

SOCIETY OF HEATING, REFRIGERATION AND AIR-CONDITIONING ENGINEERS,
INC.

1791 Tullie Circle, NE / Atlanta, GA 30329
404-636-8400

TC/TG/TRG MINUTES COVER SHEET

(Minutes of all meetings are to be distributed to all persons listed below within 60 days following the meeting.)

TC/TG/TRG No. TC 4.7 DATE: June 14, 2015

TC/TG/TRG TITLE: Energy Calculations

DATE OF MEETING: January 26, 2016 LOCATION: Orlando

MEMBERS PRESENT	YEAR	MEMBERS ABSENT	YEAR	EX-OFFICIO MEMBERS &
Joe Huang (CHAIR)	2012	Dr Kamel Haddad, Phd	2013	See attendance sheet additional attendees
Bass Abushakra (VICE CHAIR)	2012	--		
Dr Jeff Haberl. PhD (Research)	2015			
Joel Neymark (Standards Chair)	2011			
Dr Wangda Zuo	2013			
Chris Balbach (Secretary)	2013			
Erik Kolderup (Handbook)	2013			
Joshua New (Webmaster)	2015			
Dru Crawley (SCM)	2015			
Ralph Muehleisen (DDM)	2013			
Ron Judkoff (Applications)	2013			
Keith Cockerham (Programs)	2013			
Dr. Neal Kruis	2015			
Dr. Malcolm Cook	2012			

Total attendance of voting members: 9 present, 1 absent.

DISTRIBUTION

ALL MEMBERS OF THE TC/TG/TRG

TAC CHAIR

Walter T. Grondzik

TAC SECTION HEAD

Michael R. Bilderbeck

SPECIAL PUBLICATIONS LIAISON

STANDARDS LIAISON

James Dale Aswegan

HANDBOOK LIAISON

David P Yuill

RAC RESEARCH LIAISON

PROF DEV COMM LIAISON

Hugh D. McMillan

CHAP TECH TRANSFER LIAISON

Harris Sheinman

STAFF LIAISON (RESEARCH)

Michael Vaughn

STAFF LIAISON (TECH SERVICES)

Michael Vaughn

STAFF LIAISON (STANDARDS)

HANDBOOK RESPONSIBILITIES

<u>Year & Volume</u>	<u>Chapter Title</u>	<u>No.</u>	<u>Deadline</u>	<u>Handbook Subcom.</u>	<u>Chair/Liaison</u>
2017 Fundamentals	Energy Estimating Methods	19	June 2016		Kolderup/Yuill

These draft minutes have not been approved and are not the official, approved record until approved by this committee.

**ASHRAE TC 4.7 Energy Calculations
Orlando Meeting**

MOTIONS AND ACTION ITEMS

MOTION: A motion passed to review the minutes from the Atlanta meeting; 6-0-2 CNV. Chair voted in abstention because there was not time to review them.

MOTION: A motion passed for a no cost extension to August 1st, 2016 for RP 1588; 7-0-2 with Chair abstaining ó Neal K. also abstaining because a member of contractor team

MOTION: A motion passed requesting co-sponsorship from TC 5.3 (Room Air Distribution) of 1741-WS òUnderstanding Fan Coil Components and How They Relate to Energy Consumption and Energy Modelingö 8-0-0 with CNV.

MOTION: A motion passed to approve the proposed St. Louis Program: 3 Seminars were proposed, including a Seminar on Design of Experiments, a seminar on ASHRAE SPC 209P, and a re-submission by Wangda. 7-0-0 with CNV.

TC/TG/TRG MEETING SCHEDULE				
LOCATION – past 12 months		DATE	LOCATION - planned next 12 months	DATE
Atlanta		June 30, 2015	St. Louis	June 28, 2016
Orlando		January 22, 2016	Las Vegas	January 2017
TC/TG/TRG SUBCOMMITTEES				
Function			Chair	
Program			Keith Cockerham	
Research			Jeff Haberl	
Handbook			Erik Kolderup	
Standards			Joel Neymark	
Data Driven Models			Ralph Muelensien	
Simulation and Component Models			Drury Crawley	
Applications			Joe Huang	
RESEARCH PROJECTS – Current			Monitoring	Report Mode
Project Title	Contractor		Comm.Chm.	At Meeting
LONG RANGE RESEARCH PLAN				
Rank	Title	W/S Written	Approved	To R & T
HANDBOOK RESPONSIBILITIES				
Year & Volume	Chapter Title	No.	Deadline	Handbook Subcom. Chair/Liaison
2017 Fundamentals	Energy Estimating Methods	19	June 2016	Kolderup/Yuill
STANDARDS ACTIVITIES - List and Describe Subjects				
SPC 140 Standard Method of Test for Building Energy Software 6 Ronald Judkoff				
SPC 205 Data Exchange Protocols for Energy Simulation of HVAC&R Equipment Performance - Chip Barnaby				
SPC 209 Energy Simulation Aided Design 6 Jason Glazer				
TECHNICAL PAPERS from Sponsored Research - Title, when presented (past 3 yrs. present & planned)				
Appendix 3				
TC/TG/TRG Sponsored Seminars - Title, when presented (past 3 yrs. present & planned)				
Appendix 4				
TC/TG/TRG Sponsored Forums - Title, when presented (past 3 yrs. present & planned)				
Appendix 5 6 NONE				
JOURNAL PUBLICATIONS - Title, when published (past 3 yrs. present & planned)				
None				

Attendance

Below is a complete listing of attendees at this meetings. It includes the voting members of the committee listed on the first page

Present at Meeting														Status 01/16
Orlando Jan 2016		Atlanta June 2015		Chicago Jan 15		Seattle Jun' 14		New York Jan 14		Last Name	First Name	Affiliation	E-mail	VM Voting CM Corres., V Visitor
YEA	Non-YEA	YEA	Non-YEA	YEA	Non-YEA	YEA	Non-YEA	YEA	Non-YEA					
	X		X				X		X	Abushakra	Bass	Milwaukee School of Eng.	abushakr@msoe.edu	VM
				X		X		X	X	Adams	Mark	ORNL	adamsm@ornl.gov	V
					X		X		X	Anderson	JR	Anderson Engineering	JRHazele@BellSouth.net	V
	X		X				X		X	Armstrong	Peter	Masdar Institute	pamstr@mit.edu	V
					X					Ashukov	Artem	Remak a.s	green.ashukov@gmail.com	Guest
							X			Bae	Nuri	Univ. of Michigan	nuri@umich.edu	V
									X	Balaras	Costas	NOA	costas@noa.gr	V
				X					X	Balbach	Chris	Performance Systems Develop.	cbalbach@psdconsulting.com	VM
			X	X		X				Baltazar	Juan-Carlos	Texas A&M University	jbaltazar@tamu.edu	V
X								X		Baker	Chris	The Weidt Group	chrisb@twgi.com	V
	X		X		X		X		X	Barnaby	Chip	cbarnaby@gmail.com	CBarnaby@wrightsoft.com	CM
									X	Beausoleil-Morrison	Ian	Carleton University	ian_Beausoleil-Morrison@carleton.ca	CM
									X	Berardi	Umberto		uberardi@pi.edu	V
	X		X							Bhandari	Mahabir	ORNL	bhandarms@ornl.gov	V
										Bilderbeck	Mike	Pickering Firm	mbilderbeck@pickeringfirm.com	V
									X	Bing	Dong	UTSA	bing.dong@utsa.edu	V
										Bosworth	David	BuildLab	bosworth@buildlab.net	V
	X		X		X					Brooks	Alamelu	ICF International	alamelub@gmail.com	V
									X	Carling	Par	EQUA	par.carling@equa.se	V
	X		X		X		X		X	Carpenter	Patrick	Fac Perf Engr	pacperfeng@comcast.net	CM
										Clark	Jordan	UT-Austin	jclark@utexas.edu	V
	X				X				X	Cokerham	Keith	Loring Engineers	kcokerham@DLBassociates.com	VM
										Collyer	Breesa	PG&E	brik@pge.com	V
	X				X		X			Cook	Malcolm	Loughborough Univ (UK)	malcolm.cook@lboro.ac.uk	VM
			X		X		X		X	Cornick	Steve	Nat'l Research Council Canada	Steve.Cornick@nrc.ca	V
	X		X		X		X		X	Crawley	Dru	Bentley	dru.crawley@bentley.com	CM
			X				X			Cumali	Zulfi	Energy System	zulfi@cumali.com	V
									X	Davidson	Tom	DLB Associates	tdavidson@dlbassociates.com	V
									X	DeGelman	Larry	TAMU	ldegelman@suddenlink.net	CM
					X		X		X	DeGraw	Jason	Penn State Univ	degraw@psu.edu	V
									X	Deringer	Joseph	Superb	jderinger@su-per-b.org	V
					X					Dong	Bing	UTSA	bing.dong@utsa.edu	Guest
										Eley	Charles	COMNET	charles@eley.com	V
	X		X		X		X		X	Ellis	Peter	Big Ladder Software	peter.ellis@bigladdersoftware.com	CM
			X		X		X		X	Fallahi	Ali	Fraunhofer CSE	afallahi@fraunhofer.org	V
										Feng	Wei	LBNL	weifeng@lbl.gov	V
										Firantello	Joseph	PSU	jfirantello@gmail.com	V
							X			Fisher	Dan	Oklahoma State Univ	DFisher@okstate.edu	VM
		X								Fontanini	Anthony	Iowa State Univ	anthony.fontanini@gmail.com	V
										Frame	Sara	Eaton's Energy Solutions Group	sara.a.frame@eaton.com	V
										Franconi	Ellen	Rocky Mountain Institute	efranconi@rmi.org	V
										Friedman	Glenn	Taylor Engineering	gfriedman@taylor-engineering.com	V
										Glazer	Jason	GARD Analytics	jglazer@gard.com	V
										Gmitter	Nick	DLB Associates	ngmitter@dlbassociates.com	V
										Gopal	Raj	Gopal Associates	rgopalmm@yahoo.com	V
										Griffin	David	Etc Group, LLC	eldergriffin@gmail.com	V
									X	Gu	Lixing	FSEC	gu@fsec.ucf.edu	V
	X		X		X				X	Haberl	Jeff	TAMU	jhaberl@tamu.gov	CM
			X						X	Haddad	Kamel	NRCan	khaddad@nrcan.gc.ca	VM
									X	Han	Guiyuan	PSU	G0H5067@psu.edu	V
										Hartley	Doug	Working Buildings	DEHartley@workingbuildings.com	V
	X								X	Haves	Philip	LBNL	phaves@lbl.gov	CM
					X					Hong	Tianzhen	LBNL	thong@lbl.gov	V
									X	Howard	Jeff	Kwhours Inc	jhoward@kwhours.com	V
	X				X		X		X	Huang	Joe	White Box Technologies	vjhuang@whiteboxtechnologies.com	CM
										Huizar	Antonio	KW Engineering	kuizar@kw-engineering.com	CM
										Im	Piljae	ORNL	imp1@ornl.gov	V
									X	Jain	Semant	Goodman Mfg	semant.jain@goodmanmfg.com	V
									X	Javed	Hassan	Masdar, Abu Dhabi	hjawed@masdar.ac.ae	V
			X		X		X		X	Judkoff	Ron	NREL	ron.judkoff@nrel.gov	VM
							X			Jump	David	QUEST	djump@quest-world.com	CM
										Karava	Panagioton	Purdue	pkarava@purdue.edu	V
							X			Kelsey	Jim	KW Engineering	kelsey@kw-engineering.com	V
									X	Kennedy	Mike	Mike Kennedy Inc	mikekennedy@energysims.com	V
									X	Kennedy	John	Autodesk	john.kennedy@autodesk.com	V
	X		X				X		X	Kim	Hyojin	TAMU	hyojinkim@tees.tamus.edu	V
			X						X	Kinney	Kris	KECCG	kinneyecg@gmail.com	CM
	X		X		X		X		X	Kolderup	Erik	Kolderup Consulting	erik@kolderupconsulting.com	VM
									X	Koran	Bill	Northwrite	bkoran@northwrite.com	V
			X		X		X			Kosny	Jan	Fraunhofer CSE	jkosny@fraunhofer.org	V
										Kota	Sandeep	Texas A&M University	radhakrishn10@yahoo.com	V

										Kota	Sandeep	Texas A&M University	radhakrishn10@yahoo.com	
										Kranti	Moncef	University of Colorado	kranti@colorado.edu	CM
X		X								Kruis	Neal	Big Ladder Software	neal.kruis@bigladder.com	VM
										Kummert	Michael	Polytechnique Montreal	michael.kummert@polymtl.ca	Guest
										Lee	Sang Hoon	LBNL	sanghlee@lbl.gov	Guest
										Li	Zhaoura	UTSA	jk463@myutsa.edu	Guest
										Lin	Cheng-Xian	Florida Int. University	lincx@fiu.edu	CM
										Liu	Shichao	UT-Austin	liu.shichao@utexas.edu	
										Liu	Xoabing	ORNL	liux@ornl.gov	Guest
										Long	Nicholas	NREL	nicholas.long@nrel.gov	
										Lyons	Peter	Peter Lyons & Assoc.	peter.lyons@fenestralla.com	V
										MacDonald	Iain	NRC Canada	iain.macdonald@nrc.gc.ca	CM
										Malherek	Elyse	McQuay	elyse.malherek@mcquay.com	V
										Malhotra	Mini	ORNL	malhotram@ornl.gov	CM
X		X								McDowell	Tim	TESS	McDowell@tess-inc.com	VM
X		X								McFadden	Galen	UTSA	stj874@myutsa.edu	Guest
										McHugh	Jonathan	MEC	jon@nchughenergy.com	V
										McNeill	James	Affiliated Engineers	jmccneill@afeng.com	
										Miura	Mayumi	Azbil Co.	m.miura.pe@azbil.com	
										Muehleisen	Ralph	Argonne	rmuehleisen@anl.gov	CM
										Mukhopadhyay	Jaya	University of Montana	jaya.mukhopadhyay@montana.edu	V
										Nelson	Ron	IMT	ron@imt.org	CM
										New	Joshua	ORNL	newjr@ornl.gov	CM
X		X								Neymark	Joel	J. Neymark & Assoc	neymark@msn.com	CM
										Ng	Lisa	NIST	lsa.ng@nist.gov	
										O'Keefe	Michael	Big Ladder Software	michael.okeefe@bigladdersoftware.com	V
X										O'Neill	Zheng	Univ. of Alabama	zhengoneill@gmail.com	CM
										Pang	Xiufeng	LBNL	xpang@lbl.gov	CM
										Paulus	Mitch	Texas A&M University	psuluzm@msoe.edu	PCM
										Pegues	Jim	Carrier	james.f.pegues@carrier.utc.com	V
										Phelan	Jerry	Bayer Material Science	jerry.phelan@bayer.com	V
										Porst	Kinga	GSA	kinga.porst@gsa.gov	V
										Premkumar	Siddarth	Gilbert Mechanical	spremkumar@gilbertmech.com	V
X		X								Pruett	John	ZMM, Inc.	jap@zmm.com	CM
										Reddy	T. Agami	Arizona State Univ	reddyta@asu.edu	V
										Reilly	Sue	Group 14 Eng.	streilly@group14eng.com	CM
										Roth	Amir	DCE	amir.roth@ee.doe.gov	V
										Sahlin	Per	EQUA	per.sahlin@equa.se	V
										Sanyal	Jibo	ORNL	sanyal@ornl.gov	V
										Selin	Markus	EQUA	markus.selin@equa.se	V
										Sharma	Chandan	FSEC	csharma@fsec.ucf.edu	V
										Shrestra	Som	ORNL	shresthas@ornl.gov	CM
X										Sheinman	Harris	CTT Liaison	hshheinma@heety.com	
										Shirey	Don	Bentley	don.shirey@bentley.com	
										Smith	Jeremy	OSU	jeremy.r.smith@okstate.edu	V
										Snyder	Steven	Johnson Controls	steven.c.snyder@jci.com	
										Sobrevilla	Andres	Munters	andres.sobrevilla@munters.com	
										Sonderegger	Robert	Iron, Inc.	Robert.sonderegger@iron.com	CM
										Stovall	Therese	Dak Ridge National Laboratory	stovalltk@ornl.gov	V
										Studer	Eric	TN2 Energy Consulting	studer@TN2Energy.com	V
										Subbarao	Kris	PNNL	kris.subbarao@pnnl.gov	V
										Swartz	Keith	Energy Center of Wisconsin	kswartz@ecow.org	V
										Swenka	Matt	The Weidt Group	matts@twgi.com	V
										Tabares	Paulo	NREL	paulo.tabares@nrel.gov	
										Taylor	Russ	UTRC	taylorrd@utrc.utrc.com	CM
										Trocka	Marija	UTRC	trckam@utrc.utrc.co	
										Ullah	Tania	NIST	tania.ullah@nist.gov	
										Varela	Ignacio	Heatcraft	ignacio.chaparro@heatcraftpd.com	V
										Wang	Liping	Univ. of Wyoming	lwang@lbl.gov	V
										Werner	Luke	EPI	luke@EPIpacific.com	V
										West	Scott	Jacobs Engineering	scott.west@jacobs.com	V
										Wetter	Michael	LBNL	mwetter@lbl.gov	VM
										White	Mike	GARD Analytics	mjwhite@gard.com	V
X										Wong	Edmund	Arup	edmund.wong@arup.com	PCM
										Wray	Craig	LBNL	CPWray@lbl.gov	
										Wright	John	University of Waterloo	jwright@uwaterloo.ca	Guest
										Xiong	Zeyu	Oklahoma State Univ	zeyu.xiong@okstate.edu	V
X										Zuo	Wangda	University of Miami	wzuo@miami.edu	VM
										Lufok	Peter	TACTech		V
										Xu	Ke	UTC-BIS		V
										Oh	Sukjoon	TAMU		V
										Kastl	Brian	AACN	kingkastl@gmail.com	V
X										Hogan	Byron	Nalor	byronhogan@yahoo.com	V
X										O'Brien	Liam	Carleton University	liam.obrien@carleton.ca	V
X										Bucking	Scott	Carleton University	scott.bucking@carleton.ca	
X										Brophy	Andy	SSR	abrophy83@gmail.com	PCM
										Garg	Vishal	IITH	vishal@iit.ac.in@uest	Guest
										Seymour	Mark	Future Facilities	mark.seymour@futurefacilities.com	Guest
										Bannister	Carren	National Research Council, Canada	carren.bannister@nrc-nrc.gc.ca	Guest

Appendix 1

TC 4.7 RESEARCH PROJECTS STATUS

ASHRAE
Technical Committee 4.7 Energy Calculations
(June 30, 2015)

Active projects

#	Title	Joint TC	Cog SC/ Contractor	PMSC	Dates / status
1588-RP	Representative layer-by-layer descriptions for fenestration systems with specified bulk properties such as U-factor and SHGC	4.5	SCM/ White Box Technologies	Haberl	Haberl reported. No-cost extension to Aug 1, 2016 requested. Vote passed to award no cost extension.
1629-RP	Testing and Modeling Energy Performance of Active Chilled Beam Systems	5.3	Applications/		Due for completion in May 2016.

Completed projects

#	Title	Joint TC	Cog SC/ Contractor	PMSC	Dates / status
1416-RP	Development of Internal Surface Convection Correlations for Energy and Load Calculations	4.1	SCM,, Univ of Texas	Dan Fisher (Chair), Steve Bruning, Jan Kosny	Completed. Final report approved by Full Committee in Chicago Jan 24, 2012.
1404-RP	Modeling, Analysis, and Reporting Protocols for Predicting Annual Energy Performance from Short-Term Building Energy Monitoring		DDM, Milwaukee School of Engineering	R. Sonderegger (Chair) J. Haberl, V. Smith	Completed. Report approved by Full Committee in Chicago Jan 24, 2012.
1413-RP	Developing standard procedures for filing missing weather data	4.2 (lead)	Oklahoma State University		Completed.

Appendix 2
RESEARCH PLAN

ASHRAE
Technical Committee 4.7 Energy Calculations
Research Plan (January 2016)

	Society status	TC 4.7 Status	Actors or TC 4.7 Prime Contact	Subcommittee*
sponsored projects led by another TC				
g standard s for filing missing ata (TC 4.2 lead)	Completed	Completed.	Chip Barnaby (member TC 4.2)	DDM
ative layer-by-layer as for fenestration with specified bulk such as U-factor and o-sponsor TC 4.5)	In Progress	In Progress	Huang / Haberl	SCM
d Modeling Energy ce of Active Chilled ems (Co-sponsor tc	In Progress	In Progress		APP
oved by TC				
r development				
l Implement Natural d Ventilation Whole-building mulations o)	RTAR unnecessary for Phase Two	Huang announced he was re-writing the WS, and would call a conference call with stakeholders and call a letter ballot if necessary.	Joe Huang , Simon Rees, Eric Kolderup, Malcolm Cook, Iain MacDonald	SCM
R Models for the of Supervisory strategies in the Handbook.	Sent back to authors,	Wangda announced re- writing the WS, and would call a conference call with stakeholders and call a letter ballot if necessary.	Wetter, Zuo	SCM
Experimental n of the Thermal and n Performance of Air on Systems Coupled ve Beams	Work Statement needs to be presented to TC4.7	Generated by TC 5.3 and submitted without TC 4.7 co-sponsorship	Fred Bauman	SCM
R Development of ed Inverse Model P1050) and Factor Toolkit	RTAR approved by RAC in February 2015, needs WS	Haberl announced re- writing the WS, and would call a conference call with stakeholders and call a letter ballot if necessary.	Jeff Haberl	DDM

Appendix 3
TECHNICAL PAPERS FROM SPONSORED RESEARCH

RP	Title	Contractor	Approved	Paper
1404	ASHRAE RP1404 - <i>Measurement, Modeling, Analysis and Reporting Protocols for Short-term M&V of Whole Building Energy Performance</i>	MSOE-ASU	Louisville June 2009	Singh, Reddy, Abushaka 2013 öPredicting Annual Energy Use in Buildings Using Short-Term Monitoring and Utility Bills: The Hybrid Inverse Model Using Daily Data (HIM-D)ö
1404	ASHRAE RP1404 - <i>Measurement, Modeling, Analysis and Reporting Protocols for Short-term M&V of Whole Building Energy Performance</i>	MSOE-ASU	Louisville June 2009	Singh, Reddy, Abushaka 2014 öPredicting Annual Energy Use in Buildings Using Short-Term Monitoring: The Dry-Bulb Temperature Analysis (DBTA) Methodö
1051	Procedures for Reconciling Computer-calculated Results with Measured Energy Data	Drexel	Chicago January 2006	Reddy, T.A., 2006. "Literature Review on Calibration of Building Energy Simulation Programs: Uses, Problems, Procedures, Uncertainty and Tools", ASHRAE Transactions, vol 112(1).
1051	Procedures for Reconciling Computer-calculated Results with Measured Energy Data	Drexel	Chicago January 2006	Sun J. and Reddy T.A., 2006, "Calibration of Building Energy Simulation Programs Using the Analytic Optimization Approach (RP-1051)", Int. J HVAC&R Research 12(1) 177-196.
1051	Procedures for Reconciling Computer-calculated Results with Measured Energy Data	Drexel	Chicago January 2006	Reddy, T.A., I. Maor and C. Ponjapornpon, 2006, "Calibrating Detailed Building Energy Simulation Programs with Measured Data- Part I: General Methodology", accepted for publication in Int. J HVAC&R Research.
1051	Procedures for Reconciling Computer-calculated Results	Drexel	Chicago January 2006	Reddy, T.A., I. Maor and C. Ponjapornpon, 2006, "Calibrating

	with Measured Energy Data			Detailed Building Energy Simulation Programs with Measured Data- Part II: Application to Three Case Study Office Buildings", accepted for publication in Int. J HVAC&R Research.
1050	Development of an Inverse Model Toolkit	Univ. of Dayton, Texas A&M	December 2001	Kissock, K., Haberl, J., Claridge, D. 2003. "Inverse Model Toolkit (1050-RP): Numerical Algorithms for Best-Fit Variable-Base Degree-Day and Change-Point Models," ASHRAE Transactions-Research, Vol. 109, Pt. 2, pp. 425 ó 434.
865	Accuracy Tests for Simulations of VAV Dual Duct, Single Zone, Four Pipe Fan Coil and Four Pipe Induction Air Handling Systems (4796)	Univ Nebraska, Texas A&M	July 2002	Yuill, G., Haberl, J. 2006. "Accuracy Tests for Simulations of VAV Dual Duct, Single Zone, Four Pipe Fan Coil and Four Pipe Induction Air Handling Systems (4796)," ASHRAE Transactions-Research, Vol. 112, Pt. 1 (January).
865	Accuracy Tests for Simulations of Constant Volume, Dual Duct and Variable Volume Air Handling Systems (4796).	Univ. Nebraska, Texas A&M	July 2002	Yuill, G., Haberl, J., Caldwell, J. S. 2005. "Accuracy Tests for Simulations of Constant Volume, Dual Duct and Variable Volume Air Handling Systems (4796, RP-865)," ASHRAE Transactions-Research, Vol. 111, Pt. 2, No. 4796, pp. 137 ó 153 (June).

Appendix 3 (continued)
TECHNICAL PAPERS FROM SPONSORED RESEARCH

1050	Development of an Inverse Model Toolkit	Univ. of Dayton, Texas A&M	December 2001	Kissock, K., Haberl, J., Claridge, D. 2003. "Inverse Model Toolkit (1050-RP): Numerical Algorithms for Best-Fit Variable-Base Degree-Day and Change-Point Models," ASHRAE Transactions-Research, Vol. 109, Pt. 2, pp. 425 ó 434.
1050	Development of an Inverse Model Toolkit	Univ. of Dayton, Texas A&M	December 2001	Haberl, J., Claridge, D., Kissock, K. 2003. "Inverse Model Toolkit (1050-RP): Application and Testing," ASHRAE Transactions-Research, Vol. 109, Pt. 2, pp. 435 ó 448.
1093	Diversity Factors and Schedules for Energy and Cooling Load Calculations	Texas A&M	June 2000	Abushakra, B., Haberl, J., Claridge, D. 2004. "Overview of Literature on Diversity Factors and Schedules for Energy and Cooling Load Calculations (1093-RP)," ASHRAE Transactions-Research, Vol. 110, Pt. 1 (February), pp. 164 ó 176.
1093	Diversity Factors and Schedules for Energy and Cooling Load Calculations	Texas A&M	June 2000	Claridge, D., Abushakra, B., Haberl, J. 2003. "Electricity Diversity Profiles for Energy Simulation of Office Buildings (1093-RP)," ASHRAE Transactions-Research, Vol. 110, Pt. 1, pp. 365 ó 377 (February).

Appendix 4

Orlando Meeting TC/TG/TRG SPONSORED SEMINARS

PRESENT:

Seminar 59: Simulation Calibration Methods: Which Should I Choose?
Seminar 67: Simulation for Cutting. Edge Building Design
Workshop 2: ASHRAE Standard 205P: Better Data, Better Models, Better Results

PLANNED:

St. Louis Meeting

Seminar on ASHRAE SPC 209
Seminar on properly setting up large scale calibration studies
Resubmission by Wangda Zou on seminar submitted for Orlando but rejected

Minutes
ASHRAE TC 4.7 Energy Calculations – Main Meeting
Orange Ballroom B, Orlando, Florida
Tuesday, January 26, 2016, 6:00-8:30 pm

Minutes recorded by Chris Balbach

Called to order @ at 6:07 PM

1. Roll call and introductions (5 minutes) Abushakra

Roll call taken with 10 voting members: Joe H, Keith, Jeff H, Erik K, Dru C, Ron J, Kamel H, Neal K, Malcolm, Wangda Z. 9 were present with 1 absent (Kamil). A quorum was met.

2. Acceptance of agenda & approve minutes of previous meeting (10 minutes) Huang

Motion by Joe H to accept. Keith C. moved to accept. Erik Kolderup seconded. No discussion.
Vote taken, result: 6 . 0 . 2 CNV. Chair voted in abstention because there was not time to review them.

3. Announcements/Liaisons (5 minutes) Huang

Dennis Wessel delivered general announcements

- 1) St Louis Seminar Abstracts are due on or before February 8.
- 2) Conference Paper Abstracts for Las Vegas are due in April.
- 3) It is possible to have programs within the TC meeting . if they are not accepted for the program schedule
- 4) TC 4.7 Chapter Roster updates due by midnight 1/26 . online update form will be used in the future
- 5) Remote voting members can be added to a TC meeting if CEC is advised in advance. Electronic votes must be verified via email. 30% max of voting members allowed for online voting to be valid
- 6) Improvements in ASHRAE website formats - TC website formats have been updated
- 7) A new App is now available for Energy Cost Benefit Analysis. 90.1 ECB . to assist with compliance forms.
- 8) TC Chair trainings are available on Sunday mornings

4. Membership (5 minutes) Huang

- TC 4.7 Membership issues with TAC have been cleared up. Joe and Bass have cross checked the roster and feel comfortable that it is correct.
- Bass A. notified that 2 voting members will be coming off after St. Louis. We may want to add more voting members. Joe is adding Joshua New as a voting member after Orlando. One year after St Louis five voting members will be rolling off.
- Kolderup . suggested that everyone in the room become a TC 4.7 corresponding member by notifying ASHRAE. Huang notified that if you do that, you become a provisional corresponding member. After attending 2 meetings in a row, you can then become a provisional member.
- Joshua New described that new website allows people to login and join now through the portal and become a corresponding member.

5. Subcommittee reports

5.1 Applications (10 minutes) **Judkoff**

Ron J (Chair) reported that TC 4.7 Applications sponsored three seminars in Orlando.

- 1) Workshop 2 on proposed Standard 205.
- 2) Seminar covering Cutting Edge Design+on Wednesday from 11:00 . 12:30
- 3) Seminar on Calibration Methods %Which should I choose+. Jaya chairing, having 4 speakers.

5.2 Data-Driven Modeling (10 minutes)

Muehleisen

Ralph M (chair) reported out. The TC 4.7 DDM subcommittee met on Tuesday evening with 19 people in attendance. There was a lively discussion of potential program submission items, and there may be a set of papers ready for the Las Vegas meeting. A. Brooks led a short discussion on how to calibrate a chiller model using short term metering which may be submitted as a program seminar for St. Louis.

Haberl gave an update on WS 1763 . specifically meant to enhance the ASHRAE IMT. Haberl advised that RAC came back to ask for more justification for the original \$200K ask. A larger discussion followed covering how results of ASHRAE software should be distributed . via older compiled language formats (or something else)? Should the products be created using open-source languages like Python or R? What should the actual software license arrangement be for ASHRAE generated software? Currently, ASHRAE requires that it needs to be acknowledged. Agami suggested should we be looking for beyond M&V based tools in the IMT. Result . vote that WS be brought to full committee.

An RTAR discussing and inverse modeling test scheme was also discussed, as well as the possibility of how a limited set of data can be used to forecast?

Finally, committee members discussed getting volunteers to help with cleanup of the handbook chapter.

Dr. Agami Reddy suggested that the research for a new IMT needs to go beyond the M&V community . for example beyond supporting ASHRAE Guideline 14 . and to help building operators deal with the data that they have, for improving operations, etc.? What are the research needs?

5.3 Simulation and Component Models (10 minutes)

Crawley

Dru C (Chair) reported out. The subcommittee met from 0600 . 0730 with 25 people present. The subcommittee focused on draft work statements and RTAR. Specifically co sponsored requests coming from TC 5.3 and TC 7.7. Understanding the how to characterize the energy related to fan coil components and how they relate to HVAC component and system energy consumption.

Henri Amastadi (representing TC 9.9 and SPC 90.4P) discussed data center modeling. They had a work statement in progress which was withdrawn. Henri shared a roadmap which included a detailed simulation path.

Joe Haung bought a revised work statement for WS 1748 - Phase 2 of estimating energy related to natural ventilation strategies. The revised WS will be brought to TC4.7 main meeting for discussion. If not submitted to RAC by August 2016, it will need to be resubmitted.

There was limited discussion on a need to revise the ASHREA HVAC 1 and HVAC2 toolkits. Jeff Haberl promised to prepare a RTAR for St. Louis.

5.4 Handbook (10 minutes)

Kolderup

Kolderup (Chair) reported that David Yuell is the TC 4.7 Handbook of Fundamentals Committee Liaison and that the deadline for our chapter 19 submission to ASHRAE is June 21st, before the St Louis summer meeting. The handbook subcommittee met earlier, from 5:00 to 6:00. The title of the Chapter is Energy Estimating and Modeling Methods+ Progress and updated drafts have been sent to the e-mail list @ TC4.7 via onebuilding.org. The chair is seeking to recruit people to cross review individual sections, specifically a section on General Considerations+ Tim McDowell has been reviewing a new section on History. There is also a new section on using energy models, as well as a new brief section on uncertainty. The section on degree-day modeling will stay but it needs updating. Neal Krus is editing the section on load calculations. Energy Model Calibration now has its own section. Ron Judkoff is updating the section on validation and testing. Guidance within the new sections of the chapter is aimed at relatively new modelers.

Dr. Agami asked why information on the Radiant Time Series is not included in this chapter. Haberl responded, describing it as a load calculation method . not energy analysis.

Erik K. advised that e-mails on the TC4.7 onebuilding.org can be viewed, which include agendas as well as links to DropBox where the draft versions reside.

David Yuell gave thanks to all who are working on it on behalf of ASHRAE.

5.4 Research (15 minutes)

Haberl

5.4.1 Research Projects

- 1588-RP Representative Layer-by-Layer Descriptions for Fenestration Systems with Specified Bulk Properties Such as U-factor and SHGC (co-sponsored with TC 4.5) (contract end date of Feb. 1, 2016)

Haberl reported that the contractor is doing well, and is entering into a layer of complexities with a path forward and a plan to resolve these issues to get a final draft issued. A draft report has been received, commented and returned. The project is requesting a no cost extension requested to August 1st. PMSC agrees with request and in general is pleased with progress to date.

Motion by Haberl Request to chair for vote for no cost extension to August 1st. Keith 2nd. Discussion to confirm PMSC recommendation.

Vote taken: Result: 7-0-2 with Chair abstaining . Neal K. also abstaining because a member of contractor team

- 1629-RP Testing and Modeling Energy Performance of Active Chilled Beam Systems (co-sponsored with TC 5.3)

Contract end date May 31, 2016. No status report presented.

5.4.2 Work Statements, RTARs, Requests for Co-sponsorship

- 1661-WS Modelica Models for the Evaluation of Supervisory Control Strategies in the ASHRAE Handbook (returned by RAC Nov 24, 2015) . SCM

Wangda explained that this was discussed in detail in the SCM subcommittee. Wangda explained the WS status and his intention. Ron Judkoff asked if an ASHRAE research project can tell the contractor what software to use as part of a WS? Wangda's general response was yes, and all models produced as part of this project will use some form of Modelica. Ron Judkoff asked if models developed under this project will work properly with OpenModelica? Wangda's response was yes. Dru commented that ASHRAE has in the past restricted toolkits to Fortran. Neal Krus commented we have a strong reason to not restrict?+Haberl responded that Models developed through ASHRAE research will be free for the public through ASHRAE at no charge and can be run on free Modelica software. A discussion ensued about licensing. Dr. Haberl recommends that Wangda continue to work with TC members to refine the proposed project scope and then come to the full TC in St. Louis for another vote. Dr. Haberl recommended Wangda solve two remaining issues prior to vote:

- (as it is)?
- 1) Are people comfortable with the fundamental concept of the work statement
 - 2) Is this project biddable as written? No vote was called.

Dr. Abushakra pointed out that non-Modelica bids would be considered non-responsive as written.

- 1748-WS Assess and Implement Natural and Hybrid Ventilation Models in Whole-building Energy Simulations (Phase 2) . SCM

Huang recommended that the WS be referred to full committee for a vote. An earlier draft of the WS (from the Atlanta meeting) did not make it out of subcommittee. This is an improved version. The major concern from the Atlanta developed WS was % this project biddable+. Malcolm has identified a building

in Chicago and can assure RAC that there is data available. Dr. Judkoff advised that the project is not funded sufficiently to collect the data needed (instrumentation, cost, etc.). Dr. Haves advised that the project may not be biddable as written as it is too vague. Dr. Haberl expressed concern that the deliverables are not well defined, that not enough shall language is contained in the work statement. Huang decided to not have a vote. Haung announced he would revise the WS, schedule a conference call discussion with key stakeholders, and call a letter vote if needed.

- 1763-WS Development of an Improved Inverse Model Toolkit (RP1050) and Diversity Factor Toolkit (RP1093) for Analyzing Building Energy Savings from Time Series Data (RTAR accepted by RAC July 29, 2015)

Haberl reported that this WS was discussed in the DDM subcommittee meeting. Copies as well as the response from RAC were distributed to TC meeting attendees. 2 specific changes were recommended by M Vaughn. IN addition, other comments (on the back of the returned WS) need to be addressed. In the same spirit as Wangda, Jeff decided not to call a vote, but to address RAC's concerns by scheduling a call with stakeholders and then a letter ballot if needed.

Requests for co-sponsorship

1741-WS "Understanding Fan Coil Components and How They Relate to Energy Consumption and Energy Modeling", from TC 5.3 Room Air Distribution

Dr. Haberl described a review of WS 1741 and the ask by TC 5.3 for TC4.7 co-sponsorship. The WS was circulated by Barnaby 5 days previously on the TC 4.7 list-serve (onebuilding.org).

The co-author is Byron Hagen . TC 5.3 Fan-Coil subcommittee chair, who attended and presented the WS to TC 4.7. The WS was originally submitted in Atlanta, was rejected and more detail was added by the subcommittee here in Orlando. Dr. Dru Crawley added that AHRI has whole research plan to do this which is under process. Dr. Haberl commented that RAC needs to know that. RAC has conditionally approved this, on the condition that TC 4.7 will be included and is supportive.

Dr. Jeff Haberl advised that TC 4.7 needs to vote, provide PES, and a proposed PMSC liaison member. Dr. Neal Kruijs volunteered to be on PMSC.

Dr. Phil Haves asked to for the author to elaborate what the perceived 2nd phase might be? Byron Hagen responded that this research is to generate the data format such that OEM's will consistently provide part load data for FC fans. A second research project might be to map sensible/latent performance to performance maps at part-load conditions. A key here is % standardized formats+that can be readily used by modelers.

Erik Kolderup commented that the scope is partly to develop data sets and partly to develop heat and mass balance equations. Byron Hagen responded that . yes . there is a need to both determine and develop a standard data format and to move AHRI 440 from single point to multi point, with as many as 27 different data points.

Chip Barnaby commented that ASHRAE Standard 205P is mentioned here.

Dr. Ron Judkoff asked where the data would live such that whole building energy modelers will be able to access it? Byron Hagen responded that if the AHRI system steering committee funds this (via co-funding) this means some (but not necessarily all) of the data collected will be in the public domain.

Dr. Jeff Haberl commented that there is a need to add deliverable(s) to Task 3 and deliverable(s) to Task 4. Byron Hagen responded by saying he would take a look.

Dr. Phil Haves asked for clarification that RAC requires that scope and deliverables be added.

Dr Ron Judkoff expressed concern that the two biggest conditions are that data be in a format compliant with ASHRAE SPC 205P format and that data be available to any modeler who chooses to use it.

Motion made by Haberl for Co-sponsorship of this WS by TC4.7

Dr. Neal Krus moved, Malcolm 2nd
Vote taken, Result: 8-0-0 CNV, motion passes.

Draft RTAR for “Data center energy calculated research and deliverables roadmap”, from TC 9.9 Mission Critical Facilities, Data Centers, etc.

No action was taken.

1787-RTAR “Ambient Outdoor Climatic Conditions at Various Heights Near Tall / High rise buildings”

From TC 9.12 Tall Buildings, no action was taken.

1788-RTAR “Contaminant Variation and Outdoor Ambient Quality at various heights near tall/ high rise buildings”,

From TC 9.12 Tall Buildings, no action was taken.

Dr. Jeff Haberl concluded by reporting that he did review an RTAR on attic testing methods, with an assessment that the RTAR needs more work.

5.5 Handbook (10 minutes)

Kolderup

Erik Kolderup (chair) reported on Handbook committee minutes and upcoming deadlines. The Handbook Chapter 19 final version will need to be submitted to ASHRAE before St. Louis meeting. A request for volunteers/subject matter experts to review subsections was made by Erik Kolderup.

5.6 Program (15 minutes)

Cockerham

Keith Cockerham reported on TC 4.7 sponsored seminars at Orlando. With respect to seminars for St. Louis .

Chris Balbach proposed one seminar session on setting up proper design of experiments for simulation studies . something like: %How to get the best results with least simulations - why you do not need 1,000,000 simulations.+ Presenters are New, Bosworth and Muehleisen.

Erik Kolderup proposes a seminar session on ASHRAE SPC 209P . this seminar will focus on the early design phase of energy modeling (box models, etc.)

Dr. Wangda Z. will resubmit a seminar which was rejected for Orlando

Keith Cokerham called a motion to approve the St. Louis program. Dr. Jeff Haberl seconded. No discussion.

Huang called a vote. Result - 7-0-0 CNV

5.7 Historical (10 minutes)

Haberl

5.8 Standards (15 minutes)

Neymark

Joel Neymark commented that we need to move ASHRAE Standard 189 to related activities - as TC 4.7 is not the cognizant committee.

SSPC 140 SMOT for Evaluating Building Energy Analysis by using Computer Programs

Neymark

Joel Neymark reported that the current version of Standard 140 is 140-2014. For commercial software tools, 13 software programs are currently listed, with 7 updated over the last year. New software approval submittals are handled by D. Ron Judkoff. For residential tools, RESNET lists 8 approved software tools. Joel Neymark commented that both ASHRAE standard 90.1 and ASHRAE Standard 189 reference ASHRAE Standard 140, while the 2015

IECC cites ASHRAE Standard 140-2011. Neymark remarked that the 2018 IECC cites 140-2014 (will cite ASHRAE Standard 140-2017 if it is ready on time).

Neymark discussed the Proposed Addendum A to ASHRAE Standard 140 . Adaptation of RP865 Airside HVAC work . NREL has delivered a final report which has been approved by the simulation trial working group participants. NREL is in the final phases of publishing this report, and expect to deliver it in March. At this time, the test specification will go normative sections, with example results in the informative portion of the standard.

Neymark reported that improvement to thermal fabric tests (Section 5.2) are also being undertaken . This work is happening in parallel to Airside 865 tests. Neymark commented that additional empirical validation test suites could be included into ASHRAE Standard 140 if the data is high enough quality. This is work sponsored by DOE . presently being done by ORNL, LBNL and NREL. Dr. Ron Judkoff comments that the 865 airside testing work is an excellent example of a research project being the basis as something that ends up in a standard.

SPC 205 . Std. Representation of Perf. Sim. Data for HVAC&R & Other Facq Equipment Barnaby

Chip Barnaby reported that the project committee is making progress in developing standard data formats. They are concentrating on performance map representations, and had seven hours of productive meetings when in Orlando. The project committee had a goal to have an APR (advisory public review) of SPC 205P voted out at this meeting but it was not achieved. Barnaby reported that Dr. Neal Krus is the new Vice Chair of the committee.

SPC 209 Energy Simulation Aided Design Kolderup

Erik Kolderup reported that the Standard was voted out with for a public review here in Orlando. A draft (incorporating the comments from the public review) should be available within 6 months.

SPC 189 Building Energy Standard for High-Performance Buildings Haberl

No comments

5.9 Web Site (5 minutes) www.ashrae.org/tc47.org New

Dr. Joshua New reported that a website has been launched with a more modern layout. This website provides the ability for members to join TC 4.7 directly via the website. The process adds members as provisional corresponding members first. The website also holds meeting minutes, publishes the meeting schedule and holds the current roster.

Dr. Joshua New reported that currently the TC4.7 website is bifurcated. There is an old website still existing at www.tc47.org. Dr. Joshua New reported that many TCs are moving away from listserve communication to the ASHRAE sponsored basecamp software. Dr. Joshua New expressed that to get on to the TC 47 ListSrv, people should send an e-mail to tc47-l@lists.onebuilding.org

6. Related activities reports (15 minutes)

SPC 189 signed MOU with ICC for better coordination, cooperation and communication. It was mentioned that this is complex but needed. Various members commented on the initiatives listed below, with no resulting action needed by the TC.

SPC 191 Water Conservation
MTG.EAS Energy Eff AHU Systems
MTG.O&MEE
MTG.BIM Building Information Modeling
SGPC 20 Documenting HVAC&R Work Process and Data Exchange Requirements
Stnd 214
TC 2.8 Building Environmental Impacts and Sustainability
TC 4.1 Load Calculation Data and Procedures
TC 4.2 Climatic Information
TC 4.3 Infiltration & Ventilation Requirements
TC 4.5 Fenestration
TC 6.5 Radiant Heating and Cooling

TC 7.5 Smart Building Systems (now includes TC 7.4)
TC 7.6 Building Energy Performance
BuildingSMART (formerly IAI International Alliance for Interoperability)

Building Smart working on Std 211, moving away from EUI metrics for existing buildings

IBPSA: USA, Canada, World

IBPSA-USA: - IBPSA-USA: Saturday meeting compliance analysis, hosting Building Simulation 2017 in San Francisco.

BPI-2400-S-2011 Standardization Qualification of Whole-house Energy Savings Est.
ASHRAE Guideline 14

Guideline 14 is out, and the committee is disbanded

IEA Annex 60 Modelica for Building Simulations

IEA Annex 60, meeting in Belgium. Next meeting at University of Miami

IEA Annex 66 Occupant Patterns
ASHRAE Historical Committee

ASHRAE is now recognizing simulation. Zulfi will be first interviewee. Followed George Walton, and interviews with people who knew Lynn Belinger and Curt Pederson. Send other ideas to Jeff Haberl.

7. Old Business Huang

No action

8. New business Huang

No action

9. Adjourn Huang

Adjourn: Moved by Dr. Neal Krus, Second by Dr. Ron Judkoff, approved 7-0-0 CNV, The meeting was adjourned at 8:40 PM.

Note TC 4.7 Email list hosted at onebuilding.org

Attachments

- A. Agenda
- B. Simulations and Component Models Subcommittee Agenda and Minutes
- C. Data-Driven Models Subcommittee Agenda and Minutes
- D. Applications Agenda and Minutes
- E. Handbook Subcommittee Agenda and Minutes
- F. SSPC 140 Agenda and Minutes

Attachment A
Agenda
ASHRAE TC 4.7 Energy Calculations – Main Meeting
Orange Ballroom B, Orlando, Florida
Tuesday, January 26, 2016, 6:00-8:30 pm

- | | |
|--|------------|
| 1. Roll call and introductions (5 minutes) | Abushakra |
| 2. Accept agenda & approve minutes of previous meeting (10 minutes) | Huang |
| 3. Announcements/Liaisons (5 minutes) | Huang |
| 4. Membership (5 minutes) | Huang |
| 5. Subcommittee reports | |
| 5.1 Applications (10 minutes) | Judkoff |
| 5.2 Data-Driven Modeling (10 minutes) | Muehleisen |
| 5.3 Simulation and Component Models (10 minutes) | Crawley |
| 5.4 Research (15 minutes) | Haberl |
| 5.4.1 Research Projects | |
| • 1588-RP Representative Layer-by-Layer Descriptions for Fenestration Systems with Specified Bulk Properties Such as U-factor and SHGC (co-sponsored with TC 4.5) (contract end date Feb. 1, 2016) | |
| • 1629-RP Testing and Modeling Energy Performance of Active Chilled Beam Systems (co-sponsored with TC 5.3) (contract end date May 31, 2016) | |
| 5.4.2 Work Statements, RTARs, Requests for Co-sponsorship | |
| • 1661-WS Modelica Models for the Evaluation of Supervisory Control Strategies in the ASHRAE Handbook (returned by RAC Nov 24, 2015) – SCM | |
| • 1748-WS Assess and Implement Natural and Hybrid Ventilation Models in Whole-building Energy Simulations (Phase 2) – SCM | |
| • 1783-WS Development of an Improved Inverse Model Toolkit (RP1050) and Diversity Factor Toolkit (RP1093) for Analyzing Building Energy Savings from Time Series Data (RTAR accepted by RAC July 29, 2015) | |
| • Requests for co-sponsorship | |
| o 1741-WS "Understanding Fan Coil Components and How They Relate to Energy Consumption and Energy Modeling", from TC 5.3 Room Air Distribution | |
| o Draft RTAR (?) "Data center energy calculated research and deliverables roadmap", from TC 9.9 Mission Critical Facilities, Data Centers, etc. | |
| o 1787-RTAR "Ambient Outdoor Climatic Conditions at Various Heights Near Tall/ High rise buildings", 1788-RTAR "Contaminant Variation and Outdoor Ambient Quality at various heights near tall/ high rise buildings", both from TC 9.12 Tall Buildings | |
| 5.5 Handbook (10 minutes) | Kolderup |
| 5.6 Program (15 minutes) | Cockerham |
| 5.7 Historical (10minutes) | Haberl |
| 5.8 Standards (15 minutes) | Neymark |
| SSPC 140 SMOT for Eval Bldg Energy Analysis Computer Programs | Neymark |
| SPC 205 – Std. Representation of Perf. Sim. Data for HVAC&R & Other Fac'l Equipment | Barnaby |
| SPC 209 Energy Simulation Aided Design | Kolderup |
| SPC 189 Building Energy Standard for High-Performance Buildings | Haberl |
| 5.9 Web Site (5 minutes) www.ashrae.org/tc47.org | New |
| To get on to TC 47 ListSrv, send an e-mail to tc47-l@lists.onebuilding.org | |
| 6. Related activities reports (15 minutes) | |
| SPC 191 Water Conservation | |
| MTG.EAS Energy Eff AHU Systems | |
| MTG.O&MEE | |
| MTG.BIM Building Information Modeling | |
| SGPC 20 Documenting HVAC&R Work Process and Data Exchange Requirements | |
| Std 214 | |
| TC 2.8 Building Environmental Impacts and Sustainability | |
| TC 4.1 Load Calculation Data and Procedures | |
| TC 4.2 Climatic Information | |
| TC 4.3 Infiltration & Ventilation Requirements | |
| TC 4.5 Fenestration | |
| TC 6.5 Radiant Heating and Cooling | |
| TC 7.5 Smart Building Systems (now includes TC 7.4) | |
| TC 7.6 Building Energy Performance | |
| BuildingSMART (formerly IAI International Alliance for Interoperability) | |
| IBPSA: USA, Canada, World | |
| BPI-2400-S-2011 Standardization Qualification of Whole-house Energy Savings Est. | |

Guideline 14
IEA Annex 60 Modelica for Building Simulations
IEA Annex 66 Occupant Patterns
ASHRAE Historical Committee

7. Old Business
8. New business
9. Adjourn

Huang
Huang
Huang

Note TC 4.7 Email list hosted at onebuilding.org

Attachment B

Agenda:



Draft Agenda

TC 4.7 Simulation and Component Models Subcommittee

6:00-7:30 pm, Monday, 25 January 2016

Lake Sheen A, Lobby, Orlando Hilton
Orlando, Florida

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- 6:00 Call to order / introductions / changes to the agenda Crawley
- 6:10 **Research Projects**
- **1629-RP** Testing and Modeling Energy Performance of Active Chilled Beam Systems (TC 5.3 / TC 4.7) (due to be completed in May 2016)
- 6:20 **Draft Work Statements/RTARs**
- **1741-WS** Understanding Fan Coil Components and How They Relate to Energy Consumption and Energy Modeling (TC 5.3, TC 7.7, requesting TC 4.7 co-sponsor) Sipes
 - **17xx-WS** Development of a Reference Building Information Model (BIM) for Daylighting Optimization (TC 1.5 / TC 4.7) Haberl
 - **17xx-WS** Development of Improved and Integrated Energy Modeling Software for Data Centers (TC 9.9 / SPC 90.4P / TC 4.7) Amistadi, Davidson
 - **1661-WS** Development and Validation of Dynamic Models for the Evaluation of Chilled-Water Systems Control Strategies in the ASHRAE Handbook (TC 4.7/ TC 7.5 / TC 1.4) Wangda/Wetter
 - **1748-WS** Assess and Implement Natural and Hybrid Ventilation Models in Whole-Building Energy Simulations – Phase 2 (TC 4.7 / TC 4.10) Fontanini/Huang
- 6:50 **New Research Topics/Research Plan**
- New Research Topics (RTARs and WSs can be submitted 4 times a year—six weeks before Winter and Annual meetings and 1 March/1 August.)
 - Several new research topics at recent meetings:
 - Research for new ground heat transfer tables in the HOF (Kruis)
 - Research for better simulations for occupants (Hong)
 - Better ~~hygrothermal~~ modeling for highly efficient buildings, including VOC issues, etc. Current project supported by the IEA (Rode).
 - Mixed mode / ventilation
 - Research on coils, higher latent loads not covered by current coil models. RTAR to be circulated (PC Thomas)
 - Updating the HVAC 01 and 02 Toolkits. RTAR to be circulated (Haberl/Huang)
- 7:20 **Program Ideas**
- 2016 Annual (St. Louis), 2017 Winter (Las Vegas), 2017 Annual (Long Beach)
- 7:25 **New Business**
- 7:30 **Adjourn**
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Next Meeting: Monday, June 27, 2016 St Louis, Missouri

Meeting Minutes:



Draft Minutes

TC 4.7 Simulation and Component Models Subcommittee

6:00-7:30 pm, Monday, 25 January 2016

Lake Sheen A, Lobby, Orlando Hilton

Orlando, Florida

6:00 Call to order / introductions / changes to the agenda

Dru Crawley called the meeting to order at 6:03. There were no additions or changes to the agenda (see below). Those present introduced themselves.

Attending: Dru Crawley (chair), Jeff Haberl, [Zulfiqar Cumali](#), Agami Reddy, [Hrash Moharrer](#), Brian Kastl, Bill Stout, Nathaniel Jones, Joe Huang, Joshua New, [Mahabir Bhandari](#), Chris Balbach, Vishal Garg, [Michell Paulus](#), Bass Abushakra, Keith Cockerham, Kris Kinney, Henry Amistadi, Alamelu Brooks, Jaya [Kathopadhyay](#), Mini Malhotra, Ron Judkoff, Philip Haves, Duncan Phyfe, Peter Ellis, Ralph Muehleisen, Tim McDowell, Case Briscoe, Erik Kolderup, Mike Witte, Lixing Gu, Don Shirey

6:10 **Research Projects**

- **1629-RP** Testing and Modeling Energy Performance of Active Chilled Beam Systems (TC 5.3 / TC 4.7) (due to be completed in May 2016)

Jerry Sipes (TC 5.3) reported that the PMS reported to the TC on Monday. The TC requested an extension of the project contract to August 2016.

6:20 **Draft Work Statements/RTARs**

- **1741-WS** Understanding Fan Coil Components and How They Relate to Energy Consumption and Energy Modeling (TC 5.3, TC 7.7, requesting TC 4.7 co-sponsor)

Jerry Sipes and Byron Hagan (TC 5.3) requesting that TC 4.7 co-sponsor this WS and provide a representative to the PES/PMS. This request will be brought to TC 4.7 at the Tuesday meeting.

- **17xx-WS** Development of a Reference Building Information Model (BIM) for Daylighting Optimization (TC 1.5 / TC 4.7)

Jeff Haberl reported no progress on this draft WS.

- **17xx-WS** Development of Improved and Integrated Energy Modeling Software for Data Centers (TC 9.9 / SPC 90.4P / TC 4.7)

The data center roadmap created by TC 9.9 and SPC 90.4P was distributed in advance to TC 4.7. Henry Amistadi reported that they were planning to go with two paths -- a simplified load and detailed energy path. Simplified path will use the modified bin method. They are not requesting any assistance from TC 4.7 at this point (WS no longer needs to be considered).

- **1661-WS** Development and Validation of Dynamic Models for the Evaluation of Chilled-Water Systems Control Strategies in the ASHRAE Handbook (TC 4.7/ TC 7.5 / TC 1.4)

Wangda reported that the work statement has been revised based on feedback after the Atlanta meeting. (WS was circulated to TC 4.7 via email before the meeting.) He went through how each comment was resolved. This WS will be brought to TC 4.7 for further discussion at the Tuesday meeting.

- **1748-WS** Assess and Implement Natural and Hybrid Ventilation Models in Whole-Building

Energy Simulations – Phase 2 (TC 4.7 / TC 4.10)

Joe Huang brought copies of the revised work statement to the meeting. This WS is intended to be Phase 2 of RP-1456 and extends the research to include hybrid ventilation. This work statement will be brought to the TC 4.7 meeting on Tuesday for further discussion. (This WS must be submitted to RAC by 15 Aug 2016 or it will be dropped from research plan.)

6:50 **New Research Topics/Research Plan**

- Possible new research topics mentioned at recent meetings:
 - Research for new ground heat transfer tables in the HOF (Kruis).
An RTAR for this topic will be brought to the next meeting.
 - Research on coils, higher latent loads not covered by current coil models – sizing and energy. RTAR to be circulated (Thomas).
No progress on preparing an RTAR.
 - Updating the HVAC 01 and 02 Toolkits. RTAR to be circulated (Haberl/Huang).
Jeff Haberl and Joe Huang said they'd be working on an RTAR for the next meeting. The RTAR should include discussion of form of deliverable of the models (programming language).

7:20 **Program Ideas**

No program ideas suggested at the meeting.

7:25 **New Business**

No new business.

7:30 **Adjourn adjourned at 7:25**

Next Meeting: Monday, June 27, 2016 St Louis, Missouri

□



Attachment C Draft Agenda and Minutes

TC 4.7 Data Driven Models Subcommittee Meeting

TC4.7 Data-Driven Models Subcommittee Monday January 25, 2016, 7:30–9:00 PM

Location: Orlando Hilton, Lake Sheen A

Agenda:

7:30 Call to order / Introductions / Changes to the agenda

Meeting began at 7:35 PM.

In attendance: Ralph Muehleisen (Chair), Jeff Haberl, Ron Judkoff, Chris Balbach, Joe Huang, Jaya Mukhopadhyay, Mitchell Paulus, Bass Abushakra, Zulfikar Cumali, Matt Brown, Yuebin Yu, Henry Amistadi, Keith Cockerham, Alamelu Brooks, Fuxin Niu, Ulricke Passe, Agami Reddy, Brian Kastl

7:40 Discussion of Program (10 minutes)

- Winter Meeting 2016 (Orlando) Review

Ralph announced the Wed. Morning 8 am, Seminar 59: Simulation Calibration Methods: Which Should I Choose?

Jaya Mukhopadhyay chair: Juan Carlos Baltazar (basic approaches), me (Bayesian methods), Ron Judkoff (calibration Method of test) Joshua New (autotune and trinity test),

- Summer Meeting 2016 (St. Louis)

Ralph asked for interest in a seminar session for St. Louis. Mentioned that speakers, abstracts and questions had to be in by Feb 8 so there was little interest.

Winter in Las Vegas

Tracks of interest:

Track 7: Modeling throughout the Building Life Cycle

Track Chair: Jeffrey Sptler / Michael Collarin

Email: sptler@okstate.edu / Michael.Collarin@parsons.com

Modeling was originally concerned primarily with building and system design specifications. The demands of energy efficient operation brought about the need for modeling of part-load operation for a variety of off-design conditions. The explosion of computational capacity and data collection capability is rapidly expanding the scope, complexity and practical applications of modeling both during design, but even more so for fault detection, diagnostics and operational optimization. Thirty years ago, people were dreaming of doing some of the things that Building Information Modeling is now bringing to reality. Presentations and papers are solicited related to all aspects of building modeling, with a particular interest in successful applications that have extended modeling into operational phases of the building life cycle.

Track 8: High Performance Buildings

Track Chair: Rachel Romero / Andrea Zarour / Mary Ann Plette

Email: rachel.romero@nrel.gov / azarour@creatorbaymechanical.com / maplette@lbl.gov

This track seeks papers and presentations on the design and measured performance of high performance commercial and industrial buildings in North America and around the world. There are numerous examples of buildings designed for high performance that have fallen considerably short of the design intent and papers that identify reasons for these shortfalls are of particular interest.

Track 5: Building Operation, Maintenance and Optimization/Commissioning

Track Chair: Alan Neely / Mike McDermott

Email: alan_neely@pnhcorming.com / mcdermott@corummanb@us.com

Operation and maintenance have always accounted for a major portion of building expenses and a much smaller level of engineering effort aimed at controlling these expenses. Over the last one to two decades, there has been an increasing realization that real engineering applied to operation, maintenance and operational optimization or "commissioning" can bring increased comfort and offers huge financial returns. This track solicits papers and presentations related to any and all aspects of this topic.

Seminar Ideas?

- DDM related to monitoring and diagnostics for track 7 or 5?

Alamelu might try to set up either a conference paper or seminar for Winter 2017 in Las Vegas.

Yeubin Yu has an interest in Sensor calibration and deterministic vs problematic, not sure of track though.

Action Item: Ralph to follow up with Alamelu and Yeubin on these

It was mentioned (mentioner shall remain nameless) that you can get free conference registration by offering to be a monitor.

8:00: Work Statements / RTAR's (50 minutes)

- Existing WS and RTAR's
 - Haberl: WS 1763. Inverse Modeling Tool Update RTAR "Development of an Improved Inverse Model Toolkit (IMT) for Analyzing Building Energy Savings from Time Series Data" (RP 1050). Haberl sent out to TC 4.7. Discuss any suggested revisions and vote to recommend approval or not at the main TC meeting.

Jeff brought handouts of the R-Tar, RAC's response, and the Work Statement. The RAC response asked about \$200k dollars (need more justification) and wanting more time spent on documentation and wanted to know how many people use the existing IMT

Here is a summary of the discussion

Q: any thought of a web app. Jeff's answer: No. Not really of interest

Q (by several people): Any thought to open source R, python, or similar scripting language

Martha Brook consultant to CEC wants something that is an open source.

Jeff's answer: Yes that can be considered. The big thing is it has to be open source in some way or at least follow the standard way of ASHRAE where source code is available to members and they can use how they want with ASHRAE acknowledgement.

Agami: We should address the question about how many people use the existing tool kit. At least rebut the question that the data are not available if we don't know.

Agami: Maybe this project could extend the application beyond M&V add some of the more predictive work. Want to be able to pull out schedules.

Action item : send text of the details about language choice to Drew for SSC subcommittee. He wants to know how we are handling it in this R-tar

Action item: Agami to work with Jeff to possibly add in more beyond M&V

!!!NOTE!!!: Zulfi didn't say anything during these discussions and wanted it noted in the minutes.

Do we want to recommend this for full committee with changes: 8 in favor no ~~opps~~?

- Data Driven Schedules? (David Bosworth, Ralph Muehleisen)

No progress since last meeting.

Action item: Ralph to talk with David and see if this is covered by WS 1763 since that incorporates IMT from the diversity tool kit.

- Inverse Modeling Test Scheme / Standards? (Chris Balbach and then David Jump and Jeff H)

David Jump working with Jessica Granderson LBL with DOE funds for "Assessment of Automated Data Modeling ..." for 2014 – 2016.

Agami: This is based on analysis of pile of portfolio data

Action Item: Ralph follow up with David Jump and Jessica Granderson to see if they want to turn into an ASHRAE project or maybe a guideline or standard.

8:30: Discussion Topic: using DDM to help support IMPVP Option E. (Chris Balbach)

Chris: Option E is not yet available but is being discussed. It would be a method to use limited data for baselines.
Question: How can you use limited data (maybe you have a whole load). We want to put this into an energy simulation as demand. On the simulation side we want to create a plant where the load is the measured load. Can we use this for developing a DDM for checking M&V of that particular component/load? We want to get a calibrated baseline model for a chiller plant.

Questions: What / how do we deal with limited data?

Bass: Isn't this a statistical in nature because we are forecasting.

Agami: we might not have enough data or data in the wrong time.

Joe: I would use a simulation program where I could inject a measured load and just run a plant simulation.

Calibrate that model and then put in the improved model.

Chris: Is there a method for extrapolating uncertainty in long term predictions from short term measurements?

Ron: Look at Kris Subbarao's work at PNNL. Discussed choice of time of year and measurements to take.

Ralph: Isn't this like RP 1404 for less than whole building

No action items.

8:45: Handbook Contributions

Cleaning up of existing material was minimal. There is a new section on uncertainty in intro from Ralph and a calibration section development being led by John Pruett.

Action item: Ralph to work with Mitchell Paulus and Yuebin Yu to review

8:55 New Business

9:00 Adjourn

Action Items:

Action Item: Ralph to follow up with Alamelu and Yeubin on papers or seminar sessions for Las Vegas

Action item: WS 1763. Jeff to send text of the details about language/open source to Drew when figured out for SSC subcommittee. He wants to know how we are handling it in this R-tar for ones from his subcommittee

Action item: Agami to work with Jeff to possibly add in more prediction beyond M&V to WS 1763

Action item: Ralph to talk with David and see if inverse methods for occupancy will be covered by WS 1763 since that incorporates IMT from the diversity tool kit.

Action Item: Ralph follow up with David Jump and Jessica Granderson to see if they want to turn their automated data assessment methods into an ASHRAE project or maybe a guideline or standard related to inverse model method of test

Action item: Ralph to work with Mitchell Paulus and Yuebin Yu to review calibration section of handbook



Attachment D Draft Agenda and Minutes

TC 4.7 Applications Subcommittee Meeting 6:00 . 7:30 pm, Monday, January 26, 2015 Monroe, 6th Floor,, Palmer House Chicago, IL

TC 4.7 Applications Subcommittee Meeting Minutes: 1/26/16: Orlando

3:30pm: Ron Judkoff, Chair, called to order.

Minutes from Atlanta Summer meeting (June 30, 2015) were circulated July 2, 2015.

The Agenda for the Orlando Applications meeting was circulated Jan 20, 2016 along with the minutes from the Atlanta meeting.

Announcements:

- ASHRAE Call for papers for St Louis (Summer 2016)(see attachment)
- ASHRAE Call for papers for Las Vegas (Winter 2017)
- Proposed changes to TC-5.2 Title Purpose & Scope, from "Duct Design" to "System Design". Bass briefed the progress. Craig Ray may have more info.
- TC 4.1 new ASHRAE/ANSI Standard 203-2014, "Method of Test for Determining Heat Gain of Office Equipment Used in Buildings". Huang briefed.

Program: (Keith Cockerham)

Orlando Conference: 2 Applications Seminars and 1 Technical Paper were presented.

- Nathaniel Jones: Seminar: Use of Simulation Tools for Cutting Edge building design.
- Tim McDowell: Seminar on Standard 205
- Jaya Mukhopadhyay: Seminar on Model Calibration

St. Louis Conference (Summer 2016):

- Seminar on 209, Energy Simulation Aided Design for Buildings Except Low Rise Residential: Eric Kolderup said that 209 went to public review in Orlando and a seminar abstract is being prepared for St. Louis.
- Tech paper on RP 1468, Development of Reference Building Model being prepared for St. Louis.

Research:

- BEMBook: no progress, it will be dropped from the agenda for St. Louis.
- Eric Kolderup Updated the activity on SPC209, *Energy Simulation Aided Design for Buildings Except Low Rise Residential*. It is being voted out for public review in Orlando. 209 requires at least two cycles of modeling and a design charrette. 209 recommends modeling throughout the design process, but only requires that a subset of the recommendations be implemented for compliance with 209. 209 encourages early design phase simulation, but it is not required.
- RP-1588, Develop multilayer window model from simple inputs. Haberl reported that the contractor report is on track, but some work remains to be done and he will ask for a no-cost extension to Aug 1, 2016 at the main TC-4.7 meeting.

RTARs:

- Guidelines on simulating tall buildings (Joe Huang), no new update.
- RP17xx. RP 17xx – RTAR to develop accuracy test method for residential attic duct system simulation. Draft RTAR was distributed and reviewed by the subcommittee. Dr. Mini Malhotra (author) explained the motivation for the RTAR, including the need to test residential duct models against a “truth standard”. Currently code-compliance models need better testing. Project will benefit ASHRAE Standard 90.2 by helping to improve the accuracy of code compliant simulations that assess energy loss/gain in residential ducts. The SC suggested more work be done on this RTAR and Mini will re-submit in St. Louis.
- IBPSA Research: Nathaniel Jones reported interest in knowing model detail vs model accuracy especially with respect to zoning. There was interest in a better understanding of where/when to stop subdividing. Chris Baker and Krishnan Gowri are possible candidates for helping with this.
- Joe Huang reported that two RTARS from Tall Buildings were looking for TC-4.7 co-sponsorship. These are “Change in Weather with Height” and “Change in Contaminants with Height”. The SC did not think there was enough of a role for TC-4.7 to co-sponsor and recommended against.
- Chris Balbach is interested in the issue of better representing output uncertainty distribution from input uncertainty distributions. He is especially concerned about how to deal with correlated inputs. It is uncertain whether this topic will be turned into an RTAR or a seminar, but we should revisit the topic in St. Louis.
- Reconciling differences between simulation results and actual energy use (Joe Huang, Son XXXX from ORNL); Jeff Haberl and Neal Kruis volunteered to review. Danny Parker from FSEC is measuring the building energy consumption in 60 houses in Florida and the data is public on a website. Joe Huang suggested that we can model the buildings using their data and see how well the model matches the dynamics. The data can be used for various purposes. Need to review the data for their availability and resolution.
- Comparing ASHRAE 90.1 App G Models to Real Buildings (Joe Huang). Nothing new to report.
- How to process, convert, or modify weather files for use in energy simulations (Jeff Haberl), nothing new to report.
- Neal Kruis will work on an RTAR to update the ASHRAE F and C ground coupling factors. (Put on the agenda for next meeting) (Nothing new to report).

The meeting was adjourned at 4:55pm.

ATTACHMENT 2: Agenda

TC 4.7 Applications Subcommittee

Draft Agenda 1

Orlando

Tuesday, 26 January 2016

3:30-5:00pm Orlando Hilton: Orange B (LL)

Introductions and Agenda Review (5 minutes)

- Sign-up sheet
- Around Room
- Agenda Mods

Announcements (5 minutes)

- ASHRAE Calls for Papers
- Proposed changes to TC-5.2 Title Purpose & Scope, "Duct Design"
- TC 4.1 new ANSI/ASHRAE Standard 203-2014, "Method of Test for Determining Heat Gain of Office Equipment Used in Buildings"

Program (15 Minutes)(Keith Cockerham)

- 2016 Winter (Orlando)
 - Nathaniel Jones: Seminar: "Use of Simulation Tools for Cutting Edge building design", (Jan 27 11-12:30, Orange Ballroom F
 - Jaya Mukhopadhyay: Seminar: "Simulation Calibration Methods: Which Should I Choose?", Jan 27 8-9:30, Orange Ballroom G
- 2016 Summer (St. Louis)
 - Tim McDowell: Resubmit a seminar about Standard 205
 - Eric Kolderup: Seminar on Standard 209 (to be discussed Orlando)
- 2017 Winter (Las Vegas)
- 2017 Summer (Long Beach)
- 2018 Winter (Chicago)

Research (65 minutes)

- Updates on related activities (10 minutes each)

- Updates on related activities (10 minutes each)
 - BEMBook and other COMNET related activities (Ellen Franconi)
 - Update on SPC209P, *Energy Simulation Aided Design for Buildings Except Low-Rise Residential* (Jason Glazer)
- Ideas for New RTARS (15 minutes each)
 - Update the ASHRAE F and C Ground Coupling Factors (Neil Kruis)
 - Optimizing change-over mixed-mode cooling systems for houses, using building simulation (Liping Wang, Jeff Haberl, Kamal Haddad)
 - Reconciling differences between simulation results and actual energy use (Joe Huang, Som Shrestha, Jeff Haberl, Neil Kruis)
 - Impact of input uncertainties on output uncertainty: Correlated vs non-correlated parameters (Chris Balbach)
 - Hybrid forward and data driven modeling (Chris Balbach)
 - Guidelines on simulating tall buildings (Joe Huang)
 - Comparing ASHRAE 90.1 App G Models to Real Buildings (Joe Huang)
 - How to process, convert, or modify weather files for use in energy simulation (Jeff Haberl)
 - Others?
- Topics for Discussion (whatever time remains)
 - Should TC 4.7 maintain a set of prototypical building models and input files, possibly building on DOE's "Reference Building Models"?
 - Any other issues or concerns (does not have to be turned into an RTAR or WS)
 - Emphasis and focus of future applications subcommittee meetings and activities



Attachment E Draft Agenda and Minutes

TC 4.7 Handbook Subcommittee
5:00-6:00 pm, Tuesday, January 27, 2015
Empire Ballroom (Lobby), Palmer House
Chicago, IL

Meeting Minutes

Orlando

Tuesday, January 26, 2016

5:00-6:00pm EST

Room: Orange B (LL) Hilton



Name	Email	Interest	Initials
Erik Kolderup, chair	erik@kolderupconsulting.com		X
Agami Reddy	reddyta@asu.edu	Data driven modeling	
Alamelu Brooks	Alamelu.brooks@icfi.com	Validation, calibration	X
Andy Brophy	Abrophy89@gmail.com	Calibration, occ beh	X
Anthony Fontanini	fontania@iastate.edu	DDM, sim components	
Artem Zkukov		MPC, param. studies	
Bass Abushakra	abushakr@msoe.edu	DDM	X
Charlie Curcija	dccurcija@lbl.gov	Calibration	
Cheng Xian Lin	lincx@fiu.edu	Data centers	
Chip Barnaby	chipbarnaby@gmail.com	Loads	
Chris Baker	chrisb@twgi.com		
Chris Balbach	cbalbach@psdconsulting.com		
Clark Denson	cdenson@ssr.inc.com		X
Craig Wray	PharmEng@PacBell.net		
Dan Fisher	dfisher@okstate.edu		
Dru Crawley	Dru.crawley@bentley.com		
Edmund Wong	Edmund.wong@arup.com	Calibration, DDM	X
Hyojin Kim	kiml@cua.edu	DD, calibration, occ beh	
J. Patrick Carpenter	facperfeng@comcast.net		X
Jeff Haberl	jhaberl@tamu.edu	DD, calibration	X
Joe Huang	yihuang@whiteboxtechnologies.com		
Joel Neymark	neymarkj@msn.com	Validation	X
John Pruett	jap@zmm.com	Calibration	X
Juan-Carlos Baltazar	jcbaltazar@gmail.com	DDM/calibration	
Keith Cockerham	kcockerham@mail.ashrae.org		X
Kris Kinney	kinneyecg@gmail.com	DDM/calibration	
Larry Degelman	ldegelman@suddenlink.net		
Liam Buckley	Liam.buckley@iesve.com	Nat vent/mixed mode	
Mahabir Bhandari	bhandarims@ornl.gov	Calibration	
Malcolm Cook	Malcolm.cook@lboro.ac.uk	Airflow modeling	X
Mark Adams	adamsmb@ornl.gov		
Mark Seymour	Mark.Seymour@futurefacilities.com		X
Michelle Sadegny	msadegny@group14eng.com		
Mini Malhotra	malhotram@ornl.gov	DDM, calibration	
Minjae Shin	minjaeshin@tees.tamus.edu	Thermal zoning	
Mitch Paulus	Paulusm14@gmail.com	Data driven modeling	X
Nathaniel Jones	nljones@mit.edu		X
Neal Kruis	Neal.kruis@bigladdersoftware.com	Ground heat transfer	X
Patrick Carpenter	facperfeng@comcast.net	DD	
Peter Armstrong	parmstr@mit.edu	MPC, CRFT, Perf maps	X
Ralph Muehleisen	rmuehleisen@anl.gov	Uncert., occ behav, cal.	X

Ron Judkoff	Ron.judkoff@nrel.gov	Validation	X
Russell Taylor		Calibration	
Sam Brunswick	sbrunswick@taylor-engineering.com	NV, mixed mode, occ beh	
Samira Elkhamli	selkhamli@worldbank.org	DDM, occ behav	
San Hoon Lee		Calibration, occ behav.	
Siddharth Premkumar	spremkumar@gilbertmech.com	HVAC sys design	
Sukjoon Oh	sukjoonoh@tees.tamus.edu	History, DDM, daylighting	
Sunglok Do	sunglokdo@tees.tamus.edu	Ground-coupled systems	
Taylor Roberts	troberts@group14eng.com	DDM	
Tianzhen Hong	thong@lbl.gov	Occupant behavior	X
Tim McDowell	mcdowell@tess-inc.com		X
Umberto Berardi	uberardi@wpi.edu	Calibration	
Vern Smith	Vernon.a.smith@gmail.com		
Zulfi Cumali	zulfi@cumali.com	Analytical methods, calibration method	X

22 attendees

- 1) Introductions and Agenda Review
- 2) Reviewed schedule
 - a. January 2016, 99% draft to TC for review (NOT QUITE THERE)
 - b. Feb 2016, web meeting – Erik will set up a Doodle poll for a late Feb web meeting
 - c. April 2016, web meeting
 - d. ~April 2016, TC4.7 email ballot
 - e. June 2016, TC approves revised chapter (final due June 21, 2016)
 - f. Early 2017, review galley prints
 - g. June 2017, publication
- 3) Discussed Handbook Online opportunities
 - a. Spreadsheets, color images, software, databases, etc.
- 4) Status updates, review outline (Link to outline: <https://www.dropbox.com/s/46817vqityiw9e/HOF%202017%20Chapter%2019%20Outline%2001-21-2016.docx?dl=0>)
 - a. General Considerations (McDowell)
 - Draft complete
 - Reviewers: Andy Brophy, John Pruett
 - b. Degree Day and Bin Methods (Huang)
 - Joe Huang started edits. Need to complete and coordinate with existing material.
 - Mitch Paulus will work with Joe.
 - c. Thermal Loads Modeling (Kruis)
 - Mostly complete draft

- Reviewers: Zulfi Cumali (space sensible load calculation methods), Joel Neymark, Edmund Wong.
 - d. HVAC Component Modeling (Kolderup)
 - Draft complete except Ground-coupled systems (McDowell to draft) and Combined Heat and Power (author not yet identified, perhaps TC 1.10 may be left out)
 - Reviewers: Tianzhen Hong, Clark Denson
 - e. Other System Modeling (Cook)
 - Drafts complete
 - Reviewers: to be identified.
 - f. Data-Driven Modeling (Muelheisen)
 - Correlation methods needs to be integrated; was moved from another section
 - Reviewers: Kris Kinney, Mitch Paulus
 - g. Model Calibration (Pruett)
 - Complete draft. Jeff Haberl noted that simple methods should also be addressed; see paper by Coakley
 - Reviewers: Xuejin Yue (?), Mitch Paulus, Juan-Carlos Balthazar.
 - h. Model Validation and Testing (Judkoff)
 - Draft complete
 - Reviewers: to be identified
 - i. Reference (Need a lead to review and update references)
 - Not yet updated. New references have been identified through the draft.
 - Neal Kruis to review the existing references for orphans. Jeff, Erik, Neal, and Joe to hold web meeting to decide which are to be deleted and which moved to bibliography.
 - j. ~~Bibliography~~ (Need a lead to review and update bibliography)
 - To be reviewed.
- 5) Reminder of editing process
- a. Use **track changes** to add notes and edits.
 - b. Use the file "I-P & SI_F17_Ch19_01-21-2016_UseForEdits.doc" as a starting point. Link, https://www.dropbox.com/s/iw0x51gqo6kw0uf/I-P%20%26%20SI_F17_Ch19_01-21-2016_UseForEdits.doc?dl=0
 - c. Files with tracked changes may be emailed to Erik Kolderup, erik@kolderupconsulting.com.
 - d. Source files and references may be uploaded to the Dropbox folder.
- 6) Next meeting
- a. Web meeting to be set up for late February.

Resources:

- Dropbox folder:
<https://www.dropbox.com/sh/9vnz7g99u6xvev2/AABXxiIB9OOMInvvAVLoiU6Ha?dl=0>.
- Description of target audience. Google Doc:
https://docs.google.com/document/d/174pP_sNvLlSMAlDZTMTomfwh9wiUibwTdl7i4EY7nBrE/edit?usp=sharing)



Agenda and Minutes provided by SSPC 140 Chair
SSPC 140 Meeting Summary –1/25/16 (submitted to TC4.7 1/26/16)

Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs.

- **Current version is 140-2014**
- **Current IRS rules** (IRS notice 2008-40, published Apr 2008) relating to the deduction for energy efficient **commercial buildings** require software used for assessing tax credits be tested to Standard 140-2007. Currently **13 programs are qualified**; 7 programs qualified updated versions. (Last check 03Dec2015). **New submittals** ron.judkoff@nrel.gov
Qualified programs listed at <http://energy.gov/eere/buildings/qualified-software-calculating-commercial-building-tax-deductions>
- RESNET lists **8 (up from 6, last check 22Jun2015)** tools as either accredited for HERS ratings, tax credit compliance, IECC performance verification, or existing home tax credit compliance. Required tests include NREL's HERS BESTEST (included in [Std 140-2011,-2014](#)), along with equipment modeling and other modeling tests developed by RESNET. **New submittals to RESNET** (<http://www.resnet.us/professional/programs/software>).
- **ASHRAE 90.1 and 189.1 reference Standard 140;**
 - **90.1-2013, published Fall 2013 cites 140-2011**
 - **Referencing of 140-2014 in process for 90.1 2016.**
- **2015 IECC cites 140-2011; IGCC citation accords with IECC. Citation of 140-2014 (or 140-2017 depending on timing) in process for IECC 2018**

Proposed Addendum A to 140-2014. (ASHRAE RP-865 Airside-Mechanical Equipment tests adaptation):

- Test suite based on ASHRAE RP-865; **first 140 suite based on ASHRAE research.**
- Airside analysis of Fan Coil (FC), Single Zone (SZ), Constant Volume (CV), and Variable Air Volume (VAV) systems.
 - These are steady-state analytical verification tests.
 - Provides basis for future Volume 2 test suite with hourly varying weather, and other steps toward testing performance in more realistic (less idealized/in-depth-diagnostic) context.
- Robust participation: 7 simulation trial participants from 4 countries + Quasi-Analytical Solution by NREL.
- **NREL final report content approved by Simulation Trial Working Group participants Dec 2015. Publication/posting by NREL expected Mar 2016.**
- **Standard 140 adaptation as 140-2014 Addendum A during 2016; PC approval to proceed applying selected content of NREL final report occurred at this meeting.**

Building Thermal Fabric Tests Update (140, Section 5.2)

- **Address advances in modeling state of the art since 1995**
- Iterate on spec revisions and simulation trials, with draft NREL final report including updated spec and example results.
- **Consideration of revisions to existing test cases and inclusion of additional excursion (parametric sensitivity) test cases continues in collaboration with SSPC 140.** Test case revisions must be compatible with current parsimonious framework of the test cases.
- Consider including version of the spec in OpenStudio (gbXML compatible) format for automated input.

Test suite progress:

- First round simulation trial
 - Updated test spec distributed July 22, 2014.
 - Results received Sep – Nov, 2014; compiled by NREL Jan 2015
 - **7 participants from 7 countries**
 - Good/constructive comments on spec.
- 2nd round simulation trial revisions
 - 17 topical revisions, to address comments from January
 - Some work remains
 - **Second round progress temporarily slowed to focus on Airside HVAC final report completion and adaptation for Std 140 (see above)**
 - Working Group (software developers) addressing first round results disagreements
 - Add extension cases as time allows; extension cases can be completed during additional rounds.
 - Window excursion cases for other glass types, and including window frames.
 - Weather driven infiltration cases – keep constant infiltration rate cases in base case to reduce noise.

Next steps:

- Continue topical revisions
 - Equivalent constant surface coefficients for programs that do not automatically calculate convective and/or radiative surface heat transfer.
 - A couple others remain.

Empirical Validation: SSPC 140 is interested in including empirical validation test suites IF they are worthy (high quality experimental data, with well vetted test specifications). **Work sponsored by DOE is in the early stages.**

On this topic we heard presentations from:

- R. Judkoff and E. Kozubal of NREL,
- P. Haves of LBNL,
- J. New of ORNL.

References to Standard 140. Standard 140 is referenced by:

- IRS, Standard 90.1
- Standard 189 (High Performance Green Building Design) Appendix D
- IECC, IGCC
- The newly developing COMNet (BPI, Energy Foundation et al) User's Manual.
- Implicitly referenced for ASHRAE Building Energy Quotient IF that is based on the COMNet User's Manual;
- RESNET references Section 7 tests (adapted from HERS BESTEST 1995).
- Florida Building Commission
- Various international references.

Full SSPC 140 meeting notes are available at <http://sspcl40.ashraeeps.org/index.html>.

Listing of test suites either included in Std 140 or listed in Annex B23 (of Std 140) is included below. (Included per Jan 2010 request by TC 4.7 Chair; a more comprehensive listing requires a literature survey.)

Analytical Verification Tests and Comparative Tests already in Standard 140 (or with addenda in progress)

- NREL/IEA 12/21 "IEA BESTEST" (building thermal envelope fabric load tests)
- NREL/IEA 22 "HVAC BESTEST Volume 1" (analytical verification tests)
- NREL/IEA 22 "HVAC BESTEST Volume 2" (comparative tests)
- NRCan/IEA 22 "Furnace BESTEST" (analytical verification and comparative)
- NREL/HERS Council "HERS BESTEST" (comparative tests, simplified residential)
- NREL/IEA-34/43 "Ground-Coupled Slab-On-Grade In-Depth Tests" (analytical verification)
- NREL/IEA-34/43 "Multi-Zone Non-Airflow" (analytical verification and comparative)
- ASHRAE RP-865 "Air-Side Mechanical Equipment Analytical Verification Tests"

Other Analytical Verification and Comparative Tests

- NREL "BESTEST-EX" (comparative physics and calibration tests, existing homes)
- ASHRAE RP-1052 "Development of an Analytical Verification Test Suite for Whole Building Energy Simulation Programs – Building Thermal Fabric
- "RADTEST Radiant Heating and Cooling Test Cases"
- IEA-34/43 Airflow Tests by Japan (final report still in progress)

Empirical Validation Tests

- "ETNA BESTEST Empirical Validation Test Specification (NREL and Electricite|de France)
- IEA-34/43: "Empirical Validations of Shading/Daylighting/Load Interactions in Building Energy Simulation Tools (EMPA, Switzerland)
- IEA-34/43 "Chilled Water and Hot Water Mechanical Equipment and Control Comparative and Empirical Validation Tests (empirical and comparative, TUD, Germany)
- IEA-34/43 "Double-Skin Façade Empirical Validation Tests" (Aalborg U., Denmark).
- IEA 22 "Daylighting/HVAC Interaction Tests for the Empirical Validation of Building Energy Analysis Tools (Iowa ERS, US)
- IEA 22 Economizer Control Tests for the Empirical Validation of Building Energy Analysis Tools (Iowa ERS, US and Spain)

- IEA ECBCS Annex 42: Comparative Testing and Empirical Validation of Annex 42 Models for Residential Cogeneration Devices (NRCan)
 - o http://cogen-sim.net/index.php?pg=&download=Annex_42_ST_B_Final_report_on_comparative_testing_and_empirical_validation.pdf
- New Research: There is a possibility of developing a test facility for empirical validation of software used to model retrofits of existing building (i.e., software that is currently the subject of the BESTEST-EX test suite). Such a test facility would be expensive relative to developing comparative and analytical verification tests, but such expense would be well justified if U.S. energy policy moves towards supporting energy efficiency retrofits of energy-inefficient houses that comprise a large portion of the current U.S. housing stock.