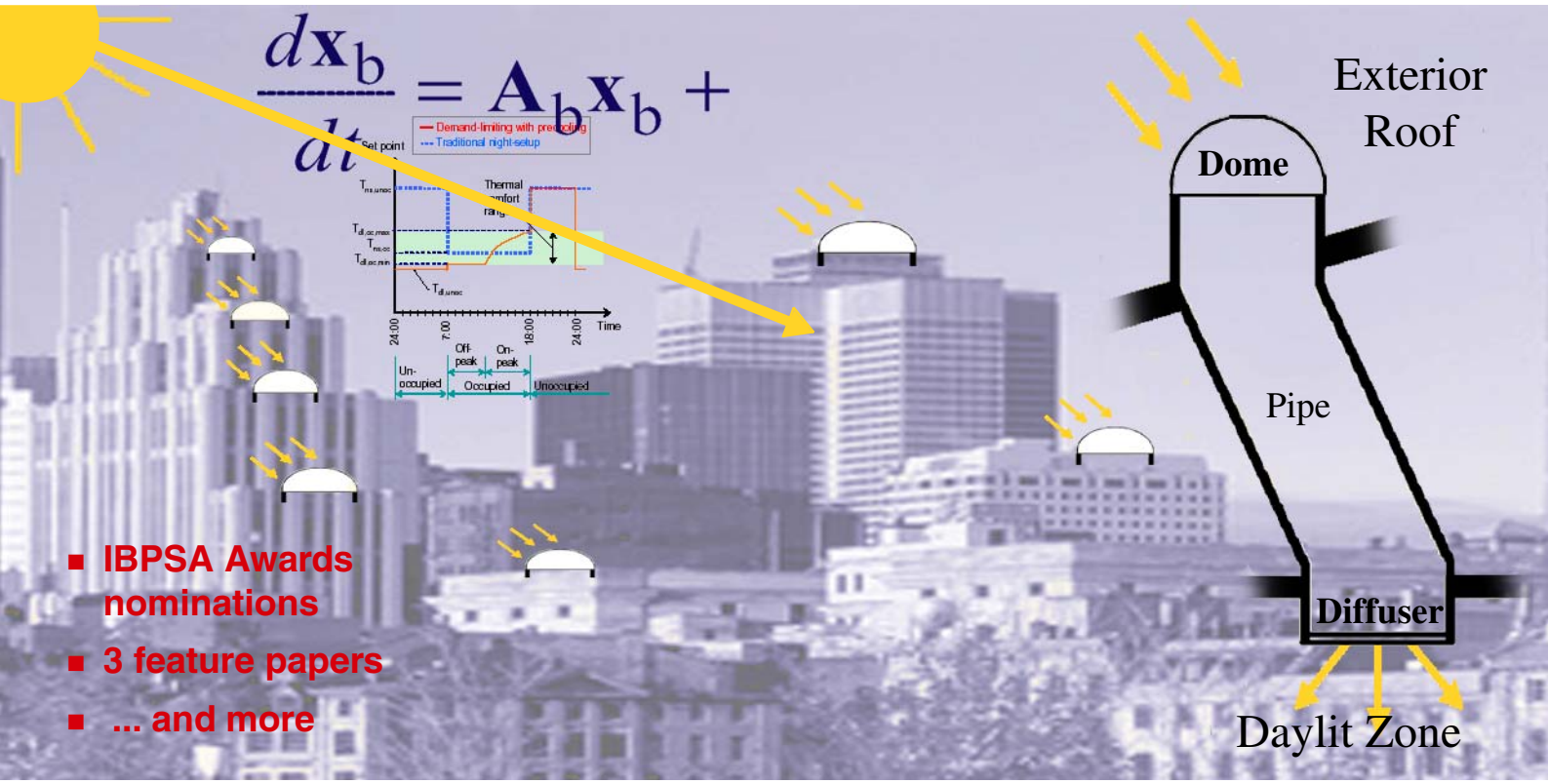
*ibpsa*NEWS

volume 14 number 2
October 2004



- IBPSA Awards nominations
- 3 feature papers
- ... and more

www.ibpsa.org

The journal of the International Building Performance Simulation Association

Contents

President's message

IBPSA Members and Friends,

Greetings from Oklahoma! I'm happy to report to you that IBPSA just passed a milestone, of sorts, by publishing online our 1000th paper. When the papers from Building Simulation 2003 were added to the website, **www.ibpsa.org**, in September, the total number of papers available online reached 1026. This represents a formidable body of work!

By the time you read this, the IBPSA board will have spent two days meeting in Montreal, at the Building Simulation 2005 conference site. Reviewing the agenda, it is perhaps not surprising that most of the items are "routine": finances, conference planning, awards, newsletter, web site, regional affiliate reports, etc. To some degree, this reflects on the maturity of the organization. We've gotten, in my opinion, very good at things we do regularly – mainly running our biennial conferences.

However, there are still several challenges that we face. The first challenge, for which IBPSA "Central" can be only partly responsible, is the continued maintenance of the regional affiliates. A second challenge is continued growth – establishing new regional affiliates – there are still plenty of open territories, and we have some obvious holes in our coverage. Finally, a third challenge, perhaps the most universal, is developing new initiatives to serve our membership and the world. Like many organizations that rely on volunteers, our biggest constraint is volunteer time. At the last board meeting, I finally cut off discussion on new initiatives, as it became clear that our ideas had greatly exceeded our available time! As always, your thoughts on new initiatives and/or meeting these challenges are welcome. Even more welcome would be volunteers!

Speaking of volunteers, two members of the IBPSA Board rolled off this year – Phil Haves and Terry Williamson. I'd like to take this opportunity to thank both Phil and Terry for their contributions over a number of years in serving on the board. I'd also like to welcome two new board members – Jon Wright and Ian Beausoleil-Morrison.

At Building Simulation 2005, IBPSA again plans to award the IBPSA Distinguished Service Award, the IBPSA Outstanding Young Contributor Award, and the IBPSA Outstanding Practice Award. Your nominations, with supporting background, are needed to insure that we continue to honor those who have contributed to excellence in our field. Nominations should be submitted to Lori McElroy (**lori.mcelroy@thelighthouse.co.uk**) by December 15, 2004. See **page 14** for more details.

This issue contains reports of recent and upcoming regional affiliate activities. In August, I had the pleasure of taking part in the first IBPSA-USA conference, SimBuild'04 in Boulder, Colorado. Thanks go to Mike Brandemuehl (the organizer), Curt Pedersen and Les Norford (co-chairs of the Scientific Committee), and many others who helped to make it possible. The conference was quite a success, with over 120 participants, including 32 graduate students.

Many of us were encouraged to see so many students at the meeting. Speaking as a professor, while some of our students will go on to become building simulation researchers, many more will go on to become practitioners. For all of the students, though, classroom/laboratory teaching of building simulation is an important activity, but one with relatively few available teaching materials. In this issue of the IBPSAnews, an original article by Jan Hensen and Marija Radošević discusses their experiences in teaching building simulation to university students.

I look forward to seeing many of you at Building Simulation 2005!

Simulation mailing list soon to change!

ATTENTION! For future IBPSA mail and announcements you need to take action!

The IBPSA mail list will soon be discontinued and consolidated under an existing listserver known as BLDG-SIM. BLDG-SIM is a mailing list for users of building energy simulation programs worldwide, including weather data and other software support resources. BLDG-SIM is intended to foster the development of a community of those users. Experienced and inexperienced users of building energy simulation programs are welcome and are expected to share their questions and insights about these programs. To assure that you receive future important news related to simulation announcements and discussions (as well as IBPSA announcements), please heed the following instructions so you will be included in the BLDG-SIM mail list:

To **subscribe** to the list,	send a blank message to: **bldg-sim-subscribegard.com**
To **unsubscribe** from the list,	send a blank message to: **bldg-sim-unsubscribegard.com**
To **send a message** to all subscribers to the list,	address your message to: **bldg-simgard.com**

Questions: If you have any questions, please contact the list owner:
Jason Glazer at **jglazer@gard.com** or +1-847-698-5686
This list is made possible courtesy of GARD Analytics, Inc., Ridge Park, IL, USA.
For further information about this list server, see the web page located at:
www.gard.com/ml/bldg-sim.htm

IBPSA Central contacts

IBPSA Central membership form

Publications order form

Membership Services and Publications

For Proceedings of past IBPSA conferences contact:
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Newsletter submissions

To submit Newsletter articles and announcements, contact:
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2206 Quail Run
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Email: **larry@taz.tamu.edu**

IBPSA Building Simulation conferences

For information about IBPSA Building Simulation conferences, contact:
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IBPSA Website

For full information on how to order IBPSA's publications, or to look at Proceedings of past IBPSA Building Simulation conferences or past IBPSA Newsletters, please look on the IBPSA Website at: **www.ibpsa.org**.

Long-range conference site coordination

For potential future conference hosting, contact:
Philip Haves (Conference Site Coordinator)
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IBPSA Regional affiliates

For information on joining IBPSA, please contact your nearest regional affiliate. If there is no affiliate in your region, join IBPSA by using the Central membership form.

IBPSA Central membership form

IBPSA-Australasia:
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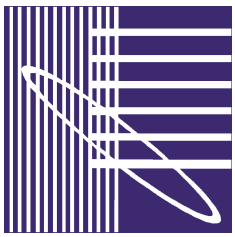

IBPSA Regional affiliates (continued)

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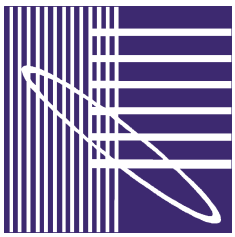
Fax: +1-781-861-2058
Email: **cbarnaby@wrightsoft.com**



IBPSA Management Board

IBPSA Sustaining Members

Sustaining members of IBPSA are those individuals or organizations that provide financial support to IBPSA at the level of US$500 or more per year. To learn about sustaining membership, please contact one of the IBPSA officers shown in this newsletter.

U.S. Department of Energy (DOE)
Washington, DC, USA

Environmental Design Solutions Limited (EDSL)
Milton Keynes, U.K.

Center for Building & Systems TNO
Eindhoven, The Netherlands

Technische Universiteit Eindhoven, TU/e
Eindhoven, The Netherlands

Dutch Society for Building Systems (TVVL)
Amersfoort, The Netherlands

Association for Computerisation in Building and Installation Technology (VABI)
The Netherlands

Building Simulation 2005

www.ibpsa.ca/bs2005

August 15-18, 2005
École Polytechnique de Montréal

Building Simulation 2005
9th IBPSA CONFERENCE + EXHIBITION
15 - 18 August, 2005
Montréal, Canada

The Building Simulation 2005 conference and exhibition will be held at École Polytechnique de Montréal. The conference will consist of keynote speeches, presentations of high quality papers, software demonstrations, and plenary sessions. There will be several social events, including a banquet, an accompanying persons program, and post-conference tours. Details of these and of the conference programme will be available on the conference website: **www.ibpsa.ca/bs2005**.

The conference will be of interest to architects, designers, researchers, environmental engineers, city planners, simulation software producers, and all academics, professionals and practitioners involved in the wide range of disciplines associated with building performance simulation.

Conference fees are:

Early registration (before June 15, 2005):	**450 CAN $**
Late registration (after June 15, 2005):	**550 CAN $**
Full time students:	**200 CAN $**
Accompanying persons:	**100 CAN $**
Printed proceedings:	**70 CAN $**
Discount for IBPSA members:	**50 CAN $**

The registration fee includes conference attendance, proceedings on CD-ROM, lunches, coffee breaks, banquet and welcome party. The accompanying persons' registration fee excludes conference attendance and proceedings.

Registration information will be posted on the conference website; in the meantime, for further information about the conference contact one of the following:

Organizing Committee :	Chair, Michel Bernier (**michel.bernier@polymtl.ca**)
	Co-Chairs, Stanislaw Kajl (**skajl@mec.etsmtl.ca**)
	and Radu Zmeureanu (**zmeur@cbs-engr.concordia.ca**)
Scientific Committee:	Chair, Ian Beausoleil-Morrison (**ibeausol@NRCan.gc.ca**)

Conference themes will include all aspects of modelling and simulation of the built environment including building service systems. A list of specific topics is given on the conference website.

Montréal

Montréal is framed by Mount Royal (230m) and the St-Laurence River. It was founded in 1642 by Paul Chomedey de Maisonneuve. It is the world's second-largest French-speaking city, with approximately 3 million inhabitants, and is a metropolis of international repute. It is the perfect marriage of North American modernity and European elegance. This multicultural mix has fostered a fertile and vibrant cultural life with art exhibitions, shows, museums, theatre, music — and nightlife that just goes on and on. Montréal is also recognized as having the finest cuisine on the continent.

Montréal is without a doubt a high-tech hub. There are around 1500 companies who invest 2 billion dollars annually in R&D activities. Aeronautical, telecommunication, and biopharmaceutical companies are the cornerstone of Montréal's economy. It is estimated that there are around 40,000 engineers working in the city.

The École Polytechnique de Montréal is one of the largest engineering schools in Canada both in terms of enrolment and research activities, with approximately 5000 students, 220 faculty members and 150 researchers.

The main conference hotels are located downtown approximately 7-8 km away from École Polytechnique de Montréal. Shuttle buses will be available to transport participants from/to the main hotels.

Other forthcoming events

Calendar

Date		Event	Venue
2004			
October	21	IBPSA-NVL Workshop: Better design through building simulation	Antwerp, Belgium
November	1-2	ESP-r Introductory course	Glasgow, Scotland, UK
November	8-9	ESP-r Advanced users' course	Glasgow, Scotland, UK
November	10-12	IBPSA-Australasia conference	Tasmania
2005			
August	***15-18***	***BS 2005***	***Montréal, Canada***

21 October 2004
Antwerp, Belgium
www.ibpsa-nvl.org

Better design through building simulation - Workshop
IBPSA-NVL

On October 21st IBPSA-NVL (the regional affiliate of IBPSA for the Netherlands and Flanders) will be holding a one day workshop for engineers, consultants and architects. In order to reach a large audience, the workshop is being organized in collaboration with the Royal Flemish Engineering Association (KVIV). The aim of this event is to provide building professionals with accurate and up to date information on the advantages of building simulation, thus widening knowledge of building performance simulation and increasing the level of expertise within the sector.

Nine speakers from the academic and professional world have been invited to share their experiences of building simulation projects. The workshop is divided into two parts. During the morning session, 5 lecturers will address the theoretical aspects of building simulation. An overview of state-of-the-art simulation programs including advanced modelling approaches for multi-zone buildings, heat-air-moisture models to describe the behaviour of the bounding surfaces and computational fluid dynamics will be discussed. Attention will be given to the options for using building simulation programs at different design stages. A brief overview of the relevant European legislation will also be presented.

The afternoon session will focus on the practical use of building simulation programs and the need for a multi-disciplinary approach. Four speakers will present their experiences of integrating HVAC-systems in an overall energy simulation environment, using CFD to model wind comfort around high-rise buildings and combining correct day-lighting and energy conservation.

The workshop will be held at the Technological Institute in Antwerp, whose address is: Ingenieurshuis, Desguinlei 214, 2018 Antwerpen, Belgium. For more information, including a booking form and full programme details, see the IBPSA-NVL website **www.ibpsa-nvl.org/** or contact Dr Dirk Saelens: **Dirk.Saelens@bwk.kuleuven.ac.be**.

1-2 November 2004
Glasgow, Scotland, UK
www.sesg.strath.ac.uk

Scottish Energy Systems Group

ESP-r Introductory course

Scottish Energy Systems Group (IBPSA-Scotland)

This event, presented by Dr Jon Hand, will take place at the premises of the Energy Systems Research Unit (ESRU) at the University of Strathclyde. It runs from 9.15am to 5pm with tea and lunch breaks. The outline for the course is:

Day 1: **Basic concepts — planning and creating models, simulation and results analysis.**
Day 2: **Skills development — increased model resolution, environmental controls, simple airflow networks, as well as demonstrations of advanced features.**

The workshop will be fast-paced and interactive and delegates should find a wealth of productive techniques and tips from experts to do simulation quicker, cheaper, and better.

ESP-r runs primarily on Unix/Linux computers and delegates should be familiar with basic operating system commands so as to ensure maximum time for exploring ESP-r. If you want to bring along your own laptop for use during the course, please let the organizers know so they can determine if it is compatible, and if you have a particular simulation project in mind, bring details and it may be used during the course!

If you are interested in attending, please contact Kathleen Whyte (email **kathleen@sesg.strath.ac.uk,** or **phone +44 141 548 3024**) as soon as possible. If you are not an SESG Member, the cost will be 340 Pounds, excluding accommodation (a list of accommodation near the University of Strathclyde can be found on the **University web page**). The course is free to SESG members. (However, those who book and do not attend will be charged a 75 Pound cancellation fee unless they give at least 3 working days' notice).

Details of all SESG events can be found at: **www.sesg.strath.ac.uk**

8-9 November 2004
Glasgow, Scotland, UK
www.sesg.strath.ac.uk

Scottish Energy Systems Group

ESP-r Advanced users' course
Scottish Energy Systems Group (IBPSA-Scotland)

This event is also presented by Dr Jon Hand and will also take place at the premises of the Energy Systems Research Unit (ESRU) at the University of Strathclyde . It runs from 9.15am to 5pm with tea and lunch breaks. The outline for the course is:

Day 1 · Review of recent changes
· Air flow networks and their control
· Adding resolution via CFD domains
· Use of Radiance
Day 2 · Skills development
· Critical QA
· Approaching complex projects via scaling and replication
· Session for managers of simulation projects
· Advanced controls
· Increased model resolution.
· Air flow networks and their control.

The topics to be covered on this course can be modified to take into account the particular requirements of course participants. Please let the organizers know if you are interested in focussing on particular aspects of ESP-r.

If you are interested in attending, please contact Kathleen Whyte (email **kathleen@sesg.strath.ac.uk,** or **phone +44 141 548 3024**) as soon as possible. If you are not an SESG Member, the cost will be 340 Pounds, excluding accommodation (a list of accommodation near the University of Strathclyde can be found on the University web page). The course is free to SESG members. (However, those who book and do not attend will be charged a 75 Pound cancellation fee unless they give at least 3 working days' notice).

Details of all SESG events can be found at: **www.sesg.strath.ac.uk**

10-12 November 2004
Launceston, Tasmania, Australia
www.arch.utas.edu.au/anzasca/

ANZAScA 2004
IBPSA-Australasia in conjunction with the Architectural Science Association ANZAScA

The 38th annual conference of the Architectural Science Association ANZAScA (formerly the Australian and New Zealand Architectural Science Association) in conjuction with IBPSA-Australasia will take place at the School of Architecture, University of Tasmania on November 10 - 12.

More details, including a registration form and a preliminary programme, are available from the conference website at:
www.arch.utas.edu.au/anzasca/

IBPSA Awards 2005

The next IBPSA Awards will be announced at Building Simulation 2005. Please read the regulations (right) and consider whether you wish to make any nominations.

The International Building Performance Simulation Association (IBPSA) will make awards for contributions to the field of building performance simulation in three categories. One award (or more at the discretion of the Board of Directors) will be made biennially in each category and will be announced at each Building Simulation Conference. The awards are:

IBPSA Award for Distinguished Service to Building Simulation

This award recognizes an individual who has a distinguished record of contributions to the field of building performance simulation, over a long period. The award consists of a certificate and $US500.

IBPSA Outstanding Young Contributor Award

This award recognizes an individual at the beginning of their career who has demonstrated potential for significant contributions to the field of building simulation. The award consists of a certificate and $US500.

IBPSA Outstanding Practice Award

This award recognizes an individual, group, or firm that has made significant contributions to the effective application and/ or advancement of building simulation in practice. The award consists of a certificate and $US500.

No member of the IBPSA Board of Directors shall be eligible for nomination to an award. The IBPSA Board of Directors will make the final decision regarding the recipient of an award.

Nominations for the Distinguished Service Award should be accompanied by a brief CV, which outlines the nominated individual's history of involvement in building performance simulation. This should include details of key publications, etc., and a summary of their specific contributions to the field.

Nominations due by 15 December 2004!

Nominations for the Outstanding Young Contributor Award should be accompanied by a brief CV, which gives a summary of the nominated individual's contributions to the field, including a list of their publications etc., and an assessment of potential for future contributions.

Nominations for the Outstanding Practice Award should be accompanied by a summary of the individual's, group's or firm's contributions to the field, and an assessment of the significance of the wider significance of their contributions.

Nominations for 2005 awards should be sent to the chair of the Awards Committee, Lori McElroy (**lori@thelighthouse.co.uk**) no later than **15 December 2004**.

Software news

www.energyplus.gov

EnergyPlus Version 1.2.1 Now Available

Dru Crawley, US Department of Energy

The next release, Version 1.2.1, of the EnergyPlus building energy simulation program became available in late September 2004. In addition to many new features, we have updated and extended capabilities throughout the existing building envelope, daylighting, and HVAC equipment and systems portions of the program. A few of the new features include:

Datasets

- Default fluid properties for water, ethylene glycol, and propylene glycol
- Example input files for all new features
- More than 100 new international weather locations including data for Belize, Cuba, El Salvador, Guatemala, Honduras, Maldives, Nicaragua, Spain, and Sri Lanka in the EnergyPlus/ESP-r weather format. (More than 680 locations available worldwide.)

Geometry/Windows/Walls/Shading

- Multi-sided polygons

Daylighting

- Skylight Light Wells
- Daylighting through interior windows
- Translucent glass

Zone Model

- Improved displacement ventilation interaction with thermal mass

HVAC

- Plate heat exchanger component added to facilitate realistic configuration of hydronic systems
- Two- and four-pipe induction units
- Variable-speed fan-powered VAV reheat terminal units
- DOE-2.1E electric chiller model
- Duel Setpoint Controls for Plant Loop for Water Loop Heat Pump
- New Water Cooling Coil (replaces Simple Coil) which is completely autosizable, options for wet/dry coil evaluation using cross- or counter-flow heat exchanger configurations
- Glycol concentrations can be specified

www.energyplus.gov

Economics

- Utility rate calculations
- Project construction cost estimating

Output

- Ventilation load report
- Each zone defined as layer in DXF
- Advanced Runtime Variables can be requested

Utilities

- Major updates to the IDFEditor including ability to open multiple IDF files and copy/paste objects between files
- Major updates to EP-Launch including ability to select a group of simulations to run and maintaining a history of simulations
- WeatherConverter now reads new format (TMY3) developed under the SWERA project (**swera.unep.net**)

Documentation and Guides

- Input/Output Reference and Engineering Reference Updated and extended for all new features and updates.
- More than 2,000 pages of documentation.

And speed improvements throughout.

More information on these and other new features in this version is available on the EnergyPlus web site: **www.energyplus.gov.**

Building Energy Tools Directory

Dru Crawley, US Department of Energy

The web-based Building Energy Tools Directory at **www.energytoolsdirectory.gov** contains information on more than 280 building-related software tools from around the world. Haven't visited lately? A number of new tools have been added over the last several months including: Cool Room Calc, flixo, BV^2, ParaSol, Umberto, UM Profiler, HAMLab, Green Building Studio, and Visual.

For each tool in the directory, a short description is provided along with information about technical expertise required, users, audience, input, output, validation, computer platforms, programming language, strengths, weaknesses, technical contact, availability and cost. A link is also provided for directly translating the web pages into more than 8 languages.

If you know of a tool (yours?) that isn't in the directory, visit **www.energytoolsdirectory.gov/your_software_here.html** or contact Dru Crawley at **Drury.Crawley@ee.doe.gov**.

Real-Time Weather Data

Nick Long, National Renewable Energy Laboratory

Hourly weather data for more than 4,000 stations around the world are continuously collected and stored and are available through a web interface. The database provides data for some locations from late 1998 through today (although there can be significant gaps in the data and most stations outside of the US start in 2002). Information includes dry bulb temperature, wet bulb temperature, wind speed/direction, atmospheric pressure, visibility, cloud conditions, and precipitation type. Data may not be available for all stations and may not be contiguous. Data are available in either comma-separated or ASHRAE IWEC formats. The user has the option of having missing data filled.

For more information, visit **www.eere.energy.gov/buildings/energyplus/cfm/weatherdata/weather_request.cfm.**

CIBSE Standard Tests for Building Design Software

Paul Strachan, Energy Systems Research Unit, University of Strathclyde

In recent years there has been a significant growth in the market for software to support building services design. One issue not widely addressed, however, is the need for these software packages to be validated prior to use. There are also associated possible professional indemnity implications of using software packages without validation.

The UK's Chartered Institution of Building Services Engineers (CIBSE) carried out market research on publications and design software and found that a sizeable proportion of members and non-members believe that the software they use accords with CIBSE methods that are set out in the CIBSE Guides. Some also believe the software they use is accredited by CIBSE.

These findings prompted CIBSE to develop standard tests to assess design software packages. These are intended to provide a means by which members could test for themselves that the software they use is producing results consistent with those produced by CIBSE methods and with good practice.

CIBSE therefore commissioned the development of a suite of software validation tests, with standardised input data, example results and expected tolerances. This set of simple tests is intended to develop a culture of software testing and validation to the industry. The main focus is on thermal performance of buildings. Since the target audience is program users, the set of tests were developed with the intention of finding

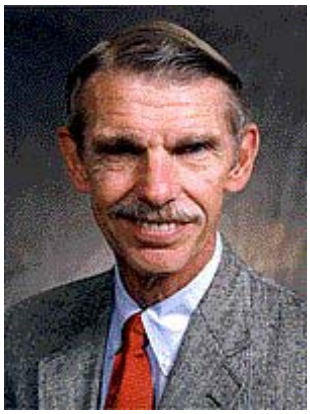
a balance between comprehensiveness and ease of application. It is likely that in the future CIBSE will expand and update the tests.

The tests include solar position, basic thermal calculations, solar shading, glazing properties, solar cooling loads, psychrometric properties, interstitial condensation, steady state heat loss, dynamic cooling loads, infiltration and ventilation, and summertime temperatures.

The tests have been published as: 'CIBSE Standard Tests for the Assessment of Building Services Design Software', Macdonald I, Strachan P and Hand J, CIBSE TM33, 2004, ISBN 1 903287 48 0.

Announcements

Solar Award for Professor William Beckman



Dr. William A. Beckman
Ouweneel-Bascom Professor
Emeritus
University of Wisconsin-Madison

The International Energy Agency's (IEA) Solar Heating & Cooling Programme is committed to expanding the market share of solar energy. By recognizing outstanding contributions made in the solar field, the IEA Solar Heating and Cooling (SHC) Programme is drawing the world's attention to solar energy as a source for heating and cooling.

This year's SHC SOLAR AWARD was presented to Professor William Beckman, Professor Emeritus at the University of Wisconsin in the United States, at the 8th World Renewable Energy Congress (WREC) Pioneer Awards ceremony in Denver, Colorado, USA on September 1, 2004.

The award is given to an individual, company, or private/public institution that has shown outstanding leadership or achievements, with links to the IEA Solar Heating and Cooling Programme, in the field of solar energy at the international level within one or more of the following sectors: Technical developments, Successful market activities, and Information.

SHC Solar Award designed by sculptor Marco Goldenbeld of the Netherlands

Prof. Beckman is the second recipient of the Award. He is recognized for the co-development of TRNSYS, a world renowned building energy analysis and research tool. TRNSYS has been used in IEA SHC work for over 25 years. His book, "Solar Engineering of Thermal Processes," continues to serve as a reference for experts participating in IEA SHC projects. In addition to developing tools and reference materials, Prof. Beckman has taught many SHC experts as director of the Solar Energy Laboratory at the University of Wisconsin. And, he has authored over 131 journal articles.

In addition to his contributions to the IEA SHC Programme, Prof. Beckman served as President of the International Solar Energy Society and was selected as a Senior Fulbright Scholar at CSIRO in Australia. He also was a Visiting Staff member of CSTB in France.

Additional information about IEA's Solar Heating & Cooling Programme, including task reports and some handbooks, can be found on their web site at: **http://iea-shc.org**.

Dr. Beckman directs the **Solar Energy Laboratory**, which supports about 15 graduate students conducting research in energy systems analysis ranging from optimal control of large HVAC systems, to assessing the impact on an electric utility of a large-scale implementation of solar water heating systems. Lab funding comes from the U.S. Department of Energy, industry, NSF, NIST and the state of Wisconsin.

Recently published book on Simulation

Malkawi, Ali M. and Augenbroe, Godfried (Ed.), Advanced Building Simulation, Spon Press (Taylor & Francis Group), New York and London, 29 Jul 2004, 252 pp, ISBN:0-203-07367-3. Or, check full description and abstract in eBooks online at **www.eBookstore.tandf.co.uk**. Click on author search and input Malkawi.

Ali Malkawi and Godfried Augenbroe are the editors of a new book on Advanced Building Simulation published in July of this year. It includes contributions from leading experts in the field both in the US and Europe and is a graduate-level student textbook as well as a guide to advanced methods for architects, engineers and other construction professionals. The book is available both as an ebook and in print. The publishers describe the work as follows:

"Advances in computer technology over recent years now mean building simulation can be used in the design process and even in the construction and daily operation of most buildings. The techniques are sophisticated and require a good deal of expertise, so relatively few designers, builders and practitioners understand the full potential of the field even though simulation can inform design decisions, enable performance analysis and diagnostic studies. This book should provide these readers with an overview of building simulation and its current advancements, and a grasp of current limitations and future directions.

To begin, the book introduces recent trends in building simulation and outlines its historic development. The book then takes the reader on a journey into three major areas of investigations: simulation with uncertainty, combined air and heat flow in whole buildings, in particular the applications of Computational Fluid Dynamics (CFD) to the built environment, and the introduction of new paradigms for the effective use of building simulation including issues of integration and potentially very significant ways for users to interact and to engage in immersed simulation."

Table of Contents

[1]University of Pennsylvania, USA [2]Georgia Tech, USA
[3]TNO Building and Construction Research Delft, The Netherlands
[4]Texas A&M University, USA [5]Technische Universiteit Eindhoven,Netherlands
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[8]Harvard University, USA [9]Vienna University of Technology, Austria

Feature articles

Some quality assurance issues and experiences in teaching building performance simulation*

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www.bwk.tue.nl/fago/hensen

ABSTRACT

Computer modeling and simulation is a powerful technology for addressing interacting technical architecture, mechanical, and civil engineering issues in passive and low energy building and systems. Assuming responsibility for the correctness of the results is of paramount importance for (future) engineers. Therefore it rightfully receives considerable attention in teaching building simulation. The validation test results discussed in this paper warn users of several issues, in particular that although a particular simulation software is commercially available and widely in use that does not necessarily guarantee its quality. The paper concludes that the main ingredients for professional and efficient quality assurance are domain knowledge and simulation skills of the user in combination with verified and validated building performance simulation software.

INTRODUCTION

As elaborated elsewhere [1], building performance simulation is possibly the most powerful technology for an integral approach of building and systems in view of global issues such as CO2 emission and fossil fuel depletion and local environmental concerns related to health, comfort and productivity.

Correct and efficient use is something which needs to be learned during education and training of professionals such as building physicists, building design engineers, environmental engineers, and heating ventilation and air-conditioning engineers.

This paper addresses some quality assurance issues in that teaching and training context.

* This paper is a modified and expanded version of a paper published/presented at PLEA 2004 (**www.plea2004.nl/**)

BUILDING SIMULATION COURSES

In the Department of Architecture, Building and Planning of the Technische Universiteit Eindhoven, teaching of building performance simulation is done through dedicated courses and by application of the technology in individual and group design project work. All class descriptions, courseware and assignments are available at **www.bwk.tue.nl/fago/hensen**

The core courseware consists of a collection of modules as described in [2] and contains introductory materials (what is, and why should building energy and environmental simulation be used), practical exercises (how to properly use a real building energy modeling and simulation environment) and materials describing theoretical background (finding out how building energy modeling and simulation actually works). This courseware can be used in a variety of ways, such as in self-learning mode, for distance learning, as online course material, for dissemination purposes, as supporting lecture material, as reference material in project work, to encourage student self-study and for research purposes.

This general courseware is also extensively used in three dedicated courses: Introduction, State-of-the-art and Capita Selecta of building performance simulation. These classes are intended for building engineering and building services 2nd year undergraduate, 1st year masters and final masters or starting PhD students. (The Introduction and Capita Selecta courses are also taught at the Czech Technical University in Prague at the civil engineering and mechanical engineering faculties.)

All courses combine a theoretical part with a practical part. In the Introduction course, the practical part consists of learning to work with commercial building simulation software which runs under the MS Windows operating system. In the State-of-the-art course the practical part involves learning to work with a research strength building simulation environment in a UNIX environment. In the Capita Selecta course a variety of software tools are used for the practical work.

QUALITY ASSURANCE

As argued before (e.g. [3], [4], [5]) a first and paramount requirement to appreciate and assure quality of modeling and simulation studies is sufficient domain knowledge by the user of the software. Apart from domain knowledge, it is also very important to make future engineers aware of quality assurance issues and to teach them knowledge and skills to be able to deliver quality in later design practice. This is one of the main topics in both the theoretical and practical parts of the before mentioned simulation courses.

Apart from the required domain knowledge, there are two other important elements in terms of quality assurance, which are very often underestimated when using computer simulation in the context of building design:

- Using a correct simulation methodology including selection of the appropriate level of modeling resolution. For example, simulation is much more effective

when used for comparing the predicted performance of design alternatives, rather then when used to predict the performance of a single design solution in absolute sense. In practice it is also often seen that high resolution modeling approaches (in particular computational fluid dynamics (CFD) and ray tracing rendering methods) are used for applications where a lower resolution method would be quite sufficient and much more efficient.

- Solving the right equations sufficiently accurately, as opposed to solving the wrong equations right. Of course a user should know which parameter values should be input in the model. In addition, there are now many modeling approaches where a user should also decide which model to use. This is specifically the case in many open simulation environments (e.g. Matlab toolboxes) and in higher resolution approaches (for example wall functions and turbulence models in CFD, and the various reflection models involved in ray tracing).

Quality assurance obviously also assumes the use of verified and validated software. There exist several techniques for verification and validation of building performance simulation software; see Appendix I. One of the most economic and effective techniques is inter-model comparison in which the simulation results from a software to be tested are compared with the results from previously tested other programs using the same model description and boundary values. An important international effort in this area is the ongoing BESTEST initiative (e.g. [6], [7]), which is now finding its first footholds in professional standards (e.g. the proposed Standard Method of Test - SMOT 140 - by the American Society of Heating, Refrigeration and Air-conditioning Engineers - ASHRAE) and national standards (e.g. the Energie Diagonse Referentie - EDR effort in The Netherlands). Appendix II provides a short overview of the BESTEST procedure.

The above mentioned theoretical issues and practical approaches are addressed at increasing levels of complexity in the Introduction, State-of-the-art and Capita Selecta simulation courses mentioned above.

SOME VALIDATION EXERCISES

During the Introduction course — which is part of the 2nd year undergraduate building engineering and building services curriculum — the students have to carry out part of the BESTEST procedure. As mentioned before, for this course we use commercial MS Windows based building simulation software. This particular software has the advantage that it is easy to learn and that it has a user interface which appeals to students. The disadvantage is that the calculation methods are not the most advanced in the field. For this reason it was decided to do some additional testing. This paper only addresses the thermal calculations, which are based on the CIBSE admittance method [8] which originally intended to provide a manual prediction method for peak cooling loads. Appendix III provides a brief overview.

The BESTEST procedure starts with very simple cases. Step by step more complexity is added in order to test different features and aspects of the software. The results which will be presented are for the simple cases and assume a single zone building sized 8 x 6 x 2.7 m^3. Some tests are for a building without windows, some involve opaque windows, and some involve transparent windows of 3 x 2 m^2 in the south facing wall as indicated in **Figure 1**. All material properties and building operation details are defined in [6]. In the BESTEST cases tested here, the floor is thermally decoupled from the ground. This is modeled in the software by a very thick layer of insulation (1m) with density and specific heat at the lowest value accepted by the software (density – 1kg/m^3 and specific heat – 1J/(kgK)).

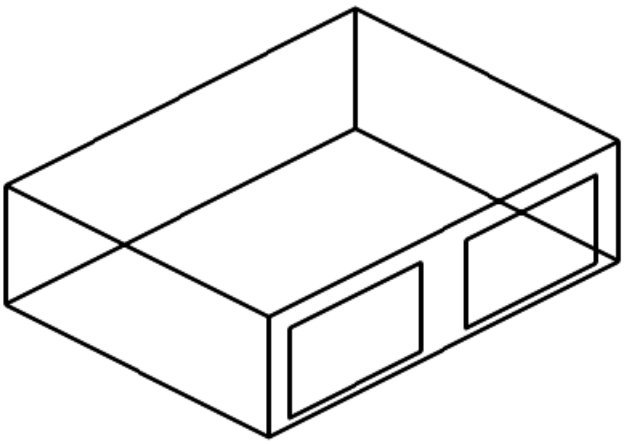

Figure 1. Geometry of the model

The tested software does not provide the option for input of internal short wave absorption, and as end-users we are not able to answer the question if and what value is used in the calculations. Therefore, although the BESTEST procedure requires different inputs for this parameter; it was only possible to enter the value of external absorption. Additionally, the value for infrared emissivity is predetermined in the software and could not be changed. However, the results for cases with higher values of infrared emissivity were in the acceptable range. This is also in agreement with the fact that most common building materials have high emissivities [8].

RESULTS

The first deviation from the BESTEST results has been observed already at the beginning of the procedure. Case number 230 (the 6th case, which tests infiltration) resulted in too high energy demand for heating as can be seen in **Figure 2**.

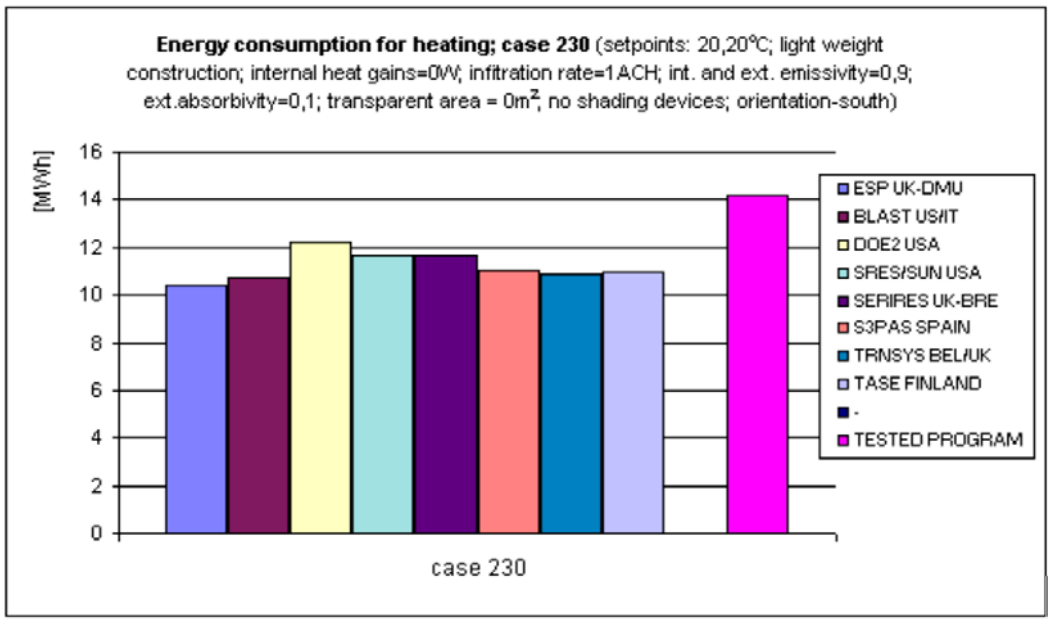

Figure 2
Annual energy consumption for heating for BESTEST case 230 predicted by the tested program in comparison to results of other programs

The deviation from the acceptable range decreases with lower infiltration rates. This was observed by comparison of the results with case 410 (**Figure 3**) where the infiltration rate is 0.5 air change per hour (ACH). For case 230, the deviation relative to the closest other is 13.5% whereas for case 410 it is only: 4.2%.

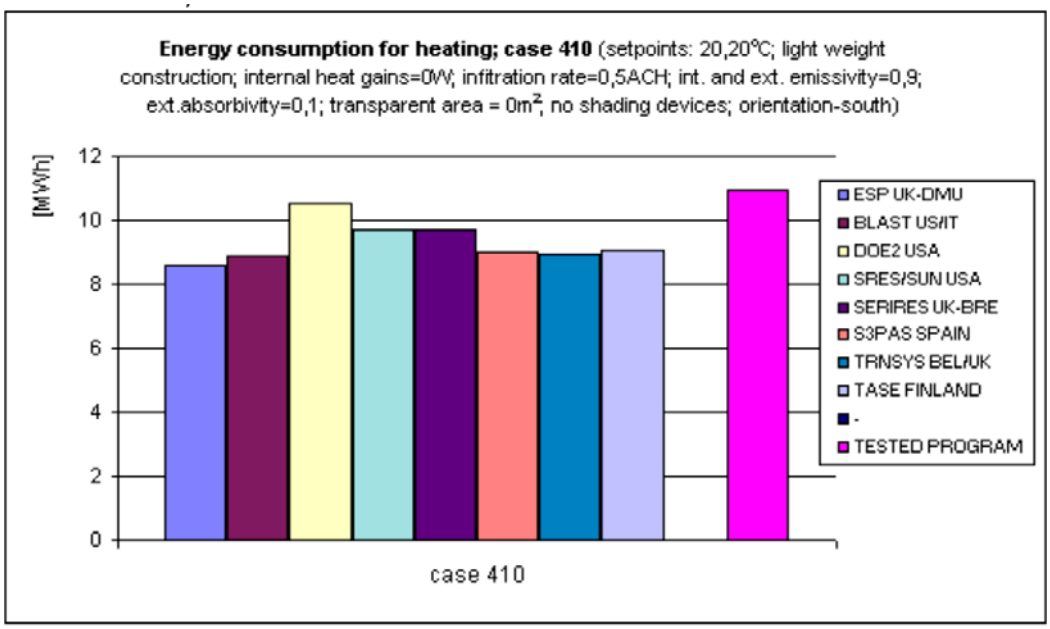

Figure 3.
Annual energy consumption for heating for BESTEST case 410 predicted by the tested program in comparison to results of other programs

The next problem relates to solar transmittance. The results for annual heating and cooling load for this specific case 270 are represented in **Figures 4 and 5**. The annual energy consumption for heating is underestimated and for cooling it appears to be overestimated.

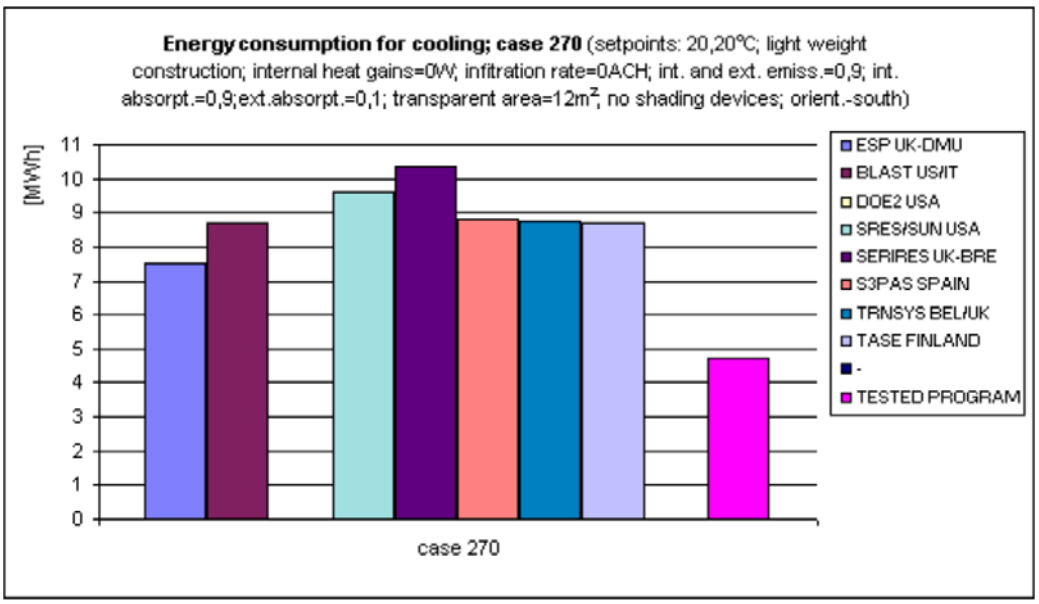

Figure 4.
Annual energy consumption for cooling for BESTEST case 270 predicted by the tested program in comparison to results of other programs

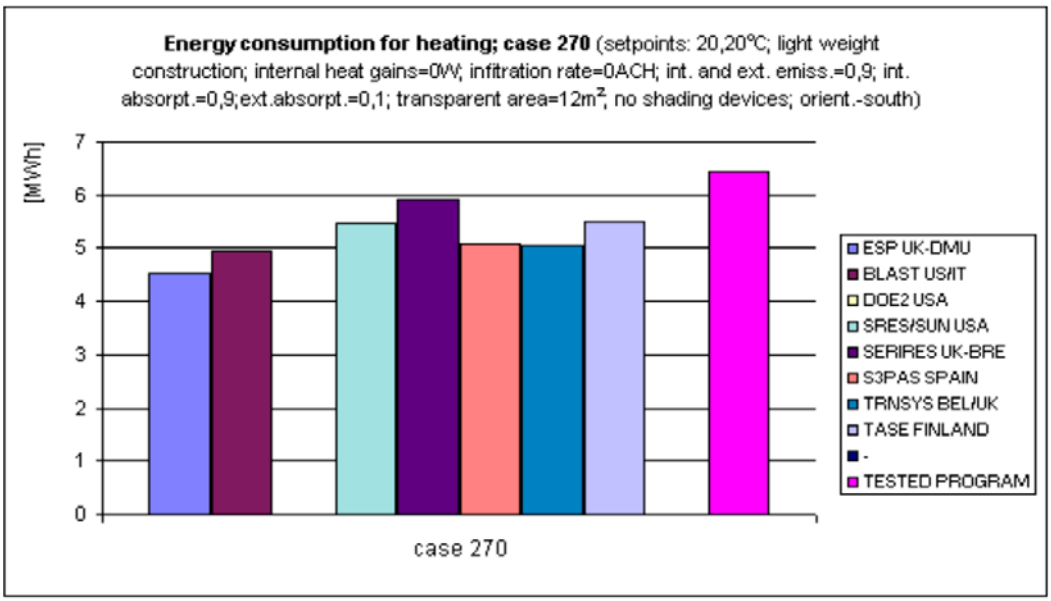

Figure 5.
Annual energy consumption for heating for BESTEST case 270 predicted by the tested program in comparison to results of other programs

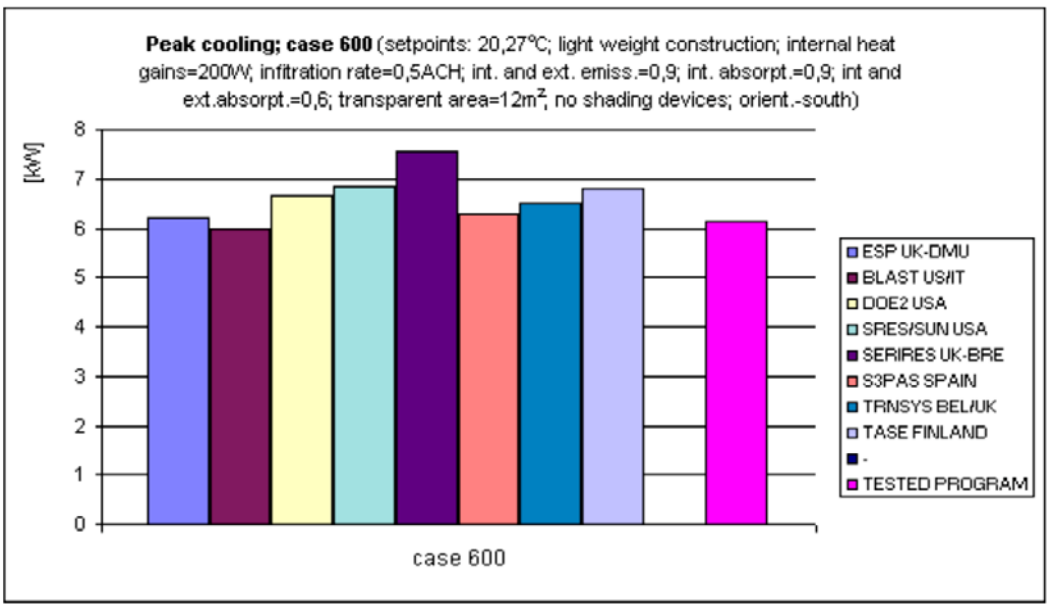

Figure 6.
Peak cooling load for BESTEST case 600 predicted by the tested program in comparison to results of other programs

It is interesting to note the results for peak cooling demand in **Figure 6**. The prediction from the tested program is acceptable.

Further analysis of the results shows that a deviation in maximum heating load appears only when there is infiltration assigned to a model. Then, the program show slightly higher values then the results in BESTEST report. For more information see [9].

DISCUSSION

Even though only a small part of the BESTEST procedure was carried out, the results indicated several errors. Although implementation and coding errors cannot be ruled out, we now think that most of these erroneous predictions are related to the underlying calculation method. The admittance method gives rise to several critical issues when used for dynamic building energy simulations.

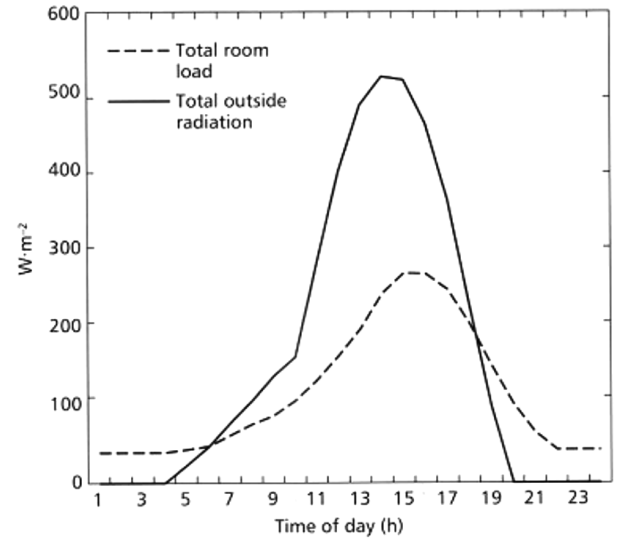

Figure 7. Solar load profile and profile of incident solar radiation during a day for a certain building [8]

Firstly, the method was originally developed as a manual calculation method for prediction of peak cooling loads and was not intended for estimating heating loads of for heating and cooling energy consumption.

Secondly, the method uses some parameters, which sound familiar but have an unusual definition, such as the solar heat gain factor at the environmental node, as briefly described in Appendix IV. Even if the user realizes this uncommon definition, he/she still faces the problem that the corresponding value is not available in literature or otherwise.

Thirdly, the method requires the user to input certain parameters that are extremely difficult or even impossible to obtain, such as the alternating solar heat gain factor of a glazing system.

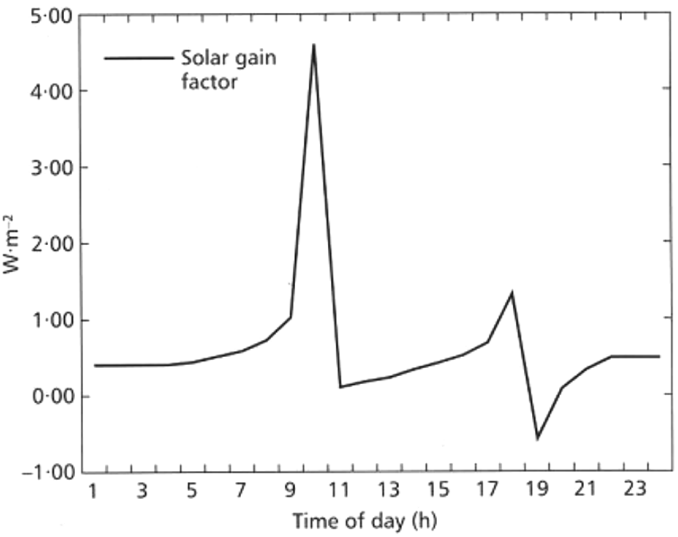

Figure 8. Alternating solar heat gain factor during a day for a certain building [8]

In order to be consistent with the admittance model the mean and alternating solar heat gain factors are defined. The alternating factor represents the ratio of the swing in solar load in an environmental node due to both indirect and direct solar heat load, and the swing in the external incident solar irradiation on the glazed surfaces. Each swing is defined relative to the mean of the specific variable. Due to the time delay associated with a surface responds to short-wave radiation, the peak load in the environmental node does not appear simultaneously with the peak in the incident solar radiation as shown on **Figure 7**. This causes variation of the alternating solar heat gain factor during a day, and there is no single value that is representative of all hours of the day (see **Figure 8**). It can be higher then one, as the **swing** in the load may be greater then the swing in the incident solar radiation in the particular moment of time.

In the literature only one value is given. For example in [10], the values are given for southwest facing windows in UK and for time of peak cooling for different windows and light/heavy construction. The value of alternating solar heat gain factor is typically lower during peak hours, due to the large swing in incident solar radiation, but this still depends on construction.

Although, use of the single value from the CIBSE guide can give reasonable accurate results for maximum loads it certainly leads to miscalculations for overall energy consumption. The deviations would depend on the building mass, because this drives thetime delay between the peaks appearances.

As it could be seen from the BESTEST results in general, the overall energy consumption for cooling was underestimated and for heating overestimated. The reason for this may be in not adequate use of the alternating solar heat gain factor. Only one value is used, while this parameter varies during the day and is construction dependent.

IN CONCLUSION

This paper has highlighted several issues related to quality assurance in building performance simulation. Taking care of these issues is in principle the responsibility of the person who uses the simulation model to predict what will happen in future reality. Appreciating this is of paramount importance for (future) engineers and therefore it rightfully receives considerable attention in teaching building simulation.

The validation test results discussed in this paper warn users of several issues, in particular that although a particular simulation software is commercially available and widely in use that does not necessarily guarantee its quality.

In our view the main ingredients for professional and efficient quality assurance are domain knowledge and simulation skills of the user in combination with verified and validated building performance simulation software.

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APPENDIX I - VALIDATION TECHNIQUES

Validation and testing is a necessary part of any software development process. It is intended to ensure credibility by eliminating physical errors, bugs, algorithm errors, and documentation errors. In [6], the authors identify seven main sources of error, which given the context of heat and mass transfer in building and plant configurations, translate into:

1. Differences between the actual weather conditions and the outdoor conditions assumed in the simulation;
2. Differences between the actual effect of occupant behaviour and those effects assumed by the user;
3. User error in deriving building and plant input files;
4. Differences between the actual thermal and physical properties of the building and plant and those input by the user;
5. Differences between the actual heat and mass transfer mechanisms operative in individual components and the algorithmic representation of those mechanisms in the program;
6. Differences between the actual interactions of heat and mass transfer mechanisms and the representation of those in the program; and
7. Coding errors.

The error sources 1 through 4 are called external since they are independent of the internal workings of the method of calculation. External errors are not under the control of the developer of the computer program. Error sources 5 through 7 are called internal and are directly linked to the internal workings of a prediction technique. Internal errors are contained within the coding of the program. Internal errors, are related to the ability of the program to predict real building and system performance when perfect input data is introduced.

There are a few techniques that can be used to assess the quality of a whole building energy simulation program:

- Empirical validation
  The results from a program are compared with the results obtained from monitoring a test cell, real building or laboratory experiment.
- Analytical validation
  The results from the program are compared with the known analytical solution or a generally accepted numerical method for a specific isolated heat transfer mechanism under very simplified, pre-defined boundary condition.
- Comparative testing
  The results are compared with results obtained from other programs. The comparing programs are usually pre-validated empirically and/or more detailed and likely more physically correct.

Each of these approaches has its strength and weaknesses. See [6].

APPENDIX II - BESTEST

BESTEST tests the program ability to model heat transfer associated with building fabric, basic thermostat controls, internal gains and mechanical ventilation [6]. It was developed for systematically testing whole building energy simulation models and diagnosing the sources of predictive disagreement. The technique consists of a series of carefully specified test case buildings that progress systematically from the extreme simple to the relatively realistic. In this method, output values for the cases, such as annual loads, annual maximum and minimum temperatures, peak loads, and some hourly data are compared and used in conjunction with diagnostic logic to determine the algorithms responsible for predictive differences. The results for each case building, defined in the BESTEST method are obtained from several state-of-the-art simulation tools, which have been empirically validated themselves (such as ESP-r and TRNSYS) and are available in [6].

The BESTEST procedure starts with light weight building tests and finishes with heavy weight. Step-by-step it incorporates different values for internal heat gains, infiltration rates, internal and external infrared emissivity, internal and external short-wave absorbivity, different area of transparent surfaces, orientations, shading devices as well as HVAC operation strategies.

The more realistic cases, although geometrically simple, test the ability of the programs to model combined effects of thermal mass, direct solar gain windows, window-shading devices, internally generated heat, infiltration, sunspaces, earth coupling, and dead band and setback thermostat control. The more simplified cases facilitate diagnosis by allowing excitation of particular heat transfer mechanisms. Simply, by modelling and simulating those specific case buildings in a program, and then comparing the results obtained for the same case using other different software (available in BESTEST report), it is possible to diagnose errors if any.

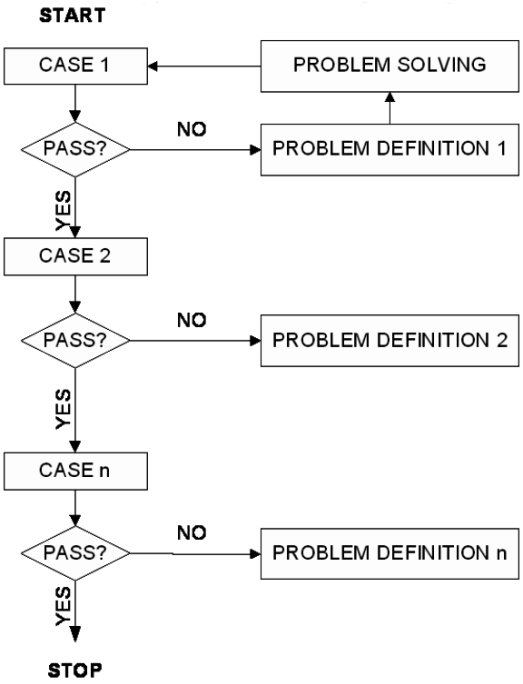

Figure 9. Validation methodology with BESTEST

Starting from the simplest model, the room without windows, tests continues over more complex models introducing or changing one of the input parameters per each new model. Hence, each upgrade of the previous models introduces and tests specific isolated algorithm. Of course, before extending the tests to a next model the results of earlier, already tested models have to satisfy certain criteria. Only then, the result of the validation will be complete. The validation process is schematically represented in **Figure 9**.

APPENDIX III – ADMITTANCE METHOD

The CIBSE admittance method dates back from the 1960's when it was developed in order to enable engineers in practice to estimate peak cooling loads using manual calculations. It basically constitutes a simple representation of a highly dynamic process; ie. the building, as a physical body with thermal mass and heat capacity, under the influence of variable outside conditions and variable internal gains.

The admittance method (also known as the "means and swings" method) uses a steady state approach for the "mean" values in combination with a dynamic part that describes all deviations from steady state, i.e. the "swings".

The admittance method is based on the assumption that all thermal dynamics can be represented by the response to a sine wave with a period of 24 hours. Using this method there is no need for solving partial differential equations and it is possible to use the method for manual calculations. By introducing several parameters the admittance method expresses the building dynamics in a simple way. The parameters are defined depending on: the type of the thermal input, thermal properties and thickness of the construction, surface finishes and furnishings within the space.

In other words, for load or temperature calculations it is necessary to determine the mean values either for temperature or for load and then the swing (mean to peak) for either one or the other value. Both values are obtained from the heat balance equation. The method involves heat balance equations for both steady state and for the deviations from the mean. The later equation involves parameters, such as: decrement and time delay of the thermal input from the outside towards inside due to the heat accumulation within the construction. The overall calculation procedure is presented in [8].

APPENDIX IV – SOLAR HEAT GAIN

This appendix tries to explain the discrepancy between solar heat gain factor (SHGF) in the admittance method and the common understanding of the same [11].

The SHGF at the environmental node in the admittance method does not consider only the heat transfer phenomena due to solar radiation through the window, but involves

also other heat transfer phenomena in the room that occur when short wave radiation enters the room. Short wave radiation is absorbed at the surface, which causes the temperature of the surface to rise. Part of the absorbed heat is conducted through the construction of the wall and accumulated and part is released into the space by convection or long-wave radiation mechanisms (**Figure 10**). The effect is a rise in environmental temperature. Accumulation inside the wall construction will influence the surface to respond on incident solar radiation after a certain time delay and with a certain decrement. That is why the SHGF value depends on the types of constructions (i.e. heavy or light).

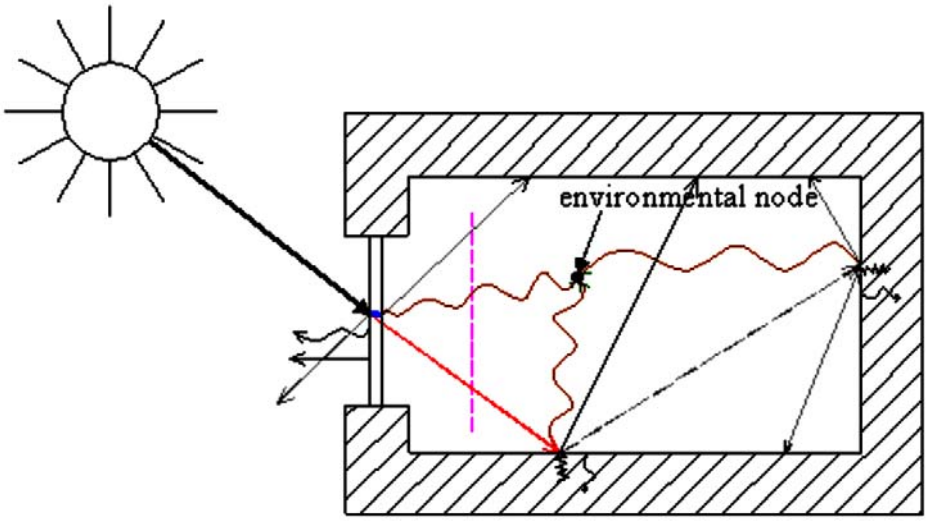

Figure 10. Heat transfer processes due to solar short wave irradiation on the window

The alternating solar heat gain coefficient for light as well as for heavy constructions input to the model in the tested program is not described by BESTEST, but taken from additional source [10]. The difference in the results could be due to the input parameters problem, but as the additional input values taken from reliable source correspond to the specific model description it can be argued that either the algorithm for solar gain calculation does not work properly or that it was not implemented in the correct way.

The algorithm that deals with solar transmittance has to be checked, improved or considered changing.

DEVELOPMENT AND APPLICATION OF AN INVERSE BUILDING MODEL FOR DEMAND RESPONSE IN SMALL COMMERCIAL BUILDINGS

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ABSTRACT

This paper describes development of an inverse building model and its application in studying the performance of a demand-limiting (DL) control strategy. The demand-limiting strategy involves precooling (PC) a building during unoccupied times, maintaining the zone temperature setpoints at the lower limit of comfort during off-peak, occupied periods, and then limiting the peak cooling rate to a target for on-peak, occupied times that keeps zone conditions within comfort limits. Data from the Iowa Energy Center (IEC), which is typical of small commercial buildings, were used to train an inverse model that was then employed as a tool to evaluate the potential for peak load reduction through control of building thermal mass. The potential for demand limiting was investigated through parametric analysis compared with night-setup (NS) control.

INTRODUCTION

In small commercial buildings, the control of dedicated HVAC equipment is achieved through the use of a thermostat, which allows the setting of zone temperature set points. Most HVAC systems employ a strategy called night-setup control. Under night-setup control, the air temperatures are in the middle of the comfort range during occupied times and the cooling system is typically inactive during unoccupied periods.

Recently there has been increased interest in the development of setpoint adjustment strategies that utilize building thermal mass to perform load shifting and peak load reduction (Braun (1990), Kintner-Meyer and Emery (1995), Keeney and Braun (1996), Keeney and Braun (1997), Braun et al. (2001), Chaturvedi and Braun (2002), Henze et al. (2004)). These strategies typically involve precooling during unoccupied periods and raising of setpoints during occupied, on-peak periods.

Transient building models are useful in the development and evaluation of strategies that take advantage of building thermal mass. Building models can be categorized as forward or inverse models. Forward models use a physical description of the building, whereas inverse models are trained using on-site measurements. Forward models are necessary for design, whereas inverse models can be useful for developing site-specific control strategies.

There has been a lot of work on the development of simplified inverse building models. Recently, Chaturvedi and Braun (2002) developed an inverse gray-box building model that was applied by Braun et al. (2002) to develop and evaluate load-shifting strategies for a large commercial building. The model uses a simplified physical representation with a thermal network of resistors and capacitors. The network is transformed to a transfer function representation and used to predict the cooling loads. The resistors and capacitors are learned using a training algorithm that minimizes model prediction errors for the overall cooling load. The model was tested using data from a field site in Chicago and was able to predict cooling loads to within about 9% for a four-week test period.

Gouda et al. (2002) also suggested a lumped parameter building model based on a thermal network. Parameters for the wall models were estimated by nonlinear constrained optimization using Kuhn-Tucker equations. Free-floating simulation results for internal air temperatures for low and high capacity rooms based on 2nd-order walls were compared with measured data.

The work described in the current paper involved further development, evaluation, and application of the inverse building model presented by Chaturvedi and Braun (2002). An inverse model was developed and applied to the

Editor's note: This paper won the award for 'Best paper with a student as lead author' at SimBuild 2004, the first national conference of IBPSA-USA, held in Boulder, Colorado, in August.

Energy Resource Station (ERS) building at the Iowa Energy Center (IEC) for the purpose of evaluating demand-limiting building thermal mass control strategies. The IEC ERS building is a relatively lightweight structure that is representative of small commercial buildings and is very well instrumented for model validation and control strategy evaluations. Recently, the International Energy Agency (IEA) reported an empirical validation of forward building models, TRNSYS, PROMETHEUS, DOE, and IDA-ICE, for the IEC ERS building (Travesi et al. (2001)).

The model trained with data from the ERS was used to estimate peak cooling load reduction associated with different demand-limiting and precooling strategies. Parametric analyses were conducted to understand the impact of the control parameters on demand-limiting performance.

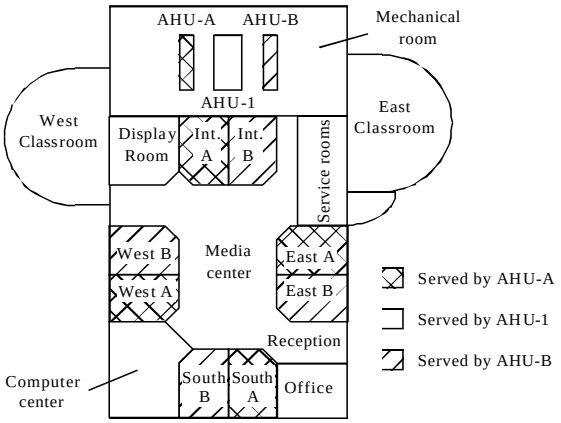


Figure 1 Schematic diagram of floor plan for the ERS

DESCRIPTIONS OF TEST BUILDING

The Iowa Energy Center ERS building is typical of small commercial buildings that employ packaged air conditioning equipment. It is a single-story building having a slab floor and is located in Ankeny, Iowa (Price and Smith (2000)). The ERS is a demonstration and test facility built to compare different energy-efficient measures, to record energy consumption, and to disseminate information concerning energy-efficient design and operation of buildings. A schematic diagram of the floor plan for the ERS is shown in Figure 1.

The ERS is divided into three major areas: the general area and two sets of test rooms, designated A and B. Each set of test rooms is comprised of East, South, West, and interior rooms. The general area consists of office space, a display room, a computer center, two classrooms, service rooms, a media center, a reception space, and a mechanical room. Each test room has 274.97 ft^2 of floor area and the ceiling is 8.5 ft high. The height of plenum zones above the test zones is 5.5 ft. The test room zones within a pair are identical and labeled 'A' and 'B'.

The IEC ERS was previously used to demonstrate the potential for load shifting associated with a simple building thermal mass precooling strategy (Braun et al. (2002)). Data from these tests were used in the current study to train inverse models. For the testing, uniform control strategies were applied to the entire facility for two different phases. In the first phase of testing (Phase 1), night-setup control was applied for the entire facility over a 9-day period. A set point of 74^{o}F was specified during the occupied period (7 a.m. to 6 p.m.) and a set point of 80^{o}F was used for the unoccupied period (6 p.m. to 7 a.m.). For the second test (Phase 2), the entire building was run with a simple precooling strategy for 8 days. The daytime cooling set point was 74 ^{o}F from 6 a.m. to 6 p.m.. Then, the temperature was setup to 80 ^{o}F from 6 p.m. to midnight. The precooling temperature set point was 68^{o}F from midnight to 6 a.m.. Internal gains within each zone were simulated using baseboard heat and lights between 7 a.m. to 6 p.m. for the entire duration of both phases. No blinds were used in the test rooms. There is an on-site weather station that recorded measurements of outdoor dry bulb, relative humidity, wind speed and direction, normal solar flux, and global horizontal solar flux during the testing period. Measurements for each zone included air flow rate, supply air temperature, return air temperature, and reheat power input. Zone sensible cooling requirements were estimated from these measurements. Data were hourly averaged.

DEVELOPMENT OF INVERSE BUILDING MODEL

Inverse building model

Figure 2 shows a thermal network for a simplified building model of the ERS. All test zones involving West, East, South, and interior rooms were modeled as a single zone enclosed by external walls, internal walls, the roof and the floor with multiple walls being lumped together as a single wall. Thus, in this study, cooling loads of the ERS building represent a total cooling load for the combined test rooms. This combination is representative of a small commercial building.

Each of the walls uses two capacitors to represent the mass of the walls and three resistors to represent the wall coupling to the ambient, the conduction within the wall and the wall coupling to the zone. It is assumed that solar radiation through windows is absorbed only on the floor. Since internal radiation is due to lights located on the ceiling, internal radiative gains are distributed only to the walls and floor. Infiltration and radiation between building outside surface and night sky are neglected. The temperature in the adjacent zone, T_{zo}, is assumed to be equal to T_z.

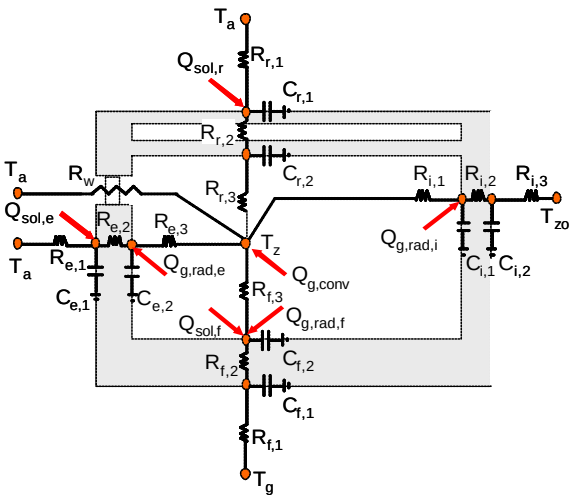


Figure 2 Thermal network for inverse building model

Using an energy balance at each node, a state-space formulation was set up for the building model as described by Chaturvedi and Braun (2002).

$$\frac{d\mathbf{x}_b}{dt} = \mathbf{A}_b\mathbf{x}_b + \mathbf{B}_b\mathbf{u}_b \tag{1}$$

$$\mathbf{Y}_b = Q_b = \mathbf{C}_b\mathbf{x}_b + \mathbf{D}_b\mathbf{u}_b \tag{2}$$

where Q_b = rate of instantaneous heat gain to the building air. The state and input vectors in the above representation are

$$\mathbf{x}_b^T = [T_{r1}, T_{r2}, T_{e1}, T_{e2}, T_{f1}, T_{f2}, T_{i1}, T_{i2}] \tag{3}$$

$$\mathbf{u}_b^T = [T_z, T_a, T_g, Q_{sol,r}, Q_{sol,e}, Q_{g,rad,f}, Q_{g,rad,e}, Q_{g,rad,i}, Q_{sol,f}, Q_{g,conv}] \tag{4}$$

There are 8 state variables (two nodal temperatures in each of the four walls) and 10 input variables in the model. Measured zone temperature, ambient temperature, solar radiation, internal radiative gains, and internal convective gains are used for input variables. Ground temperature is assumed constant. The ground temperature was estimated using experimental results from Thomas and Rees (1999) and Zhou et al. (2002) that give an estimated steady-

state floor surface heat flux of 5 W/m^{2}K. The ground temperature was estimated to be 63.5°F. It is also assumed that the internal radiative gains are distributed within an even heat flux to the interior surfaces of the walls and floor. It was assumed that 90% of the lighting energy was radiation and 10% was convection. For the heaters, 5% was assumed to be radiation and 95% convection. The elements of the coefficient matrices in the state space representation are in terms of the resistors and capacitors used in the different walls. The state-space representation is then solved using the methodology of Seem et al.(1989) to obtain a comprehensive transfer function for heat gain in terms of the input variables and previous heat gains as:

$$Q_{b,k} = \left(\sum_{j=0}^{N_{\mathbf{x}}} \mathbf{S}_{b,j} \mathbf{u}_{b,k-j} \right) - \left(\sum_{j=1}^{N_{\mathbf{x}}} e_{b,j} Q_{b,k-j} \right) \quad (5)$$

$S_{b,j}$ and $e_{b,j}$ are determined from the matrices $\mathbf{A}_b, \mathbf{B}_b, \mathbf{C}_b$, and $\mathbf{D}_b$ involving resisters and capacitors. Further solution details are found in Seem et al. (1989). The instantaneous sensible zone cooling load $Q_{c,k}$ can be calculated using an instantaneous energy balance on the zone given as:

$$C_{z,eff} \frac{dT_{z,k}}{dt} = Q_{b,k} - Q_{c,k} \quad (6)$$

The zone temperature is assumed to vary linearly, so that the left-hand-side of equation 6 is expressed as:

$$\frac{dT_{z,k}}{dt} = \frac{T_{z,k} - T_{z,k-1}}{\Delta t} \quad (7)$$

where $\Delta t = 1$ hour. From equation 5, $Q_{b,k}$ is expressed as a function of the instantaneous zone temperature. However, for computational simplicity, it is assumed that the average heat gains and average cooling rate are constant throughout the hour and are evaluated at the average temperature over the hour and the variation in set point is linear over the hour.

The training algorithm is divided into two phases, a global search and a local search (Chaturvedi and Braun (2002)). The global search uses a systematic search to determine reasonable values of the building resistors and capacitors. It uses initial parameter estimates obtained from a crude building description to appropriately bound the parameters and searches within the bounded region. The local search uses a local non-linear regression method to further improve the R and C estimates by minimizing the root-mean-squared error between measured and calculated cooling loads for the training duration. The combination of a local and a global phase provides a robust algorithm for determining an accurate model and only requires minimal preliminary building information. Parameters determined through global and local searches are: effective window transmittance for solar radiation, effective zone capacitance, and the thermal resistances and capacitances shown in Figure 2. Effective zone capacitance appears in equation 6 and effective transmittance is used to calculate solar gains through windows.

Tables 1 and 2 give the bounds used for the global search in the model training for the ERS building.

Table 1 Material property bounds used in model training algorithm

PROPERTY	BOUNDS	ELEMENT TYPE			
		EXTERNAL WALL	INTERNAL WALL	ROOF AND CEILING	FLOOR
k_t (Btu/hr-F-ft)	Min	1E-3	1E-3	1E-5	1E-3
	Max	1.0	1.0	5E3	1.0
$r * C_p$ (Btu/F-ft^3)	Min	0.1	0.1	0.1	0.1
	Max	30	10	50	30

Table 2 Physical property bounds used in model training algorithm

BOUNDS	τ_{eff}	h_i (Btu/hr-ft^2-F)	h_e (Btu/hr-ft^2-F)	$C_{z,eff}$ (Btu/F)
Min	0.1	0.1	2.0	0
Max	0.9	1.0	6.0	800

Table 3 Cases of data sets for testing performance

DATA SET CASES	TRAINING	TESTING
I	phase 1 (9 days)	phase 2 (8 days)
II	phase 2 (8 days)	phase 1 (9 days)
III	first 6 days of phase 1 + phase 2 (14 days)	repetition of last 3 days of phase 1 (9 days)
IV	phase 1 + first 5 days of phase 2 (14 days)	repetition of last 3 days of phase 2 (9 days)

The trained model can be used to calculate transient building cooling loads for arbitrary periods if the inputs are provided.

Validation of model

The measured data sets for the phase 1 (9 days from August 3 to August 11, 2001) and phase 2 (8 days from August 13 to August 20, 2001) tests at the ERS building were used as inputs to the inverse building model. A part of the data was used for training the model and the remainder was used for testing the model. Table 3 represents four cases that were considered for training and testing of the inverse model. In cases of III and IV, portions of data from both phase 1 and phase 2 were used for training. In each of these cases, only 3 days of data were not used for training and these 3 days were repeated 3 times in sequence to obtain 9-day test sequences.

Model performance is described in terms of a prediction error, E_{rms}, as defined in equation 8.

$$E_{\text{rms}}(\%) = \frac{100}{Q_{\text{m,max}}} \sqrt{\frac{\sum_{k=1}^{N_{\text{test}}} (Q_{\text{m,k}} - Q_{\text{c,k}})^2}{N_{\text{test}} - 1}} \tag{8}$$

Testing performance of the inverse model for the four cases is shown in Figure 3. The bars represent errors for model testing given for the entire test period ('Whole period') and the last 3 days of the test data ('Last 3 days'). Generally the model performs well in estimating cooling loads compared with measured cooling loads. The E_{rms} values were within 8% except for the case of training with phase 2 and testing with phase 1 data, which had about a 12% error. A better model could be obtained if more data were available over a wider range of conditions. For the remainder of the results presented in this paper, a model was used that was trained using all of the data from the phase 1 and phase 2 testing. This model resulted in an E_{rms} of 6.22% for the training data set.

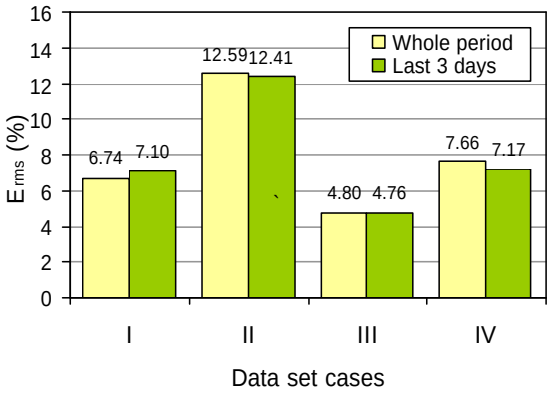


Figure 3 E_{rms} of inverse model with 4 cases of training and testing data sets

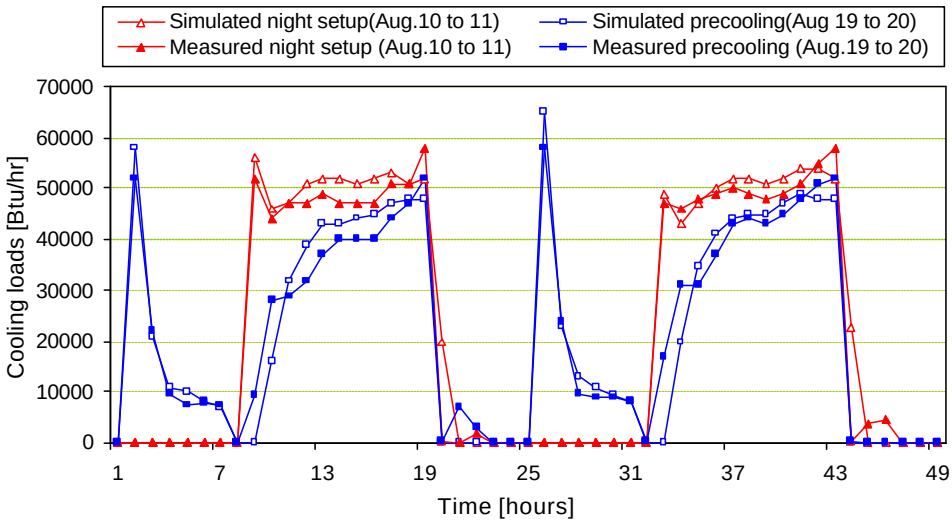


Figure 4 Comparison of measured and simulated cooling loads (inverse model) for night-setup and precooling control strategies

Figure 4 compares the calculated and measured cooling loads for two days of the phase 1 and phase 2 test periods obtained using the model trained with all available data. These two days had similar solar radiation and ambient temperature conditions. Therefore, the cooling loads shown in Figure 4 are useful for evaluating the impact of precooling on load shifting as well as evaluating model performance. The simulated cooling load matches the actual cooling loads very well. For both simulated and measured results, the occupied period load was about 23% less for the precooling tests and the peak load was reduced by about 9%.

The precooling control strategy used for the phase 2 testing was not designed to maximize peak load reduction. Much greater peak load reductions would be possible if the zone temperatures were varied within the comfort region rather than being held constant. Such a strategy would keep the zone temperatures low at the beginning of occupancy and raise them later in the day. This would have the effect of increasing the early occupancy loads and decreasing the late occupancy loads. The impact of such a demand-limiting strategy on peak loads was evaluated using the inverse model developed in this study for the ERS. Results are presented in the next section.

APPLICATION OF INVERSE BUILDING MODEL

Demand-limiting strategy

A demand-limiting (DL) control strategy in this study is defined as a strategy that aims to "limit" the peak cooling load to a specified target cooling load during the on-peak period by adjusting room set point temperatures within the comfort range. Figure 5 represents set point temperatures for both night setup (NS) and DL control strategies. In the DL strategy, the building is precooled by lowering the set point to $T_{dl,unoc}$ (e.g., 67°F) during a portion of the unoccupied period leading up to the occupied time.

During the occupied period, the set point is set at the lower end of the comfort limit at $T_{dl,oc,min}$ (e.g., 69°F) until the cooling load would exceed a certain target demand-limiting cooling load. When the building cooling load would exceed the target load, the set point temperature is increased in order to limit the building cooling load to the target load. After the occupied period, the setpoints are set up to $T_{ns,unoc}$ (e.g., 80°F) until the start of the next precooling period.

In this study, the target load was adjusted each day through iteration so as to utilize the entire comfort range. The secant method was used to determine the target load that would yield a zone temperature at the end of the occupied period of $T_{dl,oc,max}$ (76°F).

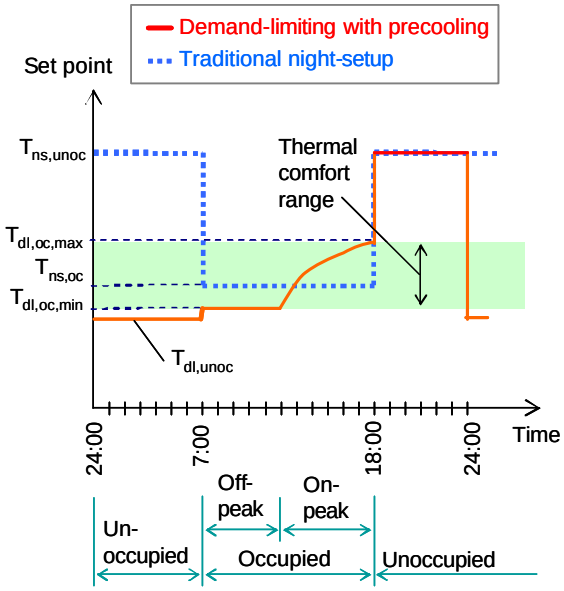
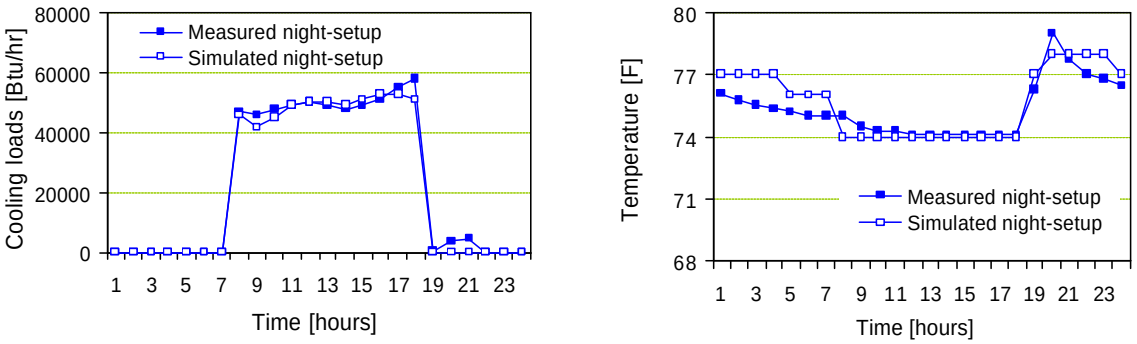


Figure 5 Set point temperatures for night-setup and demand-limiting strategies



(a) Cooling loads *(b) Zone temperatures*

Figure 6 Measured and simulated (inverse model) cooling loads for night-setup operation on August 11 test in Phase 1

Description of parametric studies

In order to evaluate the potential for the DL control strategy, one day from the phase 1 (Aug. 11) testing was chosen for comparison with a base case of NS control. Every simulation was conducted for an identical set of ten days in a row to erase the initial condition effects and reach a steady-periodic behavior. Figure 6 shows how well the inverse model estimates cooling loads and zone temperatures for this single day under NS. The times are measured from midnight. Cooling loads occurred from 7 a.m. to 6 p.m.. The model did a good job of calculating the cooling loads under NS control.

The demand-limiting period, or on-peak period where the DL strategy is applied, was varied by changing the start-time (DL start time) from 7 a.m. to 3 p.m.. The precooling period was also changed by varying the start-time (H_{pc}) from 10 p.m. to 7a.m.. A start-time of 7 a.m. for precooling represents no precooling during the unoccupied period and is a limiting case. Other setpoints that impact peak loads for the DL and NS strategies were also considered. Table 4 shows the range of parameters considered in this study.

Table 4 Parameter variations

PARAMETERS	VALUES
DL start time	7 a.m. to 3 p.m.
H_{pc}	10 p.m. to 7 a.m.
$T_{dl,oc,min}$(^{o}F)	67, 69, 71, 73 °F
$T_{dl,unoc}$ (^{o}F)	63, 65, 67, 69 °F
$T_{dl,oc,max}$ (^{o}F)	74, 76, 78, 80 °F
$T_{ns,oc}$ (^{o}F)	72, 74, 76, 78, 80 °F
$T_{ns,unoc}$ (^{o}F)	80 °F

The performance of the DL strategy was measured in terms of a peak load ratio (*PLR*) defined as the ratio of the peak load under the DL strategy to the peak load for the base case NS strategy or

$$PLR = \frac{Q_{max,dl,op}}{Q_{max,ns,op(@T_{ns,oc}=74°F)}} \tag{9}$$

The base case NS strategy had an unoccupied setpoint ($T_{ns,unoc}$) of 80°F and an occupied setpoint of ($T_{ns,oc}$) of 74°F.

For NS control, the impact of the occupied setpoint on demand was also considered. In this case, a peak load ratio under NS (PLR_{ns}) is defined as

$$PLR_{ns} = \frac{Q_{max,ns,op@T_{ns,oc}}}{Q_{max,ns,op(@T_{ns,oc}=74°F)}} \tag{10}$$

Results and discussion

The effects of start times for demand limiting and night precooling on peak cooling load reduction are shown in Figure 7. The temperature set points for these results are $T_{dl,unoc}$=67°F, $T_{dl,oc,min}$=69°F, $T_{dl,oc,max}$=76°F, and $T_{ns,unoc}$=80°F. PLR has a small dependence on the precooling duration (H_{pc}) when the demand-limiting period begins in the afternoon. However, precooling becomes more important as the start of the on-peak period moves earlier in the day. For an on-peak period beginning at 7 a.m., the maximum peak load reduction was about 23% compared to NS control. For an afternoon start to the on-peak period, the peak load reduction for the on-peak period was about 40% even without any precooling.

Figures 8 and 9 show selected detailed results from the cases considered for Figure 7. These figures compare hourly cooling loads and zone temperatures for the NS and DL strategies for a morning and afternoon start to the demand-limiting period. For the results of Figure 8, the DL strategy involved precooling the building from midnight to 7 a.m. and demand-limiting began at 7 a.m.. The peak load under NS occurred around 5 p.m. in the afternoon. As a result of precooling, the DL strategy resulted in very low loads during the early morning hours. When the load reached the target, then the setpoint was raised following a trajectory that kept the load constant. The zone temperature set point increased until it reached 76 °F at the end of the on-peak period.

For the results of Figure 9, the start time for demand limiting was 1 p.m. As a result, the setpoint was kept low during the morning hours for the DL strategy and the late morning loads were slightly greater than those for the NS control. With a short demand-limiting period, the peak reduction was significantly greater than for the results of Figure 8. The energy storage is more significant compared to the total load for a shorter demand-limiting period. Although not shown here, the application of DL control without precooling results in a significant early morning load spike that occurrs at the start of the occupied period.

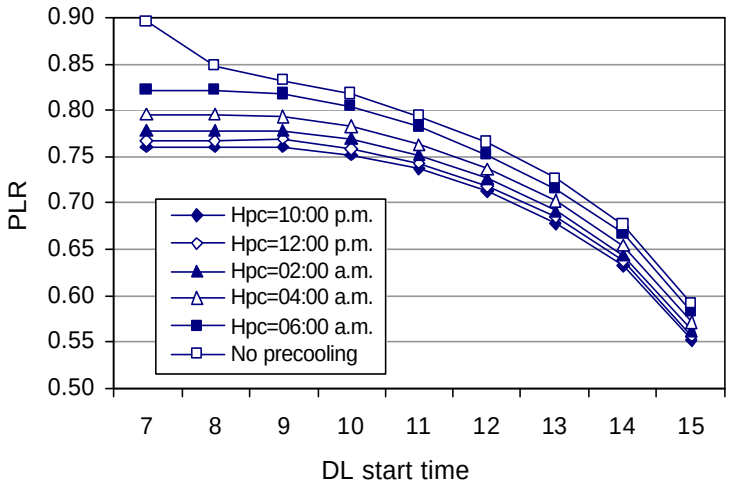
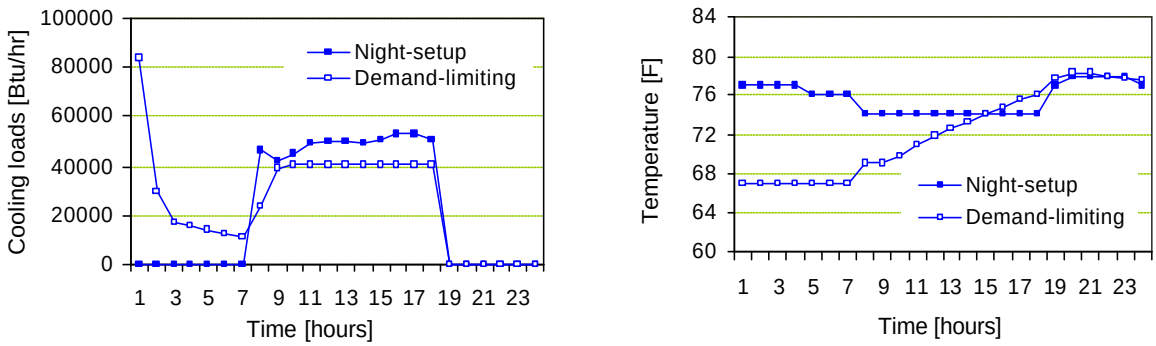
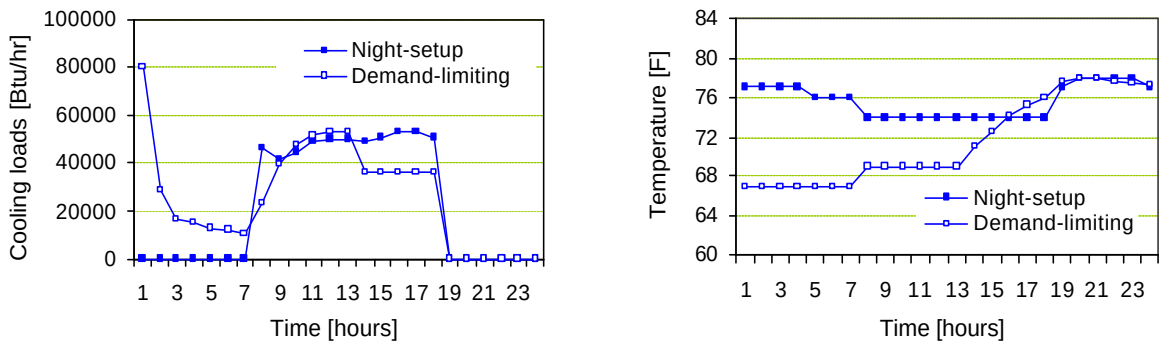


Figure 7 PLR with H_{pc} varying DL start time



(a) Cooling loads *(b) Zone temperatures*

Figure 8 Simulated NS and DL control (PC start-time (H_{pc}) of midnight and DL start-time of 7 a.m.)



(a) Cooling loads *(b) Zone temperatures*

Figure 9 Simulated NS and DL control (PC start-time (H_{pc}) of midnight and DL start-time of 1 p.m.)

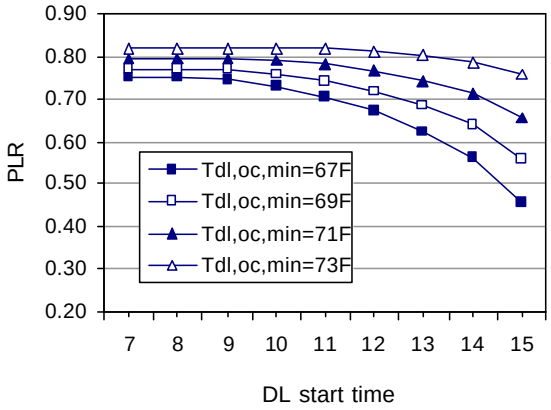


Figure 10 PLR dependence on $T_{dl,oc,min}$ and DL start time

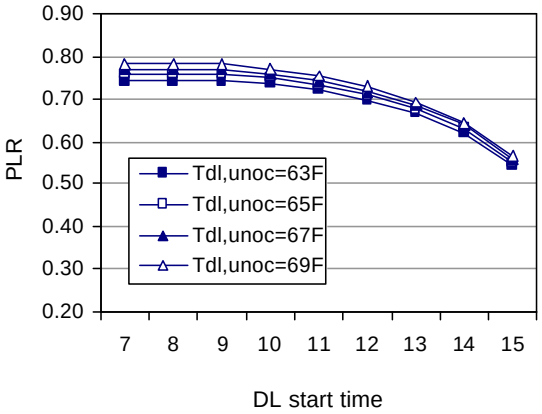


Figure 11 PLR with $T_{dl,unoc}$ varying DL start time

Figure 10 shows how *PLR* is affected by the variation of $T_{dl,oc,min}$ (set point temperature during the off-peak occupied period) under DL control. Other set point conditions were $T_{ns,unoc}$=80°F, $T_{dl,unoc}$=67°F, $T_{dl,oc,max}$=76°F and H_{pc}=12 midnight. Peak load reduction increases (*PLR* decreases) with decreasing $T_{dl,oc,min}$, with a greater impact occuring for shorter on-peak periods. The effect of DL start-time on peak load reduction becomes greater as $T_{dl,oc,min}$ is reduced. Figure 11 shows the impact of $T_{dl,unoc}$ (set point for night-precooling during the unoccupied period) on *PLR*. Other set point conditions were $T_{ns,unoc}$=80°F, $T_{dl,oc,min}$=69°F, $T_{dl,oc,max}$=76°F, and H_{pc}=12 midnight. The impact of $T_{dl,unoc}$ is small and *PLR* decreases slightly as $T_{dl,unoc}$ is lowered.

Figure 12 shows *PLR* as a function of $T_{dl,oc,max}$. Other set point conditions were $T_{ns,unoc}$=80°F, $T_{dl,unoc}$=67°F, $T_{dl,oc,min}$=69°F, and H_{pc}=12 midnight. The impact of $T_{dl,oc,max}$ on peak load reduction is greater than that of other set point temperatures under DL. As $T_{dl,oc,max}$ increases, *PLR* decreases (greater peak load reduction). *PLR* also decreases as the DL start-time increases and its impact gets larger as $T_{dl,oc,max}$ increases.

It's interesting to compare the peak load reduction of DL strategies with that associated with increasing the occupied setpoint for night setup control. Figure 13 shows the impact of $T_{ns,oc}$ on PLR_{ns}. As $T_{ns,oc}$ (set point temperature during occupied period under NS) increases, PLR_{ns} decreases about 10% compared to the peak cooling load under NS with an occupied set point temperature of 74°F. The effect on peak load reduction of raising this set point is significantly less than the effect of employing the DL control strategy.

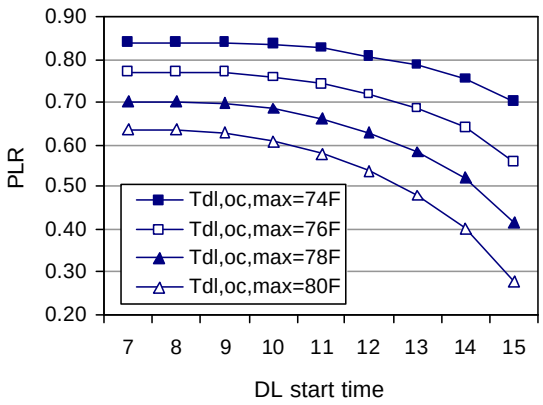


Figure 12 PLR with $T_{dl,oc,max}$ varying DL start time

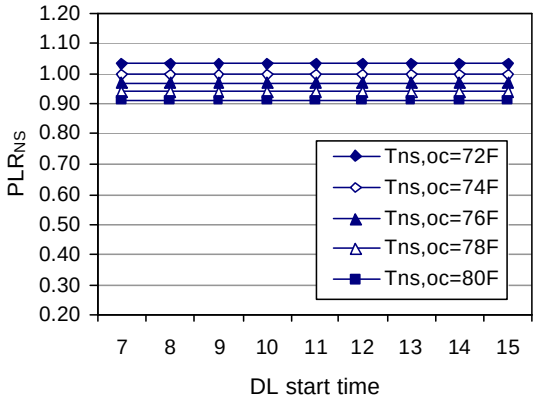


Figure 13 PLR_{ns} with $T_{ns,oc}$ varying DL start time

CONCLUSIONS

An inverse building simulation model based on a simplified thermal network was developed for a facility that is representative of small commercial buildings. The building model was then used to evaluate the potential for peak load reduction with a demand-limiting control strategy that utilizes energy storage within the building structure.

The peak demand during the on-peak period was reduced by about 25% to 45% with the demand-limiting strategy depending on the start time of the on-peak period as compared with conventional control. The potential for peak load reduction with the DL strategy increases significantly as the start of the on-peak, demand-limiting period moves to later in the day. Also, as the demand-limiting period starts later, the peak load reduction becomes more sensitive to the temperature setpoints employed prior to and during the demand-limiting period. When the demand-limiting period begins in the afternoon, demand reduction is insensitive to the amount of precooling applied in the unocuppied period.

The facility considered in this study is relatively lightweight and is representative of many small commercial buildings. Greater potential should be possible for large commercial buildings because of a smaller ratio of external area to thermal mass, the use of heavier weight materials, and the availability of more favorable electrical rate structures. However, small commercial buildings are an excellent application for use of building thermal mass because the savings are significant and they account for a significant portion of the total cooling requirements for commercial building stock. Further, it is easier to develop an intelligent controller for small commercial buildings since they typically use packaged air conditioners with a single thermostat controlling a single unit for individual zones.

NOMENCLATURE

A	=	coefficient matrix in the state space representation
B	=	coefficient matrix in the state space representation
C	=	capacitance (Btu/F)
C	=	coefficient matrix in the state space representation
DL	=	demand-limiting control strategy
D	=	coefficient matrix in the state space representation
E_{rms}	=	RMS error (%)
E	=	scalar transfer function coefficients for past histories of heat flow
H_{pc}	=	night precooling start time
h	=	convective heat transfer coefficient (Btu/hr-ft^2-F)
k_t	=	thermal conductivity (Btu/hr-ft-F)
N	=	number
NS	=	night-setup control strategy
PC	=	precooling control strategy
PLR	=	peak load ratio
Q	=	rate of heat transfer (Btu/hr)
Q_b	=	rate of instantaneous heat gain to the building air (Btu/hr)
$Q_{c,k}$	=	calculated cooling load at time step k (Btu/hr)
$Q_{m,k}$	=	measured cooling loads at time step k (Btu/hr)
$Q_{m,max}$	=	maximum measured load during the testing period (Btu/hr)
R	=	thermal resistance (F-hr/Btu)
S	=	series of row vectors containing transfer function coefficients for past histories of heat flow
T	=	temperature (F)
t	=	time (hour)
u	=	vector of input variables
x	=	vector of state variables
Y	=	vector of output variables

Greek

τ_{eff}	=	effective window transmittance for solar radiation
r	=	density (lb/ ft^3)

Subscripts

a	=	ambient
b	=	building
dl	=	demand-limiting control
e	=	external wall
eff	=	effective
f	=	floor
g	=	ground
g,rad	=	radiative internal heat gain
g,conv	=	convective internal heat gain
i	=	internal
k	=	time stage
max	=	maximum
ns	=	night-setup control
oc	=	occupied period
op	=	on-peak period
r	=	roof and ceiling

sol	=	solar irradiative absorption	**x**	=	state variable
test	=	test period	z	=	zone
unoc	=	unoccupied period	zo	=	adjacent zone
w	=	window			

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SIMULATION OF TUBULAR DAYLIGHTING DEVICES AND DAYLIGHTING SHELVES IN ENERGYPLUS

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ABSTRACT

Tubular daylighting devices (TDDs) and daylighting shelves are two methods for bringing natural exterior daylight into the hard-to-reach, interior spaces of a building. Recently two models to simulate these devices were added to the EnergyPlus whole-building energy analysis program. In addition to modeling their daylighting effects, solar gains and conductive/convective heat transfer are also integrated into the zone heat balance. This paper presents an overview of the concepts and algorithms implemented in EnergyPlus to simulate TDDs and daylighting shelves. Preliminary testing efforts are also described.

INTRODUCTION

Tubular daylighting devices (TDDs) and daylighting shelves are two methods for bringing natural exterior daylight into the hard-to-reach, interior spaces of a building. TDDs, also known as tubular skylights or light pipes, channel the daylight incident on an exterior dome to an interior diffuser via multiple internal reflections in a pipe. Daylighting shelves, or simply light shelves, are composed of an inside shelf and/or outside shelf which divides a typical window into an upper and lower portion. The inside shelf diffuses daylight from the upper window onto the ceiling. The outside shelf acts as a reflector, changing the amount of daylight incident on the upper portion of the window.

The strategic use of daylighting devices in a building design can reduce the electric lighting load and result in energy savings. However, daylighting devices also have a thermal impact. A building with too much fenestration, for example, can actually increase the overall building energy usage because of greater solar gains and greater heat losses. A daylighting analysis must be combined with a whole-building energy analysis to determine the overall energy impact of daylighting devices.

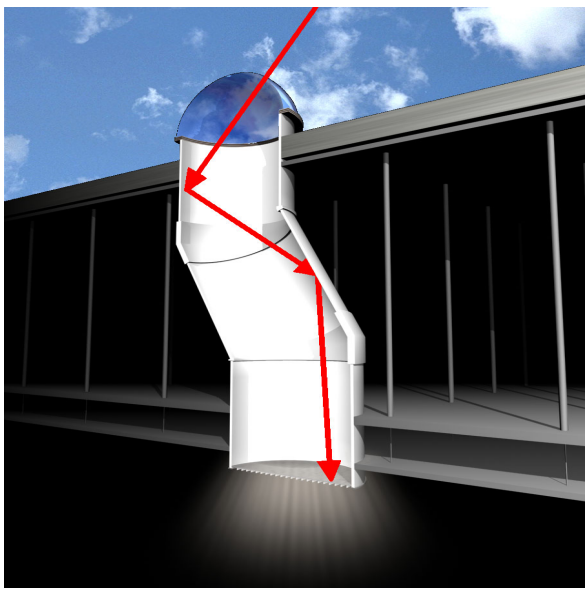

Figure 1. Tubular daylighting device.

EnergyPlus is one recent program that is capable of both daylighting and energy calculations for a building. The daylighting model is derived from the DOE-2.1E daylighting algorithm (Winkelmann et al. 1985). Daylight factors are calculated to determine illuminance levels at locations in a zone. Direct beam illuminance is calculated by ray tracing. Diffuse illuminance due to internal reflections in the zone is calculated using the split-flux method. The effects of multipane windows and window coverings such as shades or blinds are also simulated. The EnergyPlus model improves on DOE-2.1E by utilizing four sky types (Perez et al. 1990), as opposed to just two sky types in DOE-2.1E. Daylight factors in EnergyPlus are also calculated hourly instead of the 20 representative annual sun positions in DOE-2.1E.

Editor's note: This paper won the 'Best paper' award at SimBuild 2004, the first national conference of IBPSA-USA, held in Boulder, Colorado, in August.

The EnergyPlus energy simulation uses the heat balance method which is based on the law of conservation of energy (Strand and Pedersen 2001). Optical and thermal calculations for window glazing are based on algorithms from the WINDOW 4 and WINDOW 5 programs (Arasteh et al. 1989; Finlayson et al. 1993). Detailed surface geometry is used to calculate shading. Both daylighting and heat balance models are described in detail in the *EnergyPlus Engineering Document* (UIUC and LBNL 2003).

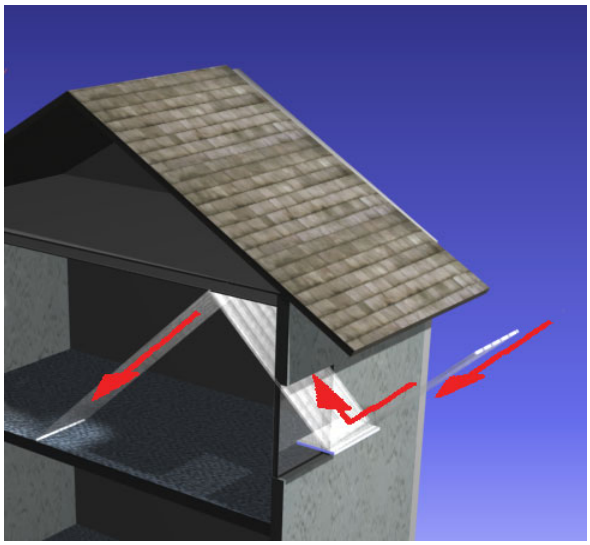

Figure 2. Daylighting shelf.

The capability to simulate TDDs and light shelves was added to EnergyPlus in version 1.1.1. The simulation of these devices is tightly integrated into both the daylighting and heat balance models. This paper gives an overview of the EnergyPlus models for daylighting devices in the context of a whole-building energy analysis.

TUBULAR DAYLIGHTING DEVICES

Tubular daylighting devices (TDDs) are constructed of three components: a dome, a pipe, and a diffuser. The dome is typically a hemisphere made of clear plastic. It allows daylight into the pipe while keeping exterior weather out. The pipe is assumed to be a smooth cylinder with a highly reflective inside surface. The surface is usually either bare polished metal or a special reflective sheet adhered to the inside. The pipe passes through one or more transition zones, channeling the daylight from the dome to the diffuser via multiple internal reflections. The diffuser is typically a prismatic or frosted plastic cover. The diffuser evenly distributes the daylight to the zone.

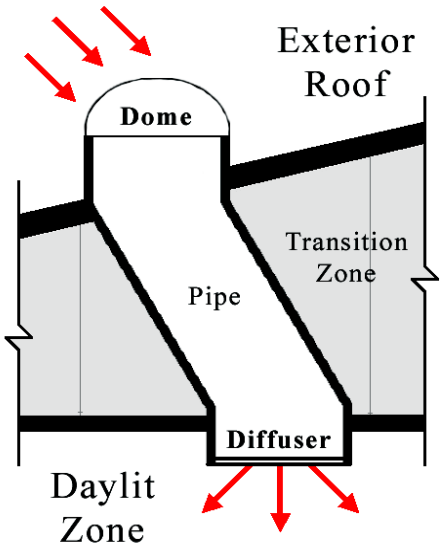

Figure 3. Tubular daylighting device diagram.

In EnergyPlus the TDD model includes three distinct, but related, phenomena:

- Daylighting
- Solar gains
- Conductive/convective gains

Solar gains and conductive/convective gains are simulated by the zone heat balance while daylighting is simulated independently.

For both daylighting and heat balance simulations, the dome and diffuser components are treated as special window surfaces to take advantage of many of the standard EnergyPlus daylighting and heat transfer routines. Together the dome and diffuser become "receiver" and "transmitter", i.e. radiation entering the dome ends up exiting the diffuser.

The pipe is simulated by a separate code module. While several different measures for characterizing TDD performance are in use (Zhang et al. 2002; Harrison et al. 1998), using the transmittance of the TDD is most compatible with the existing EnergyPlus daylighting and heat balance code. Calculation of the transmittance of the pipe component and the overall TDD for different types of radiation is fundamental to all phenomena covered by the model.

Pipe beam transmittance

The transmittance of a beam of collimated radiation is derived from the integration of the transmittance of many parallel rays. The transmittance of a discrete ray through a pipe is dependent on the reflectivity of the inside pipe surface, the aspect ratio of the pipe, the incident angle of the ray, and the point of entry into the pipe.

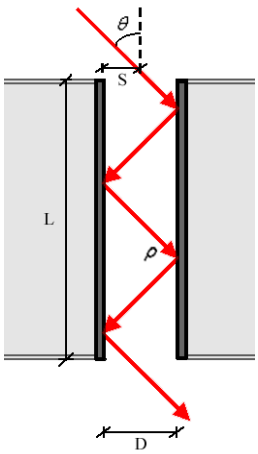

Figure 4. Discrete ray in a pipe.

For an opaque surface, the reflectivity is:

$$\rho = 1 - \alpha \tag{1}$$

where α = surface absorptivity. Visible (i.e. daylighting) and solar absorptivities of the pipe material are specified in the input file. These yield visible and solar reflectivities, respectively. Measured reflectivities for commercial TDDs range from 0.90 to 0.99. Although the actual surface reflectivity is slightly dependent on the incident angle, the model assumes a constant reflectivity for all angles.

The full analytical expression for the transmittance of a beam of light in a highly reflective pipe has been developed by Swift and Smith (1994) and verified by experiment. By integrating over all rays incident on the pipe entrance, they find the transmittance of a beam of collimated radiation to be:

$$\tau = \frac{4}{\pi}\int_{s=0}^{1} \frac{s^2}{\sqrt{1-s^2}} \rho^{INT[a\tan\theta/s]} \left(1-(1-\rho)\left(a\tan\theta/s - INT\left[a\tan\theta/s\right]\right)\right) ds \tag{2}$$

where

a = L/D, the aspect ratio of the TDD

ρ = surface reflectivity

θ = incident angle

s = entry point

INT[x] = a function returning the integer part of x

This integral does not have an analytical solution and must be calculated numerically. It was found that a large number of points (100,000) were necessary to achieve an acceptable accuracy. Since the integration is time consuming and the transmittance of the pipe must be utilized many times at every timestep, values are calculated once over a range of incident angles during an initialization procedure and then stored in a table. The tabulated values are interpolated to rapidly give the transmittance at any incident angle. A polynomial fit was also considered but it was found that interpolation gave superior results.

During initialization of each unique TDD, the program integrates and tabulates values separately for the visible and solar transmittance of the pipe. The results are subsequently used in the daylighting simulation and heat balance simulation respectively.

The effect of bends in the pipe on beam transmittance is not included in this model. Recent research (Zhang et al. 2002) has suggested that a 30 degree bend has a 20% loss in transmitted light. If the effect of bends must be simulated, it can be approximated by the user by appropriately decreasing the transmittance of the diffuser material.

TDD beam transmittance

The beam transmittance of the TDD takes into account the dome and diffuser transmittances in addition to the pipe transmittance.

$$\tau_{TDD}(\theta) = \tau_{dome}(\theta)\tau_{pipe}(\theta)\tau_{diffuser} \tag{3}$$

where

$\tau_{dome}(\theta)$ = beam transmittance of the dome glazing at the incident angle

$\tau_{pipe}(\theta)$ = beam transmittance of the pipe at the incident angle, as described above

$\tau_{diffuser}$ = diffuse transmittance of the diffuser glazing

The dome transmittance is based on the EnergyPlus calculation for a regular flat window. The model does not take into account refraction due to the curvature of the dome surface.

Diffuse transmittance is always assumed for the diffuser component because multiple internal reflections in the pipe scatter the beam with a diffusing effect. Although the light exiting the pipe is not isotropic, it can be approximated as diffuse. The use of a prismatic or frosted diffuser on the TDD, however, ensures that the

light delivered to the zone is very close to isotropic diffuse.

The calculation of TDD diffuse transmittance is considerably more complex and is handled differently in daylighting and heat balance simulations. The details are discussed in the following sections.

Daylighting

The daylighting simulation of the TDD treats the diffuser surface as a regular window illuminated from the outside by sun, sky, and ground reflections. However, the TDD model replaces the window glazing transmittance with the appropriate overall TDD transmittance and converts all transmitted light to diffuse.

The illuminance due to the direct beam of the sun is found using the TDD beam transmittance $\tau_{TDD}(\theta)$ as described above. The incident angle θ is relative to the dome surface.

The illuminance due to sky radiation and ground reflected radiation is calculated by integrating over the sky and ground within the viewable hemisphere. This is done separately for each of the four sky models. For the TDD, the transmittance of each sky or ground element is also found using the TDD beam transmittance at the incident angle of the sky or ground element relative to the dome.

Solar gains

Solar radiation incident on a window is calculated separately as sun, sky, and ground reflected radiation. A different transmittance must be applied for each type of radiation. For beam radiation, the TDD beam transmittance $\tau_{TDD}(\theta)$ for the solar spectrum is as described above.

For sky and ground radiation, EnergyPlus uses the Perez sky model (Perez et al. 1990). This is an anisotropic distribution modeled as the superposition of three simple distributions: a diffuse isotropic background, a circumsolar brightening near the sun, and a horizon brightening. While the daylighting model is capable of calculating the luminance of any position in the sky, the solar model only calculates the ultimate irradiance on a surface. For this reason it is not possible to integrate over an angular distribution function for sky radiance. Instead the diffuse transmittance for sky and ground radiation is handled piecewise.

$$\tau_{diff,aniso} = \frac{\sum I_{trans,aniso}}{\sum I_{inc,aniso}} = \frac{I_{trans,iso} + I_{trans,circum} + I_{trans,horiz}}{I_{inc,iso} + I_{inc,circum} + I_{inc,horiz}} \quad (4)$$

Substituting in the appropriate transmittances:

$$\tau_{diff,aniso} = \frac{\tau_{diff,iso} I_{inc,iso} + \tau(\theta) I_{inc,circum} + \tau_{diff,horiz} I_{inc,horiz}}{I_{inc,iso} + I_{inc,circum} + I_{inc,horiz}} \quad (5)$$

where

$\tau_{diff,iso}$ = diffuse isotropic transmittance

$\tau(\theta)$ = beam transmittance at incident angle θ of sun

$\tau_{diff,horiz}$ = diffuse transmittance of the horizon

It is important to note that transmittances above are for the overall TDD. The transmittance of the dome and diffuser must be included to account for their angular dependencies as well. The beam transmittance is used as an approximation for all circumsolar radiation. The diffuse isotropic transmittance is found by integrating the beam transmittance over all angles in the hemisphere.

Some solar radiation is inevitably absorbed by the TDD before it reaches the interior zone. Every reflection in the pipe leaves behind an amount of solar radiation that depends on the surface absorptivity. Rays incident at a greater angle make more reflections and leave behind more absorbed solar radiation in the pipe wall.

The total absorbed solar radiation in the TDD is the sum of the following gains:

- Inward bound solar radiation absorbed by multiple pipe reflections
- Outward bound solar radiation absorbed by multiple pipe reflections due to:
  - Reflection off of diffuser surface (inside of TDD)
  - Zone diffuse interior shortwave radiation incident on the diffuser from lights, etc.
- Inward flowing absorbed solar radiation in dome and diffuser glazing

All absorbed solar radiation in the TDD is distributed among the transition zones that the pipe passes through between dome and diffuser.

The complexity of the exact solar distribution in the pipe is not modeled. Instead the assumption is made that transition zone heat gain is proportional to the length of pipe in each zone. Any exterior length of pipe also receives a proportional amount of heat, but this is lost to the outside. Since the user specifies the length of pipe in each transition zone in the input file, there is flexibility for adjusting the lengths, and hence the heat gain, to match a predetermined solar distribution. The user, for example, may be able to estimate a distribution

from experimental measurements (perhaps using infrared thermography), or calculate a distribution using an external model when future research makes such available.

Conductive/convective gains

For conductive and convective heat gain, TDDs are treated as one entity with an effective thermal resistance (i.e. R-value) between the outside and inside surfaces. The outside face temperature of the dome and the inside face temperature of the diffuser are calculated as usual by the outside and inside heat balances respectively. Normal exterior and interior convection and IR radiation exchange occurs for both surfaces.

Although little research has been done to measure the thermal characteristics of TDDs, one experiment (Harrison et al. 1998) reports an average effective thermal resistance of 0.279 m^2 K/W for a commercial TDD measuring 0.33 m in diameter by 1.83 m in length. This value, however, reflects a measurement from outside air temperature to inside air temperature. The EnergyPlus model assumes an effective thermal resistance from outside *surface* temperature to inside *surface* temperature.

The National Fenestration Rating Council (NFRC) has included a method for determining the U-value of TDDs in the latest *NFRC 100* publication (NFRC 2002). Rated TDD U-values for participating manufacturers can be found using the on-line *NFRC Certified Products Directory*. Typical R-values for one product line range from 0.366 to 0.419 m^2 K/W. Again, this value reflects heat flux from outside air temperature to inside air temperature. Care must be taken to subtract off outside and inside surface heat transfer coefficients before using with EnergyPlus.

The heat transfer effects of convection of air in the pipe, including stratification and infiltration, must also be taken into account by the user when estimating the effective thermal resistance. Note that the effective thermal resistance does not take into account any heat transfer between the pipe component and the transition zones through which the pipe passes.

Testing

Preliminary testing of the model has consisted of simulating TDDs for specific cases where the results are well-known. These cases are not meant to take the place of a detailed validation against experimental data or ray tracing simulations, but rather to serve as a check that the results are reasonable. The primary concern is to ensure an energy balance and eliminate programming errors.

The fundamental new feature of TDDs in both daylighting and heat balance models is the algorithm for calculating the beam transmittance of the TDD pipe component. To test the algorithm, interpolated values from EnergyPlus were calculated over a range of aspect ratios and reflectivities for beam radiation at an incident angle of 30 degrees. In the graph below, the EnergyPlus values are compared to the results of ray tracing simulations performed at the Florida Solar Energy Center for the TDD pipe geometry (McCluney 2003).

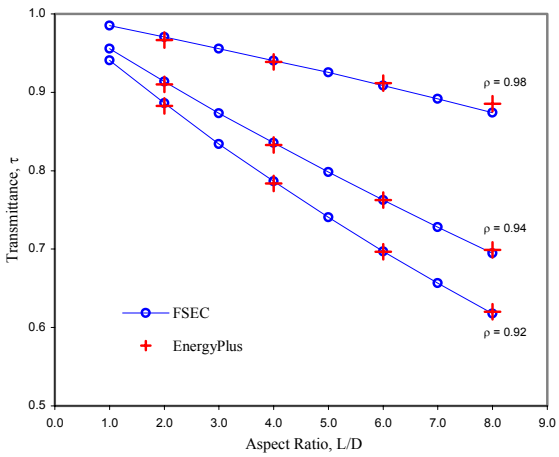

Figure 5. Pipe transmittance comparison.

As shown in Figure 5, the results compare very well. Unfortunately, ray tracing results for incident angles other than 30 degrees were not available for comparison.

The remaining test cases use a side-by-side simulation of two zones: one with a TDD and the other with an equivalent window or heat transfer surface. Other than the TDD or window, the zones have identical geometry and construction and should give the same simulation results. The zones are separated by enough distance in the simulation such that neither zone can shade the other at any time. For daylighting tests, the illuminance map feature in EnergyPlus was used to report a grid of illuminance levels throughout both zones. For heat balance tests, i.e. solar and conductive/convective gains, the total heating and cooling loads of both zones were reported.

A basic daylighting test case was performed to test the receiver-transmitter effect between dome and diffuser and the diffusing characteristic of the diffuser component. The TDD zone consisted of a TDD passing through an attic zone with a flat roof. The TDD received daylight at the north end of the roof and

transmitted daylight above the south end of the zone. The reference zone consisted of a window (i.e. skylight) with a diffusing shade on a flat roof with no attic above the south end of the zone. The TDD diffuser and window were identical in size and position relative to the zone. Since the TDD pipe obviously changes the overall transmittance of the receiver-transmitter combination, the TDD transmittance was temporarily modified in the code to match the transmittance of the reference window with a diffusing shade. The final test case simulation showed the illuminance map to be identical for both zones. The TDD daylighting model, therefore, is successfully receiving daylight at the dome surface and transmitting it as diffuse illumination at the diffuser surface.

To test the TDD heat balance model, solar gains and conductive/convective gains were examined separately. For the solar gains test case, efforts were made to minimize the effects of conductive/convective heat transfer. Both TDD and reference window were set to be highly insulated. The effective thermal resistance of the TDD was set very high and the conductivity of the window material was set near zero. To eliminate radiation heat transfer, the TDD dome, TDD diffuser, and reference window surface were set to have near zero emittance and absorptance. The TDD zone consisted of a TDD passing through an attic zone with a flat roof. The reference zone consisted of a window on a flat roof with no attic. Since the small area of a typical TDD surface makes its thermal impact difficult to detect in a zone heat balance, the areas of the TDD surface and window surface were enlarged to nearly the size of the zone roof in order to exaggerate any discrepancies. Again, as for the daylighting test case, the TDD transmittance was modified to match the reference window. The final test case simulation showed the total heating and cooling loads to be identical for both zones under two different design day conditions. This indicates that the TDD model is correctly adding solar gains to the zone heat balance.

Finally, to test the conductive/convective gains in isolation, a simulation was performed under no solar conditions by setting the sky clearness factor to zero. The TDD zone consisted of a TDD passing through an attic with a flat roof. However, the height of the attic zone was reduced to nearly zero in order for the TDD dome surface and reference surface to be at the same height, which affects the calculation of exterior convection coefficients. The reference zone consisted of a special R-value-only heat transfer surface in place of the reference window on a flat roof. The R-value of the reference surface was matched to the effective thermal resistance of the TDD. Enlarged surface areas where again used for both TDD and reference surfaces. The final test case simulation showed the total heating and cooling loads to be identical for both zones under two different design day conditions. This indicates that the TDD model is also correctly adding conductive/convective gains to the zone heat balance.

DAYLIGHTING SHELVES

Daylighting shelves, or simply light shelves, are constructed of up to three components: a window, an inside shelf, and an outside shelf. The inside shelf acts to reflect all transmitted light from the upper window onto the ceiling of the zone as diffuse light. The outside shelf changes the amount of light incident on the window. All light reflected from the outside shelf that enters the window also goes onto the zone ceiling. The inside shelf and outside shelf are both optional. However, if neither shelf is specified in the input file, the daylighting shelf object has no effect on the simulation.

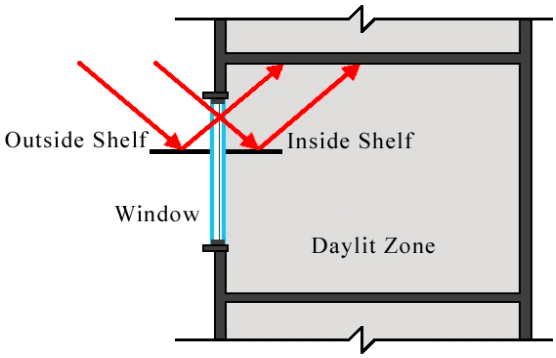

Figure 6. Daylighting shelf diagram.

The window is divided into two window surfaces: an upper window and a lower window. The upper window interacts with the daylighting shelf but the lower window does not, except to receive shading from the outside shelf. Daylighting shelves are simulated separately for daylighting and the zone heat balance. The general model is similar in both cases, but the details vary.

Inside shelf daylighting

In the split-flux method, daylight is "split" into upward-going and downward-going flux. Beam radiation is always considered to be downward-going. A diffusing shade on a vertical window, however, will equally divide the flux into upward-going and downward-going components.

The inside shelf is modeled in the daylighting simulation by converting all light transmitted by the

upper window into diffuse upward-going flux. It is assumed that no beam or downward-going flux can pass the end of the shelf regardless of the position or orientation of the shelf. Daylight transmitted by the lower window is not affected by the inside shelf.

Inside shelf heat balance

In the heat balance simulation the inside shelf is defined as an interzone heat transfer surface, i.e. partition. Since it does not have an external boundary condition, it is essentially equivalent to internal mass. Because the shelf surface has two sides that participate in the zone heat balance, the surface area is doubled by the program during initialization. Like regular internal mass in EnergyPlus, the shelf surface is allowed to interact convectively and radiatively with the zone air and other zone surfaces.

The zone interior solar distribution is modified by the inside shelf. Regardless of the solar distribution algorithm selected in the input file, all beam solar radiation transmitted by the upper window is incident on one side (half the doubled surface area) of the shelf surface. The beam radiation that is not absorbed by the shelf is reflected throughout the zone as diffuse shortwave radiation. The treatment of sky and ground radiation is unchanged; both are added directly to the zone diffuse shortwave. The beam, sky, and ground radiation transmitted by the lower window is not affected by the inside shelf.

Outside shelf daylighting

In the daylighting model the luminous flux transmitted by the upper window is determined by integrating over the sky and ground and summing the luminance contribution of each sky or ground element. The luminance of any intervening exterior or interior surfaces is assumed to be zero. Defined as a shading surface, the effect of the outside shelf during the integration is to block part of the view of the ground, thereby reducing the window transmitted flux due to diffuse ground luminance. After the integration is complete, the shelf model calculates the amount of diffuse light that is reflected through the window by the outside shelf and adds it as a lump sum to the upward-going flux transmitted by the window.

The amount of reflected light incident on the upper window due to the outside shelf is determined using a view factor from window to shelf. The program automatically calculates an exact view factor for adjacent perpendicular rectangles based on the dimensions of the window and shelf. If the window and shelf have a different geometry, the user can optionally specify their own view factor in the input object.

Outside shelf heat balance

The heat balance simulation does not do a sky and ground integration. View factors to sky and ground are used instead. Similar to the daylighting calculation, the view factor from window to shelf is also used here to determine the incident reflected solar radiation due to the shelf. The total incident radiation on the upper window is the sum of the beam, sky, ground reflected, and shelf reflected radiation. With the incident radiation determined, the remainder of the window heat balance is calculated normally.

No other thermal effects are considered for the outside shelf. There is assumed to be no conduction between the outside shelf and inside shelf, i.e. no heat fin effects.

Testing

Preliminary testing of the daylighting shelf model was similar to the side-by-side simulation test cases for TDDs. A shelf zone and an equivalent reference zone are simulated and illuminance map and total heating and cooling load results are compared. Inside and outside shelves are tested separately. Only the upper window is defined in the test cases; the lower window is not affected by the daylighting shelf and does not require a test.

The objective of the daylighting test case was to verify that the inside shelf yields diffuse upward-going illumination. The shelf zone consisted of an inside shelf and an upper window in a south facing wall. The reference zone consisted of an upper window with a diffusing shade in a south facing wall. The code was temporarily modified to direct all of the diffuse transmitted daylight from the shaded window upward to match the effect of the inside shelf. The final test case simulation showed the illuminance map to be identical for both zones. The shelf daylighting model correctly converts all daylight to diffuse upward-going flux.

To test both the daylighting and heat balance effects of the outside shelf, the shelf zone consisted of an outside shelf and an upper window in a south facing wall. Adjusting the user-specified view factor from the upper window to the outside shelf to be 0.5, the window viewed the shelf like an artificial ground, stretching infinitely to the horizon. The reference zone consisted of an upper window with a diffusing shade in a south wall. The code modification described above to convert all light to upward-going flux was also used in this case. The ground reflectance was specified in the input file to match the reflectance of the shelf so that both zones should see an expanse to the horizon with the same reflectivity. The final test case simulation showed the illuminance map and total heating and cooling loads to

be identical for both zones. The shelf model is correctly adding illuminance and solar gains due to reflection off of the outside shelf.

CONCLUSION

The new TDD and daylighting shelf models add advanced daylighting simulation capabilities to EnergyPlus that are not available in other whole-building energy analysis programs. The models simulate both daylighting and zone heat balance effects, including solar gains and conductive/convective heat transfer.

Preliminary testing indicate that the models are expected to yield reasonable results. A more detailed validation should be undertaken to further verify the accuracy of the daylighting models by comparing EnergyPlus results to experimental data or ray tracing simulations from other daylighting programs.

Many of the simplifying assumptions described for both TDDs and daylighting shelves leave room for future development. In particular, a more comprehensive thermal model of the conductive/convective heat transfer for TDDs is needed to replace the effective thermal resistance approximation. Unfortunately, the thermal behavior of TDDs is not yet well understood. A new model must await additional experimental research results.

ACKNOWLEDGMENT

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News from Affiliates

IBPSA-Australasia

Veronica Soebarto, University of Adelaide

Full contact information for IBPSA-Australasia is on page 5

IBPSA Australasia is organising a conference (with fully refereed papers) in conjunction with the Architectural Science Association ANZAScA (formerly the Australian and New Zealand Architectural Science Association), to be held at the School of Architecture, University of Tasmania, on 10 - 12 November 2004. For more information,visit **www.arch.utas.edu.au/anzasca/**.

IBPSA-Canada

This last June, IBPSA-Canada (**www.IBPSA.ca**) held its biennial conference in Vancouver, British Columbia. The Canadian conference on building energy simulation was hosted by the British Columbia Institute of Technology at their downtown Vancouver campus. EnerSys Analytics Inc. organized the 3-day event and obtained support from the following organizations:

- Natural Resources Canada, CANMET Energy Technology Centre
- United States Department of Energy, Energy Efficiency and Renewable Energy
- British Columbia Institute of Technology, School of Construction and the Environment
- BC Hydro
- British Columbia Buildings Corporation
- Canada Green Building Council

Full contact information for IBPSA-Canada is on page 5

eSim 2004 received nearly 80 registrations from government labs, universities, and private industry. Most delegates were from Canada with the remainder coming from Europe, the USA, Japan, New Zealand and the Middle East.

The event kicked off with pre-conference workshops on Hot3000/ESP-r and EnergyPlus. The three-day bilingual (English and French) conference featured 32 full-length peer-reviewed technical papers and a friendly competition among seven building simulation tools. Invited speakers gave presentations on local, national and global perspectives on the application of simulation, in addition to past and future trends in building simulation.

Hard copies of the conference proceedings (nearly 300 pages) were distributed to delegates while PDF versions of all the papers are freely available from the eSim website (**www.eSim.ca**). This web site also contains the final conference programme, photographs, and will contain the results of a post-conference survey.

IBPSA-France

Gilles Lefebvre, Université Paris-XII Val de Marne

Full contact information for IBPSA-France is on page 5

The IBPSA France biennial conference took place in Toulouse (in south-west France) on October 7 and 8th. 23 oral papers were presented to 42 participants. For the first time, the conference was organized in the framework of the AICVF annual congress (HVAC French association, see **www.aicvf.org**).

IBPSA France is now a technical group of AICVF and is led by a new board:

President : E. Wurtz (La Rochelle University)
Treasurer : G. Kraus (INSA Lyon)
Relation with professionnals: Franck Lainault (GDF)
Link with the French professional magazine CVC : Hervé Castet (EDF)

Link with research labs : A. Trombe (INSA Toulouse)
IBPSA France conference organization: Gilles Lefebvre (Paris XII University)
Communication : François Garde (La Réunion University)
Web site : Laurent Mora (LEPTAB)
Link with AICVF : Dominique Marchio (CENERG - ENSMP)

Further information about IBPSA-France and its activities can be found on their web site at: **www.ibpsa-france.net**.

IBPSA-Netherlands+Flanders

Jan Hensen, Center for Buildings and Systems TNO - TU/e, Netherlands

Full contact information for IBPSA-NVL is on page 6

IBPSA-NVL is organizing a one day workshop for engineers, consultants and architects on 21 October 2004, to take place in Antwerp, Belgium. For further details, see page 11.

In line with the aims described in the previous edition of IBPSA News, this event is being organised in collaboration with the Royal Flemish Engineering Association (KVIV).

IBPSA-Scotland

Lori McElroy, The Lighthouse Trust, Glasgow

Full contact information for IBPSA-Scotland is on page 6

IBPSA-Scotland is organising two two-day courses on ESP-r. Both courses will be presented by Jon Hand; one is an introductory course, on 1 and 2 November, and the second is for Advanced Users and will run on 8 and 9 November. For further details, see pages 12 and 13.

IBPSA-USA

Chip Barnaby, Wrightsoft Corporation, USA

Here is the affiliate report from IBPSA-USA, together with a report of the SimBuild conference 2004 organized by IBPSA-USA at Boulder, Colorado, this August.

1. Membership. IBPSA-USA's current membership is about 180.
2. Legal status. IBPSA-USA is legally incorporated, with paperwork filed in the State of Virginia and current through 2004.

3. Financing. IBPSA-USA currently charges no membership fees. It relies instead on its share of the profit from the international meetings. It also charges a nominal fee for attendance at its semi-annual meetings, with the balance drawn from its reserves.

4. Activities. The primary on-going activity of IBPSA-USA to date has been its semi-annual meeting, held in conjunction with ASHRAE national meetings. The IBPSA winter meetings include demonstrations of software from vendors and others. The summer meetings allow time for IBPSA-USA members and guests to discuss topics of interest. All meetings include dinner and an after-dinner speaker. Attendance at recent meetings was 50 at Anaheim, CA (January, 2004) and 22 at Nashville, TN (June, 2004). Brief summaries of IBPSA-USA activities are provided to IBPSA for inclusion in ibpsaNews.

   In August, 2004, IBPSA-USA sponsored the SimBuild 2004 conference at the University of Colorado. A separate conference report is included following this article.

   IBPSA-USA also recently contracted for development of PowerPoint presentations on the subject of simulation. This work was completed in early 2004. The slides are available to others in the IBPSA community, contact Phil Haves (see below).

   Current activity centers around efforts to work jointly with the United States Green Building Council (USGBC). USGBC promulgates the Leadership in Energy and Environmental Design (LEED) rating system that often requires simulation for project evaluation. There appears to be a natural fit for IBPSA-USA to offer simulation training and/or technical support to LEED practitioners.

5. The URL for IBPSA-USA is **www.ibpsa.us**.

6. Contacts for IBPSA-USA are:

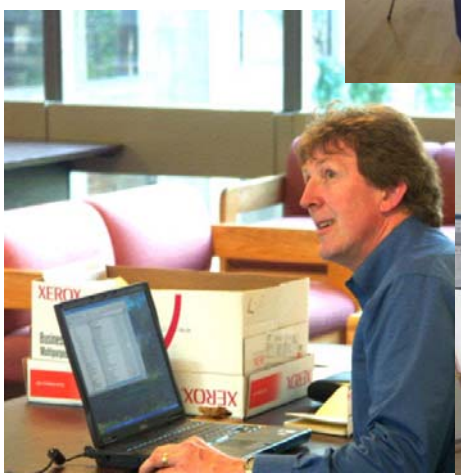
Name	*Office*	*Affiliation*	*eMail*
Phil Haves	President	Lawrence Berkeley National Laboratory	**phaves@lbl.gov**
Mike Brandemuehl	Vice-President	University of Colorado	**michael.brandemuehl@colorado.edu**
Peter Ellis	Secretary	National Renewable Energy Laboratory	**peter_ellis@nrel.gov**
Chip Barnaby	Treasurer / Affiliate Rep	Wrightsoft	**barnaby@wrightsoft.com**
Marlin Addison	Board Member	Arizona State University	**marlin.addison@doe2.com**
Tim McDowell	Board Member	Thermal Energy System Specialists	**mcdowell@tess-inc.com**
Curt Pedersen	Ex-officio past president	University of Illinois	**cpederse@uiuc.edu**
Les Norford	Ex-officio past president	Massachusetts Institute of Technology	**lnorford@mit.edu**

Report on SimBuild 2004

Phil Haves, Chip Barnaby, Les Norford, Curt Pedersen, Mike Brandemuehl, Jeff Spitler

IBPSA-USA held its first national conference August 4-6, 2004, on the Boulder campus of the University of Colorado, attracting 123 total attendees, including 15 invited speakers. There were 48 peer-reviewed technical papers, 14 student posters and 11 non-refereed presentations made during the first two days, covering a wide variety of subjects, including airflow modeling, heat and mass flow, lighting, simulation tools, warm-climate design, optimization, measurement and test, and fault detection. The third day focused on the practice of designing sustainable buildings and featured case studies and hands-on simulation workshops. Plenary addresses were given by Michael Holtz, founding principal and president of Architectural Energy Corporation, David Claridge, professor of mechanical engineering at Texas A&M University, and Daniel Nall, senior vice-president of Flack + Kurtz Consulting Engineers. Graduate students who participated in the conference organized their own poster session.

Some of the graduate students from Oklahoma State University

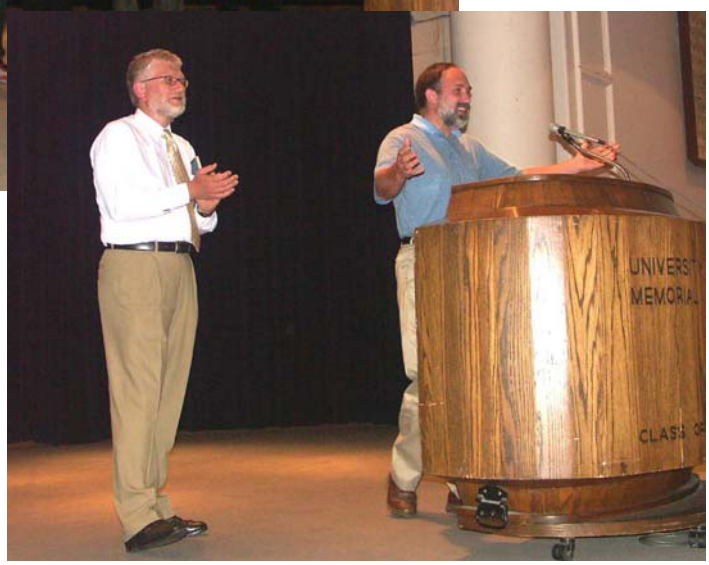


Mike Brandemuehl of the University of Colorado, Conference Chair

Student poster projects were available for review throughout the conference

Outstanding work was recognized at a conference banquet. Dan Nall was honored with an outstanding practitioner award, Fred Winklemann, recently retired head of the simulation group at Lawrence Berkeley National Laboratory, received a lifetime achievement award. The best-paper award went to Peter Ellis of the National Renewable Energy Laboratory, and Richard Strand and Kurt Baumgartner of the University of Illinois, authors of "Simulation of Tubular Daylighting Devices and Daylighting Shelves in EnergyPlus." The award for best paper with a student as lead author went to Kyoung-Ho Lee and James Braun of Purdue University, authors of "Development and Application of an Inverse Building Model for Demand Response in Small Commercial Buildings." Both of the award-winning papers are published within this issue of IBPSA News. Mike Brandemuehl, professor of architectural engineering at the University of Colorado and the conference chair, was recognized for organizing a very successful meeting.

Dan Fisher presents awards to deserving students.



During the banquet, IBPSA-USA President Phil Haves shares the platform with Dan Fisher to invite students to receive their awards.

A CD of the conference proceedings is being assembled, including papers, presentations, questions, comments on the papers and authors' responses. Details about CD availability will be posted on **www.ibpsa.us**. Selected papers will also be included in special issues of *Building and Environment* and *Energy in Buildings*.

The principal sponsor of the conference was the US Department of Energy; the other sponsors were the Colorado Governor's Office of Energy Management and Conservation, ASHRAE, the AIA Colorado North chapter, the Colorado chapter of the US Green Buildings Council, Renewable Choice Energy, Estes McClure & Associates and Flack + Kurtz.

The conference was preceded by a well-attended two-day EnergyPlus workshop. Attendees had opportunity before and afterward to enjoy the beautiful summer weather and spectacular scenery of the Front Range of the Rocky Mountains.. Additional SimBuild2004 photos are posted at: **www.mae.okstate.edu/Faculty/spitler/photos/Boulder/**

The next SimBuild conference will be held in the summer of 2006, at a location as yet to be determined.

An impromptu reunion of Curt Pedersen and his distinguished graduate students arranged in order of graduation date (oldest first). Seated on both sides of Curt are former graduate students Doug Hittle (left) and Jeff Spitler (right). Standing left to right are former graduate students Rich Liesen, Dan Fisher, Rick Strand, Peter Ellis and current student Rahul Chillar.

No one's sure if Jeff Spitler (a) has forgotten something really important, (b) is overwhelmed by a spectacular poster presentation, or (c) is killing a fly.

IBPSA Membership Information Sheet and Application:

The following information is for membership and orders for IBPSA proceedings. You may order directly from the forms below, or you can request by e-mail a hard copy of the request sheet. Conference proceedings are not part of the membership fee, though they are significantly discounted for members. We are not able to process credit card orders at this time.

IBPSA is comprised of International Regional Affiliates. If you are located within one of the affiliated regions listed on the IBPSA website at http://www.ibpsa.org/regional.htm , please contact the appropriate representative regarding membership in IBPSA. If you are not within any of the affiliated regions, you may join IBPSA central by using the attached form.

Members of the affiliate organization are automatically considered full members of IBPSA-Central. If you are joining IBPSA, please inquire as to the affiliate organization in your region. Additional affiliates may be forming soon.

The IBPSA Newsletter is published twice annually. It contains instructions on how to create an IBPSA affiliate in your region (start-up grants are available from IBPSA), as well as announcements for Building Simulation Conferences. All members of IBPSA's Regional Affiliations receive the newsletter.

TO LEARN MORE ABOUT IBPSA in general, look at the World Wide Web page at "http://www.ibpsa.org"

Thank you for your interest in IBPSA. Join to get more news from the Newsletter.

Jeff Haberl, IBPSA Publications
jhaberl@esl.tamu.edu

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IBPSA MEMBERSHIP INFORMATION

"The professional association devoted to improve the built environment through computer simulation and analysis"

Mission

The International Building Performance Simulation Association (IBPSA) was founded to advance and promote the science of building performance simulation in order to improve the design, construction, operation and maintenance of new and existing buildings worldwide.

Goals:

Along with building designers, owners, operators and developers,

* Identify problems with the built environment that may be solved by improved simulation tools and techniques
* Identify the performance characteristics of buildings on which simulation should be focused
* Identify building performance simulation R & D needs and transfer new developments to the user
* Promote standardization of the building simulation industry
* Inform and educate its members and the public regarding the value and the state-of-the-art of building performance simulation.

Activities:

* Biannual International Building Simulation Conference.
* Resource publication on simulation tools (under development)
* Newsletter announcing upcoming events and software tools.
* Sponsorship of regional workshops and seminars on simulation.

MEMBERSHIP APPLICATION …….. For IBPSA Central……...

Membership Classification Desired (check one): Effective date: Sept. through Aug.

__ Sustaining member.. US$ 500/year
An individual, company, or institution in related practice.

__ Member.. US$ 75/year
A graduate from a college or university, or a registered professional engineer or architect.

__ Student Member.. US$ 25/year
An individual who is a full-time student (Include copy of current enrollment i.d.).

Amount Enclosed: US$ _____

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IBPSA PUBLICATIONS ***Effective March 2003***
www.ibpsa.org

Proceedings of IBPSA's Building Simulation conferences as long as stocks last. Prices follow:

Item	#Papers/pp	Price (US$)	Conf. Location	Dates
BS'85	59 / 416	$40	Seattle, WA (USA)	12 Aug. '85
BS'89	54 / 300	$40	Vancouver, Canada	23-24 June '89
BS'91	85 / 675	$40	Nice, France	20-22 Aug. '91
BS'93	71 / 570	$40	Adelaide, Aus.	16-18 Aug. '93
BS'95	81 / 717	$40	Madison, WI (USA)	14-16 Aug. '95
BS'97	119 / 976	$25 (CD-ROM)	Prague, Czech Republic	08-10 Sep. '97
BS'99	183 / 1470	$50 (3 vol.)	Kyoto, Japan	13-15 Sep. '99
BS'99	183 / 1470	$35 (CD-ROM)	Kyoto, Japan	13-15 Sep. '99
BS'85 – BS'95		$40 (CD-ROM)	5 conferences	'85 '89 '91 '93 '95
BS'01	174 /1404	$40 (CD-ROM)	Rio de Janeiro, Brazil	13-15 Aug. '01
BS'01	174 /1404	$60 (2 vol.)	Rio de Janeiro, Brazil	13-15 Aug. '01
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BS'85 – BS'03		$100 (CD-ROM)	9 conferences (> 1000 papers)	'85 '89 '91 '93 '95 '97 '99 '01 '03

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International Building Performance Simulation Association

The regionalization of IBPSA

To whom it may concern

Dear Colleague:

You may be aware of the International Building Performance Simulation Association (IBPSA) which has existed since the late 80s to represent and promote the application of computer-based design and management techniques in the construction industry worldwide.

To further the goals of the organization, we have embarked on a regional development program by which we plan to stimulate the establishment of regionally based, autonomous organizations who are affiliated to IBPSA. In this way we hope to achieve the correct balance between the servicing of practitioner needs at the local level and the provision of information flow at the international level.

I am writing to you to ask whether you might be interested in exploring further the possibility of establishing an IBPSA affiliated organization in your part of the world. To help you reach a decision, there follows details on the regionalization proposal. A copy of IBPSA's Strategy Plan, IBPSA's By-Laws and more general information about IBPSA's activities, biannual Building Simulation conferences, etc. is available from its web site at: http://www.ibpsa.org/

IBPSA very much hopes that you will see merit in this idea and is looking forward to receiving your reply in the near future.

Yours sincerely

The IBPSA President

IBPSA Regionalization Guidelines

IBPSA's Mission
The International Building Performance Simulation Association (IBPSA) is a non-profit making organization that was first incorporated in January 1987. The Association's principal mission is to promote and advance the practice of building performance simulation in order to improve the energy and environmental performance of new and existing buildings worldwide.

IBPSA seeks to achieve its goals through the establishment of a range of products and services aimed at informing and equipping those who are involved in the construction industry and who seek to utilize computer-based tools to good effect. To this end, the **IBPSA Strategic Plan** identifies nine specific areas that encompass the organization's activities. These are:

1. ***Strategic Alliances*** with professional organization such as the engineering and architectural societies. The intention is to engender a better understanding of the profession's requirements and the technology's potential.

2. ***International Conference Series*** to periodically collate and preserve those developments that comprise the current state-of-the-art.

3. ***Technical Development Program*** aimed at influencing the direction the technology of building simulation might take at any given point in time.

4. ***Educational Initiatives*** concerned with the teaching of building simulation in the higher education institutions and in the context of continuing professional development.

5. ***Harmonization Activities*** in an attempt to regularize the application of the different modeling systems through the definition of standard methods for performance assessment and the provision of standard support data.

6. ***Member Recruitment*** aimed at extending the IBPSA products and services to those practitioners who can most benefit from the new technology.

7. ***Products and Services*** devised in response to the profession's evolving needs.

8. ***Technology Transfer*** concerned with the delivery of training in all aspects of computer-based performance assessment at all stages of the building life cycle.

9. ***Regional Development*** to subject the foregoing activities to appropriate regional influences and enable their effective delivery.

This document addresses the last area concerned with regional development in order to more effectively address local needs and create a mechanism for an international exchange of know-how and best practice.

Rationale
IBPSA has achieved significant success at the international level - largely through its biannual conference program (Vancouver '89, Nice '91, Adelaide '93, Wisconsin '95 and Prague '97) and worldwide electronic mailing facility. IBPSA has also recognized the difficulties surrounding the development of products and services that are appropriate to the day-to-day needs of its members.

The underlying causes of these difficulties are twofold. Firstly, the geographical spread of IBPSA members is wide and gives rise to a requirement to cover disparate work practices, technologies and professional needs. Secondly, IBPSA's organizational structure is such that the coordination of activities at the local (regional) level is problematic. At the same time like-minded, but regional, organizations are making significant progress at the local level through their seminar, workshop, publications, training and software development activities.

If the construction industry were to be well supported in its attempts to harness effectively the emerging IT and simulation technologies then the establishment of regionally based support organizations was essential. Equally essential was the creation of a structure by which these organizations could affiliate in order to disseminate their know-how and promote their local best practice. Only in this way could the benefits of the new technology be understood and future standardization enabled. It was with the view of a network of autonomous regional organizations that IBPSA has turned to regionalization and is encouraging existing or newly formed groups to become IBPSA affiliates.

Structure and Operation

Under the existing structure, IBPSA affiliates are financially and administratively independent. In practice, this means that they raise and deploy their funds as long as these funds are under the control of elected officers and are used in pursuit of aims and objectives that are consistent with those of IBPSA. IBPSA-Central concentrates its resources on issues such as inter-region communication, international conferences and product standardization. In this way IBPSA complements and empowers the regional affiliates in their attempts to inform and support their members in the context of local design issues and concerns. The entire IBPSA network is represented by a 15-member Board comprised of an executive and regionally elected officers.

The following guidelines have been devised to assist with the establishment and operation of an IBPSA regional affiliate.

1. Organizers of a new regional affiliate should prepare a brief proposal for the IBPSA Board of Directors. This should outline the proposed name, geographic territory, organizational structure and goals and objectives (if different from those included in the IBPSA charter statement). Affiliation depends only on the organization having a purpose and mission consistent with those of IBPSA. The Affiliate and IBPSA then enters into a specific agreement by defining their working relationship based on regional considerations prevalent at the time.
2. Regional affiliates may be named **"IBPSA <region>"** or they may use any other appropriate name. Their letterhead and other publicity material should indicate that they are "an affiliate of IBPSA".
3. For regions with limited financial resources, IBPSA can provide a limited amount of **matching start-up funds** (see below) to aid the initial set-up of the affiliated organization. A case for support should be submitted to the IBPSA Secretary for consideration by the Board. (See attached proposal guidelines.)
4. The financial structure of a regional affiliate is independent from IBPSA. This means that affiliates will retain all member dues or other funds raised by their activities.
5. IBPSA will provide affiliates with a list of operational guidelines (see attached by-laws), contact information for persons available to assist the local organizer and electronic images of the IBPSA logo.
6. The regional affiliate will provide membership data to IBPSA for use in mailing IBPSA materials.

7. Members of the regional affiliates will automatically be full members of IBPSA. Any given individual or organization will pay dues directly to IBPSA only if there is no regional affiliate operating in their area.
8. IBPSA will make newsletters and other IBPSA materials available to all members of the regional affiliates either in printed form or in downloadable electronic format from the IBPSA web page. This will be at no cost or at a nominal cost depending on the circumstances. Other services may be provided by IBPSA to the regional affiliates for a fee.

Start-up Proposal Guidelines:
It has been the IBPSA Board's policy to grant start-up funds to regions that are in need of matching funds to get the organization officially registered and/or to purchase initial office support equipment. The proposal should be submitted to the IBPSA board and should contain the following elements:

1. Name of Affiliate: i.e., **IBPSA-<region>.**
2. Geographic territory covered.
3. Organizational structure – The IBPSA Charter is founded on a set of board- and member-approved by-laws (see attached). Each Affiliate's organizational structure is therefore expected to adhere to the same or similar principles of operation.
4. Officers -- i.e., Specify the officers that will be constitute the board (e.g., Chairperson, secretary, treasurer, etc. – see IBPSA by-laws)
5. List of goals and objectives – Must be consistent with the mission statement and objectives of the IBPSA Charter.
6. Minutes of the first organizational meeting, indicating organizational business transacted.
7. List of initial members and their affiliations (can be those attending the first meeting).
8. Proposed activities of the affiliate.
9. Proposed amount of annual membership dues.
10. Breakdown of costs associated with set-up of the Affiliate organization.
11. Amount of matching funds provided by the Affiliate.
12. Amount of the requested support from IBPSA. *

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* Please note that IBPSA's policy is to provide start-up funds with the expectation that the Affiliate will return the granted amount once the region reaches financial stability. The Affiliate is therefore asked to return the funds on a voluntary basis, so other regions can be assisted in the same fashion.

Becoming an IBPSA Affiliated Organization

If you would like to become an affiliated organization then please write to the IBPSA Secretary at the address given at http://www.ibpsa.org . Alternatively, you may wish to discuss the matter further with one of the IBPSA office bearers or a representative of one of the existing affiliates whose addresses can also be found at http://www.ibpsa.org.