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: January 22, 1998

TC/TG/TRG TITLE: Energy Calculations

DATE OF MEETING: January 20, 1998 LOCATION: San Francisco

MEMBERS PRESENT	YEAR APPTD	MEMBERS ABSENT	YEAR APPTD	EX-OFFICIO MEMBERS & ADDIT'L ATTENDANCE
Chip Barnaby	1995			
Bill Bahnfleth	1996	George Reeves	1993	
Dan Fisher	1994	Per Sahlin	1996	
Carol Gardner	1997	Jeff Haberl	1996	
Philip Haves	1994	Sanford Klein	1997	
David E. Knebel	1994	Jean Lebrun	1996	
Les Norford	1994	Jeff Spitler	1995	
Robert Sonderegger	1994	Fred Winkelmann	1996	
Ed Sowell	1994	Michael Witte	1994	
George Walton	1996			

DISTRIBUTION

ALL MEMBERS OF THE TC/TG/TRG

TAC CHAIRMAN: Irv Bales

TAC SECTION HEAD: Jeff Biscup

LIAISONS:

Program: Larry Degelman Journal: none

Handbook: George Reeves

TECHNICAL SERVICES: Claire Ramspeck

MANAGER OF RESEARCH: William A. Seaton

ADDITIONAL DISTRIBUTION:

ASHRAE TC/TG/TRG ACTIVITIES SHEET

DATE: August 5, 1997

TC/TG/TRG NO.: **TC 4.7** **TC/TG/TRG TITLE:** **Energy Calculations**

CHAIRMAN **Charles Barnaby** **VICE CHAIRMAN** **Robert Sonderegger** **SECRETARY** **Jeff Spitler**

TC/TG/TRG MEETING SCHEDULE

LOCATION - past 12 months	**DATE**	**LOCATION** - planned next 12 months	**DATE**
Philadelphia, PA	1/28/97	Toronto	6/23/98
San Francisco	1/20/98	Chicago	1/26/99

TC/TG/TRG SUBCOMMITTEES

Function	**Chair**
Simulation Applications and Inverse Methods	Dan Fisher 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	Approv	To R & T
1.	See attachment 4			
2.				
3.				
4.				

HANDBOOK RESPONSIBILITIES

Year & Volume	Chapter Title	**No.**	Deadline	**Handbook Subcom. Liaison**
1997	28 Energy Estimating Methods			NONE

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)

Appendix 2

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)

Who Needs Moisture Calculations, Toronto (6/98)
How should ASHRAE Computer Models be Expressed? (Boston)
Priorities for Near-Term Developments in Building Simulation Programs (San Antonio),
Fast Multizone Models for System Optimization (San Antonio)

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

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*** In order to preserve the e-mail addresses for all attendees, this is actually a complete list of attendees and recent attendees. It includes the voting members of the committee listed on page 1. An X in the "Present?" column indicates presence at this meeting.**

Appendix 1

RESEARCH PROJECTS -- CURRENT

Project Title	Contractor	Comm.Chm.	At Meeting
RP-699 Ice-On-Pipe Brine Thermal Storage System (??)		Knebel	?
865-RP Development of Accuracy Tests for Mechanical System Simulation	Penn State/Texas A&M	Walton	Yes
987-RP Loads Toolkit	Univ. of Illinois	Crawley	Yes

Appendix 2

TECHNICAL PAPERS FROM SPONSORED RESEARCH

June 1997

664-RP Fisher, D.E., C.O. Pedersen. 1997. Convective Heat Transfer in Building Energy and Thermal Load Calculations. ASHRAE Transactions V 103 n 2.

January 1997

787-RP Rock, B., D. Wolfe. 1997. A Sensitivity Study of Floor and Ceiling Plenum Energy Model Parameters. ASHRAE Transactions v 103 n 1 1997.

June 1995

741-RP Spitler, J.D., J.D. Ferguson. 1995. Overview of the ASHRAE Annotated Guide to Load Calculation Models and Algorithms ASHRAE Transactions v 101 n 2 1995.

Appendix 3

TC/TG/TRG SPONSORED SYMPOSIA

Title, When Presented

FUTURE:

Toronto - June 1998

Symposium: *Accuracy Tests for Simulation Programs*
Chair - *Mike Witte*.
Potential speakers Haberl, Yuill

Symposium: *Baseline Calculations for Measurement and Verification of Energy and Demand Savings*
Chair – *Robert Sonderegger*.

Chicago - January 1999

Symposium: *Application of Heat Balance Methods to Energy and Thermal Load Calculation*
Chair – *Chip Barnaby*.

Seattle - June 1999

Symposium: *Recent Innovations in HVAC System Modeling*
Chair – *Russ Taylor*.

Symposium: *Parameter Estimation for Modeling Actual Building Systems*
(or seminar) Chair – *Carol Gardner*.

PAST:

Boston - June 1997

TC 4.7/9.6 Symposium--"*Field Methods for Analyzing Equipment, Building and Facility Energy Use*"
Chair: Agami Reddy (409/862-2189, areddy@loanstar.tamu.edu).

San Antonio - June 1996:
Symposium: *External Environmental Impacts*
Chair - S. Reilly.

Symposium: *The Great Energy Predictor Shootout II*
Chair - Haberl

Atlanta - February 1996:
Symposium: *User Tools for Building Energy Simulation*
Chair - C. Gardner; three papers promised

Chicago - January 1995:
Symposium: *More New Algorithms for Computer Energy Analysis*

Appendix 4

TC/TG/TRG SPONSORED SEMINARS

FUTURE:

Toronto - June 1998

"Beyond Spreadsheets: Using equation solvers and modular simulation environments for energy calculations" to be chaired by Phil Haves

Chicago - January 1999

"Neural Nets – What are they and what can they do", Chaired by Moncef Krarti

Seattle - June 1999

"Parameter Estimation for Modeling Actual Building Systems" (or may be a symposium), Chaired by Carol Gardner

PAST:

Boston - June 1997

"Practical Applications of Energy Calculations" chaired by Barnaby;

Philadelphia - January 1997
TC 4.7/9.6 Seminar--"Calibration of Computer Simulation for Building Energy Analysis" Taghi Alereza

Atlanta - February 1996:

Measurement of Energy and Demand Savings-ASHRAE Guideline 14P
Chair: George Reeves (co-sponsored with TC 9.6, Systems Energy Utilization)

San Diego - June 1995:

Innovative Uses of Building Energy Simulations Programs - C. Barnaby

Jan. 1995 - Innovative Uses of Computer Simulation - C. Gardner
Jan. 1995 - Predictor Shootout II: Measuring Results for Energy Conservation Retrofits - J. Haberl
Jan. 1995 - Energy Calculations for Measure Analysis - ?

Jan. 1994 - User Tools for Computer Energy Analysis - C. Gardner
Jan. 1994 - User Tools for Building Energy Simulation - C. Gardner
Jan. 1994 - Standardizing Formats for HVAC Component Models - How to Avoid Reinventing the Wheel - P. Sahlin

ASHRAE TC 4.7 Energy Calculations

AGENDA

6:00 - 8:30 PM, Tuesday, January 20, 1998
Marriott Salon 4 San Francisco, CA

1. Roll Call and Introductions	Spitler
2. Accept Agenda and Approve Minutes of Boston Meeting	Barnaby
3. Announcements	Barnaby
4. Membership	Sonderegger
5. Subcommittee Reports	
5.1 Simulation and Component Models	Fisher
987-TRP Loads Toolkit	Crawley
5.2 Applications and Inverse Methods	Huang
865-TRP Accuracy Tests for Mech. System Simulations	Walton
5.3 Ad Hoc Neutral Model Format (NMF)	Sowell
5.4 Research	Crawley
930-WS Neural Nets	
1049-WS Building System Design Synthesis	
1050-TRP Inverse Toolkit contractor selection	Kreider
1051-WS Hourly Measured/Simulated Comparison	
1052-WS Analytical Verification Suite revisions	Crawley
5.5 Handbook	Norford
5.6 Program Toronto / Chicago / Seattle	Gardner
5.7 Standards: SPC-140, SMOT for Energy Software	Judkoff
6.0 Reports on Related Activities	
IBPSA / IBPSA-US	Crawley
GPC 14P Measurement of Energy/Demand Savings	Sonderegger
TC 9.6 Systems Energy Utilization	Reddy
IAI International Alliance for Interoperability	Crawley
7.0 Old Business	
Educational outreach	Hittle

8.0 New Business

Subcommittee structure Barnaby

9.0 Adjourn

ASHRAE TC 4.7 Energy Calculations

Minutes

The meeting was called to order 6:08 pm with 10 members present and Jeff Haberl monitoring by conference phone. Attendance is given on cover sheet. Minutes taken by Dan Fisher

Jeff Biscup, section head for Section 4, and Carl Speich, Section 4 Research, each gave a brief report. Speich noted that work statements are due on Seaton's desk by February 13.

Sonderegger requested that consideration of a TC 9.6 work statement for co-sponsorship be added to the agenda. Barnaby requested that discussion of 1050 TRP moved to end of agenda in order to facilitate compliance with ASHRAE rules that only voting TC members be present to discuss selection of contractors for ASHRAE research. ***Action Item:*** There was a motion by Haves, seconded by Norford, to accept agenda as amended. Committee unanimously passed the motion.

Crawley requested that research plan shown in the Boston minutes be corrected. ***Action Item:*** Spitler will communicate with Crawley to correct the minutes. ***Action Item:*** There was a motion by Sonderegger, seconded by Norford, to accept the minutes. Committee unanimously passed the motion.

Barnaby made the following announcements:

- From Larry Degelman (Programs): All program submissions must be prioritized. Also reviews of symposium papers should be "double blind".
- The ASHRAE Journal is looking for papers.
- TC 4.4 and TC 4.9 are merging under TC 4.4.
- Regina Stafford is the new HQ contact for scope and rosters.
- RAS considers workstatements by category as follows: "Advanced Concepts", "Basic and Applied Research", "Technology Transfer". Toolkits are not considered in the Technology Transfer category.
- Barnaby's article on TC4 7 history was published in Insights. ***Action Item:*** Spitler will post Barnaby's Insights article on TC 4.7 history on TC 4.7 web site
- LeBrun's Liege Conference is officially co-sponsored by ASHRAE. ***Action Item:*** There was a motion by Haves, seconded by Crawley , to allow LeBrun to claim TC 4.7 sponsorship of Liege conference. Committee unanimously passed the motion.

Barnaby announced that the following members will be rolling off the TC 4.7 roster as of the end of June: Haves, Knebel, Sowell. New members have not been determined. After the June meeting Sonderegger will assume responsibilities as TC4.7 Chair, Spitler as Vice Chair, Crawley as Secretary and Barnaby as Research Chair.

- Fisher reported for the Simulation and Component Models Subcommittee. Minutes of the subcommittee meeting are shown in **Attachment 1**. Fisher submitted a work statement titled *Compilation of Diversity Factors and Schedules for Energy and Cooling Load Calculations* (**Attachment 2**) for committee approval and reported that TC 4.1 co-sponsorship had already been obtained. ***Action Item:*** There was a motion by Sonderegger, seconded by Norford, to approve the work statement with the following editorial changes: 1)Upgrade reference section, including addition of a reference to the TC 9.6 ASHRAE project by Alereza which compiled a library of available data sets. 2)Discuss Selection of Day Types. 3)Require uncertainty

analysis. 4)Require bidder to prove access to data sets. The motion was approved by a vote of 9/0/1 (chair abstaining). A PMSC consisting of Reddy, Bahnfleth(chair), Huang, LeViseur (TC 4.1) to monitor the project.

Huang reported for the Applications and Inverse Methods Subcommittee. The minutes are shown in **Attachment 3**.

Sowell reported for the Neutral Model Format ad hoc committee. Minutes are shown in **Attachment 4** He asked for comments on the draft work statement to produce an NMF to spreadsheet converter [**Attachment 5**]. Sowell also reported on a new modeling language, "Modelica", which could eventually subsume NMF. Committee will continue to press for NMF and monitor Modelica progress.

Barnaby announced the merger of the NMF ad hoc committee with the Simulation and Component Models Subcommittee

Crawley reported on the disposition of ongoing research projects.

- *987-TRP Loads Toolkit*: Crawley reported that project is on schedule. Outline of toolkit document with some completed sections is due by Toronto.
- *865-TRP Accuracy Tests for Mech. System Simulations*: Walton reported that project is back on track. Report will be submitted to PMSC 30 days prior to Toronto. Vote scheduled in Toronto. ***Action Item:*** There was a motion by Walton, seconded by Norford, to grant a No Cost Extension for RP 865 until August 31, 1998. The motion was approved by a vote of 9/0/1 (chair abstaining).

Crawley reported on the status of several work statements.

- 1049-WS *Building System Design Synthesis* was returned from RAC for revisions. Revisions were made as shown in **Attachment 6** and co-sponsorship from TC1.5 and TC4.6 was obtained. ***Action Item:*** There was a motion by Haves, seconded by Norford to approve the work statement *1049-WS Building System Design Synthesis* for RAC consideration with minor editorial changes. The motion was approved by a vote of 9/0/1 (chair abstaining). A PMSC consisting of Pedersen (chair), Sowell, Knebel, Robert Potter (TC1.5) was appointed to monitor the project.
- 930-WS Neural Nets was rejected by RAC for the second time. A&IM suggested that the work statement be withdrawn. ***Action Item:*** There was a motion by Norford, seconded by Walton to withdraw the work statement from the research plan. The motion was approved by a vote of 9/0/1 (chair abstaining).
- TC 9.6 seeks co-sponsorship of the work statement "*Development of Procedures to Determine In-situ performance of HVAC Air-Side Systems*" There were several objections to particulars in the work statement and a general feeling that the committee did not have enough time to properly evaluate it. ***Action Item:*** There was a motion by Sonderegger, seconded by Norford for TC 4.7 to Co-Sponsor *Development of Procedures to Determine In-situ performance of HVAC Air-Side Systems*. The motion was rejected by a vote of 2/3/5 (chair abstaining).

Norford reported for the Handbook committee [**Attachment 7]**. Minor revisions are anticipated for the next cycle.

Carol Gardner reported for the program committee[**Attachment 8**]. Phil Haves noted that the correct title of his Seminar is "*Beyond Spreadsheets: Using Equation Solvers and Modular Simulation in Energy Calculations*". Haves' seminar was moved to Chicago and Krarti's neural net seminar was moved to Toronto. ***Action Item:*** There was a motion by Haves, seconded by Bahnfleth to approve the plan. The motion was approved by a vote of 9/0/1 (chair abstaining)

Laisons:

- Judkoff reported for SPC-140, SMOT for Energy Software. The committee is planning for a letter ballot before Toronto seeking committee approval to put SPC-140 out for public review.
- Crawley, IBPSA / IBPSA-US liaison, reported on the Prague BS 97 conference.
- Reddy, GPC 14P Measurement of Energy/Demand Savings laiason reported that committee will not be done by Toronto.
- Reddy, TC 9.6 Systems Energy Utilization laiason, volunteered to send work statements in progress to Barnaby
- Crawley reported that ASHRAE has become a member of IAI (International Alliance for Interoperability**)**.

Old Business

- Hittle reported on his efforts to develop a workshop: *Software for HVAC Engineers*. He suggested that the BLAST Support Office or Gren Yuill might like to run the workshop. ASHRAE requires that software be in public domain. Hittle, Pedersen and Yuill will discuss the possibility.

New Business

- Barnaby presented the new committee structure shown in **Attachment 9.**

Jan Kreider reported on contractor selection for *1050-TRP Inverse Toolkit.* The Proposal review committee received only one proposal. Deficiencies in the proposal were such that the review committee recommended that proposal be returned to bidder for clarification. ***Action Item:*** It was moved and seconded **"**To request, through the Manager of Research, additional information from the single bidder on 1050-WS "Development of a Toolkit for Calculating Linear, Change-point Linear, and Multiple-Linear Inverse Building Energy Analysis Models" The motion carried 9-0-1 CNV

The meeting was then adjourned.

Attachment 1

TC 4.7 Energy Calculations

Minutes: Simulation and Component Models Subcommittee

January 19, 1998, 8:00-9:30, M/Walnut

The meeting was convened at 7:58 by D. Fisher.

Introductions and Announcements

Thirty one people were present as shown on the attached roster.

Work Statements

1. *Building System Design and Synthesis*
   This work statement which was submitted in Boston was returned by RAS for revision. Phil Haves gave an overview of the reasons for its return. The work statement was revised to address RAS concerns, and co-sponsorship from both TC 1.5 and TC 4.6 was obtained. The "demonstration" program was removed from the scope at the suggestion of TC 4.6. Carl Speich from Section 4 Research provided additional constructive criticism of the workstatement. Les Norford and Phil Haves agreed to rewrite the Work Statement to address Carl's concerns and submit the revised document to the full committee for approval.

2. *Compilation of Diversity Factors and Schedules for Energy and Cooling Load Calculations*
   Dan Fisher gave a brief overview of the workstatement. TC 4.1 made several suggestions to improve the work statement and voted to co-sponsor the project. Although the work statement requires a substantial amount of work to complete the reference section, the subcommittee agreed to submit the work statement to the full committee for approval with the following additions and corrections:
   - Add *Information for Bidders* section.
   - Clarify that a library of schedules and diversity factors is the deliverable.
   - Specify calculation of diversity factors for both peak load and energy calculations.

3. *Modeling Two- and Three-dimensional Heat Transfer through Composite Wall and Roof Assemblies in Hourly Energy Simulation Programs*
   Joe Huang presented an overview of the project. Lixing Gu noted that TC 4.4 has an ongoing similar project for steady state conduction. Although the projects are quite different they sound similar enough to warrant some interaction with TC 4.4. Joe Huang agreed to delay the project for one more meeting cycle and seek co-sponsorship with TC4.4.

4. *Modular simulation of Building Envelope Performance*
   Although some progress was made on the work statement, a revised version did not make it to the meeting (both authors were absent). Phil Haves noted that it would be good to let Loads Toolkit get a bit further on before pushing this work. A revised version is expected for consideration in Toronto.

Program

1. *Chicago Symposium, January 1999*
   Application of Heat (and Mass) Balance Methods to Energy and Thermal Load Calculations
   Chair: Chip Barnaby. ***Reviewers are needed.***
   Deadlines: Abstracts by Jan 21, 1998.
   Manuscript: April 2, 1998.
   Revised Final: July 15, 1998.
   Three abstracts have been received so far:
   - "Modeling the Energy Effects of Combined Heat and Mass Transfer with Vapor Adsorption in Building Elements", Liesen and Pedersen
   - "An Energy Consumption Comparison of One- and Two-Dimensional Radiant Cooling Slab Models using the Heat Balance Method", Strand and Pedersen
   - "Multivariable Newton-Raphson Method for Heat Balance Base Building Thermal Loads Simulation", Dong, Pedersen, and Fisher.
2. *Seattle Symposium, June 1999*
   Recent Innovations in HVAC System Modeling
   Chair: Russell Taylor
   Jean LeBrun noted that TC 4.6 has a Dynamic Models Symposium scheduled for Seattle. This subcommittee will retain this program.
3. Forums and Seminars
   Forum: *Who Needs Moisture Calculations*, Toronto, Mike Brandemuehl
   Seminar: *Beyond Spreadsheets: Using Equation Based Solvers in Energy Calculations*, Toronto, Phil Haves

Research Projects

Dru Crawley reported on RP 987: *Loads Toolkit.* The PMSC recommended that the toolkit be produed on CD ROM with no paper version.

Old Business

Curt Pedersen agreed to contact Special Publications to expedite the production of the primary toolkit. Dru Crawley suggested that this toolkit also be produced on CD ROM and volunteered to assist in its production.

New Business

Chip Barnaby presented the proposed subcommittee restructuring. The plan is to form an Applications subcommittee and narrow the scope of the current A&IM subcommittee to Inverse Methods. The new Applications Subcommittee would have more focus on Program and Technology Transfer activities and projects than the other two subcommittees. Phil Haves noted that the Simulation subcommittee has over last 25 years on focused on the detailed design stage. There is a need eed to apply simulation to later stages of building life cycle (e.g. commissioning, operation/maintenance).

Rich Liesen: Move to adjourn. Walton: Second.

Adjourn 9:28 pm.

Simulation and Component Models Subcommittee

Meeting Attendance
January 19, 1998, 8:00-9:30, M/Walnut

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Attachment 2

Work Statement From TC 4.7
Co-Sponsored by TC 4.1

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

Background

In most buildings, internal heat sources such as office equipment, lights and people account for a large percentage of the calculated cooling load. Indeed, building energy calculations are often dominated by the magnitude of the hourly internal gains. In spite of this fact, until recently very little attention has been given to this aspect of energy calculations. The ASHRAE HOF currently provides no guidance in this area. Although the indoor work environment has undergone a complete transformation in the last 15 years—with a computer, printer or copier on every desk; the ASHRAE literature has not been updated.

RP-822 [1] sponsored by TC 4.1 clearly addresses a large part of the problem. This experimental research project analyzed various types of office equipment to determine the steady state rate of convective and radiative heat transfer from the equipment. Steady state operation of the equipment, however, tells only half of the story. People enter and leave the building, lights and monitors are turned on and off and computers cycle down to "energy saving" mode. This diversity in the operating schedule is usually accounted for by means of a "diversity factor" or an hourly schedule. To provide all of the tools necessary to estimate the impact of internal heat sources on the cooling load, both steady state operating conditions and the diversity that is expected in the steady state operation must be accounted for.

Justification of Need

Hourly energy calculations require the specification of both the maximum expected energy transferred to the space by equipment, people and lights, and the diversity or schedule that is expected to modify the peak energy. The uncertainty attached to both of these numbers is very high. Recent studies indicate that energy engineers routinely "guess" high by a factor of two to five! (Wilkins, USACERL Report) There is a marked disparity between the level of detail and the accuracy that is expected from other aspects of the energy calculation, such as the calculation of conduction heat transfer through the envelope and the level of accuracy that is possible in the estimation of internal gains. The seriousness of the problem is highlighted by the fact that the magnitude of the internal gains routinely dominate the energy calculation. The most significant contribution to the cooling load is estimated without any assistance from the ASHRAE literature. As a result, in spite of tremendous advances in computing power and the availability of detailed and accurate methods for other aspects of the procedure , the uncertainty attached to the estimation of cooling loads is still unnecessarily high. To remedy the neglect of this area two steps must be taken. First, the steady state heat transfer rates from modern office equipment must be measured. Second, deviation of this equipment from steady state operating conditions in various office environments must be assessed. The first area has already been addressed. The research proposed in this work statement will begin to address the second area.

Objective

The overall objective of this project is the compilation of a library of schedules and diversity factors for energy and cooling load calculations in various types of indoor environments. Two sets of diversity factors, one for peak cooling load calculations and one for energy calculations, will be compiled. A subset of the library will be included in the ASHRAE Handbook of Fundamentals.

The overall objective will be met by completing the project in three phases with review and direction by the PMSC provided between each phase:

- The first phase will determine the availability in the American and European literature of diversity factors and schedules for the calculation of internal gains. Some literature examples with more or less details about this topic are [2], [3] and [4].
- The second phase will identify relevant existing data sets and apply statistical methods to extract diversity factors and schedules.
- The third phase will compile available diversity factors and schedules with appropriate use guidelines in a library that is suitable for inclusion in the ASHRAE literature.

Scope

1. Perform a thorough review of the literature related to the scheduling of office and laboratory equipment, lights and people.
2. Compile diversity factors and schedules from all available sources, including the European literature. Existing diversity factors and schedules should be compiled for all commercial building types including offices, hospitals and laboratories.
3. Identify sets of hourly or sub-hourly office building energy use data suitable for the extraction of diversity factors and schedules. Data sets for other types of buildings are beyond the scope of this project.
4. Apply statistical methods to the selected data sets to estimate 24 hour normalized profiles (i.e. fraction of peak gain), and diversity factors for cooling load and energy calculations.
5. Provide clear guidance on the application of diversity factors and schedules to various types of buildings and office environments. These guidelines should account for differences in both use and business culture. Types of equipment and other heat gains aggregated in data sets should be clearly delineated.

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. Data sets shall be submitted to the PMSC for approval prior to the extraction of schedules or diverstiy factors

d. A library of diversity factors and schedules with relevant documentation shall be submitted in electronic format only on 3 1/2" diskette(s).

e. 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. The final report shall include all developed computer code, in both fully commented source and executable versions. 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.
- Two copies on diskette(s), one in ASCII format and one in Microsoft Word 6.0.

f 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.

a. 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.

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

It is estimated that the project will require 12 person months and a total cost of $75,000.

Additional Information for Bidders

The successful bidder will demonstrate:

a familiarity with both load calculation and energy calculation procedures and the application of diversity factors and schedules to each.

b familiarity with available hourly and sub-hourly data sets and experience in extracting information from these sets.

Although the scope of the project is limited to office building data sets, additional consideration will be given to proposals that include data analysis for other types of buildings.

References

1. RP-822
2. Wilkins, C, ASHRAE Journal
3. Lister, Larry, USACERL Report
4. Norford, L.,; Hatcher, A.: "Electricity Use in Information Technologies", Annu. Rev. Energy, 1990. 15:423-53.

5. Dandridge, C.; Roturier, J.; Norford, L: “Energy policies for energy efficiency in office equipment - Case studies from Europe, Japan and the USA”, Energy Policy 1994 22 (9) 735-47.
6. Bosko, K.L.; “Metered Energy Consumption and Analysis of Energy Conservation Techniques in Desktop PC’s and Workstations”. MIT, 1996.

Contributors

Dan Fisher, Klaus Sommer

MINUTES

TC 4.7 Subcommittee on Applications and Inverse Methods
Monday, January 19th, 1998, 6:00 - 7:30 p.m.
Marriott "Walnut" Room (B2)
Chair: Jeff Haberl
Acting Chair: Joe Huang

AGENDA

1. Introductions (all)
2. Discussion of the minutes from June 1997 (all)
3. Discussion of Work Statements:

1052 WS: "Development of an Analytical Verification Test Suite for Whole-building Energy Simulation programs -- Building Fabric (Judkoff).

1051 WS: "Toolkit for calibrating computer simulation program..." (Haberl)

930 WS: "Development of a Toolkit for Predicting Building Thermal and Electricity Use from Measured Data Using Neural nets" (Krarti)

Others?

4. Review and vote on A&IM Long Range Research Plan (all)

NOTE: Copies of TC 4.7 Long Range Research One-pagers were attached to TC 4.7 minutes from Boston and can be obtained on Jeff Spitler's Web page.

5. Old Business (all)
6. New Business (all)
   + ASME meeting in Maui
   + Committee reorganization
7. Adjourn

Attendees:

J.Huang, J.Haberl (speaker phone), J.Neymark, C.Barnaby, J.Wilson, D.Fisher, F.Buehl, J.Hensen, L.Lawrie, D.Claridge, R.Sonderegger, M.Krarti, C.Gardner.

Joe Huang opened the meeting at 8:00 p.m. followed by introductions.

The minutes from the June ASHRAE meeting were circulated and discussed. The minutes were moved (Buehl) seconded by (Claridge). Minutes approved.

The discussion then went to the Work Statements.

(1052 WS) "Development of an Analytical Verification Test Suite for Whole-building Energy Simulation programs -- Building Fabric (Judkoff).

Chip said that this WS came back from RAS and that he had voiced his frustration about the fact that every time RAS changes members.

Barnaby and Crawley said that they needed to discuss the comments from RAS and decide how to rewrite this before the next RAS meeting.

(1051 WS) "Development (1051-WS) Development of a Toolkit for Comparing the Results of Hourly Building Energy Simulation Programs against Measured Energy and Internal Environmental Data

Haberl explained the RAS comments and the editing that had been done on the WS.

J.Wilson wanted to know if this would be hourly or monthly data to be used to calibration.

Haberl said that it would be both. Hourly data for complete calibrations. Monthly calibrations for simple tests.

Claridge said that monthly data points is probably not very useful.

Haberl then read some of the additional features about the WS.

Haberl asked if anybody knew if the WS needed to be revoted on.

Barnaby said that the scope needed to be rewritten to include "computer code".

ACTION: Claridge, Sonderegger and Barnaby agreed to act as readers of 1051 WS and will forward comments to Haberl who will incorporate them. The WS needs to be more clear so that someone can read it that has not worked on it. Reviewers will have comments back by February 13th, 1998

ACTION: Haberl will email WS to Claridge. Huang will distribute to Sonderegger & Barnaby.

ACTION: Haberl will have comments back to by February 20th, 1998.

Discussion then went on to 930 WS.

(930 WS) Development of Procedures for Predicting Building Thermal and Electricity Use from Measured Data Using Neural Networks

Moncef described the comments that had come back from RAS and express his frustration about continuing to get the WS back from RAS.

Haberl mentioned that he agreed with Krarti that this had had a lot of effort and nothing had gone forward.

Huang felt that it was ashamed that this was the committee on inverse methods and that it kept getting WS on inverse methods rejected.

Sonderegger mentioned that there were two issues, 1) where is the proper home for neural networks, and 2) if there is a home can this WS be taken to that TC. There had been a flurry of activity and that now things had calmed down and that maybe its time had passed.

Haberl mentioned that one of the comments that keeps coming back is "why do we need neural nets".

Sonderegger said that if this type of comment keeps coming back then maybe it is a signal that they just don't want this type of work.

Barnaby said that maybe this needs to sent to other TCs that are more closely related.

Huang agreed with Sonderegger that maybe this WS belongs in another TC where it can go forward.

Wilson suggested that maybe neural nets needed to be tied to deregulation and that this may help to generate more interest in neural nets.

MOTION: (Krarti) moved (Claridge) seconded, to remove WS 930 from the A&IM long range research plan.

Discussion then moved to the Long Range Research plan. Haberl agreed to forward copies of one-pagers to Joe Huang to include with the minutes.

ACTION: Joe and Dru said that they would be happy to would be happy to work on the WS for preparing weather data for simulation programs. Dru reminded the subcommittee that he had several other people that had also offered to help on this one (for example Fred Buehl).

New Business.

Claridge then mentioned the 1999 ASME meeting in Maui and invited papers.

Barnaby then discussed the new direction that TC 4.7 was moving and suggested that A&IM needed to be broken into two sub-committees, one on inverse methods and one on applications.

Crawley and Sonderegger suggested changing the name from "inverse methods" to "data driven" methods.

Sonderegger also mentioned that we needed to revisit the priorities that RAS has now assigned to WS. For example, RAS is now pushing for "high risk" research. RAS wants more technology transfer and WS that generate applied work.

Dan Fisher mentioned that 4.7 just went from three committees to two and now we were asking to go back to three again.

Barnaby said that he was questioned at the Committee chair meeting about why TC 4.7 was made up the way that it was.

Claridge mentioned that this was one of the joys about TC 4.7 was that it was organized by topics which kept the committee meetings fully populated.

Sonderegger was concerned that A&IM was producing WS that kept getting returned and that this might be an indication that the sub-committee needed reworking.

Crawley felt that the issue was that RAS had too many WS and not enough funding and that this was why they had rejected so many.

Haberl mentioned that George Kelly's new TC had done well with their WS and that maybe A&IM could take some lessons about how to put their WS in the right form so that they will be approved by TC 4.7 and then by RAS.

Haberl mentioned that separating Inverse from Applications would probably kill the Inverse methods within TC 4.7 and that probably this would bring new blood into the subcommittee especially if the subcommittee had a new chairman.

Barnaby then mentioned that TC 9.6 had several WS that sounded very much like the belonged in A&IM, including one on In-situ tests of HVAC systems, one on uncertainty calculations for measuring energy use and one on alternative methods for analyzing utility bills.

Haberl mentioned that he was aware of these WS that they had been discussed at previous A&IM meetings and it was felt that they had a better chance within TC 9.6.

Barnaby said that it was his intention to discuss the reorganization at the full committee meeting and that he just wanted to get some reaction at the subcommittee meeting before it went forward.

The meeting was adjourned at 7:40 p.m.

Attachment 4
NMF Minutes (Sowell)

TC 4.7 Ad Hoc NMF Subcommittee
San Francisco
Tuesday Jan 20 1998
4:00-6:00 PM

NMF Translator
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a. Availability of ASHRAE NMF translator was discussed. We will have to ask Bill Seaton of legal requirements in regard to making the translator available at the Bris Data Web site. (note: Sowell has since been contacted by Seaton asking for the Web address. I shall assume the matter has been resolved between him and Sahlin.)

b. We heard brief testimony regarding problems with the translator. Bugs appear to be present. A big problem is that it apparently does not emit TRNSYS 14.2 syntax.

c. It was decided that in the TC is to continue with NMF there should be a new WS to address following issues:

1. Add committee-approved hierarchical modeling capability.
2. Fix bugs.
3. Make compatible with latest TRNSYS version.
4. budget for language growth at least during the project.

d. Due to appearance on new modelling language Modelica on the scene, the whole NMF issue should be reviewed. Sahlin seems to suggest that Modelica MAY supercede. On the other hand, NMF may be all ASHRAE needs, and we should stick with it rather that chase after another dream.

Work statements

a. The Modular Simulation WS will be handled bt the Simulation Subcom.
b. Buhl has been working on the WS for spreadsheet NMF translator. A draft was reviewed. (this submitted to the TC in San Francisco).

Status of the Ad Hoc Committee

The Subcommittee noted that it has existed longer than is proper for an ad hoc committee. Problems of getting enough TC members involvemed in its work were noted, partially due to meeting time crunch. It was decided to recommend to the TC that its activities be folded into one of the standing committees.

Attachment 5

TITLE

Method for Accessing NMF Models in a Spreadsheet Environment

BACKGROUND

Engineers develop models in a variety of formats – mathematical description, various computer programming languages, spreadsheets. This variety of formats has always created difficulties in standardizing, disseminating, and exchanging such models. The Neutral Model Format (NMF) has been developed to overcome these difficulties by providing a common, readable, and unambiguous means of expressing equation based models of interest to the HVAC engineering community [1,2].

For NMF to fulfill its potential, models expressed in NMF must actually be used by engineers. To this end, translators from NMF to several simulation environments have been developed [3,4]. Such a translator can, for instance, take a cooling coil model expressed in NMF and produce a TRNSYS TYPE subroutine in FORTRAN. The translators, then, provide a way for the NMF models to be used by the HVAC engineering community.

Despite the existence of well established simulation environments and equation solvers such as TRNSYS, HVACSIM+, IDA, SPARK, EASE, and TKSolver, many engineers prefer to use spreadsheets for their calculations and modeling. Spreadsheets have several strong advantages – ease of data input, powerful and flexible output displays, compatibility with other software such as word processors – to balance their limited modeling capabilities.
Therefore it can be expected that engineers will continue to use spreadsheets, often as a result employing oversimplified models, or duplicating models already described in NMF.

JUSTIFICATION OF NEED

HVAC engineers need efficient and easy to use ways to perform engineering calculations, component modeling, and system simulation. Using NMF models in a spreadsheet will provide a way for HVAC engineers to use common, sophisticated models in a user friendly, familiar environment.

OBJECTIVES

Create the translation and other software needed to take HVAC models expressed in NMF available to users of spreadsheets.

SCOPE

(1) Define a subset of models expressible in NMF that can be used in spreadsheets.

(2) Create an automatic translator from NMF to a widely used programming language such as C or Visual Basic that can be compiled into functions which can be accessed in a commonly used spreadsheet.

(3) Use the translator to translate a meaningful subset of an existing NMF library into the form usable by the spreadsheet and perform an example calculation using the translated NMF library. This calculation should be at the level of a complete HVAC secondary system with simplified controls.

BENEFIT

This research will benefit ASHRAE members and HVAC engineers who perform their modeling tasks in spreadsheets by giving them access to existing and future NMF model libraries, thus increasing their efficiency and capability in modeling HVAC components and systems. The research will also benefit ASHRAE by expanding the usefulness of NMF and hence encouraging the development of common, reusable models.

DELIVERABLES

A report, suitable for publication, in which the translator software and the example models and calculation are presented in a form satisfactory to the PMS.

A PC compatible diskette containing code, test data, and software developed for the project.

Progress and Financial Reports shall be made to the Society through its Manager of Research at quarterly intervals.

The Principal Investigator shall report in person to the TC at the annual and winter meeting and answer such questions regarding the research as may arise. A Final Report shall be prepared and submitted to the Society by the end of the contract period covering complete details of all research carried out on the project. Unless otherwise soecified, six draft copies of the final report shall be furnished for review by the PMS. Following approval by the PMS and TC 4.7, the following will be deliverd:

- Four bound copies;
- One unbound copy, printed on one side only, suitable for reproduction;
- Two copies on 3 ½ inch diskettes – one in ASCII format and one in Rich Text Format (RTF).

A Technical or Symposium paper on this research shall be prepared in a form suitable for presentation at a Society Meeting. The paper shall conform to Section 5 of the Society's Author's Manual for Technical and Symposium Papers.

LEVEL OF EFFORT

I t is estimated that the project will require 12 person months of effort with the total project completed within a 6 month time perid based on an estimate of 6 person months of the Principal Investigator and six person months of a research assistant. The expected cost is $60,000.

REFERENCES

[1] Sahlin,P., Bring, A., and Sowell, E.F. "The Neutral Model Format for Building Simulation", Version 3.02, Report, Dept. Building Sciences, KTH, Stockholm, 1996 (available at ftp://urd.ce.kth.se/pub/reports/nmfre202.ps)

[2] Sahlin,P., “NMF Handbook – An Introduction to the Neutral Model Format”, Research Report, Dept. Building Sciences, KTH, Stockholm, Feb. 1996 (available at ftp://urd.ce.kth.se/pub/reports/handbook.ps)

[3] Final Report on 839-RP

CONTRIBUTORS

Fred Buhl
Ed Sowell

WORK STATEMENT 1049-WS
FROM
TC 4.7 ENERGY CALCULATIONS

CO-SPONSORED BY
TC 1.5 COMPUTER APPLICATIONS
AND
TC 4.6 BUILDING OPERATIONS DYNAMICS

ADVANCED CONCEPTS

TITLE

Building System Design Synthesis and Optimization

BACKGROUND

Design of buildings that minimize their impact on the global environment while meeting the needs of the occupants for a high quality indoor environment requires that both the envelope and the mechanical systems be well matched to the particular characteristics of climate, site, utility rate structure, occupancy etc. In many cases, designers do not attempt this matching, for such reasons as a lack of tools appropriate for complex problems and fees that do not permit investigation of alternatives to a limited number of conventional systems. One approach to this problem is to develop computer-based tools that can assist designers by automatically generating and comparing alternative design solutions.

Traditional building simulation methodologies allow building systems to be modeled either as prescribed systems, as in BLAST [1], DOE-2 [2] etc., or as user-described systems, as in HVACSIM+ [3], TRNSYS [4] etc. In each case, the configuration of the system is determined before the simulation is run and cannot be changed 'on the fly' during the run. The user can optimize a particular system design by varying particular parameters and re-running the simulation, and can then choose between designs involving different system configurations by comparing the results of runs with different (optimized) system configurations. In programs such as BLAST and DOE-2, the user is restricted to the configurations that have been implemented by the developer, which naturally tended to be conventional systems for conventional buildings. In those programs, such as HVACSIM+ and TRNSYS, that have the flexibility to allow the user, rather than the developer, to specify the system configuration, the process of actually specifying the configuration is time consuming and error-prone and is also limited by the ability of the user to generate alternative, feasible, configurations. A highly desirable advance would be for alternative configurations to be generated automatically.

Some programs, e.g. TRNSYS, can perform parametric variations automatically. Automatic configuration generation and variation, together with automatic parameter variation, could then be combined with a suitable search technique to synthesize an optimal design. The resulting optimization problem may, in general, be categorized as a mixed-integer nonlinear programming (MINLP) problem, containing integer variables to define a configuration and size components and continuous variables to represent component model parameters. Problem constraints can include lower and upper parameter bounds as well as bounds on operational variables such as temperatures, humidities and flow rates.

Similar optimization problems associated with synthesizing optimal configurations of heat exchangers, distillation columns and chemical reactors are the subject of extensive research reported in the chemical engineering technical

literature ([5] for example). Commercial software products that determine an optimal configuration of chemical process components are already available.

A number of minimization algorithms have been applied to different classes of synthesis problems. Some use numerically computed gradients to advance toward a minimum while others search for the minimum using only computations of the objective function. Methods which use gradients in the solution of problems with continuous variables and a continuous objective function (e.g. sequential quadratic programming) may be combined with integer programming solution methods to solve MINLP type problems. Other methods such as simulated annealing and genetic algorithms sample the objective function surface and approach a region "most likely" to contain the global minimum according to some stochastic or heuristic rule. These algorithms have the advantage of being able to escape local minima but use relatively large amounts of computational time [6,7].

The application area for the 'proof of concept' prototype goal oriented simulation program to be developed in this project is secondary HVAC systems. This application area has been selected because there is a wide variety of systems to meet building thermal loads and because several comprehensive libraries of models of secondary system components have already been developed [3,4,8,9].

JUSTIFICATION

Current simulation programs are mainly used to confirm performance and optimize sizing and operational parameters once the basic design decisions have been made. Simulation would be able to play a much more significant role in design if simulation programs were set up also to help designers in the early stages of design. In particular, the ability to generate and investigate a wide range of system configurations would allow novel and innovative system configurations to be synthesized and assessed much more easily and efficiently, leading to system configurations that are better matched to the particular requirements of each design.

OBJECTIVE

Develop methods for the synthesis of optimal configurations of HVAC systems. Demonstrate a prototype program that implements these methodologies to synthesize optimal configurations of secondary HVAC systems.

SCOPE

The main elements of a prototype optimal system synthesis program are:

a) A *configuration generator*. A configuration consists of a set of components (fans, coils etc.) and a set of connections between the components. The possible connections are limited by the need for compatibility of type (e.g. connect air to air, not air to water) and compatibility of direction (i.e. connect inlets to outlets not inlets to inlets).

b) An automatic *editor* for the selected simulation program(s) that will generate input files corresponding to the different designs produced by the configuration generator.

c) A *component-based simulation program*, together with a set of models that predict the quantities necessary to evaluate the cost functions of interest (e.g. first cost, life cycle cost). Currently available component libraries

contain models that will predict energy and environmental performance. Meaningful design optimization also requires a prediction of first cost (i.e. purchase cost plus installation cost). For each class of component (e.g. coils, fans) the first cost can be expected to be a fairly simple function of size and it should be possible to extend current models to predict approximate first cost without significant difficulty.

d) An *optimization program* suitable for minimizing or maximizing a user defined objective with respect to a set of integer and continuous variables along with constraints. Functionally, at each iteration, the optimization routine will output a set of variable values. The editor will then create an input file for the simulation program from the variable set. The simulation program will run, predicting costs or other values used in the objective function. The user specified scalar objective function will be calculated and the resulting value returned to the optimization routine.

e) A *run-time supervisor* that can use one or more minimization techniques in order to optimize the design.

The tasks involved in developing a prototype building system synthesis program for HVAC secondary systems are:

1. Produce an inventory of existing design alternatives for secondary systems, itemizing the components used and the ways in which they can be connected to each other and to components and sources/sinks outside the boundaries of the system. Define a set of pseudo-components (e.g. sources of ambient air, chilled water) that will be used to impose boundary conditions on the simulation. Select a limited set of configurations to be used in testing the configuration generator, as discussed below.

2. Review component-based simulation programs and select suitable program(s) and component models for target application.

3. Extend component models to include an approximate estimate of first cost. A simple cost model is sufficient for the 'proof of concept' goal-oriented simulation to be developed here, but the implementation should allow for more accurate and realistic cost models to be added in later versions.

4. Develop configuration generator: group component model inputs and outputs into 'links' of pre-defined type (e.g. moist air, water refrigerant) consisting of pre-defined variables (e.g. a moist air stream can be defined by its temperature, humidity ratio, mass flow rate and, if relevant to the calculations, pressure). Develop a method that allows a wide variety of physically realizable HVAC secondary system configurations to be generated automatically. Consider possible ways in which the number of configurations can be limited, e.g. elimination of redundant components, setting a (user-defined) threshold on system complexity. Implement the configuration generator in such a way that the criteria for eliminating particular configurations can be changed easily by the user.

5. Test the configuration generator by verifying (a) that it can generate all of the test set of configurations referred to in (1) above, and (b) that the constraint functions serve to disallow impossible or prohibited configurations.

6. Develop an editor or editors that will generate input files for the simulation program(s). The components and their connections will be defined by the configuration generator. The boundary conditions will be determined by the design brief and the initial values and feasible ranges of the parameters will be determined from expert knowledge, e.g. rules of thumb. The editor must account for the following:

    a) Generation of initial values and feasible ranges for the parameters. One possibility that should be investigated is the automation of the psychrometric analysis methods used in conventional system sizing.

    b) Automatic generation of a control strategy for each configuration. One possibility would be to perform an on-line optimization at each time step to generate the optimal operating point, since a system model is

necessarily available. If this proves too difficult, the more restricted objective of optimizing for design conditions could still be addressed as a limited proof of concept.

c) Characterization of each configuration by a set of variables (such as coil UA) that define the search space for the optimizer.

7. Review optimization methods and select one or more methods for implementation. The selection criteria should reflect the nature of the design problem and should include the ability to deal with local minima, constraints and a combination of discrete and continuous variables. (Various parameters relating to system sizing are discrete, e.g. available coil size, in addition to the discrete nature of alternative system configurations.)

8. Implement the selected optimization method(s) in a software environment that allows the simulation program(s), together with the appropriate input files, to be called in order to evaluate the value of the selected cost function for different parameter values.

9. Develop a set of design briefs for use as test problems for the goal-oriented simulation. These should differ in complexity and include cases where the optimal design can be established analytically and others where there are several design configurations that are close to the optimum. Use an exhaustive search technique to identify the global minimum, and all the local minima, within an appropriate, explicitly defined region of the design space.

10. Test the prototype optimum system synthesis program using the test problems developed in (9) and, where possible, modify the approach and the software to improve its performance.

11. Assess the overall performance of the prototype and the technical viability of the approach. If appropriate, make recommendations for further work:

    a) how the approach could be further developed generically;

    b) how the prototype implementation could be made more robust;

    c) how the approach could be implemented in other application areas (e.g. primary systems);

    d) how the practical utility of the approach could be assessed, e.g. by trials involving practicing designers.

INTERACTION WITH PROJECT MONITORING SUBCOMMITTEE

It is necessary that the contractor interact closely with the project monitoring subcommittee. The contractor will be required to make the following submittals for Project Monitoring Subcommittee (PMS) approval:

1. Choice of component-based simulation program(s) and available component models (Task 2).

2. A viable design for a configuration generator that will produce configurations of interest while eliminating to the maximum extent possible configurations that an expert would consider to be unrealizable or otherwise of no interest (Task 4).

3. The configurations used to test the configuration generator (Task 1) and the results of the tests (Task 5).

4. A working version of editor that generates input for the simulation program from system defined by the configuration generator (Task 6).

5. Choice of optimization program. If at all possible, the program should be an existing, well documented and tested approach for which executable code is available (Task 7).

6. An initial test problem to be optimized.

    a) Choice of an appropriate problem (Task 9). For example, the objective may be to select an optimal system that meets the annual heating/cooling loads and ventilation requirements for four different zones. To focus effort on system configuration and evaluation, pre-calculated loads should serve as boundary conditions for system and plant components, much as is done in common building energy simulation programs. The scope of the problem should be limited to one for which all results for all possible configurations can be calculated within reasonable time/computational constraints.

    b) A set of possible components that will be available to the configuration generator to meet the requirements of the initial test problem.

    c) A demonstration of the program's ability to find the optimal solution to the test problem, with comparative results for all possible configurations (Task 10).

7. A list of three test problems of increased scope. For example, the problems could include more zones and a broader list of components available to the configuration generator. The intent should be to probe the optimal solution to a problem of increased dimension, large enough that all possible configurations can not be simulated in any reasonable amount of time (Tasks 9 and 10).

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. 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. The final report shall include all developed computer code, in both fully commented source and executable versions, and thorough documentation of program input and output variables and assumptions underlying the program. 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.
    - Two copies on diskette(s), one in ASCII format and one in Microsoft Word 6.0.

a. 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.

b. 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.

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

It is estimated that the project will require 42 person months of effort with the total project to be completed within an 36 month time period, based on an estimate of 6 person-months of the Principal Investigator and 36 person months of a research assistant. The expected cost is $175,000. The projected time and cost reflect the scope of work and the need for a sustained effort by researchers with appropriate skills. The contractor is expected to identify personnel and their commitment to the project, with an emphasis on continuity.

OTHER INFORMATION FOR BIDDERS

The successful bidder will demonstrate:

1. Familiarity and experience with suitable optimization methods and their implementation;

2. Familiarity and experience with HVAC modeling and simulation;

3. Experience with writing and testing computer code to be used by others.

Bidders should also explain their approach to the design of the configuration generator.

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AUTHORS

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Attachment 7

TC4.7 Handbook Subcommittee Meeting
Monday, January 19, 1998

Present:

Bill Bahnfleth
Doug Hittle
Les Norford (chair)
George Walton

The meeting began at 5 p.m. Norford reviewed key points from the meeting held on Sunday morning by the chairman of the ASHRAE Handbook Committee for TC handbook subcommittee chairs. For the 2001 HoF, the schedule is includes the following checkpoints:

January 1998	review of chapter completed, revisers committed
June 1998	first draft prepared by the subcommittee
June 1999	draft approved by the TC
January 2000	final version approved by TC
April 2001	HoF to printer

TC4.7's handbook subcommittee is on schedule for the revision of Chapter 30, "Energy Estimating and Modeling Methods." The 2001 HoF will be published in the same formats as those available for the 1997 HoF: print or CD versions.

The Handbook Committee chair noted that when a chapter undergoes a major revision (as was the case for TC 4.7's chapter 30 in the 1997 edition), the subsequent revision is usually devoted to minor changes. The major revision typically covers 80% of the needed changes and the subsequent revision addresses 80% of the remaining 20%. Norford met briefly with Dave Claridge, the Handbook Committee's liason for TC 4.7, who agreed with Norford that the major/minor revision sequence was appropriate for chapter 30.

Members of the subcommittee also concurred with the assessment that a relatively minor revision was appropriate. Hittle and Bahnfleth shared detailed comments, noted on photocopies of the chapter. The comments included elimination of undefined jargon; addition of several references; coordinating with TC4.1 for coverage of the heat balance method, given that TC 4.1 aims to include this method in the loads calculation chapter; updating the loads/systems/plant discussion in the introduction to reflect work on the Energy Plus program; and modest tightening of the new section on inverse methods. Norford identified the need for a modest amount of new information on ground coupling (as suggested by Claridge); NMF; and the Loads Toolkit now in preparation. Given the nature of the comments, subcommittee members considered the review to be the first stage of the revision. Further, it was suggested that the subcommittee chairman seek TC consent to his asking for help from TC members on specific topics.

Walton will review the chapter after the San Francisco meeting concludes. Norford will obtain from ASHRAE an electronic version of the text and begin to enter the changes for the June 1998 meeting.

The meeting adjourned at 5:50. Subsequent to the meeting, Norford met with Barnaby, who noted that the TC is placing more emphasis on applications (achieved in part by the announced formation of a subcommittee devoted solely to applications. Barnaby further noted that what the chapter offers practitioners has long been a question. The Handbook Subcommittee will seek help in strengthening the chapter's appeal to practitioners.

Attachment 8

TC4.7 Program Plan
San Francisco ASHRAE Conference
January 20, 1998

***Toronto* Conference** (all materials due Feb 6) -

Forum, "Who Needs Moisture Calculations " Chair - Mike Brandemuehl

Seminar, "Beyond Spreadsheets" Chair - Phil Haves

Symposium, "Baseline Calculations for Measurement and Verification of Energy and Demand Savings" Chair - Robert Sonderreger

Symposium, "Accuracy Tests for Simulation Models" Chair - Mike Witte

Chicago Conference (materials due July 31, 1998)

Symposium, "Application of Heat and Mass Balance Methods to Energy and Thermal Load Calculations" Chair - Chip Barnaby (mostly UI papers)

Seminar, "Neural Nets - What are They and What Can They Do ? " Chair - Moncef Krarti

Seattle Conference (materials due Feb. 5, 1999)

Symposium, "Recent Innovations in HVAC System Modeling" Chair - Russ Taylor

Seminar or Symposium, "Parameter Estimation for Modeling Actual Building Systems" Chair - Carol Gardner

Attachment 9

Proposed Subcommittee Structure

Simulation and Component Models

- First principles models and algorithms
- Solution techniques

Inverse Methods

- Data-driven methods
- Related statistical procedures
- Simulation calibration

Applications

- Case studies
- Design and problem solving procedures
- Input data compilations (materials properties, internal gains,)
- "Technology transfer"