ibpsaNEWS

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Apr 2023

The Future Conference

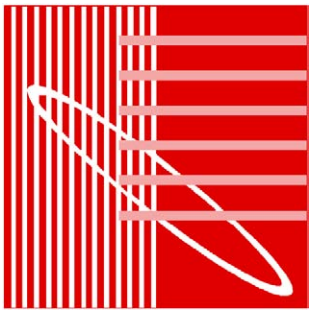
The Conference of the Future

FEATURES Reflections on IBPSA-England's online conference BSO22 from the conference Chair and the recipients of Best Paper Awards, and a developer and a user of EnergyPlus discuss *When and how should I update my Energy Modeling Software?*

SOFTWARE NEWS from DesignBuilder, Climate.OneBuilding.org & IES

CALENDAR OF EVENTS 14 conferences and other events for your diary

plus Ask A Modeler Q&A, an update on BS 2023, news from IBPSA-England and IBPSA-Nordic, a list of the latest papers published in the Journal of Building Performace Simulation, and more



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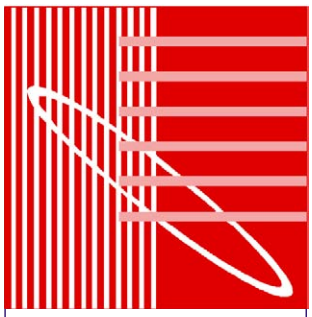

President's message

Dear IBPSA Colleagues and Friends

Finally, it's spring in the northern hemisphere! Here where I live, in Washington, D.C., the cherry trees were out 2 weeks earlier than normal after a mild winter. But extreme weather continues to be the norm these past months for many places around the world.

Back to IBPSA – let's start with what your board of directors does / is doing. The IBPSA board manages the activities and finances of the organization, and our board committees are the core:

- **Affiliate & Membership Development**
  Merged membership and affiliate development committees. Focused on helping new affiliates to start up and determining the needs of the broader membership.
- **Awards and Fellows**
  Responsible for IBPSA's awards – Fellows, Distinguished Achievement, Outstanding Young Contributor, Innovative Application, and the recently added Godfried Augenbroe award.
- **Communications**
  Responsible for the *ibpsa*NEWS and other communications, including our web site.
- **Conference**
  Solicit Building Simulation conference proposals, recommend and select next conference organizers and location, and work with organizers for the current (2023) and future Building Simulation conferences.
- **Education**
  Organize educational seminars throughout the year on topics of building performance simulation.
- **Equality, Diversity, and Inclusion**
  New committee looking at ways to ensure that IBPSA is properly addressing these important issues. (see the cover article on page 9 for more on EDI and how it was made a critical part of the recent BSO 2022 conference).
- **Projects**
  Manage IBPSA sponsored research projects.
- **Publications**
  Responsible for ensuring that our publications, particularly Building Simulation conference paper, and regional affiliate conference papers, are available to a broad audience through our website.
- **Standards**
  Newly formed committee to work with other organizations on building performance simulation-related standards. More on that in the next *ibpsa*NEWS.

Membership and participation in our committees is open to all IBPSA members. If you are interested and can participate in regular committee meetings, please contact the committee chair (see the website **www.ibpsa.org/contacts** for specific contacts).

Beginning this January, the IBPSA board now meets bimonthly. In the past, the executive committee (officers and directors-at-large) met regularly. But we found that many of the affiliate representatives (who are ex officio members of the board) were attending as well, so we now have regular meetings of the whole board. IBPSA board meetings are open; please contact one of the officers if you are interested in participating in upcoming meetings.

Look out in late April/May for information and a call for nominations for our annual election, which takes place in early summer (June/July). Usually, the election covers 5 directors-at-large and about half of the affiliates' representatives.

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 Profs Yiqun Pan and Da Yan. See more information on **page 20**. Looking forward to seeing you there!

Check out the forthcoming calendar of events on **page 16**. Also of note in this issue of the newsletter is the calendar for the new IBPSA Education Seminar Series and an interview on updating your energy software curated by IBPSA-USA. 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 seeing more of the IBPSA community over this next year.

Dru Crawley
President IBPSA

Best of 'Ask a Modeler':

BEM practitioners share tips and updates

'Ask a Modeler' is an advice column for the building simulation community. Each month, a question posed by the IBPSA community is answered by recognized building professionals to get their expert perspectives. The Ask a Modeler Subcommittee's mission is to disseminate building energy modeling (BEM) ideas and knowledge by bringing world-class BEM experts, practitioners, and enthusiasts to an accessible, curated advice column. Below, we are reprinting a few of these columns from the past several months. For everything from updating energy-modeling software to strategic advice for leveling-up your BEM career, you can find it here!

How do we better prepare students for the building simulation industry?

— Prof. Wellwisher or Prof. Student's Favorite

Dear Prof. Wellwisher,
Wherever I go, professors ask me "What can I do to better prepare students for the building simulation industry?". The question often leads to a really fiery and interesting discussion.

As an emerging professional with all my university experiences and challenges still fresh in my mind, I believe that understanding the question is more important than the answer. When you understand the challenges students face in their transitioning period, the solutions follow and bring in various amazing ideas for implementation with them.

For students, the biggest challenge is how to begin the job search. Students often send emails to professionals or connect with them over LinkedIn inquiring about open positions without a good understanding of the various building simulation jobs available in the market and their corresponding responsibilities. For professors, the challenge is the confusion about what students need to be taught so that they are universally equipped to take any job in the building simulation industry. Having interacted with various AEC firms daily to do multiple workshops and training as a part of my job, I have often heard about collaboration issues between architects and engineers or consultants. Thus, for employers, the challenge is to find young professionals with a quality of team playmanship (yes, this is a real word!) as well as technical expertise.

I offer three solutions to these challenges based on my own personal experience: NBC (no, not National Broadcasting Company):

"N" for Networking

When I was siloed to my own research during the pandemic, my academic advisor notified me of a volunteer role for IBPSA-USA as a note-taker for two different focus groups. It provided me with an opportunity to interact with experienced professionals and led to a leadership role as a Student Director followed by a Director role for the same organization. People cannot notice you when they don't know you exist. Bringing opportunities, no matter how big or small, and educating or motivating students to Network with industry experts is a great way to get them involved and prepare them for the job market without someone having to send 20 emails as referrals.

"B" for basics

Nowadays I see that several employers in the building simulation industry are opening numerous positions and I envy that because I am a pandemic graduate and faced a hiring freeze (fortunately, I managed to get an amazing job). However, different employers use different analysis tools and each is looking for proficiency with the tools that they use, so it can often be difficult for professors and students to decide on which one to teach and learn. The key here is to learn and be prepared with the Basics. If a student has a good understanding of the heat transfer process between the surroundings and the fabric of the building, it won't be difficult to click on a button and decide if higher wall insulation can affect that building's Energy Use Intensity or not. With firm foundations in the subject, one can quickly adapt to the new tool or software that the company is asking for. Of course, tools provide automation and speed up the process, so having some basic understanding of the popular tools and data science languages such as Python and R would provide added benefits in the job search. However, I do want to emphasize that intelligence and understanding is what makes a student stand out in the job market.

"C" for collaboration

Collaboration, the act of working together, drives the entire world. No one person can run a business, school, country, or a relationship for that matter. Individuals often become accustomed to competing in school, but good employers love to see employees collaborate. It leads to better decisions because then they cater to a wide and diverse audience with different perspectives and alignments. Back in my school, once we learnt the basics, we were introduced to a new course where we as building performance experts had to work with final year M.Arch students as their consultants. Each of us worked for 2 different students running analyses (daylight, energy, thermal comfort etc.) that helped them to make their design decisions. This was a great experience that I try to share with as many people as I can because it not only familiarized us (building performance students) with the industry, but also prepared "about to graduate" architects on how to collaborate with their consultants and accept suggestions on improving their designs.

These are my two (or maybe 3) cents worth, but I really feel there is so much more to this question that can be addressed mainly because students will be our future leaders. They will soon be leading the way and addressing much more challenging issues than we currently have on our plate. Providing better education and guidance is our responsibility to make sure our industry is passed on to good hands for it to flourish and further save the world!

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As heat pump water heaters reach higher adoption, what do I need to know in order to properly model them?

— Hot For Heat Pump

Dear Hot For Heat Pump,

Q: What special considerations do I need to make to model a heat pump water heater?

Good question! Heat pumps are getting more attention these days for both space conditioning and water heating as electrification is increasingly seen as part of the path to reducing emissions. You might have plenty of experience modeling water heaters and feel like you're a pro with plant loops, but heat pump water heaters (HPWHs) do require some additional considerations. I've been modeling HPWHs for over a decade and did my thesis on

modeling HPWHs with one of the first national scale analyses of their performance, so I've picked up a lot of tips for modeling this technology. Heat pump water heaters have been around for decades, but in the last 10-15 years multiple major water heater manufacturers have launched and refined product lines. This article focuses on modeling residential integrated HPWHs, but many of the considerations would also apply for split HPWHs or those sized for commercial buildings. A model that gives you good results for an electric resistance tank may not provide accurate results if you just add a heat pump. To be able to do a good job modeling an HPWH, the first step is to know how the actual equipment operates. If you don't understand how the physical equipment operates, you won't know if your model is behaving correctly or not.

Q: How do HPWHs work?

As the name implies, HPWHs integrate a heat pump with a water storage tank. This heat pump works like any other heat pump, pulling heat out of the ambient air and moving it into the water storage tank. While most of the load is met through the heat pump, the tank frequently also includes one or more backup electric resistance elements. The heat pump is much more efficient, but it heats the tank more slowly than the elements, so the elements tend to turn on when there are large loads. Under default controls, the HPWH will favor the heat pump, but at a certain point if the heat pump doesn't have the capacity to provide adequate hot water the backup elements will turn on. The exact setpoint where the heat pump and element(s) turn on is based on the onboard control logic and is specific to each manufacturer. Most HPWHs also have multiple operating modes, which may disable the backup elements entirely. The control logic to use in simulation is generally derived through comparisons with measured laboratory data.

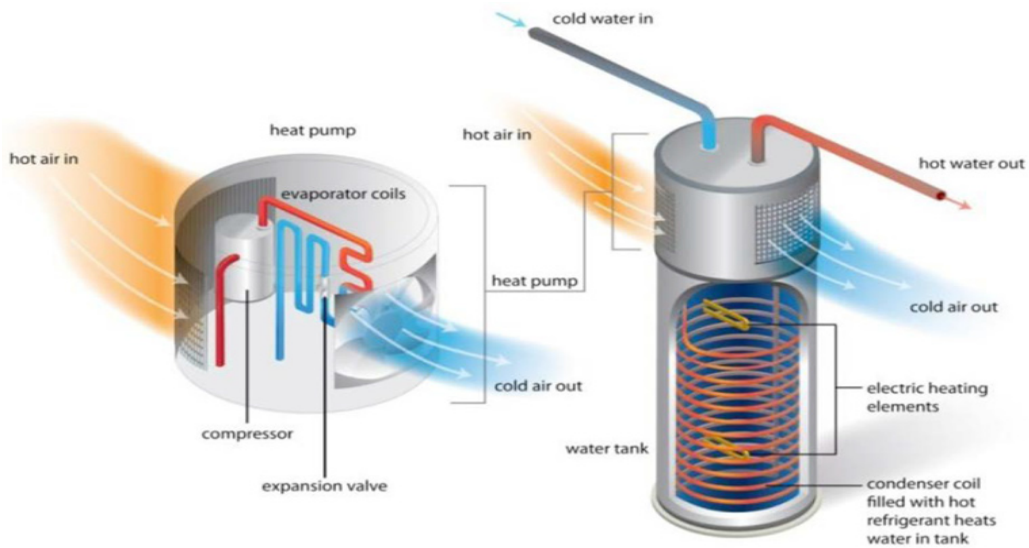

Figure 1: Schematic of an HPWH. The HP evaporator sits on top of the tank, and wrapped condenser coils transfer heat into the tank. Backup heating elements are frequently included and may trigger depending on the water heating load and operating mode. (Image by NREL.)

Q: What additional information do I need to model an HPWH?

There are two critical pieces of information you need to model HPWHs: you need to know the performance of the heat pump under the full range of conditions, and how the HPWH controls which heat source is operating. Performance maps are generally derived through detailed laboratory testing under a broad range of ambient conditions and then validated against additional data not used in the derivation. If you are modeling residential integrated products, the EnergyPlus example files for HPWHs include a performance map derived from extensive

comparisons to laboratory data. This performance map could be used for any systems with a similar heat pump (the primary concern is using the same refrigerant), split or integrated. The type of refrigerant used has a large impact on the thermodynamics of the heat pump, which are captured in the performance map. Most HPWHs today use R134a as the refrigerant. However, it would not be appropriate to use this map with HPWHs using a different refrigerant such as CO_2. For the control logic, you can either derive your own based on measured data or look at what is used in existing HPWH models to inform your setpoint and deadband assumptions. There are existing models in OpenStudio-HPXML and ResStock, tools designed to be able to model residential buildings all across the US, for a HPWH from a major manufacturer that you could pull control logic from. You could also look at HPWHSim, a tool designed specifically for HPWH modeling, to see what control logic they use for different products.

Q: What else should I watch out for?

Timestep length matters much more for an HPWH than it does for gas or electric tanks. Larger timesteps have two main implications: the water draw profile may be spread out across the entire timestep, and the HPWH has fewer opportunities to make a control decision. Some BEM tools have a separate timestep for the water heater to address the less frequent control decisions. EnergyPlus includes an adaptive timestep algorithm where it will take larger timesteps when nothing is happening and smaller timesteps when control decisions are being made (generally during hot water draw), but for tools that don't, it's important to have small enough timesteps that the model can accurately figure out which heat source needs to trigger during recovery. Larger timesteps may smooth out demand for hot water such that the model uses the wrong heat source. If a large draw happens across a 10 minute window, for example, modeling with hourly timesteps will require that same event to be evenly distributed across the whole time step. This flow rate matters because it affects the internal tank temperature dynamics. A large draw over a 10 minute window might require the backup element to turn on, but if this draw were averaged over an hour, the heat pump could keep up with the rate of demand. Shorter timesteps can avoid this problem, with 1 minute timesteps being ideal for capturing the real spikes in hot water usage, especially in residential buildings.

You also want to use a stratified tank model when modeling HPWHs rather than a mixed tank. Mixed tanks are assumed to be a single uniform temperature, while stratified tanks account for vertical differences in tank temperature. The heat pump performance depends on the temperature of water adjacent to the condenser, which is generally in the bottom half of the tank. Assuming a fully mixed tank will not accurately represent the temperature of the lower half of the tank, especially during recovery from draws, which will affect the COP and capacity calculations using the performance map.

Now that you know the pitfalls you will encounter, you too can become an expert in HPWH modeling. Happy modeling!

Jeff Maguire
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We want to hear your interesting, entertaining, or just-plain-odd questions about life and building performance simulation. Submit your questions to **askamodeler@ibpsa.us** *to be answered by prominent building performance simulation experts. Note that questions requiring an immediate response should be submitted to the community of experts at* **unmethours.com**. *Read our other past columns at* **www.ibpsa.us/ask-a-modeler**. *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**. ■

Building Simulation & Optimisation 22:
Reflections on a successful online conference

Professor Rob McLeod (Technical University of Graz and Chair IBPSA EDI Committee) interviewed Professor Sukumar Natarajan (University of Bath and BSO 22 Conference Chair) after the conference to compare impressions of the event and consider what lessons it offers for future online conferences.

Rob McLeod (Rob): *Sukumar, thank you for agreeing to be interviewed. Before I begin, I would like to extend my congratulations to you and your colleagues from the University of Bath and IBPSA-England for the success of the recent BSO 2022 online conference. The theme of the conference was 'The Global South' and from an Equality, Diversity, and Inclusion (ED&I) perspective, there were several aspects which really impressed me.*

First off, what made you decide upon 'The Global South' as the conference theme?

Sukumar Natarajan (Sukumar): Thanks for inviting me to interview, Rob, and for your warm words on BSO 2022. Although there is no agreed definition of the Global South, we have been using it as an umbrella term for a few years now to represent the less "developed" parts of the world.

I became interested in the Global South through doctoral research by my students in Mexico, Jordan, India and Qatar and simultaneously through three projects, two on low-energy building design in South Africa and India and a third on refugee shelters in different parts of the world, but largely in the Global South.

"the Global South will be responsible for doubling the world's built floor area in the next 3-4 decades"

Two key facts emerged from the various strands of research. One, that the Global South will be responsible for approximately doubling the world's built floor area in the next 3-4 decades. This presents both a threat and an opportunity in terms of carbon mitigation and adaptation. Two, that the challenges in the Global South are fundamentally different from those in the Global North in terms of data, skills, culture, systems, verification and cost. Viewed collectively, I thought it was time our community had an opportunity, through BSO 2022, to discuss and learn from one another to determine how best we can contribute to meeting these challenges.

Rob: *Did you reach your target for the diversity of attendees, and do you think it really was an inclusive event?*

Sukumar: I think there were some definite successes. More than half the papers presented were from the Global South, many of these by young researchers. Just under half of all presentations were by women. On the other hand, we don't seem to have attracted many women with childcare responsibilities, for example, which was an aspect we thought we could address through our conference structure.

Rob: *I think I only paid £10 for the attendance fee; this must be the cheapest conference I've ever attended. How did you manage that, or did you just leave a zero off the price list by mistake?*

Sukumar: Ha! I was just about to say in relation to the earlier question that the fees we charged also played a part in this. Most conferences are prohibitively expensive for those in the Global South, and we thought it likely that this was potentially leaving many good researchers out. Once again, it is hard to tell from the registration data we have but I would guess that around 15-20% of the attendees might not have been able to make it to the conference at the usual cost of well over £1,000 when factoring in air-fare, visa fees, accommodation and the conference fees. We charged those in the Global South just £50 to come and present their work.

As far as the £10 goes, we had this idea that conferences – or at least parts of a conference – are interesting to a much wider audience than the presenters alone. So, we thought we could really lower the barrier to entry by charging an attendance-only rate for the whole event that would make it easy to join (and leave!).

"Most conferences are prohibitively expensive for those in the Global South"

Rob: *Why did you choose a virtual format for this event - was this purely due to the ongoing COVID 19 pandemic or were there other factors behind this decision?*

Sukumar: This was a decision driven in part by the arrival of the Omicron variant in December 2021, in part by the EDI issues we have been discussing thus far, and also by the energy and carbon cost of long-distance travel.

By the time BSO 2022 came around, however, normal travel and life had more or less resumed, though there were rail strikes on the days of the conference! But our view in December 2021 was that it would be too risky as vaccination uptake was unclear, and unevenly spread in the world, and the potential emergence of new variants was not yet fully understood.

However, even in September 2021 there was already an emerging idea that only a virtual conference would truly allow us to commit to our EDI and carbon mandate. A physical conference by its very nature imposes cost and carbon that we were keen to avoid.

Interestingly, some presenters from the Global South contacted us in mid-2022, saying they would prefer an in-person event as they were keen to travel! So perhaps we need to do another one just to find out how that turns out.

Rob: *One of the big detractors of online conferences must be the potential lack of interaction between attendees and presenters, as well as the absence of that mingling vibe that a lot of people are looking for. Did you consciously think about how to address these issues in the planning of the event?*

Sukumar: This was thoroughly debated, and we bounced around many ideas. We had initially planned on hosting the event on a new platform designed to enhance interactivity between attendees. COVID has generated many new virtual platform vendors who had picked up on the need for better quality online conferencing and we did product demos with a few. These usually include an element of visual graphics, virtual tables, ways for attendees to meet and connect independent of the programme, etc. Eventually, however, we fell back on Zoom for various reasons.

I think the wins on EDI and Carbon definitely come at a cost. At our wash-up meeting after the conference we reflected on the fact that, although we don't know because we could not run the experiment, even with a highly interactive platform we may not have generated the sort of "excitement in the air" that one would get at a physical conference. The fact is that once you have travelled a long way to be somewhere, you will generally choose to be there for many more sessions than in an online event. It's the audience that creates the conference feel, the speakers are just there to anchor the event.

Rob: *One thing I really enjoyed was the passionate debate 'Building energy modellers are not literate' between Professor David Coley (for) and Dr Annie Marston (against). I understand this topic arose from a controversial paper David Coley and his colleagues published a few years ago. It was a very civilised debate, yet somewhat surreal watching Annie arguing from the inside of her car whilst David appeared to be in his kitchen. Are you planning a new career in reality television and did you ever worry that broadcasting a live debate on such a contentious topic might go badly wrong?*

Sukumar: We really did not know how this would go, and it was almost touch and go at the end as Annie was on a flight back from Europe on the same day! I gather she just parked on the side of the road to debate with David. The connection was amazingly good for both, which was a relief. There was a mini pre-debate prep just so the speakers knew one another a little, but this was brief, so we were really trusting both our speakers to deliver. This was definitely the most enjoyable part of the conference for me too. The speakers were great and the audience interaction was brilliant! I think a new career in reality TV may well be possible now that I have pulled off a debate on a topic that almost no one agrees on 🙂

Rob: *Finally, if you had to do it all over again (and we really hope you will sometime) would you do anything differently?*

Sukumar: I probably won't have the appetite to host another event for a few years now! The online format is intriguing and has many clear benefits, but at the same time I wonder what an EDI and Carbonpositive in-person conference looks like. Hopefully someone will show us soon that such an event can be held in an inclusive manner and without greenwashing.

Key lessons from BSO 2022

With diversity and inclusion particularly in mind, Sukamar and Rob identified 7 key lessons from BSO 22 for organisers of future online conferences:

1. **Theme:** This was an important consideration for us from the start. While the reasons for the selection of a Global South (GS) focus for the conference are obvious, we also had to ensure that those who viewed themselves as not operating within a GS focus did not feel excluded and thus feel less invested. So, while "ED" is addressed to a good extent by a theme like the GS, the "I" needs to be potentially even broader than one might at first imagine. While it seems unlikely to me that BSO will do another GS focused event (but who knows), it would seem sensible for all IBPSA events to consider how the work being presented is made meaningful to the GS, given that so much of the new build activity in the next 30 years will occur in the GS.
2. **Virtual platform:** We investigated several fee-paying virtual platforms with costs ranging from £4k to £13k. Our eventual selection of a "free at the point of use" platform (i.e. one for which fees had already been paid institutionally) eventually came down to the fact that our full-paper conversion rate was ~50% from the abstract stage. This had no doubt to do with the fact that we had to postpone the event due a disagreement within IBPSA-England on what the role of the theme is (see 7 below). It would seem to me that for a conference with a larger submission footprint, a fee-paying platform would easily pay for itself even with relatively low fees.
3. **Fees:** Our choice of a virtual event, driven largely by the uncertainty posed by the emergence of Omicron in late 2021, was a double-edged sword. On the one hand, we could experiment with an attendance-only rate of just £10, which is an absolute steal for a conference of this type. Even speaker

fees were low – tied in purposely with the GS theme to enable people who might not otherwise consider attending due to the high bar of entry imposed by typical conference fees. This resulted in a substantial crop of papers (~50%) from the GS. So there is no doubt a low-fee mandate is likely to succeed again. On the other hand, it is hard to maintain audience numbers in any given session of a virtual conference. Travelling to a destination locks people in and is likely to drive better audience numbers per session. But this can be balanced by the flexibility offered by a virtual conference where people selectively attend the sessions of greatest value and interest. So, the "feel" of such an event is quite different and, once embraced, equally rewarding.

4. **Flights and travel:** The avoidance of significant cost of travel and the resultant CO_2 is an obvious plus for such a conference. In addition, logistical difficulties are transferred from the physical (our conference occurred in the middle of strikes and weather-related rail cancellations) to the virtual (the main issue now being maintaining a stable and good quality connection with the attendee, mitigated through pre-testing with our IT staff).
5. **Time-zone integrity:** If people are attending from different parts of the world, it is important that conference and individual timing is carefully mapped to ensure it is neither too early nor too late for speakers / attendees. This meant a 1100 – 1600 UTC window with paper presentations occurring after 1200.
6. **Speaker diversity:** we actively sought speakers from the GS including female speakers. This was obviously important for us in addressing our core theme but given what I said in (1) it would seem appropriate to ensure such representation continues and is expanded. There is a lot of good work going on but it can only be captured if we maintain a clear mandate to do so.
7. **Timeline integrity:** While it was relatively "easy" for us to postpone the event due to its virtual nature (so this is a plus in terms of flexibility compared to an in-person event), this is however something that should absolutely be avoided as it dilutes the integrity of the timeline.

Rob McLeod *is a full professor in Building Physics and Sustainable Design in the Institute for Building Physics, Services and Construction at Graz University of Technology, Austria. He is also the Chair of the Equality, Diversity, and Inclusion (EDI) committee of IBPSA-World and a former vice-chair of IBPSA England. His main research themes focus on enhancing resilience and wellbeing in the built environment, addressing issues such as overheating, energy poverty and indoor air quality. He has more than 20 years of international experience in senior roles in the built environment and currently leads the CovEd and ImpAQS research projects, funded by the Austrian Federal Ministry of Education, Science and Research.*

Sukumar Natarajan, *FHEA, is Professor of Environmental Design in the University of Bath's Department of Architecture and Civil Engineering. The overall aim of his research is to deliver healthy and comfortable low-carbon buildings that perform well into the future. This research lies at the intersection of three key global grand challenges: climate change, energy security, and health. He has secured £9.2M in research funding from a range of funding bodies for this research and is a prize-winning teacher in environmental design.*

Impressions from the winners of Best BSO 22 Paper Awards

Two papers were selected for Best Paper Awards at BSO 22. Derek Mitchell was presented with the Best BSO 2022 Paper Award for his paper *Simulating the built environment for another globally distributed species*, and Tariené Gaum, Henry Odiri Igugu and Jacques Laubscher rreceived the Best Special Focus Paper Award for *Using a system dynamics framework to develop a decision-making model for Building Energy Efficiency Codes in the Global South*.

As part of our exploration into the future of conferences and the experience gathered at BSO 2022, Eleonora Brembilla asked Tariené Gaum, Jacques Laubscher and Derek Mitchell to share their impressions of the conference with the broader IBPSA community.

Eleonora Brembilla (EB): Tariené, Jacques, Derek, many thanks for agreeing to be interviewed. Could you please briefly introduce your work and the explain its relevance for the building performance simulation community, and for society in general?

Tariené Gaum (TG): Our paper addresses the lack of Building Energy Efficiency Codes (BEECs), specifically within the Global South. Subsequently, the Sustainable Levels Indicators Model, Matrix and Maps (SLIM3) decision-making tool (development of which is still in progress) will encourage simulation practitioners towards optimised and contextualised building simulations. The research further supports the development of BEECs by creating a knowledge-sharing database that is contextually appropriate, promoting implementation and enhancing information accessibility. This paper forms part of my PhD research project which aims to help Global South countries which lack BEECs, and ultimately facilitates enhanced metrics and accurate data for building performance simulations as the Global South develops.

Jacques Laubscher (JL): Our research group is looking at new definitions for the concept of a Global South and at the complex dynamics that can redefine areas of the world in view of climatic, population and emissions challenges. We believe that achieving a better understanding of such dynamics will enable the creation of building energy efficiency goals and codes that can successfully be implemented in the Global South. On top of this, the application of BIM and BEM methods is key to achieving these goals, and our team is fully dedicated to embedding them in research, practice and education.

Derek Mitchell (DM): My work simulates buildings with worldwide distribution - from maritime temperate to arid desert - that are selected and constructed to create an air-conditioned environment to raise young and facilitate the industrial activity of sugar refining. However, these are not humans, but honeybees! One unexpected result was that even small changes in the size of the honeybee could have profound effects on the internal convection air flow and the energy involved. This drove honeybee evolution into creating subspecies, with very subtle differences that have large impacts on their adaptation to the different conditions. The work has demonstrated that non-human species can have more complexity in their interaction with their environment than commonly thought. It also shows that simulation allows us to explore occupant/ habitat combinations that do not occur in reality, and to find out why evolution has trodden a particular path. The key lesson for the wider community of building performance simulation is that we should be ready to shed our assumptions when dealing with conditions outside of our own cultural, climate and species norms.

EB: *How did you hear about BSO 22 and what do you think of the conference format? If you have been to previous IBPSA (or other) conferences, how do you think BSO 22 compared to those?*

DM: I found BSO 2022 when searching for something that dealt with simulating the built environment in a technical fashion yet was looking at its impact and relevance; I had found that engineers could take on board the biology of honeybees much more easily than biologists could understand the physics of honeybee nests/hives. In the words of one engineer after hearing of my research: "Oh, it's just another built environment".

TG: I came across the BSO 2022 conference as the University of Bath forms part of my information network. Having worked with Professor Sukumar extensively on an international collaboration project in 2019 (*Preparing the South African Built Environment for Climate Change Resilience*, supported by the UKRI Newton Fund and the Royal Academy of Engineering), I was excited to take part in the conference. I have attended a few other international conferences (both in person and virtually), but this was my first IBPSA conference. I thought it was extremely well organised, structured and presented, with a strong cross-disciplinary approach. We all know it can be challenging to host an online event that truly simulates in-person collaboration and knowledge sharing. Despite the obvious lack of conversations over lunch, I thought the conference hosts did an excellent job in organising debating sessions that really encouraged participation from the audience. What truly stood out for me from BSO 2022 was the range of highly knowledgeable researchers, keynote speakers and experts from across the globe. The BSO and IBPSA conferences certainly provide an excellent platform for students, emerging researchers, industry experts and experienced academics to share knowledge and enhance collaboration between the Global North and Global South.

JL: I was invited to the conference as keynote speaker and followed as many parallel sessions as I could. The conference was very well structured, and I appreciated how clearly the abstracts and presentations were divided into thematic groups. It really helped me navigating the programme and finding the sessions that were closer to my interests. Of course, the remote format makes it more difficult to network and establish relationships, and it makes it much easier to get distracted by other tasks, but it comes with environmental advantages too.

EB: *Have you got any suggestions on how to improve IBPSA conferences in the future?*

TG: In my personal view, despite understanding the reasons for hosting an all-virtual conference, I do believe that the knowledge sharing, interactions and collaborations from in-person conferences are much more impactful. I also think that traveling, meeting new people, experiencing diverse cultures, and exploring new environments brings about unique perspectives that can change our perception of the world.

DM: I must admit I also prefer conferences in person.

JL: What I would like to see more are follow-ups of the key topics discussed during the conference. One example could be a journal special issue dedicated to the conference theme of the 'Global South'. But there could be many other ways - the important thing is to keep the conversation going between different parts of the world and different disciplines, to achieve key development goals all together.

EB: *Thank you all again for your participation in this interview, and my congratulations to you and the other authors for winning Best Paper Awards!*

Tariené Gaum is a PhD student and full-time lecturer at the Department of Architecture and Industrial Design at the Tshwane University of Technology, Pretoria, South Africa, with specific focus on Building Physics and Systems Design.

Jacques Laubscher is a practising Professional Architect, a Professor in Architecture and the current Head of the Department of Architecture and Industrial Design at the Tshwane University of Technology, Pretoria, South Africa. Jacques holds a PhD in Architecture (University of Pretoria), a Master's degree in Urban and Regional Planning (University of the Free State), an MBA in Education Management (Haaga-Helia University, Finland) and a Higher Education Teaching Certificate (Harvard).

Derek Mitchell initially set out on a career in Mechanical Engineering but switched to the world of Microelectronics via Physics and thus later to Telecommunications. He is now back to Mechanical Engineering at the University of Leeds, UK, pursuing a PhD with a perhaps surprising application area – honeybees.

Forthcoming events

Date(s)	Event	Further information
2023		
20-23 May 2023	**IAQVEC** Tokyo, Japan	**https://iaqvec2023.org**
11-14 June 2023	**Healthy Buildings Europe** Aachen, Germany	**www.ukaachen.de/kliniken-institute/hb2023-europe/about/welcome-to-hb-europe-2023**
24-28 June 2023	**ASHRAE Annual Conference** Tampa, Florida, USA	**www.ashrae.org/conferences/2023-annual-conference-tampa**
14-18 August 2023	**SuDBE: International Conference on Sustainable Development in Building and Environment** Espoo, Finland	**www.sudbeconference.com**
14-18 August 2023	**Time Series Analysis Summer School** Copenhagen, Denmark	
26 August - 01 September 2023	**NLITED Summer School** Gdansk, Poland	**www.nlited.eu/gdansk-2023**
28-31 August 2023	**International Radiance Workshop** Innsbruck, Austria	**www.uibk.ac.at/bauphysik/lehre/radianceworkshop2023.html.en**
04-06 September 2023	**BS 2023** **Shanghai, China**	**https://bs2023.org**
11-13 September 2023	**ASHRAE Building Performance Analysis Conference** Austin, Texas, USA	**www.ashrae.org/conferences/topical-conferences/2023-building-performance-analysis-conference**
15-23 September 2023	**CIE 30th Quadrennial Session** Ljubljana, Slovenia	**https://slovenia2023.cie.co.at**
September 2023 (TBC)	**BauSIM** Vienna, Austria	
November 2023 (TBC)	**uSIM Conference** TBC, Scotland, UK	
2024		
20-24 January 2024	**ASHRAE Winter Conference** Chicago, Illinois, USA	**www.ashrae.org/conferences/2024-winter-conference-chicago**
2025		
2025 (dates TBC)	**CLIMA World Congress 2025** Milan, Italy	

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

11-14 June 2023
Aachen, Germany
www.ukaachen.de/kliniken-institute/hb2023-europe/about/welcome-to-hb-europe-2023

18th Healthy Buildings Europe Conference

Healthy Buildings is one of the most influential conferences on sustainable solutions for a healthy and sustainable indoor environment, and aims to bridge the gap between science and practice. This year's theme is *Beyond disciplinary boundaries – Transdisciplinary perspectives on multisensory stimulation for innovative and creative solutions in a Post-Covid era*. We have set up an interesting program and are offering on-site attendance with all the benefits of in-person conferences like social interaction, fruitful discussions, and personal exchange.

The last decade offered a multitude of knowledge gained and solutions developed within individual disciplines. Sensible application of these, however, requires a holistic understanding of interdependencies between and across disciplines. At the same time, current crises, such as climate change and COVID-19 pandemic, show the need for inter- and transdisciplinary collaboration to shape the future of healthy and stimulating built environments.

Highlights will include:

- TED-style keynotes, which transfer latest research and future visions related to methods and findings from research and practice
- A new poster format that will leave behind so called "text-walls" in favor of posters that are motivating to look at and engage with the corresponding authors
- A visit to the beyond-state-of-the-art laboratory facilities of the Urban Energy Lab 4.0 and University Hospital, which range from advanced chemical analysis, biomonitoring over multi-perceptual subjective human laboratory experiments to full scale façade and HVAC test benches
- A conference dinner in the Stadtpalais, where participants will be able to explore the historical parts of Aachen city and "feel like Karl the Great"

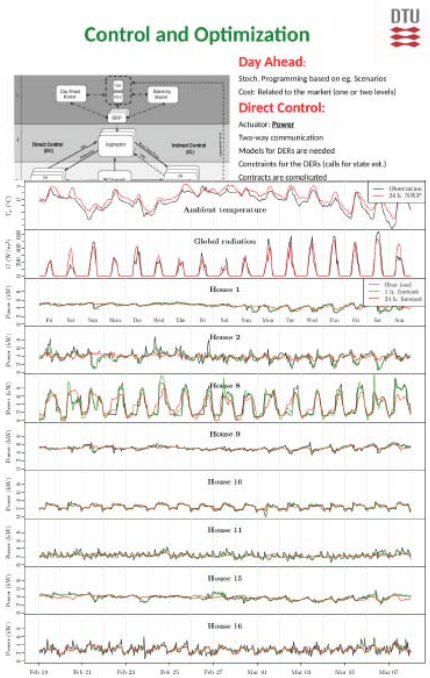
The event has been organized by University Hospital RWTH Aachen and RWTH Aachen University under the auspices of ISIAQ (the International Society of Indoor Air Quality and Climate). RWTH Aachen University, one of Germany's leading institutes of higher education in technology, spreads all over Aachen city. Established in 1870, it is one of Germany's Universities of Excellence with an emphasis on electrical and mechanical engineering, computer sciences, physics, and chemistry. The Faculty of Medicine is one of ten departments of RWTH Aachen University and part of the University Hospital. The Faculty's approach to science and innovation is interdisciplinary, and characterized by a translational performance aiming at the consistent translation of basic scientific findings into clinical application.

For more information, please visit **www.ukaachen.de/kliniken-institute/hb2023-europe/about/welcome-to-hb-europe-2023**. ■

14-18 August 2023
Technical University of Denmark, Fredericia, Denmark

Time Series Analysis Summer School -

with a focus on modelling and forecasting in energy systems



To integrate renewable and fluctuating power generation sources we need to model, forecast and optimize the operation of distributed energy resources, and need self-tuning models for each component in the system. For example, for a building with PV and a heat pump, we need a model which uses weather forecasts and control variables to predict PV power, heat pump load and the indoor temperature in the building. These, together with electricity prices, can then be used for Model Predictive Control (MPC) of the heat pump and shift its load to match the generation of power. There are many other applications of data-driven models, including performance assessment, flexibility characterization, and fault-detection; these topics will also be presented. In this summer school, the statistical techniques behind the models will be explained, with focus on non-parametric (e.g. kernels and splines) models, discrete and continuous time models (grey-box modelling with SDEs). We will use R and provide exercises to get a "hands-on" experience with the techniques.

$$\min_{\{u_k\}_{k=0}^{N-1}} \phi = \Sigma_{k=0}^{N-1} c' u_k$$
$$\text{Subject to} \quad x_{k+1} = Ax_k + Bu_k + Ed_k$$
$$y_k = Cx_k$$
$$u_{min} \leq u_k \leq u_{max}$$
$$\Delta u_{min} \leq \Delta u_k \leq \Delta u_{max}$$
$$y_{min} \leq y_k \leq y_{max}$$

A student who has met the learning objectives of the course will be able to:

- Understand maximum likelihood estimation techniques
- Formulate and apply non-parametric models using kernel functions and splines, with a focus on solar and occupancy effects
- Formulate and apply time-adaptive models
- Formulate and apply models for short-term forecasting in energy systems, e.g. for heat load in buildings, and electrical power from PV and wind systems
- Apply statistical model selection techniques (AIC, BIC, likelihood-ratio tests, model validation)
- Formulate and apply grey-box and digital twin models, model identification, tests for model order and model validation, and advanced non-linear models
- Understand MPC, through applied examples in energy systems
- Understand flexibility functions and indices

The School will be held exclusively on-site at DTU Fredericia; it will not be available online. The participation fee is 250 Euros for members of the research community, and more (tba) for industry participants. A social event and dinner is included. Register by signing up for DTU course 02960 through the DTU studyplanner (DTU students), **conferencemanager** (most other students) or DTU **open university** (industrial participants). Registration closes on 15 June 2023. For any further information please

contact Henrik Madsen (hmad@dtu.dk) or Peder Bacher (pbac@dtu.dk).

The venue is the Maskinmesterskolen Fredericia (Fredericia College of Marine and Technical Engineering) campus in Fredericia, southern Denmark. Fredericia is well served by trains from across Europe, and about 3 hours by train from Copenhagen airport. Participants must arrange their own accommodation. ■

SuDBE: Sustainable Development in Building and Environment

14-18 August 2023
Espoo, Finland
www.sudbeconference.com

The SuDBE conferences, held biennially since 2003, focus mainly on the topics of sustainable design and operation, building energy efficiency, green building, low-carbon technology, ecological cities, renewable energy, thermal comfort and indoor air quality. SuDBE2023 will be held at Aalto University, in Espoo, Finland. Topics include:

- Green and Sustainable Building Development Response to Climate Changes
- Practice and Development of Healthy Buildings
- Indoor Environment (air quality, thermal comfort, acoustic, light)
- Low-carbon and Intelligent Buildings (energy, system, and operation)
- Innovative Geo-techniques and Structural Engineering
- High-performance Structure
- Urban Ecological Infrastructures
- Sustainable Urban Renewal

For more information about the conference, please visit www.sudbeconference.com. ■

2023 ASHRAE Building Performance Analysis Conference

Holistic Building Analysis: Linking Operational Energy, Embodied Carbon and Comfort

11-13 September 2023
Austin, Texas, USA
www.ashrae.org/2023BPAC

The 2023 ASHRAE Building Performance Analysis Conference takes place on 11-13 September 2023 in Austin, Texas. The theme for the conference is *Holistic Building Analysis: Linking Operational Energy, Embodied Carbon and Comfort*.

"This year the conference theme is intended to highlight the need for a holistic approach to adequately address multiple challenges in building analysis from carbon to comfort," says John Bynum, conference chair. The conference once again will feature the 2023 ASHRAE LowDown Showdown modeling competition seeking a new, creative reuse of the Houston Astrodome. For more information, visit www.ashrae.org/2023BPAC or email meetings@ashrae.org. ■

BS 2023: 18th IBPSA International Conference & Exhibition

Simulation for the low-carbon design/operation/city

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

Preparations for IBPSA's 18th International Conference are in full swing and it is expected to be held as scheduled in Shanghai, China, from 4 to 6 September, 2023! Thanks go to experts and scholars from all over the world for their strong support of the conference and of the abstract review process. BS2023 will offer a broad range of highly interactive sessions with research leaders, keynotes from experts, dedicated workshops and exhibitions. Devoted to the theme *Simulation for low-carbon design/operation/ and the low-carbon city*, the conference will provide an exciting platform for participants to share their latest academic and research progress, including cutting-edge technologies and innovations in building simulation for low-carbon design, operation, and city development!

The conference will feature a variety of topics, including:

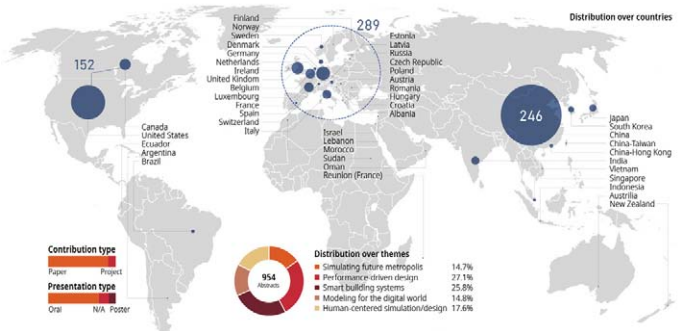
Simulating the future metropolis	Performance-driven design
■ Regulations/codes towards carbon neutrality	■ Parametric/Automatic design
■ Urban-scale simulation	■ Active/Passive/Zero-carbon buildings
■ District energy systems	■ Weather & climate adaptation
■ Demand responses & grid interactive	■ Building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

Advanced modeling towards a digital world	
■ Big data & machine learning	■ New software development
■ BIM & interoperability	■ Education
■ Advanced modeling techniques/application	

There has been an unprecedented and overwhelming response to the Call for Abstracts: at the close of submissions, 954 abstracts from more than 40 countries worldwide had been received. To ensure a high quality review process, scholars whose abstracts were accepted were required to submit the full text before 20 March 2023. To provide direct engagement and participation opportunities for student members, BS2023 includes a Student Modelling Competition as a crucial part of the conference. This year's competition program aims to design and optimize a nearly net zero carbon emission building using Building Performance

Simulation. Participating teams are encouraged to use active measures (such as photovoltaic, battery storage, charging pile or ice storage) and passive measures (such as fluctuating room temperature, thermal storage in walls, controllable lighting and other demand side management) for carbon reduction in the operation phase. 19 young and energetic teams from 14 institutes spanning 7 countries in Asia, Africa, America and Europe have already notified their intent to take part.



The final piece of good news is that China has lifted travel restrictions and there is no longer any testing or quarantine for inbound passengers, which makes things much easier for participants! Please feel free to contact us directly (**info@bs2023.org**) or visit the website of the Chinese Embassy in your departure country for more details about visa and entry policy.

Online registration opened on 1 April 2023. We will offer the Early Bird discount until 30 June 2023. Please visit **https://bs2023.org** for more details! Fees are:

Physical Attendance	Delegate	Student
Early Bird	$ 900	$ 550
Standard	$ 990	$ 600
On-site	$ 1080	$ 650

Virtual Attendance	Delegate	Student
Early Bird	$ 300	$ 300
Standard	$ 350	$ 350

BS 2023 is a hybrid event, but we strongly recommend you attend in person, for a better social networking experience, a more interactive discussion, and a great chance to enjoy the beauty and culture of China! Shanghai, the "Oriental Pearl of Asia", offers a colorful and attractive world to visitors, including buildings in diverse architectural styles, excellent cuisine, bustling shopping centers, and distinctive local culture!

Key dates

- Final notification of paper acceptance: 31 May 2023
- Early bird registration deadline: 30 June 2023
- Registration deadline: 25 August 2023

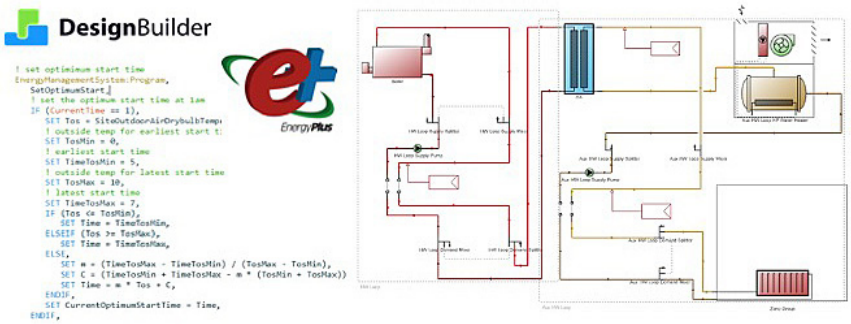
Don't forget to follow us on our website **bs2023.org**. For questions, please contact **info@bs2023.org**, and for sponsorship affairs or activity proposals: **sponsor@bs2023.org**

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

Software news

Modelling HVAC systems in DesignBuilder

DesignBuilder includes a variety of tools to model and simulate HVAC systems at both the early and detailed modelling stages. Early stage modelling uses the EnergyPlus Simple HVAC Ideal Loads method to quickly assess the impact of different HVAC system choices on energy use and indoor comfort.

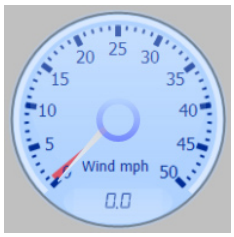


DesignBuilder's free webinar **Modelling HVAC Systems: From Concept Through Detailed Design** summarises the different stages of HVAC modelling. It demonstrates a typical workflow from Simple through Detailed HVAC modelling, clearly illustrating how DesignBuilder's HVAC modelling options cater for all project stages and system complexities.

DesignBuilder's **Advanced HVAC System Modelling** webinar shows how to model complex EnergyPlus HVAC systems using Detailed HVAC in DesignBuilder for a more accurate representation of the building's HVAC system performance. This webinar demonstrates how to use predefined Detailed HVAC templates and add HVAC components such as heat exchangers to develop bespoke system configurations. It also shows how the EnergyPlus EMS runtime scripting tools can be used to configure more advanced HVAC controls to simulate load shifting to ensure optimal grid electricity usage.

In addition to these webinars, DesignBuilder's free **Detailed HVAC tutorials** provide step-by-step instructions on how to model different types of HVAC systems using Detailed HVAC components. These tutorials show how to quickly and easily create and edit EnergyPlus Detailed HVAC systems (including pre-configured templates for ASHRAE 90.1), and also how to create systems from scratch.

DesignBuilder offers powerful tools for modelling and simulating both simple and detailed HVAC systems. Both for new early-stage modellers using simple HVAC and for advanced stage modelling using Detailed HVAC, DesignBuilder aims to offer the tools needed to accurately simulate a building's HVAC system in faster and easier ways. ■



New Building Reference Year and Future Climate Dataset for 564 Canadian Locations from Climate.OneBuilding.Org

We are pleased to announce that more than 18,000 weather data files for Canadian locations created by National Research Council Canada (**https://nrc.canada.ca/en**) are now available from **Climate.OneBuilding.org**. These include:

- Typical Meteorological Years using the TMY/ISO 15927-4:2005 methodologies
- Temperature reference years (typical, extreme cold, extreme warm) based on future climate models

Data are provided for 1991-2021, and seven future periods coinciding with 0.5, 1, 1.5, 2, 2.5, 3, and 3.5°C of global warming; representing 2003–2033, 2014–2044, 2024–2054, 2034–2064, 2042–2072, 2051–2081, and 2064–2094, respectively. NRCC also produced moisture reference years for hygrothermal applications, which are not included in the Climate.OneBuilding dataset. More information about the creation of the files is provided in Gaur and Lacasse 2022 (**https://www.mdpi.com/2306-5729/7/4/42**).

To see a list of the newly available data, visit **https://climate.onebuilding.org/WMO_Region_4_North_and_Central_America/CAN_Canada_Future** or view the KML (**https://climate.onebuilding.org/WMO_Region_4_North_and_Central_America/Region4_Canada_NRC_Future_EPW_Processing_locations.kml**) in Google Earth, Google Maps, or other mapping tools.

With this update, Climate.OneBuilding.org now provides TMYx climate data at no cost for more than 16,100 locations in more than 250 countries and another 21,000 files from other data sources. All data have been through extensive quality checking to identify and correct data errors and out of normal range values where appropriate.

For more information or to download any of the climate data (no cost), go to **Climate.OneBuilding.org**. ■

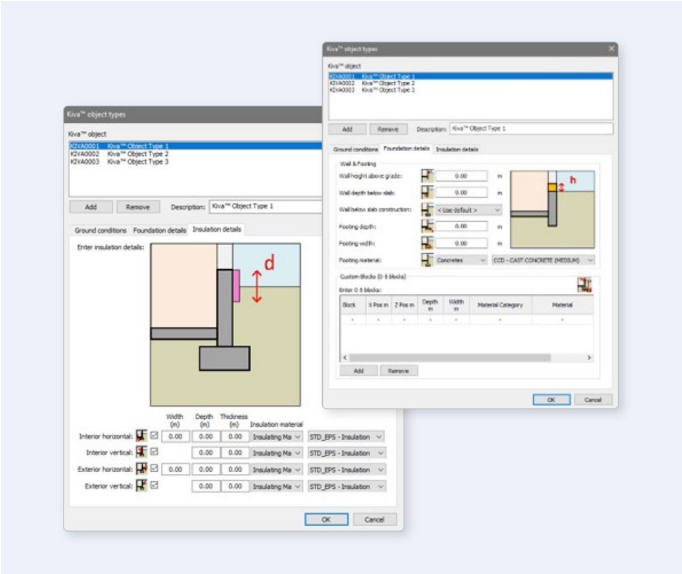
IES Release new Feature Pack & Building Performance Modeling Student Handbook

New software release: IESVE 2022 Feature Pack 3

This new Feature Pack adds Ground Heat Transfer with KIVA™ to IESVE. The new KIVA™ ground coupling co-simulation engine has been added to APACHE's Constructions Database for both heating/cooling loads calculations and energy simulation.

A free on-demand session is available to learn more at **https://learn-on-demand.iesve.com/p/ground-coupling-in-iesve**.

Also included is an update to ASHRAE Design Day Weather data from the 2021 Handbook—Fundamentals (Version 7).



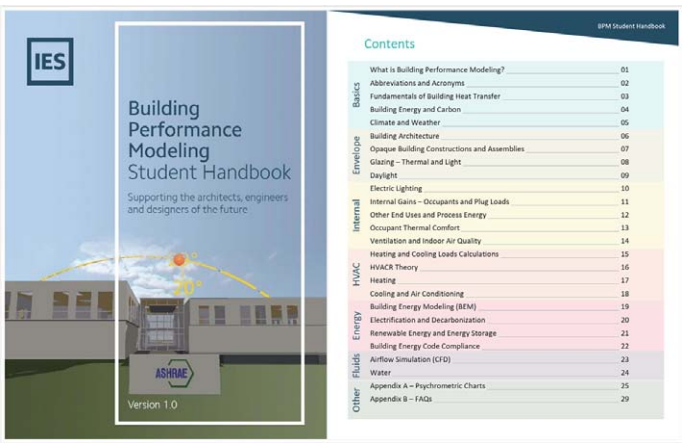
Other new features include:

- UK Compliance: Scottish Section 6 (2022) DSM & SBEM - EPC Update
- UK Compliance: Section 3 Scotland - Overheating
- Loads & Energy: Ground Heat Transfer
- Miscellaneous Enhancements: SunCast Solar Exposure, Content Store

Read more about the new features at **www.iesve.com/ve2022** .

New Building Performance Modeling Student Handbook

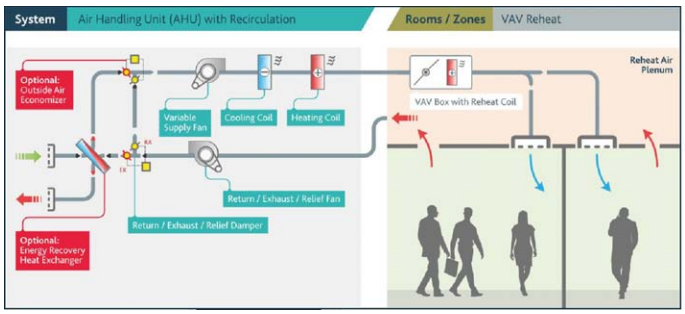
With guidance from the academic industry, version 1 of this Building Performance Modeling Student Handbook aims to support educators and students by coupling the technical fundamental concepts of building science with the art of Building Performance Modeling.



Download the Handbook at **www.iesve.com/corporate/guides/bpm-student-handbook-2023v01.pdf**

New Upskilling Session & Whitepaper

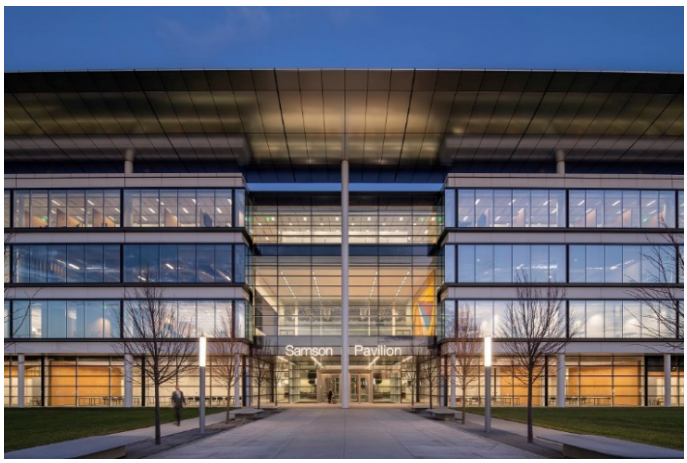
A Variable Air Volume (VAV) system is one of the most common HVAC systems used in buildings. This upskill for IES session and accompanying whitepaper explain how VAV control strategies are setup in the ApacheHVAC Application.



Access the Session & Whitepaper at **https://learn-on-demand.iesve.com/p/implementing-a-vav-control-strategy-in-apachehvac** .

Latest IESVE Case Studies

Foster + Partners

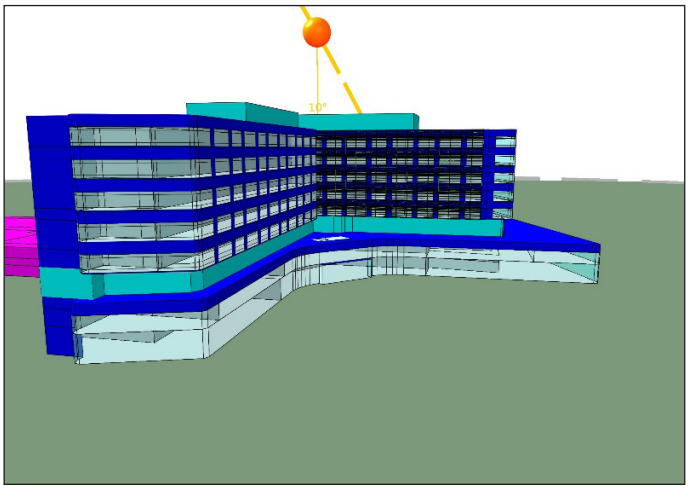


With the help of IESVE, Foster + Partners design and engineering teams are creating buildings that meet emissions and energy performance targets, fulfil client briefs and ensure optimal occupant wellbeing and comfort.

Read the case study at **www.iesve.com/products/case-studies/28925/foster-and-partners** .

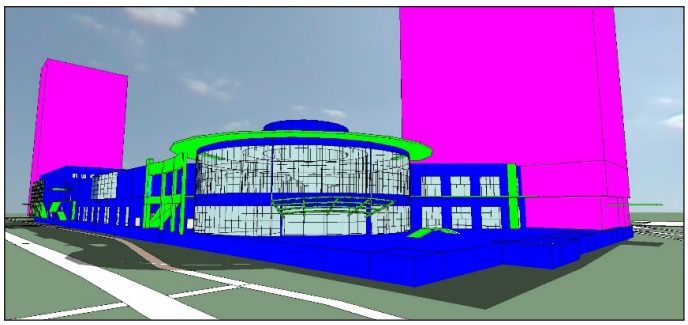
TLC Engineering Solutions

TLC Engineering Solutions used the IES Virtual Environment (IESVE) to carry out the detailed energy modeling required to ensure that Boca Raton Regional Hospital complied with the 2020 Florida Building Energy Code.



Read the case study at **www.iesve.com/products/case-studies/32135/boca-raton-hospital** .

ChaAC I+N+C.



A long-term user of the IES Virtual Environment (IESVE), ChaAC I+N+C. recently undertook model calibration training using IES' Intelligent Control and Analysis tool, iSCAN. Since the training, its first calibrated modelling project – an existing mall in Europe – was a great success, with the model calibrated within 87% accuracy of the actual operational performance of the building.

Read the case study at **www.iesve.com/products/case-studies/33081/chaac-inc**. ■

When and how should I update my Energy Modeling Software?

Energy modeling software plays an important role in research and engineering practice. From IBPSA-USA, here is an interview to discuss strategies on when and how to update to a new version of an energy modeling software for your project, and how to integrate simulations with other applications.

I'm Andy Berres, a researcher in computational urban science, and I have invited Rashmi Baliga, a practitioner using EnergyPlus, and Edwin Lee, the lead developer for EnergyPlus, to discuss this question: When during my project lifecycle should I update energy modeling software, and how should I go about it? We will discuss this using the example of EnergyPlus.

Andy Berres (Andy): *What are the priorities for updates to EnergyPlus from a developer point of view?*

Edwin Lee (Edwin): Our biggest priority is to provide new features and capabilities that meet the ever changing needs of industry. Each year, we solicit feedback from our key users, stakeholders, consultant groups, and lab partners, and prioritize the most important features. Features are selected from this prioritized list based on industry demand, available funding, and especially any features that enable EnergyPlus to support projects that include Diversity, Equity, and Inclusion (DEI) initiatives. Over the last couple of years, I've been most involved in developing the Python ecosystem around energy, which includes carving out an API, implementing Python plugins, and making sure EnergyPlus becomes a usable library and tool with many applications.

Andy: *You mentioned engagement with DEI efforts. What does that engagement look like?*

Edwin: While EnergyPlus is simply a mathematical physics engine, we have the opportunity to engage DEI experts when selecting features and capabilities in the engine. New features that support DEI could be configurations or system types that were not supported previously. Our approach is to interact with experts in industry, DOE, and NREL, and include them in our feature review prioritization process. We hope that, now that DEI has become such a focus, case studies start defining needs that we can respond to as a simulation engine development team.

Andy: *What concerns and considerations do you have on the practitioner side for updating software company-wide through the lifetime of projects?*

Rashmi Baliga (Rashmi): We work on a lot of large-scale healthcare and lab projects. They're not limited to pre-canned systems and configurations, which means we need workflows to generate and test those custom configurations. Most teams or modelers have their own workflows and processes to convert project data into an energy model file. Whenever we upgrade to a new EnergyPlus version, we have to rerun all the testing that we did to be confident in the custom setup that we've created. The lifetime of projects that we work on is long compared to the development software update cycle, and we would need to update multiple versions of the scripts to reflect the changes in IDF files with each version. It is impractical for us to run all possible combinations and test each release. It just adds up to a lot of work if we try to update frequently.

Andy: *When is it important to upgrade software?*

Rashmi: I think I will start by discussing when we choose not to upgrade software. If I upgraded my software in the middle of the project when the timeline is challenging, just because I have the feature available, it could cause a lot of changes that I wasn't anticipating. Modelers wouldn't upgrade software at a challenging time when there's a limited scope for testing. There's also a cost to updating the version when there's confidence in the existing stable workflow and its physics. It is better to just assess new features released at the start of a project. When I'm starting a new project, I check if there are any software updates that would help me model my project better and then I stick with this version through the end of that specific project. It really makes sense to invest time in the early stages of a project, when people have an expectation that model numbers and inputs can change. So that's a better time to test rather than towards the end when you're submitting for LEED and an upgrade could change everything. That's not something we like to do. The features that drive us to make these upgrades are usually major bug fixes, any feature additions that would really enhance the quality of our modeling or our confidence in modeling, and speed improvements. Speed improvements can really help when you're running multiple simulations!

Edwin: Easy: every time there is an EnergyPlus release, I need everyone to upgrade to the latest version that day and throw away anything they've done before! [laughs] I'm very glad that Rashmi answered that first because it would be easy for a developer to give that kind of naive answer, right? Trying to put myself in the shoes of an application user, I would agree a good time to upgrade is when there's a need, such as an impactful new feature or bug fix. For EnergyPlus specifically, we are actively working on making the upgrade version change process much smoother. We have supported a JSON input structure for multiple years, and will eventually move away from IDF inputs, making it easier to develop and maintain workflows. We would like eventually to get to the point where EnergyPlus can accept an input file of any number of versions back and run with it. We're really trying to reduce the maintenance that interface developers and practitioners have to put forth to manage version changes, so hopefully that will get better all the time.

Rashmi: That's really encouraging to hear, thanks for sharing that. We're thinking about using the OpenStudio SDK because with the SDK, we don't have to change the translation with the interface and the SDK. But there are challenges with how much we can customize with the SDK because not everything is surfaced. With EnergyPlus, if I open an IDF and use an IDF Editor or some other text editor, I can connect nodes however I want, but I cannot always do that with the SDK. There are challenges with having too many wrappings around the native EnergyPlus, so it's good to hear about the JSON structure because I would definitely be excited to start using it.

Andy: *When you have a new release, how do you envision reconciling differences between the previous and the new version?*

Edwin: Testing on EnergyPlus has expanded greatly over the last 10 years. We now have 2000 unit tests, 700 integration tests, and a suite of API tests that run on every commit of EnergyPlus across 3 platforms and multiple configurations checking outputs and identifying regressions on multiple platforms. So when someone makes a commit to our repo, within a couple hours it runs those thousands of tests and we get a report back that says, ''These three tests failed and five files have differences''. Before we merge any of those changes in, we have to either get rid of those differences or explain why the result changed. It is expected that some changes to EnergyPlus will cause changes in results: bug fixes can fix problems; features can add physics that just weren't captured before. In conjunction with that, we have a file that goes out with EnergyPlus releases that tracks major output changes. Structural, or major, output changes are called out in that file to help alert users

to what might have caused changes in their models. I imagine a user would look at the change log, the output changes file, see if there's anything on the community side, and then reach out to our help desk if they're seeing a difference in their building model that doesn't seem to make sense with what's being seen out there. I think there are several steps that I would invite people to use, but I'm curious what Rashmi thinks. Is that tractable, or is that just a silly, naive answer?

Rashmi: No, it's definitely not naive. I think that that reflects a lot of what we do. I will say that, at AEI, we are more in the weeds of EnergyPlus than many other EnergyPlus users. If I was a user who is primarily consulting, and I wanted to catch up on all this with no knowledge of GitHub or development, it would be challenging to understand what a commit, or a pull request, or an issue is on GitHub when that page comes up. I think it would be useful to have a TL;DR type of documentation that separates what you need to know from what you can know if you want to, before this huge list of bug fixes and things that are less relevant to the end user, because it just gets overwhelming when considering upgrades on a tighter time frame for the workflows. Other than that, we pretty much do what you said. An example I found is when I was trying to add an air source heat pump configuration that wasn't available in EnergyPlus v8.8, but was available in EnergyPlus v9.3. I upgraded a v8.8 model I had that did not have a heat pump and decided to run both to see what the difference was, and I saw energy change. Like you said, bug fixes and additional physics can cause the results to change, and I saw the outdoor air calculation output was different for the same input. It could be really hard to track down why it's happening, and that's exactly why we wouldn't do it in the middle of a project. It is really difficult to explain that type of stuff to clients, and it harms the credibility of your consulting when you have less confidence about the end results. That's just something that we deal with, and if there's a major change, it would be good to have something easier for a user who's not quite as involved with the development cycle of EnergyPlus to understand.

Edwin: That's really great to hear, I definitely think we can do that. I think that's a great idea.

Andy: *Finally, is there a good way for practitioners to let the EnergyPlus team know what they need?*

Edwin: Every summer, while our project budget is being set, we solicit feature requests from a long list of stakeholders: all our national lab partners, a lot of contractors and small businesses, universities, and a big list of power users that keep coming back and contacting EnergyPlus. We then consolidate that list, look for duplicates, and prioritize them with the help of DOE. If a user has a need that isn't met by that, and if they have the available time, it's also possible that they contribute and partner with the development team to get a new feature implemented. It can be a student who's working on their thesis, and they would like to see this added into EnergyPlus, or it might be a company that just has an interest in getting something into EnergyPlus, but it couldn't be funded by existing funding streams. If they have time available and someone to work on it, then someone from the EnergyPlus team can help shepherd that feature through the development process, from the proposal design all the way through, and get it into EnergyPlus, which could be a more direct route.

Dear readers, I hope you have enjoyed this discussion about updating EnergyPlus, and I hope you will join us for Part 2 next month, when we discuss the question of how you can connect EnergyPlus with other applications, and what cool opportunities there are. Trust me — you won't want to miss this! - Andy

Rashmi Baliga, Building Performance Consultant

Rashmi Baliga is a Building Performance Consultant at Affiliated Engineers, Inc (AEI). She consults on building and campus-level sustainability and resilience using energy, carbon and water analysis to meet client goals. She is passionate about bringing transformative change to the built environment. In her work, she primarily uses EnergyPlus for energy modeling. She can be contacted at **rashmi.b95@gmail.com** .

Edwin Lee, Researcher IV-Mechanical Engineering

Dr Edwin Lee has been actively involved in building simulation since 2005. He joined the EnergyPlus development team in 2007 and contributed as a team member until he received his PhD in 2013. Upon joining NREL's research team, Edwin took over technical development of EnergyPlus and has led EnergyPlus since then, overseeing substantial projects such as the translation from Fortran to C++, opening the source code on GitHub, and developing the Python API and Plugin systems for EnergyPlus. He can be contacted at **Edwin.Lee@nrel.gov** .

Andy Berres, Research Scientist in Urban Data Science

Dr Andy Berres is a research scientist at Oak Ridge National Laboratory. Andy received a PhD in computer science from the University of Kaiserslautern, Germany in 2015, and has 10 years of experience in computing, and 4 years of experience in buildings research on occupancy modeling and nation-scale building simulation workflows. Andy serves on the IBPSA-USA Research Committee, as chair of the Publications working group, and as co-chair of the Hackathon working group. ■

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-England

IBPSA-England BSO 2022

IBPSA England hosted their Sixth Conference, the Second Virtual Building Simulation and Optimisation (BSO) Conference, in 2022. The event was hosted by the University of Bath's Centre for Energy and the Design of Environments (EDEn) and sponsored by IES.

The conference aimed to bring together leading experts, researchers and practitioners from around the world to discuss and share their latest research and best practices in building simulation and optimisation. The event was entirely virtual, which allowed for more inclusivity, making it easier for colleagues to participate who would have struggled to secure funding to attend in person.

The conference accepted papers on traditional BSO themes such as building simulation software and models, occupancy modelling, whole-life carbon models, indoor environmental quality, and urban and district scale simulation of climate and energy use. Its special focus was on building simulation and optimisation in the Global South, exploring specific challenges such as affordable simulations, simulations in informal cities, simulations of natural ventilation in hostile outdoor environments, and solar energy in informal and overcrowded settlements.

The event also featured a debate, which was moderated by the Conference Chair Professor Sukumar Natarajan. Speakers argued for and against the motion *Building energy modellers are not literate*, with audience polling used to measure audience sentiment before and after the debate. The conference also showcased key outputs from a series of high-profile research grants awarded under the Newton Fund between researchers in the UK and India.

Overall, the conference provided a valuable platform for experts in the building simulation and optimisation field to share their latest research and practices, as well as to address challenges and explore opportunities for designing buildings that are sustainable, energy-efficient, and healthy.

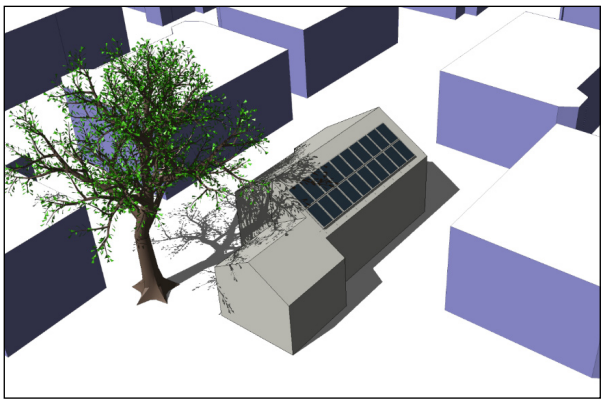
The recordings from the conference, including the debate and keynotes, can be accessed on IBPSA-England's YouTube channel, **www.youtube.com/@ibpsaengland7132** , and there are retrospectives from the conference Chair Sukumar Natarajan, IBPSA ED&I Committee Chair Rob McLeod and the recipients of Best Paper Awards on **pp 9-15** of this edition of *ibpsa*NEWS. ■

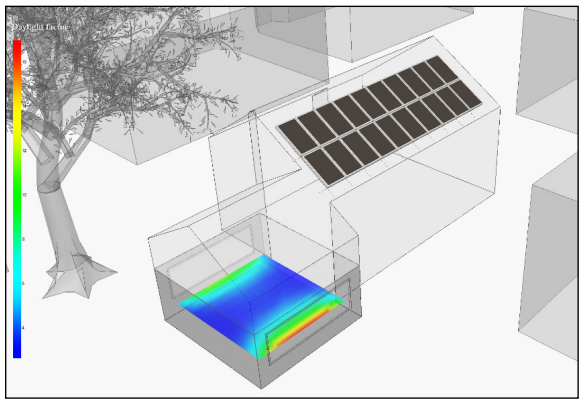
IBPSA-Nordic

Nordic HVAC Teacher Seminar #1

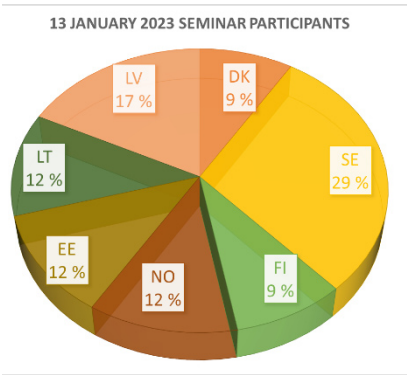
A new kind of event was kicked off on 13 January 2023: the very first HVAC and building energy teachers' seminar! It is dedicated to the Nordic and the Baltic universities as IBPSA Nordic actively supports the education of upcoming building simulation professionals. The HVAC Teacher Seminar aims to provide a complete framework for continuous learning and teaching: biannual online meetings; frequently updated, open, and available exercises along with their copylefted material and documentation focusing on relevant subjects; a growing community; and available support. The exercises are done using IDA ICE; they aim to introduce the key physical phenomena and the modelling assumptions.

The opening session included two subjects: Swan daylight credit completion and a PV generation-electricity consumption comparison with real-life measurements for different modeling options.





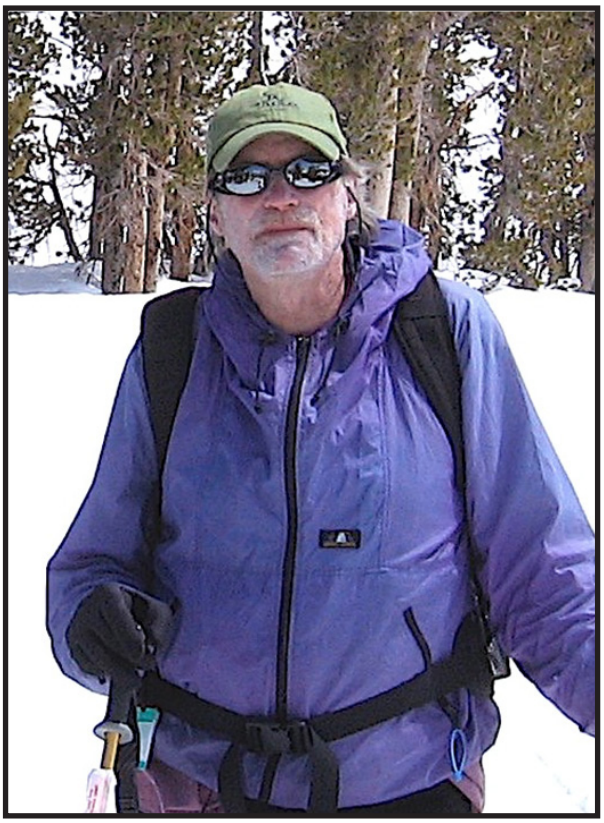
Despite their busy teaching calendars, 34 teachers from 7 countries took part.



The next event will take place on 18 August 2023. Maybe you have an interesting concept in your mind that you want to demonstrate to your students? Or you have an idea about a real-life example but you don't have time to develop it? Please send us your idea! The seminar's objective is to help teachers in both producing and distributing versatile examples and to teach concepts that are vital for all students of the building energy field to visualize and understand. See you online on 18 August!

Enrolling and more information from the website **https://ibpsa-nordic.org/ibpsa-nordic-hvac-teachers-seminar or mika.vuolle@equa.fi** . ■

Remembering Fred Buhl, 1944-2022



Fred Buhl, a long-time member of the research staff in the (now) Building Technology and Urban Systems Division, died on September 20, 2022, after a short illness. Fred was a Senior Scientific Engineering Associate at the time of his retirement in 2010. He received a Bachelor's degree in physics from Yale University in 1966 and began his career at the lab as a UC Berkeley grad student doing high energy physics research at the Bevatron, working in Group A (Alvarez). In 1976, he joined Art Rosenfeld to work in the then nascent field of modeling energy use in buildings. Art had obtained funding from the California Energy Commission to initiate this work - one of the first major projects in the then newly formed Energy and Environment Division. This model development work, for which Fred had a major role, became the Cal-ERDA model. Cal-ERDA led to DOE-1, then to DOE-2.x and more recently EnergyPlus - all increasingly sophisticated computer programs used to investigate energy use in buildings and to design buildings with improved energy efficiency.

Fred made important contributions to the modeling and simulation of heating and cooling systems in buildings. In particular, he was the primary author of the HVAC sizing features in EnergyPlus, which are key to making the program useful to building designers, and continued to enhance those capabilities until his retirement. He also made significant contributions to the development of the highly modular SPARK system simulation tool, work that paved the way for the development of the current generation of flexible simulation tools for buildings and connected systems.

The development of EnergyPlus has been a major effort involving multiple national laboratories and other organizations, funded by DOE. In 2003, Fred and his colleagues in the Simulation Research Group (along with several outside collaborators) were awarded an R&D 100 Award for the EnergyPlus software.

Fred was born in Cleveland, Ohio on October 22, 1944 and with his brother Ted spent most of his 'growing-up' years in Ohio. In 1999, he married Cecelia Webster and they adopted a daughter, Natalya (Natasha), from Russia in 2003. Cecelia died in 2007. Fred is remembered for his perceptive technical contributions spanning 35 years at LBL, his generous support for junior colleagues and his dry wit. Fred was an enthusiastic runner, backpacker and backcountry skier and shared many running, hiking and skiing adventures with his friends. He is survived by his daughter Natalya and nieces Sarah Schutt (Carey, OH) and Kristin Stringfellow (Upper Sandusky, OH). ■

INTERNATIONAL BUILDING PERFORMANCE SIMULATION ASSOCIATION

LIVE WEBINAR SERIES

IBPSA Education Seminar Series 2023

Urban scale building energy simulation models are emerging as powerful tools for cities and regions seeking to increase energy efficiency and reduce greenhouse gas emissions of their buildings. In this seminar series, leading researchers working on large scale models will discuss the concepts, challenges and state of the art.

The series will begin with a presentation by Dr Yu Qian Ang of MIT who will introduce the concepts and explore the different use cases for urban scale models.

Professor Rajan Rawal of CEPT University will discuss the application of large scale models to rapidly developing cities in the global South, focusing on the challenges and lessons learned in developing a model of the city of Ahmedabad.

Shyam Amrith of UCL will give a presentation on the use of urban scale models for decision making, looking at how optimisation can be applied beyond individual building applications.

Dr Aysha Demir of Wyoming University will present on calibration of urban scale models, looking specifically at the impact of spatio-temporal resolution.

In the final webinar of 2023, Dr Tianzhen Hong of Lawrence Berkeley National Laboratory will discuss the way ahead, looking at opportunities and challenges for urban scale models.

Programme

30 March 2023 14.00 UTC
Use cases for urban scale building energy simulation
Dr Yu Qian Ang
Register at https://bit.ly/IBPSA_webinar_Mar23

17 May 2023 09.00 UTC
Developing an Urban Building Energy Model for Ahmedabad – key challenges and lessons learned
Prof Rajan Rawal
Register at https://bit.ly/IBPSA_webinar_May23

03 July 2023 11.00 UTC
The use of urban scale simulation in stock level retrofit decision making
Shyam Amrith
Register at https://bit.ly/IBPSA_webinar_Jul23

20 September 2023 16.00 UTC
The impact of spatio-temporal resolution on calibration of urban energy models
Dr Aysha Demir
Register at https://bit.ly/IBPSA_webinar_Sep23

14 November 2023 17.00 UTC
Urban Scale Building Modeling: Opportunities and Challenges
Dr Tianzhen Hong
Register at https://bit.ly/IBPSA_webinar_Nov23

Yu Qian Ang

Rajan Rawal

Shyam Amrith

Aysha Demir

Tianzhen Hong

IBPSA on social media

IBPSA has several internet presences on social media in addition to its main web site, its webinars, and affiliates' sites. Thanks to Mike Barker for collating the list below:

Main IBPSA web site	**www.ibpsa.org**
*There is a wealth of material on the main web site, including past editions of ibpsa*NEWS *back to 1988 and* ***links to affiliates' web sites at:***	**www.ibpsa.org/affiliates**

Linkedin:	
IBPSA	**www.linkedin.com/company/ibpsaworld**
IBPSA Group	**www.linkedin.com/groups/75552**
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IBPSA - EnergyPlus + Modelica	**www.linkedin.com/groups/2085105**
JPBS	**www.linkedin.com/company/journal-of-building-performance-simulation**

YouTube (IBPSA University)	**www.youtube.com/@IBPSAUniversity**

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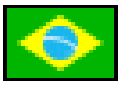

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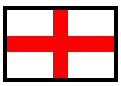

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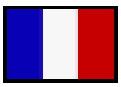

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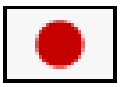

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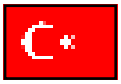

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For additional information about IBPSA, please visit the Association's web site at **www.ibpsa.org**. **For information on joining, contact your nearest regional affiliate.**

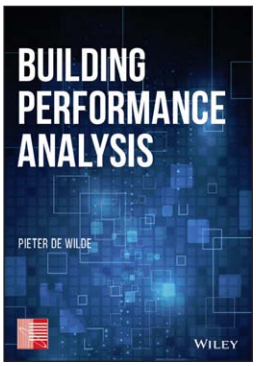
Members can subscribe to the IBPSA mail list (and, if desired, unsubscribe or edit) via a web interface which is available at **http://lists.onebuilding.org/listinfo.cgi/bldg-sim-onebuilding.org**. Note that this mailing list is solely for IBPSA-related notices and to ensure that you receive future important IBPSA updates (including the election process and announcements of IBPSA News releases).

For any other purposes, please use the BLDG-SIM list. BLDG-SIM is a mailing list for users of building energy simulation programs worldwide, including weather data and other software support resources. BLDG-SIM is intended to foster the development of a community of those users. Experienced and inexperienced users of building energy simulation programs are welcome and are expected to share their questions and insights about these programs.

If you have any questions with respect to the BLDG-SIM, please contact the list owner:
Jason Glazer at **jglazer@gard.com** or +1 847 698 5686. This list is made possible courtesy of GARD Analytics, Inc., Ridge Park, IL, USA. For further information about this list server, see the web page located at **http://lists.onebuilding.org/listinfo.cgi/bldg-sim-onebuilding.org**. ■

Books by IBPSA Fellows

Building Performance Analysis (Wiley, 2018)



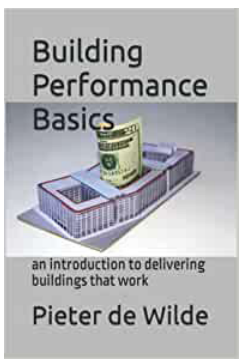
Building Performance Analysis is the go-to resource for those who want to have a deep understanding of what building performance is. The book is endorsed by IBPSA.

Offering a comprehensive and systematic overview of the concept of building performance analysis, *Building Performance Analysis* brings together many existing notions and ideas in one title. A substantial book, it has 11 chapters, 600 pages, and cites over 1600 references. 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.

Written for the building science community, 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. It emphasizes that building performance has many aspects, and challenges the community to address those that get less prominence in the literature.
3. Going 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 researchers seeking to develop questions and hypothesis. This is intended as matter for discussion, debate, and deeper exploration. ■

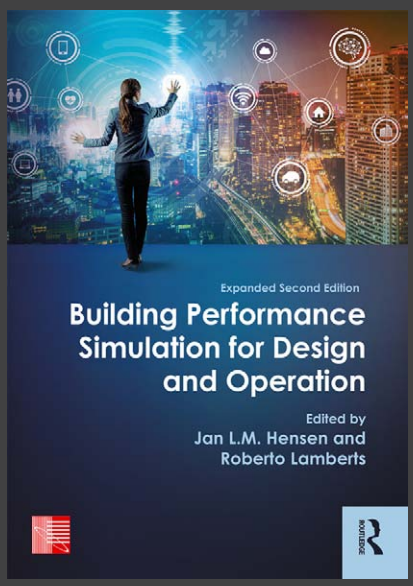
Building Performance Basics (Amazon KDP, 2022)



Building Performance Basics is a short book intended as an introductory text for students at BSc and MSc level, a primer for those entering the industry, and a refresher for those who are already in practice but want to sharpen their view. As *Building Performance Analysis* (above) 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? 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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Edited by **Jan L.M. Hensen**, Technical University of Eindhoven, the Netherlands and **Roberto Lamberts**, Federal University of Santa Catarina, Brazil

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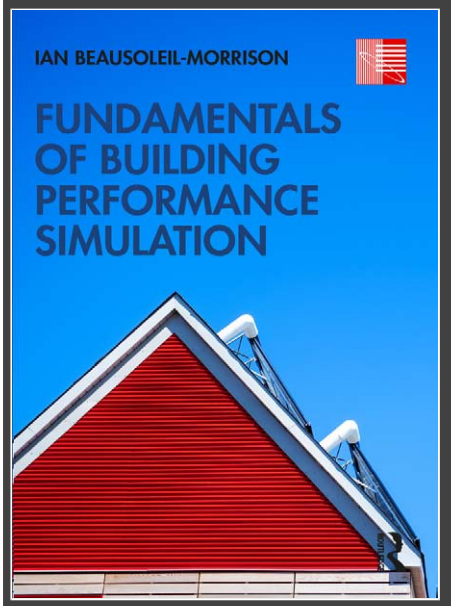

Fundamentals of Building Performance Simulation

Ian Beausoleil-Morrison, Carleton University
Ottawa, Ontario, Canada

Fundamentals of Building Performance Simulation pares the theory and practice of a multi-disciplinary field to the essentials for classroom learning and real-world applications. Authored by a veteran educator and researcher, this textbook equips graduate students and emerging and established professionals in architecture and engineering to predict and optimize buildings' energy use. Each subject is introduced without reference to particular modelling tools while problems at the end of each chapter provide hands-on experience with the tools of the reader's choice.

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Special Issue: Methods for climate-resilient building performance simulations under impacts of changing climate

The deadline for abstract submission for this SI has passed, *Details of this issue are on page 47.*
Submissions for other future issues are always welcome at https://bit.ly.JBPSsubmit .

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https://doi.org/10.1080/19401493.2022.2110944

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Seon Jung Ra, Han Sol Shin & Cheol Soo Park (2023) Implementation of real-time model predictive heating control for a factory building using ANN-based lumped modelling approach, Journal of Building Performance Simulation, 16:2, 163-178 https://doi.org/10.1080/19401493.2022.2125581

Clotilde Pierson, Mariëlle P. J. Aarts & Marilyne Andersen (2023) Validation of spectral simulation tools in the context of ipRGC-influenced light responses of building occupants, Journal of Building Performance Simulation, 16:2, 179-197 https://doi.org/10.1080/19401493.2022.2125582

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Muhammad Zeeshan, Zaib Ali & Emad Ud Din (2022) Thermal performance prediction of street trees inside isolated open spaces – evaluations from real scale retrofitting project, Journal of Building Performance Simulation, ahead-of-print
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September Special issue:

Methods for climate-resilient building performance simulations under impacts of changing climate

Context:

As a result of changing climate, urbanization, and densification, there is a rapid increase in air conditioning usage in buildings worldwide. Meanwhile, climate change also increases the frequency of extreme events such as heat waves, wildfires, and power outages. Therefore, buildings and their energy systems should be designed and operated to be resilient to ensure a safe, healthy, comfortable, energy-efficient, and low-carbon indoor environment during extreme events. To address these new challenges, it is essential to develop new methods and models for building resilient performance simulations under the impacts of changing climate and assess resilient cooling and overheating protection solutions.

Aims:

This SI intends to gather state-of-the-art research on the methods of climate-resilient building performance simulations for overcoming the challenges of climate change. The resilient technologies to improve the building performance includes, but are not limited to, passive and active cooling and heating technologies, such as the technologies to manage external heat gains, enhance personal comfort, to remove and control sensible and/or latent heat from indoor environments, as well as to improve survivability of building occupants.

Topics:

Topics in this Special Issue are expected to include:

- Methods for climate modeling for resilient buildings and communities designs.
- Uncertainty analysis, validation/calibration approach of building performance modeling for resilience.
- Novel modelling/simulation approaches for resilient buildings.
- Case studies of resilient buildings with validation data and new key performance indexes (KPIs).
- Assessment of resilient cooling technologies under the impacts of climate change in different climate conditions.
- Software development techniques and interoperability issues with direct applicability to climate-resilient building performance simulations.
- New standards, codes, and guidelines developments supported by evidence and data to improve building climate resilience.
- Understanding mitigation measures to improve survivability of buildings and occupants under climate change and extreme weather.

Special Issue Editors:

Dahai Qi, Université de Sherbrooke, Canada; Liangzhu (Leon) Wang, Concordia University, Canada; Mohamed Hamdy, Norwegian University of Science and Technology, Norway; Mohammad Heidarinejad, Illinois Institute of Technology, USA

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The ***Journal of Building Performance Simulation*** (JBPS) aims to make a substantial and lasting contribution to the international building community by supporting our authors and the high-quality, original research they submit. The journal also offers a forum for original review papers and researched case studies

We welcome building performance simulation contributions that explore the following topics related to buildings and communities:

- Theoretical aspects related to modelling and simulating the physical processes (thermal, air flow, moisture, lighting, acoustics).
- Theoretical aspects related to modelling and simulating conventional and innovative energy conversion, storage, distribution, and control systems.
- Theoretical aspects related to occupants, weather data, and other bou
- Methods and algorithms for optimizing the performance of b the systems which service them, including interacti
- Uncertainty, sensitivity analysis, and cali
- Methods and algorithms for va
- Development and va fault detec
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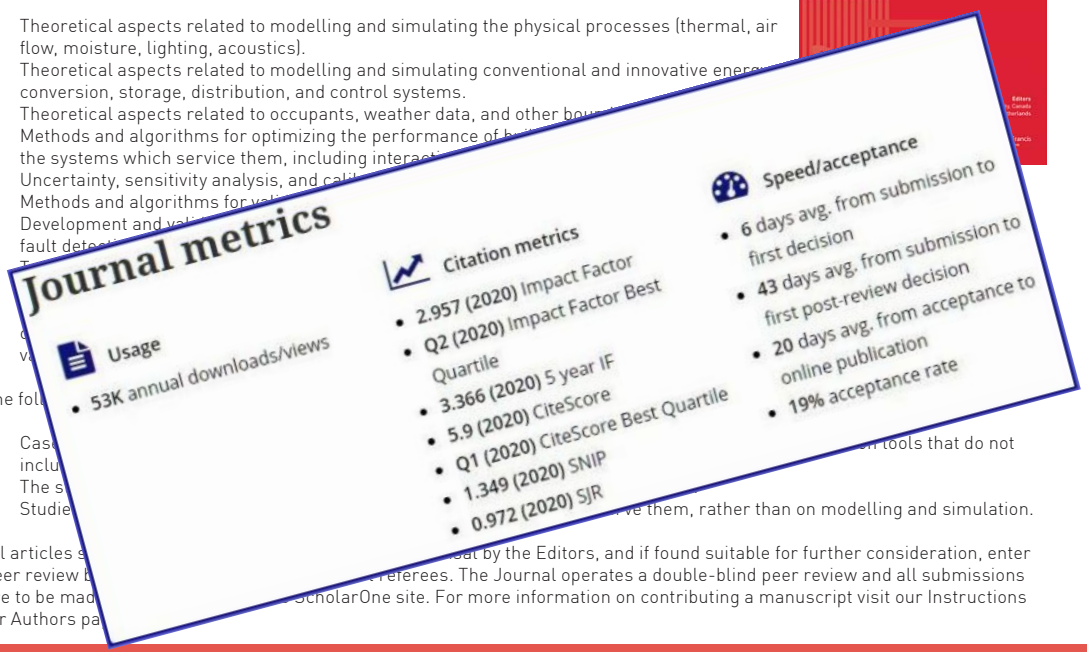

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