AMERICAN 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 person listed below within 60 days following the meeting.)

TC/TG/TRG No. TC 4.7 DATE: Oct. 15, 2003

TC/TG/TRG TITLE: Energy Calculations

DATE OF MEETING: July 1, 2003 LOCATION: Kansas City

MEMBERS PRESENT	YEAR APPTD	MEMBERS ABSENT	YEAR APPTD	EX-OFFICIO MEMBERS & ADDIT'L ATTENDANCE
Dru Crawley (CHM)	2000	Ian Beausoleil-Morrison	2000	
Les Norford (VC)	2000	Klaus Sommer (INTL)	1999	
Dan Fisher (SEC)	2002			
Vern Smith (RES)	2000			
Jeff Haberl (PROG)	2002			
Jim Willson (APP)	2000			
Agami Reddy (IM)	1999			
Joel Neymark (SC)	2000			
Jan Hensen (INTL)	2000			
Chip Barnaby	1999			
Phil Haves	2000			
Moncef Krarti	1999			
Tim McDowell	2002			
Rick Strand	2001			
Robert Sonderegger	2002			
Gren Yuill	2000			

DISTRIBUTION

ALL MEMBERS OF THE TC/TG/TRG

TAC CHAIR	William E. Murphy
TAC SECTION HEAD	Eckhard Achim Groll
SPECIAL PUBLICATIONS LIAISON	Marily A Listvan
JOURNAL/INSIGHTS LIAISON	Harvey Sachs
STANDARDS LIAISON	Richard D. Hermans
HANDBOOK LIAISON	William S. Fleming
PROGRAM LIAISON	Kelley Cramm
RAC RESEARCH LIAISON	Sheila Hayter
ALI LIAISON	Alexander J Boone
TEGA LIAISON	Charles E. Gulledge III
STAFF LIAISON (RESEARCH)	Michael R. Vaughn
STAFF LIAISON (TECH SERVICES)	Michael R. Vaughn
STAFF LIAISON (STANDARDS)	Claire Ramspeck

ASHRAE TC 4.7 Energy Calculations

CHICAGO MEETING

ACTION ITEMS

1. Chicago minutes were approved. (Haberl/Barnaby 11-0-0 CNV)

2. Motion to provide a letter of support for the workstatement developed by TC 4.1 titled, "Fenestration…" (Barnaby/Smith 14-0-0 CNV)

3. Motion to accept the final research report for RP-1222, 'Incorporation of Nodal Room Heat Transfer Models into Energy and Load Calculation Procedures.' (Smith/Yuill; 14-0-0 CNV)

4. Motion to grant a no cost extension for RP-1049, Building System Design Synthesis, until March 1, 2004 (Smith/Willson; 14-0-0 CNV)

5. Motion to grant a no cost extension for RP-1197, Updated Energy Calc Models for Residential Equip until March 1, 2004 (Smith/Barnaby; 14-0-0 CNV)

6. Motion to accept the research plan for 2004/2005 unchanged from the 2003/2004 plan (Smith/Haberl; 14-0-0 CNV).

7. Motion to post presentation material of symposium KC-03-02, Inverse Methods for calculating energy savings from energy conservation retrofits, on the web site pending approval from ASHRAE and contributing authors. (Haberl/Barnaby; 14-0-0 CNV)

8. Motion to post presentation material of symposium KC-03-10, Coupling of Building Air Flow and Energy Modeling Programs, on the web site pending approval from ASHRAE and contributing authors. (Haberl/Barnaby; 14-0-0 CNV)

9. Motion to post presentation material of Seminar 48, Successful Applications of Energy Simulation in Building Design, on the web site pending approval from contributing authors. (Haberl/Barnaby; 14-0-0 CNV)

10. Motion to accept the program ranking for the Anaheim meeting:
    #1 , Seminar 'Modeling Phase Change Materials in Building Envelopes,
    #2 Seminar" Applications and Experiences with the new EneryPlus Software
    #3 Forum Modeling Phase Change Material Applications in Building Envelopes
    #4 Forum "Do ASHRAE Members need an Energy simulation model of refrigerated warehouses"
    Approved . (Haberl/Barnaby; 14-0-0 CNV)

11. Motion to cosponsor TC 9.1 Anaheim seminar titled, 'Energy Analysis for Laboratory Buildings', (Sonderegger/Willson; 14-0-0 CNV)

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TC/TG/TRG MINUTES COVER SHEET

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TC/TG/TRG No. TC 4.7 DATE: July 5, 2003

TC/TG/TRG TITLE: Energy Calculations

DATE OF MEETING: July 1, 2003 LOCATION: Kansas City

TC/TG/TRG MEETING SCHEDULE			
LOCATION – past 12 months	**DATE**	**LOCATION - planned next 12 months**	**DATE**
Chicago	January 28, 2003	Anaheim	January 27, 2004
Kansas City	July 1, 2003	Nashville	June 30, 2004

TC/TG/TRG SUBCOMMITTEES	
Function	**Chair**
Simulation and Component Models	Ian Beausoliel-Morrison
Applications	Jim Willson
Data-Driven Modeling	Agami Reddy

RESEARCH PROJECTS – Current		**Monitoring**	**Report Mode**
Project Title	**Contractor**	**Comm.Chm.**	**At Meeting**
Appendix 1			

LONG RANGE RESEARCH PLAN				
Rank	Title	W/S Written	Approved	To R & T
	Appendix 2.			

HANDBOOK RESPONSIBILITIES				
Year & Volume	Chapter Title	**No.**	Deadline	**Handbook Subcom. Chair/Liaison**
2005 Fundamentals	Energy Estimating Methods	31		Strand/Fleming

STANDARDS ACTIVITIES - List and Describe Subjects

SPC 140 Standard Method of Test for Building Energy Software – Joel Neymark

TECHNICAL PAPERS from Sponsored Research - Title, when presented (past 3 yrs. present & planned)

Appendix 3
TC/TC/TRG Sponsored Symposia - Title, when presented (past 3 yrs. present & planned)
Appendix 4
TC/TG/TRG Sponsored Seminars - Title, when presented (past 3 yrs. present & planned)
Appendix 5
TC/TG/TRG Sponsored Forums - Title, when presented (past 3 yrs. present & planned)
None
JOURNAL PUBLICATIONS - Title, when published (past 3 yrs. present & planned)
None

Attendance

This is a complete listing of attendees at this and the prior three meetings. It includes the voting members of the committee listed on the first page. Email addresses are listed for those who have explicitly authorized their inclusion in the minutes, which are posted on the TC's web site.

Present at TC 4.7 meeting?					Last name	First name	Email
Add to email list	Kansas City July 2003	Chicago January 2003	Honolulu June 2002	Atlantic City Jan 2002			
X	X	X			Abushakra	Bass	abushakr@msoe.edu
X	X				Anderson	J.R.	jrhazel@bellsouth.net
				X	Armstrong	Peter	parmstr@mit.edu
		X	X	X	Bahnfleth	Bill	wbahnfleth@psu.edu
	X	X	X	X	Barnaby	Chip	CBarnaby@wrightsoft.com
			X		Bauman	Fred	fbauman@uclink.berkeley.edu
		X	X	X	Beausoleil-Morrison	Ian	IBeausol@nrcan.gc.ca
				X	Black	Al	ablack@mcclureeng.com
			X		Bojic	Milorad	bojic@knez.uis.ac.yu
		X			Bradley	Brian	bbradley@nrcan.gc.ca
		X	X	X	Brandemuehl	Mike	michael.brandemuehl@colorado.edu
		X			Braun	Jim	jbraun@ecn.purdue.edu
	X	X	X	X	Carpenter	J Patrick	pcarpenter@kling.us
	X			X	Chantrasrisalai	Chanvit	chanvit@okstate.edu
	X	X		X	Claridge	David	Claridge@esl.tamu.edu
	X	X	X	X	Crawley	Dru	Drury.Crawley@ee.doe.gov
X	X				Degelman	Larry	larry@taz.tamu.edu
	X			X	Deng	Zheng	zhengd@okstate.edu
	X	X			Eldridge	David	dancingdavid@hotmail.com
	X	X	X	X	Fisher	Dan	DFisher@okstate.edu
		X		X	Fleming	Bill	flemg@aol.com
			X		Gowri	Krishnan	k_gowri@pnl.gov
		X			Guan	Don	yzguan@ksu.edu
	X	X		X	Haberl	Jeff	JHaberl@esl.tamu.edu
				X	Haddad	Kamel	khaddad@nrcan.gc.ca
X	X				Haiad	Carlos	Carlos.haiad.sce.com
	X	X	X	X	Haves	Philip	PHaves@lbl.gov
	X	X	X		Hensen	Jan	j.hensen@tue.nl
	X	X	X	X	Huang	Joe	YJHuang@lbl.gov
				X	Iu	Ipseng	iip@okstate.edu
				X	Jin	Hui	jinh@okstate.edu
		X	X	X	Judkoff	Ron	ron_judkoff@nrel.gov
X	X				Klaassen	Curtis	curtk@energy.iastate.edu
	X			X	Kong	Weixiu	weixiu@okstate.edu

Present at TC 4.7 meeting?					Last name	First name	Email
Add to email list	Kansas City July 2003	Chicago January 2003	Honolulu June 2002	Atlantic City Jan 2002			
X	X				Koran	Bill	William.koran@honeywell.com
	X	X		X	Kosny	Jan	kyo@ornl.gov
	X			X	Krarti	Moncef	krarti@colorado.edu
		X			Kreider	Jan	
			X		Lawrence	Tom	lawrenct@ecn.purdue.edu
		X			Lawrie	Linda	Linda@lawrie.com
		X	X		Liesen	Richard	r-liesen@uiuc.edu
X	X				Lisenbee	Larry	lrlisenb@southern.com
X	X				Liu	Xiaobing	Xiaobin@okstate.edu
X	X	X			MacCracken	Mark	mmaccracken@calmac.com
	X	X		X	McDowell	Tim	Mcdowell@tess-inc.com
	X	X	X	X	Neymark	Joel	neymarkj@msn.com
	X	X	X	X	Norford	Les	lnorford@mit.edu
		X		X	Parson	Jim	parsons@me.msstate.edu
		X			Phillips	Duncan	Duncan@cedarmere.ca
	X	X	X	X	Pedersen	Curt	cpederse@uiuc.edu
	X	X	X	X	Reddy	T. Agami	reddyta@drexel.edu
		X	X	X	Rees	Simon	SJRees@okstate.edu
				X	Riemer	Paul	paulr@twgi.com
		X			Rode	Carsten	car@byg.dtu.dk
X	X				Sahlin	Per	per.sahlin@equa.se
		X			Scheatzle	David	scheatzle@asu.edu
X	X				Shirey	Don	shirey@fsec.ucf.edu
X	X				Silvetti	Brian	bslivetti@calmac.com
	X	X	X	X	Smith	Vernon	VSmith@archenergy.com
			X	X	Sommer	Klaus	Klaus.Sommer@vt.fh-koeln.de
	X	X	X	X	Sonderegger	Robert	rsonder@siliconenergy.com
	X	X	X	X	Spitler	Jeffrey	Spitler@okstate.edu
	X	X	X		Strand	Rick	R-Strand@uiuc.edu
	X	X	X	X	Walton	George	GWalton@nist.gov
			X	X	Wassmer	Mike	wassmer@colorado.edu
	X	X	X	X	Willson	Jim	jimwill@indy.net
	X	X	X	X	Wray	Craig	CPWray@lbl.gov
	X		X		Wright	Jonathan	J.A.Wright@lboro.ac.uk
	X			X	Xiao	Dongyi	xdongyi@okstate.edu
	X	X	X		Yuill	Gren	yuill@unomaha.edu
				X	Zhang	Yi	y.zhang@lboro.ac.uk
		X			Zhu	Daming	zdmhvac@yahoo.com

Appendix 1

RESEARCH PROJECTS

TC 4.7 RESEARCH PROJECTS STATUS

Active projects

#	Title	Joint TC	Cognizant Subcommittee/ Contractor	PMSC	Dates / status
1049-RP	Building System Synthesis and Design	1.5	Sim/Comp Loughborough University Jonathan Wright	Curt Pedersen (chair), Ed Sowell, Dave Knebel, Ron Nelson (TC 1.5), Mike Brandemuehl (TC 4.6), Jan Hensen	WS: 1-20-98 (SF) Rec: 6-22-99 (Seattle) NCE: 7-31-03 (6-25-02) NCE: 3-1-04 (7-1-03)
1050-RP	Development of a Toolkit for Calculating Linear, Change-point Linear, and Multiple Linear Inverse Building Energy Analysis Models		Inv U. of Dayton Kelly Kissock	Jan Krieder (chair), Robert Sonderegger, Moncef Krarti, Agami Reddy	WS: 7-1-98 (Boston) Rec: 6-23-98 (Toronto) NCE: 3-31-01 (6-27-00) NCE: 10-1-01 (1-30-01) **Accept final report: (1-28-03)**
1197-RP	Updated Energy Calculation Models for Residential HVAC Equipment	7.6	Sim/Comp U Colorado Michael Brandemuehl	Chip Barnaby (chair), Craig Wray, Brian Dougherty (TC 7.6)	WS: 2-8-00 (Dallas) Start: 1-02 NCE: 3-1-04 (7-1-03)
1222-RP	Incorporation of Nodal Room Heat Transfer Models into Energy and Load Calculation Procedures		Sim/Comp MIT, Chen		**Accept final report (7-1-03)**

Appendix 2

RESEARCH PLAN

ASHRAE
Technical Committee 4.7 Energy Calculations
2004-2005 Research Plan
1 August 2003

TC 4.7 approved no new RTARs for consideration on the 2004-2005 Research Plan.

Title	TC Priority 2003-2004	Prior TC priority	Society status	TC Status	Comments	Subcom
Technical and Usability Enhancements to the Energy Calculation Toolkits	0	1 (2003-2004	RTAR 2004-19, accepted	WS draft in progress	Dan Fisher:	SCM
Development of a Procedure for Base-lining Energy Use at Large Central Plants	0	2 (2002-2003)	RTAR, prioritized	WS draft in progress	Moncef Krarti, Jeff Haberl: Need to find additional support	DDM
Procedures and Data for High-Performance Residential Design	0	1 (2002-2003)	RTAR, accepted	WS draft in progress	Mike Witte, Vern Smith	A
Procedures for Reconciling Computer-Calculated Results With Measured Energy Data (1051-TRP)	0	3 (1998-1999)	Contract award approved, June 2003		TC responded to Tech Council comments – reconsidered and approved at Kansas City meeting, June 2003	DDM
Improving Load Calculations for Fenestrations with Shading Devices	Co-sponsor		RTAR 2004-12, prioritized.	TC 4.1 RTAR. Draft WS approved by TC 4.1; co-sponsorship approved by TC 4.7 at June 2003 meeting	Chip Barnaby	

SCM = Simulations and Component Models
DDM = Data Driven Modeling (formerly Inverse Methods)
A = Applications

Appendix 3
TECHNICAL PAPERS FROM SPONSORED RESEARCH

RP	Title	Contractor	Approved	Paper
987	Loads Toolkit	UIUC, Pedersen	Atlanta, January 2001	Pedersen, C.O., D.E. Fisher, R.J. Liesen, and R.K. Strand. 2003. "ASHRAE Toolkit for Building Load Calculations." ASHRAE Transactions 109(1). To be presented in Chicago, January 29, 2003
1052	Verification Test Suite	OSU, Spitler	Atlanta, January 2001	Rees, S.J., D. Xiao, and J.D. Spitler. 2002. "An Analytical Verification Test Suite for Building Fabric Models in Whole Building Energy Simulation Programs." ASHRAE Transactions. 108(1):30-41.
1145	Two- and Three-Dimensional Heat Transfer	Enermodal	Atlanta, January 2001	Carpenter, S.C., J. Kosny, and E. Kossecka. 2003. "Modeling Transient Performance of 2 and 3-D Building Assemblies: ASHRAE 1145-RP." ASHRAE Transactions 109(1). To be presented in Chicago, January 29, 2003
1093	Diversity Factors	TAMU, Haberl	Cincinnati, June 2001	Abushakra, B., D.E. Claridge and J.S. Haberl. "Electricity Diversity Profiles for Energy Simulation of Office Buildings;' "Electricity Diversity Profiles for Peak Cooling Load Determination in Office Buildings;" and "Overview of Literature on Diversity Factors and Schedules for Energy and Coolling Load Calculations." Submitted to ASHRAE December 27, 2001.
865	Accuracy Tests	UNO, TAMU	Honolulu, June 2002	Yuill, G.K. and J.S. Haberl. "Development of Accuracy Tests for Mechanical System Simulations."
1222	Nodal Models	MIT, Chen	Honolulu, June 2002	Two papers submitted to Int. J. of HVAC&R Research
1050	. Inverse Modeling TK	U Dayton, TAMU	Kansas City June 2003	*Kissock;JK., J.S.Haberl D. E. Claridge*, "Inverse Modeling Toolkit - Numerical Algorithms"
1050	. Inverse Modeling TK	U Dayton, TAMU	Kansas City June 2003	*Haberl, J.S., A. Sreshthaputra, D. E. Claridge*, *J.K. Kissock,"* Inverse Modeling Toolkit - Applications"

Appendix 4
TC/TG/TRG SPONSORED SYMPOSIA

Current as of August 2003

PLANNED:

ANAHEIM / JANUARY 2004

1. **Symposium** "Applications and Knowledge-based Tools for Enhanced Building Energy Simulation"
    - Organized by TC 4.7 (Data Driven and Applications)
    - Chaired by Vern Smith
    - Status: merged with KBS Symposium at K.C. 2 papers have been reviewed, 1 paper needs significant, 2 KBS technical papers on conceptual design.

NASHVILLE/JUNE 2004

1. **Symposium** "Validation of building simulation programs thru ASHRAE Standard 140"
    - Organized by TC 4.7 (Applications)
    - Chaired by Jim Willson
    - Status: 5 papers being considered (865RP, Overview, HVAC Bestest, Iowa Empirical Tests, Jelena Srebric)
2. **Symposium** "Recent Advances in Simulation"
    - Organized by TC 4.7 (Sim and Comp Models)
    - Chaired by Dan Fisher
    - Status: New
3. **Symposium** "Modeling Moisture Sorption/Desorption by Building Materials"
    - Organized by TC 4.7 (Sim and Comp Models)
    - Chaired by Jan Kosny
    - Status: New

PAST:

Kansas City, June-July 2003

Inverse Methods for Calculating Energy Savings from Energy Conservation Retrofits (*Chair: Jan F. Kreider)*

Coupling of Building Airflow and Energy Modeling Programs (Co-sponsored with TC4.10 Chair: Jelena Srebric)

Chicago, January 2003

Recent Advances in Energy Simulation: Building Loads (Co-sponsored with TC4.1/Chair: Jan Hensen)

Honolulu, June 2002

Recent Advances in the Thermal Simulation of HVAC Equipment
(Co-sponsored by TC4.1/Chair: Ian Beausoleil-Morrison)

Atlantic City, January 2002

Tools and Techniques for Calibration of Component Models
(TC1.5 sponsor; TC4.7 co-sponsor/Chair: Agami Reddy)

Cincinnati, June 2001

Better Inputs for Better Outputs (TC9.6 co-sponsor/Chair: Jim Willson)

Atlanta, January 2001

Analysis Tools for the Design of Low-Energy Cooling Systems (Chair: Joe Huang)

Minneapolis, June 2000

International Experience with Weather Data for Simulation and Design, Part 1: Simulation, Ventilation and Daylighting (TC 4.2 co-sponsor/Chair: Dru Crawley)

International Experience with Weather Data for Simulation and Design, Part 2: Simulation
(TC 4.2 co-sponsor/Chair: Dru Crawley)

Seattle, June 1999

*Applications of Heat and Mass Balance Methods to Energy and Thermal Load Calculations (*Chair: Chip Barnaby)

*Accuracy tests for simulation models (*Chair: Mike Witte)

Appendix 5
TC/TG/TRG SPONSORED SEMINARS

Current as of August, 2003

PLANNED:

ANAHEIM / JANUARY 2004

1. **#1 Seminar** "Applications of HVAC-01 Primary and Secondary Toolkit"
    - Organized by TC 4.7 (Applications)
    - Chaired by Jean Lebrun/Dru Crawley
    - Status: New
2. **#2 Seminar** "Application and Experiences With the New EnergyPlus Software",
    - Organized by TC 4.7 (Applications)
    - Chaired by Joe Huang
    - Status: New

NASHVILLE/JUNE 2004

1. **Seminar** "Simulation Without Tears"
    - Organized by TC 4.7 (Applications)
    - Chaired by Joe Huang
    - Status: New

PAST:

Kansas City, June-July 2003

Successful Applications of Energy Simulation in Building Design (Chair: Vernon A. Smith)

Chicago, January 2003

Getting started in Building Simulation (Chair: Chip Barnaby)

Using Monitored Data for Solving Engineering Problems (Chair: Agami Reddy)

Atlantic City, June 2001

Commercial Use of Building Energy Simulation Software (Chair: Kamel Haddad)

Cincinnati, June 2001

A Review of State of the Art in Building Simulation Programs (Chair: Dru Crawley)

Atlanta, January 2001

Low-Energy Cooling Case Studies (Chair: Phil Haves)

Dallas - January 2000

ASHRAE's Software Toolkits for Energy Calculations (Chair: Dru Crawley)

ASHRAE TC 4.7 Energy Calculations

Tuesday, July 1, 2003, 6:00-8:30 p.m.
New York B, Ballroom Level, Hyatt
Kansas City, Missouri

1. Roll call and introductions Fisher

- Convened at 6:04 pm

2. Accept agenda & approve minutes of Chicago meeting Crawley (Attachment A)

Minutes accepted (Haberl/Barnaby 11-0-0 CNV)

3. Announcements/Liaisons Crawley

- CIBSE
- Section reorganization has happened. TC 47 unaffected with 6 section 4 TCs "load Calculations and Energy Requirements"
- 20 MB server space for each TC
- research summary: 75 projects underway; 20 completed during last year. 8-10 new projects will start before Anaheim.

4. Membership Crawley

- Bahnfleth, Brandemuehl, Carpenter Walton rolling on
- Sommer, Barnaby, Krarti, Reddy rolling off

5. Subcommittee reports

5.1 Applications: Jim Willson (chair) reporting: (**Attachment B)**

- two seminars added to program

5.2 Data-Driven Modeling Agami Reddy (chair) reporting: **(Attachment C)**

- 1051-TRP Procedures for Reconciling Computer-Calculated Results with Measured Energy Data under consideration by RAC
- Discussed the scope of the subcommittee. Wants to expand scope beyond monitored data only. Requests an expansion of scope to include synthetic data.
- Pedersen mildly objected to calling simulation results 'data'.
- Briefly discussed the current RTARs under consideration by the committee

5.3 Simulation & Component Models Beausoleil-Morrison chair, Dan Fisher reporting: **(Attachment D)**

- Program changes reported and research action items deferred to research report.
- 1049-RP Building System Design Synthesis (Loughborough Univ) Pedersen reporting. RP-1049 requests no cost extension until March 1, 2004
- 1197-RP Updated Energy Calc Models for Residential Equip. (UC-Boulder) Barnaby. RP 1197 requests no cost extension until March 1, 2004

5.4 Research, Vern Smith reporting **(Attachment E)**

- 3 RTARS on society research plan
- Send work statement to Shiela and Mike
- DF will forward electronic copy to Vern
- TC 4.7 agreed to support the TC4.1 work statement and will write a letter to that effect
- RP-1222 accepted by a vote of 14-0-0 CNV
- PES appointed by Chair to review URP titled: A Novel Technique for the Rapid Simulation of Transient Heat-Flow in Buildings
- No cost extension granted to RP-1049
- No cost extension granted to RP-1197
- Tech council rejected RP-1051. Committee requested that tech council reconsider.
- Research Plan has no new RTARS. Research plan will be submitted as is.

5.5 Handbook, Strand (chair) reporting **(Attachment F)**

- TC level changes must be approved by Anaheim. Handbook due by Feb. 1, 2004
- Noted some of the changes discussed by the committee.
- The latest version of the chapter is on the web site.

5.6 Program, Haberl **(Attachment G)**
- Haberl reporting

5.7 Standards, Neymark reporting **(Attachment H**
SSPC 140 SMOT for Eval of Building Energy Analysis Computer
- Public review to begin on SPC 140
- Discussed additional test cases

New IEA Annex on Validation Methods
- Neymark reporting
- Possible new projects include multizone test cases, ground coupling, double façade and empirical models based on Iowa Energy Center facility.
- Cases could be included in SPC 140.
- Wray suggested integrating moisture methods with IEA and SPC 140. Crawley suggested that this is an opportune time in the cycle to get this work on the IEA agenda.
-

5.8 Web Site, Simon Rees reporting
- Rees reporting
- Space and format issues are on the horizon
- Wray reports that a motion on allowing links to other sites is under consideration.
-

6. Reports on related activities

6.1 GPC 20 XML Definitions for HVAC&R
- Phil Haves reporting
- Discussion on defining use cases

6. 2 TC 4.1 Load Calculations
- Chip Barnaby reporting
- Non-residential chapter under fire because of its impracticality
- Non-residential procedures under development

6.3 TC 4.2 Climatic Information
- Dru Crawley reporting
- Additional data will be included

6.4 TC 4.5 Fenestration
- Curt Pedersen reporting
- Communication improving

6.5 TC 4.6 Building Operation Dynamics
- Mke Brandemuehl reporting

6.6 TC 4.11 Smart Building Systems
- Les Norford reporting
- Current issues: Fault detection in chillers and air handlers and self configuration

6.7 TC 9.6 Systems Energy Utilization
- Agami Reddy reporting
- Jim Willson appointed as new liaison.

6.8 IAI International Alliance for Interoperability
- Phil Haves reporting

6.9 IBPSA (USA, Canada, BS 2003)
- Norford reporting for IBPSA-USA.
- Preliminary planning for first national conference in Boulder next year.
- Two powerpoint presentations under development promoting use of simulation in design.
- Hensen reporting for BS2003
- IBPSA Canada 2004: Vancouver conference in June

6. 10 TC 6.5 Radiant Space Heating Systems
- Rick Strand reporting

- RTAR to develop a radiant system module is currently under development.
- Walton volunteered to assist in writing the work statement

6.11 TC 6.3

- Craig Wray reporting
- ACCA standard has run crossways of ASHRAE copyright issues

6.12 TC 9.1

Patrick Carpenter asked that we consider co-sponsoring a seminar in Anaheim.

7. Old Business

- No old business

8. New business

- Haberl brought up the problem in 90.1 of erroneous application of simulation. Asked that committee consider Motion to co-sponsor appropriate communication to society with TC9.6 to request that sufficient resources be made available to Standard 90.1 to perform state-of-the-art modeling.
- Committee's sense was that writing this letter might have far reaching implications and should only be pursued with
- Motion withdrawn

9. Executive Session

10. Adjourn

Meeting adjourned 8:31 pm (Crawley/ Sonderegger)

Attachments

A. Agenda
B. Applications Subcommittee Minutes
C. Inverse Methods Subcommittee Minutes
D. Simulation and Component Models Subcommittee Minutes
E. Research Subcommittee Minutes
F. Handbook Subcommittee Minutes
G. Program
H. SSPC 140 Minutes

ASHRAE TC 4.7 Energy Calculations
Agenda

Tuesday, June 30, 2003, 6:00-8:30 p.m.
New York B, Ballroom Level, Hyatt
Kansas City, Missouri

1. Roll call and introductions Fisher

2. Accept agenda & approve minutes of Chicago meeting Crawley

3. Announcements/Liaisons Crawley

4. Membership Crawley

5. Subcommittee reports
   - 5.1 Applications Willson
   - 5.2 Data-Driven Modeling Reddy
   - 5.3 Simulation & Component Models Beausoleil-Morrison
     - 1049-RP Building System Design Synthesis (Loughborough Univ) Pedersen
     - 1197-RP Updated Energy Calc Models for Residential Equip. (UC-Boulder) Barnaby
   - 5.4 Research Smith
   - 5.5 Handbook Strand
   - 5.6 Program Haberl
   - 5.7 Standards Neymark
     - ProgramsJudkoff
   - 5.8 Web Site Rees

6. Reports on related activities
   - GPC 20 XML Definitions for HVAC&R Haves
   - TC 4.1 Load Calculations Barnaby
   - TC 4.2 Climatic Information Crawley
   - TC 4.5 Fenestration Pedersen
   - TC 4.6 Building Operation Dynamics Brandemuehl
   - TC 4.11 Smart Building Systems
   - TC 9.6 Systems Energy Utilization Reddy
   - IAI International Alliance for Interoperability Haves
   - IBPSA (USA, Canada, BS 2003) Norford/Beausoleil-Morrison/Hensen/Spitler
   - TC 6.5 Radiant Space Heating Systems Strand
   - TC 6.3 Wray

7. Old Business

8. New business

9. Executive Session

10. Adjourn

TC 4.7 APPLICATIONS SUBCOMMITTEE
Kansas City Meeting Minutes
Tuesday, July 1, 2003, 3:30-5:00p
Chateau B, Mezzanine, - Hyatt Regency

Attending:

Jim Willson	jimwill@indy.net
Robert Sonderegger	Robert.sonderegger@itron.com
Jeff Haberl	jhaberl@esl.tamu.edu
Curt Pedersen	cpederse@uiuc.edu
Joe Huang	YJHuang@lbl.gov
Vern Smith	vsmith@archenergy.com
Jelena Srebric	jsrebric.@psu.edu
Atila Novoselac	aqn102@psu.edu
Dongyi Xiao	xdongyi@okstate.edu
Weixiu Kong	weixiu@okstate.edu
Rob Hitchcock	RJHitchcock@lbl.gov
W. Stuart Dols	wsdols@nist.gov
Brent Griffith	Brent_Griffith@nrel.gov
Klaus Sommer	Klaus.Sommer@fh-koehn.de
Francois Dubrous	fdubrous@ncran.gc.ca
Dru Crawley	Drury.Crawley@ee.doe.gov
Xianbing Lin	xiaobin@okstate.edu
Moncef Krarti	krarti@colorado.edu

Chair Jim Willson called the meeting to order at 3:35 pm. Jim reviewed the agenda and asked if anyone had any additions.

Review Chicago Minutes
Since most were not completed or reported on (due to person's absence), they are re-capped at the end of the these minutes.

Motion to accept the minutes passed by voice vote (Haberl / Pedersen).

Review of Programs Pipeline:
Jeff Haberl reported that this subcommittee has 4 items for the Anaheim meeting.

Program Event	Title	Chair
Symposium	Applications and Tools for Enhanced Building Energy Simulation	Smith
Symposium	Knowledge-based Tools for Building Design Simulation	Reddy
Symposium	Validation of Building Simulation Programs Thru ASHRAE Std 140	Neymark
Seminar	Application of HVAC-01 Primary and Secondary Tool Kit	Lebrun

Reddy's symposium may be merged with Smith's to have enough papers for one symposium.

Neymark's symposium will be rescheduled for Nashville.

The seminar proposed by Jean Lebrun may move to Nashville because Jean is not here to report.

This subcommittee has one seminar, "Successful Applications of Energy Simulation in Building Design", scheduled for Wednesday at the 10:15 to 12:15 time slot. Vern Smith is the chair; Jan Hensen, Jim Douglas, and Curt Hepting are the presenters.
Action Item: Vern Smith Copies of the presentations will be posted to the TC 4.7 web site.

Action Item: Joe Huang Joe agreed to try to organize a seminar on E+: "Applications and experience using E+"

Review of Research Pipeline:

Jim reviewed the list on draft research plan. Further action was postponed until after the scheduled discussion on using energy simulations in the design process.

DISCUSSION: Getting the Design Team to Use Energy Simulation from the Start of the Design Process
Jim gave an overview of the background materials referenced in the agenda that he emailed to everyone prior to the meeting. The following items were referenced:

SUGGESTED BACKGROUND MATERIAL:

- BLDG-SIM E-mail exchanges (Agenda attachment)
- **Ibpsa NEWS, Spring 2003, pp. 21-26** (available at www.ibpsa.org)
- From a Designers Perspective.doc (Agenda attachment) Varkie Thomas' letter.

Jim reviewed the goals of the discussion (listed below).

SECTION 1: Given that there will never be a simulation tool that is perfect for everybody, **What Can We Do To Expand Use of the Current Tools in the Early Stages of the Building Design Process ?**

- Success stories
- What one can do with use of a simulation that can't be done without (LEED project certification, ASHRAE 90.1 compliance on certain types of buildings or systems, etc)
- How to get started
- How to use it effectively
- How to use it with confidence

[The goal of this discussion is to arrive at two specific items for each of the following – including

target dates and names of coordinator's.]

A. Seminar Presentations at ASHRAE @ Anaheim or Nashville
B. ASHRAE Journal Articles
C. Program with Speakers for ASHRAE Chapter Meetings
D. Symposium for ASHRAE @ Nashville or Orlando

SECTION 2: What Needs to be Done or Developed to Make it Easier for the Building Design Team to Use Simulations Earlier in the Process and Can We Achieve Any of this through ASHRAE?

SECTION 3: What Research Needs to Done to Upgrade the Usability or and/or Applicability of Building Energy Simulations to the Early Stages of the Design Process ?

The following is a summary of comments, observations, and questions raised during the discussion period.

Rob Hitchcock commented that there are tools available for preliminary energy impact analysis, but use by designers is driven by fees. If decision makers within owners or A/E firms

Jeff Haberl says that academic institutions are turning out architects that don't know how and don't have any interest in energy conservation. He gave an example of state building that had been analyzed by Eley associates that had many ECMs, but the architect basically gutted the suggested energy conservation plan.

Curt Pedersen mentioned a discussion with Varkie regarding the trend that simulation use by architects will be driven by code requirements and there are many codes now starting to drive it.

Standard 90.1, Appendix B budget baseline, and LEED (which has incentives that promote use of energy simulations) were two items mentioned as driving forces.

Dru Crawley: energy simulation is not required for a LEED rating – only if you need the energy-based points.

Rob: Players coming to the table are the ones who have to drive decisions.

Jeff: Natural gas pricing this winter may give more impetus for using simulations.

Robert Sonderegger: O&M is thought to be the path by many owners.

Rob: In many companies, different departments control O&M and capital construction budgets.

Rob: California – Are energy simulations more prevalent in California design projects due to Title 24?

Joe Huang: Short project timelines are a problem – how do you make simulation more time efficient for users of tools?

Rob: Interoperability in design tools may move the industry toward more use of tools.

Curt: Varkie pointed out that the time required for developing the input geometry and schedules for complex buildings are barriers to using energy simulation tools.

Klaus Sommers: In Europe energy simulations are part of the standard practice for building design due to standards and codes. Perhaps we could adapt or borrow some features from European practice.

Rob: If the aerospace industry started making buildings, the building industry would be in trouble.

Jim: The challenges to greater use of energy simulation are (1) perceived effort and (2) the view that the information is not needed.

Jeff: Vendors should get tools into student's hands for free. They will expect to have these tools available at their work places.

Curt: He gave out free Energy Plus CDs with a small excel interface to some students. Six out of 46 used it and only one gave any feedback.

Jeff: Top designers have it in their heads and they know how to create an energy-efficient design using their experience and rules-of-thumb.

Someone mentioned energy content and sustainability – the construction industry uses very energy intensive materials, and promoting reduced energy content as a sustainability concept has led to political problems with manufacturers.

Jim directed the discussion to seminar and symposium topics.

Jim: TC 4.7 had a seminar in Chicago on getting started in simulation that attracted high interest. Should we be trying to repeat this?

Rob: What was the follow up to the seminar?

Jeff: We could have another session on "getting started."

Jim: ASHRAE technology awards – may be some of those projects used simulations and we could use these as a basis for another seminar.
Jeff: knows

Dru: TC 2.8 wants to monitor LEED buildings. Perhaps we could sponsor a joint seminar.

Klaus: There may be some famous architects that use simulations who would be willing to speak at a seminar.

Joe: "Energy Simulations without Fears" – cases where people used simulations and had good success. Nashville.

Klaus: seminar titled "Energy Simulation Success Stories"

Jeff: Disneyworld does lots of simulation work. How about inviting someone from Disney to discuss their process. Charlie Culp invited someone from Disney to speak at a conference. Dru has some contacts.

Jeff: Terrorism may be another angle that we should look at.

Jeff: In support of sustainability – there are aspects of energy simulations that are being overlooked. Heat rejection from building condensers – can get at it by clever investigation of simulation results. Dry vs. wet cooling tower – impact on water use is often overlooked. Energy simulations do not currently provide parasitic water use estimates from the energy use.

Jim: Water savings estimates can be used as part of justification for a retrofit project. Trace 600 and 700 calculate it directly.

Jeff: NASA – what it takes to prepare usable air on the shuttle.

Research idea: A toolkit for sustainability simulations. Water use, sewer, tower,

Simulation to effect on environment.

Adjourned at 5 pm

CHICAGO MEETING ACTION ITEMS – RECAP

Action Item: Yuill will call Les Norford and find out details regarding the proposed IBPSA speaker materials and feasibility of coordinating his short course development with the IBPSA efforts. He will report back on his findings and progress.

Action Item: **Willson** agreed to work with HB SC chair on what should be done and then make assignments. Haberl suggested that this be done soon so that we don't miss the review cycle.

Action Item: Smith and Walton volunteered to look at the HB chapter sections with direction from Willson.

Action Item: Willson agreed to chair the symposium titled "Validation of Building Simulation Programs" that Joel Neymark had been organizing.

Action Item: Willson will contact Alan Daley to ask if he would consider preparing an article based on his seminar this morning.

Action Item: Judkoff noted that it is time to publish a Journal article on Standard 140 since it will be used and cited by codes. **Willson** will send an e-mail to Judkoff to remind him to write the article.

Action Item: Smith to continue working on the draft WS for "Procedures and Data for High Performance Residential Design." Mike Witte prepared the first draft.

Action Item: **Willson** will coordinate with Agami Reddy about research ideas and relationship with Inverse Methods committee.

TC 4.7 SUBCOMMITTEE: DATA-DRIVEN MODELING
Monday, 30th June 2003,7:30 to 9:00 p.m.
Pershing E, BR Floor, Westin, Kansas City
Chair: Agami Reddy

AGENDA

1. Introductions

2. Approval of the minutes from the Chicago meeting, January 2003

1. Discussion and prioritizing "Research Wish List"- Long Range Research Plan

4. Discussion of WS and RTARs

- WS- Development of a procedure for baselining energy use at large central plants - Reddy

- RTAR- Methodology to identify which specific load curtailment measures…..- Sonderegger

- RTAR- Characterizing building cooling thermal loads from short-term monitoring- Abushakara

- RTAR- Others…

5. Discussion on:
   - better ways to digest past research
   - how best to disseminate research results
   - how best to coordinate research and results with allied TC and SC
   - maintain expertise within SC even when membership changes

6. Program

7. Old Business

8. New Business

9. Adjourn

MINUTES

Reddy started the meeting at 7:40 p.m. The agenda was passed out and introductions were made. Attendance list is attached as Appendix 1.

Reddy then asked the committee to review the scope of the subcommittee.

Scope of the SC: *To develop physically plausible modeling methodologies and models using monitored data. These models should be applicable to base-casting energy use, secondary and primary equipment, systems and whole building energy use, and should be easy to use and suitable for automation.*

Sonderegger suggested expanded the scope to add the words "synthetic data". Significant discussion followed this comment. It was finally decided to raise this issue at the full TC and interpret the scope of the SC to include this type of data also.

Reddy then asked the subcommittee to review the Chicago minutes. He said that the name change was discussed at the last subcommittee. He mentioned that Crawley had asked for the subcommittee to prepare a wish list, which is attached as Attachment 2. page. The objective of the wish list was to create ideas for RTARs.

MOTION: to approved the minutes (Haberl), second (Krarti). Approved.

Reddy then continued the discussion of the wish list. The subcommittee decided to moved item #3 down to the bottom of the list.

Smith mentioned that there was a similar WS from the TC 4.7 Subcommittee and that the DR subcommittee needed to communicate with the Simulation and Components subcommittee.

Item #5 was suggested by Claridge. Item #6 was also suggested by Claridge in support of work for Guideline 14.

Items #7, 8 and 9 were suggested by Haberl who was asked to provide some explanation of #7 and #8. He said that he was not convinced that the current IMT was suitable for modeling demand savings.

Sonderegger said that they had just completed an extensive analysis of the load factor as a proxy for demand savings. Reddy said that there was an area of statistics called "peak fitting" which could be used for such purposes. Claridge added that he had had experience that showed that selection of the models was not obvious and that there was clearly room for expanding the current state of affairs. Reddy asked whether or not this would be for 15-minute, hourly or daily. Haberl said that the procedure would need to be useful for ASHRAE engineers to apply to the most typical data.

Sonderegger said that there may be a useful correlation between monthly load factor and demand and that this should be looked into. Clearly this was a data analysis job. Kissock added that demand was becoming more important that this topic was certainly important. Reddy asked whether or not it would be possible for forecasting demand by analyzing the demand for a building, and perhaps correlating to some particular device. Sonderegger said that there were some obvious correlations, but that there were always certain events that were unpredictable. One fertile application was for large building operators to know if they were going to

exceed their energy budget for the month, and whether or not they needed to take extraordinary measures to change their use.

Reddy said that one of the facility managers he knows watched the demand every 15-minutes and shuts things down if the demand is going to beat their level. Sonderegger said that there is certainly a need for making demand baselining more accessible. However, he cautioned the subcommittee to overuse the word "baselining". Sonderegger suggested that the subcommittee might want to bundle these together into one RTAR.

ACTION: Haberl and Sonderegger will combine #7 and #8 into an RTAR. Dropping the water and adding dynamic forecasting.

Reddy suggested combining #7 and # 9 into a new one to be called "renewables and sustainability".

Reddy then asked the subcommittee to read the WS on baselining the energy use of large central plants (attached as Appendix 3). The subcommittee had quite a bit of discussion on this, including how to model individual components, how to link all these strategies together, how to use or modify existing ASHRAE toolkits.

ACTION: Reddy will work with Haberl to modify this WS for discussion in Anaheim. Krarti will help Reddy and Haberl on this WS.

Discussion then moved on to Sonderegger's RTAR, entitled "Owner-centered Building Energy Datamart" (appendix 4). Where a "datamart" is a database that has information about specific topical areas of data that are prepared for rapid retrieval. This sort of thing was done before simulation programs were everywhere and consisted of simple models. The new application would utilize calibrated simulation models that are preconfigured to answer specific questions, without having to configure and run another simulation model. This datamart would have a database that is combined with intelligent queries. A well designed datamart would have query actions for a broad range of questions.

Huang said that once the model is built, it is then easier to build a simple spreadsheet or easy interface that runs the model. Sonderegger said that his datamart would be able to answer question such as "how can I participate in a demand load program? What do I shed?" Reddy asked if this systems would be a combined calibration and expert system. Sonderegger said that this would be one possible way of configuring this. Maor said that this would need some sort of sensitivity analysis that is built on this the calibration analysis. He said that this would need to be simple, that the building operators are not always willing to use simulation.

ACTION: Sonderegger will work with others to revise this for discussion in Anaheim.

Reddy asked Sonderegger to report on this at the main TC 4.7 meeting.

Sonderegger said that TC 4.6 has a similar WS entitled "Virtual building emulator for simulations."

Discussion then moved to the RTAR by Abushakra, entitled "Characterizing building cooling thermal loads over a year from short-term monitoring" (appendix 5).

Abushakra explained the WS. He added that the IMT needed 12 months of data to work best. However, what is needed is to be able to characterize heating and cooling loads from short-term data. Can short-term

monitoring be used to characterize long-term performance? What needs be done to do this? What seasons should the building be visited during? How does this vary from one system to the next? From one part of the country to the next? What time scale needs to be used.

Sonderegger said that the justification for long-term monitoring from short-term measurements speaks for itself. Often is the case where the performance contract starts in one month and the baseline needs to be developed in a few months. Therefore, there needs to be a way to leverage this into an annual model.

Smith said from a practical point of view that three weeks was the minimum for characterizing the use of a facility. Haberl suggested that the RTAR reference the previous work in SMTP and Subbarao's work on short-term measurements for commercial buildings.

Kissock suggested that there were lots of datasets that now say that we expect VAV systems to bend here or there. One might blend that rules-of-thumb with first principles.

It was also suggested that such tests consider co-heating tests, etc.

Reddy suggested that the RTAR limit itself to a specific class of building.

ACTION: Abushakra will edit this for discussion in Anaheim.

There was then quite a bit of discussion about RTARs from the subcommittee. Reddy mentioned that because of time delays, discussion on the RTARs by Claridge be deferred to the next ASHRAE meeting Smith said that RAC really wanted good justification for RTARs.

TC 4.7 has 3 RTARs that are in need of WSs. One by Mike Witte, the baselining RTAR, and one is for technical enhancements to the toolkits. All these need WS to go forward.

It was decided that the SC not propose ant RTARs to the full TC at this stage but polish three of the draft RTARs along with the WS for the Anaheim meeting.

Meeting adjourned at 9:30 pm

Appendix 1: ATTENDEES

	6/03	**1/03**	**NAME**	***EMAIL***
	X	X	Bass Abushakara	Abushakr@msoe.edu
	X		David Charette	Charette.david@lte.ireq.ca
	X		David Claridge	dclaridge@tamu.edu
	X	X	David Eldridge	dancingDAvidE@hotmail.com
	X	X	Jeff Haberl	jhaberl@esl.tamu.edu
	X		Joe Huang	yjhuang@lbl.gov
	X		Kelly Kissock	kkissock@udayton.edu
	X		Bill Koran	William.koran@honeywell.com
	X		Moncef Krarti	krarti@colorado.edu
	X		Itzhak Maor	imaor@pwius.com
	X		Jocelyn Millette	Millette.jocelyn@lte.ireq.la
		X	Jean Lebrun	j.lebrun@ulg.ac.be
		X	Geoff Levermore	Geoff.levermore@umist.ac.uk
	X	X	Les Norford	lnorford@mit.edu
	X	X	Vernon Smith	vsmith@archenergy.com
	X	X	Robert Sonderegger	Robert.sonderegger@itron.com
		X	Jon Wright	j.a.wright@lboro.ac.uk

June27, 2003

Appendix 2:
TC 4.7: Data-Driven Modeling Subcommittee
Research "Wish List"

Purpose of Wish List
This document is a work in progress. Its purpose is to allow the Data-Driven Modeling subcommittee to establish a "wish list" of research priorities for the future. The intention is for the subcommittee to focus the development of new RTARs/work statements on the priorities developed from this exercise.

Instruction to members
Members are requested to provide their suggestions on suitable topics for research to Agami Reddy (reddyta@drexel.edu) by email in plain text format. These will be added to the table below on a continuous basis. Thank you.

	Topic	Proposed by	Date	Status/ Priority	Assigned to
1	Procedure for baselining energy use at large cen plants	Haberl/Krarti	2002	RTAR	Reddy
2	Methodology to identify which specific load curtailment measures to implement in a building response to a pre-specified demand reduction an	Sonderegger	1/03		Sonderegger
3	Procedure to develop performance models of HVAC&R equipment from published manufactu data	Reddy	1/03		
4	Characterizing building cooling thermal loads o year from short-term monitoring	Reddy	1/03		Abushakara
5	Procedures for adjusting baseline models for M& projects due to creep and other causes	Claridge	1/03		Claridge
6	Procedures to rehabilitate missing building ener data	Claridge	1/03		Claridge
7	Development of procedures for baselining water a facility	Haberl	5/03		
8	Development of procedures for baselining electr demand savings	Haberl	5/03		
9	Development of in-situ procedures for baselinin energy savings from renewable projects	Haberl	5/03		

Appendix 3:
STATEMENT OF WORK

TITLE:

DEVELOPMENT OF A PROCEDURE FOR BASELINING ENERGY USE AT LARGE CENTRAL PLANTS

TC/TC:

TC 4.7 Energy Calculations

Research Category:

O&M Tools

Estimated Cost:

Basic and Applied

BACKGROUND/STATE-OF-THEART:

The commercial sector accounts for approximately 15% of the total US energy consumption. Half of the commercial sector energy use is attributed to multi-building facilities. Several of these multi-building facilities are served by large central plants that produce energy forms directly used in the buildings (such as steam, hot water, chilled water, and electricity) from primary fuel sources (including natural gas, fuel oil, and potable water). Thus large central plants as designated in this solicitation include prime movers (diesel generator sets, gas turbines,…), cooling equipment (absorption and vapor compression chillers), boilers and the associated transportation and control systems. The U.S. Department of Energy, which calls such plants as "Building Cooling, Heating and Power Generation (BCHP) facilities" has identified this area as an important area of research, and is supporting R&D on new equipment, enhancing the efficiency of existing equipment, and control integration of the diverse equipment used. However, the USDOE is not interested in developing baselining methodologies which is the primary focus of this solicitation.

The potential to reduce energy use in multi-building facilities is significant. Colleges and universities are examples of multi-building facilities with a central plant. It is estimated that 83% of college and university floor-space is located in a multi-facility served by a central plant. For instance, energy conservation programs sponsored by some state universities have been able to achieve 30% reduction in energy consumption. If this reduction is extrapolated to all the US college and university facilities, it would provide about $1.3 billion in reduced energy bills or about 10% of total budget of US Department of Education allocated to post-secondary education.

One important element that ensures the effectiveness and the success of energy conservation programs is a procedure to assess and quantify the energy and/or cost savings attributed to implemented retrofit measures. Recently, several procedures and guidelines for measuring and verifying energy savings for individual buildings have been developed. Among the methods proposed for the measurement of energy savings are those proposed by ASHRAE Guideline 14P, the National Association of Energy Service Companies (NAESCO), the Federal Energy management Program (FEMP), the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE), the Texas LoanSTAR program, and the North American Energy Measurement and Verification Protocol (NEMVP) sponsored by DOE and later updated and renamed the International Performance Measurement and Verification Protocol (IPMVP).

However, none of the existing base-lining procedures are applicable to large central plants serving multiple buildings. One of the main features of large central plants is that they include the relatively complex energy interaction between the several equipment types used in central plants such as boilers, chillers, turbines, pumps, and heat exchangers. In a typical central plant, primary fuel sources (such as natural gas, fuel oil, potable water, and purchased electricity) are used by a utility plant to produce various energy forms (such as steam, hot water, chilled water, and generated electricity) supplied to the buildings. The conversion of the primary fuels to energy forms is accomplished through numerous energy conversion processes performed within the utility plant. Any base-lining procedure for central plants should be capable of accounting for the various thermal interactions between the multiple

equipment types commonly used in the plant.

JUSTIFICATION AND NEED/ADVANCEMENT TO STATE-OF-THE-ART:

In order to improve the savings evaluation for large central plants, a simplified base-lining procedure is needed to measure the energy savings from retrofits of multi-building facilities. This procedure should have the ability to identify various system effects such as those due to equipment replacement, changes in operational strategies, weather variation, addition or subtraction of building stock, or equipment degradation. The base-lining procedure would facilitate the comparison of energy savings retrofits between multi-building facilities.

It is expected that the development of an accepted procedure for base-lining energy use at large central plants will complement and widen the applicability of the existing guidelines and standards for measuring savings from energy retrofits in commercial buildings including multi-building facilities (such as ASHRAE Guideline 14 and IPMVP). The procedures outlined in this work statement could result in an ASHRAE publication that can be widely distributed to ASHRAE members. ASHRAE has already developed and is distributing software toolkits that contain computer-modeling routines of primary (HVAC01) and secondary (HVAC02) systems. Therefore, the final result of this work is intended to be a methodology, complete with algorithms, presentation formats, and quantitative references, of how to reconcile the results of simulation programs developed with such toolkits with actual data.

The project will benefit the following:

1. ASHRAE to buttress the credibility of the use of baseline procedures based on ASHRAE methods by the energy engineering community.
2. Software code developers and users to develop standard baseline procedures fit measured data from actual buildings.
3. ASHRAE members as a guide for more effective baseline procedures for use in their day-to-day practice.
4. ASHRAE Guideline 14 to strengthen its use in large central plants.
5. Performance contractors and energy service companies with a consensus calibration method for baselining large central plants.

OBJECTIVES AND SCOPE:

The main objectives of this research project are:

(a) to develop a step-by-step procedure or methodology that will allow building energy professionals to baseline energy use at large central plants that serve multiple buildings. The procedure would account for different plant component efficiencies, operational strategies, variable weather conditions, and addition or elimination of building stock and/or plant equipment. The procedure should also explicitly recognize the uncertainty associated with the baselining procedure;

(b) to demonstrate this methodology by applying it to two central plants where monitored data are available. The data should span several months or preferably a complete year. The developed procedure should demonstrate the accuracy needed to measure savings from retrofits to equipment in the central plant for a multi-building facility;

(c) to document the whole procedure so that it could be used by practitioners.

Given the wide variety of energy systems and equipment that can be used in large central plants, the proposed research should also identify a few of the important and widely used generic or prototypical system configurations. System configurations such as thermal energy storage should also be included. Further, the proposed research will also include the option of selling electricity generated onsite back to the local electric utility. Finally, the research should also identify and provide suggestions as to the type and length of short-term and long-term data that need to be collected in order to identify a suitable baseline model.

TASKS

Task 1) Prepare an annotated bibliography review listing various pertinent publications in this area.

Task 2) Identify generic or prototypical cooling plant systems where certain retrofits have been performed, and where both pre-retrofit and post-retrofit data are available.

Task 3) Identify two case study sites where hourly monitored data is available and which are consistent with the generic designs identified in Task (2).

Task 4) Develop a baselining methodology of widespread applicability. Modify this methodology as appropriate, and specify the types of special system considerations in the two case study sites selected which led to the proposed modifications.

Task 5) Illustrate proposed baselining methodology on the two case study sites.

Task 6) Prepare user manual.

DELIVERABLES

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

a. Progress and Financial Reports

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

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

b. Final Report

A written report, design guide, or manual, (collectively, "Final Report"), in a form approved by the Society, that summarizes the bibliographic search, baselining methodology, monitored data protocols, and user manual shall be prepared by the Institution and submitted to the Society's Manager of Research and Technical Services by the end of the Agreement term, containing complete details of all research carried out under this Agreement. Unless otherwise specified, six copies of the final report shall be furnished for review by the Society's Project Monitoring Subcommittee (PMS).

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

- An executive summary in a form suitable for wide distribution to the industry and to the public.
- Two bound copies
- One unbound copy, printed on one side only, suitable for reproduction.
- Electronic copy of the source code developed, any data collected during the study and documentation explaining the use of the code and the format of the data.
- Two copies on disks; one in PDF format and one in Microsoft Word.

c. Technical Paper

One or more papers shall be submitted first to the ASHRAE Manager of Research and Technical Services (MORTS) and then to the "ASHRAE Manuscript Central" website-based manuscript review system in a form and containing such information as designated by the Society suitable for presentation at a Society meeting. The Technical Paper(s) shall conform to the

instructions posted in "Manuscript Central" for a technical paper. The technical paper title shall contain the research project number (xxxx-RP) at the end of the title in parentheses, e.g., (9999-RP).

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

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

LEVEL OF EFFORT

It is estimated that the project will require approximately 18 months to complete at a cost of about $120,000. This estimate includes two (2) person-months of labor by the Principal Investigator and eighteen (18) person-months of labor by a graduate student or junior staff person.

OTHER INFORMATION FOR BIDDERS

1. Bidders are expected to demonstrate a familiarity with published work related to this study and to provide evidence of previous research they have performed that is relevant to this study.

2. Bidders are expected to outline the main characteristics of the baselining methods they envision implementing and evaluating. In addition, the bidders must justify why the selected baselining methods was chosen.

3. Bidders should provide a preliminary list of cooling plants which could be potentially used as case study sites.

4. Bidders must include a project plan, project timetable, budget details, and proposed documentation in support of the project methodology.

5. If relevant, bidders are expected to explain the implementation platform and language that they envision using (e.g., FORTRAN, C++, etc.) and how the software will be documented.

EVALUATION CRITERIA

The following weighting will be used in the selection of the Contractor:

1. Contractor's understanding of the Work Statement, as revealed in the proposal: 15%
2. Quality of methodology proposed for conducting research: 20%
   The methodology should include a description of a feasible methodologies, along with a few which the bidder envisions evaluating. The degree to which the proposed methods represent the breadth of the baselining methods that appear in the literature will be an important factor in this criterion.
3. Contractor's capability in terms of facilities and ability to get monitored data: 15%
4. Qualifications of personnel for this project: 20%
   Of special importance is the experience and qualifications of the personnel identified in the proposal related to baseline model development, and equipment involved in the operation of large central plants.
5. Student involvement: 5%

6. Probability of contractor's research plan meeting the objectives of the Work Statement: 20%
7. Performance of contractor on prior ASHRAE projects or other energy projects (No penalty for new contractors): 5%

CONTRIBUTORS:

Jeff Haberl
Moncef Krarti
Agami Reddy

REFERENCES

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Appendix 4
Research Topic Acceptance Request (RTAR)

TC/TG: TC 4.7 (ENERGY CALCULATIONS)

Title: **Owner-centered Buildng Energy DataMart**

Research Category:

TC/TG Priority:

Estimated Cost $100,000

Other Interested TC/TGs:

Possible Co-funding Organizations:

Handbook Chapters to be Affected by Results of this Project: Residential Cooling and Heating Load Calculations, Non-residential Cooling and Heating Load Calculation Procedures, Residential Cooling and Heating Load Calculations.

State-of-the-Art/Background

Considerable effort has been put into developing software, manuals, and other tools, to enable the designer and engineer to calculate energy use in buildings. The emphasis has traditionally been on providing maximum flexibility to enable the user of such tools to calculate energy use for the widest possible range of building types, and for the broadest selection of weather and operating conditions. This type of generality requires a high degree of technical sophistication by the user and places many products of ASHRAE's past research outside the reach of a building operator. Yet it is the building operator who has arguably the greatest influence on continued energy efficiency of an existing building.

Building owners and operators are often very knowledgeable in the detail of their facility and their local weather and operation, but have little use for the generality offered by traditional simulation tools, nor have the time required to acquire, and maintain, proficiency in using them. Yet the same building owners and operators are in great need for the *answers* provided by those same simulation tools, and they need to be quick answers to quick, topical questions. Traditionally, we have offered mainly complex answers to questions both simple and complex, and then only after a long, and soon forgotten, learning curve.

Justification/Advancement of the State of the Art

A building owner frequently needs to know the energy impact of specific measures in his facility only, such as, for example:

- *What energy and demand savings would result from turning off my chiller for 3 hours, tomorrow afternoon?* Note that the question is about a specific situation only, e.g. a 100-ton centrifugal chiller in Milwaukee; it is not for all types of chillers anywhere in North America over an entire year.
- *Should I participate in the load curtailment program offered by my local utility?* Strapped for summer-time capacity, my local utility has offered me and other commercial customer an opportunity to sign up for a program whereby we would commit to curtail our load, on demand, in return for $10/kW with between 1 and 24 hours notice. I am interested, but really don't know how many lights and how much equipment I have to turn off to achieve a worthwhile demand reduction, and therefore am hesitant to sign up.
- *What are my best operational measures to reduce demand?* We are participants in our local utility's demand curtailment program. A call has just come in from the utility asking us to shed 250 kW within the next 3 hours. What should we do?

The common theme of these examples is the need for a building-centered system that can simulate energy use with a minimum of effort on the part of the operator. Existing energy simulation programs can the required answers, but only with considerable effort

and knowledge on the part of the building operator. Much configuration and calibration is required to make the simulation conform to the facility.

Objectives

To develop a complete DataMart that can be loaded and configured for a specific facility using and existging simulation tool. The IT industry refers to a *DataMart* as a comprehensive store of topical information optimized for quick access and summarization. This DataMart will provide a complete, owner-oriented, query system that can provide quick, accurate answers to recurring energy questions specific to the facility.

Two major modes will be supported by the DataMart: A configuration mode and a query mode. The configuration mode is required at the beginning, but is later only infrequently exercised, and serves to calibrate the underlying simulation program to the current facility's needs – facility geometry, location, system type, operating schedules, occupancy type and duration, etc. It also serves to pre-calculate a large number of parametric cases specific to the facility, but with different operating strategies and different weather assumptions. These precalculated results are stored in the DataMart..

The operator mode makes use of the information developed in the calibration mode. It is essentially a database query system that can quickly retrieve answers to commonly asked questions from the DataMart. Since many questions will be for conditions that do not correspond exactly to the cases modeled in the configuration mode, an *interpolation engine* will be required that can adapt the results from the configuration mode to the specific conditions relevant to the operator's question.

Appendix 5
RESEARCH TOPIC ACCEPTANCE REQUEST (RTAR)

TITLE

Characterizing Building Cooling Thermal Loads over a Year from Short-Term Monitoring

TC

4.7 Energy Calculations

Background/State-of-the-Art

In 1992, the commercial buildings in the United States consumed 5,490 trillion Btu of energy. In comparison, residential households consumed 10,010 trillion Btu in 1993, and manufacturing establishments consumed 21,700 trillion Btu in 1994 (CBECS 1995). Managing this substantial energy use in the commercial building sector became inevitable and urged a variety of decision-makers, government bodies, organizations, building owners and managers, and utility companies to address it properly. The energy use in the commercial building sector involves more complexities than do other building sectors. To help standardize the procedures used for energy savings determination, the Department of Energy (DOE) published the International Performance Measurement and Verification Protocol (IPMVP).

In the baselining of building energy use, energy analysts in general showed reluctance in using laborious and complicated methods. Previous work on modeling building energy performance included several analytical and empirical methods used for the purpose of baselining and/or assessing the impact of retrofit measures. On the other hand, while different studies utilized short-term monitored data sets for commissioning building HVAC systems, verifying energy savings, and evaluating DSM programs, very few authors have attempted to baseline building energy use based on short-term monitoring.

Most methods used for baselining of building energy performance when monitored data are available are inverse linear regression models. In some cases, detailed forward simulations using energy simulation programs like DOE-2 and BLAST are also used. Inverse methods that have been used for baselining included the degree-day methods, bin methods, equivalent thermal parameters (ETP) models, Fourier series methods, time series "Box Jenkins" models, multiple linear regression models, change-point models, principal component analysis (PCA), singular value decomposition (SVD), inverse binning approach, neural networks, and genetic algorithms. On the other hand, the forward methods included simplified calibrated models, and the heat balance and weighting factor methods that are the basis of detailed simulation programs like DOE-2 and BLAST.

It should be noted that all of these methods require long-term periods of monitored data. Inverse methods are basically developed with long-term periods of hourly or daily data (one whole year), and forward models are usually calibrated with long-term periods of hourly data, and in a less accurate approach, with monthly utility bills.

Short-term monitoring has been used by energy analysts, mainly, as a cost effective alternative to long-term monitoring to evaluate the impact of demand side management (DSM) programs (to identify individual DSM measures, and estimate retrofit savings), and to calibrate detailed energy simulations (DOE-2), while very few attempts have tackled the use of baselining based on short-term monitoring.

JUSTIFICATION AND NEED/ADVANCEMENT TO STATE-OF-THE-ART

Models used for characterizing the energy use in commercial buildings typically require long periods of monitored data which may not be available. Moreover, handbook coefficients and parameters are required for detailed simulations, which also need to be calibrated with actual data. On the other hand, most of the previous work using short-term data sets for predicting annual energy use did not provide a procedure for the selection of the best time of the year for conducting the monitoring, or how long this period of time should be. One possible approach to predicting long-term building loads from short-term data is to use a calibrated systems model. However, this requires specialized skills beyond most energy professionals. Further, HVAC systems have set points (such as the cold or hot deck reset temperatures) which are sometimes dependent on seasons; the building may also be operated differently during different seasons of the year. A short-term monitoring protocol will therefore fail to adequately capture

these variations unless the analyst acquires such information by other means, like from the EMCS system or from the building energy manager.

Moreover, the IPMVP, contains no method suitable for baselining building energy use and savings calculations when only short-term monitored data are available. A building energy baselining method which: (1) can be applied to the commercial building sector, (2) requires a very short period of monitoring of energy consumption and weather conditions, (3) is cost and time effective, (4) provides accurate long term prediction, (4) specifies the optimum length, frequency and timing of the monitoring period, (5) simplifies the modeling procedure, and (6) gives insight into the uncertainty resulting from using different time periods for the monitoring, becomes a cost effective method that the energy analysts can use with some certainty.

This research project should address the data availability problem that energy analysts face when modeling the energy performance of commercial buildings. Can the energy analyst afford to wait for one whole year to collect the required data to be able to use the already available inverse methods? Would he/she baseline the building using forward simulation programs such as DOE-2, which requires him/her to perform a calibration task with long-term monitored data (same problem again!) to improve the simulation, or would he/she calibrate the DOE-2 simulation, then, with utility bills only? One answer to the above questions is a method that enables the long-term characterization of building energy use based on short-term monitoring coupled with statistical data.

In general, previous studies that attempted to use short-term monitoring for long-term prediction lacked the appropriate investigation of four major factors needed to accomplish this objective: (1) optimum length of the monitoring period, (2) optimum time or season of the monitoring period, (3) the exclusive and necessary variables to monitor, and (4) the most appropriate modeling technique and its ease of use.

To overcome this problem, a novice approach was developed recently, taking into consideration the practicality sought by energy analysts when developing energy baseline models, in terms of time (cost) and effort (complexity) involved. The new method, called the Short-term Monitoring Long-term Prediction (SMLP) method. The SMLP method limited the in-situ measurements of energy use to a relatively short period and included a selection procedure for the best two-week data period based on the characteristics of weather data. Given that buildings have a discernable weekly cycle, the two-week monitoring period showed to cover a minimum number of such cycles. The method presented a short-term monitoring protocol that gives enough insight into the long-term prediction of building energy performance for many uses. The SMLP model, however, did not include a temperature change-point in the predicted energy use; such a change-point is a general feature exhibited by the VAV systems, and as a result the long-term predictions for VAV systems were less accurate than those for CAV systems. A modified approach following the SMLP model would include a change-point methodology to widen the capabilities of the method. Nevertheless, the SMLP approach in its procedural steps and organization is prototypical and could be followed and applied to different climate zones and building categories to reach a wider generalization of the results.

OBJECTIVE AND DELIVERABLES

The main objective of this research is to develop and evaluate a new method for baselining, predicting and evaluating the energy performance of commercial and institutional buildings when only short-term monitored data are available. The new method should provide an accurate baseline model from an optimally chosen short period of hourly energy data, based on sound statistical procedures, in order to obtain reliable long-term characterization within acceptable margins of uncertainty. The method is expected to be cost and time effective, provide accurate long term prediction, specify the optimum length, frequency and timing of the monitoring period, simplify the modeling procedure, and finally, give insight into the uncertainty resulting from using different time periods for the monitoring. The method should also include a procedure that enables analysts to evaluate the uncertainty of models based on any particular short-term data set, so that a trade off between accuracy of results, and cost and convenience of performing the monitoring stage becomes possible.

The new method could have a wide use among energy analysts, utility companies, ESCO's, researchers, academics, and students who will profit from its capabilities, and yet its simplicity. It will also enhance the applicability of existing guidelines and standards such as ASHRAE Guideline 14, and IPMVP.

Deliverables of this research project would include a final report that documents the new model, describes its use, and presents a verification through case studies.

Contributor
Bass Abushakra

TC 4.7 Simulation and Component Models
Kansas City Meeting Minutes
Agenda

Monday June 30, 6:00 pm-7:30 pm
Westin, Pershing E

Call to Order
The meeting was called to order at 6:05 pm with 32 members present as shown in attachment 1.

Program
The Anaheim seminar on moisture will be upgraded to a symposium for presentation in Nashville. A moisture forum was planned for Anaheim. Planned program is shown below:

- Anaheim / January 2004
  Forum
  "Thermal Modeling of Phase Change Materials in Building Envelopes: Old problems, New Developments"
  Organized by TC 4.7 (Sim and Comp Models)
  Chaired by Jan Kosny
- Nashville / June 2004
  Seminar
  "Modeling Moisture Sorption/Desorption by Building Materials"
  Organized by TC 4.7 (Sim and Comp Models)
  Chaired by Jan Kosny
- Nashville/June 2004
  Symposium
  "Recent Advances in Simulation"
  Organized by TC 4.7 (Sim and Comp Models)
  Chaired by Dan Fisher

Research in Progress
Brief reports on the following research projects were submitted:

- 1049 RP 'Design Synthesis' (Jon Wright, PI). Robert Sonderegger reporting

ACTION ITEM: PI requests a no-cost extension through Mar. 1, 2004.

- 1197 RP 'Updated Energy Calculation Models for Residential HVAC Equipment' (Mike Brandemuehl, PI), Chip Barnaby reporting.

ACTION ITEM: PI requests a no-cost extension through Mar. 1, 2004.

Workstatements
The following workstatements were discussed by the committee to prepare them for full committee consideration and inclusion in the research plan.

Technical and Usability Enhancements to the Energy Calculation Toolkits

- Dan Fisher, lead contributing author

ACTION ITEM: Fisher will correct and modify workstatement as recommended by the committee. Workstatement will be ready for full consideration in Anaheim.

Improving Load Calculations for Fenestration with Shading Devices **(5 minutes)**

- TC 4.1 took lead on RTAR. TC 4.7 and TC 4.5 supporting TCs
- Chip Barnaby, TC 4.7 liaison

ACTION ITEM: Subcommittee requests that chair write letter of support for this TC 4.1 work statement

RTARS In Progress
The following RTARs which are in various stages of development were discussed :

Energy Performance Simulation Model for Refrigerated Warehouses
- Jan Kosny, Joe Huang lead contributing authors. Jan Kosny reported that there was considerable interest in this workstatement from the relevant section 10 TCs. He advised that this workstatement is likely to develop quite slowly since there seems to be a variety of opinions on the scope of the workstatement.

Models for Natural and Hybrid Ventilation
- Joe Huang and George Walton lead contributing authors. Paul Linden and his associate Guilmerme put together a draft workstatement at Joe Huang's request. George suggested with Huang concurring that the workstatement was premature since validation data sets did not exist.

  ACTION ITEM: Walton and Huang will draft a workstatement to develop a validation data set for natural and hybrid ventilation system model development.

Create algorithms to allow mapping of manufacturer's or available data to simulation inputs
- Mike Brandemuhl volunteered to work with Bojic and Bruce Billedeaux on this RTAR.
- No progress to report.

Assess impact of explicit modelling of radiant heating (in-floor, wall panels, gas fireplaces, etc.) and radiant cooling and devise appropriate modelling strategies
- Jan Kosny and Rick Strand reported that TC 6.5, Radiant Space Heating and Cooling, is developing a similar workstatement. Rick Strand is participating in the development of the TC 6.5 workstatement and will serve as liaison to the Simulation subcommittee.

New Business:
- Jeff haberl noted that there are no toolkits for thermal duct models. The committee agreed that there was a need to pull together existing information and tasked Haberl to develop an RTAR.

- Jeff also expressed concern that Standard 90.1 was developing simulation path guidelines without consulting TC 4.7.

ACTION ITEM: The committee recommends that the chair write a letter to the standards committee expressing concern over the lack review of Standard 90.1 simulation guidelines.

- Vern Smith stated that the committee had received an unsolicited research proposal (URP).

ACTION ITEM: The committee requested that the chair appoint a PES consisting of Tim McDowell, Phil Haves, Rick Strand, Jan Kosny, Chip Barnaby and Moncef Krarti.

The meeting was adjourned at 7:32 pm

Attachment 1

KC	Chicago	Honolulu	Last Name	First Name	E-Mail
X	X	X	Barnaby	Chip	cbarnaby@wrightsoft.com
X	X		Bass	Abushakra	abushak@msoe.edu
	X	X	Beausoleil-Morrison	Ian	ibeausol@nrcan.gc.ca

KC	Chicago	Honolulu	Last Name	First Name	E-Mail
	X		Berinato	Reed	rrb144@psu.edu
	X		Bernier	Michel	michel.bernier@polymtl.ca
		X	Bojic	Milorad	bojic@knez.uis.ac.yu
	X		Bradley	David	bradley@tess-inc.com
	X	X	Brandemuehl	Mike	michael.brandemuehl@colorado.edu
	X		Cane	Doug	caneta@compuserve.com
X			Candsberl	Dennis	drcrm@aol.com
	X		Carrilho Graca	Guilherme	gcg@ucsd.edu
	X	X	Crawley	Dru	drury.crawley@ee.doe.gov
X			Chanvit	Chantrasrisalai	chanvit@okstate.edu
X			Charette	David	Charette.david@lte.ireq.ca
X			Cornish	Tracy	tcornish@taylor-engineering.com
		X	Curcija	Charlie	curcija@ceere.org
X			Deng	Zheng	zhengd@okstate.edu
	X		Deringer	Joseph	jderinger@deringergroup.com
X			Deru	Michael	Michael_deru@nrel.gov
	X		Eldridge	David	dancingdavide@hotmail.com
X	X	X	Fisher	Dan	d-fisher@uiuc.edu
	X		Gardner	Carol	gems@teleport.com
X	X		Griffith	Brent	griffith@mit.edu
X	X		Haberl	Jeff	jhaberl@tamu.edu
X		X	Haves	Philip	phaves@lbl.gov
	X	X	Hensen	Jan	j.hensen@tue.nl
X			Hern	Shawn	shhern@yahoo.com
	X		Hofu	Kiu	hwu@csupomona.edu
	X	X	Huang	Joe	YJHuang@lbl.gov
			Iu	Calvin	iip@okstate.edu
		X	Judkoff	R.	Ron_judkoff@nrel.gov
X			Kong	Weixiu	weixiu@okstate.edu
X	X		Kosny	Jan	kyo@ornl.gov
X			Koran	William	William.koran@honeywell.com
X			Krarti	Moncef	krarti@colorado.edu
X			Khalifa	Hezzat	ez@ecs.syr.edu
X			Kissock	Kelly	kkissock@udayton.edu
	X	X	Liesen	Richard	r-liesen@uiuc.edu
			Lawrence	Tom	lawrenct@ecn.purdue.edu
	X		Lebrun	Jean	j.lebrun@ulg.ac.be
	X		Levermore	Geoff	geoff.levermore@umist.ac.uk
X			Liu	Xiaobing	xiaobin@okstate.edu
	X		MacCracken	Mark	mmaccracken@calmac.com
			Mangini	Jim	jim.mangini@carrier.utc.com
X	X		McDowell	Tim	mcdowell@tess-inc.com
X			Millette	Jocelyn	Millette.jocelyn@lte.ireq.ca

KC	Chicago	Honolulu	Last Name	First Name	E-Mail
	X		Morrison	Andrew	caneta@compuserve.com
X	X	X	Neymark	Joel	neymarkj@sni.net
X		X	Norford	Les	lnorford@mit.edu
	X		Novoselac	Atila	aqn102@psu.edu
	X		Olsen	Erik	eolsen@owpp.com
		X	Parsons	Jim	parsons@me.msstate.edu
X			Padhmanabhan	Sankar	padhman@okstate.edu
X		X	Pedersen	Curt	cpederse@uiuc.edu
X	X	X	Reddy	T. Agami	Reddyta@drexel.edu
X	X	X	Rees	Simon	SJRees@okstate.edu
X			Shenoy	Arun	aruns@okstate.edu
X			Shirey	Don	shirey@fsec.ucf.edu
X	X	X	Smith	Vernon	vsmith@archenergy.com
	X		Smith	Sean	sean_smith@waterfurnace.com
X	X	X	Sonderegger	Robert	rsonder@siliconenergy.com
X			Sommer	Klaus	Klaus.sommer@fh-koeln.de
	X	X	Spitler	Jeffrey	spitler@okstate.edu
	X		Srebric	Jelena	jsrebric@psu.edu
X		X	Strand	Rick	r-strand@uiuc.edu
X			Tang	Kenneth	tangkenneth@hotmail.com
		X	Theios	Jason	jason-theios@guardian.com
	X		Thornton	David	thornton@tess-inc.com
X		X	Walton	George	gwalton@nist.gov
X	X	X	Wright	Jonathan	J.A.Wright@lboro.ac.uk
			Xiao	Dongyi	xdongji@okstate.edu
	X		Xu	Peng	pxu@lbl.gov
X			Yuill	Gren	yuill@unomaha.edu

Title
Technical and Usability Enhancement to the Energy Calculation toolkits

Background
Over the last ten years, ASHRAE TC 4.7 and 4.1 have directed the development of a trilogy of toolkits for energy and loads calculations. The *Toolkit for Secondary HVAC System Energy Calculations* [1] was completed first, followed by the *Toolkit for Primary Hvac System Energy Calculations* [2] and the *Toolkit for Building Load Calculations* [3]. Algorithms from the toolkits have been used in the development of public domain softare and most recently in the development of commercial load calculation programs using ASHRAE's new cooling load calculation procedures [4].

A recent research initiative by ASHRAE [5] focused on models and algorithms required to design state-of-the-art, low energy building systems. Although this work has resulted in toolkit compatible Fortran modules, they have never been integrated into a release version of the toolkits and are therefore unavailable to the ASHRAE membership in a usable format.

In addition, ASHRAE research project 1117-RP [6], experimentally validated the algorithms in the ASHRAE loads toolkit. As a result of this work, several defects in the toolkit algorithms were identified. These defects were corrected by the investigators and are available to ASHRAE in the RP1117 final report, but have not been incorporated into the loads toolkit.

The three toolkits were originally designed to work together as an integrated package. However, the rapid evolution of electronic documents and the advent of Fortran 90/95 while the trilogy was being developed resulted in three separate toolkits published in completely different formats using different versions of Fortran. The first toolkit was published in printed form only with Fortran 77 subroutines on an accompanying diskette. The second toolkit was published electronically as a single document with Fortran 77 subroutines. The third toolkit was published using a linked pdf format with a well-developed navigation scheme. The code for this toolkit was written in Fortran 90.

Prior to the development of the toolkits, TC 4.7 sponsored the development of several annotated bibliographies [7,8]. These provided background material and served as guiding documents for the development of the toolkits. Although portions of the bibliographies are cited or included in the toolkit documentation, the bibliographies would serve the ASHRAE membership best by directly linking the bibliographies to the toolkits.

Justification
In order to support the recently developed ASHRAE cooling load procedures and in order to make the results of recent ASHRAE research available to the ASHRAE membership, it is critical that the ASHRAE loads toolkits be technically enhanced, integrated and updated using the latest electronic publishing technology. Since the cooling load procedures are based explicitly on toolkit algorithms, it is essential that the integrity of the toolkits be maintained at the highest level. Toolkit defects and omissions corrected by ASHRAE research project RP-1117 must be implemented in the loads toolkit in order to ensure that reliable cooling load calculation procedures are developed for the ASHRAE membership.

In addition, the usability of the toolkits is significantly hindered by incompatibilities between the three toolkits. The first two fo the three toolkits are written in Fortran 77. Many features in Fortran 77 have already been obsolesced by Fortran 90/95. In conjunction with the required code upgrade, enhancing the toolkit documents to support electronic distribution will facilitate production, distribution and use of the toolkits. Including the annotated bibliographies developed under the direction of TC 4.7 would further enhance the integrated toolkit.

Objective
The three main objectives included in the proposed work are to correct and extend the toolkit algorithms, upgrade and enhance the toolkit documentation and integrate the three toolkits and the two annotated bibliographies on a single CD. Each major objective includes several specific goals as follows:

RESEARCH SUBCOMMITTEE
Kansas City
1 August 2003

TC 4.7 approved no new RTARs for consideration on the 2004-2005 Research Plan.

Title	TC Priority 2003-2004	Prior TC priority	Society status	TC Status	Comments	Subcom
Technical and Usability Enhancements to the Energy Calculation Toolkits	0	1 (2003-2004	RTAR 2004-19, accepted	WS draft in progress	Dan Fisher:	SCM
Development of a Procedure for Base-lining Energy Use at Large Central Plants	0	2 (2002-2003)	RTAR, prioritized	WS draft in progress	Moncef Krarti, Jeff Haberl: Need to find additional support	DDM
Procedures and Data for High-Performance Residential Design	0	1 (2002-2003)	RTAR, accepted	WS draft in progress	Mike Witte, Vern Smith	A
Procedures for Reconciling Computer-Calculated Results With Measured Energy Data (1051-TRP)	0	3 (1998-1999)	Contract award approved, June 2003		TC responded to Tech Council comments – reconsidered and approved at Kansas City meeting, June 2003	DDM
Improving Load Calculations for Fenestrations with Shading Devices	Co-sponsor		RTAR 2004-12, prioritized.	TC 4.1 RTAR. Draft WS approved by TC 4.1; co-sponsorship approved by TC 4.7 at June 2003 meeting	Chip Barnaby	

Additional TC 4.7 RTARs and WSs in Process – status as of 1 August 2003

Title	**TC Priority 2004-2005**	**Prior TC priority**	**Society status**	TC Status	**Lead/ Comments**	**Subcom & Priority**
Development of a Toolkit of HVAC Models (Algorithms) for Refrigerated Warehouses				No progress (Jan-03); Draft in progress (Jun-03)	Jan Kosny (Joe Huang, Kamel Haddad)	SCM
Models for Natural and Hybrid Ventilation				New RTAR draft (Jan-03)	Paul Linden, Guilmerme	SCM
Algorithms for Mapping Manufacturer's or Available Data to Simulation Inputs				New RTAR draft (Jan-03); no progress Jun-03.	Milorad Bojic, Bruce Billedeaux, Brandemuehl	SCM
Explicit Modeling Strategies for Radiant Heating and Cooling				New RTAR draft (Jan-03); no progress Jun-03	Milorad Bojic, Jan Hensen, Rick Strand	SCM
Exterior Boundary Conditions (shading by external objects and deep-sky temperature)				Concept proposed Jan-03; No progress Jun-03	**Tim McDowell; Jan Hensen, Jeff Spitler**	**SCM**
Moisture absorption/desorption by building materials and furnishings				Concept proposed Jan-03; Draft RTAR distributed for comment Jun-03	**Rich Liesen, Jan Kosny, Mike Brandemuehl (forum input).**	**SCM**
Owner-centered Building Energy DataMart				Concept proposed Jan-03; RTAR draft reviewed Jun-03	**Robert Sonderegger**	**DDM**
Characterizing Building Cooling Thermal Loads over a Year from Short-Term Monitoring				Concept proposed Jan-03; RTAR draft reviewed Jun-03	**Agami Reddy, Bass Abushakara**	**DDM 3 (Jun-03)**
Procedures for adjusting baseline models for M&V projects due to creep and other causes				Concept proposed Jan-03; discussed Jun-03	**Dave Claridge**	**DDM 4 (Jun-03)**
Procedures to rehabilitate missing energy use data				Concept proposed Jan-03; discussed Jun-03	**Dave Claridge**	**DDM 5 (Jun-03)**
Procedures for baselining energy savings for renewables and sustainability projects				Concept proposed Jun-03	**Jeff Haberl**	**DDM 6 (Jun-03)**
Procedures for baselining electricity demand savings				Concept proposed Jun-03	**Jeff Haberl**	**DDM 7 (Jun-03)**
Defining Performance Factors for Primary and Secondary Equipment Simulation Inputs for Commercial Buildings		2 (2000 – 2001)		No progress (Jan-03)	LeBrun, Nall, Bahnfleth,	A
Analysis and Testing of the Energy Cost Budget Method in ASHRAE 90.1				No progress (Jan-03)		**A**
Characterization of Building Secondary Thermal Loads from Chiller Electric Use Data				No progress (Jan-03)	**Robert Sonderegger, Agami Reddy**	**A**

SCM = Simulations and Component Models
DDM = Data Driven Modeling (formerly Inverse Methods)
A = Applications

Work Statements listed below were on Prior Society Research Plans, but will not go forward for reasons listed.

Title	TC Priority 2004-2005	Prior TC priority	Society status	TC Status	Notes	Lead Sub-com
Development of Comparative Test Cases for Evaluating Simulation Models of Slab, Crawl Space and Basement Heat Transfer Through Adjacent Ground	0	2 (2001-2002)	RTAR, accepted	Hold, IEA work underway		SCM
Inverse Bin Procedures for Analyzing Energy Savings	0	3 (2001-2002)	RTAR, accepted	Drop	dropped	A
Standard Operating Conditions in North American Residential Buildings (1163-TRP)			Cancelled by Tech Council after bids received and evaluated			A
Development of Detailed Descriptions of HVAC Systems (Templates) for Energy Simulation Programs (1198-WS)		3 (2000 – 2001)		Rejected 3/00 (?)	TC will not pursue further (Jan-02)	SCM

SCM = Simulations and Component Models
DDM = Data Driven Modeling (formerly Inverse Methods)
A = Applications

ASHRAE TC4.7 HANDBOOK SUBCOMMITTEE NOTES
Monday, June 30, 2003, 5:00-6:00PM
Kansas City Westin Pershing E (Ballroom Level)

The meeting was called to order at 5:07pm by Rick Strand (Chair) followed by introductions of all those present.

Validation Section Addition

Ron Judkoff gave a brief summary of the status of the validation section that he authored with Joel Neymark. The section is entitled "Model Validation and Testing" based on ANSI/ASHRAE Standard 140. While it has been proposed in the past that this section be added as an appendix to the current chapter 31, Ron requested that perhaps it would be more logical to add this as a section inside the chapter, perhaps at the end of the chapter to preserve the current continuity. Rick Strand noted that current there is a reference in the chapter on page 31.3. The committee is recommending the following sentence be added: "More information on model validation and testing can be found in the section of this chapter entitled 'Model Validation and Testing' and in ANSI/ASHRAE Standard 140." Strand noted that the new section has been available on the TC4.7 Handbook web site since March and that no further comments have been received. The section will remain on the web site for the convenience of committee members.

Brief Progress Report on Action Items from Chicago

Rick Strand gave a brief report on activity on action items that were determined at the Chicago meeting:

Electronic Handbook Additions. Here is the response that we received from ASHRAE regarding proprietary software additions: "It's okay to include, for example, a spreadsheet done in Excel, just like a Word document, or any other file prepared with the particular software (which most end users are likely to have anyway). If we have to provide software for reading the item, that gets a little more complicated, so we should try to provide items in forms that the end users will have the capability to read."

Examples of Electronic Additions. None received to date.

New Validation Section. Posted on TC4.7 web site, no further comments received

Request for assistance in reviewing current chapter met with very limited success. Volunteers from Honolulu meeting who did not provide information for Chicago meeting did not provide any information since the Chicago meeting.

Corrections. Discussed in more detail under "Developments Since Chicago".

Meeting notes for Chicago. Submitted to TC4.7 Secretary, Dan Fisher.

Developments Since Chicago

Due to a file copy error, Rick Strand brought only the enhancements provided by Agami Reddy and a few copies of some requested changed to the controls section by Phil Haves. There have been numerous change requests and additions that are being proposed (in addition to the validation section). These are attached to the end of these notes with a brief summary provided here.

Corrections. Questions have been asked about Equations 36, 42, and 49. The problem with Equation 36 seems to be straightforward and was addressed in the Chicago meeting. No additional feedback has been received so the committee is recommending that this equation be changed to bring it in line with the HVAC1 toolkit. There was some discussion of Equation 42. After an initial analysis, Rick Strand did not feel that there was a need for any change to the equation, but several of the committee members felt that there may in fact be a conversion factor from days to hours missing in the equation. This requires further study and the chair requests that those more familiar with the Bin Method take part in this discussion. A user noted a discrepancy between Equation 49 and data in Table 5 in the SI edition of the chapter. Rick Strand has tracked down the original reference and believes that there is a need to change equation 49 in both editions as well as data in Table 5 (see appendix to these notes for more details). Other minor editing changes are briefly summarized in the changes appendix to these notes.
Additions. The main additions that have been proposed include the Validation section as well as an enhanced section on boiler models (to bring its level of detail in line with the chiller model details) and an update to the inverse chiller model section. Several other minor edits have been requested in the controls section and to reflect recent energy program releases.

Other Items for Discussion

Chapter Review for Handbook Guidelines (needed feedback by June 15!). ASHRAE has requested a special review for all chapters to make sure that they are in agreement with ASHRAE's official purpose of the handbook. This information is contained in the ASHRAE Author and Reviser's Guide. No feedback was received before the meeting; however, Vern Smith and Klaus Sommer volunteered to perform this review of the chapter within the next few weeks. Rick Strand will provide both Vern and Klaus with the updated Reviser's Guide (or the web site where it can be downloaded) and will email Klaus an electronic copy of Chapter 31 (already done). Strand will submit feedback to Mark Owen and Bill Fleming.
Chapter Review for Updated References. Rick Strand noted that there are still some volunteers from the Honolulu meeting who have not completed the review of the chapter to determine if any of the references could be updated. Strand will make one more attempt to contact those who have not completed their assignment soon after the Kansas City meeting.
Future Direction of Chapter 31. While there are a lot of ideas on potential things to add to the chapter, there has been little movement to actual produce any special electronic additions. With the deadline for changes to Chapter 31 for the four-year cycle rapidly approaching, it seems that we need to concentrate on the current corrections and additions for now. Rick Strand reminded the committee that we must have all changes approved at the Anaheim meeting and submitted by February 1, 2004. Thus, we only have one meeting cycle left to make edits to Chapter 31.
Addition of a Loads Toolkit Reference. Dan Fisher volunteered to complete a review of the introductory material in the chapter to see how the recently completed loads toolkit could be added (as a reference or otherwise) to the chapter.

Summary of Action Items for Anaheim

- With the assistance of the TC4.7 webmaster Simon Rees, Rick Strand will make sure that all changes and additions are available on the TC4.7 handbook website for review by the committee.

- Committee members need to review all the additions and corrections that will be posted on the website and propose corrections or other enhancements
- Rick Strand will coordinate all changes and additions and have everything prepared for a final vote by the full TC in Anaheim
- Vern Smith and Klaus Sommer will perform a "Handbook Guidelines" review of Chapter 31 within the next several weeks.

The meeting was adjourned at approximately 5:55pm.

ATTENDANCE LIST

Name	Affiliation	Email Address
Rick Strand	UIUC School of Architecture	rkstrand@uiuc.edu
Simon Rees	Oklahoma State University	sjrees@okstate.edu
Ron Judkoff	NREL	Ron_Judkoff@nrel.gov
Joel Neymark	Neymark & Associates	neymarkj@msn.com
Vern Smith	Architectural Energy Corporation	vsmith@archenergy.com
Jim Willson	Honeywell	jimwill@indy.net
Agami Reddy	Drexel University	reddyta@drexel.edu
Bill Fleming	Handbook Liaison	flemg@aol.com
Klaus Sommer	University of Applied Science Cologne, Germany	Klaus.Sommer@fh-koeln.de
Roberto Zecchin	University of Padova	roberto.zecchin@unipd.it
Bass Abushakra	Milwaukee School of Engineering	abushakr@msoe.edu
Sankar Padmanabhan	Oklahoma State University	padhman@okstate.edu
Shawn Hern	Oklahoma State University	shhern@yahoo.com
Kenneth Tang	Oklahoma State University	tangkenneth@hotmail.com
Arun Shenoy	Oklahoma State University	aruns@okstate.edu
Chanvit Chantrasrisalai	Oklahoma State University	chanvit@okstate.edu
Moncef Krarti	University of Colorado	krarti@colorado.edu
Dan Fisher	Oklahoma State University	dfisher@okstate.edu
Ez Khalifa	Syracuse University	ez@ecs.syr.edu

TC4.7 Handbook Subcommittee

Summary Report on Errors in Chapter 31 (Energy Estimating and Modeling Methods)

June 26, 2003

Correction to Equation 36

Equation 36 is currently listed as follows:

$$W_{in} = W_{in,FL} + \left(1 - \frac{N_c}{N_{c,FL}}\right) W_{pump} \qquad (36)$$

HVAC1 Toolkit uses W_s in place of $W_{in,FL}$ in this equation.

Proposed Corrections:

- Change "$W_{in,FL}$" in Equation 36 to "W_s" to bring it in line with the HVAC1 toolkit
- Remove "$W_{in,FL}$ = full-load power" from descriptions following Equation 36 and replace it with "W_s = isentropic power"
- Handbook chair has forwarded this information to Mark Owen at ASHRAE who can then respond to the user.

Correction to Equation 42

Here is the problem as described by the user of the handbook:

> "I have been poring over some manual calculations of heating energy estimates for a few days now, and I suspect that the 2001 Fundamentals Handbook Chapter 31, Equation 42 has an error. I compared this equation to Equation 1 of 1985 Fundamentals, Chapter 28 and found that they are essentially very similar with the exception that the 1985 equation has a constant of "24 hrs./day" and a correction factor "Cd". Is it possible that the 2001 equation should include the 24 hrs./day conversion, if not the correction factor?"

In the both versions of Chapter 31, Equation 42 is shown as:

$$Q_{h,yr} = \frac{K_{tot}}{\eta_h} DD_h(t_{bal}) \qquad (42)$$

Action Needed:

- We need to determine whether or not a change is needed. A review of the pertinent literature (Erbs, Klein, and Beckman 1983) appears to suggest that the 24 is only needed if the term "N" that factors into DD_h was in degree-hours rather than degree-days. The potential changes to this equation need to be clarified.
- Handbook chair will forward the agreed upon resolution to Mark Owen at ASHRAE who can then respond to the user.

Typographical errors in a reference

Two names were misspelled in a 1995 reference for Chapter 31. Metcalf was misspelled as Metcalfe and Pedersen was misspelled as Pederson.

Action Needed:

- Handbook chair has forwarded this information to Mark Owen at ASHRAE though it is possible that this reference will be replaced by another anyway.

Reference to Table 10

There is a typographical error on page 31.20, 2nd column, last paragraph. The text refers to Table 10 when it should refer to Table 9. This was listed in the Additions and Corrections section of both the 2002 and 2003 Handbooks.

Action Needed:

- None—this has already been addressed by ASHRAE and will be made for the 2005 edition.

Equation 52

Equation 52 had a typographical error where thetas appear in the equation. These thetas should be phi in all cases. ASHRAE is already aware of this problem and will correct it (no action needed by TC4.7).

Action Needed:

- None—this has already been addressed by ASHRAE.

Equations 49, 51, and 52 and Table 5

There is a discrepancy between Equations 49, 51, and 52 and the values listed in Table 5 of Chapter 51. This was noted by a user. Basically, the values for σ_m, ϕ, and DD_h calculated by these equations do not match the values listed in Table 5 of the SI edition. The values listed in Table 5 of the IP edition do match the values once the correction to Equation 52 listed above and a minor correction to Equation 49 are taken into account.

Here is the current version of Equation 49 from the Handbook (same in both SI and IP):

$$\sigma_m = 3.54 - 0.02907\bar{t}_o + 0.0644\sigma_{yr} \qquad (49)$$

In both the SI and IP editions, there is a typographical error in the third coefficient in this equation. The value should be 0.0664 rather than 0.0644. This is based on the source article: Erbs et al. (1983). In addition, since this is an equation for temperature difference, it is impossible for the first coefficient to be the same in both editions. The value of 3.54 appears to be correct for IP units. However, the

source article (which was written in SI units), lists this first coefficient as 1.45. Making these corrections in the SI edition results in values for σ_m that are very close to those listed in Table 5. It is unclear where the values for ϕ came from—they should be identical to those in the IP edition. Using equation 51 to calculate ϕ results in values very close to the IP edition values listed in Table 5. Making these corrections to σ_m and ϕ for the SI edition results in different values for DD_h.

Here is a quick summary of Table 5 as it currently stands:

Month	t_0 average	N (day/mo.)	σ_m	ϕ	DD_h
Jan	0.1	31	2.03	1.32	463
Feb	0.8	28	2.01	1.34	399
Mar	5.1	31	1.89	0.95	312
Apr	11.2	30	1.71	0.41	133
May	16.8	31	1.55	-0.21	31
Jun	22	30	1.40	-0.92	3
Jul	24.8	31	1.32	-1.33	1
Aug	23.8	31	1.34	-1.18	1
Sep	20.2	30	1.45	-0.66	7
Oct	14.8	31	1.60	0.02	59
Nov	8.6	30	1.79	0.66	202
Dec	1.9	31	1.98	1.19	406

The values for DD_h are correct based on the values for σ_m and ϕ listed in Table 5 and the corrected Equation 52. However, the values for σ_m and ϕ are NOT correct based on Equations 49 and 51.

Using the corrected versions of Equations 49 and 52 and the actual results of Equation 51, we get the following data for Table 5:

Month	t_0 average	N (day/mo.)	σ_m	ϕ	DD_h calculated	DD_h (`01 SI)
Jan	0.1	31	2.03	1.37	481	463
Feb	0.8	28	2.01	1.39	415	399
Mar	5.1	31	1.89	1.00	329	312
Apr	11.2	30	1.71	0.47	147	133
May	16.8	31	1.55	-0.14	38	31
Jun	22	30	1.40	-0.84	4	3
Jul	24.8	31	1.31	-1.26	1	1
Aug	23.8	31	1.34	-1.10	2	1
Sep	20.2	30	1.45	-0.58	9	7
Oct	14.8	31	1.60	0.09	70	59
Nov	8.6	30	1.78	0.72	217	202
Dec	1.9	31	1.98	1.24	426	406

Values in Table 5 in the IP edition appear to be correct based on the (corrected) Equations 49, 51, and 52.

In the current version of Table 5, there is no direct correlation between the DD_h values in the SI and IP editions. With this correction, all of the monthly calculated values for DD_h show the appropriate conversion factor of 1.8 between the two unit systems (degree-days is a delta temperature term). In addition, the total number of degree-days is closer to that listed in Table 6 (which is from a separate source).

Proposed Corrections:

- In the IP edition, change the third coefficient in Equation 49 to 0.0664 to match the original reference
- In the SI edition, change the first coefficient to 1.45 and the third coefficient in Equation 49 to 0.0664 to match the original reference
- Replace the data in Table 5 in both editions with new data. This will correct some round-off errors in the IP edition and errors in the SI edition.
- Handbook chair has forwarded this information to Mark Owen at ASHRAE who can then respond to the user and will resummarize the changes in a future email.

Action Needed:

- Committee needs to agree that these changes are correct and appropriate. They seem to be supported by the source article and the fact that the correction of the equations and the values in Table 5 will result in values in both editions that make sense (one can use the 1.8 delta temperature conversion factor on DD_h to get the values for Table 5 in the other unit system).
- Once the committee agrees with the changes, the handbook chair will forward a summary of these changes to ASHRAE.

TC4.7 Handbook Subcommittee

Summary Report on Proposed Additions/Changes to Chapter 31 (Energy Estimating and Modeling Methods)

June 26, 2003

VALIDATION SECTION

A new section on validation was written by Ron Judkoff and Joel Neymark based on work for Standard 140 (Method of Test for the Evaluation of Building Energy Analysis Computer Programs). This section is to be added as an appendix to Chapter 31 to preserve the current text flow in the chapter. A version of this section was initially presented at the Honolulu meeting in June 2002 and modified prior to the Chicago meeting. It has been on the TC4.7 web site under handbook for at least 6 months. No additional feedback has been received. This section is approximately 11 pages long and is not duplicated here for sake of brevity.

Proposed Changes

- Add the "Model Validation and Testing" section as submitted (most recent version August 2002) as an appendix to Chapter 31
- Add the following text to the paragraph which begins "ASHRAE Standard 140 on page 31.3, column 1: "More information on model validation and testing can be found in the section of this chapter entitled 'Model Validation and Testing' and in ANSI/ASHRAE Standard 140."

Action Needed

- Approve text addition to page 31.3 or revise as needed
- Vote for approval of new section pending further editorial changes and report this vote to the full TC

BOILER MODELS SECTION

Agami Reddy, in reviewing Chapter 31, noted that there is much more detail on chillers than there is on boilers. He authored an addition to the chapter which is shown below after minor editing by the handbook chair.

Proposed New Section

The available literature on boiler models is fairly extensive, ranging from steady-state realizations (DeCicco 1990, Lebrun 1993) to detailed dynamic simulation (Bonne and Jansen 1985; Lebrun 1985). Besides these two types of modeling approaches, there is a third modeling approach which combines

these two schemes (Laret 1991; Malmstrom et al., 1985).

Dynamic models are meant to describe the transient behavior of the equipment. Consequently, these models need to accurately capture the combustion process and the complex energy exchange that occurs inside the combustion chamber. Usually, this kind of model is very detailed and demanding to formulate and use. In almost all cases, this level of detail is not needed for the simulation of domestic hot water boilers. However, in more complex situations (large boilers in large buildings, district heating systems, co-generation systems) where a complete and detailed representation of heat distribution, emission, and operation and control under varying external conditions is warranted, a dynamic boiler model should be considered.

Although in reality, all the major variables of boiler may vary with the load and environmental conditions, the assumption of steady-state conditions during burner-on and burner-off times results in a relationship between input and output variables that is much simpler than those used in dynamic models. Model evaluation against actual measurements shows that the steady-state model can provide sufficient accuracy for energy calculations (relatively long time periods, such as weeks or months) with regard to the measuring procedure accuracy.

Fig.7 Boiler Modeled with Elementary Components→keep figure, change figure caption to: Boiler Steady-State Modeling Approach

In this steady-state modeling approach, it is assumed that, during continuous operation, the boiler can be disaggregated into one adiabatic combustion chamber and two heat exchangers as shown in Figure 7. The following fluid streams flow through these three components:

(i) Across the combustion chamber (CC): air (subscript a) and fuel (subscript f) streams at the inlet and combustion gas (subscript fg) at the outlet;
(ii) Across the first heat exchanger (HEX1): combustion gas outlet stream & supply water stream (subscript in);
(iii) Across the second heat exchanger (HEX2): heated water stream (subscript out) & a fluid representing the environment.

The boiler model is characterized by three parameters, which represent the following heat transfer coefficients:

UA_{ge}: between the flue gas and the environment in CC
UA_{gw}: between the flue gas and the water in the HEX1
UA_{we}: between the water and the environment in HEX2

The primary model inputs to the model are the leaving water set point temperature ($T_{w,out}$) and control model and the load characteristics, i.e. the entering water temperature and water flow rate ($T_{w,in}$ and $\dot{m}_w$). Secondary model inputs include the air, fuel and ambient temperatures (T_a, T_f & T_e) as well as the fuel/air ratio (f).

Modern boilers are air-tight, so there is almost no air circulation across the combustion chamber when the burner is off. In this case, the boiler behaves as a simple water-environment heat exchanger (i.e. HEX1 and HEX2 are combined into one) and the thermal model is reduced to that of a simple heat exchanger.

Combustion Chamber Model. The mathematical description of the combustion chamber model allows the calculation of the flue gas mass flow rate and the flue gas enthalpy $h_{fg,in1}$ (expressed in J/kg flue gas) at the inlet of the flue gas-water heat exchanger (HEX1). The calculated flue gas mass flow rate is not necessarily the one associated with the specified value of the flue gas-water heat transfer coefficient-area product. Therefore, the following empirical relationship is used to adjust the value of this coefficient to the calculated value of the flue gas mass flow rate.

$$\dot{m}_{fg} = 1 + \frac{1}{f}\dot{m}_f \tag{1}$$

$$h_{fg,in} = \frac{h_{fg,in1}}{1 + \frac{1}{f}} \tag{2}$$

$$(UA_{gw})_{calc} = UA_{gw}\left(\frac{\dot{m}_{fg}}{(\dot{m}_{fg})_{rated}}\right)^{0.65} \tag{3}$$

where:

$h_{fg,in1}$ is a known function of the composition of the combustion products and of the flue gas temperature at the inlet of the gas-water heat exchanger (J/kg flue gas);

$h_{fg,in}$ is the gas enthalpy at the outlet of the gas-water heat exchanger (J/kg fuel);

$(\dot{m}_{fg})_{rated}$ is the flue gas mass flow rate associated (kg/s) with the specified value of the gas-water heat transfer coefficient-area product.

Flue Gas-Water Heat Exchanger Model. The first step is to calculate the heat transfer rate across HEX1 (Q_{gw}):

$$Q_{gw} = \varepsilon_{gw} C_{fg} (T_{fg,in} - T_{w,in}) \tag{4}$$

where

$C_{fg} = c_{p,fg}\dot{m}_{fg}$ is the heat capacity flow rate of the flue gas. (5)

$\varepsilon_{gw} = \frac{1 - \exp(-NTU(1-C))}{1 - C\exp(-NTU(1-C))}$ is the effectiveness for HEX1 (6)

For a counter-flow heat exchanger

$$NTU = \frac{UA_{gw}}{C_{fg}} \text{ and } C = \frac{C_{fg}}{C_w} \tag{7}$$

where $C_{fg} \le C_w$ and $C_w = c_{p,w}\dot{m}_w$

The temperature of the flue gas leaving HEX1 ($T_{fg,out}$) can be calculated from

$$\varepsilon_{gw}(T_{fg,in} - T_{w,in}) = (T_{fg,in} - T_{fg,out}) \tag{8}$$

Other unknowns need also to be calculated. In HEX1, heat is transferred from hot flue gas to the water

$$Q_{gw} = C_w(T^*_{w,out} - T_{w,in}) \quad (9)$$

from which the temperature of the water leaving HEX1 and entering HEX2 is:

$$T^*_{w,out} = \frac{Q_{gw}}{C_w} + T_{w,in} \quad (10)$$

Water-Environment Heat Exchanger Model. In HEX2:

$$\varepsilon_{\text{we}}(T^*_{w,out} - T_e) = (T^*_{w,out} - T_{w,out}) \quad (11)$$

where

$$\varepsilon_{\text{we}} = 1 - \exp(-\frac{UA_{we}}{C_w}) \quad (12)$$

Then the water temperature at the outlet of the HEX2 is

$$T_{w,out} = T_e + \frac{T^*_{w,out} - T_e}{\exp(-\frac{UA_{we}}{C_w})} \quad (13)$$

Consequently, heat loss from the hot water in HEX2 is

$$Q_{we} = C_w(T^*_{w,out} - T_{w,out}) \quad (14)$$

Useful heat given to the water stream:

$$Q_b = Q_{gw} - Q_{we} \quad (15)$$

Finally, efficiency of the boiler is given by

$$\eta = \frac{Q_b}{\dot{m}_f * FLHV} \quad (16)$$

where *FLHV* is fuel lower heating value.

The main outputs of this model are:

1) The "useful" boiler output, i.e. its leaving water temperature (to be compared with its set point), or its corresponding "useful" power (i.e. the net rate of heat transfer by the heated water, Q_b);
2) Its energy consumption, i.e. the burner fuel flow rate or the corresponding efficiency ($\dot{m}_f$ & η).

As "secondary" model outputs, we may consider:
1) Flue gas temperature, specific heat and corresponding enthalpy flow in the chimney;
2) Environmental loss in the boiler room (Q_{we}).

The three-parameter model allows simulation of boilers using most conventional fuels under a wide range of operating conditions with less than 1% error. A two-exchanger model appears to be flexible enough to describe boiler behavior at different load conditions and water temperatures. This simple model is stated to accurately predict the sensitivity of a boiler to variations of burner fuel rate and airflow rates as well as water-environment losses.

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Proposed Changes Summary

- Replace the current "Boiler Model" section on page 31.14 with the above text (note that the current Figure 7 is kept) making the appropriate adjustments and additions to the reference list at the end of Chapter 31.

Action Needed

- Review of proposed change/addition by the members of the handbook subcommittee.
- Following the review, submit to full TC for approval.

INVERSE CHILLER MODELS SECTION

Agami Reddy, in reviewing Chapter 31, noted that there has been an update to the Gordon-Ng chiller model that is current described on pages 31.28 and 31.29. He authored recommended the following replacement material (minor editing by the handbook chair).

Proposed New Section

The Generalized Gordon and Ng (GN) model (Gordon and Ng, 2000) is a simple, analytical, universal model for chiller performance based on first principles of thermodynamics and linearized heat losses. The model predicts the dependent chiller COP [defined as the ratio of chiller (or evaporator) thermal cooling capacity Q_{ch} by the electrical power *E* consumed by the chiller (or compressor)] with specially chosen independent (and easily measurable) parameters such as the fluid (water or air) temperature entering the condenser T_{cdi}, fluid temperature entering the evaporator T_{chi}, and the thermal cooling capacity of the evaporator. The GN model is a three-parameter model that takes the following form:

$$\left(\frac{1}{COP}+1\right)\frac{T_{chi}}{T_{cdi}}-1=a_1\frac{T_{chi}}{Q_{ch}}+a_2\frac{(T_{cdi}-T_{chi})}{T_{cdi}Q_{ch}}+a_3\frac{(1/COP+1)Q_{ch}}{T_{cdi}} \qquad (58a)$$

where the temperatures are in absolute units.

If the following substitutions are introduced:

$$x_1=\frac{T_{chi}}{Q_{ch}},\ x_2=\frac{(T_{cdi}-T_{chi})}{T_{cdi}Q_{ch}},\ x_3=\frac{(1/COP+1)Q_{ch}}{T_{cdi}} \text{ and } y=\left(\frac{1}{COP}+1\right)\frac{T_{chi}}{T_{cdi}}-1 \qquad (58b)$$

the model given by equation (58a) becomes:

$$y=a_1x_1+a_2x_2+a_3x_3 \qquad (58c)$$

which is a three parameter model with no intercept term. The parameters of the model in equation (58c) have the following physical meaning:

$a_1=\Delta S$, the total internal entropy production in the chiller,

$a_2=Q_{leak}$, the heat losses (or gains) from (or in to) the chiller,

$a_3=R$, the total heat exchanger thermal resistance = $\frac{1}{C_{cd}}+\frac{1}{C_{ch}}$

where C is the effective thermal conductance.

The authors of the GN model point out that Q_{leak} is typically an order of magnitude smaller than the other terms. Though small, it is not negligible for accurate modeling. It should be retained in the model if the other two parameters being identified are to be used for chiller diagnostics.

Previous studies (Reddy and Anderson, 2002; Sreedharan and Haves, 2001) found that the GN model and the multi-variate polynomial (MP) models were comparable in their internal and external predictive abilities. The GN model requires much less data if selected judiciously (in fact, even four well-chosen data points can yield accurate models as demonstrated by Corcoran and Reddy, 2003) than the MP model though the correlation structure of the GN model is poor (the regressors are highly correlated). However, this applies only to designed experiments and not to field monitored data which are highly correlated in time since one has no control over the time sequence of the incoming data. It has been shown by Reddy et al. (2003) using hourly data during an entire cooling for a large

centrifugal chiller that the GN model, because of its ill-conditioning of the regressor matrix, results in a sequence of 300 data points essentially having the same "information" content as 20 "independent" data points. Jiang and Reddy (2003) tested the GN model formulation against more than 50 data sets covering various generic types and sizes of water-cooled chillers, and found excellent internal and predictive ability (in the range of 2% to 5%).

REFERENCES

Gordon, J.M. and K.C. Ng, 2000. Cool Thermodynamics, Cambridge Press, Cambridge

Corcoran, J.P. and T.A. Reddy, 2003. "Improving the Process of Certified and Witnessed Factory Testing for Chiller Procurement", *ASHRAE Trans*., Technical Paper 4619, January.

Jiang, W. and T.A. Reddy, 2003. "Re-evaluation of the Gordon-Ng Performance Models for Water-Cooled Chillers", *ASHRAE Transactions*, June.

Reddy, T.A. and K.K. Andersen, 2002. "An Evaluation of Classical Steady-State Off-Line Linear Parameter Estimation Methods Applied to Chiller Performance Data", *HVAC&R Research Journal*, Vol. 8, no.1, p101, January.

Reddy, T.A., KK. Andersen and D. Niebur, 2003. Information Content of Incoming Data During Field Monitoring: Application to Chiller Modeling, *HVAC&R Research Journal*, October.

Sreedharan, P. and P. Haves, 2001. "Comparison of Chiller Models for Use in Model-Based Fault Detection", International *Conference for Enhanced Building Operations* (ICEBO), organized by Texas A&M University, Austin, TX, July.

Proposed Changes Summary

- Replace last paragraph on page 31.28, equation 58, and the first paragraph on page 31.29 with the text shown above, making the appropriate adjustments and additions to the reference list at the end of Chapter 31.

Action Needed

- Review of proposed change/addition by the members of the handbook subcommittee.
- Following the review, submit to full TC for approval.

SYSTEM MODELING: OVERALL MODELING STRATEGIES SECTION

Recently released energy analysis programs are much more capable than programs were in the past. This requires some text modifications to this section (see page 31.16-17) to reflect the current state of the art.

Excerpt from Current Section

The principal disadvantage of the alternative approach, and the reason that it has not been widely used, is that it demands more computing resources. However, programs that, to one degree or another, implement simultaneous solution of the loads, system, and plant models have been developed by Clarke (1985), Park et al. (1985), Klein et al. (1994), and Metcalf et al. (1995).

Proposed Change

The principal disadvantage of the alternative approach, and the reason that it has not been widely used in the past, is that it demands more computing resources. However, computer technology has advanced to the point where most desktop computers are able to run programs using the alternative approach in a reasonable amount of time. Programs that, to one degree or another, have implemented simultaneous solution of the loads, system, and plant models have been developed by Clarke (1985), Park et al. (1985), Klein et al. (1994), Taylor et al. (1990, 1991), and Crawley et al. (2000). Some of these programs simulate the loads, systems, and plants using subhourly time steps.
New Reference: Crawley, D.B., L.K. Lawrie, C.O. Pedersen, and F.C. Winkelmann. 2000. "EnergyPlus: Energy Simulation Program," *ASHRAE Journal*, Vol. 42, No. 4 (April), pp. 49-56.

Proposed Changes Summary

- Replace current paragraph with proposed new paragraph
- Change word “conceivable” in the second line of the second full paragraph on page 31.17, column 1 to “possible” or “now possible” so that it reads: “An alternative strategy, in which all calculations are performed at each time step, is **now possible**. Here the load, system, and plants equations are solved simultaneously at each time interval.
- Remove the Metcalf reference from the end of the chapter and add the Crawley reference

Action Needed

- Review of proposed change/addition by the members of the handbook subcommittee.
- Following the review, submit to full TC for approval.

TABLE 1 ADDITION

EnergyPlus was released in April 2001 and this should be reflected in Table 1.

Proposed Changes

- Add EnergyPlus to the computer simulation line after DOE-2 and BLAST.
- Add "Crawley et al. 2000" to the reference list after the program names
- Change the comment on this line to read "Hourly **and subhourly** simulation programs with system models."

Action Needed

- Review of proposed change/addition by the members of the handbook subcommittee.
- Following the review, submit to full TC for approval.

TC 4.7 PROGRAM PLAN
Kansas City ASHRAE Meeting
Approved - July 1st, 2003

ANAHEIM / JANUARY 2004

3. **Symposium** "Applications and Knowledge-based Tools for Enhanced Building Energy Simulation"
    - Organized by TC 4.7 (Data Driven and Applications)
    - Chaired by Vern Smith
    - Status: merged with KBS Symposium at K.C. 2 papers have been reviewed, 1 paper needs significant, 2 KBS technical papers on conceptual design.
4. **#1 Seminar** "Applications of HVAC-01 Primary and Secondary Toolkit"
    - Organized by TC 4.7 (Applications)
    - Chaired by Jean Lebrun/Dru Crawley
    - Status: New
5. **#2 Seminar** "Application and Experiences With the New EnergyPlus Software",
    - Organized by TC 4.7 (Applications)
    - Chaired by Joe Huang
    - Status: New
6. **#3 Forum** "Modeling Phase Change Material Applications in Building Envelopes"
    - Organized by TC 4.7 (Sim and Comp Models)
    - Moderated by Jan Kosny
    - Status: New
7. **#4 Forum** "Do ASHRAE Members Need an Energy Simulation Model of Refrigerated Warehouses"
    - Co-organized by TC 10.5 (Refrigeration Distribution and Storage Facilities), TC 10.8 (Refrigeration and Load Calcuations) and TC4.7 (Sim and Comp Models)
    - Moderated by Daniel Dettmers, Don Fenton and Jan Kosny
    - Status: New

NASHVILLE/JUNE 2004

1. **Symposium** "Validation of building simulation programs thru ASHRAE Standard 140"
    - Organized by TC 4.7 (Applications)
    - Chaired by Jim Willson
    - Status: 5 papers being considered (865RP, Overview, HVAC Bestest, Iowa Empirical Tests, Jelena Srebric)
2. **Symposium** "Recent Advances in Simulation"

- Organized by TC 4.7 (Sim and Comp Models)
- Chaired by Dan Fisher
- Status: New

3. **Symposium** "Modeling Moisture Sorption/Desorption by Building Materials"
    - Organized by TC 4.7 (Sim and Comp Models)
    - Chaired by Jan Kosny
    - Status: New
4. **Seminar** "Simulation Without Tears"
    - Organized by TC 4.7 (Applications)
    - Chaired by Joe Huang
    - Status: New

SSPC-140 SMOT FOR BUILDING ENERGY SOFTWARE

Kansas City, June 30, 2003 (submitted July 01, 2003)

Chair: R. Judkoff

Vice Chair: J. Neymark

ATTACHMENTS

A. Agenda for June 30, 2003 meeting
B. Compliance SubC / 90.1 ECB liaison report, Kansas City, June 29, 2003

ADDITIONAL ATTACHMENTS AVAILABLE UPON REQUEST

(contact Joel Neymark at neymarkj@msn.com)

B1. Previous Minutes from Compliance SubC in Chicago.
B2. Compliance SubC Address list
C. Previous SSPC 140 minutes
D. SSPC 140 Address List

CORRESPONDANCE SINCE LAST MEETING

Addendum a incorporates HVAC BESTEST, Volume 1 (cases E100-E200) into Standard 140. Neymark has been working with ASHRAE Staff on editorial revisions to the public review draft of Addendum a to Standard 140. ASHRAE Staff sent Addendum a to SPLS in early June.

On June 27, 2003 SPLS voted unamimously (8-0-0) to approve Addendum a of Standard 140 for Public Review.

DIAGNOSTIC TESTS

The primary purpose of the meeting was to report on progress related to: SPLS approval of Addendum a (incorporating HVAC BESTEST, volume 1 into Standard 140), and adoption of Standard 140 by Standard 90.1. Also discussed were: updates of relevant activities in other codes and standards, and adding further new test cases to Standard 140.

Attendees (see mailing list for full names, etc)

Voting Members
Crawley (arrived after vote on previous minutes approval)
Fairey
Judkoff (chair)
Knebel
Rees
Walton
Witte
Gowri
Pegues
Sahlin
Shirey
Xiao

Non-Voting Members
Neymark (vice chair)

Absent Voting Members
Beausoleil-Morrison
Winkelmann
Wilcox

Other
Cornish
Deru

General

No Roster changes this cycle.

Chair's Announcements

SSPC 90.1 approved for publication the following language as Addendum p to Std 90.1:

Add the following to Section 11.2.1

"11.2.1.4 The simulation program shall be tested according to ANSI/ASHRAE Standard 140 and the results shall be furnished by the software provider."

Add the following to Section 12

"ANSI/ASHRAE 140-2001 Standard Method of Test for Evaluation of Building Energy Analysis Computer Programs".

An explanatory foreword was also included

Addendum a to Standard 140, incorporating HVAC BESTEST E100-E200 analytical verification test cases for unitary space cooling equipment using performance map models, was approved by SPLS for public review. Public review should begin some time this summer.

Congratulations to Xiao for Carrier award (best paper for < 32 yrs old), and Xiao, Rees and Spitler for a best paper award; both awards for their RP-1052 (analytical verification of envelope simulation models) paper.

Congratulations to Crawley for receiving the Distinguished Service Award.

New IEA Task (SHC 34 / ECBCS 43) jointly supported by the SHC and ECBCS Executive Committees for continued work on simulation tool evaluation was approved in June 2003.

Committee Discussion

Approval of Prior Minutes

Motion (Walton): Accept Minutes of January 2003 Chicago minutes [See attachment C].
2nd (Knebel):

Vote: Yes = 6, No = 0
Absent = Beausoleil-Morrison, Crawley, Wilcox, Winkelmann
Motion = passed.

Tax Credits and IECC Chp 4. Update [Fairey]

SB 597 is an energy efficiency and alternative energy tax credit bill (sponsored by Grassley of Iowa) that includes language to strengthen software certification procedures. This language still refers to the California ACM (compliance method), but is open to use of 140. Criticism of 140 exists related to bands

of acceptance. In this legislation nobody is pushing for alternative to ACM for commercial buildings [but see below regarding relationship between IECC and 90.1], but there is local likelihood for use of ACM in residential where Std 140 has support.

IECC. In March 2003 DOE proposed to modify the document such that it would decrease in size from 300 to 30 pages, to simply the residential code. The current chapter 4 (performance requirements) would be reduce to a section (404). NREL has proposed to put in a software certification method to support Section 404. PNNL is waiting for the update to Section 404 to complete their RESCHECK software.

Related Research Activities (updates and intentions regarding inclusion in Std 140)

HERS BESTEST: Fairey has intention to find funding to modify (code language compatible) HERS BESTEST, and expects to see future progress.

Furnace Tests: The fuel-fired furnace test cases final report has been approved by the Task 22 experts, and IEA Solar Heating and Cooling Programme ExCo approval is expected in the near future. At the previous meeting in Chicago NRCan (absent at this meeting) indicated they are prepared to make the effort to convert this into code language for use with 140.

RP-865 Air-Side HVAC Analytical Verification Tests: Walton reported that the RP-865 final report has been submitted to ASHRAE. Knebel volunteered to help Walton bring these test cases into Standard 140. **Action Item (Knebel, Walton): Develop plan to incorporate RP-865 into Std 140.**

RP-1052 (Rees): While using 1052 for testing EnergyPlus, LBNL found a problem (typo) with calculation of window absorptance (at high incidence angle). The same typo exists in a portion of the analytical solution software that accompanies 1052. There are other typos in the final report (not known to affect software yet). Rees is maintaining an errata file. The committee discussed that ASHRAE (Mike Vaughn) could also maintain an errata repository.

Simon also announced that he is going to work at DeMontfort University (UK) beginning August 5. This may affect his ability to continue participating with SSPC 140.

IEA Task 22 Related Research Activities Updates

Judkoff announced that New IEA tool evaluation task 34/43 (see above) was approved by SHC and ECBCS ExCos. Projects to include:

empirical: advanced windows and shading using EMPA facility, mechanical equipment tests using Iowa Energy Center ERS facility

comparative: ground-coupling tests, multi-zone tests, double-façade tests

Ground Coupling Tests: This is a series of tests for comparing programs to the results of advanced ground-coupling models. The test specification needs revision: current base case development is done or close to done, parametric variations need refinement. So far we have results for HOT3000, SUNREL, and EnergyPlus. Simulation capability has gotten to the point that detailed ground modeling is feasible for whole-building simulations.

RADTEST: These are tests of the ability of software to model floor embedded radiant systems. The final report for this work approved by the IEA Task 22 experts in April 2003, and is in the final Executive Committee approval phase.

New HVAC BESTEST cases: These are expansion of HVAC BESTEST cases that includes more dynamic loading and weather, air-mixing, thermostat setup, undersized equipment, and various economizer controls. The final report for this work approved by the IEA Task 22 experts in April 2003, and is in the final Executive Committee approval phase.

ETNA Empirical Tests: This is a series of empirical tests based on the BESTEST methodology. Includes conduction, solar gains, various heater types, insulated floor (mass test). Much of the data is just to empirically characterize the test cell UA and capacitance, so that overall material property uncertainty is minimized (i.e. a common problem regarding empirical studies has been addressed). All data has been collected. Specification writing is in progress. EDF needs to put data in public domain before IEA can use it.

CEN Standards Related to Simulation Software, and european Energy Performance Directive (EPD): As a result of the EPD, European energy efficiency standards are going in a performance path directive. However, the approach for software qualification testing being promulgated by CEN utilizes lowest common denominator models. After model is tested "crippled" it must be used crippled. Problem is e.g. angle-dependent optical properties are not allowed. The good news is that people involved in CEN (e.g. Millet) are also interested in participating in the new IEA task.

New Business

Fairey requested that SSPC 140 consider developing test cases for air distribution system leakage modeling. He noted that Standard 152P that contains a relevant calculation procedure should be approved at this meeting. This could be the starting point for a test specification. FSEC also has a calculation procedure.

Witte mentioned that the EnergyPlus team has developed test cases for performance map comparisons for chillers, fans, pumps, etc, and also some global energy balance tests, and that these could be candidates for inclusion into Standard 140.

Meeting Adjourned.

References

ANSI/ASHRAE Standard 90.1-2001, *Energy Efficient Design of New Buildings*. ASHRAE, Atlanta, GA.

ANSI/ASHRAE Standard 140-2001, *Method of Test for the Evaluation of Building Energy Analysis Computer Programs*. ASHRAE, Atlanta, GA.

BSR/ASHRAE/IESNA Addendum p to ANSI/ASHRAE/IESNA Standard 90.1-2001, *Energy Standard for Buildings Except Low-Rise Residential Buildings.* ASHRAE, Atlanta, GA.

SSPC 140-Attachment A

AGENDA – SSPC 140

STANDARD METHOD OF TEST FOR THE EVALUATION OF BUILDING ENERGY ANALYSIS COMPUTER PROGRAMS

Monday, June 30, 2003; Kansas City, MO

Time: 14:15 to 18:15 on Monday, June 30
Location: Hyatt Suite 3222 (32nd floor)
Chair: Ron Judkoff

TOPICS

1. Introductions

2. Acceptance of Previous Minutes

3. Adjustments to Agenda

4. Update regarding SPLS approval of revisions to Std 140 (incorporating HVAC BESTEST) for public review *[Hargan]*

5. Standard 90.1 Software Compliance using Std 140 *[Neymark]*

6. Tax Credits and IECC Chp. 4 Update *[Fairey]*

7. Related Research Activities (updates and intentions regarding inclusion in Std 140)

   - HERS BESTEST *[Fairey]*
   - Furnace Tests *[Beausoleil-Morrison]*
   - RP-865 Air-Side HVAC Analytical Verification Tests *[Walton]*
   - RP-1052 Envelope Analytical Verification Tests *[Rees]*

8. IEA Related Research Activities Updates

   - IEA New Task update *[Judkoff]*
   - New HVAC BESTEST cases *[Neymark]*

- RADTEST *[Judkoff/Neymark]*
- Ground Coupling Tests *[Judkoff]*
- ETNA Empirical Tests *[Neymark]*
- ERS Empirical Tests *[Judkoff]*
- CEN Standards Related to Simulation Software *[Judkoff]*

9. New business
10. Adjourn

SSPC 140 Attachment B. Compliance SubC / 90.1 ECB liaison (Neymark) report, Kansas City, June 29, 2003

Standard 90.1 has recently been working on Addendum P, which adds the following language to chapter 11 on Energy Cost Budget (simulated performance based) compliance:

Add the following to Section 11.2.1

"11.2.1.4 The simulation program shall be tested according to ANSI/ASHRAE Standard 140 and the results shall be furnished by the software provider."

Add the following to Section 12

"ANSI/ASHRAE 140-2001 Standard Method of Test for Evaluation of Building Energy Analysis Computer Programs"

An explanatory foreword was also included.

Public review ended in early June with one comment received that was later withdrawn. On Saturday June 28 ECB SubC approved publication of Addendum P. On Sunday June 29 Addendum P was approved by full 90.1, voting unanimous except for 1 abstension.

Per the ECBSubC Chair (Jason Glazer) publication will occur pending some procedural formalities, including:

- letter-ballot of absent 90.1 members
- Standards Committee approval
- etc

The addendum will be incorporated in the 90.1-2004 revision.

The stated language means that results would be furnished only to organizations adopting 90.1, and only for approval of a building using the ECB method.

It may also be a good time to propose to IECC (for its non-residential section) to use 90.1's language adopting 140.