ibpsaNEWS

May 1990

International Building Performance Simulation Association, Inc.
Post Office Box 282, Orleans, Ontario, CANADA K1C 1S7

Volume 3, Number 2

JUNE IBPSA MEETING TO BE HELD IN ST. LOUIS

The next meeting of IBPSA will be held on Saturday, June 9, 1990, in conjunction with the ASHRAE Annual Meeting in St. Louis, Missouri, USA. This general IBPSA meeting will run from 5:30 to 7:30 p.m. and will be held in Meeting Room 23 of "Directors' Row" on the 2nd floor of the Adams Mark Hotel in St. Louis. Highlighting this meeting will be further planning for Building Simulation '91. This meeting is open to anyone interested in building simulation; only paid IBPSA members may vote.

MEMBERSHIP RENEWAL TIME!

IBPSA memberships renew in January of each year. Annual dues are US$75.00 for Members, US$500.00 for Sustaining Members, and US$25.00 for Student Members. Members who joined IBPSA at the Building Simulation '89 conference may renew their membership for 1990 at the rate of US$37.50. Please send your 1990 dues to the IBPSA Treasurer:

IBPSA
c/o ADM Associates, Inc.
Mr. Taghi Alereza
3299 Ramos Circle
Sacramento, CA 95827

IBPSA GENERAL MEETING

Saturday, June 9, 1990
5:30-7:30 P.M.

Room 23 (2nd Floor)
Adams Mark Hotel

St. Louis, Missouri, USA

PLANS SET FOR BUILDING SIMULATION '91

by Rik Van de Perre

The next IBPSA building simulation conference will take place in Europe in Nice/Sophia-Antipolis on the French Riviera on August 20-22,1991. This second world congress on technology improving the energy use, comfort and economics of buildings worldwide, will focus on six basic areas:

- ***Models for Environmental Building Performance Analysis***
  Heat and mass transfer, comfort, daylighting, acoustics, air quality, controls, and equipment

- ***Computer Implementations***
  Mathematical and numerical methods, general and specific solvers, object-oriented environments, intelligent environments, database structures, graphical standards, computer visualization, real-time simulations

- ***Programs and Software***
  Technical presentations and on-site demonstrations of various public domain and commercial products

- ***User Interfaces***
  Dynamic user modelling, intelligent front- and back-ends, links between drafting and simulation environments

- ***Design Integration***
  Architectural and engineering design optimization, computer integrated manufacturing, building management, energy policy, regulatory measures and industrial standards

- ***Technology Transfer***
  National and international case-studies on how to match the potential of building simulation with the needs of the building community

(See Building Simulation '91 on p. 2)

BUILDING SIMULATION '91
(cont'd from p. 1)

The conference will be preceded by a four-day cultural tour in the North of Italy (Florence, Venice, etc.), and followed by several technical tours after the conference (including a two-day visit to the CEC Joint Research Centre (JRC) at ISPRA in the Alps Lake district).

The IBPSA BS'91 conference is an excellent opportunity for corporations and researchers worldwide to improve international and trans-continental technology transfer and to explore new possibilities for co-operation and joint ventures, especially with European organizations (from both East and West).

Take your diary and block out the period from August 15 to August 25, 1991 (or at least from August 20 until 22, '91), for your most important 1991 appointment with building simulation technology, as well as with the European cultural heritage and the French hospitality.

All IBPSA members will soon receive a first call for papers. If you are not yet enrolled, contact the IBPSA secretariat immediately. Further information can be obtained from the conference organizer or the conference project manager.

Conference Organizer

Philippe Geril
IBPSA-BS'91
Coupure Links 653
B-9000 GHENT
BELGIUM

FAX: 32/91/24.40.93
E-mail: GERIL@BGERUG51.BITNET

Project Manager

Rik Van de Perre
VUB-eenheid ZONE
Pleinlaan 2
B-1050 BRUSSELS
BELGIUM

FAX: 32/2/641.22.82
E-mail: rvdperre@zone2.vub.ac.be

USE OF IBPSA MAILING LIST

The IBPSA Board of Directors has approved use of the IBPSA mailing list by outside parties. The IBPSA mailing list will be available on a single-use rental basis at a price yet to be determined. Anticipated uses will be announcements of software, short courses, conferences, and other items of interest to the IBPSA membership. If you do not want your name and address to be released, please notify the society in writing. Address your request to:

IBPSA
c/o ADM Associates, Inc.
Mr. Taghi Alereza
3299 Ramos Circle
Sacramento, CA 95827

IBPSANET

In order to improve communications within IBPSA, the Newsletter and Publications Committee is promoting the use of electronic mail. For those of you who routinely use electronic mail, you know what the benefits are. For those of you who have not, the main benefit is immediacy without the need for FAXes or "telephone tag".

For years, most government and educational institutions have been connected to the Internet or to BITNET for exchanging electronic mail with other institutions worldwide. Private firms and private computing services have been slow in getting connected for various reasons. Last year, the CompuServe service in the U.S. added Internet mail capabilities to its electronic mail system. CompuServe users can now send mail to any Internet address in the world just as easily as sending a message to another CompuServe user. This opens the world of e-mail to anyone in the U.S. and Canada for a nominal fee.

For IBPSA members outside North America who do not work at a university or public institution, the editors do not currently know of a good low-cost solution. There are ways to access CompuServe through international networks, but this can be very costly. If anyone has information about better ways to connect these members, please notify the *ibpsaNEWS* editors.

Also, if anyone knows of any other private services that can handle Internet mail, please let us know.

How to Get Connected to ibpsaNET

Send e-mail to the ibpsaNEWS editors at:

Internet
Michael_J_Witte@um.cc.umich.edu

BITNET
USERLJ4R@UMICHUM

CompuServe users can send mail to Internet addresses by using the format:

INTERNET:Michael_J_Witte@um.cc.umich.edu

The best way to use Internet addresses is to record them in your personal address book on CompuServe and to refer to them by the person's name. Internet users can send mail to CompuServe users by using the format:

xxxxx.xxxx@compuserve.com

(Note: Use a period in place of the normal comma in the CompuServe user id when sending mail to CompuServe.)

BEWARE! CompuServe charges can add up quickly at rates of US$12.50/hr and up. The only reasonable way to use this service for electronic mail is to use a program such as AUTOSIG which lets you compose messages offline, dials up CompuServe, automatically delivers and picks up messages, and then lets you read the messages offline. The important thing is to get on and off of the service as quickly as possible to minimize charges. If you need a copy of AUTOSIG for the IBM-PC, please send an IBM diskette (any format) to the address listed below.

If you are not currently a CompuServe user, but would like to get an account for e-mail purposes, please write or call for information:

ibpsaNEWS
c/o Michael J. Witte
University of Michigan
College of Architecture and Urban Planning
2000 Bonisteel Blvd.
Ann Arbor, MI 48109-2069

Telephone: (313)763-3518
(313)764-1340
FAX: (313)763-2322

IBPSA ELECTS OFFICERS AND BOARD OF DIRECTORS

The first regular election of officers and Board of Directors was conducted at the IBPSA General Meeting in Atlanta in February. The newly elected officers and board members will serve a term of two years in accordance with the IBPSA bylaws.

Officers

President: Edward Sowell
Vice President/President Elect: Dan Seth
Secretary: Dwight Beranek
Treasurer: Taghi Alereza

Board Members

Jean LeBrun
Rik Van de Perre
Joe Clarke
Gren Yuill
Ed Knipe
Zulfi Cumali
Marx Ayres
Fred Winkelmann
Linda Lawrie
Robert Sonderegger
John Mitchell

IBPSA FINANCIAL REPORT

by Taghi Alereza, IBPSA Treasurer

IBPSA

Summary of Financial Status
as of January 19, 1990

Starting Balance (June 19, 1989)	US$4,361.75
Membership Dues	887.50
Transferred Funds from BS '89	22,390.70
Interest (1/19/90)	324.49
Expenses	(309.42)
Net Balance	US$27,655.02

SOFTWARE ANNOUNCEMENTS AND REVIEWS

To all building performance simulation software developers:
Please submit news releases announcing new products and significant product improvements. These announcements will be published in *ibpsaNEWS* free of charge.

ATLANTA MEETING MINUTES

INTERNATIONAL BUILDING PERFORMANCE SIMULATION ASSOCIATION

Atlanta Meeting

February 10, 1990

MINUTES

1. The meeting was called to order by President Ed Sowell at 7:10 P.M. on Saturday, February 10, 1990, in Room 311 of the Georgia World Congress Center in Atlanta, Georgia, USA.

2. Secretary Dwight Beranek passed around a signup list. 29 people, including 26 IBPSA members, were in attendance.

3. The agenda was presented by President Sowell. It was accepted unanimously by a voice vote.

4. The minutes of the last meeting in Vancouver, B.C., Canada, were presented and accepted unanimously by a voice vote.

5. There were no announcements.

6. Committee Reports

6.1. Membership Committee

Taghi Alereza reported that there were 38 paid up members prior to Building Simulation '89. 50 more members paid at BS '89 for a total of 88 paid members. 19 members have been invoiced for which 1989 dues have not been paid. Dues for 1990 are now due.

A motion by Mike Witte, seconded by Marx Ayres, to charge new members that signed up at BS '89 $37.50 for 1990 dues passed unanimously.

John Mitchell offered to place an IBPSA ad in the International Solar Energy Journal. Other places to advertise were discussed. Mike Witte and Mick Schwedler offered to write articles suitable for publication in magazines to help publicize IBPSA.

6.2. Finance Committee

Treasurer Taghi Alereza presented a detailed financial report. As of January 19, 1990, there was a balance in the treasury of US$27,655.02. The contract with MCC for BS '89 is paid up and closed out. A pie chart or other summary of the financial report will be sent to Mike Witte for publication in *ibpsaNEWS*.

6.3. Program Committee

A separate proposal for conducting "Building Simulation '91" in Europe by Rik van de Perre and BEPAC were discussed. It was recommended that BS '91 be held in Nice, France, in September 1991. A motion by Doug Hittle, seconded by John Mitchell, to accept Rik van de Perre's proposal and hold BS '91 in July or early August carried unanimously. An informal hand count of attendees indicated that 13 could attend the conference in September '91 and 15 could attend in July or early August. The exact date will be determined after the meeting in consultation with Rik and the board of directors.

A clear consensus of the attendees insisted that BS '91 be clearly an IBPSA undertaking, not a joint conference with European and other organizations. It was agreed that financial control of the conference would be with the IBPSA Board of Directors. A motion by Doug Hittle, seconded by Zulfi Cumali, to authorize the Board of Directors to expend up to $10,000 in support of the conference passed unanimously. The attendees felt that the conference should be planned as a money making event.

A steering committee for the conference would be appointed by the President. Carol Gardner volunteered to be on the steering committee. Zulfi Cumali volunteered to be on the Scientific Committee for the conference. Jeff Haberl volunteered to review papers.

6.4. Newsletter Committee

Mike Witte urged that articles be prepared for the IBPSA newsletter. There are several "departments" that could be assigned to individuals that would stay on top of events in those areas. Mike reported that the newsletter costs approximately $200 an issue.

A proposal by Henry Amistadi to produce "The Research Feature" and "Research News" departments of the IBPSA newsletter was discussed. A motion by Dwight Beranek, seconded by Zulfi Cumali, to authorize the Board of Directors to spend up to $2000 in start up funds for this work (provided there is a definite product) passed with a vote of 10 in favor and 7 opposed.

A consensus of the attendees was reached in favor of releasing the IBPSA mailing list to others for a fee.

6.5. Research Committee

Linda Lawrie presented a report for the committee. A list of research areas was discussed. A motion by Doug Hittle, seconded by Dwight Beranek, to have an April 15, 1990, deadline for members to offer comments on IBPSA research priorities passed unanimously. A research "agenda" will be presented for approval at the next IBPSA meeting based upon this and other input. A representative from DOE stated that DOE welcomed IBPSA input to their R&D priorities.

7. Old Business

7.1. Planning

Ed Knipe will update the long range plan by the next meeting using discussions held on the subject at this meeting.

7.2. Executive Secretary

Ed Sowell discussed the list of duties for an IBPSA executive secretary that was proposed by Mike Witte and Ed Knipe. Chip Barnaby will send information to Ed Sowell on suggested contractors.

7.3. Affiliations

A discussion was held regarding a proposed affiliation with BEPAC. The Board of Directors had recommended adoption of the proposal. A motion to accept the proposal was passed.

8. New Business

8.1. Election of Officers

The election of officers was conducted by Secretary Dwight Beranek. In a secret ballot, Ed Sowell was elected President; Dan Seth, Vice President/President Elect; Dwight Beranek, Secretary; and Taghi Alereza, Treasurer; each against opponents. The slate nominated for Board of Directors was elected unanimously. The new Board members are:

Marx Ayres	Joe Clarke
Zulfi Cumali	Ed Knipe
Linda Lawrie	Jean Lebrun
John Mitchell	Robert Sonderegger
Rik Van de Perre	Fred Winklemann
Gren Yuill	

Each officer and board member serves a two year term.

8.2. Next Meeting

After discussion, it was agreed that the next meeting would be held in St. Louis in conjunction with the ASHRAE Annual Meeting. In order to avoid conflicts with ASHRAE events, the meeting will be held on Saturday night, June 9, 1990, from 5:30 to 7:30 P.M.

9. The meeting adjourned at 10:20 P.M.

Dwight Beranek
Secretary

Please submit any corrections to the minutes to Secretary Beranek:

Dwight Beranek
HQ U.S. Army Corps of Engineers
CEMP-ET
20 Massachusetts Ave., NW
Washington, DC 20314

FORUM

Dialogue of interest to the IBPSA membership may be submitted for publication in this section of *ibpsaNEWS*. Letters which are addressed to a specific IBPSA member will be forwarded to that person for reply prior to publication. The editors reserve the right to edit all submissions.

To: Ed Sowell
From: George Walton
Subject: Sparse Matrix Methods vs. SPANK

Ed, I think that much of the difference in our views of simulation is that we are looking at different parts of the problem. For example, I had not thought my analysis of the simultaneous equations for the heat transfer between rooms was a very special problem. I thought it was not as sparse as would be expected in a "real" case. It may be unfair to compare it with SPANK methods for HVAC networks that reduce the number of equations by a factor of 50 as mentioned in your letter, but your letter fails to mention that SPANK reduced the number of equations for thermal conduction analysis by a factor of only 2. SPANK seems well suited for HVAC networks for which it was originally developed. The reason my paper discussed sparse methods is that SPANK had been compared only to non-sparse solutions, which makes SPANK look very good indeed. Sparse methods should be used where appropriate. They are not appropriate for a system of a few equations, but if SPANK were to reduce a 10,000 equation problem to 500 equations, those equations would tend to be sparse.

In recognizing a "convergence" of methods, it was not my intent to say that matrix methods had all the answers, only that several interesting methods had been demonstrated that we should study for their applicability to our simulation problems. In particular, the idea that you call a "pre-set" in SPANK appears especially useful. I did not credit that "advantage" to SPANK because it can be implemented in other methods as well. If it were an integral part of the SPANK solution, I assume it would have been mentioned in the original SPANK description. I am presently using this idea in a new sparse matrix simulation, and I am finding some very encouraging results.

I believe there is a good reason for looking at the solution of simultaneous equations from the matrix point of view, and that is the body of mathematical literature which tells us if the equations are solvable at all.

All of this discussion has not touched the bigger problem of nonlinear equations and their solvability. The number of different phenomena which occur in buildings makes it difficult to know how all potential nonlinear equations can be solved. This will require that we look again at our fundamental approach to the simulation of buildings.

See you in St. Louis.

UPCOMING CONFERENCES AND MEETINGS

The 3rd International Conference on System Simulation in Buildings
December 3-5, 1990
Liège, Belgium
For more information, contact:
Georges LIEBECQ
University of Liège
Laboratory of Thermodynamics
Rue Ernest Solvay, 21
B-4000 Liège
Belgium
Phone: 32-41-52.01.80
Telex: 41.397 univlg b
FAX: 32-41-52.54.39

In-Situ Heat Flux Measurements in Buildings -- Applications and Interpretation of Results
May 22-23, 1990
Hanover, New Hampshire, USA
For more information, contact:
Steve Flanders
U.S. Army CRREL
72 Lyme Road
Hanover, New Hampshire
USA
Phone: (603)646-4302
FAX: (603)646-4278

International Symposium on Energy, Moisture, Climate in Buildings
September 3-6, 1990
Rotterdam, The Netherlands
Sponsored by CIB International Council of Building Research

Building Simulation '91
August 20-22, 1991
Nice/Sophia-Antipolis, France

RESEARCH NEWS

Research news will include the following topics:

Current Activities
New Releases
Publications, Software, and Databases
People in Research
National and Laboratory Research Plans
News from Other Societies

Current Activities

The Texas LoanSTAR Monitoring and Analysis Program: A Brief Introduction

Jeff Haberl, David Claridge, Dennis O'Neal, Warren Heffington, W. Dan Turner, Texas A&M University; Malcolm Verdict, Texas Governor's Energy Management Center

The Texas LoanSTAR program is an eight year, $98 million revolving loan program for energy conservation retrofits in Texas state, local government and school buildings funded by oil overcharge dollars. Public sector institutions participating in the program must repay the loans according to estimated energy savings in four years or less. As part of this program a statewide Monitoring and Analysis Program (MAP) has been established.

The major objectives of the LoanSTAR MAP are to: 1) verify energy and dollar savings of the retrofits, 2) reduce energy costs by identifying operational and maintenance improvements, 3) improve retrofit selection in future rounds of the LoanSTAR program, and 4) initiate a data base of energy use in commercial and institutional buildings located in Texas.

In 1988, the Governor's Energy Management Center (GEMC) of Texas received approval from the U.S. Department of Energy to establish a $98.6 million statewide retrofit demonstration revolving loan program, the LoanSTAR (Loan to Save Taxes and Resources) Program. The LoanSTAR program uses a revolving loan financing mechanism to fund energy-conserving retrofits of state, public school and local government buildings. Retrofit projects are identified by energy audits conducted by engineering teams under contract to the GEMC. Each retrofit competes for funds on the basis of the estimated payback period, ability to repay the loan through energy savings, engineering assessment of the viability of the retrofit, and the staff's ability to monitor the project effectively.

The projects funded by LoanSTAR primarily include retrofits to lighting, HVAC systems, building shell, electric motors, energy management and control systems (EMCS), and boilers and thermal energy recovery systems. Retrofits using alternative or renewable energy systems and load management are also being considered.

The LoanSTAR MAP is administered through the Governor's Energy Management Center (GEMC) and conducted primarily at the Energy Systems Laboratory at Texas A&M University. A Monitoring and Analysis Review Committee (MARC) has been established to provide ongoing contact with other monitoring and analysis efforts to ensure incorporation of applicable techniques and results from those efforts.

The primary work for the MAP has been divided into 5 tasks which include: Task 1) the audit review and assignments, Task 2) hardware selection and installation, Task 3) a calibration facility, Task 4) systems communications bench test, and Task 5) monitoring analysis and reporting.

Table 1 presents monitoring progress statistics through April 1990. About 245 channels of hourly information are scheduled for installation to record data from 30 sites encompassing 4,250,000 square feet of conditioned space.

In order to facilitate communications with any manufacturer's field data recorder the LoanSTAR program is developing a public domain Data Recorder Management System (DRMS). Figure 1 illustrates the conceptual structure of the Data Recorder Management System (DRMS). The DRMS will perform several functions, including: programming of field recorders, scheduling the polling calls, and translation of commands and data records for different manufacturers' recorders. Common-format data from the DRMS are then passed into the storage processing system where permanent and on-line storage are maintained. The on-line storage will be a SQL-based Relational Data Base Management System (RDBMS) to facilitate easy retrieval of the heterogeneous data.

The engineering savings estimates for the LoanSTAR retrofit measures rely on numerous assumptions made by the auditors. Some of the most crucial estimates are the electrical gains,

building schedules, and lighting schedules. One way to improve energy audit assumptions is through the use of calibrated computer models. A procedure is being developed for "calibrating" the inputs used by the DOE-2 building simulation program to actual buildings. Similar "calibration" procedures for less detailed programs, such as ASEAM, are also being investigated.

The design of the monitoring program is meant to measure and evaluate the ingredients (fuels being consumed), products (comfort, illumination, etc.), and influencing parameters (weather, schedules, etc.) of a building's energy usage.

There are many different ways of designing an experiment to measure the energy savings from an energy conservation retrofit. Because of the diversity of the types of experiments being monitored in the LoanSTAR program, each building will have its own experiment plan. In general the experiments will rely either on the measurement of energy consumed directly at the retrofit device (sub-metered) or at the whole-building boundary.

Figure 2 illustrates a typical before-after analysis of retrofit savings. For each site before-after, point-in-time, and time-sequence information measuring the influencing parameters and system requirements are evaluated to determine if energy savings match those of the audit estimates. Corrective measures, if needed, and feedback to owners and operators is also planned.

Detailed reports concerning the LoanSTAR program, availability of metered data, and software developed can be obtained from the authors. The first year efforts include the monitoring of hourly data from over two-dozen buildings using microcomputer-based field recorders supplied by several different manufacturers. Future efforts include investigating the feasibility of utilizing EMCS-based monitoring and data-sharing with the HVAC service industry to reduce monitoring costs and expanding the program into additional sites.

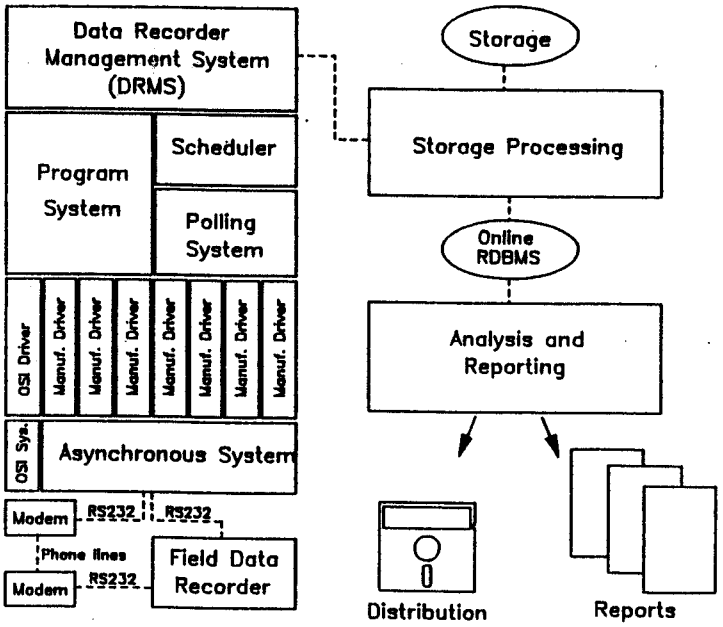


Figure 1. LoanSTAR Data Recorder Management System (DRMS). A schematic figure of the Data Recorder Management System is shown in this figure. Data are retrieved periodically from various field recorders via RS232 or modem using the appropriate manufacturer's driver. Once the data are translated to a common format they are then stored for analysis and reporting in a Relational Data Base Management System (RDBMS).

Table 1. LoanSTAR MAP First-Year Monitoring Estimates.

This table contains figures for the monitoring efforts through April 1990. The number of channels represents the approximate number of channels being recorded at each site. The square footage is the total for each monitoring level.

Monitoring Level	Number of Channels	Number of Buildings	Total Sqft.	ECRMs Being Monitored.
1	1 to 6	14	2,450,000	VAV, lighting, Variable Speed Pumps, economizers, EMCS.
2	8 to 16	12	1,050,000	VAV, lighting, VSP.
3	30 to 50	4	750,000	VAV, boiler mods, chiller mods, VSP, EMCS.
TOTAL	245	30	4,250,000	

NOTES:

1. The average cost per channel is about $1,300. Thermal metering and large aggregations of electrical panels can raise the price per channel significantly.
2. Typical installation time is about 6 weeks from the approval of the loan by the GEMC.

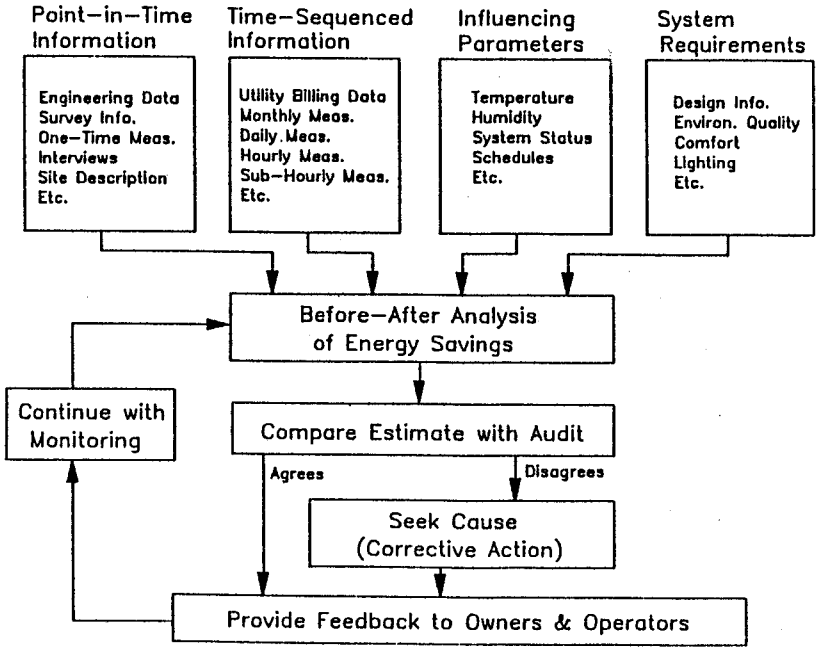


Figure 2. Before-After Analysis of Energy Conservation Retrofit Savings. This flowchart illustrates the before-after analysis of retrofit savings. For each site before-after point-in-time and time-sequenced information, influencing parameters, and system requirements are evaluated to determine if energy savings match those of the audit estimates. Corrective measures (if needed) and feedback to owners and operators is also provided.

New Releases

A review of newly released publications and software from National Laboratories, ASHRAE, and Universities will appear in this department of *ibpsaNEWS*. Bibliographic citations will be collected in topical areas taken from the IBPSA research topics list. If you work at a research institution, please add Henry Amistadi, P.O. Box 904, Brunswick, Maine, 04011, USA, to your mailing lists for annual reports, program summaries, and report bibliographies. This will help to insure that these listings are complete. If you know of any reports that have been missed in this listing, please send the complete citation to Henry Amistadi at the above address.

An Experimental Investigation of Air Flow and Convective Heat Transfer in Enclosures Having Large Ventilative Flow Rates

Jeffrey David Spitler, Ph.D. Thesis, Department of Mechanical and Industrial Engineering, University of Illinois at Urbana-Champaign, December 1990.

Ordering Info: $10.00 per copy, Catalog Number 1050-0090. Address orders to: BLAST Support Office, University of Illinois, 140 Mechanical Engineering Building, 1206 W. Green Street, Urbana, Illinois 61801

Abstract

The prediction of convective heat transfer in enclosures under high ventilative flow rates is primarily of interest for building design and simulation purposes. Current models are based on experiments performed forty years ago with flat plates under natural convection conditions.

In order to investigate convective heat transfer in buildings, a full-scale experimental facility was developed with several unique features: fifty three individually controllable heated panels which allow the room surfaces to be near isothermal, thus minimizing radiation; capability of using two different inlets; a ventilation system capable of providing temperature-controlled air at flow rates between two and one hundred air changes per hour; an air speed and temperature measurement system; and a flow visualization system.

A large number of experiments were performed with varying inlet locations and sizes, inlet temperatures, and flow rates. The room outlet temperature was identified as the most suitable reference temperature for the calculation of film coefficients. Film coefficients were successfully correlated to the jet momentum number, J. The correlations form the basis for a new convective heat transfer model that was implemented into the Building Loads Analysis and System Thermodynamics program. The new model was exercised and shown to yield much more accurate results than the current, natural convection based model.

Additional Information

Basic Features of Experimental Room

A. 53 individually controlled heated surfaces
B. Air flow rates: 15, 30, 50, 70, and 100 air changes per hour (ACH)
C. Air inlet temps: 16, 21, and 26°C
D. Ceiling and side wall inlets
E. With and without furniture
F. Air speed and temperature measurements: roughly 1 ft. cubed regions
G. Radiation correction virtually eliminated

Conclusions

The experimental apparatus produced very consistent, high quality data which allowed the following conclusions to be drawn:

1. The room outlet temperature is the most desirable air temperature on which to base heat transfer coefficients. This is an important conclusion since virtually every load and energy calculation algorithm in use today makes that assumption. The concept of a well-stirred zone which leads to that model in the algorithms did not accurately describe an average room temperature, but apparently the outlet temperature does integrate the effects of the room heat transfer when used to determine the heat transfer coefficient.

2. Conventional heat transfer coefficients published in the ASHRAE handbooks are not correct for high ventilative flow rate applications. However, the measured heat transfer coefficients on vertical surfaces do extrapolate near published values at low flow rates. The heat transfer coefficients obtained using ceiling diffusers are significantly different, and do not approach the published values at low flow rates.

3. When the new heat transfer coefficient models were installed in BLAST, a night-time cool-down example showed hourly ventilative cooling rate differences of up to a factor of two.

Some Numerical Results

$J = \frac{\text{inlet stream momentum}}{\text{weight of air in room}}$, Ar = Archimedes number, h = Film coefficient (W/m^2 - °C)

Surface	New Correlation	h for 15 ACH	h for 100 ACH	ASHRAE/ BLAST h
Side Wall Inlet (Ceiling & Floor Results Applicable for Ar < 0.3)				
Ceiling	$h = 0.6 + 59\ J^{1/2}$	1.4	5.8	0.948
Walls	$h = 1.6 + 93\ J^{1/2}$	2.8	9.7	3.076
Floor	$h = 3.2 + 44\ J^{1/2}$	3.8	7.0	4.040
Ceiling Inlet				
Ceiling	$h = 11.4 + 210\ J^{1/2}$	16.8	47.4	0.948
Walls	$h = 4.2 + 81\ J^{1/2}$	6.3	18.1	3.076
Floor	$h = 3.5 + 47\ J^{1/2}$	4.7	11.5	4.040

Ventilation Control for Energy Conservation: Digitally Controlled Terminal Boxes and Variable Speed Drives

Scott Englander, PU/CEES Report No. 248, Center for Energy and Environmental Studies, Princeton University, Princeton, NJ 08544-5263. March, 1990.

Ordering info: $19.10 per copy. Address orders to "Documents Secretary" at above address.

Abstract

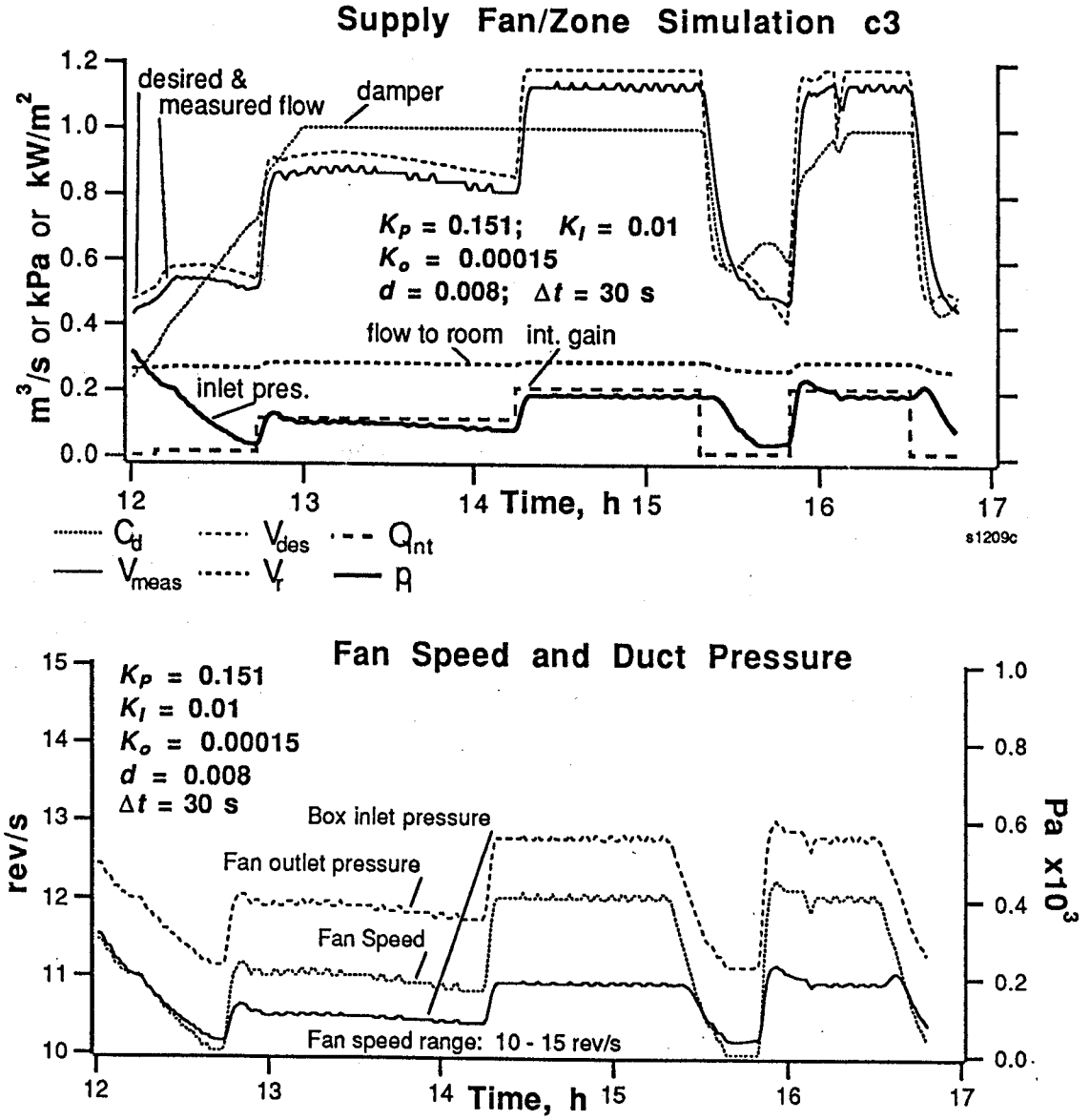
For several years, electronic variable speed drives (VSDs) have been used on fan motors in large building variable air volume (VAV) ventilation systems, often replacing inefficient variable inlet vanes (VIVs) as a means of regulating supply duct pressure and return airflow. Few, if any, published studies of measured energy savings and fan performance have been done. The first major portion of this thesis is a case study of a VSD retrofit, in which the drives were installed on two 50 hp and two 20 hp fan motors in a commercial office building with a variable air volume distribution system. Pre- and post-retrofit part-load fan motor performance is examined using analysis of motor input power as a function of air flow. This analysis shows that despite considerable savings over inlet vanes (35%), their high cost results in a relatively long payback period, favoring incorporation of VSDs in new construction rather than as a retrofit item, except in buildings operating continuously, for which the payback is 2.7 years. Unusually high pre- and post-retrofit flow rates and energy consumption for one of the fans were found to be the result of a distribution system malfunction. The significant reduction in savings underscores the necessity of correcting distribution system problems as part of any VSD retrofit.

Measurements revealed that reducing supply duct static pressure can significantly boost the savings achievable with VSDs. This is not ordinarily possible, however, in conventional VAV systems with pneumatic zone control, where duct static pressure must be held constant at a high level so that terminal boxes are not "starved" for air during high cooling load conditions. Decreasing static pressure in a nearly identical system employing VIV fan control had no significant effect on fan power, in contrast to the results for VSDs, where the magnitude of savings due to decreasing static pressure set point is half of the savings due to the installation of VSDs alone.

The second major focus of this thesis is on terminal boxes using direct digital control (DDC). DDC has only recently been applied to terminal boxes, and has opened a new realm of possibilities for improving supply fan and zone temperature control, both in energy-efficiency and comfort; nevertheless, little field experimentation with new control strategies has been done. DDC terminal boxes have two advantages over their pneumatically controlled predecessors that make them particularly well-suited for improving fan control in VAV systems: inherent communications capability and improved flow characteristics—supply air flow rate is controlled to set point, independent of pressure. In a system using VSDs to regulate duct static pressure, these two features would permit a supply fan control strategy in which duct static pressure can be minimized, without sacrificing occupant comfort or adequate ventilation.

In the course of developing a static pressure minimization control strategy, it was necessary to explore the response of terminal boxes to changes in inlet pressure. An instrumented DDC terminal box was installed in an unoccupied office space; test results were used to create and calibrate computer models of a DDC fan-powered terminal box, ducts and zone, for use with the public domain dynamic simulation program *HVACSIM+*. Zone temperature and flow rate control loops are represented using a discrete-time proportional plus integral controller model. Validation of the system model was performed by subjecting the model to time-varying boundary conditions derived from measured data, with satisfactory results.

Preliminary evaluation of the proposed static pressure minimization control algorithms using simulation yielded encouraging results, showing that such a strategy is feasible in systems combining VSDs and DDC terminal boxes. Other control improvements possible with DDC zone control technology are discussed. Finally, an examination of the current status and future directions of dynamic HVAC simulation tools is presented.



Results of supply fan and zone simulation, using the modified PI control algorithm proposed in this study, for one set of controller parameters. This discrete-time supply fan speed controller uses feedback of desired and measured flow rate from zone controllers to minimize fan speed (and hence static pressure and fan power). Eighteen five-hour simulations demonstrate the effect of parameter changes. The combination of parameters shown here results in a rapid decrease of terminal box inlet pressure, causing the damper to open wide, while still providing the desired flow rate.

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