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: May 15, 2001

TC/TG/TRG TITLE: Energy Calculations

DATE OF MEETING: January 30, 2001 LOCATION: Dallas

MEMBERS PRESENT	YEAR APPTD	MEMBERS ABSENT	YEAR APPTD	EX-OFFICIO MEMBERS & ADDIT'L ATTENDANCE
Jeff Spitler (CHM)	2000	Carol Gardner	1998	
Dru Crawley (VC)	2000	Moncef Krarti	1999	
Bill Bahnfleth (PGM)	1998	Gren Yuill	2000	
Chip Barnaby (RES)	1999			
Les Norford (SECY)	2000			
Jan Hensen (INTL)	2000			
Klaus Sommer (INTL)	1999			
Ian Beausoleil-Morrison	2000			
Phil Haves	2000			
Joel Neymark	2000			
Agami Reddy	1999			
Vern Smith	2000			
Jim Willson	2000			
Michael Witte	1998			
Craig Wray	2000			

DISTRIBUTION

ALL MEMBERS OF THE TC/TG/TRG

TAC CHAIR	Ed Gut
TAC SECTION HEAD	Byron Jones
SPECIAL PUBLICATIONS LIAISON	Ramon Pons
JOURNAL/INSIGHTS LIAISON	Chad Dorgan
STANDARDS LIAISON	David Knebel
HANDBOOK LIAISON	David Claridge
PROGRAM LIAISON	Emil Friberg
RAC RESEARCH LIAISON	Sheila Hayter
TEGA LIAISON	William Knight
EDUCATION LIAISON	Donald Colliver
ENV HEALTH COMMITTEE LIAISON	William Fisk
STAFF LIAISON (RESEARCH)	William Seaton
STAFF LIAISON (TECH SERVICES)	Martin Weiland
STAFF LIAISON (STANDARDS)	Claire Ramspeck

ASHRAE TC 4.7 Energy Calculations
ATLANTA MEETING
ACTION ITEMS

Minutes approved, 12-0-0, chair not voting.

No-cost extension to August 31, 2001 for 865-RP. Approved 14-0-1, chair not voting.

No-cost extension to October 1, 2001 for 1050-RP. Approved 14-0-1, chair not voting.

Final report for 987-RP. Approved 14-0-1, chair not voting.

Final report for 1052-RP. Approved 13-0-2, chair not voting.

Final report for 1145-RP. Approved 14-0-1, chair not voting.

Program plan approved 13-0-1, chair not voting.

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DATE OF MEETING: January 30, 2001 LOCATION: Atlanta

TC/TG/TRG MEETING SCHEDULE

LOCATION - past 12 months	**DATE**	**LOCATION - planned next 12 months**	**DATE**
Minneapolis	6/27/2000	Cincinnati	June 26, 2001
Atlanta	1/30/2001	Atlantic City	January 15, 2002

TC/TG/TRG SUBCOMMITTEES

Function	**Chair**
Simulation and Component Models Applications Inverse Methods	Dan Fisher Joe Huang Jeff Haberl

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
1.	Appendix 2.			
2.				
3.				
4.				

HANDBOOK RESPONSIBILITIES

Year & Volume	Chapter Title	**No.**	Deadline	**Handbook Subcom. Chair/Liaison**
2001 Fundamentals	Energy Estimating Methods	31	February 2000 Dallas	Norford/Claridge

STANDARDS ACTIVITIES - List and Describe Subjects

SPC 140P Standard Method of Test for Building Energy Software - Ron Judkoff

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

none

TC/TC/TRG Sponsored Symposia - Title, when presented (past 3 yrs. present & planned)

Appendix 3

TC/TG/TRG Sponsored Seminars - Title, when presented (past 3 yrs. present & planned)

Appendix 4

TC/TG/TRG Sponsored Forums - Title, when presented (past 3 yrs. present & planned)

Characterizing the Performance of Central Plants for Multi-Building Campuses, Chicago (1/99)
Who Needs Moisture Calculations in Building Energy Simulations? What Do You Need?, Toronto (6/98)
How should ASHRAE Computer Models be Expressed? Boston (6/97)

JOURNAL PUBLICATIONS - Title, when published (past 3 yrs. present & planned)

Additional 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
Agree to email on list	Atlanta January 2001	Minneapolis June 2000	Dallas February 2000	Seattle June 1999			
			X	X	Abushakra	Bass	
			X		Addison	Marlin	
X	X	X			Anderson	J R	Anderson@netten.net
					Ayres	J Marx	
		X	X	X	Bahnfleth	Bill	WPB5@psu.edu
X	X	X	X	X	Barnaby	Chip	CBarnaby@wrightsoft.com
X	X	X		X	Beausoleil-Morrison	Ian	IBeausol@nrcan.gc.ca
X	X	X		X	Black	Al	ABlack@mcclureng.com
				X	Blair	Nathan	
		X			Blake	Jeff	
		X			Bowman	Jim	
X	X	X	X	X	Brandemuehl	Mike	Michael.Brandemuehl@colorado.edu
X	X				Brau	Jean	jean.brau@insa-lyon.fr
X	X	X	X	X	Buhl	Fred	WFBuhl@lbl.gov
				X	Callan	David	
				X	Carpenter	Allen	
		X			Carpenter	J Patrick	
X	X		X		Claridge	David	Claridge@esl.tamu.edu
					Clark	Dan	
X	X	X	X	X	Crawley	Dru	Drury.Crawley@ee.doe.gov
		X	X		Degelman	Larry	
X	X				Del Porte	Scott	shd@fluent.com
				X	Desjarlais	Andre	
		X			Dewitte	Jorre	
X	X	X	X		Eldridge	David	eldridd@okstate.edu
		X	X	X	Fisher	Dan	DFisher@okstate.edu
				X	Flake	Barrett	
				X	Fraser	Kathleen	
X	X				Garde	Francois	garde@univ-reunion.fr
			X	X	Gardner	Carol	
X	X	X	X		Gu	Lixing	Gu@fsec.ucf.edu
X	X	X	X	X	Haberl	Jeff	JHaberl@esl.tamu.edu
X	X	X			Haddad	Kamel	KHhaddad@nrcan.gc.ca
			X		Hanby	Victor	
X	X	X	X	X	Haves	Philip	PHaves@lbl.gov
		X			Henderson	Hugh	
X	X			X	Hensen	Jan	JaHe@fago.bwk.tue.nl

Present at TC 4.7 Meeting?					Last Name	First Name	Email
Agree to email on list	Atlanta January 2001	Minneapolis June 2000	Dallas February 2000	Seattle June 1999			
			X		Henze	Gregor	
				X	Holmes	Michael	
X	X				Howell	Jamie	jamieh@customenergy.com
X		X	X		Huang	Joe	
X	X				Hydeman	Mark	MHydeman@taylor-engineering.com
					Judkoff	Ron	
			X	X	Katipamula	Srinivas	
		X			Kelso	Richard	
X	X				Kimura	Ken-ichi	kkimura@mn.waseda.ac.jp
				X	Kissock	Kelly	
X	X				Klaassen	Curtis	curtk@energy.iastate.edu
X	X		X	X	Knappmiller	Kevin	KevinK@kevtec.com
				X	Knebel	Dave	
X	X	X	X		Kosny	Jan	kyo@ornl.gov
		X			Kossecka	Elisabeth	
		X	X	X	Krarti	Moncef	
X	X		X	X	Kreider	Jan	Kreider@bechtel.colorado.edu
			X		Lamberts	Roberto	
					Lawrie	Linda	
		X	X	X	Leber	Jon	
			X	X	Lebrun	Jean	
				X	Levermore	Geoff	
X	X				Liesen	Richard	R-Liesen@uiuc.edu
			X		Loomans	Marcel	
X	X				Lotfi	Nemat	nematlotfi@hersheys.com
X	X	X	X	X	McDowell	Tim	Mcdowell@tess-inc.com
				X	McGowan	Alex	
				X	Medina	Mario	
		X	X	X	Morner	Svein	
X	X		X		Mottillo	Maria	Mmottilo@nrcan.gc.ca
X	X	X	X	X	Neymark	Joel	NeymarkJ@sni.net
X	X	X	X	X	Norford	Les	LNorford@mit.edu
X	X	X	X	X	Pedersen	Curt	CPederse@uiuc.edu
		X		X	Purdy	Julia	
X		X	X	X	Reddy	T. Agami	
X	X	X	X	X	Rees	Simon	SJRees@okstate.edu
			X		Rittelmann	Bill	
			X		Rock	Brian	
X	X				Scharpf	Dan	dfs@fluent.com
					Selkowitz	Steve	
X	X	X	X	X	Smith	Vernon	VSmith@archenergy.com
				X	Somasundaram	Sriram	
X	X	X	X	X	Sommer	Klaus	Klaus.Sommer@vt.fh-koeln.de
X	X	X	X	X	Sonderegger	Robert	rsonder@siliconenergy.com
		X	X		Sowell	Ed	

Present at TC 4.7 Meeting?					Last Name	First Name	Email
Agree to email on list	Atlanta January 2001	Minneapolis June 2000	Dallas February 2000	Seattle June 1999			
X	X	X	X		Spitler	Jeffrey	Spitler@okstate.edu
X	X	X	X	X	Strand	Rick	R-Strand@uiuc.edu
X	X	X	X	X	Walton	George	GWalton@nist.gov
				X	Wetter	Michael	
X	X	X	X	X	Willson	Jim	jimwill@indy.net
X	X			X	Winkelmann	Fred	FCWinkelmann@lbl.gov
X	X		X	X	Witte	Mike	MJWitte@gard.com
X	X	X	X	X	Wray	Craig	CPWray@lbl.gov
X	X			X	Wright	Jonathan	J.A.Wright@lboro.ac.uk
		X			Wyndham-Wheeler	Paul	
			X	X	Yuill	Gren	

Appendix 1

RESEARCH PROJECTS

TC 4.7 Research Projects Status

Active projects

#	Title	Joint TC	Cognizant Subcommittee/ Contractor	PMSC	Dates / status
865-RP	Accuracy Tests for Mechanical System Simulation		Sim/Comp Penn/TAMU Gren Yuill	George Walton (chair), Ron Judkoff, Robert Sonderegger, Dave Knebel	Rec: 2-20-96 (San Antonio) NCE: 2-28-98 (7-1-97) NCE: 8-31-98 (1-20-98) NCE: 3-31-99 (6-23-98) NCE: 3-31-00 (1-27-99) NCE: 3-31-01 (2-8-00) NCE: 8-31-01 (1-30-01)
987-RP	Preparation of a Toolkit for Building Load Calculations	4.1	Sim/Comp Univ. of Illinois Curt Pedersen	Dru Crawley (chair), Chip Barnaby, George Walton, Dave Knebel; Tom Romine (TC 4.1)	Rec: 1-28-97 (Phil) End: 12-31-99 NCE: 7-31-00 (6-22-99) NCE: 3-31-01 (6-27-00) Accept report: 1-30-01
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) Rejected all proposals: 6-23-98 (Toronto) Rec: 6-22-99 (Seattle) End: 8-02?
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 (1-30-00)
1052-RP	Development of an Analytical Verification Test Suite for Whole Building Energy Simulation Programs – Building Fabric		Sim/Comp OSU Jeff Spitler	George Walton (chair), Ron Judkoff, Joel Neymark, Fred Winkelmann	WS: 7-1-97 (Boston) Rec: 6-23-98 (Toronto) Start: 1-1-99 NCE: 3-1-01 (2-8-00) Accept report: 1-30-01
1093-RP	Compilation of Diversity Factors and Schedules for Energy and Cooling Load Calculations	4.1	App TAMU (TEES) Jeff Haberl	Agami Reddy (chair), Bill Bahnfleth, Joe Huang, Suzanne LeVisuer (TC 4.1)	WS: 1-20-98 (SF) Start: 2-1-99 NCE: 3-31-2001 (2-8-00)
1145-RP	Modeling Two- and Three-Dimensional		Sim/Comp Enermodal	Ian Beausoleil-Morrison (chair); George Walton;	WS: 6-23-98 (Toronto) Rec: 6-22-99 (Seattle)

	Heat Transfer Through Composite Wall and Roof Assemblies in Hourly Simulation Programs		Engineering Ltd	Fred Winkelmann, Doug Hittle (TC 4.1)	Accept report: 1-30-01

Appendix 2

LONG-TERM RESEARCH PLAN

Technical Committee 4.7 Energy Calculations
2001-2002 Research Plan
August 1, 2000

Priority 2001 – 2002	Prior priority	Status	Title	Subcommittee
0		Revision	Procedures for Evaluating Computer Calculated Results Against Measured Energy Data (1051-WS)	Inverse Methods
0	3 (1999-2000)	Cancelled Tech Council 3/00 Reconsideration 10/00	Standard Operating Conditions in North American Residential Buildings (1163-TRP)	Applications
0	1 (2000-2001)	Returned 3/00 Resubmit 9/00	Updated Energy Calculation Models for Residential HVAC Equipment (1197-WS)	Simulation and Component Models
1		Approved by TC; submit 9/00	Incorporation of Nodal Room Heat Transfer Models into Energy and Load Calculation Procedures	Simulation and Component Models
2		Draft WS	Development of Comparative Test Cases for Evaluating Simulation Models of Slab, Crawl Space and Basement Heat Transfer Through Adjacent Ground	Applications
3		Draft WS	Inverse Bin Procedures for Analyzing Energy Savings	Inverse Methods

Appendix 3

TC/TG/TRG SPONSORED SYMPOSIA

PLANNED:

Chicago – January 2003

Integrating Airflow Modeling into Energy Analysis Programs (Chair: Ian Beausoleil-Morrison)

Honolulu – June 2002

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

Atlantic City – January 2002

Applications and Development of Calibrated Models for Chillers and Cooling Towers(TC1.5, 4.6 and 8.6 co-sponsors/.Chair: Agami Reddy)

Interoperability and Tool Portability (Chair: Chip Barnaby)

Cincinnati – June 2001

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

PRESENT:

Atlanta – January 2001

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

PAST:

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)

Chicago - January 1999

*Application of Heat Balance Methods to Energy and Thermal Load Calculation (*Chair: Chip Barnaby)

Toronto - June 1998

Baseline Calculations for Measurement and Verification of Energy and Demand Savings (Chair: Robert Sonderegger)

Appendix 4

TC/TG/TRG SPONSORED SEMINARS

PLANNED:

Atlantic City, June 2001

Commercial Use of Building Energy Simulations (Chair: Kamel Hadad)

Automated Baseline Procedures Using Inverse Methods (Chair: Jeff Haberl)

Cincinnati, June 2001

Pathways to Wider Use of Building Simulation Programs (Chair: Dru Crawley)

PRESENT:

Atlanta, January 2001

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

PAST:

Dallas - January 2000

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

Chicago - January 1999

Simulation Tool Interoperability and Component Model Portability (Chair: Phil Haves)

Toronto - June 1998

Neural Nets: What Are They and What Can They Do? (Chair: Moncef Krarti)

ASHRAE TC 4.7 Energy Calculations
Tuesday, January 30, 2001, 6:00-8:30 p.m.
Room 304E, Georgia World Congress Center

1. Roll call and introductions. Chairman Jeff Spitler called the meeting to order at 6:00 p.m. Voting members in attendance were Jeff Spitler, Bill Bahnfleth, Dru Crawley, Chip Barnaby, Les Norford, Jan Hensen, Ian Beausoleil-Morrison, Phil Haves, Joel Neymark, Agami Reddy, Vern Smith, Klaus Sommer, Jim Willson, Mike Witte, and Craig Wray

2. Accept agenda & approve minutes of Minneapolis meeting. The agenda for this meeting is shown in Attachment A. Wray moved (Neymark seconded) to approve minutes for the Minneapolis meeting. The motion was approved 12-0-0 CNV. The attendance list has a new column, asking those present to indicate a willingness to have their email addresses listed.

3. Announcements.

- SSPC 90.1 is seeking members.
- There is a new publication category – technical bulletins posted on ASHRAE's web site. Subcommittees might consider identifying appropriate material.
- ASHRAE encourages collecting seminar slides for TC web sites. Crawley will consider doing so for his toolkit seminar and Haves will investigate doing this for his seminar at this meeting. It is optional. Spitler or Crawley will prepare PDF files for posting.
- NRC Canada is hosting a conference on building simulation, June 13-14, 2001, in Ottawa. Information is available at the web site, www.esim.ca. Conference organizers need reviewers for abstracts; those interested should contact Beausoleil-Morrison.

4. Membership. Spitler announced that he has turned in the roster for the coming ASHRAE year, to take effect after the June meeting. Witte will roll off and Rick Strand will join as a voting member and become chairperson of the handbook subcommittee. Tentatively, Beausoleil-Morrison will chair the program subcommittee and Neymark will chair the standards subcommittee. Joe Huang will be in China and his replacement as applications subcommittee chair will be identified later.

5. Subcommittee reports.

5.1. Applications Subcommittee. Subcommittee Chair Huang reported on activities of the subcommittee. Minutes are shown as Attachment B.

1093-RP. Diversity Factors and Schedules for Energy and Loads. Reddy reported on the PMS meeting (see Attachment C). The work by Texas A&M University is almost complete, lacking a summary with guidelines to users for selecting profiles and technical papers, of which three or four are expected. The March 31, 2001 deadline will be met. No action is required at this meeting, but an email ballot for approval or no-cost extension is expected. Barnaby noted that Bill Seaton said that if a contractor delivers a final report to ASHRAE Headquarters by the due date, the contract is considered to be satisfied even without TC approval of the report. Wray will check.

5.2 Inverse Methods Subcommittee. Subcommittee Chair Haberl reported that the subcommittee had a lively meeting this afternoon, with extensive discussion of RTARs and work statements. Minutes are shown as Attachment D.

865-RP. Accuracy Tests for Mechanical System Simulation. PMS Chair Walton reported substantial activity by the contractors (Texas A&M and University of Nebraska/Omaha). Haberl will take the lead in finishing the work. Crawley moved (Neymark seconded) that TC 4.7 approve a no-cost extension to August 31, 2001. The motion was approved 14-0-1 CNV.

1050-RP. Development of a Toolkit for Calculating Linear, Change-Point Linear and Multiple-Linear Inverse Building Energy Analysis Models. PMS Chair Kreider stated that reports on software, scheduled to be delivered in Fall 2000, were not and time and that the contractor, University of Dayton was not at Atlanta. He therefore cancelled the PMS meeting. The subcontractor, Texas A&M University, asked for a no-cost extension until October 1, 2001, which Kreider supports on the basis of progress, albeit slow. Reddy moved (Bahnfleth seconded) that the request for a no-cost extension be approved; the motion was approved 14-0-1 CNV.

5.3 Simulation & Component Models Subcommittee. Simon Rees reported on the subcommittee's activities in the absence of subcommittee chair Dan Fisher. The minutes are found in Attachment E.

987-RP Preparation of a Toolkit for Building Loads Calculations. PMS Chair Crawley stated that the contractor (U. Illinois) has prepared new models, documentation, and a CD, and that the work is substantially complete. Outstanding issues include a license agreement (code can be used in the purchaser's business if ASHRAE is given credit and held harmless), module copyright, and editorial changes. Crawley and Barnaby will work with ASHRAE to prepare the CD for production and sale, hopefully for Cincinnati. The PMS voted 5-0 in favor of recommending that TC 4.7 approve the final report. Crawley moved (Barnaby second) that the final report be approved, subject to minor editorial changes. The motion was approved 14-0-1 CNV. TC 4.7 has now produced three complete toolkits and it was suggested that the chair consider appointing someone to assess what work will be required to maintain them and make them more widely available.

1049-RP Building System Design and Synthesis. PMS Chair Pedersen reported on work by the contractor, Loughborough University, described more fully in Attachment F. Jon Wright, the new PI, gave an extensive report to the PMS, noting that the project is 37% complete through 47% of the allotted time. Simulations are being performed with IDA and Java is being used for everything else.

1052-RP Development of an Analytical Verification Test Suite for Whole Building Energy Simulation Programs – Building Fabric. PMS Chair Walton reported that the contractor, Oklahoma State University, has prepared 16 analytic tests and has compared results for specific cases with BLAST. An interactive program allows the user to change convection coefficients and conductivities. Witte described testing against EnergyPlus. The report needs further editorial review, references to show that the test algorithms are correct, and a better description of the test program. The PMS recommended, on a 3-1 vote, that TC 4.7 approve the final report; Neymark opposed on the basis of a lack of documentation of the verification of the analytic solutions, which he considered to be more than an editorial change. Crawley moved (Wray second) that the final report be approved, subject to changes to be monitored by the PMS. The motion was approved 13-0-2 CNV.

1145-RP Modeling Two- and Three-Dimensional Heat Transfer Through Composite Wall and Roof Assemblies in Hourly Simulation Programs. PMS Chair Beausoleil-Morrison reported that the contractor, Enermodal, submitted a final report a week before this meeting and that three PMS members and four additional reviewers were reviewing it. Remaining work is considered to be editorial in nature. Beausoleil-Morrison stated that the report will include enough information to permit others to generate equivalent one-dimensional layers. Huang stated that post-processing to finite-difference code will be provided as a listing. Beausoleil-Morrison moved (Willson second) that TC 4.7 approve the final report. The motion passed, 14-0-1 CNV.

5.4 Research Subcommittee. Research Subcommittee Chair Barnaby reviewed the current research plan, details of which are found in Attachment G.

1163-TRP Standard Operating Conditions in North American Buildings. While it is feasible for TC 4.7 to resubmit a work statement after Tech Council turned down the TRP, further effort is not considered worthwhile.

Barnarby reported that ASHRAE's research funding is shrinking from $3.3M in recent years to $2.9M, which will significantly reduce the number of new projects in the short term because current spending is at the higher level.

Spitler chaired an extended discussion that centered on ASHRAE's request that TCs document the success of ASHRAE's research program. Associated with this request and the current level of research funding is a need to develop a strategic research plan for the future. Approaches to documenting success include:

- Review of past WS that led to research projects, to compile claimed benefits
- Review handbooks to highlight material coming out of ASHRAE research
- Survey of academics to determine where tools are used
- Note non-ASHRAE books that use ASH material, such as McQuiston, Parker and Spitler)
- Compile information provided by Bill Seaton about sales of ASHRAE publications.
- Compile a list of short courses, such as the one Pedersen taught based on 875-RP.
- Look for evidence of TC 4.7-traceable code in commercial use, including home-energy rating system web pages and computational tools that make use of DOE-2

A number of points were made in the discussion:

- Wray noted the difficulty in financially quantifying benefits.
- Haberl suggested that DOE (Crawley) could estimate the benefits of DOE-2, which relies on early ASHRAE research and is in turn used in support of ASHRAE Standard 90.
- Bahnfleth urged that a clear narrative of TC 4.7's large goals be prepared.
- Willson noted that such deliverables as the TC 4.7-sponsored toolkits are in the public domain and asked if commercial programs could be identified that make use of this knowledge. For example, PG&E (Hydeman) has reportedly used pieces of toolkit code in Cool Tools. Wrightsoft has a bin-method tool and Barnaby has made use of the ASHRAE publication on the modified bin method. Willson suggested that commercial offices be surveyed. Haberl added that the IBPSA members and conference attendees could be surveyed.
- Haberl noted that the bin method is still widely used as a teaching tool and that he has used results from 741-RP. He further noted that members want to be able to click on equations in an electronic handbook, download them and use them, and that the toolkits would be very useful in this context.
- Witte stated that many research results are not in commercial tools and that it would be useful to both encourage and track implementation efforts.
- Haves noted that not all research projects are successful and that it might be useful to look for common themes among those that are not, as a means of revising the way we do business.
- Bahnfleth asked if we have been responsive to the membership in putting together a research plan. Do our plans and goals align with the membership's needs, whether or not we achieve what we want?
- Brandemuehl asked if members understand the role of ASHRAE research, which produces results that may be embedded in commercial tools. In short, it is important to identify the impact ASHRAE research has had on other researchers.
- Witte suggested that there be a list of HVAC-related graduate students who once worked on ASHRAE-funded research and are now in industry.
- Wray expressed a need for continual information from chapters about research needs. Haves respond that little has come back. Those with criticisms have tended to be small firms with general needs, which don't see the benefits of specialized research. A better mechanism is needed to solicit needs.

Spitler announced the formation of two ad-hoc committees, each faced with a need to make substantial progress by mid-April:

1. Information request. This committee will follow-up on ideas listed in the minutes, track down information, and put together a document with an overview and specific factoids, testimonials and statistics. Vern Smith will act as chair. Spitler, Brandemuehl, Willson, Haydeman (Smith to ask), and Crawley will serve. Spitler will ask educators to provide information. Hensen will be asked to provide an international perspective.
2. Research plan. This committee will write a strategic research plan for TC 4.7, covering how to proceed in future to develop projects that will generate new knowledge and impact practitioners. The research plan should reflect coordination with other TCs, at least at section level. Haves will act as chair, joined by Spitler, Barnaby, Tim McDowell, Wray, and TC 4.7 subcommittee chairs.

5.5 Handbook. Handbook Chair Norford reported that he is reviewing galleys for the approved chapter and would attempt to insert a sentence about SMOT 140 (see Attachment H). Haves noted that local ASHRAE chapters directed most of their criticisms to the handbooks, believing that much useful material had been discarded in favor of newer and less practical research results. He suggested that several TCs might work together on portions of the handbook, rather than on individual chapters. Claridge stated that the electronic version of the handbooks, soon to be the official versions, will be updated annually. Barnaby noted that the handbooks lack coherent design procedures. Haves asked that the incoming Handbook Chair, Rick Strand, establish a high-profile agenda early in the next handbook cycle.

5.6 Program. Program Chair Bahnfleth outlined current and future program plans, detailed in Attachment I. Bahnfleth moved (Barnaby second) that TC 4.7 approve the program plan and presented. The motion was approved, 13-0-1 CNV.

5.7 Standards (SPC-140 SMOT). Neymark reported that SPC140P will become an SSPC upon publication of Standard 140. Judkoff will chair the committee, which will need new members. Neymark's report is provided as Attachment J.

6. Reports on related activities.

IBPSA. Barnaby reported that the Atlanta meeting of IBPSA-USA featured software demonstrations from seven vendors and an interoperability demonstration. Paul Linden spoke at dinner about airflow modeling using physical simulations with salt solutions dinner. Building Simulation '01 will be in Rio, August 13-15.

GPC 14P Measurement of Energy and Demand Savings. Sonderegger reported that the draft guideline has been voted for public distribution.

International Alliance for Interoperability. Crawley had nothing to report.

SPC 152 MOT Design & Seasonal Efficiencies of Residential Thermal Distribution Systems. Walton asked that this item be removed.

TC 4.1 Load Calculations. Spitler reported that the load calculations handbook chapter has been approved, as has 987-RP.

TC 4.2 Weather Information. Crawley reported that the 2001 Handbook of Fundamentals will contain monthly cooling design conditions and climate information for 220+ non-North America weather locations.

TC 4.5 Fenestration. Pedersen has nothing to report.

TC 4.6 Building Operation Dynamics. Brandemuehl reported that the work statement on dynamic cooling-coil modeling has been approved but not yet sent out for bid.

TC 4.11 Smart Building Systems. Norford had nothing to report.

TC 9.6 Systems Energy Utilization. Reddy reported that a forum on utility deregulation generated much interest and that a seminar on the same subject is planned.

7. Old business. None

8. New business. Haves and/or Barnaby will serve as liaison to the new XML committee, which is seeking ASHRAE approval as a GPC.

9. Adjourn. The meeting adjourned at 8:30 p.m.

ASHRAE TC 4.7 Energy Calculations

Agenda

Tuesday, January 30, 2001, 6:00-8:30 p.m.
Room 304E, Georgia World Congress Center

1. Roll call and introductions	Norford
2. Accept agenda & approve minutes of Dallas meeting	Spitler
3. Announcements	Spitler
4. Membership	Spitler
5. Subcommittee reports	
5.1 Applications	Huang
Life Cycle Cost Analysis	Huang
1093-RP Diversity Factors & Schedules for Egy & Loads (TA&M)	Reddy
5.2 Inverse Methods	Haberl
865-RP Accuracy Tests for Mech System Simulation (PSU/TAMU)	Walton
1050-RP Inverse Toolkit (U Dayton)	Kreider
5.3 Simulation & Component Models	Fisher
987-RP Loads Toolkit (UIUC)	Crawley
1049-RP Building System Design Synthesis (Loughborough U.)	Pedersen
1052-RP Analytical Test Suite Whole Bldg Egy Progs (OSU)	Walton
1145-RP Modeling 2&3-D Ht Transfer Thru Composite (Enermodal)	Beausoleil-Morrison
5.4 Research	Barnaby
1163-TRP Standard Operating Conditions in North American…	Spitler
Discussion of ASHRAE Research Funding Status	Barnaby
Research Program Success Documentation	Spitler/Fisher/Huang/Haberl/Barnaby
5.5 Handbook	Norford
5.6 Program	Bahnfleth
5.7 Standards (SPC-140 SMOT)	Judkoff/Neymark
6. Reports on related activities	
IBPSA	Barnaby
GPC 14P Measurement of Energy and Demand Savings	Sonderegger
IAI International Alliance for Interoperability	Crawley
SPC 152 MOT Design & Seasonal Eff'cies of Resid Thermal Distr Systems	Walton
TC 4.1 Load Calculations	Spitler
TC 4.2 Weather Information	Crawley
TC 4.5 Fenestration	Pedersen

TC 4.6 Building Operation Dynamics	Brandemuehl
TC 4.11 Smart Building Systems	Norford
TC 9.6 Systems Energy Utilization	Reddy

7. Old Business
8. New business
9. Adjourn

Web Site and Mailing List

TC 4.7 Web Site: http://www.mae.okstate.edu/tc47/

TC 4.7 E-mail List: This list is to be used only for commu nications related to TC 4.7. Do not distribute messages of any commercial nature. To subscribe or unsubscribe to the list, you must send an e-mail command to the address:

MAIL-SERVER@GARD.COM

Leave the subject line blank (if your e-mail software requires a subject, you may use a space). To subscribe to the mailing list, the body of the message should include the following:

SUBSCRIBE TC47-L

To unsubscribe from the mailing list, include the following in the body of the message:

UNSUBSCRIBE TC47-L

To see a list of subscribers, include:

LIST TC47-L

For a list of all available commands, include:

HELP

To send a message to all subscribers to the list, address your message to:

TC47-L@GARD.COM

Note: ASHRAE staff are not involved in the operation of these lists. Please do not ask them for help. If you have any questions, please contact: Mike Witte mjwitte@gard.com 847-698-5685 FAX 847-698-5600

TC 4.7 Subcommittee Meeting Schedule

(excerpted from http://www.ashrae.org -- Search for TC 4.7)

*TC 4.7 1049-RP (10) (OVH) Sunday 10a-12:00p 155W
*TC 4.7 1050-RP (10) Sunday 12:00-2:00p 155W
*TC 4.7 1145-RP (10) Sunday 2:00-3:00p 155W
*TC 4.7 987-RP Sunday 3:00-4:00p 155W
*TC 4.7 1093-RP (5)(OVH) Monday 7:00-8:00a 254W
*TC 4.7 Handbook (10) Monday 5:00-6:00p 202E
*TC 4.7 Simulation and Component Models (30) Monday 6:00-7:30p 202E
*TC 4.7 Applications (25) Monday 7:30-9:00p 202E
*TC 4.7 1052-RP (10)(OVH) Monday 11:15-12:15p 254W
*TC 4.7 Inverse Methods (15) Tuesday 3:30-5:00p 304E

Room assignment codes: All meeting rooms at the Georgia World Congress Center (GWCC) have numerical identification. The GWCC has meeting rooms on both the East and West Concourse. East Concourse has 2 levels and the West Concourse 3 levels. The number of the room identifies what level it is on, i.e., 308 E is on Level Three, East Concourse. Level Three on both the East and West Concourse is street level. East Concourse is the side closest to the Omni Hotel.

TC 4.7 Programs

Sunday, 8 a.m.- 10 a.m., Seminar: Low Energy Cooling Case Studies, Room 363W, GWCC
Sunday, 10:15 a.m. - 12:15 p.m., Symposium: Analysis Tools for the Design of Low Energy Cooling Systems, Room 363W, GWCC.

AGENDA

TC 4.7 Subcommittee on Applications
Monday, 29 January, 7:30 - 9:00 p.m.
202E, Georgia World Congress Center
Chair: Joe Huang
Secretary: Jeff Haberl

1. **Introductions (5 minutes)**
2. **Accept agenda and approve minutes of Minneapolis meeting (5 minutes)**
3. **Announcements (5 minutes)**
4. **Program Update (10 minutes)**

   Atlanta: Symposium on "Better Inputs for Better Outputs" (Willson)

   Cincinnati: Seminar on "Commercial Use of Building Energy Simulations" (Haddad, Addison, Huang)

   New Ideas?

5. ***Research***

   Discussion (15 minutes)

   Document benefits of TC 4.7's research program (Barnaby)
   Explain task purpose, develop method for quantifying benefits, identify volunteers for

   Should TC 4.7 develop a standard or guideline for Life-cycle Cost Analysis ?

- **Ongoing Project (5 minutes)**

  1093-RP "Diversity factors and schedules for energy and loads" (Reddy, PMC Chair)

- **Work Statements in Progress (30 minutes)**

  "Development of ground coupling cases for the proposed ASHRAE SMOT 140"

  (Neymark, Beausoleil-Morrison)

  "Methodology to define bounds of variability in building energy use predictions using detailed simulation models and how it can be incorporated in the design process" (Haddad, Wyndham-Wheeler)

  "Development of standardized computer input files for describing typical residential homes

  and the most common energy conservation retrofits" (Haberl, Kosny, Blake)

  "Defining performance factors for primary and secondary equipment simulation inputs for commercial buildings" (LeBrun, Nall)

  "Analysis and testing of Energy Cost Budget Method in ASHRAE 90.1" (Bahnfleth)

  "Energy performance simulation model for refrigerated warehouses" (Kosny, Huang)

7. Long Range Research Plan (10 minutes)

8. Old and New Business (5 minutes)

9. Adjourn

ATTENDANCE LIST

ASHRAE TC 4.7 Subcommittee on Applications
Monday, 29 January 2001, 7:30 - 9:00 p.m.
202E, Georgia World Congress Center

Name	E-mail:
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Michael Witte	Miwitte@gard.com

The meeting was called to order by Huang at 7:38 p.m.

Minutes from the Minneapolis meeting were distributed, an agenda and a sign-up sheet were then sent around, followed by introductions.

The committee was reminded that the minutes from the Minneapolis meeting were posted on the web.

A motion to approve the minutes (Barnaby), 2nd by (Smith). Approved.

Announcements were then made. Huang announced that we were looking for a replacement for Chair for the Applications subcommittee.

Joel Neymark announced that SPC 140 has been reformed as SSPC 140 and that they were looking for potential members.

Joe Huang then moved on to give an update on program. The symposium for "better inputs for better outputs" (Willson) is on track for Cincinnati.

Huang mentioned that there was also a Seminar scheduled for Cincinnati, "Commercial use of Building Energy Simulations" (Haddad)

Haddad mentioned that this was intended to bring in people that work in the private sector. A copy of the abstracts was distributed for discussion. Huang mentioned that the reason that he was circulating this was to discuss if this was the intended purpose of this. Huang said that a conference call was held to discuss this and that it was determined that a second call for papers was necessary since the papers were not on track. ACTION: Marlin Addison agreed to put the call for papers out, but no progress had been made on this.

It was mentioned that the Seminar authors would be encouraged to see if they would change their topics.
The committee agreed that it would be nice to get presentations from simulation users regarding how they use simulation.

ACTION: Smith agreed to see if he could get some abstracts.

There was additional discussion about what kind of papers were needed. Huang reminded the committee that the purpose of the Seminar was to bring in others not on this committee to discuss how they use simulation.

ACTION: Huang agreed to recontact Marlin to get another call for papers.

ACTION: Huang agreed to try to contact Steven Winter Associates.

ACTION: Fred Winkleman agreed to submit names from people that use DOE-2 as practitioners.

ACTION: Jan Hensen suggested to get someone from Ove Arup. Phil Haves said that he would help with this.

Huang then asked for additional ideas for Seminars.

Ian Beausoleil-Morrison suggested doing a Seminar on "Overcoming the barriers on the adoption of simulation". Beausoleil-Morrison said that this could include techniques used in other parts of the world to enhance the use of simulation.

Haberl said that simulation was being used in web applications, in home energy rating systems and in energy efficient mortgage programs.

Haves added that simulation was used in baselining tools.

Witte added that GRI had developed a DOE-2 based analysis with a simple front end.

Huang mentioned that DOE-2 was used in some roofing analysis programs.

Varkie Thomas of SOM has also developed an automated simulation analysis.

ACTION: Beausoleil-Morrison agreed to put more thought into this for the next meeting, possibly for Atlantic City.

ACTION: Joel Neymark and Jeff Spitler agreed to do a Symposium on "validation of computer simulation programs." This include analytical and comparative techniques, possibly for Honolulu. Haberl mentioned that there was a good chance there would be a paper from RP865.

The committee then moved to discussed research.

Barnaby and Spitler discussed the fact that TC4.7 was being asked to "document the impact of TC 4.7 research". Spitler also asked the subcommittee to look forward as well. How can we advance the state of the art in practice?

Haberl asked if the table included the completion of a publication.

Spitler said that for every project we needed to provide a list of benefits. He said that they had received a list of papers, reports, etc.

Haberl suggested that it would be good to know which textbooks this was being used in, also if the material was being used in class.

Huang mentioned that the California Energy Commission has sponsored work that could be traced to ASHRAE work.

Haberl mentioned that at the Handbook Seminar this morning someone asked that they would like to click on an equation and have a model download and run.

Spitler said that TC4.7 needed a strategic plan to see how these could get to the membership quicker.

Huang said that a note had been forwarded to him by Bruce Hunn about life cycle cost analysis.

Crawley said that there were ASTM publications on this.

Haberl said that there were some life cycle equations in TC 1.8's chapter.

Crawley said that BLCC 5 was also available from NIST over the web.

ACTION ITEM : Huang will forward e-mail to Crawley, who will write a reply with suggested sources on life-cycle costing.

Huang said that the next subject was discussion 1093RP. He said that the PMSC had a meeting with the contractor. The project was basically complete, a final report had been submitted, and recommendations had been made to go into the final copy. 49 profiles were submitted from 36 buildings. The main concern of the committee was that the contractors provide recommendations on typical load profiles for lighting and plug loads for typical large, medium, and small offices. The committee also asked for a user's guide, to be completed by 3/31/01.

Huang then wanted to go through the work statements in progress.

Discussion then moved to the WS "Development of comparative test cases for evaluating simulation models of slab and basement heat transfer to the adjacent ground.".

Neymark said that this was in progress. The level of effort seemed to be expanding as this was being discussed.

Jan Kosny said that this WS needed to be divided into parts. He suggested to divide this into, perhaps: slab on grade, then maybe basements.

Beausoleil-Morrison said that this was needed to develop a SMOT for ground heat transfer, including the method of test, type of comparisons, etc. That this was meant to be only a comparative test.

Neymark then outlined the work that would be needed to be a comparative test.

Beausoleil-Morrison said that he felt that there were at least 3 main models that were available. The contractor would be asked to do a literature search, develop test cases, etc.

Haberl asked if this also had some analytical tests as well. Beausoleil-Morrison said that this was not intended to be a analytical test.

Beausoleil-Morrison said that most of the work was in defining the work to be done, and then performing the simulations that would need to be done.

Kosny said that ORNL has 7 to 8 years of slab on grade building.

Haberl said that TAMU has 2 years of hourly data on a house in Texas.

Krarti reviewed what was needed to validate the model.

ACTION: Jan Kosny volunteered to help with the WS. Moncef Krarti will also provide comments.

Spitler said that the subcommittee needed to consider how this fits into TC4.7's long range research plan, for example how would these results be used, etc.

Spitler said that perhaps some other WS needed to be developed that would get simulation into the hands of users. That maybe this was useful but not as useful as some other RTARs.

Neymark said that this would help improve the reliability of the models.

Spitler asked how this would effect DOE-2 or EnergyPlus. Fred Winkelmann responded that Krarti and Bahnfleth were working on new models for EnergyPlus.

ACTION: Neymark and Beausoleil-Morrison said that they would work on this with input from Kosny and Krarti.

Huang said that there were 5 more WS in development.

One RTAR was "Methodology to define bounds of variability….". Huang said that Agami had started this but did not have time to work on this.

ACTION: Haddad wanted to continue to work on this.

Huang then moved on to discuss "development of standardized computer simulation…". Haberl said that no progress had been made on this.

Kosny wanted to add more information about statistics.

Buhl said that the "prototype" code was needed.

Haberl said that the purpose was to produce a reduced input simulation file that used dynamic variables.

ACTION: Haberl and Kosny will work on this WS. Huang also agreed to help with this.

Discussion then moved to "Energy performance simulation model for refrigerated warehouses", by Jan Kosny.

Kosny reviewed the specifics about this proposal and the committee thought it was a good idea.

Huang recommended that Kosny get in touch with TC 10.5 on Refrigeration Storage Facilities.

Krarti has also done analysis on foundation heat flows from refrigerated warehouses.

ACTION: Kosny said that he would work on the WS, with help from Huang and Krarti.

Discussion then moved to the long range research plan. Huang said that this would be moved to the next meeting in Cincinnati.

There was a motion to adjourn that was seconded. The meeting was then adjourned at 9:05 p.m.

TECHNICAL COMMITTEE 4.7 – ENERGY CALCULATIONS
APPLICATIONS SUBCOMMITTEE
Work Statement under Development

PROJECT TITLE

Methodology to Define Bounds of Variability in Building Energy Use Predictions Using Detailed Simulation Models and How It can be Incorporated in the Design Process

BACKGROUND

Designers in engineering firms use detailed building and plant energy simulation programs (such as DOE-2, TRNSYS, BLAST, or HVACSIM+) in order to size equipment and determine the corresponding seasonal and annual energy use of alternative designs. Final selection is based on several factors such as client desires, architectural aesthetics, optimal space usage, first costs and operating costs. The focus of this project is on the first cost of the HVAC equipment and its associated seasonal and annual energy costs.

Simulation results from building energy programs are inherently deterministic in that a unique value or a profile (over a design day) is found. The effect of variability in the input drivers such as internal loads, lighting levels, operating hours, or occupancy patterns can be studied by repeating the simulations with the new set of inputs, an exercise often referred to as "sensitivity analysis". Though experienced designers include this effect in some form or another (a common option is to over-design equipment), there is a need to systematize this process by exploring the various techniques that could be used for this purpose and suggest one or two methods which could be adopted by the professional community. This is bound to lead to sounder and more rational design selections.

OBJECTIVES

There are three objectives to this project :

1. Identify different methodologies used in allied engineering fields whereby the bounds of variability or uncertainty in the resulting energy use predictions (either a diurnal profile for equipment sizing or monthly peak and total energy use values) can be quantified in terms of the uncertainty in the input drivers. Several methodologies have been used, which can be broadly separated into two categories: deterministic and stochastic or probabilistic. The sensitivity analysis option is inherently deterministic, while techniques such as the Bayesian approach (Carroll and Kammerud, 1998) would fall under the probabilistic category.
2. Select at least two different methodologies (which the contractor would need to justify) and adopt them for use with existing detailed building energy use simulation algorithms. Evaluate the two methodologies with realistic variation in the input drivers. Past ASHRAE research results such as RP 1093 on "Diversity Factors and Schedules for Energy and Loads" and other existing sources of data should be identified and used during this evaluation. The impact on the simulation results with uncertainty in the input drivers should be evaluated for two or three different locations and two or three different types of buildings.
3. The contractor should study and determine whether the increased simulation effort and analysis is justified during the design phase in terms of "better" HVAC and plant selection, in other words, whether such a

methodology is justified from a practical point of view. Concrete recommendations as to what is needed in terms of documentation and training should be spelled out so that the methodology could be adopted by the building engineering community.

Estimated budget AND DURATION

$ 95,000 over 18 months

WORK STATEMENT CONTRIBUTOR

T.Agami Reddy, Drexel University

References

Carroll, W.L. and Kammerud, R.C., 1998, "White Paper: Cooling Load Profile Issues", PG&E *CoolTools* Project, report submitted to PG&E, October.

TECHNICAL COMMITTEE 4.7 – ENERGY CALCULATIONS

APPLICATIONS SUBCOMITTEE

Work Statement under Development

PROJECT TITLE

Development of standardized computer simulation input files for describing typical residential homes & the most common energy conservation retrofits.

BACKGROUND

It has been estimated that there are millions of homes sold in the United States each year that could utilize a simulation-based energy efficient rating system to help qualify buyers for larger mortgages. Such a rating system would qualify a homeowner for a larger mortgage based on the lower anticipated utility rates as simulated by a building energy simulation program. Current proprietary software that perform such tasks yield widely different answers when compared to one another, and because their internal code is proprietary, are difficult and costly to verify and/or upgrade. Although efforts have been developed to test the accuracy of such codes against specific test cases (i.e., the HERS BESTEST procedure developed by Judkoff et al. at NREL) it is virtually impossible to audit each and every transaction from different programs to determine if a specific mortgage application is utilizing the proper input values for a specific software package.

Another problem with the existing proprietary software is that none of the packages have been developed in such a way that they could be quickly and inexpensively run (i.e., run on PCs at the mortgage lending office) and yet would allow for a centralized audit of each and every transaction (if one should ever be needed). This problem can be illustrated with a simple example using one state.

In Texas, for example, it has been estimated that at least 250,000+ mortgages could benefit from energy efficient mortgages. If a centralized processing system is used to process all applications (as is proposed with at least one of the systems) then 4,807 applications would need to be processed each week, which amounts to 120 applications processed each hour of a 40 hour work week (assuming that a bank would want a quick turn-around). This leaves only 30 seconds to process each applications which is greater than the time it takes receive the input file, perform an annual simulation on the residence with a simulation program such DOE-2 and return the answer. Therefore, none of the current proprietary software systems, as currently configured, could handle the anticipated processing loads without expensive modification to their internal source codes.

Therefore, it is proposed to develop a verifiable, *public-private* software system that would accomplish this task. In such a proposed public-private software system the *public portion* of the software would consist of: 1) well-documented EnergyPlus templates that would be used to accurately simulate the most common energy efficient residential design options, 2) compliance checking rules, and 3) an audit transfer file protocol for transferring a copy of the site-specific information of each simulation to a central depository.

The *private portion* of the software system would then consist of Graphical User Interfaces (GUIs) that would be developed, maintained and sold by private software developers using ASHRAE's software specifications. This proposed public-private software system would deliver well-developed, cost effective software that could be easily validated, and yet remain flexible to accommodate changes in energy efficient design in the future.

Economically, there is plenty of motivation for developing such software systems. If a $25 fee is charged for the processing of an energy efficient mortgage application (a reasonable amount based on other fees that are already being charged), then several million applications of the program each year would equal $75 million per year in potential total revenue. If a proposed public-private software system of fees could be developed then this amount

could be divided between the banks ($5/applicant, $15 million/year), the private software developers ($15/applicant, $45 million/year) and a national entity that could be established for archiving the 3 million uses each year and promoting new R&D on the public domain templates ($5/applicant, $15 million/year). If the use of the software reduced the average residential utility bill by 10 to 20% it could save $100 to $200 per year per customer which would amount to $300 to $600 million in reduced energy bills nationwide for the anticipated 3 million loan applicants each year.

The proposed system is based on the well-proven procedures used by USDOE to develop the DOE-2, and now the EnergyPlus, software. The public-private partnership would deliver a cost effective verifiable software that utilizes privately developed and maintained GUIs. Adding new EnergyPlus input file templates that simulate new energy efficient design options could easily be accomplished with the public-private system and quickly disseminated to customers. The cost of developing such a system is also minimized because the cost is shared with private developers who are rewarded when users use their software (perhaps on web-based platforms).

Finally, the proposed system is designed to be flexible to allow for future modifications. This is an important feature in a dynamic market such as the housing market where new energy efficient designs are developed each year. The flexibility would also allow for research and development to take advantage of new EnergyPlus simulation techniques developed by the USDOE and ASHRAE. Examples of this include improved ground heat transfer models and models that can simulate air flow between the rooms of a house.

JUSTIFICATION

At the current time ASHRAE does not have well-documented simulation templates for typical residential housing types that could be used by private residential energy analysis software developers to develop energy efficient mortgage (EEM) rating software or home energy rating (HER) software. Although procedures have been developed to test EEMs and HER software packages (i.e., HERS BESTEST), such procedures are not capable of providing verifications on a transaction by transaction basis. Furthermore, proprietary software that has been developed for EEMs and HER analysis gives widely varying results for the same house and are not capable of being easily expanded to keep up with new energy efficient technologies being developed for the residential housing market.

It is therefore necessary to develop EnergyPlus templates and a basic calculation framework for accurately calculating the annual energy use of residential housing. Such a basic system would be capable of simulating complex housing types with a relatively few inputs, and would be easily expanded by adding new templates that could then be incorporated into proprietary packages (in much the same way that the DOE-2 program is developed and delivered to users). Software vendors could then concentrate their efforts on the GUIs and rely on ASHRAE-funded efforts to develop the computational engine.

ASHRAE has already initiated several previous efforts to develop similar toolkits for simulating Primary (HVAC01) and Secondary (HVAC02) systems, and is currently developing a toolkit for inverse calculation methods (RP1050). The proposed toolkit would be similar to these previously developed toolkits.

The project will benefit the following:

1. ASHRAE to widen the acceptance and applicability of simulation methods in the analysis of energy conserving features of residences.
2. Software code developers/users as an aid for developing home energy rating software (HER) and energy efficient mortgages (EEM).
3. HVAC building energy analysis book publishers as an aid for developing more effective text and courses.

4. ASHRAE for use in developing effective training programs for users of simulation programs, and as a means of residential simulation program documentation.
5. ASHRAE members as an aid for better understanding of how simulation programs can be used in their day to day practice.
6. ASHRAE for use in a better understanding of why and how building energy software programs can be used to improve HVAC performance and indoor air quality.

OBJECTIVE:

The objective of this project is to develop public-domain input templates for the EnergyPlus program and a computational framework that can be used as the basic computation engine for private residential energy analysis software developers. These input templates would consist of a library of the most common residential housing shapes and HVAC-system combinations that would reduce the needed inputs to a minimum number of variables that could be passed to the program by a privately-developed GUI.

The templates and the input variables from the GUI would then be fed to the EnergyPlus program to perform the calculation using a standard weather file. Results would then be passed back to the private GUI for display. The reduced input file and EnergyPlus instruction set would then serve as the audit trail for checking purposes.

SCOPE:

The specific *tasks* necessary to accomplish this are as follows:

1) Perform a literature search to document the relevant work.

2) Develop and verify standardized EnergyPlus input file templates for simulating selected energy conserving features for typical US residences.

3) Develop a pre-processing control program that incorporates site-specific information describing a residence with the standard EnergyPlus templates and the appropriate weather files for use by the EnergyPlus simulation program.

4) Develop standard outputs that will allow for proprietary programs to develop a post-processing control program that extracts specific information from the standard EnergyPlus output files for use by Home Energy Rating Software (HERS), Model Energy Codes (MEC), Energy Efficient Mortgage (EEM) programs or other programs that could present the information in a more useful graphical format.

5) Develop a prototype compliance checking routine that would detail how the templates and framework are to be used to check compliance for energy efficient mortgages, etc.

6) Develop a standard audit transfer file that could be used to send documentation to a centralized depository for collection and analysis.

WORK PLAN

Task 1) Perform a literature search to document the relevant work.

Task 2) Develop and verify standard EnergyPlus input file templates for simulating selected energy conserving features in residences.

This task would include the development of a library of dynamic EnergyPlus input file templates for analyzing housing types commonly found in the major U.S. climates. Such templates would include models that would be capable of simulating houses with one or more conditioned zones, attics, attached garages, crawlspaces, etc. Use of "dynamic" variables would be necessary, which are similar to the DOE-2 "##INCLUDE" variables that would allow the user to use simplified generic descriptions of a house (e.g., windows on the east side are 10% of the floor area, etc.). Development of a library of input file templates would allow for a number of commonly available houses to be simulated (i.e., one zone, two zone, one story, two story, etc.).

The templates would allow for the constrained analysis of typical energy efficiency measures, including:

1) (envelope measures) wall, roof and floor insulation levels, window types, size and placement, exterior colors of roof and wall,

2) (mechanical systems) equipment type, equipment efficiency, duct leakage and duct heat gain, natural ventilation, etc.,

3) (occupant) varying electrical usage and schedules; interactions of internal heat gain with space heating/cooling loads and thermal mass; thermostat setpoint schedules, DHW load characterization, etc.

(4) (building layout and site analysis) multiple building types (1-story, 2- story, one zone, two zone, L-shaped, square-shaped, multizone, etc.), shading of exterior surfaces, solar absorptance of exterior surfaces, rotation of the building plan, etc.

(5) (cost information) input variables for local utility rates, etc.

The proposed public domain EnergyPlus template framework would also allow for the development and verification of new energy efficiency design options to be added in the future.

Task 3) Develop a pre-processing control program that incorporates the site specific information with the standardized EnergyPlus input file templates and U.S. weather files for use by the simulation program.

This task would develop the file structures and control procedures that would demonstrate how the site-specific information and weather data are to be combined with the EnergyPlus program during execution. The site-specific files and EnergyPlus input file templates would consist of ASCII files to facilitate easy viewing of the file contents for editing purposes. The weather files would consist of the appropriate TMY2 or WYEC2 files for the U.S. cities. All files and control processes would be fully documented to allow for easy transfer to the private GUI developers.

Task 4) Develop a post-processing control program that would allow for standard information to be extracted for use by Home Energy Rating Software (HERS), Model Energy Codes (MEC) and Energy Efficient Mortgage programs.

This task would consist of the identification of the relevant EnergyPlus output pages and information that would need to be extracted for assembling data to be fed to Home Energy Rating Software (HERS), Model Energy Codes (MEC) and Energy Efficient Mortgage programs. A demonstration extraction program would also be included that extracts selected information and places the information in an example file.

Task 5) Develop a prototype compliance checking routine that would show how the templates and framework are to be used to check compliance for energy efficient mortgages, etc.

This task would consist of the development of a program that would develop energy use "targets" that would be used to check for compliance of a specific simulation run, including how the compliance numbers are extracted from

an EnergyPlus simulation. Such a demonstration program would used by the private GUI developers to develop their compliance checkers that would actually perform the compliance check each time the program is run.

Task 6) Develop a standard audit transfer file that could be used to send documentation to a centralized depository for collection and analysis.

This task would consist of the development and demonstration of an audit transfer file that will be used by all private GUI developers to record all paid transactions when their software approves an energy efficient mortgage. This audit transfer file could then be sent electronically to a central office for archival and analysis purposes via the internet. The audit transfer file would contain all relevant site-specific information (name, address, building characteristics, weather file used, etc.) to allow the central office to re-simulate the building in cases where a dispute arises and/or for nationwide analysis of program usage.

DELIVERABLES

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

b) The Principal Investigator shall report in person to the TC at the annual and winter meetings, and answer such questions regarding the research as may arise.

c) All computer code will be documented according to the recommendations of ASHRAE's computer software policy. This shall include:

d) A well documented, complete FORTRAN 90 source code that can be freely distributed or licensed by ASHRAE.

e) FORTRAN 90 executable code for MS DOS and MS Windows personal computers, including electronic copies of input and output file examples for testing purposes.

f) ASHRAE shall retain copyright of all computer code delivered as part of this project and all derivative works from such computer code.

g) A Final Report shall be prepared and submitted to the Manager of Research by the end of the contract period covering complete details of all research carried out on the project. Unless otherwise specified, six draft copies of the final report shall be furnished for review by the Project Monitoring Subcommittee (PMS).

h) Following approval by the PMS and the TC, final copies of the final report will be furnished as follows:

- An Executive Summary suitable for wide distribution to the industry and to the public.
- Six bound copies.
- One unbound copy, printed on one side only, suitable for reproduction.
- Two copies on electronic media, in Microsoft Word 6.0.

i) One or more Technical Paper(s) shall be submitted in a form suitable for presentation at a Society meeting. The Paper(s) shall conform to the Society's "Submitting Manuscripts for ASHRAE Transactions" which may be obtained from the Special Publications Section.

j) All papers or articles submitted for inclusion in any ASHRAE publication shall be made through the Manager of Research and not to the publication's editor.

k) A Technical Article suitable for publication in the *ASHRAE JOURNAL* may be requested by the Society. This is considered a voluntary submission and not a deliverable.

LEVEL OF EFFORT

1. Obtain, review, and categorize the readily available technical literature relevant to the simulation of residential buildings.

1) Perform a literature search to document the relevant work.

- Labor for researchers and engineers: 10%

2) Develop and verify standardized EnergyPlus input file templates for simulating selected energy conserving features for typical US residences.

- Labor for researchers and engineers: 40%

3) Develop a pre-processing control program that incorporates site-specific information describing a residence with the standard EnergyPlus templates and the appropriate weather files for use by the EnergyPlus simulation program.

- Labor for researchers and engineers: 30%

4) Develop standard outputs that will allow for proprietary programs to develop a post-processing control program that extracts specific information from the standard EnergyPlus output files for use by Home Energy Rating Software (HERS), International Building Codes (IBC), Energy Efficient Mortgage (EEM) programs or other programs that could present the information in a more useful graphical format.

- Labor for researchers and engineers: 5%

5) Develop a prototype compliance checking routine that would detail how the templates and framework are to be used to check compliance for energy efficient mortgages, etc.

- Labor for researchers and engineers: 5%

6) Develop a standard audit transfer file that could be used to send documentation to a centralized depository for collection and analysis.

- Labor for researchers and engineers: 10%

Total person-months = 18 person-months, approx. cost $95,000, completed in 18 calendar months or less.

OTHER INFORMATION FOR BIDDERS

1. Contractor will demonstrate their knowledge of simulation programs, including the EnergyPlus program.

2. The proposed budget shall include a reasonable breakdown of the costs of performing the work, including travel, programming, computer supplies, computers, etc.

3. The proposal shall include a detailed timetable including the logistics of accomplishing the major tasks outlined above.

The successful bidder shall demonstrate:

4. Their familiarity with simulation programs, and the simulation of residential structures.

5. Their familiarity with data from residential HVAC and other systems, including the ability to obtain such data, and a knowledge of methods used to statistically analyze such data.

6. Their ability to conduct a thorough literature search, including personnel experience, and knowledge of the sources of such materials, and demonstrated report writing capabilities..

7. Their project plan, project timetable, budget detail, and proposal documentation in support of the project methodology.

ESTIMATED COSTS:	DURATION:
$95,000	18 calendar months

CONTRIBUTORS:
Jeff Haberl
Joe Huang

APPLICATIONS SUBCOMITTEE
Work Statement under Development

PROJECT TITLE

Defining Performance Factors for Primary and Secondary Equipment Simulation Inputs for Commercial Buildings

OBJECTIVE

The objective of this research is to develop guidelines on how to model commercial HVAC equipment in hourly building energy simulation program relying only on performance specifications obtained from the manufacturer. This is the situation typically confronted by users of simulation programs in engineering applications, but the mapping of manufacturer's performance data to the inputs needed by programs such as DOE-2 or BLAST is neither straightforward nor well-understood. The available data are often incomplete, and may differ in their assumptions and terminology. On the other hand, the input descriptions required by simulation programs often appear to many engineers as idiosyncratic and differ from industry conventions. The project seeks to bridge this gap between what the manufacturer's data provide and what the simulation programs need. This research would include: (1) literature review of what types of technical information are available from manufacturers and an assessment of their usefulness for building energy simulations, (2) review and explanation of how commercial HVAC equipment are modeled in commonly used simulation programs, (3) develop guidelines and procedures on transforming manufacturer's specifications to input data for simulation programs, and (4) assembling such information into an ASHRAE Toolkit including the appropriate documentation, software if needed, and examples of its application for various types of equipment.

BENEFITS

The project will benefit ASHRAE membership as well as the general public as follows:

1. Improve the accuracy of energy simulations and design calculations by eliminating or reducing a source of error in modeling assumptions.
2. Promote the use of computer simulations as a tool for engineering design and evaluating system performance.
3. Inform the ASHRAE membership and the wider engineering profession of the relationships between manufacturer's specifications and seasonal performance of HVAC equipment.

ESTIMATED COST AND DURATION12

$50,000 over 12 calendar months

METHOD OF PUBLISHING RESEARCH RESULTS

A Technical Paper will be presented at an ASHRAE meeting. An ASHRAE special pub. may also result.

POTENTIAL CO-SPONSORS

None yet identified.

WORK STATEMENT CONTRIBUTORS

Dan Nall, Jean LeBrun

TECHNICAL COMMITTEE 4.7 – ENERGY CALCULATIONS
APPLICATIONS SUBCOMMITTEE
Work Statement under Development

PROJECT TITLE

Energy Performance Simulation Model for Refrigerated Warehouses

BACKGROUND

Refrigerated warehouses are traditionally of highly insulated lightweight construction. In the last decade, several research studies have indicated that significant energy saving can be achieved if the design of such buildings were improved and optimized based on results from detailed whole-building energy simulations (ref ?). At present, it is still extremely difficult to analyze the energy performance of refrigerated warehouse using available building energy simulation programs due to the very low temperature inside such warehouses, and the special requirements this places on the building shell and cooling system.

Refrigerated warehouses are composed mainly of three areas: the freezer, office, and loading dock. The freezer area constitutes the majority of the warehouse space and is maintained at temperatures as low as -30°F. The building envelope is fabricated with highly insulated material. A desiccant cooling system is recommended as a supplement to the main refrigeration system to dry the air in the loading dock. Such a system removes humid air from near the loading dock door, dries it with a desiccant wheel, and return it to the back wall of the dock which is in front of the freezer doors. This dry air serves as a buffer zone that reduces the amount of moist air entering the freezer. This allows the freezer to defrost less frequently, as well as prevents ice and condensation to form on the loading dock floor. The cooling load handled by the gas-powered desiccant system lessens the electricity peak demand and usage.

OBJECTIVE

The goals are to promote energy-efficient design, construction, and operation of refrigerated warehouse buildings through the use of whole building energy simulations. This effort will require analysis of the thermodynamic stresses of the building fabric, and the requirements for the cooling equipment and operations. Based on this information, the project will modify or adapt existing building energy simulation techniques to produce a model or procedure for making whole building simulations, and then use that method to identify energy-efficiency improvements in the design, construction, and operations of refrigerated warehouses. This simulation model will likely require the integration of the building envelope system with a combined desiccant/vapor compression HVAC equipment.

SCOPE

1. Development of a whole building simulation model for refrigerated warehouses

2. Validate the computer model using experimental data from existing refrigerated warehouse.

ESTIMATED BUDGET AND DURATION

$ 120,000 over 18 months

WORK STATEMENT CONTRIBUTORS

Jan Kosny, Joe Huang

Report by PMSC on Progress of ASHRAE 1093-RP

Compilation of Diversity Factors and Schedules for Energy and Cooling Load Calculations

(January 29, 2001)

The PMSC (Reddy, Huang and LeViseur- Bahnfleth absent) and the contractors (Jeff Haberl and David Claridge) met at 7:00 am to review progress. The project is basically complete since a draft final report has been submitted a few months back. The PMSC reviewed the document and made certain specific recommendations on summarizing the research results into a small set of prototype profiles for lighting and plug loads for typical large, medium and small offices, along with a user's guide.

The following milestones were set:

(i) The contractors will provide a detailed response to the PMSC in about two weeks regarding the recommendations, and how they propose to address these.
(ii) The contractor would submit the revised final report by end of February to the PMSC members.
(iii) The PMSC will hold a conference call with the contractor in mid-March to discuss the final report.
(iv) The PMSC chair will contact pertinent TC 4.7 personnel and Bill Seaton regarding outcome, i.e., whether the project has been completed to satisfaction, or whether an extension beyond the March 31st end-date is required.

The overall agreement was that the performance of the contractors was satisfactory. At least three papers to be written based on this research, and Suzanne LeViseur to organize pertinent symposium.

TC 4.7 SUBCOMMITTEE ON INVERSE METHODS

Tuesday, January 30th, 2001, 3:30 to 5:00 p.m. (90 minutes)
Congress Center, 304E

Chair: Jeff Haberl
Secretary: Joe Huang

MINUTES

AGENDA

1. Introductions

2. Discussion of the minutes from the Minneapolis meeting, June 2000

3. Program
- June 2001 meeting (Cincinnati)
- January 2002 meeting (Atlantic City)
  SEMINAR "Automated baseline procedures using inverse methods" (Haberl)
- June 2002 meeting (Honolulu)
  SYM "Inverse methods for calculating savings from energy conservation retrofits" (Kreider)
  PAPER "RP1050 Inverse methods" (Kissock et al.)
  PAPER "SMTP Method" (Abushakra)
  PAPER "Neural Network Savings Calculation Method" (Krarti)
- January 2003 meeting (Chicago)
- June 2003 meeting (Kansas City)

4. Discussion of Work Statements
- WS 1051 "Procedures for reconciling computer-calculated results with measured energy data" (Haberl/Sonderegger)
- WS "Inverse bin procedures for analyzing energy savings" (Haberl)
- WS "Development of a procedure for baselining energy use at large central plants." (Krarti)
- RTAR "Methodology Development to Extend ASHRAE Semi-empirical Chiller Models to include Models for Screw Chillers, Package Air-conditioners, and Heat Pumps." (Reddy)
- RTAR Genetic Methods (Nelson)
- TITLE ONLY Inverse Methods for Parameter Determination for HVAC01 and HVAC02 Toolkits (LeBrun)
- Other work statements (all)?

5. Long Range Research Plan

6. Old Business

7. New Business

8. Adjourn

ATTENDANCE

NAME	AFFILIATION	EMAIL
Jeff Haberl	Texas A&M	Jhaberl@tamu.edu
Joe Huang	LBNL	Yjhuang@lbl.gov
David Eldridge	OSU	Eldridd@okstate
Ian Beausoleil-Morrison	NRC Canada	Ibeausol@nrcan.gc.ca
Jim Willson	Honeywell	Jimwill@indy.net
Fred Hollman	Consulting Engineer	Fhollman@easyon.com
Chip Barnaby	Wrightsoft	Cbarnaby@wrightsoft.com
Vern Smith	AEC	Vsmith@archenergy.com
Kamel Haddad	NRC Canada	Khaddad@nrcan.gc.ca

The meeting was called to order at 3:51 by Jeff Haberl, followed by introductions.

Haberl reviewed the agenda with the subcommittee members and suggested to the members that Item #4 would be discussed first followed by item #3. Haberl encouraged the attendees to look at the TC 4.7 Inverse minutes which are posted on the TC 4.7 web page.

MOTION: It was moved by Huang and Seconded by Ian, to approved the meetings. Motion passed.

Haberl then moved to the discussion of the Work Statements (WS). All were submitted as RTARs at the 2001 Minneapolis subcommittee meeting. Haberl gave a brief introduction to each, and then gave the attendance 10 minutes to read the WS 1051.

WS 1051 was then discussed, entitled: "Procedures for reconciling computer-calculated results with measured energy data". This was first written by Haberl. Major editing was then done by Robert Sonderegger a year ago. Sonderegger returned the WS back to this subcommittee at the Minneapolis meeting, where there were relatively minor editorial comments. For this meeting, Haberl made revisions based on comments received, but the WS is essentially the same as what was presented in Minneapolis.

WS # 2 "Inverse bin procedures for analyzing energy savings", also by Haberl. This was edited in response to comments received at the Minneapolis meeting.

WS # 3 "Development of a procedure for baselining energy use at large central plants". This WS was originally written by Moncef Krarti, who is unable to attend. Therefore, Haberl suggested that discussion on this WS be moved to the end of the meeting.

The subcommittee then read WS 1051 : "Procedures for reconciling computer-calculated results with measured energy data", followed by a lively, productive discussion.

Beausoleil-Morrison recommended that some activity be added to demonstrate and independently test the procedure (under Item Number 3). He wanted clarification on what building types are being considered. Haberl said the procedures are not meant to be limited to specific building types.

Barnaby thought that the absence of a standard calibration technique is not a good enough justification for the work, i.e., there are many activities in ASHRAE for which no standard procedure exists, but which ASHRAE does not fund. Therefore, the WS must give a better justification on the benefits for a calibrated model.

Willson said that a calibrated model is very useful as the most accurate predictor for energy savings. However, the acceptance of results from a calibrated model requires a good amount of education. Willson also thought that the procedure must include monthly data, and not just hourly data. There are many instances where hourly data do not exist, but monthly data already do.

Haberl said the WS has gone through several iterations, and was therefore deemed to be pretty "tight", and had had hopes that it would voted out of subcommittee for discussion at the main TC 4.7 meeting.

Barnaby mentioned that there was no hurry since ASHRAE had more "approved" work statements than they had money for at the moment, and therefore it was reasonable to take one more iteration on this, with additional discussion and possible action at Cincinnati.

Beausoleil-Morrison said that the development of calibrated models would also increase its acceptance by designers.

Haberl suggested that extra text be added on the benefits of this WS to GPC-14.

Willson wants the calibration procedure to handle monthly data because that is often all that is available. Haberl said that he cannot envision a calibration procedure that did not require site visits or some measured data. He also told the subcommittee that GP-14 had two calibration procedures: monthly plus short-term measurements and long term measurements and that he felt that this WS should try to support GP-14 with the procedures that are developed.

Beausoleil-Morrison said that calibration of residential building energy use in particular has to work off of monthly data.

ACTION: Both Beausoleil-Morrison and Willson recommended that additional text be added explicitly that the procedure will work with monthly data. Haberl agreed to this.

Willson then mentioned that it was not clear to him what the benefits to GP-14 were. Haberl agreed that this could be tightened up.

ACTION: Haberl will add text on what are the specific benefits of GP-14 and performance contracting.

Haberl then summarized all the recommended changes, and would incorporate them into the WS .

1) Addition of material clarifying the development of monthly and hourly calibration methods.

2) Addition of benefits to performance contracting, mention of specific benefits to GP-14.

3) Addition of #5 to "benefits" "Performance contracting…"

4) Clarification of #4 to be more specific about benefits to GP-14.

5) Demonstration to include "independent test" of the procedure.

ACTION: Haberl will edit the WS and send it out to the subcommittee quickly.

ACTION: Barnaby will review and return the WS to Haberl, who will then prepare it for Cincinnati.

Discussion went on to the second Work Statement.

WS #2 -"Inverse bin procedures for analyzing energy savings".

Beausoleil-Morrison said the WS sounded like it's saying 1050-RP is not good enough.

Haberl said that there were questions about the usefulness of 1050-RP since it does not cover all building types, and that there are many cases of buildings with more than one change-point for which the model developed would not work.

In response to a question by Willson, Haberl clarified that the inverse bin method requires hourly data. Beausoleil-Morrison followed that up by suggesting the WS be modified to say that the previous models were okay if one had only monthly or daily data, but that if one had hourly data, one can use the inverse bin model specified by this WS.

Beausoleil-Morrison suggested that the WS be modified to say this would be an "enhancement" rather than new module in the existing 1050 toolkit (which implies that 1050RP needs more work).

Vern Smith asked about the public-domain nature of the proposed software, referring to the decision of the EnergyPlus team to not use the ASHRAE primary toolkit due to concerns about the rights. There was quite a bit of discussion about this. Barnaby informed the group that this was a mistake by ASHRAE that the HVAC01, HVAC02 and LOADS toolkits were supposed to be public domain. He said that ASHRAE staff had made a mistake with the HVAC01 toolkit and inserted the "boilerplate" copyright statements instead of the carefully worded copyright statement that the PMSC required to assure that the source code would be completely public domain (all that is required is that any derivative work give reference to the fact that it contains algorithms from ASHRAE).

Haberl said that the software was specifically intended to be publicly available, and usable by others without restrictions in future works.

ACTION : Haberl will modify the WS to make it more clear the inverse bin tool will be usable only on hourly data, and that it's an "enhancement" to the 1050-RP toolkit,

Haberl decided to table discussion on the third WS because the author (Krarti) was unable to attend.

ACTION: Haberl will notify Krarti to edit the WS to match the new format for WS (as posted on the ASHRAE web page) and have Krarti bring to the Cincinnati meeting for a lively discussion.

The discussion now moved to program. Haberl said that this subcommittee has no program for Cincinnati or Atlantic City. However, there is symposium on "inverse method for calculating savings from energy conservation retrofits" for Honolulu (originally scheduled for Atlantic City, but moved to Honolulu due to the delay of the deliverables from to1050RP). This symposium contains one or more papers on 1050RP, a paper by Abushakra (LBNL), and one on neural networks by Krarti.

Haberl asked for new ideas for program at upcoming ASHRAE meetings. Haberl asked whether there was any interest in getting contractors of energy service companies (ESCOs) to participate in a program on what tools they use to calculate energy savings?

Willson thought that the ESCO industry need time to review and digest GP-14. However, he thought that it would be reasonable to expect that in the future they would probably have materials to contribute to a seminar or forum.

Haberl then mentioned to the committee that he was aware of several web sites that were performing automated baseline calculations, which used inverse methods. He suggested that this would make a good seminar for Atlantic City. There was some discussion on this, and the subcommittee agreed that this would indeed be a good topic for a seminar.

ACTION : Haberl agreed to chair a seminar on "Automated baseline procedures using inverse methods" for Atlantic City, and bring a completed package to the meeting in Cincinnati.

The agenda now moved to the Long Range Research Plan. Haberl said that this will be discussed at the meeting in Cincinnati. He encouraged the subcommittee members to forward any and all thoughts about possible RTARs and/or other research ideas for discussion at the Cincinnati meeting.

ACTION: Haberl will make the following changes to the agenda: (1) the Fourth WS by Reddy should be listed as a RTAR, (2) all ONE PAGERS should be listed as RTARs.

Haberl thanked the members of the subcommittee for their attendance and lively discussion and invited them to be at the TC 4.7 Inverse Subcommittee meeting in Cincinnati.

MOTION: There was a motion to adjourn the meeting by Huang, seconded by Beausoleil-Morrison. Motion carried.

The meeting was adjourned at 5:05 p.m.

MEETING ADJOURNED.

ATTACHMENTS:

WS 1051 "Procedures for reconciling computer-calculated results with measured energy data" (Haberl/Sonderegger)
WS "Inverse bin procedures for analyzing energy savings" (Haberl)
WS "Development of a procedure for baselining energy use at large central plants." (Krarti)

WORK STATEMENT FROM TC 4.7 ENERGY CALCULATIONS

TITLE

(WS 1051) Procedures for reconciling computer-calculated results with measured energy data.

Background

U.S. businesses and institutions spend an estimated $175 billion per year for energy. Of that amount, the fraction under performance contracts and energy service agreements is currently growing, aided by cheaper monitoring technology and integration with EMCS systems. Energy simulation programs are used both for estimating potential savings as well as to help in verifying savings from retrofits actually installed. The potential accuracy afforded by today's energy simulation programs is high. Yet the reliability of the results is frequently compromised by a lack of certainty that the simulations reflect actual conditions. While it is easy to match simulation results with utility bills, it is considerably harder to match daily or even hourly data. There is little systematic guidance available to the practitioner, neither qualitative nor quantitative. How do I reconcile calculated and actual results when they differ? How do I translate an observed pattern of discrepancy into the most appropriate change of my simulation assumptions? What should I do if contradictory changes in assumptions reduce discrepancy to the same degree?

The comparison of the results from a simulation program to measured data has always been recognized as an important factor in substantiating how well the simulation model represents a real building. To reconcile simulation results to measured monthly utility data has been the preferred method for many years. Most of these methods rely on simple comparisons including bar charts, monthly percent difference time-series graphs, and monthly x-y scatter plots. Yet monthly comparisons fall short of the level of comparison that is needed when the simulation is used to evaluate changes that amount to less than 10 to 20% of a building's total energy use.

More recent efforts have compared hourly simulations to hourly measured data. Unfortunately, at hourly levels of comparison, many of the traditional statistical and graphical comparison techniques become overwhelmed with too many data points. A few advanced methods have been proposed that include carpet plots, comparative 3-D time-series plots, and weather day type analysis to characterize the observed discrepancies. How-to manuals have been compiled and methods to simplify this task.

It is time to cull the best from the existing body of research and develop a coherent methodology for the practicing energy engineers. To help the practitioner substantiate computer simulations of energy savings, ASHRAE seeks to develop a toolkit of procedures to effect and document the successful reconciliation of computer simulations to measured data from actual buildings.

Computers have been used extensively during the past three decades as effective heating, ventilating, and air-conditioning (HVAC) design tools to supplement tedious manual energy calculations (Ayers and Stamper 1995). As computing technology has become affordable, engineers and architects have begun to take advantage of hourly simulation programs on desktop personal computers (PCs) that can inexpensively and quickly perform load calculations (ASHRAE 1991).

In recent years measurement technology has become sufficiently inexpensive and ubiquitous to make it practical to monitor energy and environmental data in great detail and over long periods of time. Energy consumption is being measured at sub-hourly intervals by utilities and building owners. Yet though both the accuracy of simulations and the availability of real data have increased, the integration of the two approaches has so far not kept pace. While both simulations and measurements are performed with considerable resolution in time and space, all that detail is jettisoned to compare aggregated simulation results to monthly utility data, an approach that has little changed since the dawn of energy calculations.

Comparing computer models to actual metered data is not a new practice. As early as 1970, recommendations were made to calibrate models based on measured data (Ayers and Stamper 1995). Some researchers and engineers have attempted to compile "how to" manuals and methods in order to simplify this task; however, in almost all cases the end result falls short of a useful toolkit of procedures (Diamond and Hunn 1981; Hsieh 1988; Kaplan et al. 1990; Hinchey 1991; Hunn et al. 1992; Kaplan et al. 1992; Haberl et al. 1993; Clarke et al. 1993; McLain et al. 1993; Bou Saada and Haberl 1995a, 1995b; Haberl et al. 1995; Manke and Hittle 1996).

ASHRAE has constituted the GPC14P *Measurement of Energy and Demand Savings* for determining the appropriate methods for analyzing energy savings from energy conservation retrofits. In its first draft for public review, the GPC14P has defined how energy savings are to be measured and characterized, one of which is calibrated simulation. Because of its broader scope, the GPC14P defines *uncertainty* in estimating savings as the standard of comparison between different energy savings calculations. Simple formulas are proposed, anchored in basic statistics, to quantify such uncertainty. Discrepancy between measured data and simulation results therefore has a direct bearing on uncertainty. The greater the discrepancy, the more uncertain are the savings predictions of the simulation, however accurate and detailed.

JUSTIFICATION

To date, no consensus guidelines have been published on how to assess the comparison of the results from a building energy simulation program against measured data from an actual building. Historically, actual comparisons have been an art form that inevitably relies on user knowledge, past experience, statistical expertise, engineering judgment, and an abundance of trial and error.

One major problem with reporting simulation accuracy rests with the calculation procedures, which have been reported in the previous work. Typically, when a model is established as being calibrated (i.e., the user states that the "accuracy" for electricity is approximately "5% per month"), the author does not reveal the techniques used other than stating that the final result is "calibrated" or "validated". Hourly or daily error values are seldom reported. Even in cases when error estimates are presented, the methods and equations used to obtain the comparisons are not.

The ASHRAE GPC14P has included calibrated simulation as a valid method for estimating energy savings. Because of the manifest lack of uniformity and abundance of confusion in calibrating simulations to actual data, the GPC has identified as an important task the development of consensus procedures for comparing the results of computer simulations to measured data.

The purpose of this research is to bring order and clarity to the intersection of simulation and measurement, and at the same time assist the practitioner in reconciling energy calculations to measured data in the most expedient way. Therefore there are two thrusts to be emphasized:

1) To define discrepancy between simulation results and measured data, and to relate it to the definition of uncertainty of energy savings estimation in the ASHRAE GPC14P; this effort should include the development of the most suitable presentation formats to characterize discrepancy;
2) To develop a set of procedures, and a method for applying them, for the purpose of diagnosing and resolving such discrepancies in the most expedient and cogent manner; this part aims at systematizing and transferring energy modelers' know-how to the realm of the practitioner.

The procedures outlined in this work statement will 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 and secondary HVAC systems. The final result of this work is a guide, complete with algorithms, presentation formats, and quantitative references, of how to reconcile the results of three programs developed with such toolkits with actual data.

The project will benefit the following:

1. ASHRAE to buttress the credibility of the use of calibrated simulation codes based on ASHRAE methods by the energy engineering community.
2. Software code developers and users to assess how well calibrated computer simulations fit measured data from actual buildings.
3. ASHRAE members as a guide for more effective use of available computer simulation codes in their day-to-day practice.
4. ASHRAE GPC14P to strengthen its calibrated simulation approach.

OBJECTIVE:

The objective of this work statement is to develop procedures and how-to-instructions to characterize and minimize the discrepancy between the results of building energy simulation programs and measured energy data .

SCOPE:

1. Locate, characterize, and categorize previously developed calibration assessment methods beginning with those listed in the references. Review and provide a brief description and usability of the techniques employed.

2. Based on the results of Task 1 develop procedures and presentation formats for comparing the results of hourly building energy simulation programs against measured energy and internal environmental data. Such procedures should include algorithms necessary to accomplish the task, such as, but not be limited to:

- statistical fitting of hourly simulated data to whole-building electricity data, whole-building heating/cooling data, whole-building lighting & other end-use data,
- graphical viewing of the progress of fitting simulated data to whole-building electricity data, whole-building heating/cooling data, whole-building lighting data at different levels of time resolution,
- fitting simulated data to measured data when comparing system component efficiency (e.g., chillers, pumps, boilers), and
- statistical fitting of hourly simulated interior temperatures to measured interior temperature measurements.

The toolkit should also include methods for using actual measured weather data in the simulation, as opposed to the more habitual typical years.

3. Demonstration examples of the procedure and toolkits using measured data from an actual building and simulations produced with the current version of at least one publicly available simulation program (e.g., DOE-2, BLAST, TRNSYS, EnergyPlus), including the necessary input files to run the program, and the hourly measured building energy & environmental data extracted for the calibration. Demonstrations should include: comparisons of simulated to measured: cooling, heating, electricity, interior temperatures, and systems and plant equipment performance data.

4. A final report documenting the methods used in conducting the project and identifying areas where additional research is needed.

5. Preparation of an ASHRAE technical paper, ASHRAE Research Journal paper, research note, and/or ASHRAE Journal Article as requested by the PMS.

DELIVERABLES:

1. Progress and financial reports shall be made to the Society through its Manager of Research and quarterly reports.

2. The Principal Investigator shall report in person to the Project Monitoring Sub-Committee (PMSC), (and full TC if deemed appropriate) at the annual and winter ASHRAE meetings, and satisfactorily answer such questions regarding the research as may arise during those meetings.

4. A DRAFT and FINAL report. The DRAFT report covering complete details of all research carried out on the project shall be prepared and submitted to the PMSC prior to the end of the contract period. This DRAFT report shall be reviewed and approved by the PMSC prior to submittal of the FINAL report to the Society for final completion of the contract.

The DRAFT and FINAL report shall include, at a minimum, the following:

- An executive summary suitable for wide distribution to the industry and the public.

- A final report that details the annotated bibliography, including PC-formatted electronic copy of all appropriate material mentioned above.

Unless otherwise specified, the final report shall be furnished in the following manner:

- Six bound copies

- One unbound copy , printed on one side only, suitable for reproduction.

- Two copies on 3-1/2 " PC-formatted diskette(s) or CD-ROM; one in ASCII format and one in the word processing format used to produce the report.

All computer code will be documented according to the recommendations of ASHRAE's TC 1.5 -- Computer Applications Technical Committee. All software documentation will be consistent with the previously developed HVAC-01 and HVAC-02 toolkits.

5. One or more ASHRAE technical paper(s) that reports the results of the project to be presented at an ASHRAE meeting. The papers shall conform to Section 5 of the Society's "Author's Manual for Technical and Symposium Papers".

6. A Technical Article suitable for publication in the ASHRAE Journal, or ASHRAE Research Journal if requested by the Society.

LEVEL OF EFFORT:

1. Obtain, review, and categorize the readily available technical literature relevant to calibration methods.

- Labor for researchers and engineers: 20%

2. Prepare toolkit of comparison procedures including examples.

- Labor for researchers and engineers: 50%

3. Produce a final, computer-readable original of the publication in a format satisfactory to both the PMS and to ASHRAE Special Publications.

- Labor for researchers and engineers: 10%

4. Prepare quarterly reports and a brief final report documenting the methods used in conducting the project and identify areas where additional research is needed.

- Labor for researchers and engineers: 5%

5. Prepare a technical paper, and a research note, and/or ASHRAE Journal Article as requested by the project monitoring subcommittee.

- Labor for researchers and engineers: 15%

Total person-months = 12 to 18 person-months, apx. cost $95,000, completed in 18 calendar months or less.

ADDITIONAL INFORMATION FOR BIDDERS:

1. Successful contractor will demonstrate their knowledge of calibration procedures and expertise in using publicly available simulation programs in their proposal.

2. The proposed budget should include a reasonable breakdown of the costs of performing the work, including travel, programming, computer supplies, computers, etc. Project responsibilities and project management will also be defined.

3. The proposal should include a detailed timetable including the logistics of accomplishing the major tasks outlined above.

PROPOSAL EVALUATION CRITERIA

The following proposal evaluation criteria will be used for selection:

(25%) Familiarity with calibration methods of at least one publicly available simulation code, and demonstrated use of such knowledge.

(20%) Familiarity with measured data from HVAC systems, including the ability to obtain such data, and a knowledge of all traditional methods used to statistically analyze such data.

(30%) Demonstrated ability to develop a useful guide for use by practicing engineers, including personnel experience, and demonstrated report writing capabilities.

(25%) Project plan, project timetable, budget detail, and proposal documentation in support of the project methodology.

CONTRIBUTOR(S):

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WORK STATEMENT FROM TC 4.7 ENERGY CALCULATIONS

TITLE

INVERSE BIN PROCEDURES FOR ANALYZING ENERGY SAVINGS

BACKGROUND

ASHRAE has funded the development of 1050RP "Toolkit for linear, change-point linear & multiple-linear inverse models", and 1093RP "Compilation of diversity factors for energy load calculations" which are intended to produce a toolkit of inverse models that can be used to calculate energy baselines (1050RP) and diversity factor calculation procedures (1093RP) to assist building energy simulations.

1050RP (Kissock et al. 1999) has identified 6 multivariate models as being the most appropriate models for modeling weather-dependent energy use that is also significantly influenced by a second or third variable (for example, electricity use or occupancy). Several of these models are shown in Figures 1a-g. These models include: mean models (Figure 1a), linear models for characterizing heating or cooling energy use (Figure 1b), three parameter models for heating (Figure 1c) or cooling (Figure 1d), four parameter models for heating (Figure 1e), and cooling (Figure 1f), and a five parameter model for a building with heating and cooling characteristics (Figure 1g) which is common of electrically heated and cooled buildings. In addition to these multivariate models 1050RP also identified multivariate, variable-based cooling and heating degree day models for modeling weather-dependent energy use in commercial buildings.

The final deliverable for 1050RP will be public domain computer code (source and executable) for calculating these multivariate, inverse models. These inverse methods have been shown to be useful for calculating savings in over 70% of the buildings in the Texas LoanSTAR program (Haberl et al. 1998). Additional information about these methods can be found in the 1997 ASHRAE Handbook, Fels et al. (1986), Kissock et al. (1998), and Ruch and Claridge (1991).

In addition to the work of 1050RP, ASHRAE research project 1093RP "Compilation of Diversity Factors and Schedules for Energy and Cooling Load Calculations" (Abushakra et al. 1999) has identified the most appropriate methods for calculating diversity profiles that describe the 24-hour weekday-weekend profiles of lighting, receptacle and/or occupancy loads for input into computer simulation programs. Of the methods surveyed by 1093RP it was determined that only a combination of four of the previous methods would produce an automated diversity profile toolkit. These methods include: the mean-standard deviation index developed by Katipamula and Haberl (1991), the interquartile analysis used by Abbas (1993), the inverse binning method by Thamilseran (1999), and Duncan's multiple range test and frequency univariate analysis (Dhar 1995).

In addition to the work of 1050RP and 1093RP, an inverse bin method has been developed by Thamilseran (1999) that has been demonstrated to be as accurate as the most accurate hourly neural network models that dominated the Predictor Shootout II (Thamilseran and Haberl 1995; Haberl and Thamilseran 1996, 1998). In the inverse bin method an hourly baseline model of a building is developed by calculating the average temperature-dependent energy use for each temperature bin for the appropriate weekday, weekend grouping.

This differs from the linear and change-point linear models shown in Figure 1 because the inverse bin method has the ability to capture more than two "bends" or points of change in the slope of the regression line through the use of "bins" which correspond to the traditional 5 F (or 2.8 C) ASHRAE bin intervals. Humidity sub-binning and/or a time-lagged analysis can also be applied as appropriate to capture a building's sensitivity to humidity and/or thermal mass effects (Thamilseran (1999). Unfortunately, ASHRAE has yet to develop a toolkit for an inverse-bin method analysis that would further enhance the library of inverse analysis methods. Such a toolkit would be developed to be compatible with the previously developed 1050RP toolkit, which accepts columnar ASCII data as input, and is controlled by an instruction file or keyboard input.

Therefore, this WS is intended to expand the capability of the previous projects 1050RP and 1093RP by developing public domain computer code that would be compatible with code developed for 1050RP that is capable of performing inverse temperature-humidity-lagged binning for weather-dependent loads. Hence, the *purpose* of this research project is to therefore to develop a toolkit for performing inverse bin method calculations to analyze weather dependent energy building energy use.

JUSTIFICATION

At the current time ASHRAE does not have a well-documented toolkit of inverse bin method calculations and the appropriate uncertainty calculations. Although procedures are being developed for multivariate, linear, change-point linear and variable-based degree day calculations (ASHRAE 1050RP), and for diversity factors for energy calculations (1093RP), no toolkit exists that contains specific computer code for empirically analyzing the energy use from most buildings using the inverse bin method.

Inverse bin methods can provide more accurate baseline models for a special class of buildings that are not well modeled by linear, change-point linear, or variable-based degree days as was demonstrated by the Predictor Shootout II where inverse bin models were shown to be nearly as accurate as the most accurate (and much more complex) neural network models (Haberl and Thamilseran 1996; 1998). Inverse bin methods also have the advantage over multivariate, linear, change-point linear, variable-based degree day calculations because the results from inverse bin method calculations can be directly compared to ASHRAE bin method calculations of annual building loads (Thamilseran 1999).

It is therefore necessary to document the existing algorithms for calculating inverse bin method models weather dependent loads, and develop a toolkit of computerized inverse bin method procedures that can be used by ASHRAE members to analyze energy use in existing buildings. Development of the appropriate uncertainty analysis for these methods is also needed.

ASHRAE has already initiated several previous efforts to develop similar toolkits for simulating Primary (HVAC01) and Secondary (HVAC02) systems. ASHRAE has also constituted GPC-14P for determining the appropriate methods for analyzing energy savings from energy conservation retrofits, which can utilize the results of the proposed research. Furthermore, the 1997 ASHRAE Handbook and an initial draft of GPC-14P has acknowledged inverse bin methods calculations as important, special purpose, before-after retrofit savings analysis model. Therefore, the development of an ASHRAE Toolkit for inverse bin method calculations will be an important enhancement to the current linear, change-point linear and variable-based degree day methods in ASHRAE's GPC-14P.

The project will benefit the following:

7. ASHRAE to widen the acceptance and applicability of inverse bin methods in the analysis of data from building mechanical systems.
8. Software code developers/users as an aid for developing inverse bin methods for analyzing measured data from mechanical systems.
9. HVAC building energy analysis book publishers as an aid for developing more effective inverse bin method texts and courses.
10. ASHRAE for use in developing effective training programs for users of inverse bin methods, and as a means of improving inverse bin method documentation.
11. ASHRAE members as an aid for better understanding of how inverse bin methods can be used in their day to day practice.
12. ASHRAE member software developers as an aid to producing more effective inverse bin method code and documentation.
13. ASHRAE for use in a better understanding of why and how building energy software programs can be used to improve HVAC performance and indoor air quality.

OBJECTIVES

The objective of this research is to develop and document procedures that will analyze interval data from HVAC system energy use and ambient conditions using the inverse bin method. This method would operate on interval data (i.e., columnar ASCII data) from on-site measurements of energy use and ambient conditions, and would calculate a bin model that captures weather dependent loads. The deliverable from this project is intended to be a modification to ASHRAE's 1050RP Inverse Method Toolkit (i.e., FORTRAN 90 software source code) for calculating linear, change-point linear and multi-linear regression models.

SCOPE

This research includes:

(1) A thorough literature search into the current algorithms that are used to empirically analyze building energy use with inverse bin method calculations, including humidity sub-binning and lagged variables.

(2) Development of FORTRAN 90 computer code that performs inverse bin method calculations that is compatible with the code developed for 1050RP, including documentation of algorithms used in the code (using hourly data), and integration of the new code into the existing code,

(3) Development of necessary uncertainty equations for inverse bin method calculations using examples that are similar to the HVAC01 and HVAC02 toolkits, including sample input files, sample output files, etc. and

(4) Integration of the new FORTRAN 90 source code into the existing 1050RP code to form a new ASHRAE toolkit including the appropriate documentation.

The specific tasks are as follows:

TASK 1. Obtain, review, and categorize the readily available technical literature relevant to the inverse bin method calculations and the appropriate uncertainty analysis indicated above, and include applications of such methods, limitations of methods and current software, and identify specific algorithms.

TASK 2. Develop well-documented FORTRAN 90 computer code which contains computer source and executable code for inverse bin method calculations that is demonstrated to be compatible with the computer code developed with 1050RP and the associated uncertainty analysis, including: example input files, output, goodness-of-fit parameters, and error checking of the input data file. The toolkit should be capable of accepting and analyzing interval data (i.e., hourly, 15-minute or less) in a format similar to the code developed for 1050RP.

The primary intention is to codify existing algorithms identified in (1) above and not develop new algorithms.

This Toolkit is intended to be similar to the HVAC01 and HVAC02 toolkits in scope and documentation, and should be demonstrated to be compatible with the 1050RP computer code. Well-documented FORTRAN 90 source and executable code in electronic form that can be freely distributed by ASHRAE is to be one of the deliverables.

TASK 3. Prepare a technical paper, and a research note, and/or ASHRAE Journal Article as requested by the project monitoring subcommittee.

DELIVERABLES

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

b) The Principal Investigator shall report in person to the TC at the annual and winter meetings, and answer such questions regarding the research as may arise.

c) All computer code will be documented according to the recommendations of ASHRAE's computer software policy. This shall include:

- A well documented, complete FORTRAN 90 source code that can be freely distributed or licensed by ASHRAE.

- FORTRAN 90 executable code for MS DOS and MS Windows personal computers, including electronic copies of input and output file examples for testing purposes.

- ASHRAE shall retain copyright of all computer code delivered as part of this project and all derivative works from such computer code.

d) A Final Report shall be prepared and submitted to the Manager of Research by the end of the contract period covering complete details of all research carried out on the project. Unless otherwise specified, six draft copies of the final report shall be furnished for review by the Project Monitoring Subcommittee (PMS).

Following approval by the PMS and the TC, final copies of the final report will be furnished as follows:

- An Executive Summary suitable for wide distribution to the industry and to the public.
- Six bound copies.
- One unbound copy, printed on one side only, suitable for reproduction.
- One copy on diskette(s) or CDROM in Microsoft Word 6.0.

e) One or more Technical Paper(s) shall be submitted in a form suitable for presentation at a Society meeting. The Paper(s) shall conform to the Society's "Submitting Manuscripts for ASHRAE Transactions" which may be obtained from the Special Publications Section.

f) All papers or articles submitted for inclusion in any ASHRAE publication shall be made through the Manager of Research and not to the publication's editor.

g) A Technical Article suitable for publication in the *ASHRAE JOURNAL* may be requested by the Society. This is considered a voluntary submission and not a deliverable.

LEVEL OF EFFORT

1. Obtain, review, and categorize the readily available technical literature relevant to inverse bin method calculations.

- Labor for researchers and engineers: 20%

2. Prepare computerized toolkit.

- Labor for researchers and engineers: 60%

3. Prepare a brief final report documenting the methods used in conducting the project and identify areas where additional research is needed.

- Labor for researchers and engineers: 10%

4. Prepare a technical paper, and a research note, and/or ASHRAE Journal Article as requested by the project monitoring subcommittee.

- Labor for researchers and engineers: 10%

Total person-months = 12 person-months, approx. cost $75,000, completed in 18 calendar months or less.

ADDITIONAL INFORMATION FOR BIDDERS

1. Contractor will demonstrate their knowledge of inverse bin methods in their proposal. Because the scope of the project is to develop software that is compatible with the previously developed Inverse Model Toolkit - IMT (1050RP), bidders should demonstrate their knowledge of the IMT software and indicate their approach to develop and integrate new computer code that is compatible with the previously developed IMT. Bidders should also indicate how they would respond to unexpected criteria. Once the Software Requirement Specification (SRS) is submitted the Project Monitoring SubCommittee (PMSC) will review the SRS before the contractor continues work on developing the software

2. The proposed budget should include a reasonable breakdown of the costs of performing the work, including travel, programming, computer supplies, computers, etc.

3. The proposal should include a detailed timetable including the logistics of accomplishing the major tasks outlined above.

4. Their familiarity with inverse bin method calculations, and demonstrated use of inverse bin method calculations.

5. Their familiarity with data from HVAC systems, including the ability to obtain such data, and a knowledge of all traditional methods used to statistically analyze such data.

6. Their ability to conduct a thorough literature search, including personnel experience, and knowledge of the sources of such materials, and demonstrated report writing capabilities..

7. Their project plan, project timetable, budget detail, and proposal documentation in support of the project methodology.

PROPOSAL EVALUATION CRITERIA

1. Contractor's understanding of Work Statement as revealed in proposal (25%).

2. Quality of methodology proposed for conducting research (25%).

3. Qualifications of personnel for this project (20%).

4. ASHRAE Student involvement (5%).

5. Probability of contractor's research plan meeting the objectives of the Work Statement (20%).

6. Performance of contractor on prior ASHRAE projects or other energy projects (No penalty for new contractors) (5%).

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AUTHORS

Jeff Haberl

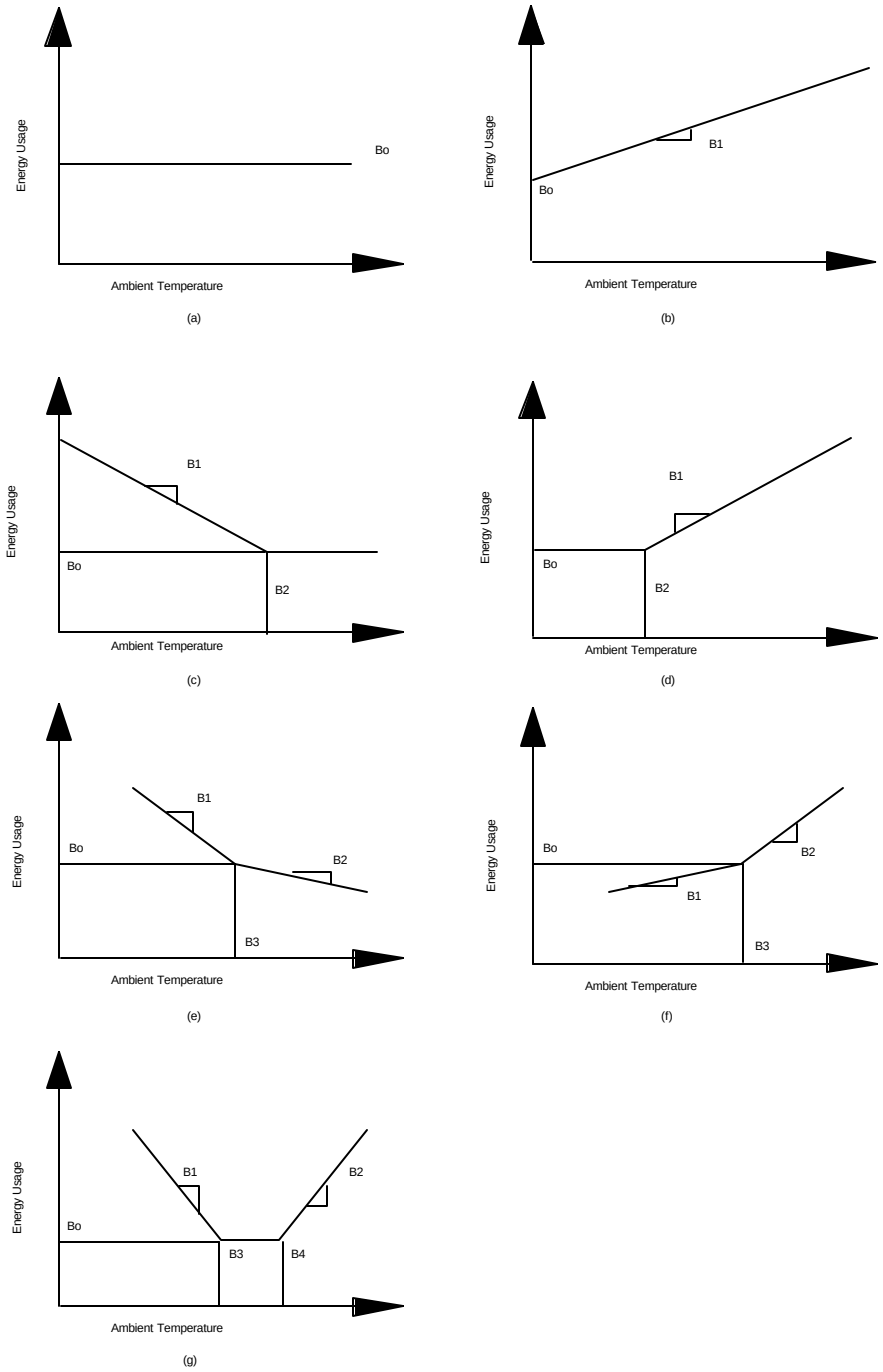

Figure 1: Several types of steady-state, single variable inverse models. Figures 1e and 1f illustrate four parameter change-point models for heating and cooling, respectively. These models are appropriate for buildings that have cooling or heating needs all year around, for example in grocery stores, and/or in large commercial buildings with significant internal cooling loads. Equations (5) and (6) present the respective expressions for calculating heating (Figure 1e) and cooling (Figure 1f) energy use using a four-parameter change-point model. In a four-parameter model, B0 represents the baseline energy use exactly at the change point B3. B1 and B2 are the lower and upper region regression slopes for weather dependent energy use below and above the change point B3.

Draft Work Statement

Development of a Procedure for Base-lining Energy Use at Large Central Plants

Background

The commercial sector accounts for approximately 15% of the total US energy consumption (OTA, 1992). Half of the commercial sector energy use is attributed to multi-building facilities (EIA, 1993). 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). 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 (EIA, 1993).

The potential to reduce energy use in multi-building facilities is significant. For instance, energy conservation programs sponsored by some state universities have been able to achieve 30% reduction in energy consumption (Hunn et al, 1995; BNP, 1995). 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 (Beasley, 1999).

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 the National Association of Energy Service Companies (NAESCO, 1993), the Federal Energy management Program (FEMP, 1992), the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE, 1997), the Texas LoanSTAR program (Reddy et al., 1994), 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, 1997).

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 several equipment used 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 demands (such as steam, hot water, chilled water, and generated electricity) supplied to the buildings. The conversion of the primary fuels to energy demands is accomplished through numerous energy conversion processes performed within the utility plant. Any base-lining procedure for central plants should be capable to account for the various thermal interactions between the multiple equipment commonly used in the plant.

Justification of Need:

In order to improve the energy performance of 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, operational strategies change, 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 14 GPC-14P and IPMVP).

Objective:

The main objective of this research project is to develop and document a procedure 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. As an application, the developed procedure would be demonstrated to measure savings from retrofits to equipment in the central plant for a multi-building facility.

Scope:

Three main phases are proposed to achieve the objective of the research:

Phase 1: Literature Review

A thorough literature search and review will be carried out to identify the energy use base-lining procedures applicable to commercial buildings. The generic methodology and the models used by each procedure should be briefly described. In addition, the capabilities of each procedure to account for variables such weather and occupancy should be summarized. Finally, the existing procedures should be evaluated for their suitability to baseline energy use at large central heating and cooling plants serving multi-building facilities.

Phase 2: Development of Base-lining Procedure for Central Plants

The contractor should develop a procedure that allows energy analysts to baseline energy use at large central plants that serve multi-building facilities. This procedure should meet the following minimum requirements:

(a) Performance models for energy consuming equipment commonly found in central heating and cooling plants in multi-building facilities including but not limited to: high pressure steam boiler, heat recovery supplemental gas (HRSG) boiler, hot water boiler, hot water heat exchanger, steam turbine generator, gas turbine generator, centrifugal chiller, absorption chiller. The performance equipment models can be based on inverse methods to establish the relationship between the inputs (typically a primary fuel source) to the outputs (such as steam, chilled water, or electricity). These equipment models should be generated using measured data or synthesized data from the manufacturer's specifications. Both daily and hourly data should be considered to generate the equipment models. Previously published

ASHRAE Toolkits (for secondary and primary equipment) may be used to develop the plant equipment models.

(b) Energy usage model for the entire multi-building facility. Several inverse models available in the literature to predict the energy use of individual buildings as a function of such independent variables such as weather, occupancy, thermostat settings, and scheduling of equipment (ASHRAE Handbook, 1999). The contractor should develop new models or build on existing models to predict the energy usage for the multi-building facility.

Phase 3: Demonstration of the Developed Procedure

The contractor should obtain measured data representing pre- and post-retrofit periods for an existing multi-building facility. Detailed description should be provided in the proposal to document the multi-building facility including the central plant equipment, the retrofit measures made to the central plants, and the data measurement procedures. should be well described and documented in the proposal.

The contractor should use the measured data to demonstrate the application of the base-lining procedure developed in phase 2 to measure and verify the savings from the retrofit measures implemented in the central plant.

Deliverables:

The deliverables include the following:

(a) Quarterly Progress and Financial Reports shall be made to the Society through its Manager of Research. The Principal Investigator shall report in person to the TC at the annual and winter meetings.

(b) A final Report shall be prepared and submitted to the Manager of Research by the end of the contract period covering complete details of all research carried out on the project. Unless otherwise specified, six draft copies of the final report shall be provided for review by the Project Monitoring Subcommittee.

(c) One or more Technical Papers shall be submitted in a form suitable for presentation at Society meeting. A Technical Article suitable for publication in the ASHRAE Journal may be requested by the Society.

Other Information for Bidders:

In the proposal, the successful bidders should demonstrate:

- Their familiarity with inverse methods applicable to commercial buildings including the models considered by RP-1050 as well as models for energy consuming equipment of central heating and cooling plants.
- Their familiarity with data from cooling and heating central plants for multi-building facilities including the ability to obtain such data and the knowledge of all common methods used to statistically analyze

such data.

- A detailed timetable that outlines the schedule for completing the major tasks outlined in this work statement.

Proposal Evaluation Criteria:

The following criteria to evaluate all proposals and select the successful bidder:

- Bidder 's understanding of the work statement as documented in the proposal: 15%
- Quality of the methodology proposed to achieve the objectives of this research project: 25%
- Quality of the data needed to demonstrate the base-lining procedure to be developed in this research: 15%
- Qualifications of the personnel to perform the tasks outlined in the proposal: 25%
- Involvement of students: 5%
- Performance of bidder on prior ASHRAE projects or related projects (no penalty for new bidders): 5%

References

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TC 4.7 Simulation and Component Models Subcommittee

Atlanta Meeting minutes: 1/29/2001

Introductions

Simon Rees was standing in for the regular chairman Dan Fisher and passed on Dan's apologies. The meeting was called to order at 6:05pm with 27 in attendance as shown on the attached attendance sheet.

Additions or corrections to agenda

None.

Program Updates

Atlanta: seminar and symposium: Low Energy Cooling: Models and Case Studies

Les Norford reported that the Symposium and Seminar at this meeting on low energy cooling systems was a success, with lots of international members in attendance. Fred Winklemann concurred. Both Les and Fred Buhl expressed concern that there was lots of useful material produced by IEA Annex 28 but some difficulty in obtaining it.

Atlantic city symposium – Interoperability and Portability

There has been no progress with the preparation of this symposium. Chip Barnaby reported that he would renew his call for papers and that there may not be time to get things ready for the Atlantic City.

Program Suggestions

Following the suggestion at the last meeting the possibility of a symposia reporting on recently completed research projects such as 987-RP, 1052-RP and 1145-RP was discussed. This would be timetabled for the Honolulu meeting. Ian Beausoleil-Morrison volunteered to coordinate this symposium. It was also suggested that some EnergyPlus related papers could be included. The title of 'Recent Developments in Energy Simulation' was suggested. Ian will see if there are enough willing authors to organize two related symposia. Jan Henson volunteered to be the second chair

Ian Beausoleil-Morrison suggested another possible topic "integrating airflow modeling into energy calculation programs" – for Chicago.

"Benefits of Research" Documentation

Jeff Spitler explained the background behind ASHRAE's current squeeze on research funding and the need to provide evidence of the benefit to ordinary members of recent research projects. This year there is 2.9 million available, down from 3.2. The current ASHRAE president has also collected a number of comments from Chapter meetings suggesting that research projects and handbook contents had become to academic and less useful to practicing engineers. JDS passed around a memo to 4.7 members "documentation of research project successes". JDS also pointed out that although the principal investigators would be willing to help, the best testimonials will come from people in industry such as Chip Barnaby or Robert Sonderegger. An *ad hoc* committee to coordinate the TC4.7 response was suggested. Vern Smith offered to work on this committee.

A list of TC4.7 projects in the 1990 – 2001 period was presented by Jeff Spitler. Chip Barnaby pointed out that there was some difficulty reporting on some projects that had had negative outcomes. JDS suggested that it was not so bad to conclude some topics were not worth spending more time and money on. JDS requested that we report something for each project.

One suggestion was that we report on the quantities of publications and CDs sold by ASHRAE that have been delivered by these projects. Phil Haves reported that Bill Seaton has already extracted some of this information and could pass on this information at the main TC4.7 meeting.

Robert Sonderegger pointed out that one of the benefits of much of the research is in educating students and that this should be highlighted in our report. Jeff Spitler offered to solicit academics on the email list for evidence of use in education.

Dru Crawley reported that DOE has figures on benefits of energy simulations (in general) in particular for DOE2. The figures are something like $20bn (discounted) in accumulated savings ($90bn undiscounted). These figures have been checked out and accredited by the Academy of Sciences. He may be able to provide a reference for this. We should be able to claim some credit for this success.

Fred Winklemann offered to report on use of research findings in Eplus and Spark.

There was general agreement that we don't want to "dumb down" the research. Phil Haves suggested that we need to work on a 'Research Strategy'. This would set out how we intend to get from new ideas to tools 'at the fingertips of practicing engineers'. It was also suggested that a useful exercise would be to go through the handbook and highlight the things in it that have come as a result of recent research projects. Phil pointed out that this would be a 'two-edged sword' in that the handbook was also being criticized and inclusion of new research into the handbook was 'part of the problem'. There was some general discussion on the purpose of the handbook.

Workstatements in Progress

Development of Detailed Descriptions of HVAC Systems (Templates) for Simulation Programs
The *ad hoc* committee set up at the last meeting (Les Norford, Fred Buhl, Moncef Krarti and Vernon Smith) had not got round to looking at this work statement that had been rejected by RAC. Les reported on some of the original reasons for its rejection. Chip Barnaby suggested that if it had been rejected it should be resubmitted as an RTAR with a new title. Jeff Spitler added that there is a book (Levenhagen?) that has been used by EnergyPlus team with lots of system diagrams that might offer the same information as this project. Les Norford will try to work on a new RTAR, along with Jan Hensen and Dru Crawley, focusing on why this new one is necessary even with the Levenhagen text available.

Workstatements "on hold" by RAC

1. Incorporation of Nodal Room Heat Transfer Models into Energy and Load Calculation Procedures
2. Updated Energy Calculation Models for Residential HVAC Equipment.

Phil Haves explained some of the background to this problem. There has apparently been a flattening off in research income but a steady rise in spending. Spending grew larger than income last year. Projects on hold we be re-prioritized by RAC when spending becomes available. Bill Seaton will then have to decide which projects on RAC's list will go out for bid. These projects are not guaranteed to go out for bidding in the next round.

Chip Barnaby pointed out that the residential HVAC equipment work statement was technically ahead of the nodal modeling work statement and had been on the research plan longer. This should be pointed out to RAC.

Report on Current Research Projects

RP 987: Loads Toolkit

Dru Crawley reported that the PMSC recommends approval pending some minor editorial changes. It will be on sale as soon as licensing issues are resolved and should be available at Cincinnati.

RP 1145: Modeling Two- and Three-dimensional Heat Transfer Through Composite Wall and Roof Assemblies in Hourly Energy Simulation Programs.

Ian Beausoleil-Morrison reported that the contractor submitted a Draft final report and that reviewers are sending reports to contractor. Approval of the draft report is recommended by the PMS pending editorial changes.

RP 1049 Building Design Synthesis

Robert Sonderegger reported that a new PI had been appointed for this project. Although there had been some concern at the last meeting that there was a lack of progress, the committee now felt positive that progress was forthcoming. The project is due August 2002 and there are no concerns regarding funding.

RP 1052 Analytic Test Suite for Whole Building Energy Programs

George Walton reported that a Draft final report had been submitted and that the PMS was recommending approval subject to editorial changes.

New Business

No new RTARs were offered

Phil Haves proposed that in order to make progress in strategic planning, a committee be set up by the TC4.7 chair. Chip Barnaby seconded this. Jeff Spitler agreed to make a committee to develop a strategy for next meeting. Chip suggested that the statement attached to the 1999 research plan might be a starting point.

Dru Crawley reported on the work of TC 4.2: 220+ international weather files were becoming available in the IWEC format. The contractor has apparently done an excellent job in providing well documented quality files.

Chip Barnaby suggested that following the completion of the loads toolkit we give more thought on how to maintain and update the three toolkits. He agreed to work with Vern Smith and Dru Crawley on some proposals for doing this type of work.

Adjournment

The meeting was adjourned at 7:38pm.

ATTTACHMENT 1: Attendance

Atlanta	Minn.	Dallas	Last Name	First Name	E-Mail
		X	Abushakra	Bass	B0a7654@unix.tamu.edu
		X	Addison	Marlin	Marlin.Addison@doe2.com
X	X		Armstrong	Peter	pr_armstrong@pnl.gov
			Axley	Jim	James.axley@yale.edu
X	X	X	Barnaby	Chip	cbarnaby@wrightsoft.com
X	X		Beausoleil-Morrison	Ian	ibeausol@nrcan.gc.ca
			Blair	Nathan	Blair@tess-inc.com
	X		Blake	Jeff	jblake@nrcan.gc.ca
	X	X	Brandemuehl	Mike	michael.brandemuehl@colorado.edu
X	X	X	Buhl	Fred	wfbuhl@lbl.gov
			Carpenter	Allen	Acarpent@nrcan.gc.ca
		X	Cho	Donngwoo	dwcho@kict.re.kr
		X	Claridge	David	claridge@esl.tamu.edu
X		X	Crawley	Dru	drury.crawley@ee.doe.gov
		X	Dongyi	Xiao	xiaodongyi@hotmail.com
X	X	X	Eldridge	David	eldridd@okstate.edu
	X	X	Fisher	Dan	d-fisher@uiuc.edu
			Flake	Barrett	bflake@afit.af.mil
X			Gu	Lixing	gu@fsec.ucf.edu
		X	Haberl	Jeff	jhaberl@tamu.edu
X		X	Haddad	Kamel	Khaddad@nrcan.gc.ca
X		X	Haves	Philip	phaves@lbl.gov
X			Hensen	Jan	j.hensen@tue.nl
		X	Hockersmith	Sean	shocker@okstate.edu
X			Holmes	Mike	Michael.holmes@arup.com
	X		Huang	Joe	YJHuang@lbl.gov
		X	Hui	Jin	jinh@okstate.edu
			Judkoff	R.	Ron_judkoff@nrel.gov
			Kelsey	Jim	Kelsey@KW-energy.com
			Kissock	Kelly	Jkissock@engr.udayton.edu
		X	Klems	Joe	jhklems@lbl.gov
			Knappmiller	Kevin	kevink@kevtec.com
X	X		Kosny	Jan	kyo@ornl.gov
X	X	X	Krarti	Moncef	krarti@colorado.edu
X			Laouadi	Aziz	Aziz.laouadi@nrc.ca
			Lawrie	Linda	L.Lawrie@computer.org
		X	Leber	Jon	jleber@energy.state.ca.us
		X	LeBrun	Jean	j.lebrun@ulg.ac.be
X			Liesen	Richard	r-liesen@uiuc.edu
X	X	X	McDowell	Tim	mcdowell@tess-inc.com

Atlanta	Minn.	Dallas	Last Name	First Name	E-Mail
			Morner	Svein	Smorner@dorganal.com
X		X	Mottillo	Maria	mmottilo@nrcan.gc.ca
		X	Moujaes	Samir	samir@me.unlv.edu
			Neymark	Joel	neymarkj@sni.net
X	X	X	Norford	Les	lnorford@mit.edu
		X	Pedersen	Curt	cpederse@uiuc.edu
	X		Purdy	Julia	Jpurdy@nrcan.gc.ca
X			Reddy	T. Agami	Reddyta@drexel.edu
			Ries	Robert	rries@cmu.edu
X	X	X	Rees	Simon	SJRees@okstate.edu
	X		Shirey	Don	Shirey@fsec.ucf.edu
X	X	X	Smith	Vernon	vsmith@archenergy.com
	X		Sommer	Klaus	klaus.sommer@vt.fh-koeln.de, Sommer.Roycroft@T-online.De
X	X	X	Sonderegger	Robert	rsonder@siliconenergy.com
X	X	X	Spitler	Jeffrey	spitler@okstate.edu
X	X	X	Strand	Rick	r-strand@uiuc.edu
		X	Sowell	Ed	sowell@fullerton.edu
		X	Subbarao	Chris	Chris.subbarao@ps.net
	X		Turcio	Wallace	wturcio@embraer.com.br
	X		Ullah	Mohammad	bdgullah@nus.edu.sg
			Visier	JC	Visier@cstb.fr
X	X	X	Walton	George	gwalton@nist.gov
X			Winkelmann	Fred	fcwinkelmann@lbl.gov
			Witte	Mike	mjwitte@gard.com
X	X	X	Wray	Craig	cpwray@lbl.gov
			Wright	Jonathan	J.A.Wright@lboro.ac.uk
		X	Wu	Hofu	hwu@csupomona.edu

RP: 1049 Progress Report Jan 28, 2001

Monitoring Committee:

Curt Pedersen (TC 4.7), chair
Dave Knebel (TC 4.7)
Ron Nelson (TC 1.5)
Ed Sowell(TC 4.7)
Mike Brandemuehl (TC 4.6)

Contractor: University of Loughborough, UK

The original PI for the project, Vic Hanby, left the University of Loughborough to take another position, and Jonathan Wright has taken over as PI. Jon prepared a detailed report on the project, and presented a status report to the PMS on Sunday Jan 27. The noteworthy items were:

1. The University of Loughborough remains committed to a satisfactory completion of the project.
2. The project is approximately 37% complete while 47% of the scheduled time has elapsed. Sufficient funding remains for completing the project.
3. A new experienced researcher, currently at Loughborough, will be joining the project in May or June. This will help pick up the pace.
4. All implementation platform questions have been resolved. The system simulation tool is IDA, and the other modules are being written in Java.
5. A Genetic Algorithm optimization technique has been selected for both the system optimization and the configuration ranking.
6. The adjacency matrix representation of configurations has been revised to make it less sparse, and more flexible.
7. Constraints on the system configuration will be formulated as:
    a. Component rules
    b. Connectivity rules
    c. Process rules (psychrometric)
    d. Design constraints (user specified)
8. An example application of the Genetic Algorithm applied to optimizing one configuration was presented.
9. The goals for the next 5 months are:
    a. Develop psychrometric and design rules for the configuration generator
    b. Evaluate the Configuration Generator -> IDA editor.
    c. Define the data structures for the system sizing optimization
    d. Implement constraint handling methods and test with a hard wired link to IDA.

The PMS conveyed the following instructions to the contractor:

1. Fans should be included in the mix of components.
2. Review options for making the configuration generation part of the optimization process.
3. Bring the additional researcher on board as soon as possible.

TC 4.7 Research Status

Last updated Feb. 1, 2001

Active projects

#	Title	Joint TC	Cognizant Subcommittee/ Contractor	PMSC	Dates / status
865-RP	Accuracy Tests for Mechanical System Simulation		Sim/Comp Penn/TAMU Gren Yuill	George Walton (chair), Ron Judkoff, Robert Sonderegger, Dave Knebel	Rec: 2-20-96 (San Antonio) NCE: 2-28-98 (7-1-97) NCE: 8-31-98 (1-20-98) NCE: 3-31-99 (6-23-98) NCE: 3-31-00 (1-27-99) NCE: 3-31-01 (2-8-00) NCE: 8-31-01 (1-30-01)
987-RP	Preparation of a Toolkit for Building Load Calculations	4.1	Sim/Comp Univ. of Illinois Curt Pedersen	Dru Crawley (chair), Chip Barnaby, George Walton, Dave Knebel; Tom Romine (TC 4.1)	Rec: 1-28-97 (Phil) End: 12-31-99 NCE: 7-31-00 (6-22-99) NCE: 3-31-01 (6-27-00) Accept report: 1-30-01
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) Rejected all proposals: 6-23-98 (Toronto) Rec: 6-22-99 (Seattle) End: 8-02?
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 (1-30-00)
1052-RP	Development of an Analytical Verification Test Suite for Whole Building Energy Simulation Programs – Building Fabric		Sim/Comp OSU Jeff Spitler	George Walton (chair), Ron Judkoff, Joel Neymark, Fred Winkelmann	WS: 7-1-97 (Boston) Rec: 6-23-98 (Toronto) Start: 1-1-99 NCE: 3-1-01 (2-8-00) Accept report: 1-30-01
1093-RP	Compilation of Diversity Factors and Schedules for Energy and Cooling Load Calculations	4.1	App TAMU (TEES) Jeff Haberl	Agami Reddy (chair), Bill Bahnfleth, Joe Huang, Suzanne LeVisuer (TC 4.1)	WS: 1-20-98 (SF) Start: 2-1-99 NCE: 3-31-2001 (2-8-00)
1145-RP	Modeling Two- and Three-Dimensional Heat Transfer		Sim/Comp Enermodal Engineering	Ian Beausoleil-Morrison (chair); George Walton; Fred Winkelmann, Doug	WS: 6-23-98 (Toronto) Rec: 6-22-99 (Seattle) Accept report: 1-30-01

	Through Composite Wall and Roof Assemblies in Hourly Simulation Programs		Ltd	Hittle (TC 4.1)	

In process

#	Title	Joint TC	Cognizant Subcommittee/ Contractor	PMSC	Dates / status
1051-WS	Procedures for Reconciling Computer Calculated Results Against Measured Energy Data (note new title)		Inv; Jeff Haberl, Robert Sonderegger	Curt Pedersen (chair), Dave Knebel, Fred Winkelmann	WS: 7-1-97 (Boston) Returned by RAS Resubmit ?
1197-TRP	Updated Energy Calculation Models for Residential HVAC Equipment	7.6	Sim/Comp Chip Barnaby	Chip Barnaby (chair), Craig Wray, Mike Brandemuehl	WS: 2-8-00 (Dallas) Returned by RAS 3-00 Approved by RAS 10-00 Awaiting bidding: 1-30-01
1222-TRP	Incorporation of Nodal Room Heat Transfer Models into Energy and Load Calculation Procedures		Sim/Comp Simon Rees	Phil Haves (chair), George Walton, Ian Beausoleil-Morrison	WS: 6/00 (Minn) RAS: 10/00 Awaiting bidding: 1-30-01

Workstatements – Applications

Title	Champion(s)	Ranking	Dates/status
Define Performance Factors for Primary and Secondary Equipment Simulation Inputs for Commercial Buildings	Dan Nall, Bill Bahnfleth		WS being developed
Characterization of Building Secondary Thermal Loads from Chiller of Electric Use Data	Robert Sonderegger, Agami Reddy		
Development of comparative test cases for evaluating simulation models of slab and basement heat transfer to adjacent ground	Ian Beausoleil-Morrison, Joel Neymark, Jan Kosny	2 (2001-2002)	
Development of Standardized Computer Simulation Input Files for Describing Typical Residential Homes and Common Energy Conservation Retrofits	Jeff Haberl, Joe Huang		No progress, 1-29-01

Workstatements – Inverse Methods

Title	Champion(s)	Ranking	Dates/status
Methodology Development to Extend ASHRAE Semi-Empirical Chiller Models to include Models for Screw Chillers, Package Air-Conditioners, and Heat Pumps	Agami Reddy, Jeff Haberl		WS being developed
Development of a Procedure for Baselining Energy Use of	Moncef Krarti, Jeff Haberl		WS 2-1-00

Large Central Plants			
Inverse Bin Procedures for Analyzing Energy Savings	Jeff Haberl	3 (2001-2002)	WS 2-1-00

Workstatements – Simulation and Component Models

Title	Champion(s)	Ranking	Dates/status
Development of Detailed Descriptions of HVAC Systems (Templates) for Energy Simulation Programs (formerly WS-1198)	Les Norford, Jan Hensen, Dru Crawley		WS-1198 rejected by RAS 3-00 Rewrite underway 1-30-01

TC 4.7 Energy Calculations
Handbook Subcommittee Meeting

Monday, January 29, 2001, 5:00-6:00 p.m.

Attendees:
Les Norford, outgoing subcommittee chair
David Eldridge
Ron Judkoff
Moncef Krarti
Joel Neymark
Rick Strand, incoming subcommittee chair
Vern Smith

Norford opened the meeting at 5:05 p.m. by noting that he is currently reviewing galleys for Chapter 31 of the 2001 Handbook of Fundamentals, Energy Estimating and Modeling Methods. Remaining work includes obtaining two missing references and a figure in SI units for the SI version, and some amount of cleanup of numbers and units in the IP version. Judkoff and Neymark stated that Standard 140, Method of Test for the Evaluation of Building Energy Analysis Computer Programs, is now approved and that it would be appropriate to describe this method of test in the 2005 chapter or sooner if ASHRAE initiates electronic versions of the handbooks with annual updates. Smith reported that ASHRAE is considering electronic versions while retaining a print version on the current four-year cycle.

Norford offered to try to insert a single sentence, not a paragraph, about SPC140 in the 2001 chapter. This will require permission of TC4.7 and ASHRAE handbook staff. Judkoff and Neymark provided the following sentence:

"ASHRAE Standard 140, Method of Test for the Evaluation of Building Energy Analysis Computer Programs, has been developed to identify and diagnose differences in predictions that may possibly be caused by algorithmic differences, modeling limitations, or coding errors."

The meeting adjourned at 6:00 p.m.

SUMMARY OF PROGRAMS AND PROGRAM PLANS

Atlanta, January 2001 (ACTUAL)

1. Symposium: Analysis Tools for the Design of Low Energy Cooling Systems (Sim-Comp/ Rich Karney DOE).

2. Seminar: Low Energy Cooling Case Studies (Sim-Comp/Phil Haves).

Cincinnati, June 2001 (Submit papers: September 29, 2000/Package to ASHRAE: February 9, 2001)

1. Symposium: Better Inputs for Better Output (Applications, TC 9.6 co-sponsor/Chair: Jim Willson. COMPLETE.

2. Seminar: Pathways to Wider Use of Building Simulation Programs (Dru Crawley)

Atlantic City, January 2002 (April 2, 2001/August 3, 2001)

1. Symposium: Applications and Development of Calibrated Models for Chillers and Cooling Towers (was Tools and Techniques for Calibration of Component Models"?) (TC1.5, 4.7 & 8.6/Agami Reddy)—4 papers in review, 8 reviewers, 7 complete, 1 pending.

2. Seminar: Commercial Use of Building Energy Simulations (Applications/Kamel Haddad)

3. Seminar Automated Baselining Procedures Using Inverse Methods (Inverse/Haberl)

4. Symposium: Interoperability and Tool Portability (Sim. Comp./Chip Barnaby)

Honolulu, June 2002 (September 2001/February 2002)

1. Symposium: Inverse Methods for Calculating Savings from Energy Conservation Retrofits (Inverse/Jan Kreider)

Chicago, January 2003 (April 2002/August 2002)

1. Symposium: Integrating Airflow Modeling into Energy Analysis Programs (Sim-Comp/Ian Beausoleil-Morrison).

MINUTES
SPC-140 SMOT FOR BUILDING ENERGY SOFTWARE
Atlanta, January 29, 2001
Chair: R. Judkoff (submitted Jan, 30 2001)

ATTACHMENTS

A. Agenda for January 29, 2001 meeting
B. Mailing List

CORRESPONDANCE SINCE LAST MEETING

Much of this log (below) was extracted from the Final Draft Submittal Report, submitted to SPLS Liason (Baxter) with copy to ASHRAE MOS (Ramspeck). Below referenced email messages and telephone call minutes are included with the Final Draft Submittal Report.

29 June 2000: A conference call is organized for 13 July to discuss SPC 140 proposed responses with Glazer; Glazer prioritizes his comments for the meeting.

13 July 2000: Conference call (SPC 140 representatives) with Glazer regarding his comments, especially 0002/001 and 0002/002. Conf call attendees: Crawley, Glazer, Judkoff, Neymark. Discussion indicates Glazer is likely to be resolvable on his comments 003 – 010, but does not commit to being likely resolvable on his comments 001 and 002.

14, 18 July 2000: Communications with ASHRAE MOS (Claire Ramspeck) and SPLS Liason (Van Baxter) regarding Glazer's comment (0002/006) on units. Baxter and Ramspeck are satisfied with only SI units. They encourage that the future group working with Standard 140 (after its initial publication) consider adding IP units in the future.

20 July 2000: email to Glazer with draft responses requesting potential resolvability based on proposed responses.

27 July 2000: Glazer sends response to committee reps (Crawley, Judkoff, Neymark) indicating he is likely to be unresolved on two comments (0002/001 and 0002/002)

2 Aug 2000: Letter Ballot (due 1 Sep) regarding approval of Proposed Comment Responses sent to full SPC 140.

4 Sep 2000: Letter Ballot (2 Aug) final tally for sending responses is: Yes = 7, No = 1 (Witte), Absent = 2 (Maeda, Wilcox). Tally reported to SPC 140 on 6 Sep 2000.

6 Sep 2000: Because there was one negative vote, the results and comments that accompanied the negative vote (including discussion of the negative-voting SPC member's support for Glazer's comments 001 and 002) were submitted to the full SPC 140, along with request for change of vote (if any) by 22 Sep 2000. Included with this email record are comments that accompanied the negative vote.

27 Sep 2000: No vote changes were received

28 Sep 2000: SPC 140 approved Responses to Commenters sent to both commenters.

26 Oct 2000: Glazer emailed Comment Reply Forms, with hard copy (signed 26 Oct) received on 30 Oct. Two of his comments (0002/001 and 0002/002) are indicated as unresolved. Additional discussion by him was included.

8 Nov 2000: Telephone discussion with ASHRAE MOS (Ramspeck) confirms that 7 – 1 committee vote completed on 28 Sep 2000 approving SPC comment responses indicates consensus opinion to move forward with publication approval.

10 Nov 2000: Lutz sends hardcopy of Comment Reply Forms indicating he is resolved on all comments.

14 Nov 2000: Lutz sends (after earlier requests) final electronic version of the graphic file to be incorporated into Standard 140 as a clarifying non-substantive change in response to his Comment 0001/003.

15 Nov 2000: Recommendation to Publish Standard 140 letter ballot distributed to SPC 140 (ballot closes 1 Dec 2000).

4 Dec 2000: Recommendation to Publish passes 8 – 0 with 2 absent.

7 December 2000: Final Draft Submittal Report for Std 140P submitted to Van Baxter (SPLS liason) with copy to Claire Ramspeck (ASHRAE MOS).

11 December 2000: Recommendation to form a Standing SPC (140) sent to Van Baxter (SPLS liason) with copy to Claire Ramspeck (ASHRAE MOS). This recommendation was approved by SPC 140 letter ballot May 27, 1999 (around the same time of SPC 140's recommendation for public review of Std 140P). It was held for submittal to SPLS until SPC publication recommendation per SPC 140 minutes of Seattle (June 99) and Chicago (Jan 99).

10 January 2001: Judkoff requested to ASHRAE Staff that Neymark become a non-voting Vice Chair

26 January: SPLS approved SPC 140's recommendation to become an SSPC 7-0-0

27 January: Judkoff and Neymark attended the Standards Committee meeting. At the meeting Standards Committee took the following actions relevant to Standard 140:

- Approved Neymark to become non-voting Vice Chair (18-0-1)
- Approved SPC 140P to become SSPC 140 upon publication of Std 140 (18-0-1)
- Approved Publication of Standard 140 (18-0-1)

In all three votes Wilcox was required to abstain as he is also a member of SPC 140.

GENERAL

None

INTERMODEL COMPARISON BASED TESTS

The purpose of the meeting was to report on Standards Committee actions of the previous Saturday.

Attendees (see mailing list for full names, etc)

Voting Members
Crawley
Haberl
Judkoff (chair)
Sonderegger
Walton
Winkelmann
Witte

Non-Voting Members
Neymark (vice chair)
Spitler

Other
Baxter (SPLS Liason)
Beausoleil-Morrison
Lutz
Rees

Committee Discussion

Approval of Prior Minutes

Motion (Walton): Accept Minutes of June 2000 meeting (Minneapolis).
2nd (Haberl):

Vote: Yes = 7, No = 0
Absent = (Fraser, Maeda, Wilcox)
Motion passed.

Discussion regarding Standards Committee Approvals

Judkoff summarized the actions of the Standards Committee on Saturday as:

26 January: SPLS approved SPC 140's recommendation to become an SSPC 7-0-0

27 January: Judkoff and Neymark attended the Standards Committee meeting. At the meeting Standards Committee took the following actions relevant to Standard 140:

- Approved Neymark to become non-voting Vice Chair (18-0-1)
- Approved SPC 140P to become SSPC 140 upon publication of Std 140 (18-0-1)
- Approved Publication of Standard 140 (18-0-1)

In all three votes Wilcox was required to abstain as he is also a member of SPC 140.

Attendees were polled regarding their desire to stay on SSPC 140. The following current voting members agreed to remain as voting members: Crawley (1yr only), Haberl, Judkoff, Walton, Winkelmann, Witte.

The following voting members are likely to become non-voting members or resign completely: Fraser, Maeda, Sonderegger, and Wilcox(?).

The following attendees have expressed interest in becoming voting members: Beausoleil-Morrison and Rees.

Over celebratory champagne, the committee discussed four possible paths for SSPC 140 to pursue after publication of Standard 140:

- compliance criteria that might be used by other Standards that may wish to reference Std 140
- other tests that may be worth bringing into Std 140: e.g. HERS BESTEST, HVAC BESTEST, 1052-RP, 865-RP, …
- maintainance/enhancement of current envelope tests: e.g. updating the envelope BESTEST results
- encourage research for development of new test cases: e.g. ground coupling, infiltration, other non-865 air-side, secondary systems not covered by HVBT, daylighting, ducts, thermal energy storage, atrium, natural ventilation, boiler models, IAQ, moisture, SHW, desiccant systems, dir/indir evap cooling, an RP to catalog systems, RP to catalog/create high quality empirical data, ….

Meeting Adjourned.

References

ASHRAE. BSR/ASHRAE Standard 140P, *Method of Test for the Evaluation of Building Energy Analysis Computer Programs*. November 2000. PC Recommendation to Publish. ASHRAE, Atlanta, GA.

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Attachment A – Agenda (emailed prior to meeting, 17 jan 01)

Greetings SPC 140 Members and Interested Parties.

The agenda for our meeting in Atlanta is included below.

SPC 140 Preliminary Agenda

Date: Monday, 29 January 2001
Time: 2:15P - 6:15P
Location: Room 157 W (1st level, west concourse of the Georgia World Congress Center)

Agenda:

1) Approval of Previous Minutes (26 June 2000, Minneapolis), attached

2) Report on Standards Committee decision regarding higher level approval of SPC 140P's recommendation to publish Standard 140P (Baxter/Judkoff)

3) Report on SPLS and Standards Committee decisions regarding higher level approval of SPC 140P's recommendation to become a Standing SPC. (Baxter/Judkoff)

4) Other (?)

Subsequent discussion depends on the outcome of the various higher level decisions regarding our recommendations; those decisions are expected to be made during the Standards Committee meeting on Saturday, 27 January.

Attachment B - SPC 140 ADDRESS LIST 12 December 2000
(note: in general email attachments should go out as both *.DOC, *.RTF and *.WP5)

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