Inside:

- Major features on predicting the hygrothermal environment in buildings and district level energy management
- Reports on events held earlier this year by IBPSA Canada and IBPSA Netherlands + Flanders, and information on 7 forthcoming events
- Two new IBPSA Affiliates

... plus information about other publications and IBPSA activities
Contents

President’s message 2
IBPSA Central contacts 4
IBPSA Board of Directors 5
IBPSA Sustaining Members 7
IBPSA Announcements 8
  IBPSA England formed 8
  IBPSA Switzerland formed 9
  Privileges and Obligations of IBPSA Members and Affiliates 11
Forthcoming events calendar 12
  ESM 2006 12
  IBPSA Australasia 2006 conference 13
  40th Annual ANZAScA Conference 13
  Clima 2007 - WellBeing Indoors - the 9th REHVA World Congress 14
  Roomvent 2007 15
  Building Simulation 2007 17
  ECOSUD 2007 17
Software news 19
  Building Energy Tools Directory 19
  EnergyPlus Version 1.4 to be available October 2006 19
Announcements 22
  Results of the California CEUS (Commercial End-Use Survey) 22
  REHVA Guidebooks 23
  Job opportunities at Lawrence Berkeley National Laboratory 27
Feature articles 30
  Prediction of hygrothermal environment of buildings 30
  District level energy management 38
News from IBPSA affiliates 46
  IBPSA Canada 46
  IBPSA Netherlands + Flanders 47
President’s message

IBPSA Members and Friends,

Welcome to this issue of IBPSA News, packed with - we hope - interesting news about ongoing and planned activities in and by our Society.

IBPSA comprises members and affiliates. You can read about the privileges and obligations of both on page 11. The essence is that we are in this together. All members are encouraged and entitled to take part in the activities of IBPSA.

We are in the lucky situation that we have many very active individuals amongst our, now more than 2000, members worldwide. You will be able to read about the various activities which take place in the, now 16, regional affiliate organizations. We are happy that recently IBPSA England and IBPSA Switzerland have been established, and that there are proposals for IBPSA affiliate organizations being discussed in another 10 regions. We also benefit from a very enthusiastic and pro-active board. On pages 5 and 6 you can see the current officers, members-at-large and regional affiliate representatives which together make up the board. By the way, all of the work they perform is on a voluntary basis. Thank you all!!

Early September was the annual board meeting; this time hosted by Jonathan Wright and Loughborough University in the UK. We discussed how we divide the board tasks amongst us. (See page 5). Some of the roles may need some explanation. For example, the Membership Development Officer (Jonathan Wright) is concerned with attracting new “sustaining” members, and developing guidelines for general membership benefits. The Affiliate Development Officer (Karel Kabele) focuses on potential new regional affiliate organizations, while the Regional Affiliate Liaison (Drury Crawley) liaises with existing affiliate organizations. You can also read on page 4 that we now have various sub-committees, for example the IBPSA awards and the website. If you would like to get involved, or have any comments, suggestions or ideas, please don’t hesitate to contact anyone of us.

There was strong competition for the 2007 IBPSA awards. We plan to announce these in the next issue of IBPSA News and to formally present the awards at Building Simulation 2007. Speaking of awards, the board also made a special recognition award to Jeff Spitler for his outstanding service as President of IBPSA for the last four years. Thanks again, Jeff, for a job well done!

Building Simulation 2007 is shaping up very nicely indeed. The board was impressed by the presentation from the organizers at the board meeting. Initial feedback based on abstract submissions is that there is a lot of interest. Don’t miss it! (See www.bs2007.org.cn.)

The board has also decided on the location for Building Simulation 2009. It is going to be held in Glasgow, Scotland. More information will follow in future issues of IBPSA News.
President’s message

We are starting to look further ahead. If you are interested in hosting Building Simulation 2011 or an international IBPSA conference further in the future, don’t hesitate to contact our Conference Location Coordinator, Jeff Spitler.

Apart from a lot of news, this Newsletter contains two scientific articles. Both are about topics which are recently gaining more interest. The first is about heat, air and moisture transfer modeling by Ozaki and Tsujimaru. The second article by Yamaguchi et al. concerns energy modeling on a district level scale.

Finally, I would like to thank all contributors and especially our Newsletter chairman Larry Degelman, and producer Marion Bartholomew for a fantastic job!

Best wishes,

[Signature]

Images from the Board Meeting

The diligent board members at work

Past-President Spitler receives his Outstanding Service award from President Jan Hensen

A quirky corner of old Loughborough ... and the new solar-screened Civil & Building Engineering building
IBPSA Central contacts

Membership Services and Publications
For proceedings of past conferences:
Jeff Haberl (IBPSA Membership Services Officer)
Texas A&M University, USA
Email: jhaberl@esl.tamu.edu

Newsletter Submissions
To submit Newsletter articles and announcements:
Larry Degelman (Newsletter Chair)
Texas A&M University, USA
Email: larry@taz.tamu.edu

Newsletter Editor
Marion Bartholomew
DBA, UK
Email: mb@dba-insight.co.uk

IBPSA Building Simulation conferences
For information about IBPSA Building Simulation conferences:
Ian Beausoleil-Morrison (Conference Liaison)
Natural Resources Canada, Canada
Email: ibeausol@nrcan.gc.ca

IBPSA Website (www.ibpsa.org)
For full information about IBPSA activities and organisation:
Fernando Simon Westphal
IBPSA-Brazil
Email: fernando@labecee.ufsc.br

Long-range conference planning
For potential future conference hosting:
Jeffrey Spitler (Conference Location Coordinator)
Oklahoma State University, USA
Email: spitler@okstate.edu

Honors and Awards sub-committee
Lori McElroy chair
Members: Ian Beausoleil-Morrison, Jonathan Wright, Wim Plokker, Gerhard Zweifel

Web sub-committee
Roberto Lamberts chair
Members: Chip Barnaby, Christoph van Treeck, Karel Kabele, Dru Crawley

To register yourself on the IBPSA mailing list go to the IBPSA home page www.ibpsa.org and click on Mailing Lists for instructions, or go directly to www.ibpsa.org/m_lists.asp. For additional information about IBPSA, visit:

- About IBPSA: www.ibpsa.org/m_about.asp
- Conferences and papers online: www.ibpsa.org/m_events.asp
- Regional affiliate web sites and contact persons:
  www.ibpsa.org/m_affiliates.asp
- Downloads/links: www.ibpsa.org/m_downloads.asp

For information on joining IBPSA please contact your nearest regional affiliate.
IBPSA Board of Directors

Elected Officers and Affiliate Representatives

President
Jan Hensen
Technische Universiteit Eindhoven, Netherlands
Email: j.hensen@tue.nl

Vice-President
Conference Liaison
Ian Beausoleil-Morrison
Natural Resources Canada, Canada
Email: ibeausol@nrcan.gc.ca

Secretary
Regional Affiliate Liaison
Drury Crawley (U.S. Department of Energy, USA) -
Email: drury.crawley@ee.doe.gov

Treasurer
Charles “Chip” Barnaby (Wrightsoft Corporation, USA)
Email: cbarnaby@wrightsoft.com

Immediate Past President
Conference location coordinator
Jeffrey Spitler (Oklahoma State University, USA)
Email: spitler@okstate.edu

Member-at-large
Newsletter Chairperson
Larry Degelman (Texas A&M University, USA)
Email: ldegelman@cox.net

Member-at-large
Affiliate Development Officer
Karel Kabele (Czech Technical Univ. in Prague, Czech Republic)
Email: kabele@fsv.cvut.cz

Member-at-large
Website Editor
Roberto Lamberts (Universidade Federal de Santa Catarina, Brazil)
Email: lamberts@ecv.ufsc.br

Member-at-large
Membership Development Officer
Jonathan Wright (Loughborough University, UK)
Email: j.a.wright@lboro.ac.uk

IBPSA-Australasia Representative
Veronica Soebarto (Department of Architecture, The University of Adelaide, Australia)
Email: veronica.soebarto@adelaide.edu.au

IBPSA-Brazil Representative
Nathan Mendes (Laboratório de Sistemas Térmicos, Pontifícia Universidade Católica do Paraná, Curitiba, Brazil)
Email: nathan.mendes@pucpr.br

IBPSA-Canada Representative
Ian Beausoleil-Morrison (Natural Resources Canada, Canada)
Email: ibeausol@nrcan.gc.ca

IBPSA-China Representative
Da Yan (School of Architecture, Tsinghua University, Beijing, China)
Email: yanda@tsinghua.edu.cn

IBPSA-Czech Republic Representative
Frantisek Drkal (Dep. of Environmental Engineering, Czech Technical University in Prague, Czech Republic)
Email: drkal@fsid.cvut.cz

(continued on next page)
### IBPSA Board of Directors (continued)

<table>
<thead>
<tr>
<th>IBPSA-England Representative</th>
<th>Lori McElroy (The Lighthouse Trust, Glasgow, UK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ian Ward (School of Architecture, University of Sheffield, UK)</td>
<td>Email: <a href="mailto:lori.mcelroy@thelighthouse.co.uk">lori.mcelroy@thelighthouse.co.uk</a></td>
</tr>
<tr>
<td><strong>Email:</strong> <a href="mailto:i.ward@sheffield.ac.uk">i.ward@sheffield.ac.uk</a></td>
<td></td>
</tr>
<tr>
<td><strong>Email:</strong> <a href="mailto:ewurt@univ-savoie.fr">ewurt@univ-savoie.fr</a></td>
<td></td>
</tr>
<tr>
<td><strong>Email:</strong> <a href="mailto:treec@bv.turn.de">treec@bv.turn.de</a></td>
<td></td>
</tr>
<tr>
<td>Email: <a href="mailto:costas@meteo.noa.gr">costas@meteo.noa.gr</a></td>
<td></td>
</tr>
<tr>
<td><strong>Email:</strong> <a href="mailto:bernard.denver@mma.ie">bernard.denver@mma.ie</a></td>
<td></td>
</tr>
<tr>
<td><strong>Email:</strong> <a href="mailto:hraska@svf.stuba.sk">hraska@svf.stuba.sk</a></td>
<td></td>
</tr>
<tr>
<td><strong>Email:</strong> <a href="mailto:gzweifel@hta.fhz.ch">gzweifel@hta.fhz.ch</a></td>
<td></td>
</tr>
<tr>
<td><strong>Email:</strong> <a href="mailto:cbarnaby@wrightsoft.com">cbarnaby@wrightsoft.com</a></td>
<td></td>
</tr>
<tr>
<td><strong>Email:</strong> <a href="mailto:hmmoa_yoshida@archi.kyoto-u.ac.jp">hmmoa_yoshida@archi.kyoto-u.ac.jp</a></td>
<td></td>
</tr>
<tr>
<td><strong>Email:</strong> <a href="mailto:w.plokker@vabi.nl">w.plokker@vabi.nl</a></td>
<td></td>
</tr>
<tr>
<td><strong>Past Presidents of IBPSA:</strong></td>
<td></td>
</tr>
<tr>
<td>1987-1991 (5 years) Ed Sowell, USA</td>
<td></td>
</tr>
<tr>
<td>1992-1993 (2 years) Dan Seth, Canada</td>
<td></td>
</tr>
<tr>
<td>1994-1997 (4 years) Joe Clarke, Scotland</td>
<td></td>
</tr>
<tr>
<td>1998-1999 (2 years) Larry Degelman, USA</td>
<td></td>
</tr>
<tr>
<td>2000-2001 (2 years) Roger Pelletret, France</td>
<td></td>
</tr>
<tr>
<td>2002-2005 (4 years) Jeff Spitler, USA</td>
<td></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Sustaining Members</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>REHVA</strong>&lt;br&gt;Federation of European Heating and Air-Conditioning Associations</td>
<td>2003-2007</td>
</tr>
<tr>
<td><strong>Québec</strong>&lt;br&gt;Agence de l'efficacité énergétique</td>
<td>2005-2007</td>
</tr>
<tr>
<td><strong>Montréal Chapter</strong>&lt;br&gt;</td>
<td>2005-2007</td>
</tr>
<tr>
<td><strong>CMHC SCHL</strong>&lt;br&gt;</td>
<td>2005-2007</td>
</tr>
<tr>
<td><strong>Concordia University</strong>&lt;br&gt;Real education for the real world</td>
<td>2005-2007</td>
</tr>
<tr>
<td><strong>École Polytechnique Montréal</strong>&lt;br&gt;</td>
<td>2005-2007</td>
</tr>
<tr>
<td><strong>Université du Québec</strong>&lt;br&gt;École de technologie supérieure</td>
<td>2005-2007</td>
</tr>
<tr>
<td><strong>Natural Resources Canada</strong>&lt;br&gt;Ressources naturelles Canada</td>
<td>2005-2007</td>
</tr>
<tr>
<td><strong>iRc</strong>&lt;br&gt;Institute for Research in Construction</td>
<td>2005-2007</td>
</tr>
<tr>
<td><strong>Itron</strong>&lt;br&gt;</td>
<td>2005-2007</td>
</tr>
</tbody>
</table>
IBPSA England formed

After a process that started during the BS’05 Conference in Montreal IBPSA now has an English Affiliate Region. Following a number of informal meetings an initial Board was set up and a Charter was drafted. A formal application to set up IBPSA-England was submitted to the IBPSA World Board in May, with approval being given in August. Like other regional affiliates IBPSA-England’s objective is to provide a forum for the exchange of information between researchers, developers and practitioners operating in the area of building performance simulation and related issues.

IBPSA-England was formally launched with a one-day event on Wednesday September 13th at the University of Sheffield. Keynotes were given by Jeff Spitler, past-president of IBPSA, LoriMcElroy of IBPSA Scotland, and Jake Hacker plus Martin Mayfield of Ove Arup, providing an industry view. This was followed by an animated discussion on the future of the fledgling organisation.

Two events are currently in preparation:

- 6 March 2007: Symposium on ‘Good practice in building performance simulation’, to be held at De Montfort University in Leicester.
- 16 November 2007: Symposium on ‘Building Simulation in the South West’, to be held at the University of Plymouth.

For the most recent information on IBPSA-England, events, or to register as a member, please visit our website at www.ibpsa-england.org.

Ian Ward, Chair and Affiliate Representative
Malcolm Cook, Vice-Chair and 2nd Affiliate Representative
Pieter de Wilde, Secretary
Jonathan Wright, Board Member
Martin Mayfield, Board Member
Mike Davies, Board Member
Dejan Mumovic, Board Member
Simon Rees, Board Member
IBPSA Switzerland formed

IBPSA Switzerland, abbreviated IBPSA-CH, was officially founded on 1 September 2006 at a meeting held in the School of Engineering and Architecture at the University of Applied Sciences of Central Switzerland in Horw. 20 people attended this first constituting general assembly of the association.

The meeting was preceded by a variety of preparatory work carried out by a team of 6 board members, including writing by-laws, translating them into 3 languages, collecting addresses of potential members, and creating a web site at www.ibpsa.ch in 4 languages (German, English, French and Italian).

IBPSA-CH is a spin-off from brenet, an existing network of Swiss universities and research institutes, which has undertaken to give the association financial and infrastructure support for an initial phase of about 5 years. The majority of the board, including the president and vice president, are brenet member representatives.

Membership is free and includes individual and corporate members. It is expected that the number of registered members will grow towards 50.

Proposed activities include:

- Region-specific workshops to introduce simulation into practice
- (Inter)national conferences to progress development and application of simulation, or dedicated sessions at established conferences
- Software-specific training workshops
- Publishing an IBPSA-CH newsletter
- Maintaining the IBPSA-CH web site to be an evolving resource on:
  - IBPSA-CH events
  - IBPSA-CH documents (eg newsletters)
  - Members / consultants database (should they wish to be identified)
  - Software availability
  - Updated news items

The list will evolve. It is also proposed to establish a research group to strengthen the simulation community’s standing with funding bodies.

IBPSA-CH’s first event, to be held this autumn, will be a series of half-day presentations at which three software tools for assessing building sustainability will be presented:

- Ecobat (http://ecobat.heig-vd.ch): This performs a detailed environmental impact assessment of building construction materials based on a life cycle approach and has a user-friendly GUI
IBPSA Announcements

- Ecoentreprise (www.ecoentreprise.ch): A web-based tool for the sustainable management of public and private companies.
- E-Green (www.green-e.ch): Evaluates the environmental impacts of a company including building energy consumption, mobility, product and services, wastes, etc.

These presentations are free and are open to all practitioners from the building industry, including planners, architects and engineers.

IBPSA-CH’s board members are:

Gerhard Zweifel, UAS Central Switzerland, Horw, President
Stéphane Citherlet, UAS Western Switzerland, Yverdon-les-Bains, Vice president
Thomas Afjei, UAS Northwestern Switzerland, Muttenz
Daniel Pahud, UAS Southern Switzerland, Canobbio
Darren Robinson, Federal Institute of Technology, Lausanne
Alois Schälin, AFC Air Flow Consulting, Zuerich
Privileges and Obligations of IBPSA Members and Affiliates

All members are encouraged and entitled to take part in the activities of IBPSA, subject to constitutional or special provisions by the management of IBPSA. The aims of the activities are to disseminate information and aid the progress of IBPSA's efforts and image.

All members have the right to participate in meetings of IBPSA, but the right to vote is subject to the provisions for voting as contained in the present By-Laws. Members holding their membership through an Affiliate are not eligible to vote if the Affiliate has not submitted its membership roster to the Secretary of IBPSA. Affiliates, therefore, need to keep their membership rosters up to date and communicate them to the Secretary.

All members joining IBPSA must undertake to observe the IBPSA constitution and By-Laws and all obligations arising from them. They must also accept the obligation to contribute to the accomplishment of the activities of IBPSA according to their particular competence.

Any member may submit any communication for consideration at a General or Special Meeting of IBPSA or the Board of Directors. The Board will indicate its decision on the proposals within a reasonable timeframe that allows for an IBPSA Board meeting, either in person or by e-mail.

Affiliates are entitled to appoint one representative to the Board and take part in activities of IBPSA. Affiliates, upon joining IBPSA, must undertake to observe the IBPSA constitution and By-Laws and all obligations arising from them. Special obligations of Affiliates include annual notification to the Secretary of IBPSA of the following items:

1. the name of the Affiliate's board representative
2. the Affiliate's membership roster
3. reports of meetings and/or conferences held by the Affiliate, and
4. other information or reports requested by the Board.

Resignation and Termination

Affiliates wishing to terminate their affiliation may do so at any time subject to 90 days notice. Notice of termination must be transmitted in writing to the Secretary. If all communications from an Affiliate to the Board have ceased for a period of two years prior to any Board meeting, that Affiliate will be considered to have resigned.
## Forthcoming events calendar

<table>
<thead>
<tr>
<th>Date(s)</th>
<th>Event</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn 2006 (3 half-days, dates tba)</td>
<td>IBPSA Switzerland presentations on software for assessing building sustainability</td>
<td><a href="http://www.ibpsa.ch">www.ibpsa.ch</a></td>
</tr>
<tr>
<td>2007</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ESM 2006 European Simulation and Modelling Conference 2006 EUROYSIS

The European Simulation and Modelling Conference is the original European international conference concerned with state of the art technology in modelling and simulation. ESM 2006 aims to provide an overview of academic research in the field of computer simulation. It is sponsored by the European Technology Institute and hosted by LAAS-CNRS ([www.laas.fr](http://www.laas.fr)).

A number of major tracks of simulation research are presented next to specific workshops, which capture the art and science of present-day simulation research.
Forthcoming events

ESM 2006 conference themes include:

- Methodology and Tools
- Simulation and AI
- High Performance and Large Scale Computing
- Simulation in Education and Graphics Visualization Simulation
- Simulation in the Environment, Ecology, Biology and Medicine
- Analytical and Numerical Modelling Techniques
- Web Based Simulation
- Agent Based Simulation


IBPSA Australasia 2006 conference


The University of Adelaide will also host a second conference, the 40th Annual ANZAScA conference immediately afterwards.

40th Annual ANZAScA conference

The School of Architecture, Landscape Architecture and Urban Design, together with the Architectural Science Association ANZAScA, will also hold the 40th Annual ANZAScA Conference at The University of Adelaide on 22-25 November, following the IBPSA Australasia Conference. For more information visit www.adelaide.edu.au/anzasca2006.
Forthcoming events

10-14 June 2007
Helsinki, Finland
www.clima2007.org

Clima 2007 - WellBeing Indoors - the 9th REHVA World Congress

The 9th REHVA World Congress will offer scientists, industry, building owners, end users, consultants, engineers, architects and policy-makers a platform for the exchange of scientific knowledge and technical solutions. The leading international scientific congress in the HVAC area in year 2007, it is being organised jointly by the Finnish Association of HVAC Societies (FINVAC), Finnish Association of Mechanical Building Services Industries (FAMBSI), Finnish Society of Indoor Air Quality and Climate (FiSIAQ) and Helsinki University of Technology (HUT).

The special congress theme is wellbeing of people indoors. The congress will cover all aspects of HVAC technology including building automation in all types of buildings.

The WellBeing Indoors – Clima 2007 congress and web service open a global window to the scientific knowledge and innovative applications of building services. The focus is on improving wellbeing in buildings in a sustainable manner by applying the latest research results and technical innovations into practice.

THEMES AND SCOPE

The scope of the Congress is HVAC and its applications in creating wellbeing in indoor environments in an environmentally sustainable manner. The conference themes are:

Healthy and productive indoor climate
- Energy performance of ventilation
- Modern ventilation technologies
- Maintenance and operation of ventilation systems
- Indoor environment, performance and productivity
- Natural and hybrid ventilation systems
- Developments in regulations and voluntary schemes
- Ventilation technology for special environments

Sustainable energy use of buildings
- Sustainable energy systems
- Energy performance of buildings and HVAC systems
- Commissioning for better performance of buildings
- Life-cycle building services (ESCO etc.)
- Refrigeration and cooling systems
- Renewable energy sources

Intelligent building management
- Building automation and energy performance
- Maximum benefit of building automation systems
- Computer based methods for design, construction and maintenance
- Open building automation systems
- Sensors and methods to control and authenticate indoor environment
Forthcoming events

Comfort and safety by modern piping systems
- Energy efficient heating and cooling systems
- Energy efficient structures
- Water safety by modern piping technology
- Water and waste conservation methods and technologies
- Sprinkler systems and fire safety in homes

CALL FOR PAPERS AND SUBMISSION DEADLINES

Abstracts submission deadline: 15 October 2006
Full paper submission deadline: 15 March 2007

The full list of topics and subtopics, as well as instructions for abstract submissions (max 300 words), are available at www.clima2007.org.

For further information, contact us via email at info@clima2007.org or by post at FINVAC, Sitratori 5, FIN-00420 Helsinki, Finland.

Roomvent 2007

The 10th Roomvent Conference on Air Distribution in Rooms will offer scientists, industry, consultants, engineers, architects and policy-makers a platform for the exchange of scientific knowledge and technical solutions. Roomvent 2007, the leading event in the area of air distribution in rooms, is a SCANVAC event being organised by the Finnish Association of HVAC Societies (FINVAC), Finnish Association of Mechanical Building Services Industries (FAMBSI), Finnish Society of Indoor Air Quality and Climate (FiSIAQ) and Helsinki University of Technology (HUT).

The special congress theme is air distribution and control techniques for productive room environments. The conference will cover all aspects of room airconditioning technology in all types of buildings.

The Roomvent 2007 conference and web service open a global window to the scientific knowledge and innovative applications of room air-conditioning. The focus is on air distribution and control techniques for productive room environments.

THEMES AND SCOPE

Human to room environment interaction
- Thermal environment
- Contaminant distribution in rooms
- Acoustical and visual environment Room environment and productivity
Forthcoming events

Plenary lecture: Human interaction with indoor climate – scientific background for comfort criteria

**Design of room environment**
- Target and design values in specific applications
- Room air conditioning, ventilation and cooling
- Design methods
- Modelling and visualisation
- Validation of designs

Plenary lecture: CFD in design – where are we today?

**Control techniques**
- Air diffusion: jets, plumes, terminal devices
- Zonal control techniques
- Demand based control techniques
- Sensors and control devices

Plenary lecture: Room air conditioning and control strategies

**Assessment of room environmental quality**
- Commissioning and inspection
- Measurement techniques
- Case studies

Plenary lecture: Assessment of Indoor Climate

**CALL FOR PAPERS AND SUBMISSION DEADLINES**

Abstracts submission deadline: 15 October 2006
Full paper submission deadline: 15 March 2007

For further information, contact the organisers via email at info@roomvent2007.org or by post at FINVAC, Sitratori 5, FIN-00420 Helsinki, Finland.
Forthcoming events

3-6 September 2007  
Beijing, China  
www.bs2007.org.cn

Building Simulation 2007  
IBPSA

Building simulation has the potential to improve the design and operation of buildings. Computer simulation can be used to predict future performance at all stages of the building life cycle: design, commissioning, operation and management. The next bi-annual IBPSA (International Building Performance Simulation Association) Building Simulation Conference and Exhibition is Building Simulation 2007, to be held from September 3 to 6, 2007 in Beijing, China. The abstract deadline has passed in September 2006, but further information about the Conference can still be found at the conference website www.bs2007.org.cn.

Additional details may be available from:  
The Building Simulation 2007 Conference Committee  
Department of Building Science  
School of Architecture  
Tsinghua University  
Beijing 100084  
P. R. China

Tel:  86-10-6278-9761  
Fax:  86-10-6277-0544  
Email: bs07@tsinghua.edu.cn

5-7 September 2007  
Coimbra, Portugal  
www.wessex.ac.uk/conferences/2007/eco2007/1.html

ECOSUD 2007

ECOSUD 2007 is the Sixth International Conference in the well-established series on Ecosystems and Sustainable Development. Organised by the Wessex Institute of Technology, UK, the University of Coimbra, Portugal and the University of Siena, Italy in collaboration with the International Journal of Ecodynamics, the meetings provide a unique forum for the presentation and discussion of recent work on different aspects of ecosystems and sustainable development, including physical sciences and modeling.

The aim of the conference is to encourage and facilitate the interdisciplinary communication between scientists, engineers and professionals working in ecological systems and sustainable development. Emphasis will be given to those areas that will most benefit from the application of scientific methods for sustainable development, including the conservation of natural systems around the world.

Previous ECOSUD conferences have been held in Peniscola, Spain (1997), Lemnos, Greece (1999), Alicante, Spain (2001), Siena, Italy (2003) and Cadiz, Spain (2005).
Forthcoming events

TOPICS

- Thermodynamics and ecology
- Sustainability indicators
- Mathematical and system modeling
- Ecosystems modeling
- Biodiversity
- Sustainability development studies
- Conservation and management of ecological areas
- Socio-Economic factors
- Energy conservation and generation
- Environmental and ecological policies
- Environmental management
- Environmental risk
- Natural resources management
- Recovery of damaged areas
- Biological aspects
- Complexity
- Remote sensing
- Landscapes and forestation issues
- Soil and agricultural issues
- Water resources
- Sustainable waste management
- Air pollution and its effects on ecosystems

Full details are available from the conference website at www.wessex.ac.uk/conferences/2007/eco2007/1.html.

CALL FOR PAPERS AND SUBMISSION DEADLINES

Abstracts submission deadline: as soon as possible
Full paper submission deadline: 3 May 2007

Abstracts can be submitted via the conference website at www.wessex.ac.uk/conferences/2007/eco2007/1.html or by email or fax to Zoey Bluff, Conference Secretariat, email zbluff@wessex.ac.uk, fax + 44 (0) 238 029 2853.
Software news

Building Energy Tools Directory

Dru Crawley, DOE


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, send the information shown here: www.energytoolsdirectory.gov/submit.cfm in an email message to Dru Crawley at Drury.Crawley@ee.doe.gov.

EnergyPlus version 1.4 to be available in October 2006

Dru Crawley, DOE

The next release of the EnergyPlus building energy simulation program, Version 1.4, became available in early October. 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. The new features include:

**INPUT**

- New dataset with performance curves for 162 chillers

**GEOMETRY WINDOW WALLS SHADING**

- More accurate modeling of exterior window screens (Material:WindowScreen)
- Window or door multipliers now allowed in AirFlowNetwork components
- Multipliers on doors and glass doors allowed
- Triangular doors and glass doors now allowed
Software news

ZONE MODEL
- New Zone thermostatic control options:
  - Operative Temperature using mix of mean radiant and air temperatures
  - Thermal comfort control using Fanger PMV values as setpoints
  - New root finder module significantly increases speed of air loop simulation

NATURAL AND MECHANICAL AIR DISTRIBUTION
- New ventilation flow report variables for individual zones
- Interior surface ventilation control can be based on adjacent zone conditions (temperature or enthalpy)

HVAC
- New SERIESACTIVE component control type provides improved temperature set point control
- New simple duct leakage model simulates energy impact of supply duct leaks in a VAV system with return plenum and constant static pressure setpoint
- New reformulated version of the DOE 2.1E EIR chiller
- New HVAC system type for Changeover-bypass VAV systems

WATER MANAGER (NEW!)
- New water manager to control and report water use throughout the building
- Update of existing HVAC components to calculate and report water consumption or condensate production
- Generalized water end-use objects that allow hot and cold water mixing at the tap, zone latent gains, drainwater heat recovery, and stand-alone or plant loop operation
- Rainwater collectors for harvesting precipitation
- Groundwater wells with pumping
- Water storage tanks for storing and reusing reclaimed water to/from end-uses, HVAC components, rainwater collectors, and groundwater wells

OUTPUT
- New predefined reports to aid in complying with standards and beyond-code programs such as the new high performance commercial building tax deduction:
  - Input Verification and Results Summary
  - Climate Summary
  - Equipment Summary
  - Envelope Summary

UTILITIES
- EP-Launch has new options to support:
  - Converting report variable and meter results to IP units
  - Options centralized in a new Options dialog box
  - Supports new output files including SCREEN, SHD and VRML
Software news

DOCUMENTATION AND GUIDES

- Input/Output Reference and Engineering Reference updated and extended for all new features and updates. Total documentation exceeds 3000 pages.
- And many other enhancements 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.
Announcements

Results of the California CEUS (Commercial End-Use Survey)

The California Commercial End-Use Survey (CEUS) project was a massive effort initiated by the California Energy Commission (CEC) to gain detailed knowledge of end-use energy use in commercial buildings in California. The study was implemented by Itron with major support provided by KEMA, ADM Associates, and James J. Hirsch & Assoc. Anticipated applications of the study results were energy forecasting, benchmarking, energy efficiency potential, and quick-response special focused studies and analysis. California’s four investor-owned utilities and one large municipal utility participated in the study. The basic approach of the CEUS project was:

- Collect detailed building shell, equipment, and operation information via an onsite survey for 2,790 commercial premises across the state.
- Use that data and an automated system designed by Itron (DrCEUS) to create detailed end-use building simulation models (eQUEST/DOE2.2), and calibrate those models using all available information including monthly billed electric and natural gas consumption, time-of-use logger data for lighting and HVAC fans, and interval metered data.
- Use utility billing data to construct a population frame from which a statistically valid sample of premises could be drawn, and which could be used to develop representative weights for each surveyed premise.
- Construct segment-level results by aggregating the weighted premise-level results, and make those results available for the various applications.

Results of the study are presented for the four utility service areas and twelve conventional building types: Small Office, Large Office, Restaurant, Retail, Food/Liquor, Unrefrigerated Warehouse, Refrigerated Warehouse, School, College, Health Care, Lodging (Hotel/Motel), and Miscellaneous. Electric and natural gas energy intensities, end-use intensities, and fuel shares are presented for three HVAC end uses (cooling, heating, ventilation) and 10 nonHVAC end uses (inside lighting, outside lighting, water heating, office, refrigeration, cooking, process, motors, air compressors, miscellaneous). Although premise-level data from the study is not publicly available, the CEUS report and appendices can be downloaded from the CEC website, www.energy.ca.gov/ceus/index.html. Additional information about the study can be obtained by contacting Tom Mayer (tom.mayer@itron.com) or Bob Ramirez (bob.ramirez@itron.com).
REHVA Guidebooks

REHVA, founded in 1963, is a European organization, connecting European professionals in the area of Building Engineering Services. REHVA represents more than 110,000 building engineers from 30 European countries. Its mission is to develop and disseminate economical, energy efficient and healthy technology for mechanical services of building; to serve its members and the field of building engineering (heating, ventilating and air-conditioning).

REHVA has published a number of guidebooks, described below.

1: Displacement Ventilation in Non-Industrial Premises
Håkon Skistad (ed)
Elisabeth Mundt
Peter V. Nielsen
Kim Hagström
Jorma Railio

Research, development and use of displacement ventilation, mainly confined to Scandinavian countries, is now gaining popularity in other countries as well.

The guidebook serves as a comprehensive and easy-to-understand design manual. The book explains the benefits and limitations of displacement in commercial ventilation and outlines where ventilation should be applied. Case studies for a restaurant, office cubicle, auditorium, meeting room and classroom are included. With displacement ventilation, warm contaminants rise to the ceiling, the contaminated air is extracted and fresh, cool air is supplied at floor level. Displacement ventilation has two main advantages over traditional mixing systems. First, it ensures improved indoor air quality throughout occupied spaces and removes more contaminants at high level than conventional mixing air distribution systems. Second, as an efficient use of energy due to its capability to remove exhaust air from the room at a higher temperature than that in the occupied zone, this strategy allows a higher inlet temperature for the same internal heat gain/load. Benefits are that less cooling is needed for a given temperature in the occupied spaces, longer periods with free cooling and better air quality in the occupied spaces.

The book also points out the limitations of displacement ventilation. The technique is no marvel that can solve all ventilation problems, but a principle that has definite advantages when applied correctly.
Ventilation effectiveness is the common notion for the indices used to characterize the ability of a ventilation system to exchange the air in the room and the ability of a ventilation system to remove air-borne contaminants. Improving the ventilation effectiveness allows the indoor air quality to be significantly enhanced without the need for higher air changes in the building, thereby avoiding the higher capital costs and energy consumption associated with increasing the ventilation rates. This guidebook does not only present the practical research on ventilation effectiveness, but also illustrates its application with case studies.

This guidebook is aimed at practising, consulting and contracting engineers. It provides easy-to-understand descriptions of the indices used to measure the performance of a ventilation system and which indices to use in different cases. It also demonstrates how to measure ventilation effectiveness in practice. Use of tracer gases, measurement equipment and how to perform measurement and calculations are introduced. Eight practical case studies are also presented and discussed.

An Electrostatic Precipitator is a device that collects particles from air or flue gas by electrostatic forces. The ESP’s discussed in this book are all for industrial processes. Indoor small units for purification of ambient air are not covered. In the early days ESP’s were developed for recovery of precious material, e.g. Cu, Ni and Zn. Environmental aspects are however the main focus today. This guidebook is aimed at the practising, consulting and contracting engineers. It provides basic knowledge of the physics and power supplies of Electrostatic Precipitators (ESP’s), practical aspects of ESP design, and examples of typical applications of ESP’s. ESP’s are characterised by low-pressure drop and very high capture efficiencies and very low power demand. They can be built for operation at high temperatures, 400 °C and above with help of special steel. Today’s
environmental legislation requirements are specified as emissions in terms of e.g. mg/Nm³ of flue gas rather than collecting efficiency. Extremely low emissions can be guaranteed for most ESP applications today. The future will see even lower emission guarantees and for many applications the ESP will remain as an important device for the removal of particulate from flue gases.

A conditioning tower. The height of the tower is approximately 30m.

The ESP is 15m long and 20m wide.

4: Ventilation and Smoking
Minimizing the exposure to ETS in buildings
Håkon Skistad and Ben Bronsema
Editors

The topic of this guidebook on ventilation and environmental tobacco smoke is extremely important in respect of indoor air quality, health and energy consumption. REHVA realises that the best protection against environmental tobacco smoke is to ban smoking indoors. But if smoking is allowed indoors, as it is in many countries, ventilation can be effectively used to reduce exposure to environmental tobacco smoke. The purpose of this guidebook is to present the state-of-the-art technology of controlling environmental tobacco smoke indoors. The guidebook presents the latest ventilation technology and illustrates the use of the technology with several practical examples for application. The book is intended for designers, installers, architects, restaurants and building owner. With its illustrations it is also an excellent textbook for vocational training.
Chilled beam cooling is a relatively new technology that has rapidly spread all over Europe. Its advantages are in low noise generation, low room velocities and flexibility. High temperature level of cooling media also improves the energy efficiency of mechanical cooling and allows longer periods of free cooling. The guidebook presents theory on the principles of chilled beam cooling and illustrates its practical applications. The chilled beam systems are primarily used for cooling and ventilation in spaces, where good indoor environmental quality and individual space control are appreciated and where the internal moisture loads are moderate. Chilled beam systems are dedicated outdoor air systems. They can also be used for heating. Active chilled beams are connected to the ventilation ductwork, high temperature cold water and when desired low temperature hot water system. The main air-handling unit supplies primary air into the various rooms through the chilled beam. Primary air supply induces room air to be recirculated through the heat exchanger of the chilled beam. In order to cool or heat the room either cold (14–17 °C) or warm (30–50 °C) water is cycled through the heat exchanger. Recirculated room air and primary air mix prior to diffusion in the space.

Room temperature is controlled by regulating the water flow rate of the heat exchanger.

This REHVA guidebook shows for the first time how to quantify the effects of indoor environment on office work, and also how to include these effects in the calculation of building costs. This is a concerted effort of researchers, engineers and practitioners. Such calculations have not been performed previously, as very little data was available on this issue. In recent years more and more information has become available on this topic. This information has been reviewed during the present work to find out whether there is solid scientific evidence that indoor environmental quality affects office work.

The quantitative relationships presented in this guidebook can be used to calculate the costs and benefits of running and operating the building, as illustrated by several examples. One of the aims of these examples is to emphasize that the costs of running the building are much lower than the benefits from improved office work obtained by reducing temperatures or improving of indoor air quality. This is further presented in the guidebook by comparing the typical costs of wages, and typical energy and operation costs.
Announcements

The main purpose of the guidebook is to increase the awareness of building owners and practitioners to indoor environmental quality and its importance for office work. This is attempted by showing how large profits can be obtained from fairly small investments. Examples on how to convince the client in practice are given.

Additional REHVA guidebooks will be published soon on:

- Low temperature heating
- CFD calculations in ventilation design
- Clean ventilation system

Orders for all Guidebooks can be made on the order form that can be found on the REHVA web site at www.rehva.com.

Job opportunities at Lawrence Berkeley National Lab

Lawrence Berkeley National Laboratory (Berkeley Lab) has been a leader in science and engineering research for more than 70 years. Located on a 200 acre site in the hills above the University of California’s Berkeley campus, adjacent to the San Francisco Bay, the Lab is managed by the University of California, operating with an annual budget of more than $500 million and a staff of about 3,800 employees, including more than 500 students. As a University of California employee, you will enjoy a generous benefits
package, including a choice of several health insurance plans, comprehensive dental coverage, generous leave and retirement benefits, and vacation, sick leave and paid holidays.

Building Science Research Positions
Join one of the leading international building science teams to develop the next generation of simulation tools for design, analysis and operation of low-energy buildings. Tackle the nation’s most pressing energy challenges in collaboration with over 200 other building science researchers and their industry partners to help develop and deploy the next generation of high performance, low-energy building solutions.

GROUP LEADER, SIMULATION RESEARCH GROUP
Computational Staff Scientist/Program Manager III- Job number 017753

Position summary
This person will lead the research and development activities of the Simulation Research Group (SRG) within the Building Technologies Department (BTD) of the Environmental Energy Technologies Division (EETD). This building science modeling group is developer or co-developer of several widely-used building energy analysis software tools, including EnergyPlus, DOE-2, SPARK, and GenOpt. This is an opportunity to help define and implement the next generation of advanced energy simulation tools designed to enhance the design and operation of energy efficient buildings. This position will be filled as either a Staff Scientist or a Program Manager.

Qualifications
Essential -- Advanced degree or equivalent experience in computational science, engineering, architectural engineering or related building science field. Three or more years experience in developing mathematical models for state of the art building energy simulation models, preferably in the HVAC area, and implementing these models in computer code. Demonstrated experience with management of successful software development efforts, including quality assurance and documentation of computer code for building energy analysis. Strong working knowledge of one or more programming languages, preferably Fortran90 and/or C/C++. Demonstrated ability to effectively manage project teams and to coordinate development with diverse technical partners. Demonstrated financial and administrative skills to manage group budgets and subcontracted efforts. Excellent verbal and written communications and presentation skills.
BUILDING ENERGY SOFTWARE ENGINEER
Research Associate Senior - Job number 019314

Position summary
The Simulation Research Group develops simulation tools to analyze building energy performance. Tools developed include DOE-2, Spark, and Genopt with a current focus on the EnergyPlus program. The successful applicant will join the Simulation Research Group to help develop future versions of EnergyPlus and related software. As part of the EnergyPlus development team this is an opportunity to actively develop new software that will enable the design, analysis, and operation of very low energy buildings. The applicant will be expected to become a skilled EnergyPlus and Spark modeler in support of performance analysis of innovative, low energy building designs and related control strategies. The applicant will be expected to modify, enhance, expand LBNL’s current hardware-in-the-loop virtual building simulation setup and develop models for use in model-based fault detection and diagnosis.

Qualifications
Essential - Advanced degree or equivalent experience in computational science, engineering, architectural engineering or related building science field. Two or more years of experience in developing mathematical models for state of the art building energy simulation models, preferably in the HVAC area, and implementing these models in computer code. Strong working knowledge of one or more programming languages, preferably Fortran90 and/or C/C++. Demonstrated ability in using either whole building energy analysis programs (such as EnergyPlus, DOE-2, ESP, eQuest) or general nonlinear differential/algebraic solvers (Spark, TRNSYS, EES, HVACSIM+, DASSL). Excellent verbal and written communications and presentation skills. Good working knowledge of at least one of the following: HVAC system design and operation; building controls; building operations.

HOW TO APPLY
PREDICTION OF HYDROThERMAL ENVIRONMENT OF BUILDINGS
BASED UPON COMBINED SIMULATION OF HEAT
AND MOISTURE TRANSFER AND AIRFLOW

Akihito Ozaki¹ and Tatsunori Tsujimaru²

¹Associate Professor, Faculty of Environmental Engineering,
University of Kitakyushu, Japan, Ph.D
²Graduate Student, Graduate School of Environmental Engineering,
University of Kitakyushu, Japan

ABSTRACT

The hygrothermal environment of the Japanese traditional house constructed by wet process with clay wall and the recent house constructed with industrial building materials are estimated through the interrelated simulation of heat and moisture transfer and airflow using THERB. Thermal theories on conduction, convection, radiation and ventilation of THERB are outlined, particularly algorithm on combined heat and moisture transfer based on thermodynamics. The consequences of this paper highlights that an indoor humidity variation is largely affected by sorption and desorption of walls, the excessive dryness during heating condition can be alleviated by increasing moisture capacity for interior finish material, and THERB has a capability to predict temperature and humidity conditions of buildings.

INTRODUCTION

Japanese houses of recent years tend to be insulated and built airtight to improve indoor thermal environment and to decrease heating and cooling load, and putting more emphasis on handiness in construction and certainty of precision, the building method and materials have both changed from the traditional house of wet type with clay wall to the house of dry type in which industrial building materials such as ceramic siding and plasterboard are used.

Due to the enforcement of the “Energy Conservation Standard for Housing” and the “Housing Performance Indication Law” in Japan, insulation and air-tightness have been all the more emphasized, and concomitantly, the qualitative descriptive explanation in the past about the housing thermal performance has shifted to numerical quantitative evaluation. As a result, insulation and air-tightness have drastically advanced, and yet, the performance is indicated by “specification standard” or “thermal loss coefficient” without reflecting ventilation, solar heat gain, thermal storage in building frame, and internal heat generation from dynamic heat transfer phenomena from human living.

In addition, the factors significantly interconnected to the comfort such as indoor humidity variation with moisture sorption and desorption of walls and thermal radiation have also been disregarded. In other words, the characteristics as variation in temperature and moisture property, specific to the individual construction method and building materials used for wet and dry types respectively have not been taken into account. This has slashed demand for the wet construction method and exponentially driven up contrariwise the demand for dry method.

It has been generally evaluated that although the wet construction method is excellent in heat storage and moisture sorption and desorption of walls (constant or equilibrium temperature and humidity) compared to the dry method, it is very limited in energy conservation due to inferior insulation and airtightness.

In the following, the hygrothermal environment and energy conservation of the wet and dry methods respectively are examined to compare the hygrothermal performance of both houses on an interrelated simulation of heat and moisture transfer and airflow by employing THERB.

SIMULATION SOFTWARE OF HYDROThERMAL ENVIRONMENT

A Heat, Air and Moisture (HAM) simulation software program called THERB has been developed for the purpose of estimating the hygrothermal environment within buildings. This software has complete HAM features including principles of moisture transfer within walls and has been validated through the standardized test in Japan like BESTEST procedure. THERB is one of the official software approved by Japanese government.

Generally simulation software to predict temperature, humidity, heating and cooling load of building spaces does not take into account moisture transfer in wall assemblies. Humidity calculation in most software is simply affected by ventilation and focuses on just the building spaces. THERB was developed to simulate humidity conditions in both building spaces and wall assemblies in detail.
Thermal theories on conduction, convection, radiation and ventilation are based upon the detailed phenomena. The P-model using the water potential, which is defined as thermodynamic energy, is a progressive feature of THERB, which incorporates moisture transfer including moisture sorption and desorption of walls. Thus THERB can predict the hygrothermal environment of the whole building taking into consideration the complex relationship between heat and moisture transfer and airflow.

The following outlines the algorithms for heat and moisture transfer used in THERB, which are derived from fundamental building physics principles.

**Theoretical Feature of THERB**

**Conductive Heat and Moisture Transfer:** The finite difference method is applied to the model of one-dimensional transient thermal conduction of multi-layer walls. Regarding thermal conduction to the ground, the finite difference method of two or three dimensions is applied to the previous calculation of the ground temperature and then the results are used as the input excitation for conductive calculation of the earthen floor and basement walls.

Water Potential which is derived by applying the chemical potential of thermodynamics to moisture diffusion is used as the driving force of moisture transfer. This approach is proposed to be more accurate than other models based on physical properties such as vapour pressure. The model called P-model using water potential makes it possible to combine moisture transfer with heat transfer perfectly, and take into account internal energy and external forces such as gravity.

Balance equations of heat and moisture transfer in material is obtained as follows.

- **Heat Balance**

  \[
  \frac{\partial C \rho T}{\partial t} + c_w \rho_w j_w \nabla T = \nabla \lambda \nabla T + r_s \nabla \lambda^*_g \nabla (\mu + \mu_j) \quad (1)
  \]

- **Moisture Balance**

  \[
  \rho_w \frac{\partial \phi}{\partial t} + \lambda \frac{\partial \mu}{\partial t} = \nabla \lambda \nabla (\mu + \mu_j) + \nabla \lambda^*_g \nabla (\mu + \mu_j) \quad (2)
  \]

where \( C \) and \( \rho \) are specific heat and specific weight of material containing water. \( c_w, \rho_w \), and \( j_w \) are specific heat, specific weight and flux of liquid phase water. \( \lambda \) is thermal conductivity. \( \lambda^*_g \) and \( \lambda^*_s \) are gaseous and liquid phase water conductivity for \( \mu_w \) and \( \mu \) gradients. \( r_s \) is heat of sorption (= latent heat of evaporation).

\( \mu_w \) is the water potential and defined from the basic thermodynamic principles as Eq.(3) to Eq.(5). The water potential is composed by saturated water potential \( \mu^*_w \) and unsaturated water potential \( \mu \). \( \mu^*_w \) expresses the thermodynamic energy of saturated vapour and \( \mu \) expresses the difference of thermodynamic energy between saturated vapour and unsaturated vapour of moisten air.

\[
\mu_w (p, T) = \mu^*_w (T) + \mu (p) \quad (3)
\]

\[
\mu^*_w (T) = 6.44243 \times 10^5 + c_{p,y} (T - 273.15)
\]

\[
- Tc_{p,y} \ln \frac{T}{273.15} + R_{s,y} \frac{T}{1.01325 \times 10^5} \quad (4)
\]

\[
\mu (p) = R_{s,y} T \ln \frac{p_w}{p} \quad (5)
\]

where \( p_w \) is the vapor pressure of the humid air, and \( p_s \) is the saturated vapor pressure at temperature \( T \). \( c_{p,y} \) is the specific heat which is expressed in units of \([J/(kg \cdot K)]\) and \( R_{s,y} = 461.50 \ [J/(kg \cdot K)]\) which is calculated by dividing the gas constant \( R = 8.31441 \ [J/(mol \cdot K)]\) by the molecular weight of water 18.016x103 [kg/mol].

\( \mu_j \) is the force water potential caused by internal energy and external forces. For instance, the force water potential which includes the influences of gravity and internal pressure is calculated by Eq.(6).

\[
\mu_j = g_z + p F_w \quad (6)
\]

where \( g \) is gravitational constant, \( z \) is height from reference position, \( F_w \) is the volume per unit weight of water, and \( p F_w \) is equal to \( R_{s,y} T \).

**Convective Heat and Moisture Transfer:** By default, the convective heat transfer coefficients are recalculated at every time step on all surfaces of the exterior, interior and cavities of buildings using dimensionless equations which are derived from either the profile method for boundary layer (based on the energy equation, the momentum equation and the fluid friction) or defined from the experimental findings according to natural or forced convection. Furthermore the natural convective heat transfer coefficients are classified into either vertical or horizontal surfaces. It is possible to use the
functional equations of the wind direction and velocity for the exterior convective heat transfer coefficients and the functional equations of the temperature difference between surface and room for the interior convective heat transfer coefficients. It is also possible to set constant heat transfer coefficients day long or modify the coefficients to take into consideration space conditioning time for every part of the building.

Table 1 Convective Heat Transfer Coefficient

<table>
<thead>
<tr>
<th>Part of Buildings</th>
<th>Dimensionless Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior</td>
<td>$Nu = 0.037$ Re$^0.8$ Pr$^{1.7}$</td>
</tr>
<tr>
<td>Interior (Vertical Plane)</td>
<td>$Nu = 0.241 (Gr_r \cdot Pr)^{0.4}$</td>
</tr>
<tr>
<td></td>
<td>$Gr_r = g \beta \Delta T_e l^3 / \nu^2$</td>
</tr>
<tr>
<td>Interior (Horizontal Plane)</td>
<td>&quot;$Nu = C \cdot Ra_f^m$</td>
</tr>
<tr>
<td></td>
<td>$Ra_f = Gr_r \cdot Pr$</td>
</tr>
<tr>
<td></td>
<td>$f = (T_e + T_s)/2$</td>
</tr>
<tr>
<td>Downward</td>
<td>C=0.54, m=1/4 (Ra$_f$ = 8E6 to 1E11)</td>
</tr>
<tr>
<td>Cavity (ventilated)</td>
<td>$Nu = 0.023$ Re$^{0.8}$ Pr$^{0.4}$</td>
</tr>
<tr>
<td>Cavity (closed)</td>
<td>$Nu = 0.035 (Gr_r \cdot Pr)^{0.38}$</td>
</tr>
<tr>
<td></td>
<td>$Gr_r = g \beta \Delta T_e l / \nu^2$</td>
</tr>
</tbody>
</table>

Gr: Grashof number, Nu: Nusselt number, Pr: Prandtle number, Ra: Rayleigh number, Re: Reynolds number, $\Delta T_e$: temperature difference between surface and air, $\Delta T_s$: temperature difference between surfaces, $g$: gravitational constant, l: length, $\beta$: expansion coefficient, $\nu$: kinematic viscosity.

The convective moisture transfer coefficients on all surfaces of the exterior, interior and cavities of buildings are calculated from the dimensionless Sherwood number, which is derived on the basis of the analogy between heat and mass transfer. The Sherwood number can be calculated by replacing the Prandtle number with Schmidt number shown in Table 1.

Thus boundary conditions of heat and moisture balance equations are expressed as follows.

- Boundary conditions

$$- \lambda \frac{\partial T}{\partial n} + r_v \cdot \lambda_v \frac{\partial \mu_v}{\partial n} = \alpha_e (T_s - T_e)$$

$$+ r_v \cdot \alpha_v (\mu_{v,i} - \mu_{v,s}) + q_s$$  \hspace{1cm} (7)

$$- \lambda_e \frac{\partial \mu_e}{\partial n} = \alpha'_v (\mu_{v,i} - \mu_{v,s})$$  \hspace{1cm} (8)

where $n_i$ is normal line vector directed inward on a boundary surface, $q_s$ is quantity of radiant heat, $T_s$, $T_e$, $\mu_{v,i}$ and $\mu_{v,s}$ are the temperature and water potential of the air and surface, respectively. $\alpha_e$ is convective heat transfer coefficient and $\alpha'_v$ is convective moisture transfer coefficient for the water potential gradient. $\alpha'_v$ can be calculated from general convective moisture transfer coefficient $\alpha'_v$ for the vapour pressure gradient on the basis of Eq.(3).

$$\alpha'_v = \alpha'_v \left( \frac{\partial p_s}{\partial \mu_v} \right) = \alpha'_v \frac{p_i}{R_w} \frac{e^{\mu_{v,i}}}{T}$$  \hspace{1cm} (9)

Radiant Heat Transfer: On the exterior surfaces of the buildings, the standard method of using the radiant heat transfer coefficients and atmospheric radiation is applied in default. Interrelated radiation between both surfaces of building and the ground can be also calculated with temperature calculation of the ground. On the interior of buildings, instead of the standard method (that is, the calculation of heat transfer between surface and indoor air and radiation between surfaces), the use of the long-wave absorption coefficient makes it possible to simulate a net absorption of radiant heat as a consequence of multiplex reflection among interior surfaces. Mutual radiation between the surfaces of cavities in walls and windows can be also calculated.

Incident Solar Radiation: Incident solar radiation on the exterior and into the interior of buildings is divided into direct and diffuse solar radiation and calculated for all parts of the building in all directions using accurate geometric calculations of

Figure 2 Multiple reflection of long-wave radiation

Figure 3 Geometric calculations of shaded and unshaded portions of the building
shaded and unshaded portions of the building by considering the influence of overhangs and wings. Isotropic model or anisotropic models can be chosen for diffuse solar radiation. Transmitted solar radiation is calculated by the multi-layer window model and considers multiplex reflection (depending on an incidence angle of solar radiation) between not only the glazing layers but also between the window and interior shade at every time step. The multiplex reflection of both direct and diffuse solar radiation among interior surfaces including re-transmission of solar radiation from the inside to the outside through the windows is calculated by using the short-wave absorption coefficient. In addition the absorption coefficients of long and short wave are applied to radiant heat emitted from lights and appliances, etc.

**Ventilation:** The network airflow model integrating a thermal model with a plant model estimates natural and forced ventilation quantities of each zone (rooms and cavities) caused by air leakage, infiltration and mechanical ventilation. As for independent ventilated cavities in the walls, it is possible to estimate airflow quantities by hydrodynamic analysis as the solution to the equations of motion, energy and continuity. Constant ventilation quantities can be also set every hour for all zones.

**Space Conditioning:** Indoor air temperature and humidity can be calculated from heat and moisture balance of a space based on convection, ventilation, internal generation of heat and moisture. By default, indoor humidity is interrelated with sorption and desorption of walls through the application of P-model. General humidity calculation that is just affected by ventilation is also available.

Sensible and latent heat load are obtained from the equations of heat and moisture balance, in which unknown quantities are space heating and cooling load, on condition that temperature and humidity are set at reference ones. Control methods for space conditioning are classified into three types: heating, cooling, and simultaneous heating and cooling. By default, humidity control and temperature control are linked. Temperature and humidity set-point and ranges can be optionally set every hour. Moreover the control of humidity is automatically performed in the case when the sensible temperature such as PMV is set as the set-point of space conditioning.

**HYGROTHERMAL PERFORMANCE OF HOUSES CONSTRUCTED BY DRY AND WET PROCESS**

**Building Model**

Figure 8 and 9, and Table 2 illustrate the 1st and 2nd floor plans and wall assemblies of the building.
Feature: Prediction of hygrothermal environment in buildings

Figure 9 Wall assemblies of building model

Table 2 Wall assemblies of the building model and U values

<table>
<thead>
<tr>
<th>Model</th>
<th>Ceiling</th>
<th>Floor</th>
<th>Exterior wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry type</td>
<td>b.1</td>
<td>0.22</td>
<td>c.1</td>
</tr>
<tr>
<td>Wet type</td>
<td>b.2</td>
<td>2.96</td>
<td>c.2</td>
</tr>
<tr>
<td>Model 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 2</td>
<td>b.3</td>
<td>0.22</td>
<td>c.3</td>
</tr>
<tr>
<td>Model 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[unit: W/(m² K)]
specification for the energy conservation standard and considered as the improved ones from the wet type. The wall composition is clay for model 1 (same as wet type), clay wall with exterior thermal insulation of 25mm silica calcium board for model 2, and a simple wet wall, for model 3, instead of clay wall, of diatomaceous soil for 15mm of surface finish with 10mm plasterboard for interior groundwork, with 60mm rock wool filling insulation inserted in between. The construction method for model 4 is the same as in model 3 except for the altered thickness of the rock wool and diatomaceous soil to 45mm and 30mm respectively.

Calculation Conditions
Table 3 shows the calculation conditions. Here, winter heating load and sorption/desorption performance of wall (alleviation of indoor excess dryness during heating) are examined. The standard weather data in Fukuoka was used for input data, where set-point of temperature for space conditioning is 22 degree with natural humidity (no humidifying) and constant indoor ventilation 0.5 times/hour all day. The space conditioning schedule for a family of 4 is made, and in order to study on the basic performance of the housing, the internal thermal generation from human living and moisture generation were disregarded. Space conditioned rooms are LDK (living room, dining room, and kitchen), a main bedroom and children’s rooms.

**Table 3 Calculation conditions**

<table>
<thead>
<tr>
<th>Weather data</th>
<th>Standard weather data in Fukuoka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run-up</td>
<td>3 months</td>
</tr>
<tr>
<td>Calculation interval</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Set-point of temperature</td>
<td>22 degree</td>
</tr>
<tr>
<td>Heat and moisture generation</td>
<td>none</td>
</tr>
<tr>
<td>Space conditioning time</td>
<td>6-9, 12-13, 17-22 (LDK)</td>
</tr>
<tr>
<td>(Living schedule of a family)</td>
<td></td>
</tr>
<tr>
<td>Air change rate</td>
<td>0.5 times per hour</td>
</tr>
</tbody>
</table>

Heating Load
Figure 10 illustrates comparative values for term heating load for the dry and wet types, and for models 1-4 between December and March. Compared to dry type, the heating load for wet type and model 1 (same clay wall as wet type with heat insulation for floor and ceiling) exceeds by as much as 65% and 37% respectively. The heating load for model 2 (clay wall with 25mm silicate calcium board for exterior thermal insulation) is large compared to dry type, but the difference shrinks to 9%. The overall coefficient of heat transfer (U value) for model 1 and 2 is 1.73W/(m²K) and 0.81W/(m²K) respectively, each of which corresponds to 4.4 and 2.1 times the coefficient of 0.39W/(m²K) for the dry type, thus making the difference of heating load between the dry type and model 2 not very large. Since the room temperature of model 2 during nighttime without heating is higher than that of dry type (refer to Figure 12), it is regarded that the heat storage of wall in daytime due to solar heat gain contributes to the decrease in heating load. This is also clear when model 3 and 4 are compared. The heat transfer coefficient for model 3 and 4 is 0.45W/(m²K) and 0.57W/(m²K) respectively, and despite the fact that the U value for model 3 is smaller, the room temperature of model 4 with higher heat storage shows slightly higher value during nighttime without heating. (The interior for model 3 and 4 is plaster finish, 15mm and 30mm respectively as shown in Figure 9) Consequently, it is regarded that the heating load for both turned out to be the same. Incidentally, since there is not so much difference in the room temperature between wet (clay wall) and dry types, having appropriate exterior insulation looks rather realistic aiming at utilizing the solar heat gain in order to expect the effect from the daytime heat storage.

Indoor Humidity
Figure 11 shows the typical winter weather condition (between January 20 and 22) in Fukuoka, Japan. Figure 12 shows indoor temperature and humidity in LDK for the dry and wet types and for models 1-4. The indoor relative humidity decreases remarkably during heating, and especially the value drops less than 30% for dry type (lowest value 27%) creating excessively dry condition. On the other hand, the relative humidity for the wet type, models 1 and 2 (clay wall for both) roughly shows 40% or more.

Upon comparing the absolute humidity, the dry type shows approximately a constant value but the value for the wet type, model 1 and 2 tends to increase during heating, following the room temperature, and decrease during hours without heating. Due to its sorption and desorption property, the clay wall is effective to regulate the excessive dry condition.
Feature: Prediction of hygrothermal environment in buildings

during winter heating. Incidentally, the indoor absolute humidity for model 2 (with exterior thermal insulation) is 0.4g/kg to 0.8g/kg higher than the wet type and model 1.

The indoor humidity for model 3 and 4 with interior finish of 15 and 30mm diatom soil, respectively, fluctuates in similar manner as wet type. Equivalent effect as clay wall is achieved by using an excellent material in sorption and desorption property for the interior.

Figure 13 illustrates the moisture quantity of sorption and desorption for unit area for the dry, wet, model 3 and 4. The dry type shows nearly no moisture transfer but the wet type evaporates moisture as much as 9.1g/(m²·h) at maximum. Model 3 and 4 evaporate 8.0g/(m²·h) and 8.7g/(m²·h) respectively at maximum. Figure 14 illustrates the frequency distribution of indoor relative humidity for the dry and wet types, and models 1-4 during December and March. The indoor humidity for the dry type concentrates in low humidity zone between 28% and 45% (32% at peak), extremely dry condition. On the other hand, the indoor humidity for the wet type, model 1 and 2 is widely distributed in the mean humidity zone between 40% and 54%. The indoor humidity for model 3 and 4 is also distributed in the mean humidity zone between 37% and 55% with 42% and 45% at peak respectively. The indoor humidity variation is largely affected by sorption and desorption of walls, and the excessive dryness during heating condition can be alleviated by increasing moisture capacity for interior material.

CONCLUSION

In this paper, the hygrothermal environment of houses is estimated by using the simulation software THERB which has been developed to include complete features on heat, moisture and air. Thermal theories on conduction, convection, radiation and ventilation of THERB are outlined, particularly algorithm on combined heat and moisture transfer using water potential (thermodynamic energy).

Then the difference of the hygrothermal environment among the Japanese traditional house (the wet type) constructed by wet process with clay wall, the recent house (the dry type) constructed with industrial building materials, and the simple wet type with higher moisture capacity (interior finish of diatomaceous soil) are compared through the interrelated simulation of heat and moisture transfer and airflow.

The results of the simulation show these major conclusions:

- the indoor humidity variation of the wet type slows down with sorption and desorption of walls
• the wet type and the simple wet type can alleviate excessive dryness during heating condition through sorption and desorption of walls
• the wet type is extremely inferior to the dry type on energy conservation even if thermal storage is taken account of
• THERBB has a capability to predict temperature and humidity conditions in both building spaces and wall assemblies in detail.

Acknowledgment
This paper has been supported by Grant-in-Aid for Scientific Research of Japan Society for the Promotion of Science.

References

Nomenclature
C specific heat [J/(kg K)]
c_{lw} specific heat of liquid phase water [J/(kg K)]
Gr Grashof number [-]
g gravitational constant [m/s²]
j_{lw} flux of liquid phase water [kg/(m² s)]
l length [m]
Nu Nusselt number [-]
Pr Prandtl number [-]
p pressure [Pa]
p_{s} saturated vapour pressure [Pa]
p_{w} vapor pressure of the humid air [Pa]
q_{r} radiant heat [W/m²]
Ra Rayleigh number [-]
Re Reynolds number [-]
r_{s} heat of sorption [J/kg]
T temperature [K]
T_{w} mean temperature of cavity surfaces [K]
V_{a} volume per unit weight of water [m³/kg]
z height from reference position [m]
α_{c} convective heat transfer coefficient [W/(m² K)]
α'_{c} convective moisture transfer coefficient for the vapour pressure gradient [kg/(m² s J/kg)]
α''_{c} convective moisture transfer coefficient for the water potential gradient [kg/(m² s J/kg)]
β expansion coefficient [1/K]
Δ T_s temperature difference between surface and air
Δ T_w temperature difference between cavity surfaces
ϕ water content [m³/m³]
λ thermal conductivity [W/(m K)]
λ_{g} gaseous phase water conductivity [kg/(ms J/kg)]
λ_{lw} liquid phase water conductivity [kg/(m s J/kg)]
µ unsaturated water potential [J/kg]
µ_{f} force water potential [J/kg]
µ_{w} water potential [J/kg]
µ''_{w} saturated water potential [J/kg]
ν kinematic viscosity [m²/s]
ρ specific weight [kg/m³]
ρ_{lw} specific weight of liquid phase water [kg/m³]
DISTRICT LEVEL ENERGY MANAGEMENT USING A BOTTOM-UP MODELING APPROACH

Y. Yamaguchi\textsuperscript{1}, J. L. M. Hensen\textsuperscript{2}, Y. Shimoda\textsuperscript{1}, T. Asai\textsuperscript{1}, and M. Mizuno\textsuperscript{1}
\textsuperscript{1} Division of Sustainable Energy and Environmental Engineering, Graduate School of Engineering, Osaka University, 2-1 Yamada-oka, Suita, Osaka 565-0871, JAPAN
yamaguchi@ees.env.eng.osaka-u.ac.jp
\textsuperscript{2} Center for Building & Systems TNO - TU/e, Technische Universiteit Eindhoven
P.O. Box 513, 5600 MB EINDHOVEN, Netherlands, http://www.kcbs.nl

ABSTRACT

An efficient urban energy system could be a highly diverse and well-integrated structure of buildings and systems. Such a structure needs an energy management framework capable of providing information on appropriate energy saving measures at any scale of implementation. This paper proposes a method to design such a framework. For quality assurance, a method to deal with the uncertainty in building properties and in operational conditions of buildings and systems is designed into the framework in order to model the energy use during the operation phase of buildings.

INTRODUCTION

A transition to sustainable urban energy systems will require a well-integrated structure on all levels; from the equipment level, via the whole building and systems level, to the neighborhood and city level. Jaccard et al. (1997) explains the concept of community energy management (CEM) that encompasses land use planning, transportation management, site design, and local energy generation and distribution planning. They showed how large impact a CEM can have on energy consumption and emission of CO\textsubscript{2} and NO\textsubscript{x}. Additionally, many researchers have recently turned their attention to local energy generation and distribution planning based on the growing recognition of its benefit. For example, according to simulation results by Burrr et al. (2003), a district heating and cooling (DHC) system integrating a solid oxide fuel cell and gas turbine combined cycle could potentially reduce CO\textsubscript{2} emission by 50\% compared to a conventional system. Yamaguchi et al. (2004) shows that implementation of the distributed generation technology in a centralized plant that supplies cooling and heating energy and electricity to a small number of neighboring buildings is more energy efficient and cost effective than separate implementations of this technology in individual buildings. From simulations based on practical operational conditions derived from field measurements, Shimoda et al. (2005) concludes that DHC systems are more energy efficient than systems individually embedded in each building.

In the current study, what we mean by district-scale energy management (DEM) is the energy management encompassing the site design and local energy generation and distribution planning at a scale from the building to neighborhood and district.

Implementation of DEM does not necessarily result in installation of a large-scale energy infrastructure. Rolfsman (2004) shows that, depending on the building characteristics, investment in building insulation could be a better solution than investment in district scale energy generation and distributions systems. The essence of DEM is to adopt appropriate measures according to the characteristics of buildings and the district as a whole. The net result will be a highly diverse and well-integrated structure of buildings and systems. Thus, DEM heightens the need for an energy management framework capable of carrying out the following tasks:
- modeling the total energy use in buildings with a sufficient resolution, and
- comprehensively evaluating various kinds of energy saving measures at various scales.

These two tasks are strongly related to each other. Understanding the structure of the energy use contributes to raising the quality of evaluation while the resolution at which the energy use is modeled depends on the evaluation task.

However, traditional approaches to model the energy use on a large-scale fail for the first task. Thus, these approaches are not suitable as basis for the management framework. In one traditional approach, the fixed demand per unit floor area or per household, given by field measurements of representative buildings, are used as the heat and electricity demand of buildings to simulate the total energy use. In another approach (Huang et al. 1991, Jones et al. 2001, Clarke et al. 2003, Shimoda et al. 2004) a number of prototypical building models are used as follows:
1) designing building prototypes each representing a building stock category with particular characteristics in terms of energy use,
2) performing simulations using these prototypical building models as input in order to predict the energy use in each building stock category, and
aggregating the total energy use by summing up the predicted energy use of all building stock categories.

Usually, this approach does not consider many building properties as determinants of energy use. This is especially so in case of commercial sector buildings. A very limited number of prototypical building models have been developed in earlier studies (mostly three or four per sector), mainly as it is practically impossible to collect detailed data on buildings (Jones et al. 2001). The framework for DEM, which will be applied to a local problem, requires a more detailed consideration of energy use in buildings, thus results in the need of redesigning it.

On the other hand, for quality assurance (Hensen et al. 2004) of a simulation task, a useful procedure to ensure the quality of simulation results has been established. Djunaeddy et al. (2003) proposes a methodology (Coupling Procedure Decision Methodology: CPDM) to select a proper model resolution for a given problem. This CPDM mainly focuses on uncertainty, which arises from simplifications in the models that are used. By following the CPDM, we can reduce the uncertainty to an acceptable level by addressing the problem with a higher resolution model than the original one, in case the uncertainty due to the original model would be significant.

The concept of the CPDM in order to maintain the quality of the results can be used in the development of the DEM framework so that it will provide reliable information. For this purpose, the methodology has to be applied not only to gathering information on building properties by a simple survey, but also to preparing more detailed information by measurements to find out, for example, how the target buildings are operated and whether components of the HVAC system are properly designed and operated as a whole.

The current paper proposes a quality assurance procedure in the context of developing the DEM framework. This procedure employs a parameter screening technique (Wit 1997) to decide the aspects that need particular attention when modeling the energy use in buildings. The final part of this paper shows a demonstration of the framework.

FRAMEWORK FOR DISTRICT SCALE ENERGY MANAGEMENT

The energy management framework has to focus on the energy use during the operation phase of buildings. In order to evaluate various energy saving measures, building and system modeling and simulation is very useful. During the design phase of buildings, simulations are carried out using low-level data, such as coarse building properties for peak cooling and heating load calculations or fixed demand per unit floor area for the selection of energy supply systems. On the contrary, the model for predicting energy use during operation phase needs relatively high-level data, which may be influenced by, for example:

- operational conditions of buildings (such as behavior of occupants, operation hours of HVAC systems, and type and density of office equipment)
- uncontrolled heat losses/gains from heating/cooling distribution systems (duct and pipes)
- energy increase due to inappropriate design and operation of HVAC systems (e.g. if the inlet/outlet temperature difference of chilled/hot water does not reach the design value, the number of heat source machines operated will increase, thus causing the heat supply efficiency to deteriorate due to a lower part load ratio).

Although to correctly incorporate such factors would require certain field surveys and/or measurements, it is important to provisionally take these factors into account in the model of the energy use and the sequel evaluation task. Unfortunately, it is not exactly clear which factors would bridge the gap between simulation and reality and would have to be dealt with in the energy management framework.

Uncertainty has traditionally been established by sensitivity analysis (Macdonald et al. 2001). Wit (1997), however, introduced a screening technique (factorial sampling method: FSM) to specify those model input parameters that have a large influence on the simulation outputs. In order to address the problem described above, we adopted FSM in a simulation model (Yamaguchi et al. 2003) in which we assumed uncertainty in both the input parameters related to construction properties and to the actual operation of the buildings and systems. According to the impact of the uncertainty on the operational energy use we designed the method to deal with uncertainty during the implementation of DEM.

Firstly, some important parameters can be gathered just by a simple survey of the building properties database. Next, additional important parameters can be identified from a relatively difficult field survey and/or measurements. In cases, however, where addressing these uncertainties a priori is infeasible, possibly because of lack of detailed information on building properties or lack of resources (e.g. time and money), the influence of these uncertainties is taken into account at the stage of evaluation of the simulation outputs.

Thus, model input parameters are categorized into the following four groups according to importance and data availability:
Feature: District level energy management

1) parameters stored in the building properties database,
2) parameters resulting from a field survey and/or measurements,
3) parameters of which the uncertainty has to be addressed in the stage of evaluation of simulation results, and
4) parameters of which the uncertainty can be ignored.

This approach could be practically feasible, as the DEM is implemented in a relatively small area covering a few neighborhoods where relatively detailed data could be available.

Problem statement

In this paper, we develop the framework to model the energy use for cooling and heating as a case study. To investigate the important uncertain factors, we identified three typical cooling and heating generation, distribution and delivery systems relating to different scales (room, building and (small) district) as shown in Figure 1. Each system requires different consideration of the uncertain factors. For example, a local (distributed) air-conditioning system that supplies cooling and heating to a specific thermal zone, may be strongly influenced by the thermodynamic characteristics of the room. On the contrary, central HVAC systems and DHC systems may be less influenced by the local thermodynamic characteristics since the loads from rooms and buildings are aggregated and thus averaged out. In such systems, the characteristics of the actual heat delivery itself may more significantly influence the system performance.

According to the scheme indicated in Figure 1, we carried out four parameter screenings. The purpose of the first screening is to understand the influence of building properties on the thermodynamic characteristics of rooms. Then, in addition to building properties, parameters relating to system alternatives were examined in order to specify the influence of uncertainty in those parameters on system performance indicators. Based on the results, the parameters were categorized into four groups as explained above by following the procedure shown in Figure 2.

Factorial sampling method (FSM)

FSM is a useful technique for finding parameters that have a large influence on the outputs of a simulation model with a large number of input parameters. In this study, we used the FSM procedure as suggested by Wit (1997).

In this procedure, we only used the two extreme values of each parameter range. These values are labeled as ‘OFF’ and ‘ON’. Initially, all parameters are set to ‘OFF’. Then one parameter is randomly selected and its value is changed to ‘ON’. This parameter’s elementary effect (change in the output solely due to changing the selected parameter) can be observed by comparing the simulation outputs with the two sets of input parameters. Next, another parameter is randomly selected without changing the values of any other parameter to observe the elementary effect of the secondly selected parameter. This process is repeated until the values of all considered parameters have been changed to ‘ON’. Repeating this observation of elementary effects $m$ times then results in a set of elementary effects $F_i^r$ ($r = 1$ to $m$) for parameter $i$. The mean value and
standard deviation of the elementary effect can be used as an indication for the influence of uncertainty in a particular parameter on the simulation output. A large mean value means that parameter $i$ affects the output significantly on its own. A large standard deviation means that the influence of parameter $i$ varies according to the value of other parameters. In order to show the influence quantitatively, the following definition was used in this paper:

$$R_{ei} = \frac{|d_{ei}| + 2 \cdot S_{ei}}{\text{Mean}_n}$$  \hspace{1cm} (1)

where $d_{ei}$ and $S_{ei}$ are the estimated mean and standard deviation of the elementary effect of parameter $i$ on a performance indicator $n$, while Mean$_n$ is the mean value of the performance indicator observed in the screening process. As $2S_{ei}$ would represent half of the 95% confidence interval if the elementary effect would have a normal distribution, the numerator represents the possible change due to parameter $i$. Thus, $R_{ei}$ is a non-dimensional value that represents the estimated influence of the uncertainty in the input parameters on the performance indicator.

First screening - influence of building properties on thermodynamic characteristics of rooms

In the first parameter screening in Figure 2, thermal building simulation was performed for a building with a floor plan as illustrated in Figure 3. This is the second floor of a 3-story-building of which all are operated similarly. The building properties and parameter screening results are summarized in Table 1. The elementary effect of these parameters are indicated with ‘+’ and ‘-’ marks. The direction of change (+ or -) follows the sign of $d_{ei}$, while the number of marks indicates the extent of the influence given by the size of $R_{ei}$. These results help to understand how building properties affect the performance of HVAC systems.

Parameter screening for 3 kinds of HVAC system

Starting from the above first parameter screening, we carried out three more parameter screenings for the HVAC systems as shown in Figure 2. We selected heat pumps or compression chillers driven by electricity (Table 2) for the parameter screenings, as their coefficient of performance (COP) is more

---

**Table 1 building properties and result of parameter screening**

| Index | Description of parameters | Values at OFF and ON | Cooling$^1$ | Heating$^2$ | HVAC ratio$^3$
|-------|---------------------------|---------------------|------------|------------|----------------
| 1     | thickness of concrete layer in outside wall | 150mm | 225mm | ++++ | ++ | +++ |
| 2     | thickness of insulation in outside wall | 0mm | 25mm | ++ | ++ | +++ |
| 3     | height of floor | 3.6m | 4.2m | ++ | ++ | +++ |
| 4     | thickness of concrete layer in floor slab | 150mm | 225mm | ++ | ++ | +++ |
| 5     | area of window on facade | 20% | 40% | ++ | ++ | +++ |
| 6     | kind of window | normal glass | pair glass with thermal insulation | ++ | ++ | +++ |
| 7     | length of overhang | 0.05m | 1m | ++ | ++ | +++ |
| 8     | radiation emissivity of outside wall | 90% | 80% | ++ | ++ | +++ |
| 9     | solar absorbance of outside wall | 0.8 | 0.25 | ++ | ++ | +++ |
| 10    | thermal conductivity of insulation | 0.028W/m°C | 0.035W/m°C | ++ | ++ | +++ |
| 11    | air change ratio due to infiltration | 0.2ACH | 0.5ACH | ++ | ++ | +++ |
| 12    | sensible heat capacity of rooms | 40k/J/m³°C | 60k/J/m³°C | ++ | ++ | +++ |
| 13    | schedule of occupants | with overtime working | without working | ++ | ++ | +++ |
| 14    | light wattage | 20W/m² | 14W/m² | ++ | ++ | +++ |
| 15    | number of occupants | 0.15 person/m² | 0.1 person/m² | ++ | ++ | +++ |
| 16    | internal heat gain from office equipment | normal setting | 2 times large setting | ++ | ++ | +++ |
| 17    | convection/radiation split ratio of heat gain fr. office equipment | 0.8 to 0.2 | 0.6 to 0.4 | ++ | ++ | +++ |
| 18    | set point temperature of conditioned rooms | 26°C (cooling), 20°C (heating) | 28°C (cooling), 20°C (heating) | ++ | ++ | +++ |
| 19    | air supply temperature for cooling | 15°C | 13°C | ++ | ++ | +++ |
| 20    | efficiency of total heat exchanger | 60% | 30% | ++ | ++ | +++ |
| 21    | quantity of outdoor air intake | 5m³/m² hour | 7m³/m² hour | ++ | ++ | +++ |
| 22    | adoption of natural ventilation | No | Yes | ++ | ++ | +++ |
| 23    | operation hours of HVAC systems | 8 a.m. to 18 p.m. | 8 a.m. to 22 p.m. | ++ | ++ | +++ |
| 24    | interruption of direct solar radiation by neighboring buildings | No interruption | Interrupted on 2 sides of outside wall | ++ | ++ | +++ |

$^1$ and $^2$ The "total" and "peak" is the annual load and peak load, respectively.
$^3$ HVAC ratio is the ratio of the annual heating and cooling loads (heating / cooling).
$^4$ The number of ‘+’ and ‘-’ marks is decided as follows: (1:R$_{ei}$ > 2.5%; 2:R$_{ei}$ > 5; 3:R$_{ei}$ > 10%; and 4:R$_{ei}$ > 20%)
Feature: District level energy management

sensitive to part-load operation than other systems such as absorption chillers. Thus, the results of these parameter screenings would be applicable to different system alternatives. Table 3 shows the definition of examined parameters relating to system alternatives.

In these screenings, the parameters listed in Table 4 were examined in terms of the following performance indicators:
- COP of the heat generation system (annual cooling and heating demand / annual primary energy consumption of the heat generation system),
- peak electricity load,
- total annual primary energy consumption for heat generation and distribution.

Table 4 shows the influence of each parameter on these performance indicators in the same way as the first parameter screening. For each system, a few building configurations were considered. The influence of the building configuration (size and zoning, index 25 and 26) are shown in Table 4 by using ‘+’ instead of ‘+’ and ‘-’ marks. For the D-AC system, some cells contain both ‘+’ and ‘-’ marks, indicating that the parameter works either positively or negatively on the indicator depending on the building configurations. (Note that we assumed two buildings for the DHC systems.)

Table 4 also contains the following information in three columns from ‘Kind’ to ‘Category’:
1) whether uncertainty arises from building properties or from the operation of buildings and systems (P or O),
2) the difficulty of field survey and measurements,
3) category (A to D) of the way of treating uncertainty in parameters decided by following the flowchart in Figure 2 (explained further on in this paper).

### Table 2 Description of system alternatives

<table>
<thead>
<tr>
<th>Term</th>
<th>System</th>
<th>Heat source machines</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-AC</td>
<td>Distributed air-conditioning system</td>
<td>Air-source heat pumps driven by electricity</td>
</tr>
<tr>
<td>C or Central</td>
<td>Central HVAC system</td>
<td>Compression chiller, Boiler</td>
</tr>
<tr>
<td>DHC</td>
<td>District heating and cooling system</td>
<td>Compression chiller, Boiler</td>
</tr>
</tbody>
</table>

### Addressing the source of uncertainty

The variance of the performance indicators obtained in the parameter screenings indicates how strongly the uncertainty in parameters affects the simulation outputs. Figure 4 shows the maximum and minimum values and the 95% confidence interval for the performance indicators. It can be seen that the variance is so large that the uncertainty would conceal the effect of energy saving measures if the model would be used for evaluating these. In order to avoid the situation in which introduced energy saving measures will not function well due to the unexpected characteristics of buildings and systems, the source of uncertainty in the model has to be appropriately addressed during the implementation of DEM.

In order to deal with the uncertainty, we observed the

### Table 3 Parameters relating to system alternatives

<table>
<thead>
<tr>
<th>System alternative</th>
<th>No</th>
<th>Description</th>
<th>Values at ‘OFF’ and ‘ON’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributed AC system</td>
<td>30</td>
<td>grade of rated COP</td>
<td>COP = 2.6 for cooling, 3.1 for heating</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>heat loss from refrigerant pipeline</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>air short circuit around the outside unit</td>
<td>no consideration</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>deterioration of rated COP</td>
<td>no deterioration</td>
</tr>
<tr>
<td>Central</td>
<td>34</td>
<td>grade of rated COP for cooling</td>
<td>no deterioration</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>deterioration of rated COP for cooling</td>
<td>no deterioration</td>
</tr>
<tr>
<td>Both in Central and DHC</td>
<td>36</td>
<td>heat loss from duct</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>heat loss from pipe in building</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>temperature fluctuation of returned chilled water</td>
<td>not considered</td>
</tr>
<tr>
<td></td>
<td>39</td>
<td>grade of rated COP for cooling</td>
<td>COP = 5</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>heat loss from district heat delivery pipeline</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>41</td>
<td>pressure loss of heat delivery pipeline</td>
<td>30m (length of pipeline)</td>
</tr>
<tr>
<td>DHC</td>
<td>42</td>
<td>deterioration of rated COP for cooling</td>
<td>no deterioration</td>
</tr>
</tbody>
</table>
Feature: District level energy management

95% confidence interval of the performance indicators as we gradually increased the number of fixed parameters by 5 steps (Case 1 to Case 5). The last 5 columns of Table 4 shows the parameters fixed in each case. Case 1 and Case 2 assume that the energy management framework is based on the traditional approach of using fixed demand per unit floor area. Case 3 assumes the traditional approach of prototypical buildings. Case 4 assumes that certain building properties, which can be gathered by a simple survey, are available. Case 5 assumes that detailed information is available for uncertain factors that require more difficult field survey and measurements.

Figure 5 shows the observed 95% confidence interval of the performance indicators caused by un-fixed parameters. As shown in the relatively large interval of Case 1 to Case 3, it is clear that the energy management framework based on the traditional approaches is not capable of providing reliable information to the evaluation of energy saving measures. As shown in Table 4, some parameters, such as thickness of insulation of outside walls and internal heat gains, work differently on the system COP of distributed air-conditioning systems compared to others. Thus, taking into account the characteristics of buildings in the framework, contributes to raising the quality of the results, especially for planning energy generation, distribution and delivery.

While carrying out a simple survey on building properties reduces uncertainty in the results, a large

| Table 4 Result of FSM and category of parameters on treatment of uncertainty |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| systems | Index | Description | System COP | Peak Electricity | Primary energy | Kind | Diff. | Category | Case | Case | Case | Case |
| | | | DAC | C | DHC | DAC | C | DHC | DAC | C | DHC | |
| 1 | 1 | thickness of concrete layer in outside wall | + - + + ++ - - - | P | D |
| 2 | 2 | thickness of insulation in outside wall | + + - + - ++ + - | P | A | O | O |
| 3 | 3 | height of floor | - - - - + + + + | P | A | O | O |
| 4 | 4 | thickness of concrete layer in floor slab | + - - - + + + + | P | A | O | O |
| 5 | 5 | area of window on façade | ++/++ + + ++ + ++ ++ | P | A | O | O |
| 6 | 6 | kind of window | + - - - - - - | P | A | O | O |
| 7 | 7 | length of overhang | - - - - - - - | P | A | O | O |
| 8 | 8 | radiation emissivity of outside wall | - + - - - - - | P | D |
| 9 | 9 | solar absorptance of outside wall | - + - - - - - | P | A | O | O |
| 10 | 10 | thermal conductivity of insulation | - - - - - - - | P | * | D |
| 11 | 11 | air change ratio due to infiltration | ++ - - ++ ++ ++ ++ | P | C | O | O |
| 12 | 12 | sensible heat capacity of rooms | ++ - - ++ ++ ++ | P | O | B | O | O |
| 13 | 13 | schedule of occupants | - - - - - - - | O | B |
| 14 | 14 | light wattage | - - - - - - - | P | A | O | O |
| 15 | 15 | number of occupants | - - - - - - - | O | B |
| 16 | 16 | internal heat gain (HG) from office equipment | + + ++ +++ +++ ++++ ++ ++ ++ | O | B | O | O |
| 17 | 17 | convection/radiation split ratio of HG fr. office equipment | - - - - - - - | O | D |
| 18 | 18 | set point temperature of conditioned rooms | - - - - - - - | O | B |
| 19 | 19 | air supply temperature for cooling | + + ++ +++ ++ | O | B |
| 20 | 20 | efficiency of total heat exchanger | + ++ + + + + | O | B |
| 21 | 21 | quantity of outdoor air intake | + + + ++ + | P | A | O | O |
| 22 | 22 | adoption of natural ventilation | ++ + + + ++ ++ | P | A | O | O |
| 23 | 23 | operation hours of HVAC systems | ++ ++ + + ++ ++ | O | B |
| 24 | 24 | interruption of direct solar radiation by neighboring buildings | +++ + ++ | P | A | O | O |
| 25 | 25 | size of building | ++ ++ ++ ++ ++ ++ ++ | P | A | O | O |
| 26 | 26 | zoning of conditioned and un-conditioned area | ++ ++ ++ ++ ++ ++ ++ | P | A | O | O |
| distributed | | | | | | | | | | | | | |
| 27 | 27 | grade of rated COP | ++ + ++ + + | O | B |
| 28 | 28 | heat loss from refrigerant pipeline | ++ + ++ + + | O | B |
| 29 | 29 | air short circuit around the outside unit | + + + ++ ++ + | O | C | O | O |
| 30 | 30 | deterioration of rated COP | ++ + ++ + ++ | O | B |
| central | 31 | grade of rated COP for cooling | +++ + ++ + | P | A | O | O |
| 32 | 32 | deterioration of rated COP for cooling | ++ + ++ + | P | O | O | O |
| both in ntral and DHC | 33 | heat loss from duct | + + + + + | O | B |
| 34 | 34 | heat loss from pipe in building | ++ + + + | O | B |
| 35 | 35 | temperature fluctuation of returned chilled water | + + + + | O | B | O | O |
| DHC | 36 | grade of rated COP for cooling | ++ + + + | P | A | O | O |
| 37 | 37 | heat loss from district heat delivery pipeline | ++ + + + | O | B | O | O |
| 38 | 38 | pressure loss of heat delivery pipeline | ++ + + + | O | B | O | O |
| 39 | 39 | deterioration of rated COP for cooling | ++ + + + | P | A | O | O |

The number of \(*\) and \(\dagger\) is decided as follows: System COP(for DA-C, 1.91 < 5% 2.95 < 7.5%, 3.97 > 10%) & for C and DHC, 1.91 < 2.5%, \(\dagger\) > 5%, 3.97 > 10%); Peak electricity load and annual primary energy consumption(1/5%, 2/5%, 3/10%, > 20%). Parameters fixed in each case for the analysis in the section "Addressing the source of uncertainty"(O indicates parameters fixed in each case) Parameters labeled as ‘P’ in ‘Kind’ without ‘\(*\)’ mark in ‘Difficulty’ and which elementary effects rated more than one ‘\(+\)’ or ‘\(-\)’ on any performance indicator Parameters labeled by ‘\(\dagger\)’ mark in ‘Difficulty’ and which elementary effects rated more than one ‘\(+\)’ or ‘\(-\)’ on any performance indicator
uncertainty still remains in the outputs as shown in the results for Case 4. Especially on the system COP, uncertainty in factors that require difficult field survey and measurements accounts for more than 50% of the variance in the outputs. Thus, the required survey and measurements have to be carried out during the implementation of DEM, in order to model the energy use in buildings with a sufficient resolution to evaluate energy saving measures.

Framework for DEM

According to the simulation results in Table 4, we established a method to deal with uncertainty in building properties and operational conditions as shown in the last column of Table 4 by following the procedure shown in Figure 2. The final design for the energy management framework is schematically shown in Figure 6. The framework comprises 3 databases, as well as a field survey and measurement scheme in addition to the simulation model. The building properties database contains building properties categorized as ‘A’ in Table 4. The uncertainty database contains the ‘ON’ and ‘OFF’ values as reference data of parameters categorized as ‘C’ to assume proper conditions for performing simulations. The field survey and measurement scheme is designed to investigate factors categorized as ‘B’. The priority of the survey and measurements is given by the value of $R_{xi}$ shown in Table 4. If the uncertainty in these factors can be prepared as reference data in a database, it will be helpful to reduce the work to carry out the detailed field survey and measurements.

Based on these databases and the scheme, the energy use in buildings can be modeled with an appropriate resolution in order to evaluate energy saving measures. Most importantly for a task of DEM, the exogenous parameter database is taken into account in the evaluation process, in order to adjust the short and long term plans on DEM according to the long term trends of the exogenous parameters, such as change in climatic conditions and life style and work style of occupants, and future prospects of available technologies and energy sources.

DEMONSTRATION OF THE MANAGEMENT FRAMEWORK

In order to demonstrate whether the developed energy management framework does indeed provide useful information when we assumed specific buildings, a Monte Carlo study was performed with two building configurations (A and B) in Figure 7 as a case study of the local energy generation, distribution and delivery planning. For each system alternative, the overall COP was observed in more than 300 simulation runs assuming the current and future situations as explained in Figure 7. Figure 8 shows the 95% confidence interval of the overall COP for each system alternative due to uncertainty of parameters categorized as ‘C’ and ‘D’ (results for the Distributed air-conditioning system and Central HVAC system are shown on each building configuration A and B respectively). The 95% confident intervals are sufficiently narrow to compare performance of these alternatives. Thus, the designed energy management framework is capable of providing reliable information for local energy generation, distribution, and delivery planning on DEM.

CONCLUSION

This paper proposes a method to develop a framework for district scale energy management that encompasses site design, local energy generation, distribution and delivery planning. A parameter...
Feature: District level energy management

screening technique is used to determine which building properties and operational conditions have to be addressed in particular. Based on the parameter screenings results, we designed a method to deal with the uncertainty in these factors, in order to predict operational energy use with a sufficient resolution for evaluating various energy saving measures. The designed framework consists of a simulation model, as the fundamental part, a building properties database, an uncertainty database and a field survey and measurement scheme. These databases and the scheme are introduced to reduce the gap between simulation results and reality. Although the method is discussed for cooling and heating energy generation, distribution and delivery planning, the proposed method could be applicable to other problems, such as planning of a micro-grid.

ACKNOWLEDGMENT
This work is supported by the Grant-in-Aid for Scientific Research, Japan Society for the Promotion of Science, No.15360310.

REFERENCES
Huang J., Akbari H., Rainer L., Ritschard R. 1991. 481 prototypical commercial buildings for 20 urban market areas, Lawrence Berkeley Laboratory, LBL-29798
Shimoda Y., Nagota T., Mizuno M. 2005. Verification of energy efficiency of district heating and cooling system using realistic parameters, Proceedings of 9th International IBPSA conference 2005, Montréal, Canada
News from IBPSA affiliates

IBPSA Canada
eSim 2006, 4-5 May 2006

eSim 2006 represented the fourth Canadian conference on building performance simulation and was hosted by the Faculty of Architecture, Landscape, and Design located within the downtown campus of the University of Toronto. The conference was held in Toronto, Ontario from May 4 to 5, with pre-conference workshops held at Ryerson University on May 3, 2006. The conference was sponsored by the following organizations: Natural Resources Canada, Canadian Mortgage and Housing, Institute for Research in Construction, the University of Toronto, and Ryerson University.

eSim 2006 brought together 66 researchers and practitioners from government labs, universities, utility companies, and private industry. Most participants were from Canada, but people also travelled from the United States, Britain, Ireland, France, Germany, Portugal, Netherlands, Turkey and Singapore to attend the conference.

The event started with a pre-conference workshop on eQuest, which was attended by 24 participants. The two-day bilingual (English and French) conference featured 32 full-length peer-reviewed technical papers. 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.

eSim conferences are designed to break even financially. A web-based survey, similar to the ones performed following the previous eSim conferences, was conducted to solicit feedback from the delegates. These results are posted on the eSim 2006 web site at www.esim.ca/2006/survey_form.asp. In general, the responses were quite positive with both the conference and presentations rated as very useful by a vast majority of those who completed the survey. The post-conference survey further indicated that the eSim format is still effective and attractive to those who prefer a more intimate conference format with fewer but higher calibre papers.

Hard copies of the conference abstracts were distributed to delegates with a CD of the full papers. Further, PDF versions of all the papers are freely available from the eSim web site at www.esim.ca. This web site also contains the final conference programme, photographs, and further information about the conference.
IBPSA Netherlands + Flanders Symposium, 14 September 2006

IBPSA-NVL held an international symposium on the very live topic of Building and Installation simulation in the light of climate change on 14 September at the Technical University of Eindhoven. Organized in conjunction with the Technical University of Eindhoven and TVVL, the Dutch technical association for installations in buildings, the symposium included seven presenters and attracted an interested audience of 80 people.

The theme of the symposium was inspired by a recent CIBSE publication *Climate Change and Indoor Environment: impacts and adaptation*. We were therefore very pleased that Professor Michael Holmes, one of the co-authors of this report, came and elucidated the conclusions. He summarized them into four simple and straightforward key words:

- **Switch off** - relating to internal and external loads
- **Spread off** - use thermal mass
- **Blow away** - apply (natural) ventilation when possible
- **Cool when necessary** - do not hesitate to include some extra cooling in order to adhere to future climate changes.

These key words very much apply to the ‘Trias Energetica’, the second theme of the symposium and of course closely linked with the presumed cause for climate change. Trias Energetica is defined as:

1. Minimize the energy requirement
2. If energy is required, apply renewable energy
3. Generate and use energy as efficient as possible

The final question was if and how simulation will play a role in this context of climate change and trias energetica. Atze Boerstra and Professor Dolf van Paassen focused on the boundary conditions for this question. Atze indicated that requirements with respect to the indoor environment tend to the adaptive approach, particularly in ‘alpha’ type buildings (non-air conditioned, with openable windows). Several standards/guidelines tend in that direction. For air conditioned buildings little will change, though it remains an open question whether warmer outdoor conditions will result in changed requirements for those buildings as well.
Changing outdoor conditions were another issue. Dolf van Paassen presented an overview of applied weather data in the Netherlands over the last 30 years. He started by stating that the importance of outdoor conditions for the building decreases as the performance of the building skin increases, but the internal load requires more attention. He indicated that the 1964/65 weather data, used as a design standard in the Netherlands over the last 20 years, actually had little verification. It was only when problems arose that the standard was re-examined, with several national and international activities being undertaken on the topic. In Dolf van Paassen’s opinion, however, the most important aspect of a reference year is to allow comparison of designs, not as an absolute value. Plant sizing required more specific information (hot period, cold period). Past weather data cannot take into account future developments, the period in which the building will function. He proposed the use of a stochastic weather model to take those changes into account.

Next, Drury Crawley from DOE presented work in using simulated futures derived from four major climate models. Besides presenting the effect of climate change in the energy use of buildings in different regions, Drury indicated that simulation can be used to answer policy questions. Furthermore, he promoted the use of the wealth of detail information that comes available through simulation. He concluded with the remark that it is cheaper to simulate than to build the wrong building.

After the break Marleen Spiekman presented EU developments related to the EPBD (Energy Performance of Building Directive) and the use of simulation in that context. An overview of what can be expected in the near future, shows that this is quite a lot, even for building owners (including dwellings!). Marleen described the tension between subsidiarity (the principle that EU directives only specify general principles, leaving technical implementation to national governments) and harmonization (the aim of a uniform approach) that is present in the EPBD. This resulted in a mandate to CEN (the European committee for the development of standards) to develop standards. Three approaches to simulation are currently being proposed: a month method, a simple hour-method, and detailed building simulations. Most countries appear to favour the first approach, while retaining the option to use a more complex method for more complex buildings. She stressed the fact that these methods are not intended as design tools, but as tools to identify the energy consequences of the most significant improvements in design. The need for the methods to be incorporated into building regulations makes transparency, robustness, reproducibility, cost and efficiency more important than detail and high individual quality. Detailed building simulation presents several difficulties in this respect.

Paul Stoelinga brought the topic back again to design and the application of simulation.
He developed a theory on the design process, describing it as a series of small steps with many possible ways forward at each, and many intermediate steps. Luckily he identified some consistency in these steps at which information is required. This information can be derived with several levels of accuracy, ranging from experience, design rules, steady state calculations to dynamical simulation. Depending on the design question in hand the required level of accuracy can be estimated. Special and innovative designs generally require the highest accuracy level as design rules are not valid. He believes that climate change will increase the application of building simulation, as we will have to deal with a new situation that we haven’t encountered yet. This will also require building simulation to be used in the early design phase. Some examples were shown to illustrate that. Interestingly Paul came to the conclusion that the outdoor climate does matter for a building, and will continue to do so, especially when designing such measures as long term energy storage in the soil.

Finally, Joop Westland presented the impact of a so-called reference year on the design and dimensioning of HVAC installation, paying special attention to local cooling. To serve the implementation of the EPBD, CEN developed a method to aggregate a reference year from the latest 10 years of real data. Simulation results for the current ‘reference’ and the CEN reference year were given. He showed that the new reference years give much higher loads than the commonly used ‘standard’ 1964/65 year. He suggested that designers should adopt the new reference year as soon as possible. This will lead towards higher capacities. The example Joop presented showed only a marginal increase in energy consumption, but with a much better comfort. Relating his conclusions to the first presenter Michael Holmes, he suggested that if everything has been done to optimize energy use and satisfy indoor requirements, designers should not hesitate to bring in some extra cooling capacity. The extra energy requirement is relatively limited and thermal indoor environmental quality can improve significantly.

The discussion at the end of the symposium focused on the need for large HVAC installations in order to anticipate changes in the climate, especially when considering quality/cost ratio. Another point that arose was the rise in electricity consumption due to cooling in the summer period, which coincided with the time that energy plants are limited in their capacity because of cooling water problems. It is clear that simulation can play an important role to quantify these problems, now and in the future.

The successful symposium was ended with a small buffet.