

Building Simulation Applications BSA 2022 - Proceedings of 5th IBPSA-Italy conference

*Original*

Building Simulation Applications BSA 2022 - Proceedings of 5th IBPSA-Italy conference / Pernigotto, Giovanni; Patuzzi, Francesco; Prada, Alessandro; Corrado, Vincenzo; Gasparella, Andrea. - ELETTRONICO. - (2023), pp. 1-540.  
[10.13124/9788860461919]

*Availability:*

This version is available at: 11583/2980215 since: 2023-07-13T14:29:31Z

*Publisher:*

Bozen-Bolzano University Press

*Published*

DOI:10.13124/9788860461919

*Terms of use:*

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

*Publisher copyright*

(Article begins on next page)

Konferenzbeiträge / Atti / Proceedings

# Building Simulation Applications BSA 2022

5<sup>th</sup> IBPSA-Italy Conference

Bozen-Bolzano, 29<sup>th</sup> June – 1<sup>st</sup> July 2022

**Edited by**

**Giovanni Pernigotto, Francesco Patuzzi,**

**Alessandro Prada, Vincenzo Corrado, Andrea Gasparella**

**bu,press**

bozen  
bolzano  
university  
press



Konferenzbeiträge / Atti / Proceedings

# Building Simulation Applications BSA 2022

5<sup>th</sup> IBPSA-Italy Conference

Bozen-Bolzano, 29<sup>th</sup> June –1<sup>st</sup> July 2022

**Edited by**

**Giovanni Pernigotto, Francesco Patuzzi,**

**Alessandro Prada, Vincenzo Corrado, Andrea Gasparella**

**bu,press**

bozen  
bolzano  
university  
press

### **Scientific Committee**

Ian Beausoleil-Morrison, Carleton University, Canada  
Jan L.M. Hensen, Technische Universiteit Eindhoven, The Netherlands  
Gregor P. Henze, University of Colorado Boulder, USA  
Ardeshir Mahdavi, Technische Universität Wien, Austria  
Athanasios Tzempelikos, Purdue University, USA  
Reinhard Radermacher, University of Maryland, USA  
Francesco Asdrubali, Università degli Studi Roma Tre, Italy  
Paolo Baggio, Università degli Studi di Trento, Italy  
Francesca Cappelletti, Università IUAV di Venezia, Italy  
Maurizio Cellura, Università degli Studi di Palermo, Italy  
Cristina Cornaro, Università degli Studi di Tor Vergata, Italy  
Vincenzo Corrado, Politecnico di Torino, Italy  
Andrea Gasparella, Free University of Bozen-Bolzano, Italy  
Livio Mazzarella, Politecnico di Milano, Italy  
Adolfo Palombo, Università degli Studi di Napoli Federico II, Italy

### **Students Tutoring Scientific Committee**

Matthias Schuss, Technische Universität Wien, Austria  
Ulrich Pont, Technische Universität Wien, Austria  
Alessia Arteconi, Università Politecnica delle Marche, Italy  
Ilaria Ballarini, Politecnico di Torino, Italy  
Annamaria Buonomano, Università degli Studi di Napoli Federico II, Italy  
Marco Caniato, Free University of Bozen-Bolzano, Italy  
Gianpiero Evola, Università degli Studi di Catania, Italy  
Federica Morandi, Free University of Bozen-Bolzano, Italy  
Francesco Patuzzi, Free University of Bozen-Bolzano, Italy  
Giovanni Pernigotto, Free University of Bozen-Bolzano, Italy  
Anna Laura Pisello, Università degli Studi di Perugia, Italy  
Alessandro Prada, Università degli Studi di Trento, Italy

### **Organizing Committee**

Paolo Baggio, Università degli Studi di Trento, Italy  
Marco Baratieri, Free University of Bozen-Bolzano, Italy  
Marco Caniato, Free University of Bozen-Bolzano, Italy  
Francesca Cappelletti, Università IUAV di Venezia, Italy  
Vincenzo Corrado, Politecnico di Torino, Italy  
Andrea Gasparella, Free University of Bozen-Bolzano, Italy  
Norbert Klamsteiner, Energytech G.m.b.H./S.r.l -Bozen, Italy  
Federica Morandi, Free University of Bozen-Bolzano, Italy  
Francesco Patuzzi, Free University of Bozen-Bolzano, Italy  
Giovanni Pernigotto, Free University of Bozen-Bolzano, Italy  
Alessandro Prada, Università degli Studi di Trento, Italy  
Fabio Viero, Manens – Tifs, Italy

# **bu,press**

Bozen-Bolzano University Press, 2022

Free University of Bozen-Bolzano

[www.unibz.it/universitypress](http://www.unibz.it/universitypress)

Cover design: DOC.bz / bu,press

ISSN 2531-6702

ISBN 978-88-6046-191-9

DOI 10.13124/9788860461919



This work—excluding the cover and the quotations—is licensed under the Creative Commons Attribution-ShareAlike 4.0 International License.

# Table of Contents

Preface .....	ix
Optimization of Daylighting and Energy Performance in Bangladesh Ready-Made Garment Factories: Use of Parametric Design, Simulation Modeling, and Genetic Algorithms <i>Md Ashikur Rahman Joarder, Md Monir Hossain, Aaron J.E. Bach, Jean P. Palutikof, Fahim Tonmoy</i> .....	1
Transient Three-Dimensional CFD Modelling of Ceiling Fans: A Comparison Between Detailed and Simplified Models <i>Francesco Babich, Akshit Gupta, Wilmer Pasut</i> .....	9
Intelligibility Prediction in Scholar Classrooms <i>Samantha Di Loreto, Fabio Serpilli, Valter Lori, Costanzo Di Perna</i> .....	17
Hybrid Heat Pump Systems: Is Predictive Control Worth Using? <i>Patricia Ercoli, Alice Mugnini, Fabio Polonara, Alessia Arteconi</i> .....	25
The Acoustic Adaptation of the Aula Magna at the University of Bologna: Auditorium and Conference Hall Scenarios Simulated in the Main Nave of Santa Lucia's Church <i>Antonella Bevilacqua, Ruoran Yan, Maria Cristina Tommasino</i> .....	33
Implementation and Calibration of a Model to Treat Naturally Ventilated Complex Fenestration Systems in TRNSYS <i>Ingrid Demanega, Giovanni Gennaro, Giuseppe De Michele, Francesco Isaia, Fabio Favoino, Stefano Avesani</i> .....	41
Heat and Mass Transfer Modelling for Moisture-Related Risks in Walls Retrofitted by Timber Materials <i>Gianpiero Evola, Alessandra Urso, Vincenzo Costanzo, Francesco Nocera, Luigi Marletta</i> .....	49
Multi-Objective Optimization Of Thermo-Acoustic Comfort Of School Buildings <i>Daniele Colarossi, Samantha Di Loreto, Eleonora Tagliolini, Paolo Principi, Fabio Serpilli</i> .....	67
A Review on the FIVA-Project: Simulation-Assisted Development of Highly-Insulating Vacuum Glass Windows <i>Ulrich Pont, Peter Schober, Magdalena Wölzl, Matthias Schuss, Jakob Haberl</i> .....	69
Influence of Sound-Absorbing Ceiling on the Reverberation Time. Comparison Between Software and Calculation Method EN 12354-6 <i>Nicola Granzotto, Paolo Ruggeri, Fabio Peron, Marco Caniato, Andrea Gasparella</i> .....	77
Simulation of Thermal and Acoustic Façade Insulation Starting From the Characteristics of the Individual Elements <i>Nicola Granzotto, Paolo Ruggeri, Fabio Peron, Marco Caniato, Andrea Gasparella</i> .....	85
Climate Change Impact on Historical Buildings: A Case Study Within the Interreg Ita-Slo Secap Project <i>Marco Manzan, Amedeo Pezzi</i> .....	95
Hourly Dynamic Calculation of the Primary Energy With Heat Pump Generation System (EN 15316-4-2): A Case Study in Italy <i>Giada Remia, Serena Summa, Luca Tarabelli, Costanzo Di Perna</i> .....	103
A Project Focused on Sound Diffusion: The Acoustics of the Auditorium Yves St Laurent of Marrakech in Combination With its Innovative Architectural Design <i>Lamberto Tronchin, Antonella Bevilacqua, Ruoran Yan</i> .....	111
On the Prints of Another Horseshoe-Shaped Historical Building: Acoustic Studies of the Bonci Theatre of Cesena <i>Antonella Bevilacqua, Ruoran Yan</i> .....	117
Acoustic Discoveries of Another Masterpiece by Antonio Galli Bibiena: The Communal Theatre of Bologna <i>Antonella Bevilacqua, Ruoran Yan</i> .....	123
In Situ Measurement of Wall Thermal Properties: Parametric Investigation of the Heat Flow Methods Through Virtual Experiments Data <i>Andrea Alongi, Luca Sala, Adriana Angelotti, Livio Mazzarella</i> .....	129

Investigating the Performance of Different Window Opening Styles for Single-Sided Wind-Driven Natural Ventilation Using CFD Simulations <i>Akshit Gupta, Annamaria Belleri, Francesco Babich</i> .....	137
The Management of the Energy Performance Simulation of a Complex Building Portfolio. The Case of the School Building Asset of an Italian Municipality <i>Claudia Bo, Enrico De Angelis, Andrea Augello</i> .....	145
Hourly-Simplified Calculation to Identify Cost-Optimal Energy Performance Requirements for the Italian Building Stock <i>Matteo Piro, Franz Bianco Mauthe Degerfeld, Giovanna De Luca, Ilaria Ballarini, Vincenzo Corrado</i> .....	153
A Novel Methodology for Risk Assessment of Airborne Transmission due to Covid-19 in University Classrooms <i>Giulia Lamberti, Roberto Rugani, Fabio Fantozzi</i> .....	161
Integrated Approach to Assess the Energy and Environmental Payback Time of Buildings Refurbishment: A Case Study <i>Marta Roncone, Francesco Asdrubali, Gianluca Grazieschi, Chiara Tonelli</i> .....	169
Comparison Between Measured and Calculated Values in Relation to Noise From Wind Turbines <i>Antonella Bevilacqua, Gino Iannace, Ilaria Lombardi, Amelia Trematerra</i> .....	177
Thermo-Hygrometric Comfort Analysis in a Real Public Conference Room to Support a Digital-Twin Targeted to Parametric Investigations <i>Roberto Bruno, Piero Bevilacqua, Daniela Cirone, Natale Arcuri</i> .....	185
Validation of Energy Simulations of a Sustainable Wooden House in a Mediterranean Climate <i>Piero Bevilacqua, Roberto Bruno, Daniela Cirone, Stefania Perrella, Natalia Shushunova, Natale Arcuri</i> .....	193
Thermal and Acoustic Simulation of a Technical Enclosure for High Voltage Control Equipment <i>Edoardo A. Piana, Somayan Basu, Francesco Palone, Simone Sacco, Roberto Spezie</i> .....	199
Investigating the Role of Humidity on Indoor Wellness in Vernacular and Conventional Building Typologies <i>Suchi Priyadarshani, Roshan R Rao, Monto Mani, Daniel Maskell</i> .....	207
An Investigation Into Thermal Performance of Buildings Built Using Upcycled End-Of-Life Photovoltaic Panels <i>Roshan R Rao, Suchi Priyadarshani, Monto Mani</i> .....	217
Determining the Energy Benefits from Passive Solar Design Integration through the Sensitivity Analysis of Different Case Studies <i>Giacomo Cillari, Alessandro Franco, Fabio Fantozzi</i> .....	225
A Novel Personal Comfort System: A Radiant Desk With a Loop Heat Pipe <i>Roberto Rugani, Marco Bernagozzi, Marco Picco, Giacomo Salvadori, Fabio Fantozzi</i> .....	233
Energy Signature Modeling Towards Digital Twins – Lessons Learned From a Case Study With TRV and GAHP Technologies <i>Massimiliano Manfren, Maria Cristina Tommasino, Lamberto Tronchin</i> .....	243
The Amintore Galli Theatre in Rimini: A Dataset of Building Simulation Tools for its Acoustic Design <i>Antonella Bevilacqua, Massimiliano Manfren, Maria Cristina Tommasino, Ruoran Yan, Lamberto Tronchin</i> .....	249
Data-Driven Building Energy Modelling – Generalisation Potential of Energy Signatures Through Interpretable Machine Learning <i>Massimiliano Manfren, Maria Cristina Tommasino, Lamberto Tronchin</i> .....	255
Estimated Versus Actual Heating Energy Use of Residential Buildings <i>Matthias Schuss, Martin Fleischhacker, Ardeshir Mahdavi</i> .....	265
Polyamide Waste Thermal and Acoustic Properties: Experimental and Numerical Investigation on Possible Reuse for Indoor Comfort Improvement <i>Manuela Neri, Eva Cuerva, Alfredo Zabaleta, Pablo Pujadas, Elisa Levi, Ondrej Sikula</i> .....	273
Assessment of Demand-Side Management on the Performance of a Single-Dwelling Mechanical Ventilation Plus Radiant Floor System <i>Paolo Bonato, Anton Soppelsa, Marta Avantaggiato, Roberto Fedrizzi</i> .....	281
Passive Design Strategies for the Improvement of Summer Indoor Comfort Conditions in Lightweight Steel-Framed Buildings <i>Nicola Callegaro, Max Wieser, Giovanni Manzini, Ivan Kharlamov, Rossano Albatici</i> .....	289
Energetic Optimisation of the Domestic Hot Water System in a Residential Building by Means of Dynamic Simulations <i>Paolo Valdiserri, Aminhossein Jahanbin, Giovanni Semprini</i> .....	299

Assessing the Climate Resilience of Passive Cooling Solutions for Italian Residential Buildings <i>Mamak P. Tootkaboni, Ilaria Ballarini, Vincenzo Corrado</i> .....	305
Ventilation of Residential Buildings in Alpine Region: A Comparison Between Natural, Mechanical, and Mixed-Mode Strategies <i>Francesca Avella, Paolo Bonato, Annamaria Belleri, Francesco Babich</i> .....	313
A Comparison Among Three Whole-Building Dynamic Simulation Software and their Applicability to the Indoor Climate Modelling of Historical Buildings <i>Francesca Frasca, Elena Verticchio, Michele Libralato, Paola D'Agaro, Giovanni Cortella, Anna Maria Siani, Cristina Cornaro</i> .....	321
QGIS-Based Tools to Evaluate Air Flow Rate by Natural Ventilation in Buildings at Urban Scale <i>Silvia Santantonio, Guglielmina Mutani</i> .....	331
Modeling Energy Consumption in a Single-Family House in South Tyrol: Comparison Between Hemp Concrete and Clay Bricks <i>Silvia Ricciuti, Irene Lara-Ibeas, Annamaria Belleri, Francesco Babich</i> .....	341
A Fully Automated and Scalable Approach for Indoor Temperature Forecasting in Buildings Using Artificial Neural Networks <i>Jakob Bjørnskov, Muhyiddine Jradi, Christian Veje</i> .....	349
Effects of Different Moisture Sorption Curves on Hygrothermal Simulations of Timber Buildings <i>Michele Libralato, Maja Danovska, Giovanni Pernigotto, Andrea Gasparella, Paolo Baggio, Paola D'Agaro, Giovanni Cortella</i> .....	357
Energy Performance Evaluation and Economical Analysis by Means of Simulation Activities for a Renovated Building Reaching Different Nzeb Definitions Targets <i>Riccardo Gazzin, Jennifer Adami, Mattia Dallapiccola, Davide Brandolini, Miren Juaristi Gutierrez, Diego Tamburrini, Paolo Bonato, Martino Gubert, Stefano Avesani</i> .....	367
Preliminary CFD Parametric Simulations of Low- and Medium-Density Urban Layouts <i>Ritesh Wankhade, Giovanni Pernigotto, Michele Larcher</i> .....	377
Smart Sensors and Auditory Sensitivity: Acoustic Optimization of Dedicated Spaces for Autistic Individuals <i>Federica Bettarello, Marco Caniato, Arianna Marzi, Giuseppina Scavuzzo, Andrea Gasparella</i> .....	387
Simulation Application for the Assessment of the Energy Performance of a Building Renovated Using I-BEST System (Innovative Building Envelope through Smart Technology) <i>Cristina Carpino, Mario Maiolo, Patrizia Piro, Roberto Bruno, Natale Arcuri</i> .....	395
Modeling Occupants' Behavior to Improve the Building Performance Simulation of Classrooms <i>Federica Morandi, Julian Donges, Ilaria Pittana, Alessandro Prada, Francesca Cappelletti, Andrea Gasparella</i> .....	403
Modeling and Measurements in Natural Ventilation of Massive Buildings: A Case Study <i>Francesco Asdrubali, Luca Evangelisti, Claudia Guattari, Marta Roncone, Lucia Fontana, Ginevra Salerno, Chiara Tonelli, Valeria Vitale</i> .....	411
Calibration of the Energy Simulation Model of a Library with a Meta-Model-Based Optimization Approach <i>Maja Danovska, Alessandro Prada, Paolo Baggio</i> .....	417
Development of a Detailed Model of Hybrid System Composed by Air-to-Water Heat Pump and Boiler <i>Erica Roccattello, Alessandro Prada, Marco Baratieri, Paolo Baggio</i> .....	427
The Role of Ventilation in Indoor Spaces During the Covid-19 Pandemic: Comprehensive Analysis of ASHRAE Standard 62.1 <i>Giovanni Francesco Giuzio, Giovanni Barone, Annamaria Buonomano, Gianluca Del Papa, Cesare Forzano, Adolfo Palombo, Giuseppe Russo</i> .....	437
Design of Energy-Neutral Smart Buildings: An Ontological Framework to Integrate LCA, BIM and PLM <i>Tarun Kumar, Monto Mani</i> .....	449
Assessing the Performance of a Simplification Algorithm for Urban Building Energy Modeling in Multi-Objective Optimization <i>Federico Battini, Giovanni Pernigotto, Andrea Gasparella</i> .....	457
Application of a Simplification Algorithm for Urban Building Energy Modeling to Complex-Shaped Educational Buildings <i>Matteo Merli, Federico Battini, Giovanni Pernigotto, Andrea Gasparella</i> .....	465
Numerical Investigation of Radiation Efficiency of a Cross-Laminated Timber Floor <i>Marco Caniato, Nicola Granzotto, Federica Bettarello, Arianna Marzi, Paolo Bonfiglio, Andrea Gasparella</i> .....	473



Assessment of Contagion Risk due to Covid-19 for a Multi-Zone Building Model of Offices <i>Riccardo Albertin, Alessandro Pernici, Giovanni Pernigotto, Andrea Gasparella</i> .....	479
Impact of Visual, Thermal, and Indoor Air Quality Conditions on Students' Wellbeing and Learning Performance in a Primary School of Bolzano, Italy <i>Giovanni Demozzi, Luca Zaniboni, Giovanni Pernigotto, Andrea Gasparella</i> .....	489
Performance Simulation of Desiccant Wheel under Dynamic Conditions: <i>Comparison between Detailed and Simplified Models</i> <i>Simone Dugaria, Andrea Gasparella</i> .....	499
BIM and Mixed Reality for Visualizing Building Energy Data <i>Dietmar Siegele, Paola Penna, Ilaria Di Blasio, Michael Riedl</i> .....	507
Impact of Solar Radiation Modelling on the Simulated Building Energy Performance in the Climate of Bolzano, Italy <i>Giovanni Pernigotto, Alessandro Prada, Aleksandr Gevorgian, Andrea Gasparella</i> .....	515
Effect of the Time Interval Base on the Calculation of the Renewable Quota of Building in an Alpine Context <i>Margherita Povolato, Alessandro Prada, Paolo Baggio</i> .....	525
Innovative Approaches for Teaching BPS: First Implementations of Business Game-Like Activities <i>Andrea Gasparella</i> .....	533

## Preface

The participation of about 100 attendees at the fifth Building Simulation Applications BSA2022 Conference, one of the first IBPSA conferences held entirely in presence after the pandemic outbreak, can certainly be claimed as a step forward in the process of overcoming the constraints and limitations imposed by the years of the Covid-19 pandemic.

11 conference sessions in two parallel tracks, 66 presentations reporting the contributions by more than 180 authors are some of the most significant figures of this event. In addition, confirming an international profile and its inclusivity call, the Conference saw a small but significant presence of delegates from abroad, especially from Austria and India.

As the previous editions, BSA 2022 focused on providing an overview of the latest applications of building simulation in the following three main fields: the use of simulation for building physics applications, such as building envelope and HVAC system modelling and their design and operation optimization; global performance and multi-domain simulations; the development through simulation of new methodologies, regulations, as well as new calculation and simulation tools.

Nonetheless, the times urged to address indoor air quality, the main topic of this edition, emphasizing the role of simulation to assess strategies able to ensure healthy and safe indoor conditions for occupants.

The engaging opening speech about “The Role of IBPSA and Post-Covid Simulation” by Prof. Lori McElroy, President of IBPSA, was followed by two innovative and capturing keynotes, “Simulation and Optimization: Supporting Building Decarbonization” by Prof. Paolo Baggio, University of Trento, Italy, and “Going Digital – Infrastructure Modeling for Resilience and Decarbonization”, by Dr. Drury B. Crawley, vice-President of IBPSA.

The conference also devoted some time to the analysis and discussion of the use of building simulation among building professionals and specialists in terms of education: The “3<sup>rd</sup> Student School on Building Performance Simulation Applications” addressed the use of building performance simula-

tion in the context of building rating systems and in relation with BIM. We also had an interesting conversation with Lori McElroy on the topic of “Building Simulation in the Profession: Work in Progress”, discussing the current most critical aspects and challenges. Finally, after the conference closing ceremony on the third day, the “Round Table for Designers and Practitioners” featured four professional experiences about the use of building simulation, with a discussion about errors, challenges, and opportunities.

The fifth edition of the BSA conference represented an opportunity to restart and revitalize the process of reducing the gaps between academia and the professional world, of rethinking the role of building simulation in the design practice for future buildings, and of opening in the face of unprecedented challenges and opportunities of a new post-pandemic society.

Andrea Gasparella, Free University of Bozen-Bolzano