



# ENERGY AND BUILDINGS

Vol. 36, No. 8

August 2004

An international journal devoted to investigations of energy use and efficiency in buildings

## CONTENTS

Special issue on 'Performance simulation for better building design' . . . . .	735
<i>J. Hensen and G. Augenbroe</i>	
An interoperability benchmark for design analysis integration . . . . .	737
G. Augenbroe, P. de Wilde, H.J. Moon and A. Malkawi	
Providing computational support for the selection of energy saving building components . . . . .	749
P. de Wilde and M. van der Voorden	
Using simulation to formulate domestic sector upgrading strategies for Scotland . . . . .	759
J.A. Clarke, C.M. Johnstone, I. Kondratenko, M. Lever, L.B. McElroy, L. Prazeres, P.A. Strachan, F. McKenzie and G. Peart	
Measurement of thermal environment in Kyoto city and its prediction by CFD simulation . . . . .	771
K. Takahashi, H. Yoshida, Y. Tanaka, N. Aoiake and F. Wang	
An approach for coupled simulation of building thermal effects and urban climatology . . . . .	781
J. Tanimoto, A. Hagiwara and P. Chintakla	
Numerical modelling and thermo: simulation of PCM-gypsum composites with ESP+ . . . . .	795
D. Heim and J.A. Clarke	
Development of a thermal energy storage model for EnergyPlus . . . . .	807
P. Ihm, M. Krart and G.P. Henze	
Spatio-temporal dynamics of solar shading for a parametrically defined roof system . . . . .	815
J. Mardaljevic	
The inlet temperature as a boundary condition for multiple-skin facade modelling . . . . .	825
D. Saelens, S. Roels and H. Hens	
The role of simulation in support of Internet-based energy services . . . . .	837
J.A. Clarke, S. Conner, G. Fujii, V. Ceros, G. Johansson, C.M. Johnstone, S. Karassou, J. Kim, M. Santamouris and P.A. Strachan	
The use of simplified weather data to estimate thermal loads of non-residential buildings . . . . .	847
F.S. Westphal and R. Lamberts	
Analytical and comparative testing of EnergyPlus using IEA HVAC BESTEST E100-E200 test suite . . . . .	855
R.H. Heminger, M.J. White and D.B. Crawley	

**Special Issue:  
Performance Simulation  
for Better Building Design**

**Guest Editors:  
Jan Hensen  
Godfried Augenbroe**



This journal is part of **ContentsDirect**, the *free* alerting service which sends tables of contents by e-mail for Elsevier books and journals. You can register for **ContentsDirect** online at: <http://contentsdirect.elsevier.com>



0378-7788(200408)36:8:1-0

06009

ELSEVIER

**Editor  
Branislav Todorović,  
University of Belgrade,  
Yugoslavia**

## ENERGY AND BUILDINGS

### Guide for Authors

the subject matter clearly under such headings as *Introduction, Experimental, Results, Discussion*, etc. All contributions should include a concise *Informative Abstract*, and a maximum of six *Keywords*. *References* should be numbered consecutively throughout the text and should be collected together in a reference list (headed *References*) at the end of the paper. All equations, tables and legends should be numbered consecutively and separately throughout the paper. All papers should also include the following on the title page, full postal and email address; fax no. *illustrations*. Line drawings should be in a form suitable for reproduction. Illustrations can be printed in colour when they are judged by the Editor to be essential to the presentation. The publisher and the author will each bear part of the extra costs involved. Further information concerning colour illustrations and the costs to the author can be obtained from the publisher.

**Submissions**  
Authors should submit their manuscripts to the Editor:  
**Branislav Todorović**  
Professor of Mechanical Engineering Faculty  
University of Belgrade  
27 Marfa 80  
11000 Belgrade  
Yugoslavia (Serbia)  
E-mail: todorob@eunet.yu

Contributions are accepted on the understanding that authors have obtained the necessary authority for publication. Submission of an article must be accompanied by a statement that the article is original and unpublished and is not being considered for publication elsewhere. Upon acceptance of an article by the Journal, the author(s) will be asked to transfer the copyright of the article to the publisher. This transfer will ensure the widest possible dissemination of information.

**Proofs**  
Authors will receive proofs which they are requested to correct and return as soon as possible. No new material may be inserted in the text at the time of proof-reading. A *Note added in proof* must be dated and the author must have requested and received the Editor's approval.

**Offprints**  
Twenty-five offprints of each paper will be supplied free of charge to the author(s). In addition, the author will receive a free copy of the issue in which the paper appears. Additional offprints may be ordered at prices shown on the offprint order form.

**Author enquiries**  
For enquiries relating to the submission of articles (including electronic submission where available) please visit Elsevier's Author Gateway at <http://authors.elsevier.com>. The Author Gateway also provides the facility to track accepted articles and set up e-mail alerts to inform you of when an article's status has changed, as well as detailed artwork guidelines, copyright information, frequently asked questions and more.

Contact details for questions arising after acceptance of an article, especially those relating to proofs, are provided after registration of an article for publication.

**There are no page charges.**

**Manuscript Preparation**  
Papers will be published in English. Upon request, Elsevier Japan will provide authors with a list of people who can check and improve the English of their paper (before submission). Please contact our Tokyo office: Editorial Service, Elsevier, K.K., 4F Higashi-Azabu, 1-Chome Bldg, 1-9-15 Higashi-Azabu, Minato-ku, Tokyo 105-0044, Japan, Tel: (+81) (3) 5561 5037; Fax: (+81) (3) 5561 5047; E-mail: [jp.info@elsevier.com](mailto:jp.info@elsevier.com). Some flexibility of presentation will be allowed, but authors are urged to arrange

**Language** Papers will be published in English. Upon request, Elsevier Japan will provide authors with a list of people who can check and improve the English of their paper (before submission). Please contact our Tokyo office: Editorial Service, Elsevier, K.K., 4F Higashi-Azabu, 1-Chome Bldg, 1-9-15 Higashi-Azabu, Minato-ku, Tokyo 105-0044, Japan, Tel: (+81) (3) 5561 5037; Fax: (+81) (3) 5561 5047; E-mail: [jp.info@elsevier.com](mailto:jp.info@elsevier.com). Some flexibility of presentation will be allowed, but authors are urged to arrange

**Disk Preparation**  
The final text should be submitted on a 3.5" disk (in addition to the hard copies and original figures). Double density (DD) or high density (HD) disks formatted for IBM compatibles or Apple Macintosh are preferred. The files should be saved in the native format of the word processing program used. Most popular word processor file formats are acceptable, though we cannot guarantee the usability of all formats. The disk format, word-processor format, file name(s) and the title and authors of the article should be indicated on the disk. The content of the disk must correspond exactly to the hard copy version of the paper.

**Manuscript Preparation**  
Papers will be published in English. Upon request, Elsevier Japan will provide authors with a list of people who can check and improve the English of their paper (before submission). Please contact our Tokyo office: Editorial Service, Elsevier, K.K., 4F Higashi-Azabu, 1-Chome Bldg, 1-9-15 Higashi-Azabu, Minato-ku, Tokyo 105-0044, Japan, Tel: (+81) (3) 5561 5037; Fax: (+81) (3) 5561 5047; E-mail: [jp.info@elsevier.com](mailto:jp.info@elsevier.com). Some flexibility of presentation will be allowed, but authors are urged to arrange

**Language** Papers will be published in English. Upon request, Elsevier Japan will provide authors with a list of people who can check and improve the English of their paper (before submission). Please contact our Tokyo office: Editorial Service, Elsevier, K.K., 4F Higashi-Azabu, 1-Chome Bldg, 1-9-15 Higashi-Azabu, Minato-ku, Tokyo 105-0044, Japan, Tel: (+81) (3) 5561 5037; Fax: (+81) (3) 5561 5047; E-mail: [jp.info@elsevier.com](mailto:jp.info@elsevier.com). Some flexibility of presentation will be allowed, but authors are urged to arrange

**Disk Preparation**  
The final text should be submitted on a 3.5" disk (in addition to the hard copies and original figures). Double density (DD) or high density (HD) disks formatted for IBM compatibles or Apple Macintosh are preferred. The files should be saved in the native format of the word processing program used. Most popular word processor file formats are acceptable, though we cannot guarantee the usability of all formats. The disk format, word-processor format, file name(s) and the title and authors of the article should be indicated on the disk. The content of the disk must correspond exactly to the hard copy version of the paper.

## ENERGY AND BUILDINGS

An International Journal devoted to investigations of energy use and efficiency in buildings

**Editorial Board**  
F.N. Arumi (Austin, TX, USA)  
H.J. Cowan (Sydney, NSW, Australia)  
P.O. Fanger (Lyngby, Denmark)  
H. Faustst (Weierberg-Launsbach, Germany)  
B. Ghoni (Ramat Hasharon, Israel)  
S.R. Hastings (Wellisellen, Switzerland)  
K.-I. Kimura (Tokyo, Japan)  
A. Mahdavi (Vienna, Austria)  
P. OSullivan (London, UK)  
A.H. Rosenfeld (Berkeley, CA, USA)  
M.L. Savitz (Los Angeles, CA, USA)  
B.K. Saxena (Roorklee, UP, India)  
S. Selkowitz (Berkeley, CA, USA)  
S.-I. Tamano (Tokyo, Japan)  
H. Yoshino (Sendai, Japan)

you or from this journal's website (<http://www.elsevier.com/locate/enbuild>), further information is available on this journal and on Elsevier products through Elsevier's web-based journals and books information systems. Issues are sent by standard mail (surface within Europe, air where necessary) to subscribers in all countries. Priority rates are available upon request. Claims for missing issues should be made within six months of the date of dispatch.

**Orders, claims, and journal enquiries**  
please contact the Customer Service Department at the Regional Sales Office nearest you:

**Amsterdam**  
Elsevier  
Customer Service Department  
PO Box 211, 1000 AE Amsterdam  
The Netherlands  
phone: (+31) (20) 4853757  
fax: (+31) (20) 4853432  
e-mail: [nlinfo-4@elsevier.com](mailto:nlinfo-4@elsevier.com)

**Orlando**  
Elsevier  
Customer Service Department  
6277 Sea Harbor Drive, Orlando  
FL 32887-4900, USA  
phone: (+1) (877) 8397726  
(or (+1) (407) 345-4020  
[customers outside US])  
fax: (+1) (407) 3837354  
e-mail: [usjcs@elsevier.com](mailto:usjcs@elsevier.com)

**Tokyo**  
Elsevier  
Customer Service Department  
4F Higashi-Azabu  
1-Chome Bldg, 1-9-15 Higashi-Azabu  
Minato-ku, Tokyo 105-0044, Japan  
phone: (+81) (3) 5561 5037  
fax: (+81) (3) 5561 5047  
e-mail: [jp.info@elsevier.com](mailto:jp.info@elsevier.com)

[Note (Latin America): for orders, claims, and help desk information, please contact the Regional Sales Office in New York as listed above]

**Aims and Scope**  
*Energy and Buildings* is an international journal devoted to investigations of energy use and efficiency in buildings

**Types of Contributions**  
Original research papers - Reviews of specialized topics - Technical notes (max. 4 pages) - Research communications - Reviews of books and reports - Notices of meetings and conferences.

**Papers** with results based on simulations are welcome but those with clear links to laboratory or field measurements are preferred. These links may include calibration, benchmarking, or comparisons of results.

**Editorial Consultant**  
**Alan K. Meler**  
International Energy Agency/  
Energy Efficiency Division (IEA/EET)  
Paris, France

**Types of Contributions**  
Original research papers - Reviews of specialized topics - Technical notes (max. 4 pages) - Research communications - Reviews of books and reports - Notices of meetings and conferences.

**Papers** with results based on simulations are welcome but those with clear links to laboratory or field measurements are preferred. These links may include calibration, benchmarking, or comparisons of results.

**Editorial Board**  
F.N. Arumi (Austin, TX, USA)  
H.J. Cowan (Sydney, NSW, Australia)  
P.O. Fanger (Lyngby, Denmark)  
H. Faustst (Weierberg-Launsbach, Germany)  
B. Ghoni (Ramat Hasharon, Israel)  
S.R. Hastings (Wellisellen, Switzerland)  
K.-I. Kimura (Tokyo, Japan)  
A. Mahdavi (Vienna, Austria)  
P. OSullivan (London, UK)  
A.H. Rosenfeld (Berkeley, CA, USA)  
M.L. Savitz (Los Angeles, CA, USA)  
B.K. Saxena (Roorklee, UP, India)  
S. Selkowitz (Berkeley, CA, USA)  
S.-I. Tamano (Tokyo, Japan)  
H. Yoshino (Sendai, Japan)

**Types of Contributions**  
Original research papers - Reviews of specialized topics - Technical notes (max. 4 pages) - Research communications - Reviews of books and reports - Notices of meetings and conferences.

**Papers** with results based on simulations are welcome but those with clear links to laboratory or field measurements are preferred. These links may include calibration, benchmarking, or comparisons of results.

**Editorial Board**  
F.N. Arumi (Austin, TX, USA)  
H.J. Cowan (Sydney, NSW, Australia)  
P.O. Fanger (Lyngby, Denmark)  
H. Faustst (Weierberg-Launsbach, Germany)  
B. Ghoni (Ramat Hasharon, Israel)  
S.R. Hastings (Wellisellen, Switzerland)  
K.-I. Kimura (Tokyo, Japan)  
A. Mahdavi (Vienna, Austria)  
P. OSullivan (London, UK)  
A.H. Rosenfeld (Berkeley, CA, USA)  
M.L. Savitz (Los Angeles, CA, USA)  
B.K. Saxena (Roorklee, UP, India)  
S. Selkowitz (Berkeley, CA, USA)  
S.-I. Tamano (Tokyo, Japan)  
H. Yoshino (Sendai, Japan)

**Types of Contributions**  
Original research papers - Reviews of specialized topics - Technical notes (max. 4 pages) - Research communications - Reviews of books and reports - Notices of meetings and conferences.

**Papers** with results based on simulations are welcome but those with clear links to laboratory or field measurements are preferred. These links may include calibration, benchmarking, or comparisons of results.

**Editorial Board**  
F.N. Arumi (Austin, TX, USA)  
H.J. Cowan (Sydney, NSW, Australia)  
P.O. Fanger (Lyngby, Denmark)  
H. Faustst (Weierberg-Launsbach, Germany)  
B. Ghoni (Ramat Hasharon, Israel)  
S.R. Hastings (Wellisellen, Switzerland)  
K.-I. Kimura (Tokyo, Japan)  
A. Mahdavi (Vienna, Austria)  
P. OSullivan (London, UK)  
A.H. Rosenfeld (Berkeley, CA, USA)  
M.L. Savitz (Los Angeles, CA, USA)  
B.K. Saxena (Roorklee, UP, India)  
S. Selkowitz (Berkeley, CA, USA)  
S.-I. Tamano (Tokyo, Japan)  
H. Yoshino (Sendai, Japan)

**Types of Contributions**  
Original research papers - Reviews of specialized topics - Technical notes (max. 4 pages) - Research communications - Reviews of books and reports - Notices of meetings and conferences.

**Papers** with results based on simulations are welcome but those with clear links to laboratory or field measurements are preferred. These links may include calibration, benchmarking, or comparisons of results.

**Editorial Board**  
F.N. Arumi (Austin, TX, USA)  
H.J. Cowan (Sydney, NSW, Australia)  
P.O. Fanger (Lyngby, Denmark)  
H. Faustst (Weierberg-Launsbach, Germany)  
B. Ghoni (Ramat Hasharon, Israel)  
S.R. Hastings (Wellisellen, Switzerland)  
K.-I. Kimura (Tokyo, Japan)  
A. Mahdavi (Vienna, Austria)  
P. OSullivan (London, UK)  
A.H. Rosenfeld (Berkeley, CA, USA)  
M.L. Savitz (Los Angeles, CA, USA)  
B.K. Saxena (Roorklee, UP, India)  
S. Selkowitz (Berkeley, CA, USA)  
S.-I. Tamano (Tokyo, Japan)  
H. Yoshino (Sendai, Japan)

**Types of Contributions**  
Original research papers - Reviews of specialized topics - Technical notes (max. 4 pages) - Research communications - Reviews of books and reports - Notices of meetings and conferences.

**Papers** with results based on simulations are welcome but those with clear links to laboratory or field measurements are preferred. These links may include calibration, benchmarking, or comparisons of results.

**ENERGY**  
and **BUILDINGS**

Volume 36/8 (2004)



ELSEVIER

AMSTERDAM — BOSTON — JENA — LONDON — NEW YORK — OXFORD — PARIS — PHILADELPHIA — SAN DIEGO — ST. LOUIS

**USA mailing notice:** *Energy and Buildings* (ISSN 0378-7788) is published monthly by Elsevier B.V. (P.O. Box 211, 1000 AE Amsterdam, The Netherlands). Annual subscription price in the USA US \$1,450 (valid in North, Central and South America), including air speed delivery. Application to mail at periodical postage rate is pending at Jamaica, NY 11431.

**USA POSTMASTER:** Send address changes to *Energy and Buildings*, Publications Expediting Inc., 200 Meacham Ave, Elmont, NY 11003.  
**AIRFREIGHT AND MAILING** in the USA by Publications Expediting Inc., 200 Meacham Avenue, Elmont, NY 11003.

**Advertising information:**

Advertising orders and enquiries can be sent to: **USA, Canada and South America:** Mr Tino DeCarlo, The Advertising Department, Elsevier Inc., 360 Park Avenue South, New York, NY 10010-1710, USA; phone: (+1) (212) 633 3815; fax: (+1) (212) 633 3820; e-mail: t.decarlo@elsevier.com.  
**Japan:** The Advertising Department, Elsevier K.K., 4F Higashi-Azabu, 1-Chome Bldg, 1-9-15 Higashi-Azabu, Minato-ku, Tokyo 106-0044, Japan; phone: (+81) (3) 5561 5037; fax: (+81) (3) 5561 5047; e-mail: jp.info@elsevier.com. **Europe and ROW:** Katrina Barton, Print Operations Co-ordinator, Elsevier, 84 Theobalds Road, London, WC1X 8RR; phone: (+44) (0) 20 7611 4117; fax: (+44) (0) 20 7611 4463; e-mail: k.barton@elsevier.com

**Abstracting Services**

This journal is cited by the following Abstracting Services: Architectural Publications Index, Cambridge Scientific Abstracts, Compendex and Engineering Index, Current Contents/Engineering, Computing and Technology, Current Energy Information, EIC/Intelligence (Energy Index), Energy Abstracts, Engineering Information Inc., Environment Abstracts, Environmental Periodicals Bibliography, Focus on TM: Global Change, Fuel and Energy Abstracts, INSPEC Abstracts, International Building Services Abstracts, Sage Urban Studies Abstracts, Science Citation Index, VINITI (Institute for Scientific Information of the Russian Academy of Sciences)

International Standard Serial Number 0378-7788

© 2004 Elsevier B.V. All rights reserved.

This journal and the individual contributions contained in it are protected under copyright by Elsevier B.V., and the following terms and conditions apply to their use:

**Photocopying**

Single photocopies of single articles may be made for personal use as allowed by national copyright laws. Permission of the Publisher and payment of a fee is required for all other photocopying, including multiple or systematic copying, copying for advertising or promotional purposes, resale, and all forms of document delivery. Special rates are available for educational institutions that wish to make photocopies for non-profit educational classroom use.

Permissions may be sought directly from Elsevier's Rights Department in Oxford, UK; phone: (+44) 1865 843830; fax: (+44) 1865 853333; e-mail: permissions@elsevier.com. Requests may also be completed on-line via the Elsevier homepage (<http://www.elsevier.com/locate/permissions>).

In the USA, users may clear permissions and make payments through the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA; phone: (+1) (978) 7508400; fax: (+1) (978) 7504744, and in the UK through the Copyright Licensing Agency Rapid Clearance Service (CLARCS), 90 Tottenham Court Road, London W1P 0LP, UK; phone: (+44) 20 7631 5555; fax: (+44) 20 7631 5500. Other countries may have a local reprographic rights agency for payments.

**Derivative Works**

Subscribers may reproduce tables of contents or prepare lists of articles including abstracts for internal circulation within their institutions. Permission of the Publisher is required for resale or distribution outside the institution.

Permission of the Publisher is required for all other derivative works, including compilations and translations.

**Electronic Storage or Usage**

Permission of the Publisher is required to store or use electronically any material contained in this journal, including any article or part of an article.

Except as outlined above, no part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without prior written permission of the Publisher.

Address permissions requests to: Elsevier Rights Department, at the fax and e-mail addresses noted above.

**Notice**

No responsibility is assumed by the Publisher for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions or ideas contained in the material herein. Because of rapid advances in the medical sciences, in particular, independent verification of diagnoses and drug dosages should be made.

Although all advertising material is expected to conform to ethical (medical) standards, inclusion in this publication does not constitute a guarantee or endorsement of the quality or value of such product or of the claims made of it by its manufacturer.

Printed in The Netherlands

Ⓢ The paper used in this publication meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).

**SPECIAL ISSUE**

**Performance Simulation for Better  
Building Design**

**Guest Editors**

*Jan Hensen*

Technische Universiteit Eindhoven, Center for Building & Systems TNO-TU/e,  
P.O. Box 513, 5600 MB Eindhoven, The Netherlands  
J.Hensen@tue.nl

*Godfried Augenbroe*

College of Architecture, Georgia Institute of Technology  
Atlanta, GA 30332-0155, USA  
Fried.augenbroe@arch.gatech.edu



Editorial

## Performance simulation for better building design<sup>☆</sup>

This thematic issue contains twelve papers that address recent advancements in the field of simulation of building behavior. The papers represent a selection of papers presented at the IBPSA 2003 conference which was held from 11–14 August 2003 in Eindhoven. The conference which was run under the theme “Simulation for better building design”, was the 8th conference in a series of double blind peer reviewed conferences hosted by IBPSA (International Building Performance Simulation Association) since 1989 when the first conference was organized in Vancouver (1989). Since then, Nice (1991), Adelaide (1993), Madison (1995), Prague (1997), Kyoto (1999), Rio de Janeiro (2001) and Eindhoven (2003) have followed. The next, Building Simulation 05 conference, will be held in Montreal. IBPSA provides a forum for researchers, developers and practitioners to foster new developments, encourage the development and proliferation of software programs throughout the industry, address standardization, accelerate integration and promote technology transfer.

Over the past two decades the building simulation discipline has matured into a field that offers unique expertise, methods and tools for building performance evaluation. It draws its underlying theories from diverse disciplines, mainly from physics, mathematics, material science, biophysics, human behavioral, environmental and computational sciences. The theoretical challenges are bountiful when one recognizes that the physical state of a building is the result of the complex interaction of a very large set of physical components. The integration of these interactions in one behavioral simulation poses major modeling and computational challenges. Its ability to deal with the resulting complexity of scale and diversity of component interactions has gained building simulation a uniquely recognized role in the prediction, assessment and verification of building performance. The building simulation discipline is continuously evolving and maturing and improvements are continuously taking place in model robustness and fidelity. As a result the discussion has shifted from the old agenda that focused on software features to a new agenda that focuses on the effectiveness of and team based control over simulation tools in building life cycle processes.

The papers in this issue extend the knowledge base in the general areas addressed above and apply building simulation in various novel fields. This thematic issue offers different perspectives on these issues and deals with the next generation of building performance simulation, recognizing the need for the management of the simulation process as an element in the larger management processes executed in the architectural and engineering office. The agenda in that field is driven by the need to increase effectiveness, speed, quality assurance, and users' productivity. An important aspect is the integration of simulation software applications with other design applications.

Different interaction paradigms with building performance information and dynamic control paradigms are emerging. They will change the way that building simulation is incorporated in decision making, during all stages of design, from inception through operation and use. Taking this one step further, it will become common place to interact with the world around us through simulation models that are executed in the background. One will be able to interrogate this simulation model about the consequences of the proposed system intervention one is about to make. This is just one manifestation of ‘invisible’ and ubiquitous simulation on which some papers offer deeper reflections. It is expected that new developments will radically influence the way that simulation is performed and its outputs used in design evolution and post occupancy decision making. Apart from this shift from simulation of phenomena to design decision making, there are a number of major trends that appear from the papers in this issue, such as the shift from the need for “raw number crunching” to the need for support of the “process of simulation”, and from “tool integration” to the “process of collaboration”.

In spite of the fact that these trends are receiving increasing attention there is no escaping the fact the building simulation discipline still has some distance to travel to bridge the traditional “divide”, caused by the asymmetric ignorance between the design and engineering disciplines in the building industry. Many aspirations remain to be achieved, such as the support for rapid evaluation of alternative designs, better adaptation of simulation tools to decision making processes, and team support of incremental design strategies. Quality assurance procedures and better management of the inherent uncertainties in the inputs and modeling assumptions in

<sup>☆</sup> Editorial for special issue of Energy and Buildings, guest edited by Jan Hensen and Godfried Augenbroe.

simulation are two other areas where more progress is needed.

195 papers were presented during the BS03 conference, twelve of which have been selected for inclusion in expanded and improved form in the thematic issue before you. The twelve papers constitute an interesting cross section of the development of the field and may be viewed as road sign to what lies ahead.

The first three papers deal with various design support issues. Augenbroe's paper describes the Design Analysis Integration (DAI)-initiative which aims to steer towards new solutions for design analysis integration that may overcome the limitations of current data-centric interoperability approaches. This paper reports on the first phase of the development, which has produced a first-generation 'workbench' prototype for managing a process driven design analysis dialogue.

The paper by De Wilde and Van der Voorden addresses the integration of building simulation tools and building design. This problem has been narrowed down to computational support for one specific type of building design decision: the selection and integration of one or more energy saving building components like solar walls, advanced glazing systems, sunspaces and photovoltaic arrays into a given building design.

The first paper by Clarke et al. describes the application of a building simulation program to construct a decision-support tool for use by Scottish policy makers. It is argued that the generic nature of the tool renders it suitable to support the cumulative roll-out of upgrade measures in the long term, both within and outside the UK. The tool is then used to appraise the impact of the upgrade measures that might be applied to the Scottish housing stock.

Then follow two papers related to the urban climate. The paper by Takahashi et al. investigates the characteristics of heat flow in urban areas, and describes a model which can be used to investigate the effect of additional green on roofs and ground in order to mitigate urban heat island effects and to improve the urban thermal environment at street level.

Tanimoto et al.'s paper describes another tool for evaluation urban heat island effects. This paper describes the objectives and fundamental methods underlying the tool, as well as the structure and numerical techniques of the software.

The next two papers deal with energy storage. The paper by Heim and Clarke describes the numerical modeling and thermal simulation of phase-change material in a whole building energy simulation environment.

Ihm et al.'s paper deal with the integration of ice based thermal storage systems in another whole building energy simulation environment.

The next four papers address a mix of issues. Mardaljevic's paper describes a new image-based technique to quantify the effectiveness of shading devices, which is founded on predictions of direct solar irradiation using hourly meteorological data for a full year. The technique produces numerical output, as well as synoptic images that reveal the spatial and temporal variation of solar irradiation.

The paper by Saelens et al. draws the attention to the importance of a correct modeling of the inlet temperature of naturally and mechanically ventilated multiple-skin facades. The paper presents experimental and sensitivity analysis results, and uses an integrated whole building energy simulation to indicate the importance of a correct inlet temperature on the energy performance.

A second paper by Clarke et al. describes possible roles for simulation support in e-services. It is about the establishment of an infrastructure which enables the development of a range of new energy, environment and health-related services for people in their homes and workplaces using the Internet and making use of building modeling and simulation.

Westphal and Lamberts present in their paper a methodology to analyse the thermal loads of non-residential buildings based on simplified weather data. The methodology showed good results for cases with low mass envelope but revealed limitation to represent thermal inertia influence on the annual cooling and heating loads.

Finally the paper by Henninger et al. discusses analytical and comparative testing of an integrated whole building energy simulation software in terms of its heating, ventilating and air-conditioning equipment models. The paper demonstrates the use of the Building Energy Simulation Test and Diagnostic Method for Heating, Ventilating, and Air-Conditioning Equipment Models (HVAC BESTEST) which was published in 2002. The authors state that these tests proved to be very useful in debugging and verifying air-conditioning equipment models and algorithms. The paper summarizes the difficulties encountered and the benefits gained in applying these quality assurance tests.

#### Acknowledgements

Many individuals and organizations have made substantial contributions towards the success of Building Simulation 2003 in Eindhoven. In addition to all reviewers, we thank in particular Joe Clarke, Roberto Lamberts, Harunori Yoshida, Jeff Spittle, Jonathan Wright and Terry Williamson for their role in the scientific executive committee and in the selection of the papers for this special issue.

Jan Hensen  
*Technische Universiteit Eindhoven*  
 Center for Building & Systems TNO-TU/e, P.O. Box 513  
 5600 MB Eindhoven, The Netherlands  
 Corresponding author. Tel.: +31-40-247-2988  
 fax: +31-40-243-8595  
 E-mail address: J.Hensen@tue.nl (J. Hensen)

Godfried Augenbroe  
 College of Architecture  
 Georgia Institute of Technology  
 Atlanta, GA 30332-0155, USA  
 E-mail address: Fried.augenbroe@arch.gatech.edu  
 (G. Augenbroe)



ELSEVIER

Energy and Buildings Volume 36, Number 8, August 2004

**ENERGY**  
and **BUILDINGS**

www.elsevier.com/locate/enbuild

## Contents

### Special Issue: Performance Simulation for Better Building Design

Special issue on 'Performance simulation for better building design' .....	735
J. Hensen and G. Augenbroe	
An interoperability workbench for design analysis integration .....	737
G. Augenbroe, P. de Wilde, H.J. Moon and A. Malkawi	
Providing computational support for the selection of energy saving building components .....	749
P. de Wilde and M. van der Voorden	
Using simulation to formulate domestic sector upgrading strategies for Scotland .....	759
J.A. Clarke, C.M. Johnstone, I. Kondratenko, M. Lever, L.B. McElroy, L. Prazeres, P.A. Strachan, F. McKenzie and G. Peart	
Measurement of thermal environment in Kyoto city and its prediction by CFD simulation .....	771
K. Takahashi, H. Yoshida, Y. Tanaka, N. Aotake and F. Wang	
An approach for coupled simulation of building thermal effects and urban climatology .....	781
J. Tanimoto, A. Hagishima and P. Chimklai	
Numerical modelling and thermal simulation of PCM-gypsum composites with ESP-r .....	795
D. Heim and J.A. Clarke	
Development of a thermal energy storage model for EnergyPlus .....	807
P. Ihm, M. Krarti and G.P. Henze	
Spatio-temporal dynamics of solar shading for a parametrically defined roof system .....	815
J. Mardaljevic	
The inlet temperature as a boundary condition for multiple-skin facade modelling .....	825
D. Saelens, S. Roels and H. Hens	
The role of simulation in support of Internet-based energy services .....	837
J.A. Clarke, S. Conner, G. Fujii, V. Geros, G. Jóhannesson, C.M. Johnstone, S. Karatasou, J. Kim, M. Santamouris and P.A. Strachan	
The use of simplified weather data to estimate thermal loads of non-residential buildings .....	847
F.S. Westphal and R. Lamberts	
Analytical and comparative testing of EnergyPlus using IEA HVAC BESTEST E100-E200 test suite .....	855
R.H. Henninger, M.J. Witte and D.B. Crawley	

The publisher encourages the submission of articles in electronic form thus saving time and avoiding rekeying errors. A leaflet describing our requirements is available from the publisher upon request.

**CONTENTS**  
**Direct**

This journal is part of **ContentsDirect**, the *free* alerting service which sends tables of contents by e-mail for Elsevier books and journals. You can register for **ContentsDirect** online at: <http://contentsdirect.elsevier.com>