, as renewable energy resources, including wind and solar energy and energy storage, becoming increasingly common, buildings can be used as electric

	<p>grid assets, to strategically support energy efficiency and demand flexibility. To accomplish this requires many stakeholders, coordinated efforts and a diversity of buildings and buildings systems components and controls.</p> <p>Track Chair: Ahmed Abdel Salam ahmed.abdel-salam@usask.ca</p>
5	<p>Cold Climate Building System Design, Operation and Resilience: The design, construction and operation of buildings in cold climate regions which experience extreme winter conditions require specific considerations for the building envelope and HVAC&R systems and resulting thermal and hygrothermal performance. Resilience in the face of extreme temperature shifts, and in some cases remoteness and permafrost, should be considered to ensure building maintain interior design conditions. This track covers efforts and topics specifically focused on buildings, building systems and equipment in cold, arctic and subarctic climates.</p> <p>Track Chair: Davide Ziviani dziviani@purdue.edu</p>
6	<p>IAQ, Energy Use, Comfort and Health of Sustainable Buildings: Indoor environmental quality, energy use and efficiency and occupant comfort and health are all priorities buildings must balance. Sustainability priorities in buildings continue to increase, requiring careful consideration of how to achieve sustainability goals without sacrificing other building functions and owner/operator priorities. This track covers each of these topics, and how they interact and impact one another.</p> <p>Track Chair: Rafi Karim rkarim@aeieng.com</p>
7	<p>Professional Development and Education: As members of a professional organization, we not only participate for the great value of technical exchange, but also the interpersonal exchange. We recognize that the single greatest strength of our organization is its membership. This track is designed to allow those professionals and educators an opportunity to develop and share knowledge in the areas of presentation skills, leadership, team-building, understanding various business operations, lean collaboration strategies, interpersonal skills, etc., and an opportunity for educators to share knowledge in the teaching and education of current and future generations of professionals. Submissions to this track may lend themselves to interactive session types such as workshops, panels and forums.</p> <p>Track Chair: Maggie Moninski maggie.moninski@gmail.com</p>
8	<p>Buildings in the Aftermath of COVID-19: The pandemic has had significant impacts on how buildings are used, and the priorities associated with building operations to ensure a healthy environment for occupants. More people are working remotely; commercial building interior design and functionality and occupant use of these buildings, ventilation and system needs and building owner, operator and occupant priorities have been impacted. This track covers these topics as our buildings transition to design and operation in the aftermath of the pandemic.</p> <p>Track Chair: Andy Cochrane acochrane@industrialairinc.com</p>



Minutes
TC 4.7 Simulation and Component Models Subcommittee
2022-01-31
22:00 EST
Virtual
Chair: Edwin Lee (edwin.lee@nrel.gov)

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[Appendix A: Resources](#)

[Appendix B: Future Program Tracks](#)

Connection Instructions

Meeting URL: [Link](#)

Meeting ID: 325362110

Dial In: +1 630-556-7958,,325362110#

Basecamp Announcement Link: [Link](#)

Call to Order & Introductions

- Ralph Muehleisen, Committee Chair
- Neal Kruis, Committee Vice-Chair
- Hyojin Kim, Secretary
- Brian Kastl, Committee Program Chair
- Joshua New, Committee Webmaster
- John Pruett, Committee Handbook Chair
- Tim McDowell, Committee Research Chair

- Joel Neymark, Committee Standards Chair
- Ron Judkoff, Multi-scale Building Modeling Subcommittee Chair
- Amanda Smith, Data-driven Modeling Subcommittee Chair
- **Edwin Lee, Outgoing** Simulation and Component Models Subcommittee Chair
- **Brian Ball, Incoming** Simulation and Component Models Subcommittee Chair

Research

Ongoing Research Projects

- **1661-RP**: Development and Validation of Dynamic Models for the Evaluation of Chilled-Water Systems Control Strategies in the ASHRAE Handbook.
 - On no-cost extension, was hoping to get it done during 2021.

No cost extension till April 2022.

Work Statements

- **1748-WS**: Assess and Implement Natural and Hybrid Ventilation Models in Whole-Building Energy Simulations - Phase 2
 - Joe sent email to Natascha Milesi-Ferretti for review to get this project moving again

It's out of the system and needs to be resubmitted and get a new number. Joe will address comments from RAC and resubmit it.

Draft RTARs

- None that I am aware of

New Research Topics

- Development of a Reference Building Information Model (BIM) for Daylighting Optimization
 - Email thread started, need to follow-up
 - Follow on to 1468 Jeff has talked with Dave Branson from 4.5 on this. Two potential RTARs.
- Follow-on to RP-1588 (WindowModeling): Address Future Work Recommendations
 - Joe action item, any update?
 - Joe will start it and Neal will review. Not many people used it - needs some work for commercial release.
- Improved Dynamic Heat Pump Modeling
 - Non-ASHRAE projects are handling this, remove from the list
- Optimizing Change-over Mixed-mode Cooling Systems for Using Building Simulation
 - Liping champion
 - Liping plans to follow up with Joe/Jeff.
- Validating morning warm-up in simulation
 - Still open to pushing on this, but no progress to report
 - Discussed in MBEM SC meeting - remove from SCM.

- Impact of Capturing Occupant Movement in a Building
 - Tianzhen update during this meeting hopefully

Tianzhen: Occupant schedules was part of End Use Load profile project and others are using agent based modeling to study people and develop schedules. But, it's not clear what a project might be.

Neal: Maybe there is a program item here if not an RTAR. Maybe we can look at better using American Time of Use Survey data (ATUS) data for energy modeling

Jeff: Guideline 45P is now a guideline and they are starting to look at occupancy effects on what you would measure(45P is about measuring information/data in buildings).

Maybe TC4.7 and MTG OBB can look at a joint program. Edwin will help coordinate!

- Automated thermal zoning methods
 - Jeff action item, any update?

Grid/Cluster method was developed by TAMU doctoral student: Shin, M., Haberl, J. 2022.

“Development of a Procedure for Automated Thermal Zoning for Building Energy Simulation”, Journal of Building Engineering, (January). Disagreement between heating vs. cooling loads. Jeff to nudge Minjae more on this.

- Optimizing the use of reduced weather data sets in simulations
 - Joe action item, any update?

Jason sent Joe a very rough draft to him. It's been circulated in 4.2 and waiting for comments. Can circulate with 4.7

- Last meeting we discussed two publications: Annotated guide to load calculation models, and HVAC 2 Toolkit

Ralph to actually get started on this as a PTAR with Jeff.

Program

Program Submissions

- No program submissions currently in place

Program Ideas

- 1661: Development and Validation of Dynamic Models for the Evaluation of Chilled-Water Systems Control Strategies in the ASHRAE Handbook. (Wangda)

Wangda is ready to present, but we may need additional speakers. Seminar for Atlanta (2023 Winter).

- 3 program ideas regarding extreme simulations, no update, probably remove from the list for now
- Modernizations in Simulation Engines
 - Edwin willing to try again on this. Maybe for Atlanta (2023 Winter).

Other Topics for Discussion

Attendance:

Full Name	Email
Muehleisen, Ralph T.	rmuehleisen@anl.gov
Haberl, Jeff	jhaberl@tamu.edu
Tim McDowell	mcdowell_tess-inc.com
Judkoff, Ron	Ron.Judkoff@nrel.gov
Liam Buckley	liam.buckley@iesve.com
RIAD ASSAF	riad.assaf@ul.edu.lb
neymarkj	neymarkj@msn.com
Emmanuel Omere	eomere@psdconsulting.com
Neal Kruis	neal.kruis_bigladdersoftware.com
Adams, Mark	adamsmb@ornl.gov
Smith, Amanda D	amanda.d.smith@pnnl.gov
Hyojin Kim (Guest)	
Erik Kolderup (Guest)	
Long, Nicholas	Nicholas.Long@nrel.gov
Liping Wang	lwang12@uwo.edu
Kim, Ji-Hyun (Jeannie)	jihyun.kim@anl.gov
Ball, Brian	Brian.Ball@nrel.gov
Joe Huang (Guest)	
Clayton Miller	clayton@nus.edu.sg
Baltazar, Juan Carlos	jbaltazar@arch.tamu.edu

Upcoming Meetings

- June 25, 2022 - Toronto, ON
- Feb 4, 2023 - Atlanta, GA
- June 24, 2023 - Tampa, FL
- Jan 20, 2024 - Chicago, IL
- June 22, 2024 - Indianapolis, IN
- Feb 8, 2025 - Orlando, FL
- June 21, 2025 - Phoenix, AZ

Appendix A: Resources

- ASHRAE's Research Proposal Process:
 - <https://www.ashrae.org/file%20library/technical%20resources/research/ashrae-research-flowchart-r6.pdf>
- 4.7 Committee Home Page:
 - <http://tc0407.ashraetcs.org/>
- 4.7 BaseCamp Page:
 - <https://3.basecamp.com/3106353/projects/8174587>

Appendix B: Future Program Tracks



Minutes
TC 4.7 DDM Subcommittee

2022-01-31

8-9 pm Pacific

Virtual

Chair: Amanda Smith, amanda.d.smith@gmail.com

[Call to Order & Introductions](#)

[Research](#)

[Ongoing Research Projects](#)

[Work Statements](#)

[Draft RTARs](#)

[New Research Topics](#)

[Program](#)

[Program Submissions](#)

[Program Ideas](#)

[Upcoming Meetings](#)

[Appendix A: Resources](#)

[Appendix B: 2021 Winter \(Chicago\) Program Tracks](#)

Connection Instructions

Microsoft Teams meeting

Join on your computer or mobile app

Click here to join the meeting<https://teams.microsoft.com/join/19%3ameeting_NDBhYTE1MmEtMDRiZC00MDEzLTg3NmQtMDhhNjY3YTM3NTQ1%40thread.v2/0?context=%7b%22Tid%22%3a%220cfca185-25f7-49e3-8ae7-704d5326e285%22%2c%220id%22%3a%22524a3cdb-4a5e-4912-a378-99c1190b8422%22%7d%7d>

Or call in (audio only)

+1 630-556-7958,,960580961#<tel:+16305567958,,960580961#> United States, Big Rock

Phone Conference ID: 960 580 961#

Find a local number<<https://dialin.teams.microsoft.com/99d5311c-737a-4ccf-b5fb-198aeb5c306f?id=960580961>> | Reset PIN<<https://mysettings.lync.com/pstnconferencing>>

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options<https://teams.microsoft.com/meetingOptions/?organizerId=524a3cdb-4a5e-4912-a378-99c1190b8422&tenantId=0cfca185-25f7-49e3-8ae7-704d5326e285&threadId=19_meeting_NDBhYTE1MmEtMDRiZC00MDEzLTg3NmQtMDhhNjY3YTM3NTQ1@thread.v2&messageId=0&language=en-US>

Call to Order & Introductions

- Ralph Muehleisen, Committee Chair
- Neal Kruis, Committee Vice-Chair
- Hyojin Kim, Secretary
- Tim McDowell, Committee Research Chair
- Joel Neymark, Committee Standards Chair
- Ron Judkoff, Multi-scale Building Modeling Subcommittee Chair
- Amanda Smith, Data-driven Modeling Subcommittee Chair

Other attendees:

- Mark Adams
- Brian Ball
- Liam Buckley
- Anthony Fontanini
- Jeff Haberl
- Tianzhen Hong
- Joe Huang
- Brian Kastl
- Yuqing Hu
- Ji-Hyun (Jeannie) Kim
- YangSeon Kim
- Erik Kolderup
- Edwin Lee
- Nicholas Long
- Emmanuel Omere
- Prateek Srestha
- Alfred Uzokwe
- Liping Wang
- Wangda Zuo

Research

[DDM Agenda](#) from 2021 Annual Conference

2 items tied to DDM in [Research Topics](#) spreadsheet TAB Topics in *ASHRAE Pipeline*

- 1921 Enhancing Whole-Building Calibrated Simulation Using Indoor Environmental Data
 - RTAR accepted; follow up with Hyojin
 - Working on WS. Hyojin plans to finalize WS with Jeff and present it to 4.7.
- 1920 Building Energy Data-Driven Prediction Modeling Toolkit
 - Clayton submitting this as a PTAR rather than RTAR
 - Starting on paperwork for the PTAR. Clayton is already working on the document. Jeff volunteered to help with PTAR.

- Jeff mentioned TC 1.5 being interested in Predictor Shootout IV. Contact Jeff if interested.

7 items tied to DDM in [Research Topics](#) spreadsheet TAB *Topics in Discussion*

- Development of an Improved Toolkit for Analyzing Building Energy Use from Time Series Data: Update to the Inverse Model Toolkit (was 1763-WS)
 - Jeff wants to continue.
- Data-driven clustering methods
 - Dropped for now.
- Best practice of using machine learning models for building energy predictions
 - Combine with the shootout III toolkit as a PTAR.

10 items to follow up on in as assigned [in Basecamp](#) after 2021 Annual meeting

Ongoing Research Projects

None.

Work Statements

None.

Draft RTARs

- ASHRAE Standard 140 for DDM
 - Residential version is a RESNET standard. Could serve as a template for a commercial version. Ron will draft an RTAR for review.

New Research Topics

- Automatic Calibration of multiple buildings / ensemble methods
 - MBEM survey discussed methods for calibrating - not enough for a RTAR but will continue working on it.
- Metadata classification
 - Stalled, but still an idea to pursue
- Can the Inverse Modeling Toolkit be used for Data Mining
 - new idea - TC1.5 idea
- New idea on connecting data driven models with physics based models by Liping

- Efforts on this topic have been already made. e.g., python integration with EnergyPlus.
- Going to controls take a look at BOPTEST. (<https://github.com/ibpsa/project1-boptest>), You can hook up RL with metamodels for training and neural nets for running building models. Easiest to connect via OpenAI gym (<https://github.com/ibpsa/project1-boptest-gym>). Similarly, look at Alfalfa for more generic OpenStudio and/or Modelica interface to the model (<https://github.com/NREL/alfalfa>)

Program

Program Submissions

- From [Program Topics](#) spreadsheet:

Program Ideas

Idea: Seminar

ML-based methods for building performance simulation

Chair: Liping (or she finds chair)

Speakers: Liping, possibly someone from Ralph's group

Conference: Undetermined (2023 Winter?)

Idea: Seminar

PCA and producing orthogonal inputs for training data

Chair: Jeff

Speakers: Jeff finds them

Conference: Undetermined (2023 Winter?)

Other Topics for Discussion

Meeting chat

[8:43 PM] Haberl, Jeff

Kim, K. and Haberl, J. (2015). "Development of a Home Energy Audit Methodology for Determining Energy-Efficient, Cost-effective Measures in Existing Single-Family Houses Using an Easy-to-Use Simulation", Building Simulation , Vol. 8, No. 5, pp. 515-528, ESL-PA-15-06-03 (June).

[8:43 PM] Haberl, Jeff

Kim, K. and Haberl, J. (2015). "Development of A Methodology for Calibrated Simulation In Single-Family Residential Buildings using Three-Paramter Change-point Model", Energy and Buildings, Vol. 99, pp. 140 - 152, ESL-PA-15-04-02 (April).

[8:46 PM] Haberl, Jeff

Algorithm for automating the selection of a temperature dependent change point model

Author links open overlay panel Mitchell T. Paulus David E. Claridge Charles Culp

<https://doi.org/10.1016/j.enbuild.2014.11.033>

A Change-Point Principal Component Analysis (CP/PCA) Method for Predicting Energy Usage in Commercial Buildings: The PCA Model | J. Sol. Energy Eng. | ASME Digital Collection

<https://doi.org/10.1115/1.2930035>

[8:58 PM] Long, Nicholas

Going to controls take a look at BOPTEST. (<https://github.com/ibpsa/project1-bopetest>), You can hook up RL with metamodels for training and neural nets for running building models. Easiest to connect via OpenAI gym (<https://github.com/ibpsa/project1-bopetest-gym>). Similarly, look at Alfalfa for more generic OpenStudio and/or Modelica interface to the model (<https://github.com/NREL/alfalfa>) (1 liked) GitHub - ibpsa/project1-bopetest: Building Optimization Performance Tests Building Optimization Performance Tests. Contribute to ibpsa/project1-bopetest development by creating an account on GitHub.github.com

Upcoming Meetings

- Feb. 4-8, 2023 – Atlanta, GA
- June 24-28, 2023 – Tampa, FL
- Jan. 20-24, 2024 – Chicago, IL

Appendix A: Resources

- ASHRAE's Research Proposal Process:
 - <https://www.ashrae.org/file%20library/technical%20resources/research/ashrae-research-flowchart-r6.pdf>
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- 4.7 BaseCamp Page:
 - <https://3.basecamp.com/3106353/projects/8174587>



TC4.7 Handbook Subcommittee

Minutes

3:00pm – 4:00 pm, January 26, 2022

Virtual

“Commitment to the ASHRAE Code of Ethics: In this and all other ASHRAE meetings, we will act with honesty, fairness, courtesy, competence, integrity and respect for others, and we shall avoid all real or perceived conflicts of interest. (See full Code of Ethics: <https://www.ashrae.org/about-ashrae/ashrae-code-of-ethics>)”

1) Sign-in / Introductions **10 attendees. Meeting start 3:01 / end 4:03 (EST).**

2) Primary focus at this meeting:

a. Open discussion of the future of our chapter: keep as one or split into two? The 2017 chapter was 53 pages; the 2021 chapter is 72 pages.

Reorganize now for future split? Include reorganization as part of this cycle.

One chair or two?

How to split references?

Is this more work for little benefit?

- How to split? **Historic, new material**
- Keep both in Fundamentals or propose one to be in another volume?

Applications for the new material, Fundamentals for historic? Portions online only?

- ASHRAE has final say – and prefers not to add chapters...
- Will need VM's to formally vote on this
- I have asked ASHRAE to add this to the Handbook Committee meeting agenda, and I will be attending that meeting to answer any questions they may have. **I attended the Handbook Committee meeting on Sunday (1/30). Overall, they were very receptive to the idea of splitting the chapter but want to see a breakdown of the material that will be in each chapter and approximate page count of each. There was no negative feedback from the Committee members. If we want to pursue this, we will need to submit a written proposal stating why we want to split the chapter, how we will split it, etc. They liked our proposed approach of reorganizing the chapter to better determine where the logical split point might be.**

Current ASHRAE President Mick Schwedler was also in the meeting. He acknowledged the issues surrounding the 2021 Fundamentals and took the blame for it: as a cost saving measure during COVID they cut several staff positions at ASHRAE. Many of these were in publications, especially

Handbook. He said they drastically underestimated the manpower required to update the Handbook, and the 2021 edition had more chapters change than usual. They have changed the review policy for all Handbooks moving forward: proofs of all chapters will be sent out to the responsible TC's, regardless of whether revisions were submitted or not. The TC's will be required to sign off on their proofs and return them to ASHRAE.

ASHRAE hot topic: decarbonization (Task Force for Building Decarbonization). Is there anything relevant to add to Chapter 19?

- b. Review / assignment of previously considered topics. Which topics will we be addressing this cycle, which will slide to next cycle (2029)?
 - c. New ideas? John P. to upload 2021 pdf to Basecamp
- 3) Topics previously discussed for consideration: John P. to post action items on Basecamp.
- a. Standard 209 is undergoing a revision / update. We will need to update references to Std 209 in Chapter 19.
 - b. Standard 205 will be published prior to the 2025 edition of Fundamentals.
 - c. Standard 229? Timeframe may extend beyond 2025 Fundamentals.
 - d. Add some content on empirical validation (Standard 140). Ron J. / Joel N.
 - e. Add content on carbon emissions. Multiple sources of emissions. Standard 209 has working group (Erik K. / Daniel V.)
 - f. Update references to ground-coupled systems and expand that content to make it more relevant to today's usage and design of those systems. Jeff H.
 - g. New section on modeling thermal resilience. This would include weatherization (Tianzhen Hong with Jason Degraw contributing to this?) and simulation – equipment changes or building changes to improve resilience. How it affects modeling / how modeling affects building choices. This is an application of energy modeling – should it be included? Tianzhen H.
 - h. Add some content on code-compliant modeling – commercial vs. residential expand?
 - i. Predictive Modeling (determining inputs)
 - j. Building Energy Modeling for Net Zero (New Chapter section)
 - k. Combined Heat and Power Systems (Ralph M. to review 2 chapters by TC1.10)
 - l. Optimization Across Multiple Buildings (Tianzhen H.?)
 - m. Grid Stuff – Demand Response, Grid Interaction / Grid Response
(Ralph M. to review chapter by TC1.9)
 - n. Elevation Variations – Air property issues, address equipment performance, geography vs. tall buildings. **Standard 140** Joel N.

- o. Dynamic High Frequency System Modeling – Modelica? Ties to grid stuff (item 4k) and controls modeling – 15 minute modeling or less. Additional issues that can arise when subhourly modeling. Michael W.
- p. Thermal Zoning – Improvement
Jeff H. has a student that has research and information.
Different zoning for winter vs. summer. Thesis available?
- q. Appropriate Simplification – Temporal and Spatial. Create table for simplified through complex modeling (with multiple levels) and when to use. Provide references to this table in text and add examples (papers). Example of Model Simplification – any research?
Tianzhen H. to coordinate and Erik K. volunteered to contribute.
- r. Terminal Unit systems (Chilled Beams, radiant floors, etc.) – Active systems easy to model; passive systems much more difficult to model. Trane has a paper on passive. Contact healthcare designers such as AEI.
Sagar R. to assist / coordinate?
- s. Renewables – tie to passive heating / cooling [check Table of Contents]. Active? Ties to resilience and grid stuff. “Passive” through “Resilient”? Photovoltaics. Energy / thermal storage. Program: Reopt. Renewables: resilient modeling and design.
Ron J. and Jeff H. volunteered to contribute / coordinate.
- t. HVAC Toolkit updates (if any) – Only Toolkit II is listed / referenced. Need to add Toolkit I. Jeff?
- u. Completed RP's – We need to contact the authors of the RP's. Names / contacts?
 - RP 1741 Fan Coils Neal K.
 - Chiller plant Control Strategies
 - RP 1742 Plug Loads
 - Others?
- v. Misc. Ideas
 - Based on the Introduction section of Joe Clarke's book -- “Energy Simulation in Building Design” (2001) 2nd Ed., Routledge – there are a few other topics that could be added in brief: Surface convection, interior and exterior IR exchange, internal gains, moisture. Proposed sections on 1. Boundary Conditions and 2. Moisture
 - Section recommended on recent work by PG&E and LBNL to develop methods to test and validate the predictions of black box models, for example:
 - i. Granderson, et. al., “Accuracy of Automated Measurement and Verification (M&V) Techniques for Energy Savings in Commercial Buildings,” Applied Energy 173 (2016) p. 296-308.
 - ii. Price, et. al., “Commercial Building Baseline Modeling Software: Performance Metrics and Method Testing with Open Source Models and Implications for Proprietary Software Testing,” Final Report, ET no. ET12PGE5312, Sept. 9, 2013, www.etcc-ca.com.

iii. Jump, et. al., "Functional Test Protocols for Commercial Building Efficiency Baseline Modeling Software," ET no. ET12PGE5312, Sept. 9, 2013, www.etcc-ca.com.

- Addressing the issue of temperature based control vs. load based control in simulation.
- Also address coupling of models? Applications and general methods? Internal vs. external.

w. Atrium Modeling

4) New Ideas?

5) Adjourn