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President's message

Dear IBPSA Colleagues and Friends

I hope that you and your families are well in the continuing challenges of the pandemic and the steep rise of energy prices. I have looked forward to again being able to travel and greet friends and colleagues, so it is really a pleasure for me to write this message while travelling from London to Athens. In my first message as IBPSA President, I want to thank Lori McElroy for her years of service as our President. Lori expertly guided the organization through the difficult time of the pandemic—going from in-person to virtual meetings to hybrid. Thanks Lori!

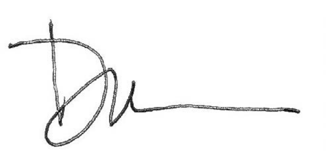
I also want to thank the outgoing board members for their service: Priya Gandhi, Australasia; Anderson Letti, Brazil; Ralph Evins, Canada; Jørgen Erik Christensen, Nordic; and Sergey Zhukovskiy, Russia. And welcome the new board members: PC Thomas, Australasia; Eduardo Graia da Cunha, Brazil; Karine Lavigne, Canada; Laurent Georges, Nordic; and Ilya Zavaleev, Russia.

Finally, congratulations to the new officers elected by the IBPSA board at their meeting last month alongside myself as President, from the USA; Pieter de Wilde, Vice President, Scotland; Carrie Brown, Secretary, USA; and Wangda Zuo, Treasurer, USA.
In our 35th year, IBPSA is making a lot of progress – with more than 5,000 members globally in 32 affiliates, representing 43 countries. Many of the affiliates are quite active with regional conferences this year. It is good to see so many of the conferences in person but many embracing hybrid or online versions. See **page 38** for information about recent activities in Australasia, France, Germany, Italy and Nordic affiliates.

Do consider participating in our next international conference, Building Simulation 2023, to be held in Shanghai on September 4-6, 2023. This conference, our 18th, is organized by IBPSA-China and chaired by Yiqun Pan and Da Yan. See more information on **page 20**. Paper abstracts are due October 29, 2022. Look forward to seeing you there!

Check out the forthcoming calendar of events on **page 17**. Also, of note in this issue of the newsletter – the Ask a Modeler column as well as an interview with Laure Itard, Ruchi Choudhary and Clayton Miller on data-driven simulation and the feature article on advances in agent-based occupant modeling. Other useful items include software updates, book announcements, and the open call for submissions to the Journal of Building Performance Simulation.

I look forward to working with the new board and the IBPSA community.



Dru Crawley
President IBPSA

IBPSA Annual General Meeting

The Annual General Meeting of IBPSA took place online on the 10th and 17th of September 2022. As a result of the elections the Board of Directors (BoD) is now composed of new officers and Directors At-Large. The next AGM will be held in Shanghai, China, in association with Building Simulation 2023.

The new Board takes this opportunity to thank all the Officers and Directors that served in the previous term, for their dedication and commitment to IBPSA and welcomes all newly-appointed and continuing Directors. A huge acknowledgement goes in particular to Past President Lori McElroy, who had the challenging task of providing direction and vision in these uncertain times.

New officers

President:	Dru Crawley
Vice-President:	Pieter de Wilde
Secretary:	Carrie Brown
Treasurer:	Wangda Zuo

Directors At-Large

Term ends 2024	Term ends 2023
Charles S. "Chip" Barnaby (USA)	Clarice Bleil de Souza (England)
Pieter de Wilde (England)	Carrie Brown (USA)
Danielle Monfet (Canada)	Dru Crawley (USA)
Andrea Gasparella (Italy)	Christina Hopfe (Germany & Austria)
Matthias Haase (Switzerland)	Lori McElroy (Scotland)

Affiliate Directors

Raul Ajmat	Argentina
PC Thomas	Australasia
Eduardo Graia da Cunha	Brazil
Karine Lavigne	Canada
Massimo Palme	Chile
Da Yan	China
Martin Bartak	Czech Republic
Marija Todorovic	Danube
Mohammad Fahmy Ramadan	Egypt
Ruchi Choudhary	England
Simon Rouchier	France
Christoph Nytsch-Geusen	Germany + Austria
Jyotirmay Mathur	India
Muhammad Nur Fajri Alfata	Indonesia
Zahra Sadat Zomorodian	Iran
Marcus Keane	Ireland
Vincenzo Corrado	Italy
Yoshiyuki Shimoda	Japan

Cheol-Soo Park	Korea
Ivan Oropeza-Perez	Mexico
Wim Plokker	Netherlands
Laurent Georges	Nordic
Piotr Narowski	Poland
Ilya Zavaleev	Russia
Nick Kelly	Scotland
Adrian Chong	Singapore
Jakub Curpek	Slovakia
Victor Moreno	Spain
Christoph Stettler	Switzerland
Gülsu Harputlugil	Turkey
Wangda Zuo	USA
Hoang Anh Dang	Vietnam

There have been changes to IBPSA Committees too. The new and remaining chairpersons are:

Affiliate Development Committee	Dru Crawley
Conference Committee	Erik Kolderup
Awards & Fellows Committee	Liam O'Brien
Website committee	Pieter-Jan Hoes and Roel Loonen
Publications Committee	Francesco Babich
Communications Committee	Christina Hopfe
Futures Committee	Joe Clarke
Education Committee	Pamela Fennell (as of November 2022)
Projects Committee	Matthias Haase
Standards Committee	Dru Crawley
EDI Committee	Rob McLeod

The Board would also like to take this opportunity to thank 3 outgoing Committee Chairs: Michaël Kummert (Awards and Fellows), Paul Strachan (Conference) and Rajan Rawal (education) for their long and continuous services.

Michaël Kummert has transformed and streamlined our assessment procedures for all of our awards using ConfTool, making the process for assessors much more manageable. This Committee can be under a lot of pressure at certain points in the conference cycle and we are indebted to Michaël for his hard work. Michaël handed over to Liam O'Brien earlier in the year, so we would also like to welcome Liam, a longstanding member of this committee.

Paul Strachan has been Conference Committee Chair for many years. The time and effort that he has devoted to the Committee is greatly appreciated and he will be missed in his role. We welcome Erik Kolderup as the new Chair; he comes in with plenty of experience having been one of the main organisers of BS2017 in San Francisco.

Rajan Rawal has been the driving force behind the Education Committee since its inception and we hope he will remain in the background to support the new Chair, Pamela Fennell, when she takes over in November 2022. We really are indebted to Rajan for making such a success of the Education Committee, through the IBPSA webinar series in particular (to which many of us have had the opportunity to contribute) and progress made on other education activities such as the IBPSA University YouTube channel. ■

Best of 'Ask a Modeler'

'Ask a Modeler' is an advice column for the building simulation community through which we hope to expand communication and create a sense of community among practitioners, researchers, and academics at all points in their building simulation careers. Each month, the Emerging Simulation Technology subcommittee poses a question submitted by an IBPSA member to recognized building professionals to get their expert perspectives. Below, we are reprinting some expert advice from the past few months; you can read our past columns at **https://www.ibpsa.us/category/aam/**. We hope that sharing these questions and insights will bring value to your work and possibly make you think about building performance modeling from a new point of view.

You can submit your questions at **askamodeler@ibpsa.us**. Note that any requiring an immediate response should be submitted to the community of experts at unmethours.com. If you are interested in replying to a question as a featured expert or have any other feedback about Ask a Modeler, please email **askamodeler@ibpsa.us**.

How do you pipeline files between different models, or create interoperability between all the different file types that are part of your work?

— Pipe Dreams

Dear Pipe Dreams,
As energy modelers, we coordinate with nearly every discipline on a project. Plainly, this means we collect and organize a wide range of information. Commonly, there can be a Revit file for the architectural design, spreadsheets with mechanical schedules and ventilation calculations for the mechanical design, and PDFs of lighting plans for the lighting design, among many other sources of information. The most ideal information gathering scenario would be that all of this data exists within a single file and is perfectly formatted for use directly in an energy simulation. As any energy modeler knows, this is unfortunately never the case – and for good reason. Every discipline has different use cases for the files and deliverables they prepare.

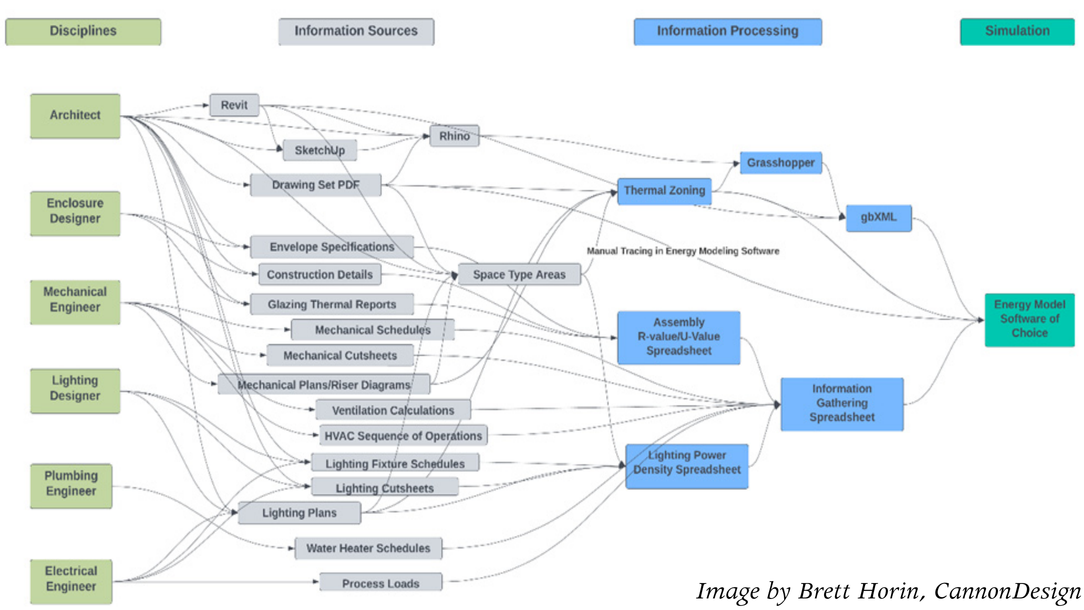


Image by Brett Horin, CannonDesign

The image (previous page) shows the network of information that needs to be gathered. Each discipline provides various sources of information that an energy modeler needs to extract and process before finally bringing the information into their energy modeling software of choice.

Part of the complexity of this information gathering is that it is not linear. Many of these information sources can come from a combination of disciplines, and then must be coordinated in the processing stage because of inherent dependencies among certain data points.

Knowing this, an energy modeler should maintain a couple of criteria: **1) be adaptable and 2) limit your sources of truth**. Adaptability is crucial because information will never be shared and produced in the same way on every project. There will be varying levels of details in BIM files, spreadsheets, and PDFs, so you need to have strategies for extracting information from many sources. With so many sources, it is important to limit your sources of truth to maintain accuracy in your models. For example, ensuring lighting power density information comes from the lighting or electrical engineer, rather than preliminary guesses from the architect, helps maintain accuracy and avoid drastic changes down the road. Confirming the format of your data sources and compiling this in a central information gathering spreadsheet can be very helpful.

One of the most common coordination hurdles is geometry translation. An architect's Revit model requires visual detail for renderings and drawing sets, while our energy models require simplified volumes to correctly simulate the physics in a simulation. These two types of geometric models do not automatically coexist. Energy modelers can rely on a number of software combinations to help automate the simplification process. A workflow I've become accustomed to is exporting a Revit model as a DXF, importing that into Rhino, simplifying using some techniques in Grasshopper, exporting as a gbXML using Honeybee, and importing that into my energy modeling software of choice. The alternative is using the PDFs of a drawing set to manually trace the building directly in your energy modeling software. Either method works perfectly fine depending on a modeler's comfort with different software tools. The former of these workflows typically helps with modeling more complex geometry and with updating as the team iterates the design.

Another hurdle is with lighting power density calculations. While these are generally simple and performed by the electrical engineer or lighting designer, energy modelers may need to tabulate their own space-by-space lighting power density calculations to match with their thermal zoning. I typically have a spreadsheet with a matrix containing a column with all of my thermal zones and a top axis with the lighting fixture schedule and wattage per fixture. Within the matrix I add the fixture counts in each zone and have the spreadsheet automatically calculate the lighting power density per zone to easily enter in my energy modeling software. Generally, your thermal zones will be solidified before the final lighting fixtures, so this method is very helpful for updating any final lighting fixture counts to easily keep the energy model updated as it approaches a final deliverable.

To the second criterion, a best practice with all of this information coordination is to limit your sources of truth. Meaning, create a designated spreadsheet to always update with the most recent information. Map out the types of files you will be obtaining from each discipline on a project and plan how and when you'll obtain that information. Create designated checkpoints when this information should be updated in your energy model. This will help create efficiency and maintain your model's accuracy.

A benefit of staying organized with your information gathering is to also help support your team members. You may have multiple people working on an energy model, or some team members may work on a daylighting simulation while you work on a thermal comfort simulation. All of these have overlapping input parameters, so maintaining consistency is important for the quality assurance of all the simulations that may be performed on a project.

Ultimately, keep in mind that energy modelers interface with nearly all disciplines on a project team. So we need to be adaptable and maintain accuracy with all of the information. Some final thoughts to keep in mind are to establish communication channels, determine checkpoints, and confirm file formats with all disciplines. There is no single, correct workflow to collect and coordinate all of this information, so it is important to figure out what works best for you and your existing workflows.

Brett Horin, LEED AP BD+C
High Performance Building Analyst, CannonDesign

How do you model buildings that use adaptive-thermal-comfort strategies?
— Adept Adapter

Dear Adept Adapter,
As modelers, we often follow the traditional approach of specifying (or selecting) static operational setpoints throughout the year (such as fixed 24°C / 75°F for cooling and 22°C / 72°F for heating in typical office buildings) in building simulations. There are often many valid reasons for us to proceed with this "static operational setpoints" approach, including lack of information about the building operation strategy or occupant preferences, alignment with the approaches used in reference models, or for simpler comparative assessment of the various design measures. While this approach may lead to acceptable results in many use cases (or applications), such as to demonstrate code compliance or to model fully air-conditioned buildings with centralized control systems, it may also lead to significant errors in many use cases, especially in buildings that are designed to operate with natural ventilation or mixed-mode ventilation strategies. In mixed-mode ventilation strategies, mechanical and natural ventilation systems work in tandem to achieve the desired environmental conditions inside the buildings. One possible resolution to overcome these errors is to define adaptive heating and cooling setpoints in the simulations.

In the last few decades, a lot of research has been conducted to better understand thermal comfort of building occupants. ASHRAE Standard 55-2020, *Thermal Environmental Conditions for Human Occupancy*, specifies the combination of environmental (dry bulb temperature, mean radiant temperature, humidity, and air speed) and personal factors (clothing and activity) that will likely produce acceptable thermal conditions for the majority of the building occupants. The adaptive model is one of the methods specified in ASHRAE 55 Standard that defines acceptable thermal environmental conditions for occupant-controlled, naturally conditioned spaces.

The adaptive model recognizes that occupants actively interact with their environment, which leads to behavioral, physiological, and psychological thermal adaptation. It also recognizes that the thermal-comfort preferences of occupants vary based on contextual and historical factors as well as with the adaptation opportunity available to the occupants (such as availability of operable windows or pedestal fans).

In recent years, adaptive models have been incorporated into several building design and operation documents. Thus, it is important for us to determine suitable adaptive setpoints. Further, several studies have demonstrated that each degree (C) change in setpoint could lead to 6-10% reduction in energy use in an office building located in a hot climate and may lead to even higher energy savings when combined with additional mixed-mode control strategies. Hence, a "dynamic operational setpoints" approach is more appropriate while simulating buildings that use adaptive thermal comfort strategies. In such cases, the modeler will have to create a more detailed setpoint schedule for the simulation.

To this end, the following approach is taken:

1. Mean daily outdoor temperature for each day is derived from the weather file (such as TMY3). This can be calculated as the simple arithmetic mean of 24-hour outdoor temperature.

2. Derive the prevailing mean outdoor air temperature by averaging (simple arithmetic mean) the mean daily outdoor temperature of sequential days.*

3. Once the prevailing mean outdoor air temperature is derived, the following graph (Figure 5.8 from ASHRAE 55-2020) can be used to calculate daily operative setpoint temperature for the simulation. Operative temperature is a simplified measure often used to estimate human thermal comfort. Its value is dependent on the air speed, dry-bulb and mean radiant temperature. It is calculated from the weighted average of mean radiant and dry-bulb temperatures inside buildings where the weight coefficient (0.5 to 0.7) is derived based on the average air speed. Mean radiant temperature is a measure used to estimate the impact of radiant heat exchange from the surfaces surrounding an occupant. It is calculated using weighted average of the mean surface temperatures surrounding the occupants where the weight coefficient of each surface is determined by the view factor from the occupant.

   Usually, the upper and lower 80% band values of operative temperature are used as cooling and heating setpoints, respectively, while modeling. If needed, this operative temperature could be converted to dry-bulb temperature based on the average air speed in the building. Where the average air speed inside the building is low (< 0.1 m/s) and the mean radiant and dry-bulb air temperatures are expected to be similar, modelers often assume dry-bulb temperature to be the same as operating temperature.

4. Finally, these daily setpoints can be incorporated into a detailed schedule to simulate buildings that use adaptive thermal comfort strategies, and even receive credit for significant energy savings.

The application of adaptive thermal comfort in buildings often leads to more responsive environmental control, enhanced levels of occupant thermal comfort, and reduced energy consumption. As modelers, it is important for us to accurately capture the benefits of adaptive thermal comfort strategy in buildings to encourage such climatically responsive building design wherever suitable.

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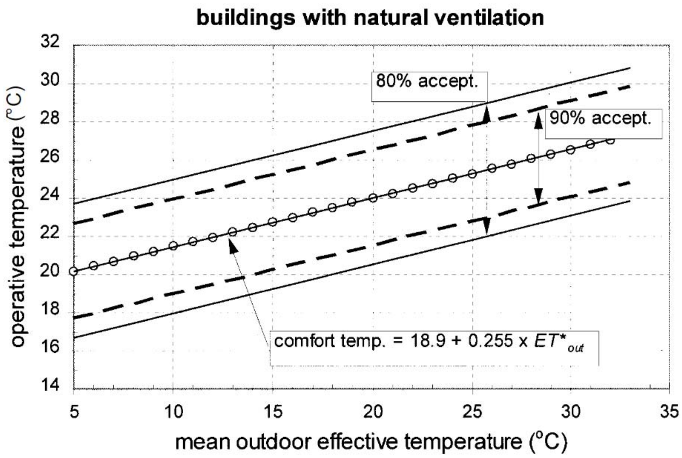
[1] Ghawghawe K, Manu S, Shukla Y. Determining the Trade-offs between Thermal Comfort and Cooling Consumption in Indian Office Buildings. Presented at Passive Low Energy Architecture 2014 (PLEA 2014), Ahmedabad, India, 16-18 December 2014.

[2] Angelopoulos C, Cook M ,Spentzou E, Shukla Y. Energy saving potential of different setpoint control algorithms in mixed-mode buildings. Presented at Building Simulation and Optimization 2018 (BSO18), Cambridge, UK, 11-12 September 2018.

* The number of sequential days in the calculations should be more than 7 but fewer than 30 days. The selection of number of sequential days or weightage (to give more weightage to recent days) could be selected by the modeler if needed.



Adaptive model for buildings using natural ventilation, upon which the ASHRAE 55 adaptive model was built. Image provided, with permission, from de Dear, R., & Brager, G. (1998). Developing an adaptive model of thermal comfort and preference. UC Berkeley: Center for the Built Environment.

Careful consideration of setpoint selection and appropriate selection of simulation inputs will add our own contribution to minimize climate impact of buildings, as well as support decarbonization of buildings.

Yash Shukla PhD
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Data-driven simulation: What's the drive?

Eleonora Brembilla interviews Laure Itard, Clayton Miller and Ruchi Choudhary

Eleonora Brembilla (Eleonora): *Thank you for agreeing to be interviewed. Let's start by getting to know you better. What is your position now? What were the most important steps in your career?*

Clayton Miller (Clayton): Thank you for the opportunity to share my thoughts! I'm an Assistant Professor at the National University of Singapore in the Department of the Built Environment in the College of Design and Engineering. My path to being a professor has bounced between academia and industry since I did my undergraduate degree in Architectural Engineering at the University of Nebraska. This path has also modulated between the different phases of the built environment including design, construction, and operations. This exploration resulted in the understanding that there are huge amounts of measured data from the buildings that are not being utilized for anything – this fact fuels my interest in the field of using data-driven models.

Laure Itard (Laure): I am Professor in Building Energy Epidemiology at Delft University of Technology in the Department of Architectural Engineering and Technology. I would say that the first important step in my career was my PhD, back in 1998, in mechanical engineering (modelling and testing of heat pumps using refrigerant mixtures). After a few post-docs, I switched to industry and discovered how important it is to do things that really work, as well as gaining project management and collaboration skills. In 2005 I went back to academia, where I was given trust and freedom to do what I wanted. At that time, I discovered that neither energy policies nor energy efficiency measures in buildings were validated. It was all model-based, and as sensors at that time were too expensive, validations were not carried out at all. That's when we started the field of Building Energy Epidemiology, making use of data that we collected and data from the Dutch National Statistics Institute. Thanks to an interdisciplinary team, with expertise in energy modelling (mine), policy and behaviour, statistics and Machine Learning (ML), we were able to find large discrepancies between models and reality; we analysed their causes, introduced calibration methods and proposed new policy recommendations. Becoming a part-time professor in a university of applied sciences next to my associate professorship at TUD gave me the possibility to further combine theory with practice and to explore the reasons for poor operation of HVAC systems, one of the multiple causes of mismatch between models and practice. This has led to our current approach to analyse BEMS (Building Energy Management Systems) data for energy and fault diagnosis, which is at the moment the core of our research.

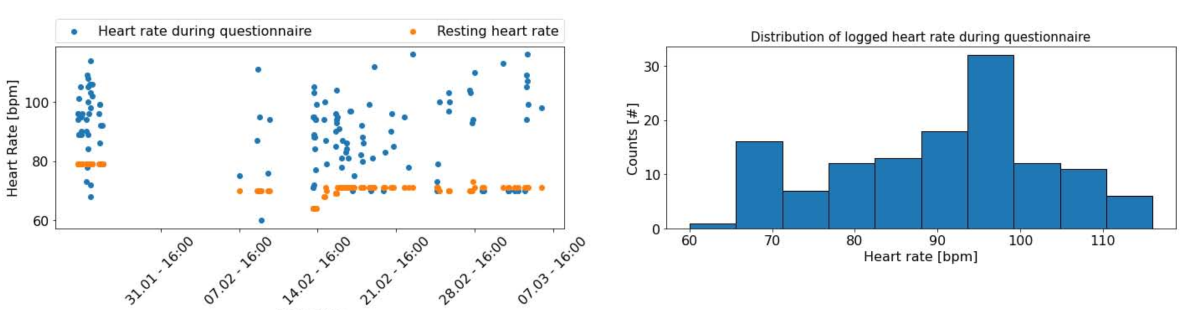
Ruchi Choudhary (Ruchi): I am Professor of Architectural Engineering in the Engineering Department at University of Cambridge. The three most influential steps in my career were: joining the building technology programme at Georgia Tech as Assistant Professor where I had the privilege to work with Professor Fried Augenbroe; moving in 2008 to Cambridge to lead the Energy Efficient Cities initiative, which consolidated my interest in urban-scale energy applications; and joining the Data-centric Engineering Programme at the Alan Turing Institute in 2018, which accelerated my group's work on working across data and simulation models.

Eleonora: *What projects are you working on right now?*

Ruchi: I work on energy use in buildings. My research covers simulation-based methodologies for the decarbonisation of buildings at various scales; uncertainty quantification in building simulation models; sustainable exploitation of underground heat (geothermal energy), the role of **digital twins** in the efficient operation of built environments, and controlled environment agriculture. I find the combined **use of data and simulation modelling** to investigate energy systems especially exciting. Working at the interface of two systems that are typically not considered together but – in reality – are interconnected is something I enjoy. For example, our project on underground climate change integrates the influences of hydro-geology, energy systems, and buildings on ground temperatures. Similarly, our project on urban farming brings together plant modelling and indoor built environment modelling. It is especially exciting to work with specialist domains outside my own core area and use that knowledge to enhance our understanding of buildings. I am an architect by education, and that background has helped instil a degree of fearlessness when working across different disciplines.

Clayton: My team has recently focused on increasing the scalability and generalizability of **machine learning** (ML) techniques in the built environment through the promotion of **large open datasets** (like the Building Data Genome 2 project (**https://www.nature.com/articles/s41597-020-00712-x**) and ML competitions (like the Great Energy Predictor III competition (**https://www.kaggle.com/c/ashrae-energy-prediction**). My team hopes these efforts will spark more interest in the building science community in moving away from custom solutions for each building, and more towards addressing the issue of scaling across a very heterogenous building stock. We also are working on the creation of human-building interaction data for behaviour characterization and performance analysis (**https://www.cozie-apple.app/**). In addition, we work on promoting **data science skills** for built environment professionals through our edX MOOC titled Data Science for Construction, Architecture and Engineering (**https://www.edx.org/course/Data-Science-for-Construction-Architecture-and-Engineering**) which has had over 25k participants worldwide since its launch in 2020.

Onboarding of the Cozie platform with students from the National University of Singapore



Examples of heart rate data collected by smartwatches during user surveys

Laure: We are currently working on two main projects, both using **advanced data analysis** techniques to reveal mismatches between predicted and actual energy efficiency of buildings and their HVAC systems. Within the Brains4Buildings project (**https://brains4buildings.org**), my group and a consortium of 38 other partners are working on energy and fault diagnosis in HVAC systems, including occupants' comfort and control interfaces, data integration issues, and energy flexibility. Our approach to automating energy diagnosis exploits conceptual models used when designing HVAC systems (P&IDS) that are then translated to Bayesian networks and fed with BEMS data. The IEBB Theme 2 project (**https://www.tudelft.nl/urbanenergy/research/iebb/theme-2-data-driven-optimization-of-renovation-concepts**) focuses on **data-driven optimization** of energy renovation concepts. One of the main issues of energy renovation is that the starting point is not known, except for the yearly energy usage. Heat resistance, infiltration flow rates, specific heat capacity are all unknown parameters, as shown in our epidemiology studies. This results in optimistic estimates of energy savings and consequent disappointment of building users. We are developing **digital twins** to reverse-engineer such building properties, using a combination of model-based approaches and data-driven approaches.

Eleonora: *Data on HVAC, on the underground and on humans. Very different applications but common simulation and analysis methods. Would you call these "data-driven simulations"?*

Ruchi: I would not define the simulations we do to be driven by data. Rather, we opportunistically make use of information (measurements, expert knowledge, observations, etc.), where needed, so that the simulations or numerical models are a better reflection of the real-world process – be it how a building is using energy, or how an energy system is operating. For example, we use data to calibrate simulation models, to quantify and propagate uncertainties in model outputs, to represent occupant actions that relate to energy, etc. Modelling of building performance is an interesting example owing to a combination of human actions and physical forces interacting with the thermodynamics of buildings in highly varying, and unique, manners. In other words, simulating the energy demand of buildings is inherently a multiscale and multi-physics modelling exercise involving asynchronous sub-processes. Thus, for many decision-making problems it becomes necessary to enhance the model with data and vice versa.

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Eleonora: *How would you then define data-driven simulation, in the context of building performance?*

Clayton: The data-driven aspect of built environment prediction is when measured data from systems and occupants can be used to infer performance in the future that has already occurred in the past. Using previous data to train models is usually faster and easier than using physics-based principles, but there are capability limitations as training data is difficult to collect or find in a scalable way.

Laure: Let me elaborate on this with a few distinctions. There are pure data-driven models (e.g. unsupervised methods like clustering). Although they may be very interesting to define categories or typologies of occupants or buildings, one of the main problems is that these models generally cannot translate into the guidance you need to design better buildings or operate them. Sometimes regression models (e.g. as used in supervised methods) are seen as purely data-driven models, but in fact, we always introduce an assumption there: that the system under consideration can be considered as a linear or quadratic (etc..) one. These models seem to be quite powerful in predicting the future energy use of a building. However, they too lack the ability to provide guidelines towards better design and operation (for instance it is quite easy to design heating energy prediction models that work well, by considering outdoor temperature, solar radiation and time of day, but for better operation we should consider set point temperatures in the HVAC systems and control rules, who which are not included in the models yet). So, I strongly believe that we should not throw away the knowledge that we gained in the past. It would be just like reinventing gravity by continuously measuring how apples fall from trees… I am quite sure that most existing models are very well-designed. The problem is not the model itself but the values of its parameters, that come with (large) uncertainties. In our field of building simulation and energy epidemiology, data-driven will refer more and more to the use of extensive datasets and time series to determine these parameters, in other words to feed and calibrate models.

'Data-driven' will refer more and more to the use of extensive datasets and time series to feed and calibrate models

Eleonora: *Can we not consider all simulations to be data-driven? I am mostly thinking of weather data here, which we have used for a long time to characterise building boundary conditions.*

Ruchi: No. Not all simulations need data. Simulations are virtual experiments and one can design experiments that are abstract in nature and have different purposes – e.g. understanding the governing behaviour of thermal storage, or the impact of wall shading on indoor temperatures. In fact, there are scenarios when it is beneficial to focus on the governing physics of the system in its idealized form without including real world perturbations.

Clayton: Most performance simulations usually have data-driven components. Weather is one good example, but also the emulation of some pieces of HVAC systems such as chillers. It's unreasonable to model a chiller at the component or physics-based level, therefore we use the performance curves of existing chillers, usually the manufacturer's test implementation in the factory. It is best practice to balance the physics-based and data-driven aspects of the simulation process to optimize the speed and accuracy overall of performance prediction.

Eleonora: *There seem to be a few concepts floating around with 'data-driven simulation', such as BIM and Digital Twins, which you have already mentioned a couple of times. How are these concepts interrelated?*

Ruchi: The pervasive use of Building Information Modelling (BIM) with its underlying semantics, in conjunction with sensor technologies and computation abilities have led to the emergence of Digital Twins in the building sector. Current variants of DTs in the building sector are built atop high-TRL technologies in ICT and machine learning (ML) to offer online IoT integration, data management, and high-quality visualizations to varying degrees. Several challenges remain though – the translation of data into actional information, standardization and validation of digital twins, and crucially, ability to host simulation models that follow the real system dynamically within the wider DT ecosystem.

Laure: Digital Twin is a term emerging at the beginning of the 21st century, I believe from the aerospace sector. I personally use the term to indicate any model trying to replicate reality by using data. It can be a purely data-driven model, or a physical model aided or calibrated by data. As for BIM, I believe it could/should become a way to store building parameters with better accuracy and to document changes, to reduce the uncertainty of model inputs. Sensors in buildings are going to be labelled more and more according to Haystack or Bricks standards. I am not sure if there is any gain

in including Building Energy Management System (BEMS) data into BIM but including sensor labelling into BIM could be a good idea!

Clayton: BIM and Digital Twins and their growth in practical projects are creating the ability for performance analysts to have a faster starting point in the development of both physics-based and data-driven models. Our team has started using digital twin representations of buildings in combination with wearables-generated human data to create more accurate thermal preference models as compared to conventional prediction methods that only use sensor data.

Eleonora: *What type of data and data format do we need in current practice to make data-driven models work? How should current practice evolve to make data-driven simulation easier?*

Clayton: A significant limitation of the use of data-driven methods is the lack of breadth and quantity of training data for the larger building stock. Simulation experts are mostly forced to use physics-based methods since they don't have a large amount of training data with quality labels that can be used for data-driven techniques. Our field needs more data from a larger range of building types and locations/climates and from a greater range of system types and sensors. This effort can be achieved if more researchers would open their data sets upon publishing papers and building owners and utility companies would create large, anonymized data sets that can be used for training data. It's important to note that the quality and usefulness of data is greatly enhanced if it includes 'labels' such as when a piece of equipment is underperforming or in fault mode. These labels can also express the experience of the occupants such as when they feel satisfied, productive, or healthy.

A significant limitation of the use of data-driven methods is the lack of breadth and quantity of training data for the larger building stock

Laure: First of all, we need more educational and training resources. I am thinking of structured courses on ML for building simulation (for building/energy experts/students) on one hand, and structured courses on energy modelling, especially thermal modelling, for data scientists on the other hand. Second, we need clear and precise labelling of sensors in buildings (now it is most often a mess, and it costs a lot of time to find out what is what). Last, we need standard open data sets (like those developed by ASHRAE for air handling units) to perform tests.

Eleonora: *In your opinion, what does the future of building performance simulation look like? I suspect you see a prominent role for data-driven models, don't you?*

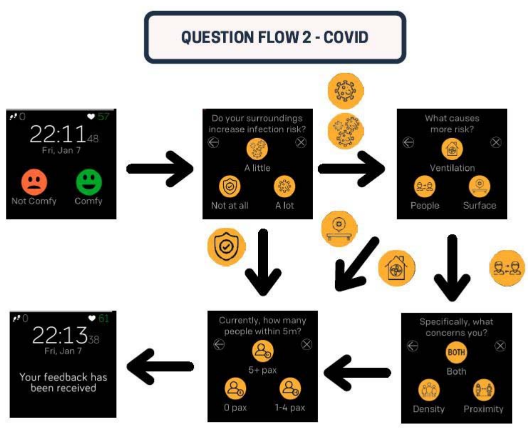
Laure: Yes sure ☺, in line with my previous answers. But data and purely data-driven models cannot replace a model based on causes and effects. It only gives correlations, but little possibility to act and to understand the underlying relationships.

Ruchi: I believe that data and AI will change building performance modelling. In the near term, we need research investments so that a new generation of software products are compatible with the processes and needs of simulations in practice. These necessitate purposeful development of (a) a new generation of hybrid data-physics models, and (b) their bi-directional couplings with data. It also calls for working in tandem with the industry at every stage, identifying needs, testing variants of technologies both under controlled conditions and on the ground.

I believe data and AI will change building performance modelling

Clayton: I believe the future of building performance analysis needs to incorporate far more information about the *occupants* that use buildings. We currently make broad assumptions about how people use buildings that are stuck in a time when spaces were used in more static ways. For example, before the Covid-19 pandemic, people would often use offices in a very structured way – coming into the office at a certain time, using an allocated desk space, and repeating the process five days a week. Now, the flexibility of office work is much different as occupants may have a diversity of spaces which they can utilize, and offices are more often being used for interaction and socializing. Understanding the various behaviours and preferences of these occupants can be captured using smartphones and smartwatches and innovative types of sensors, including using computer vision. There are numerous data-driven uses for these data in the performance simulation process and a broader range of objectives can be studied beyond just energy and thermal comfort. We can understand better the noise, distraction, health, mobility, privacy, and wellness of occupants by capturing better data from them. Humans' behaviour isn't physics-driven and therefore data-driven models have a promising future in this area. However, humans are super complex, their attention is limited, and privacy is a major issue so there is a significant amount of work to do!

The future of building performance analysis needs to incorporate far more information about the occupants that use buildings



Smartwatch dashboard displaying questions on Covid-19 risk related to the user's environment

Eleonora: *Very exciting work to do, I would say! Thank you all very much for your extensive and informative answers!*

Forthcoming events

Date(s)	Event	Further information
2022		
14-18 November 2022	**DATASUN Scientific School** Le Bourget du Lac and Le Grand Bornand, France	**www.univ-smb.fr/solaracademy/2022/07/18/datasun-scientific-school-14th-to-18th-of-november-2022-le-bourget-du-lac-le-grand-bornand-french-alpes**
25 November 2022	**uSim 2022** Glasgow, Scotland, UK (online)	**http://usim2022.org/webpages/about_uSIM22.html**
2023		
04-08 February 2023	**ASHRAE Winter Conference** Atlanta, Georgia, USA	**www.ashrae.org/conferences/ashrae-conferences**
20-23 May 2023	**IAQVEC** Tokyo, Japan	**https://iaqvec2023.org**
24-28 June 2023	**ASHRAE Annual Conference** Tampa, Florida, USA	**www.ashrae.org/conferences/2023-annual-conference-tampa**
August 2023 (TBC)	**International Radiance Workshop** Innsbruck, Austria	
04-06 September 2023	**BS 2023** Shanghai, China	**https://bs2023.org**
2024		
September 2024 (TBC)	**BauSIM** Vienna, Austria	

Note that the dates in this calendar may, but do not necessarily, include pre and/or post-conference workshop days

14-18 November 2022
Le Bourget du Lac and Le Grand Bornand, France

DATASUN Thematic School

The DATASUN scientific school, organized by the Solar Academy Research University School, will take place from 14-18 November 2022 in Le Bourget du Lac and Le Grand Bornand in the French Alps.

DATASUN will be about data, its use, analysis and handling for solar energy related studies. It is suitable for Masters and PhD students, researchers, engineers and practitioners, and will include plenary sessions, workshops, and a visit to the experimental facilities at INES. Participants will have the opportunity to learn about new topics, to share their research with the scientific community during a poster session, and to develop their social networks.

Date	Monday 14 November	Tuesday 15 November	Wednesday 16 November	Thursday 17 November	Friday 18 November
Place	Le Bourget du Lac, and departure for Le Grand Bornand	Le Grand Bornand	Le Grand Bornand	Le Grand Bornand	Le Grand Bornand, travel back to Le Bourget du Lac / Chambéry
9h to 10h30	Mathieu DAVID (PIMENT - UR)	Alexandre BENOIT (LISTIC - USMB)	Roberto CASTELLO (EPFL)	Leon GAILLARD (Heliocity)	Marion PERRIN (Oscaro Power)
10h30 to 11h	Break	Break	Break	Break	Break
11h to 12h30	Robert BLAGA (West University of Timisoara)	Evelina TRUTNEVYTE (UNIGE)	Gilles DESTHIEUX (HES-SO Hepia)	Demba DIALLO (Geeps - Univ. Paris Saclay)	François MARECHAL (EPFL)
12h30 to 14h	Lunch				
14h to 16h	Visit of INES and INCAS Platform, Travel to Le Grand Bornand	Poster session PhD Student	Workshop 2	Activities	End and travel back to Le Bourget du Lac / Chambéry
16h to 16h30		Break	Break		
16h30 to 18h30		Workshop 1	Workshop 3	Poster Presentation UNITA Students	
18h to 19h		End of the day / Team Work (UNITA)	End of the day / Team Work (UNITA)	Gala dinner	

Theme	Solar forecasting	Applied IA method	City and Territory Scale	Market prospective	Global scale

For more information see the DATASUN Scientific school website **www.univ-smb.fr/solaracademy/2022/07/18/datasun-scientific-school-14th-to-18th-of-november-2022-le-bourget-du-lac-le-grand-bornand-french-alpes**, or email us at **Scientific-School.Solar-Academy@univ-smb.fr**

Register at **https://docs.google.com/forms/d/e/1FAIpQLSdJrRFk41HkDP3fdhPT1B9IhnfFaMW4W3mMakKlKCNl05AORQ/viewform?vc=0&c=0&w=1&flr=0**

The DATASUN organization team

25 November 2022
online
http://usim2022.org/webpages/about_uSIM22.html

uSIM 2022: 3rd IBPSA-Scotland Conference

Urban Energy in a Net Zero World

The 3rd installment of IBPSA-Scotland's uSIM Conference series will be organised by the Energy Systems Research Unit (ESRU) and hosted by the University of Strathclyde, Glasgow, on 25 November 2022.

The conference will be ONLINE this year at **https://usim2022.org**, primarily in response to the ongoing pandemic, but also in an effort to reduce IBPSA-Scotland's carbon footprint and to make the conference more affordable and accessible to researchers from a wide range of backgrounds. Following on from Glasgow hosting COP 26 the theme of this year's conference is "urban energy in a net zero world".

Conference theme

The 2022 conference will focus on the challenge of transitioning the built environment's energy needs to net zero. The uSIM mantra is 'beyond the building' focusing on the application of building simulation to community and urban-scale challenges. Applying building simulation to these wider energy systems brings its own unique set of challenges in areas ranging from data acquisition for multiple buildings to simulation of energy networks. uSIM will bring together experts from academia and industry to explore these and to progress the state-of-the-art in knowledge and capabilities.

The core topics are:

- Modelling and simulation of urban areas and communities
- The new electrical demand - the electrification of heat and transport
- Modelling and simulation of urban energy networks
- Hydrogen in buildings and communities
- Smart energy - orchestration of demand, supply and storage
- Zero carbon technologies for urban areas and communities
- Cooperative approaches to net zero - positive and negative energy districts
- Data analysis, visualisation and performance metrics
- Domestic and non-domestic stock modelling
- Calibration, verification and validation beyond the building scale
- Case studies in urban and community energy systems modelling

The uSIM Team ■

4-6 September 2023
Shanghai, China
https://bs2023.org
info@bs2023.org

BS 2023: 18th IBPSA International Conference & Exhibition

Simulation for the low-carbon design/operation/city

The 18th International IBPSA Conference and Exhibition Building Simulation 2023 (BS2023) will be hosted by Tongji University & Tsinghua University in Shanghai, China from 4-6 September 2023. As usual, BS2023 offers a broad range of highly interactive sessions with research leaders, keynotes from experts, dedicated workshops and exhibitions.

We send you a warm welcome to join this biennial event and make an impact. The scientific and technical sessions will cover the entire spectrum of building simulation, including research papers, project reports and workshops. It is a great opportunity for both professionals and beginners from academia or industry to share their most innovative ideas. The BS2023 call-for-abstracts is still open at **https://bs2023.org/submit/** and we are looking forward to your submission! Authors will be invited to submit a full paper if their abstract is accepted. Following double-blind peer review, all accepted and presented papers will be published in the conference proceedings.

Conference topics

The list of topics to be addressed includes (but is not limited to):

Simulating future metropolis	Performance-driven design
■ Regulations/codes towards carbon neutrality	■ Parametric/Automatic design
■ Urban-scale simulation	■ Active/Passive/Zero-carbon buildings
■ District energy systems	■ Weather & climate adaptation
■ Demand responses & grid interactive	■ Building physics
■ Urban renaissance & cultural heritage	■ CFD & airflow

Smart building systems	Human-centered simulation/design
■ Heating, ventilation and air conditioning	■ Occupant behavior
■ Commissioning, diagnostics & control	■ Thermal comfort
■ Validation, calibration & uncertainty	■ Indoor environmental quality
■ Simulation vs. reality	■ Microclimate
■ Optimization	■ Healthy buildings

Modeling for the digital world

- Big data & machine learning
- BIM & interoperability
- Advanced modeling techniques/ application
- New software development
- Education

BS2023 will be held in hybrid mode (combining offline and online), in order to prepare for any unpredictable circumstances in the future. It is easy for the researchers around the world who are interested in participating to arrange their travel plans. We will provide all support (including visa applications, hotel reservations) to participants to be on-site next September. Meanwhile, we would like to make it possible for authors who find it difficult to travel to China to attend the conference. Authors can therefore switch flexibly either way between on-site and virtual at any time before the online registration closes on 25 August 2023.

Key dates

Paper abstracts due:	29 October 2022
Abstract acceptance notification:	10 December 2022
Early registration opens:	1 January 2023
Deadline for full papers:	1 March 2023
Final notification of paper acceptance:	31 May 2023
Deadline for early registration:	30 June 2023
Online registration closes:	25 August 2023

For all questions, please contact **info@bs2023.org**
Sponsorship affairs or activity proposals: **sponsor@bs2023.org**
Don't forget to follow us on our website! **bs2023.org**.

We can't wait to meet you at BS2023 in Shanghai!

Yiqun Pan, School of Mechanical Engineering, Tongji University, Shanghai 200092, China

Da Yan, Building Energy Research Center, School of Architecture, Tsinghua University, Beijing 100084, China

BS 2023: Student Modelling competition

As part of the Building Simulation Conference (**https://bs2023.org**), IBPSA is organizing the biennial student modelling competition. The aim is to facilitate wider participation in the conference and to provide a competitive forum for student members of the building simulation community. It is expected that several tutors of relevant courses in universities around the world will use this competition as part of their teaching material. Entries will be judged prior to the conference with an award being made at the conference in Shanghai in September 2023.

The 2023 student modelling competition is about the *Simulation, design and optimization of a nearly zero carbon emission building*. The modelling brief will be published on the BS 2023 website shortly.

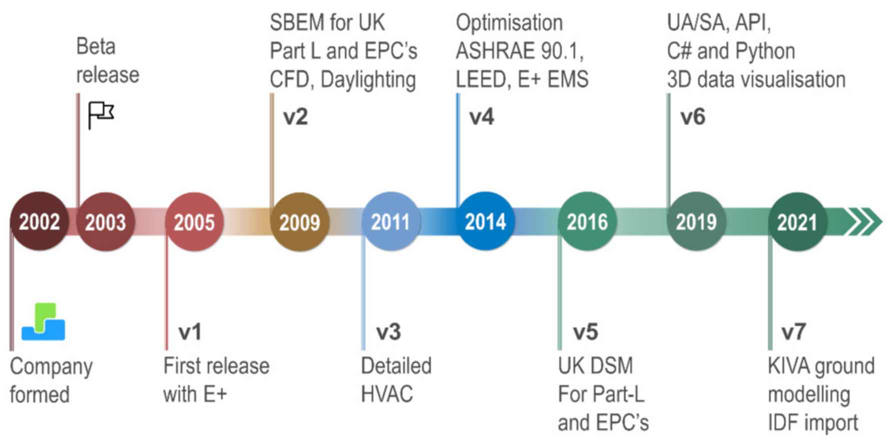
Key dates

- 30 December 2022: Notification of intent: all students who intend to submit will have to notify the BS modelling competition team via email to **student@bs2023.org**
- 30 April 2023: Deadline submission: the requested report should be sent by email in PDF format to **student@bs2023.org**
- 1 June 2023: Winners informed
- 4-6 September 2023: BS2023 conference

For further information, please contact **student@bs2023.org** ■

Software news

DesignBuilder turns 20!



On 19th August 2022, DesignBuilder officially celebrated its 20th birthday! DesignBuilder was the first available EnergyPlus GUI and, according to the AIA 2030 Commitment reporting program, it is still the most widely used interface to EnergyPlus today. The first beta version was released in 2003 and since then the software has evolved to provide a fully integrated toolkit enabling users to perform a wide range of analyses. These include energy and comfort, HVAC, daylighting, cost, design optimisation, CFD, BREEAM/LEED credits, and reports complying with several national building regulations and certification standards.

Looking to the future, we are pleased to announce some structural changes that will help us better serve our growing army of loyal customers for the next 20 years! Our updated thinking, priorities, and what you should expect in the years ahead are summarised on the About Us webpage (**https://designbuilder.co.uk/about-us**). We are excited to embark on this next stage of our evolution and look forward to continuing our journey with you, helping you to reduce the built environment's impact on our planet in ever faster, easier, and more productive ways!

New tutorials

We have released a number of new free short tutorials that provide concise guidance to help you get started using the software. They also enable existing users to refresh their knowledge with the latest tools, techniques, and tips to help improve their modelling efficiency. The tutorials cover a wide range of topics including:

- Basic Geometry
- Basic Model Data
- Heating Design, Cooling Design and Simulation
- Detailed HVAC
- Natural Ventilation

The tutorials are freely accessible at **https://designbuilder.co.uk/training/tutorials** and cover several essential areas of DesignBuilder modelling. If you have never received DesignBuilder training or were trained using earlier versions of the software, we would strongly recommend that you view these short high-impact tutorials.

People generally learn most effectively by "doing" rather than "watching", so please do try out the techniques shown in the tutorials while they are fresh in your mind using our free 30-day trial (**https://designbuilder.co.uk/software/free-30-day-evaluation**). And above all, we hope you find the tutorials useful and fun!

New webinars

We have been running live webinars to illustrate the most important new features in the software. A number of new webinars have been added to the website (**https://designbuilder.co.uk/training/webinars**) including

- **Advanced HVAC System Modelling**
- **Modelling Façade Systems in High-Performance Buildings**
- **Modelling HVAC Systems: From Concept Through Detailed Design**

For up-to-date information on our new releases subscribe to our free monthly newsletter here: **https://designbuilder.co.uk/about-us/newsletter**. ■

IES Interoperability Update: free on-demand webinar

Designers and engineers use different tools during the design, commissioning and operation phases of a project, often needing to import and export into multiple platforms. Data exchange is a known challenge; key pieces of data are often missing and models often need to be altered after import, leading to longer project times and frustration. But what if platforms seamlessly worked together, creating your own ecosystem and increasing productivity?

This recent webinar from the IES team provides the latest update on interoperability with IES technology. The speakers explain how the design process can be speeded up and true digital design and operation facilitated by new data exchange options.

The recordings show how to:

- **IMPORT** architectural models easily into IESVE, with demonstrations of:
  - the NEW Pollination process Revit/Rhino to IESVE
  - the updated gbXML process Revit to IESVE

- **EXPORT** IESVE models easily to:
  - Design platforms (MagiCAD, Stabicad, MEPWorx)
  - Part L1 SAP (Quidos, JPA)
  - LCA (OneClickLCA)
  - IES Technology (iSCAN, Calibration Tool)

and include:

- a first look at the new IES Calibration modelling tool.

The speakers are Niall Gibson, Business Development Manager, IES, Douglas Bell, Consultancy Manager - BIM & Lighting, IES Consulting, and David Ross, ICL Partner Operations Manager, IES.

The recordings are at: **https://go.iesve.com/interoperability-webinar-oct-22/ibpsa** ■

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sketchbox powered by slipstream

Sketchbox - Slipstream Launches Free and Simplified Energy Modeling Tool

Slipstream, a nonprofit organization with a mission to accelerate climate solutions for all, recently launched a free version of its simplified energy modeling tool, Sketchbox.

Sketchbox is a simple, web-hosted front end for the eQuest/DOE2 energy modeling tool with common-sense default values that was originally built as an internal tool to provide early design support for Slipstream's clients. Over the years Slipstream added functionality to make it useful throughout the design process, as well as for retrofits and renovations.

The tool is now available for anyone to use at no cost. There is also a paid version that allows for more complex models, saved projects, and the ability to download the raw DOE2 files for use in eQuest.

The interface includes best practice default inputs that respond to changes in modeling parameters. The simplicity makes Sketchbox approachable for less technical users or those without prior experience in energy modeling. To support use as a simple, quick tool, Sketchbox assumes:

- Buildings and shells are rectangular shapes with perimeter and core zoning
- Loads are spread evenly throughout spaces
- One per shell program type, HVAC system, and schedule; multiple shells possible
- Energy conservation measures are applied individually (no bundling) and progressively

To ty it out, visit: **https://www.sketchbox.io**
To read more: **https://slipstreaminc.org/sketchbox**
Documentation is at: **https://docs.sketchbox.io** ■

Modelling Case Study: ASHRAE Headquarters Building, Atlanta, USA

Liam Buckley, Vice-President, IES West Coast - North America

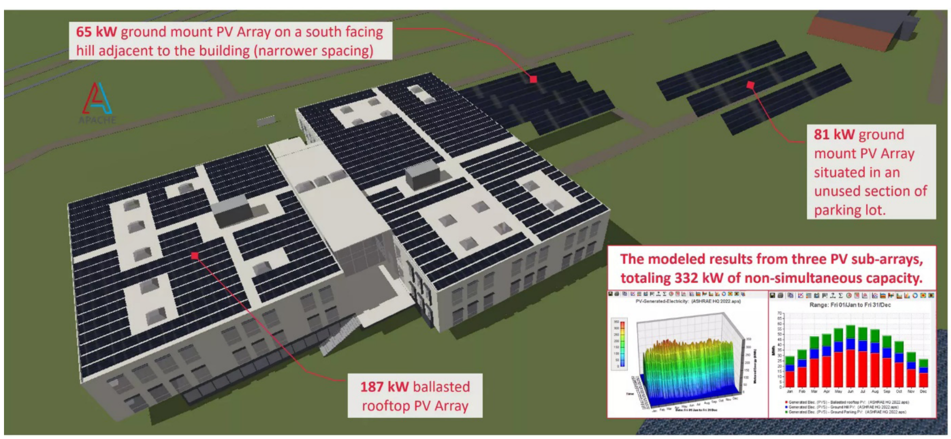
ASHRAE are one of the foremost industry pioneers in the decarbonization of the built environment and their new global Headquarters building in Atlanta, renovated to operate as a net-zero-energy (NZE) building, is testament to this. The project design team, which includes IESVE users, Integral Group, employed a range of innovative design strategies to achieve this net-zero energy ready building.

Along with some fellow ASHRAE Members of Technical Committee 4.1, I recently had the pleasure of doing some building performance analysis on this ASHRAE Headquarters building. From a simulation-aided design perspective, four aspects of the project are worth highlighting:

1 Net-Zero Energy Building

ASHRAE's new headquarters is designed to operate as an all-electric at Net-Zero Energy (NZE) building, thanks to the installation of a 332-kW photovoltaic (PV) system. The PV system is a combination of three sub-arrays, which are sub-metered in the Building Energy Model (www.iesve.com/software/building-energy-modeling) shown below:

- 187 kW ballasted rooftop array on east & west wings
- 65 kW ground mount on a south-facing hill adjacent to the building
- 81 kW ground mount situated in an unused section of a car parking area

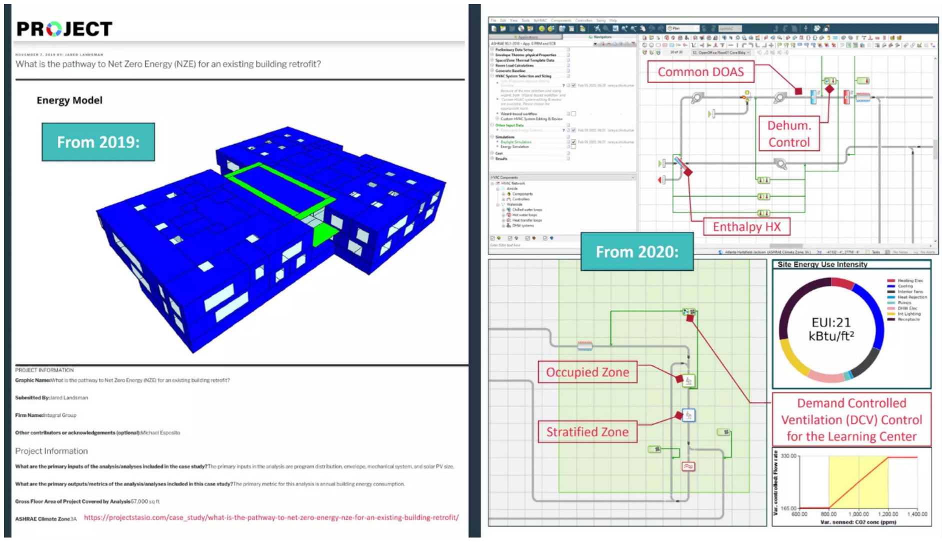


2 Simulation throughout the design phases

Thanks to the PV installation, a limiting Energy Use Intensity (EUI) of 21 kBtu/ft2 was targeted for this existing building refurbishment. Iterative design options throughout the design phases resulted in a range of low-energy solutions. These include:

- A reconfigured window-to-wall ratio (WWR) and 18 new skylights.
- Common Dedicated Outdoor Air Systems (DOAS) for outdoor air ventilation, coupled with enthalpy heat recovery.
- Radiant panels and Ceiling Fans.

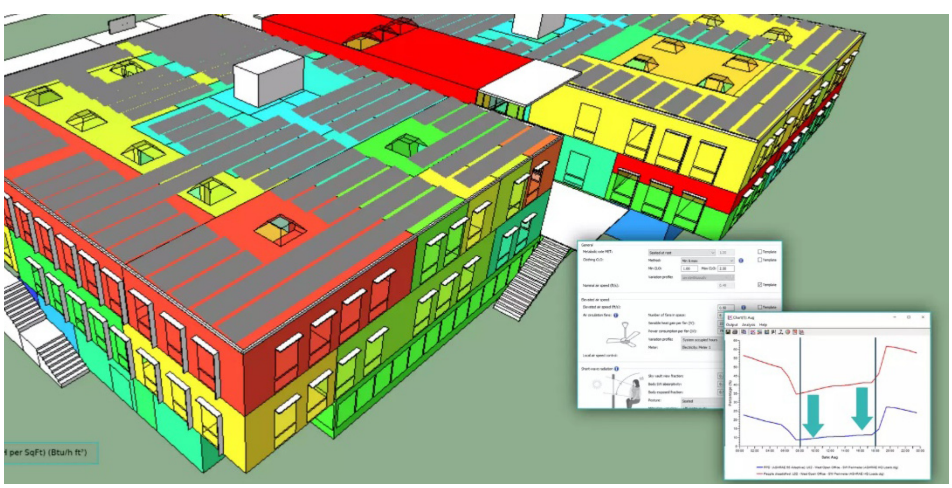
- Demand Control Ventilation (DCV) in high occupancy spaces and Displacement Ventilation (DV).
- Six water source-heat pumps (WSHPs)



3 Optimized load calculations using the ASHRAE Heat Balance Method

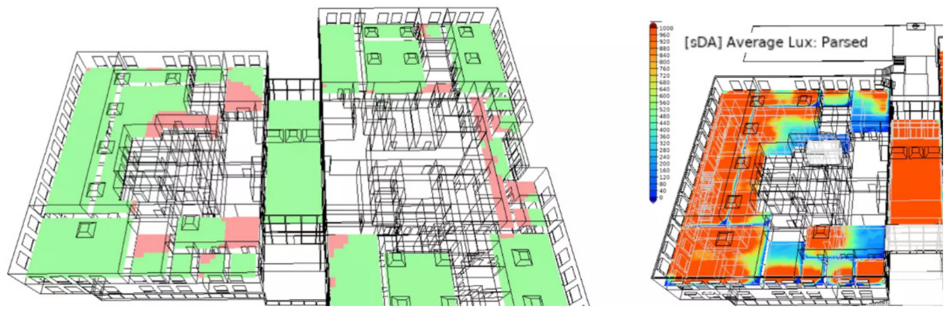
For over 20 years, ASHRAE has recommended the Heat Balance (HB) Method (explained at **www.iesve.com/software/loads**) as the preferred method for calculating heating & cooling loads. With such a low-energy target in mind, a considerate zoning strategy and accurate load calculations are very important. The load analysis for the ASHRAE building included the effects of:

- Horizontal and vertical solar shading on most windows
- Sensible loads at the zone and latent loads at the AHU
- Heat gains from the reversible ceiling fans
- Adaptive thermal comfort for occupants and the operative temperature.



4 Exceptional daylight performance (Spatial Daylight Autonomy, sDA)

Of the many daylighting metrics available, (**www.iesve.com/software/daylighting-and-lighting-design**) Spatial Daylight Autonomy (sDA) likely best considers the annual sufficiency of indoor daylight levels. In the regularly occupied spaces of the ASHRAE HQ, the working plane analysis areas are considered for sDA, for the percentage that meets a minimum illuminance level of 300 lux, for 50% of the operational hours per year. The 18 new skylights provide an exceptional daylight performance, which is especially impressive considering the simultaneous requirements from a thermal/energy perspective.



About ASHRAE

Founded in 1894, ASHRAE is a global professional society committed to serve humanity by advancing the arts and sciences of heating ventilation, air conditioning, refrigeration and their allied fields. ASHRAE recently launched a Task Force for Building Decarbonization (TFBD), so they continue to demonstrate leadership and promote the organization's mission. To learn more about ASHRAE and the TFDB, visit **www.ashrae.org/about/mission-and-vision** *and* **www.ashrae.org/about/ashrae-task-force-for-building-decarbonization**.

To learn more about ASHRAE's state-of-the-art, high-performing net-zero-energy efficient global headquarters building, go to **www.ashrae.org/newhq, www.ashrae.org//File%20Library/About/New%20HQ/ASHRAE-Global-Headquarters.pdf** and **integralgroup.com/ashraehq**.

This article was originally posted at **www.iesve.com/discoveries/casestudy/27424/ashrae-headquarters**. ■

Recent advances in agent-based occupant modeling

Jeetika Malik[1], Tianzhen Hong[1], Ardeshir Mahdavi[2], Elie Azar[3]

[1]Lawrence Berkeley National Laboratory, USA

[2]TU Wien, Austria

[3]Carleton University, Canada

1. Introduction

Occupant behavior (OB) regarding their presence, movement and interactions with building systems has a strong influence on building performance. Realistic representation of occupants and their energy-related behavior in building performance simulation (BPS) models is therefore crucial for supporting building design and operations. While several modeling techniques exist to represent OB in buildings, the agent-based occupant modeling approach has become increasingly popular within the simulation community because of its potential to represent complex and dynamic aspects of occupant-related processes. Agent-based modeling (ABM) is an advanced computational technique that can capture key human behavior properties, such as heterogeneity, learning and adaptation, interactions, negotiations or even the emergent effects arising from collective behavior. These properties make the agent-based paradigm a promising choice for representing reasoning and decision-making of the human-building interactions and improving the fidelity of BPS. Furthermore, ABM applications are particularly advantageous over conventional techniques to model occupants' presence and behavioral decisions arising from functional, physiological, psychological, and social parameters.

While ABM offers great potential for modeling human-building interactions and capturing the impact of human factors in building performance, a considerable knowledge gap exists within the BPS community related to its appropriateness for different use cases, as well as the required granularity of model input or the integration of occupant elements into such models. A collaborative effort by a group of international researchers within the framework of the IEA EBC's Annex 79 is geared towards bridging this gap and providing an improved understanding of ABM of OB in buildings. This effort includes establishing a 'level-of-detail'(LoD) concept for representing OB in agent-based environments, developing a conceptual framework to guide the selection of the appropriate OB granularity in ABMs, and exploring the suitability of LoDs of ABM with respect to different use cases within BPS.

2. A Level-of-Detail approach for agent-based models

The granularity adopted in representing OB in agent-based environments can have a significant impact on building performance results and is therefore an important matter that has not been sufficiently addressed. A simple model with fixed or static occupant actions and movement schedules may ignore the impacts of diverse OB on building performance, thereby leading to over-simplified simulation results. On the other hand, a detailed empirically grounded model may have too many elements that render the model too difficult to interpret. It is therefore necessary to address the appropriate level of detail concerning the representation of the occupants within BPS in terms of their presence, movement, decision-making processes, interactions, learning and other behavioral features.

Through a level-of-detail (LoD) approach, researchers have introduced a novel framework for the optimal resolution of OB representation in agent-based environments. The concept of LoD, borrowed from other built environment domains, such as 3D city modeling, emphasizes in the ABM environments the level of behavioral dynamics and semantic richness in OB. The LoD in an agent-based model is defined as the degree of detail or the level of granularity for representing complex human behavior in BPS. Ten occupant-centric attributes that denote the *model complicatedness* and *model complexity* in agent-based environments collectively describe the LoD for occupant representation. *Model complicatedness* refers here to the model structure, i.e., the spatial and temporal resolution, number of occupant agents, heterogeneity among the agents, and representation of their interactions. *Model complexity* describes the model behavior, such as how agent interactions at a micro level affect their actions and produce emergent effects at the macro level. The attributes are briefly explained in Table 1. A model may or may not encompass all the ten attributes. For example, a simpler model may not assume any sensing or prediction capabilities in occupants' behavior.

Table 1:Ten occupant-centric attributes for defining the Levels of Detail

Model Domain	LoD Attribute	Description
Model complicatedness	Representation	Depiction of occupants' behavior at aggregated, group, or individual level.
	Heterogeneity	Diversity in occupants' characteristics that affects their decision-making, such as preferences or attitudes.
	Zoning	Location of occupants in the environment, such as whole building level, space type, such as core or perimeter offices, or sub-space level, such as near windows.
	Occupant presence and movement	Occupancy representation, ranging from fixed schedules to rule-based or even stochastic schedules.
	Modeling formalism	Representation of occupants' decision-making processes, ranging from a set of logical rules to an elaborate behavioral model reflecting underlying mechanisms.
Model complexity	Interactions	Direct or indirect processes to depict inter-occupant exchanges, such as communications or negotiations.
	Learning	Occupants' ability to learn from previous experience and change their decision-making patterns over time.
	Sensing	Capability to sense internal and environmental variables for consideration in decision making.
	Prediction	Anticipating future consequences of actions for successful decision making
	Collectives	Emergent effects arising from multiple individual-level occupant interactions.

Based on the ten attributes depicting OB in ABM, a conceptual framework is put forward, as illustrated in Figure 1. The proposed framework, centered around the concept of LoDs for OB representation in ABMs, considers four influencing parameters, namely simulation objective, selected performance indicator, spatial scale, and building typology to select the optimal resolution or LoD. Additionally, there are other aspects, such as the data needs, computing efforts required for model development, as well as the desired accuracy of simulation results that must be considered to arrive at the optimal OB granularity. For instance, a coarse LoD with limited or no model complexity may be appropriate for estimating relative energy performance for different design options using granular KPIs, such as energy use intensity or ENERGY STAR score. A finer LoD with individual-level OB specifics for this case may needlessly burden the model without any significant improvement on the reliability of the desired output.

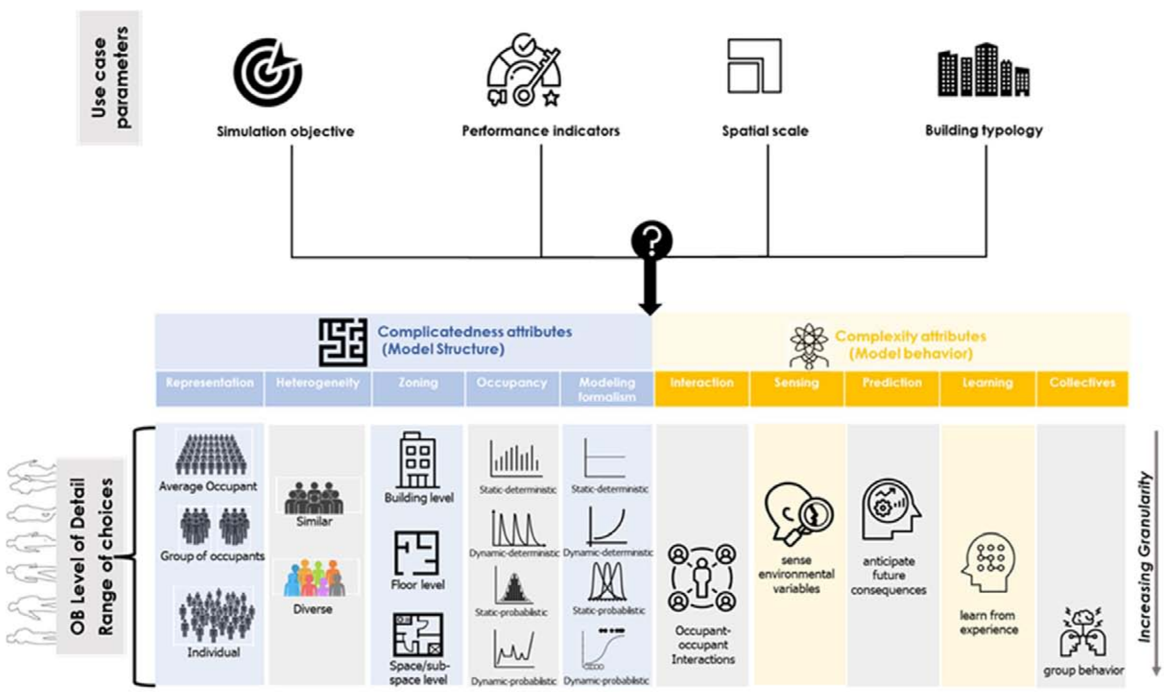


Figure 1: A Levels of Detail framework for occupant representation in ABM

The framework is flexible enough to allow the varied combinations of model structure and model behavior elements at different granularities, i.e., hybrid LoDs to suit the specific use cases. For example, static occupancy (low granularity) schedules and floor level zoning (medium granularity) may be combined with learning and interaction capabilities (high granularity). The hybrid LoD approach is effective for use cases including different sub-models (such as lighting operations or window adjustments) that may require different degrees of detail to suit the aim of the simulation. However, given the non-linear relationship between model complexity and complicatedness, the hybrid LoDs must be adopted with careful consideration of their impact on the simulation results. To put it in another way, modelers must consider the sensitivity of model structure as well as model behavior on the simulation outcomes while selecting the hybrid LoDs.

As a general guideline, there are three key matters that a modeler must deliberate before choosing the OB LoD in ABMs. The first relates to identifying the significant OB aspects that could influence model outcomes and need to be captured. For instance, an ABM intended to estimate the peak heating or cooling loads in a building may not be affected by occupants' visual comfort preferences. The second issue deals with striking an optimal balance between a model's accuracy and the required effort to develop it. Modelers are often tempted to develop detailed OB models because of the availability of rich OB data and advanced computing resources; however, a detailed model may not necessarily yield the most accurate results. In fact, a model as complicated as the real world (i.e., not simplified), will be difficult to interpret and may not offer any explanatory power. Therefore, a finer LoD must only be adopted if it offers a substantial improvement in model outcomes compared to its coarser counterpart. The third matter of concern is the data acquisition and model validation for creating the model at the required LoD. An elaborate ABM often requires qualitative as well as quantitative occupant data which may nor may not be available. Furthermore, model validation must also be carefully thought of to ensure a correct and accurate representation of the real-world phenomenon studied. Overall, a parsimonious modeling approach considering a trade-off between the influencing factors must be adopted to arrive at an optimal and balanced OB granularity.

3. Suitability of different LoDs for agent-based occupant modeling

Agent-based occupant modeling approaches within BPS have a myriad of applications across different building lifecycle stages, spatial scales, and contexts. However, the choice of optimal LoD is case- and context-specific. Here, we formalize four different LoDs of OB in agent-based environments (see Table 2) and discuss their suitability to support diverse use cases. LoD O-0 represents average occupants at building level zoning with occupant models comprising rule-based schedules or simple equations and no model complexity. In theory, LoD O-0 has no dynamic OB element and does not require an agent-based approach but some of its model attributes can serve to develop hybrid LoDs. LoD O-1 comprises homogenous OB with dynamic-deterministic schedules to model occupant presence, movement, and action. Besides, models at this granularity include model complexity limited to sensing and prediction. LoD O-2 incorporates occupant heterogeneity, static-probabilistic models for modeling occupancy and decision-making process, along with interaction and learning complexities. At LoD O-3, occupants are modeled as individual agents and their actions are represented through dynamic-probabilistic models. This LoD also consideres complexities in OB arising out of learning, interactions, and emergent effects.

LoD O-1 may support use cases concerning aggregate performance indicators, such as annual energy use intensity or relative performance of different design/retrofit options. Higher LoDs, such as hybrid LoD 1.5 (with a combination of OB attributes from LoD 1 and 2) or LoD 2, may be useful for high temporal and/or spatial resolution, such as forecasting peak hourly demand to arrive at effective demand management strategies or load shape analysis at the disaggregated zone level. LoDs O-2.5 and O-3 can capture behavioral complexities and thus could aid in use cases involving occupant-centric performance indicators or those involving holistic OB factors, such as exploring the influence of socio-cultural factors on energy use behavior. Higher LoDs (>LoD O-2) may also be useful for contexts with greater human-building interaction, such as energy estimation in mixed mode buildings to capture diversity in occupant's decision-making processes. In contrast, for controlled environments such as auditoriums or retail stores, where occupants' interaction with buildings is minimal, a coarse LoD would be appropriate. For urban scale applications, such as estimating thermal resilience during extreme weather events, lower LoDs (<LoD O-2) may be sufficient to capture the OB patterns as a finer OB resolution may not be effective due to the averaging effects.

Table 2: Four levels of detail for representing occupant behavior

Levels of Detail	Representation	Heterogeneity	Zoning	Occupancy	Modeling Formalism	Interaction	Learning	Sensing	Prediction	Collectives
LoD O-0	Average Occupant	None	Building Level	Static-deterministic	Static-deterministic	No	No	No	No	No
LoD O-1	Average Occupant	None	Floor Level	Dynamic-deterministic	Dynamic-deterministic	No	No	Yes	Yes	No
LoD O-2	Group of Occupants	Yes	Detailed Space Type	Static-probabilistic	Static-probabilistic	Yes	Yes	Yes	Yes	No
LoD O-3	Individual	Yes	Detailed Internal	Dynamic-probabilistic	Dynamic-probabilistic	Yes	Yes	Yes	Yes	Yes

4. Future Directions

This research aimed to improve the understanding of agent-based occupant modeling within BPS to inform energy modelers on why, when, and how to apply the agent-based approach. The broader goal is to motivate the simulation community to create innovative ABM applications to support energy efficiency, flexibility, and resiliency in buildings. An effort is underway to demonstrate the applicability of the proposed LoD framework which involves five different case studies at different spatial scales and building typologies. Results from these case studies will be used to fine-tune the ABM LoDs and the proposed framework to make them clearer and more usable. Such an effort would also support the development of a set of guidelines describing best practices and stepwise approaches to implement OB and assist researchers and practitioners through the ABM simulation process.

While ABMs offer great potential to improve occupant-centric building design and operation by realistic emulation of occupant-related processes and behaviors, there exist several challenges that the BPS community must overcome. The first issue is the data availability for programming occupant agents and validating their behaviors. Though there exist several open access databases, such as the ASHRAE Global Occupant Behavior Database and the ASHRAE Global thermal comfort Database, the generalization of these datasets is a very challenging task. Moreover, there is still a dearth of semantically rich datasets to support the development of empirically grounded ABMs. Secondly, the scalability of ABMs to support urban-scale applications is an important avenue for future research. Lastly, energy modelers must also delve into approaches to standardize occupant modeling in agent-based environments through the development of an OB ontology built on a robust behavioral theory that captures human activities, interactions with buildings, and decision making.

Acknowledgments

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technologies of the United States Department of Energy, under Contract No. DE-AC02-05CH11231. Authors benefited from participation and discussion in the project (2018–2023) Annex 79, Occupant-centric building design and operation, under the International Energy Agency's Energy in Buildings and Communities Programme.

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Calls for Nominations for IBPSA Awards and Fellows

Achievement Awards

The Board of Directors of IBPSA is seeking nominations for Awards to be presented at Building Simulation 2023, in Shanghai, China (September 4-6, 2023). IBPSA provides four awards for outstanding work in the building performance simulation field. These awards are provided on a biennial basis at each Building Simulation Conference, provided there is a qualified candidate. The awards are:

1. IBPSA Distinguished Achievement Award

This award, formerly named the IBPSA Award for Distinguished Service to Building Simulation, recognizes an individual who has a distinguished record of contributions to the field of building performance simulation, over a long period.

2. IBPSA Outstanding Young Contributor Award

This award recognizes an individual at the beginning of their career who has demonstrated potential for significant contributions to the field of building performance simulation.

3. IBPSA Innovative Application Award

This award recognizes an individual, group or firm, who has made a significant contribution to the effective application and/or advancement of building performance simulation in practice. The award may be given for a unique or noteworthy use of simulation in practice; development of simulation software or supporting software that has had a significant impact on industry practice; or other contribution that has advanced building performance simulation in practice.

4. Godfried Augenbroe Award

This new award, in honour of the late Prof. Godfried Augenbroe, recognizes a recent outstanding PhD thesis on the topic of building performance simulation. Eligible candidates will have been awarded their PhD in the two years since the last biennial IBPSA World Simulation Conference.

Achievement Award nominations

Nominations for awards must be made by an independent third party and submitted by February 1, 2023. We would like as many high-quality nominations as possible, so please contact the Chair of the Awards and Fellows Committee, Liam O'Brien (**liam.obrien@carleton.ca**), to ask questions about a possible nomination if required. Detailed instructions to submit nominations and a list of recent past recipients of these awards can be found on the IBPSA website: **www.ibpsa.org/?page_id=62**. The nomination submission portal will be opened in due time.

Fellows of IBPSA

The Board of Directors of IBPSA is seeking nominations for the 2023 class of Fellows. The IBPSA membership grade of Fellow recognizes individuals who are:

> *"A member who has attained distinction in the field of building performance simulation, or in the allied arts or sciences, or in teaching of major courses in said arts and sciences, or who by way of research, simulation code development, original work, or application of building simulation on projects of a significant scope, has made substantial contribution to said arts and sciences, and has been active in the field for at least ten (10) years".*

The IBPSA Board of Directors elects new Fellows on a two-year cycle, culminating with recognition at the biennial Building Simulation conferences.

Fellow nominations

Nominations for Fellows of IBPSA may be made by IBPSA members other than the nominee. The deadline for nominations is 1 February 2023. We would like as many high-qualified nominations as possible, so please contact the Chair of the Awards and Fellows Committee, Liam O'Brien, to discuss a possible nomination if required (**liam.obrien@carleton.ca**). Nominations should include details of the nominee's accomplishments in one or more of the following categories: industrial leadership, research, simulation code development, application of building simulation on projects of significant scope, educational leadership, and significant technical contributions to the allied arts and sciences. Detailed instructions to submit nominations and a list of IBPSA fellows can be found on the IBPSA website: **www.ibpsa.org/?page_id=310**. The nomination submission portal will be opened in due time.

Student Travel Awards - supporting students to attend BS2023

Travel to IBPSA Conferences can be costly - especially for students. In order to assist as many students as possible to participate in Building Simulation 2023, IBPSA will grant up to five travel awards valued at up to US$1,000 each to students presenting peer-reviewed papers. The selection committee bases its decisions upon the following selection criteria:

- need for financial assistance, evidenced in a letter of recommendation from the student's supervisor/advisor of studies (must be on university letterhead);
- overall quality of the peer-reviewed paper;
- relevance of contribution to the field of and/or furthering the effective application of building simulation.

To be eligible, the student must be:

- enrolled in a graduate program related to building simulation at the time of the conference; and
- their thesis project must be directly related to building simulation.

Student Travel Award applications

The deadline for applications is two weeks after the BS2023 paper deadline. Details on applications will be published on the IBPSA website in due time: **www.ibpsa.org/?page_id=62**. ■


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News from IBPSA affiliates

IBPSA affiliates are asked to submit a report to the IBPSA Board each year to keep Board members informed about their activities and membership. These are too detailed to include in ibpsaNEWS, so affiliates have been asked to make their latest annual report available through their web sites, and this section includes only selected, recent news. Other news from affiliates may be available from their websites; the URLs for these are available on the IBPSA Central web site at www.ibpsa.org/?page_id=29.

IBPSA-Australasia

Priya Gandhi, Vice President IBPSA Australasia

Carbon and climate positive: getting it done at the Australasian Building Simulation Conference

How can we use simulation to push boundaries on climate resilience, adaptive design, and decarbonising our built environment? How can we also ensure that these spaces are designed for people (healthy, comfortable, useful) as well as the planet?

We explored these questions and many others during the Australasian Building Simulation Conference, hosted jointly by AIRAH and IBPSA Australasia in Brisbane, Australia in July 2022. Using a hybrid in-person and online format we gained insights from simulation experts around the world and allowed more equitable access for attendees, while also delivering an engaging and interactive two-day in-person experience. We had close to 100 total attendees with four keynotes and 26 papers presented.

The keynote speakers were diverse in background and expertise, and united in their thought-provoking calls to action. On Day 1 Victor Olgyay (Rocky Mountain Institute Carbon Free Buildings Practice, USA) shared a "zero over time" approach as the most effective way to carbon neutral. Professor Joe Clarke (University of Strathclyde, Scotland) identified key needs for a new standard of building performance simulation (BPS+) to meet the demands of a net zero world.

During Day 2 we were awed by Professor Susan Ubbelohde (Loisos + Ubbelohde, USA) and her wealth of experience in delivering beautiful, functional, high performance spaces through simulation and collaboration. For our final keynote address, we heard from Associate Professor Jen Martin (University of Melbourne School of Biosciences, Faculty of Science, Australia), a scientist who has innovated the field of science communication. She shared practical tips and persuasive reasoning for why we need to make our technical work more accessible and improve how we communicate.

The conference paper presenters also gave us a lot to think about. While we can't share every single great idea or insight, here are a few:

- Don't forget housing - we all live in homes, best they are considered in our climate resilient future
- We need better precipitation data!
- Wind Driven Rain is a key factor in determining interstitial moisture.
- Artificial neural networks can be used to predict performance of borehole heat exchangers
- Retrofitted honeycomb blinds do reduce HVAC energy use but only when operated effectively.

- Poo has potential (for ambient loops)! The economic advantages will increase as carbon prices rise.
- Why are we still using PMV when the models are inaccurate, and perhaps based on a group of the population that isn't all that diverse?
- Let's question our assumptions of thermal comfort and reap the benefits in energy savings!
- Natural ventilation is a ticket to energy efficiency and fuzzy neural networks can help us with that.
- Economy cycles are not as simple as we think, and at the very least the challenge is to avoid a poor outcome rather than perfection in controls. But getting your supply air temp reset right might be most of the answer.
- Machine learning really is an active tool in testing our theories, and can be used in real time to optimise the operation of our buildings.
- Using a sensible and dehumidifying coil separately can produce some useful energy efficiency savings
- Your experience is as important, if not more, than your ability to use the software.

Congratulations to speakers Aaron Bach (Griffith University) and Tobias Kramer (Queensland University of Technology) who won our first ever "best paper presentation" awards. The conference proceedings are freely available as a pdf at **www.airahfiles.org.au/Conferences/2022/BuildingSimulation/2022-BuildingSimulation-ConferenceProceedings.pdf**.

Thanks to all presenters, attendees and reviewers, and also Emily Mclaughlin and Brendan Pejkovic at AIRAH for conference organisation, Veronica Soebarto (University of Adelaide) for chairing the scientific committee, and Priya Gandhi (Atelier Ten), Quentin Jackson (Aurecon) and Nicki Parker (Norman Disney & Young) of the technical organising committee. ■

Clockwise from top left: IBPSA Australasia board members PC Thomas, Manasa Marasani and Priya Gandhi, Quentin Jackson, and past-president Paul Bannister

IBPSA-France

The laboratory of Materials and Mechanical Engineering (MATIM) of the University of Reims organised the IBPSA France conference at the University Institute of Technology IUT-RCC, Châlons en Champagne site, on 19 and 20 May 2022. This hybrid event brought together more than 70 in-person participants and about ten virtual attendees, made up of doctoral students and reseachers. The main theme of the conference was summer thermal comfort. There were 27 oral presentations and 15 posters. Current advances in energy consumption prediction, digital data processing, life cycle analysis and summer comfort at different scales, from the building to the neighborhood, as well as hygrothermal transfers in bio sourced materials, were discussed.

Katharina Brockstedt from EnviroBat Grand Est was invited to speak about summer comfort from the perspective of building professionals (below left).

A round table discussion about the challenges of simulation for the design and management of buildings during heatwaves provided an opportunity to share feedback from several researchers (below right).

At the end of the conference, the best poster and the best oral presentation awards were given to Estefania Alvarez Del Castillo Cardoso from Grenoble Institute of Technology (Grenoble INP) and Adrien Toesca from the Centre for Energy and Thermal Sciences of Lyon (CETHIL).

The conference proceedings will be available online on the conference website **http://conference2022.ibpsa.fr**

IBPSA-Germany + Austria

BauSIM 2022 in Weimar

Climate change, a global pandemic and an energy shortage in Europe: 3 crises that presently have a hold on society, but which tools developed by the IBPSA community of building performance simulation experts can help to solve. Against this background, approximately 150 attendees from research, development and industry met in Weimar, Germany for BauSIM 2022. The conference was organised by IBPSA-Germany+Austria under the direction of Professor Conrad Voelker and Dr Albert Vogel (Chair of Building Physics and Head of WG Acoustics respectively, both at the Bauhaus-University Weimar). This year the conference themes attracted remarkable interest not only from the building simulation community but also from the wider society. Public interest was as high as ever and for the first time there was TV coverage of the event.

The conference included 90 presentations in 14 sessions discussing highly topical papers relating to energy simulations of buildings and city districts, indoor environment and comfort, BIM-based planning tools, validation and quality controls as well as numerical methods and optimization. However not only thermal and energy simulation, building services and indoor environment were represented, but another first was the presence of acoustic simulations at this year's BauSIM!

BauSIM 2022 was opened by Professor Conrad Voelker and the chancellor of the Bauhaus-University Weimar, Dr Horst Henrici. His address was followed by keynotes by Professor Arno Schlueter (ETH Zurich, Switzerland) and Professor Christina Hopfe (TU Graz, Austria), and IBPSA-Germany+Austria president Professor John Grunewald presenting an open letter addressed to the German Government demanding rapid action to incorporate the European Union's Energy Performance of Building Directives into German standards.

▲ Serious business ...

... and the not-so-serious ▼

The presentation and discussion of new developments and research in building simulation was accompanied by a multitude of other, non-scientific events, from a drum circle that had all attendees involved and entertained, to the conference's own brand of beer, BauSIM 2022 beer. Building Physics Weimar opened its laboratories in guided tours and participants could have a look at the climate chamber, the acoustics lab and the Schlieren lab.

After three highly informative days the conference was closed by a fascinating acoustics keynote by Dr Josep Llorca Bofi, a best paper award was given to Max Zorn, and five further papers were nominated for publication in the German journal Bauphysik.

The community will meet again at the next BauSIM conference, to be held in Vienna in 2024. ■

IBPSA-Italy

BSA 2022

The 5th Building Simulation Applications event, BSA 2022, organized by IBPSA-Italy and the Free University of Bozen-Bolzano, took place in Bolzano, Italy, from 29 June to 1 July 2022. After many virtual and hybrid conferences in the last three years, BSA 2022 was fully in-presence and attracted about 100 participants. There were eleven conference sessions in two parallel tracks, with 66 presentations by more than 180 authors, and with a small but significant share of participants from abroad, including Austria, Bangladesh, Denmark and India, realizing the international and inclusive vision of the organizers.

Like previous BSA conferences, the conference aimed to provide an overview of the most up-to-date applications of building simulation in three main fields:

1. the use of simulation for building physics applications, such as building envelope and HVAC system modelling, and their design and operation optimization,
2. global performance and multi-domain simulations, and
3. the development through simulation of new methodologies and regulations, as well as new calculation and simulation tools.

Topics that featured prominently included indoor air quality and the role of simulation in assessing strategies to ensure that indoor conditions are healthy and safe as well as comfortable for building occupants.

BSA 2022 opened with an inspiring speech by Professor Lori McElroy, President of IBPSA, on the role of IBPSA and simulation post COVID, and included keynotes on the use of simulation and optimization to support building decarbonization by Professor Paolo Baggio, University of Trento, and on modelling infrastructure for resilience and decarbonization, by Dr Drury Crawley, Vice President of IBPSA. Lori McElroy and Andrea Gasparella also engaged in a captivating conversation, discussing building simulation in the profession as a work in progress, in which they addressed the most critical aspects and challenges involved in fostering the use of building simulation among building professionals and specialists.

▲ Andrea Gasparella and Lori McElroy discussing building simulation in design practice

BSA 2022 included two additional events: the **3rd Student School on Building Performance Simulation Applications** for graduate and undergraduate students during the first day, and a **Round Table for Designers and Practitioners** after the closing ceremony. These were designed to expand the horizons of of current and future building simulation practitioners outside academia. The school included several topics of special interest to design practitioners, particularly the role of building simulation in building rating systems and its relationship to BIM. The Round Table brought together four professionals in an instructive discussion of the errors, challenges, and opportunities of building simulation.

▲ A talk during the Student School

This 5th BSA conference provided an excellent opportunity for many people from academia and the professional world to meet and discuss building simulation, to understand its current role in the design of future buildings and to address the challenges of a new post-pandemic society. ■

▼ At the end of the conference

IBPSA-Nordic

BuildSim Nordic 2022

Christian Anker Hviid and Mandana S. Khanie, Conference chairs

The 10th BuildSim Nordic 2022 conference and the 2nd international Nordic conference for IBPSA was held on 22-23 August 2022 in a newly-renovated building at the Technical University of Denmark. Organized jointly by the University and the Danish chapter of IBPSA, it was hosted jointly by the DTU Construct and DTU Sustain Departments and was open to members and non-members of IBPSA-Nordic.

Beyond providing a platform for exchanging ideas, issues, and research findings, IBPSA Nordic 2022 was about meeting and encouraging international collaboration and strategic partnerships, and attracting the next generation of building experts.

The weather was at its best, enabling Copenhagen to impress the audience with its charm, Nordic touch, and flavors of the city, and creating an ideal atmosphere for meeting up. As the organizing committee, we aimed to provide a framework for a holistic view of building performance in all its aspects. Seventy-six presentations were given, in two parallel tracks on each conference day, disseminating the latest knowledge in our field. Topics from daylighting and weather adaptation to design, performance, energy, and new software and tools were covered. The conferences hosted four workshops under the themes of daylighting, building and flexibility, and developments in simulation. With 95 participants from 22 countries, the conference created a platform for exchanging ideas, issues, and research findings, facilitating national and international collaborations.

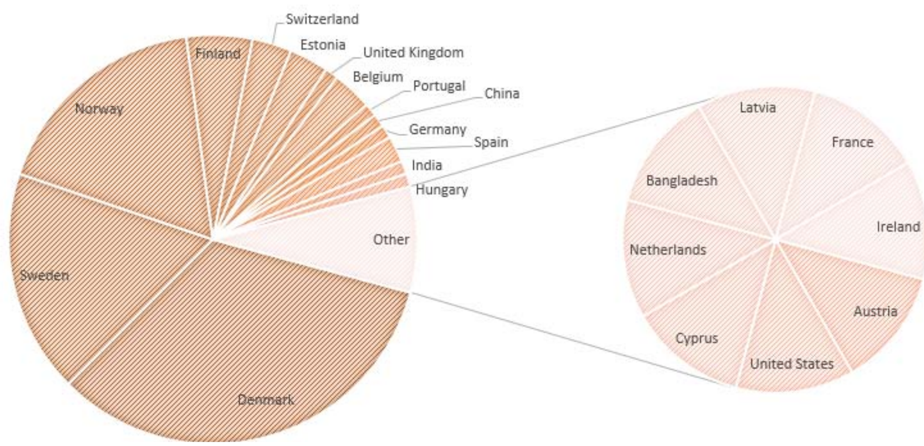
30% of the organisations represented were from industry, with delegates from thirty-three universities and 16 industry organisations participating in the conference.

Four Keynote speakers gave presentations on decarbonization in the building sector, energy performance gaps, generative design, and daylighting in buildings

Summer School participants, who presented their work in a poster session

A one-week specialized summer school in daylighting in buildings, NLITED, preceded the conference. 21 students at Bachelor, Masters, and PhD levels participated, presenting their work in a poster session. The conference was followed by a three-day Modelica training session, providing a total of two weeks of knowledge exchange between the university and industry and engaging young future building scientists and experts. A technical tour showcased how students engage with data and how building operators merge BIM and operation data to monitor the campus as a small city. Finally, a networking dinner at the Boatbar by Copenhagen's famous canals provided opportunity for participant interaction and a reminder of how physical meetings can enhance communication and support creativity.

On the final day, awards sponsored by LYS Technology Ltd were presented for the best paper selected by the scientific committee, the best poster selected by a selection panel, and three social media awards. ■



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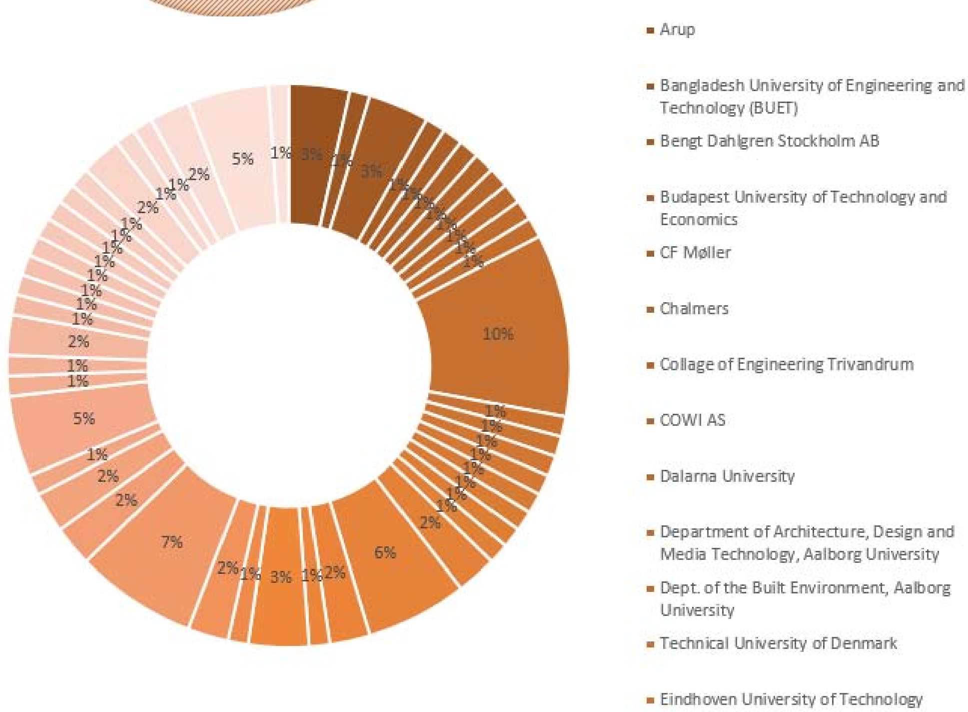
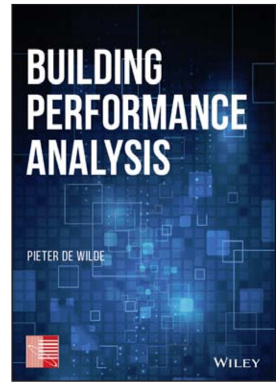


Participants from 22 countries spanned multiple continents. 30% of the organisations represented were from industry, with delegates from thirty-three universities and 16 industry organisations.

Building Performance Analysis (Wiley, 2018)



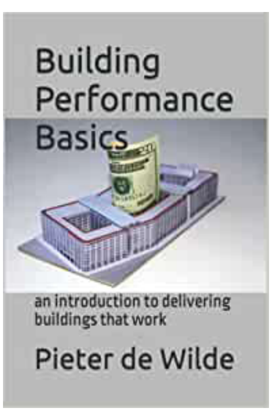
Building Performance Analysis is the go-to resource for those who want to have a deep understanding of what building performance is. The book is endorsed by IBPSA.

Building Performance Analysis offers a comprehensive and systematic overview of the concept of building performance analysis, bringing together many existing notions and ideas in one single title. It consists of three main parts. Part I deals with the foundations of building performance, Part II deals with performance assessment, and Part III with the impact of applying of building performance analysis throughout the building life cycle. The book concludes with an epilogue that presents an emerging theory of building performance analysis.

Building Performance Analysis is a substantial book: it has 11 chapters, 600 pages, and cites over 1600 references. It is written for the building science community. Amongst others, it aims to make the following contributions to the field:

1. It reviews the significant body of knowledge on building performance that already exists.
2. The book emphasizes the fact that building performance deals with a wide variety of performance aspects. In doing so it challenges the community to address some of the aspects that get less prominence in the literature.
3. It goes beyond simulation as a tool for building performance analysis: it also discusses physical measurement approaches, expert judgment, and stakeholder evaluation. It offers a review of the many analysis approaches available in each of these categories.
4. The emergent theory in the epilogue is intended as a key resource for those whishing to do further work in the field and needing to develop research questions and hypothesis. This is intended as matter for discussion, debate, and deeper exploration. ■

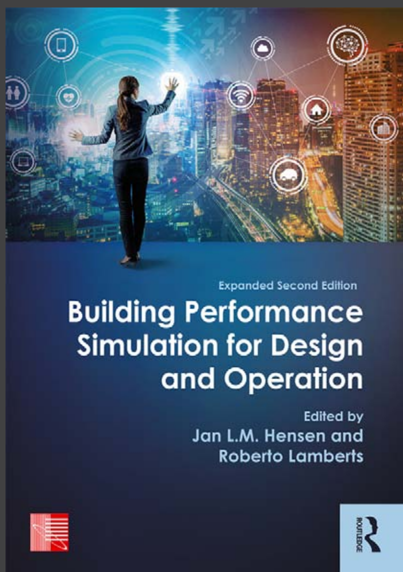
Building Performance Basics (Amazon KDP, 2022)



Building Performance Basics is a short book that offers an introductory text for students at BSc and MSc level. It also serves as a primer for those entering the industry, and as refresher for those who are already in practice but want to sharpen their view. As Building Performance Analysis is rather encyclopaedic, this booklet has been written with a different tone and set-up: short and cheerful, published with Amazon KDP in order to be quick to market, brief and to the point, and more persuasive in order to champion the importance and role of building performance.

Building Performance Basics deals with core questions about building performance: Why is it important? What exactly is it? Where does it play a role? When are there opportunities? Who should champion building performance? How do we quantify it? And How much performance should we aim for?

Building Performance Basics aims to provide a solid foundation for further professional development and learning about building performance, and for claiming leadership about building performance in practice. In academic courses, it provides context to modules that introduce students to hands-on performance quantification efforts using simulation, measurement and occupant surveys. In industry, this book can be used at any time where there is a wish to refresh a role as building performance champion. ■



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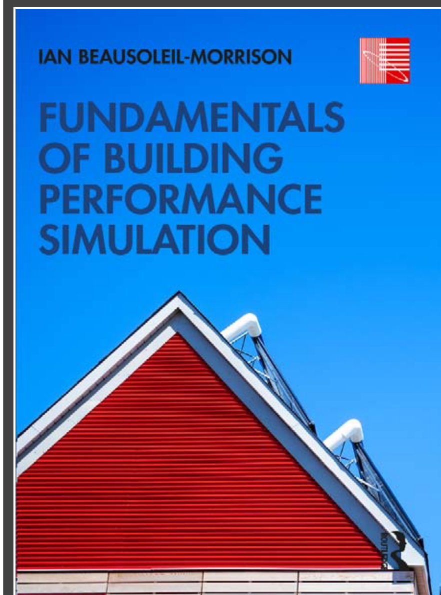

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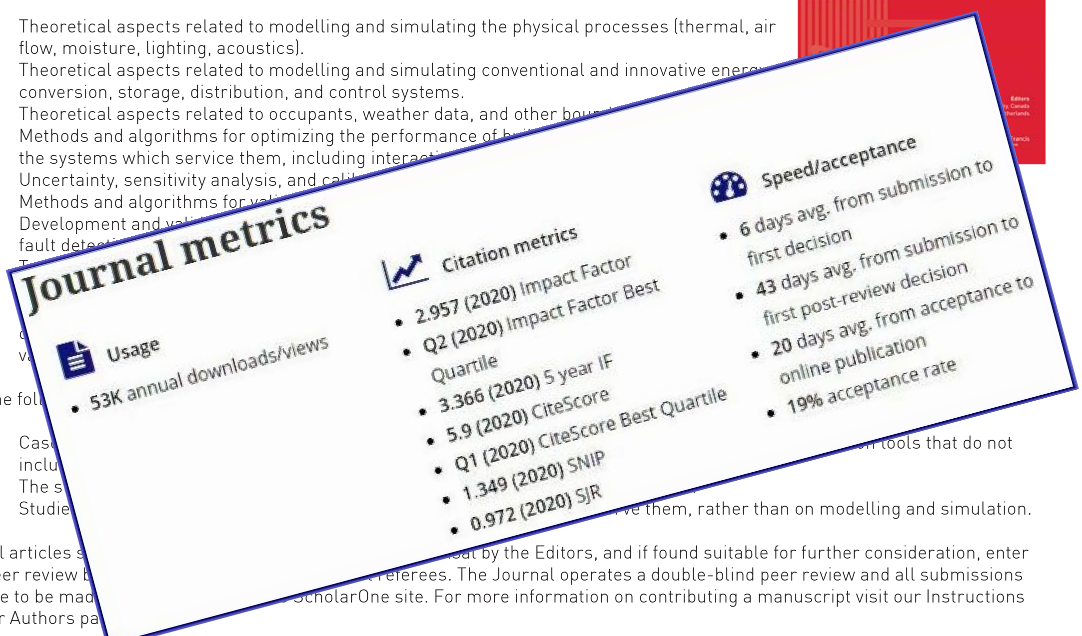

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