

Zhelun Chen, Ph.D.

Research Scientist

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RESEARCH & TEACHING INTERESTS

Research Vision

Explore the development and evolution of buildings and cities in the global challenges of 1) environmental and climate change, 2) grid transformation, and 3) data explosion.

Research Interests

Computing and modeling for smart buildings and cities in the themes of 1) dynamic building system simulation; 2) artificial intelligence in buildings; 3) well-being in the built environment; 4) grid-interactive efficient buildings; 5) building energy modeling; 6) renewable energy integration in buildings; 7) fault detection and diagnostics.

Teaching Interests

1) HVAC engineering; 2) data engineering and data science in buildings; 3) built environment.

EDUCATION

Drexel University Ph.D., Architectural Engineering, GPA: 4.0/4, Advisor: Prof. Jin Wen <i>Dissertation: Advanced Solver Development for Large-scale Dynamic Building System Simulation</i>	Philadelphia, PA 09.2015-09.2019
University of Pittsburgh M.S., Mechanical Engineering, GPA: 4.0/4	Pittsburgh, PA 09.2012-03.2015
Beijing Institute of Technology B.S., Thermal Energy and Power Engineering, GPA: 3.0/4	Beijing, China 08.2008-06.2012

WORK EXPERIENCE

Research Scientist, Drexel University, Philadelphia, PA	06.2020-Present
Postdoctoral Researcher, Drexel University, Philadelphia, PA	11.2019-06.2020
Research and Teaching Assistant, Drexel University, Philadelphia, PA	09.2015-09.2019
Professional Tutor, Manor College, Jenkintown, PA	01.2015-05.2015
Tower Structural Analyst, Crown Castle, Canonsburg, PA	04.2014-08.2014
Intern, Missionary TECH Team, Longview, TX	06.2013-08.2013

RESEARCH PROJECTS

Drexel University, Philadelphia, PA	09.2015-present
<ul style="list-style-type: none">HILFT (<i>Hardware-in-the-Loop Laboratory Performance Verification of Flexible Building Equipment in a Typical Commercial Building</i>, https://research.coe.drexel.edu/caee/bseg/hilft-doe-benefit-9153/)<ul style="list-style-type: none">Led the development of three HIL testbeds to test the demand flexibility of HVAC systems in typical commercial buildings, including an AHU-VAV system, an air-source heat pump, and a water-source heat pump.Developed simulated building models for HVAC system testing using EnergyPlus and Matlab, integrating various models and software to accurately reflect the dynamics of real buildings.Designed and implemented supervisory control models for typical and high-performance commercial buildings, ensuring compliance with industry standards and guidelines.Established experiment protocols and conducted quality checks on experimental data to generate reliable and accurate test results.ANNEX 81 (<i>IEA EBC - Annex 81 - Data-Driven Smart Buildings</i>, https://annex81.iea-ebc.org/)<ul style="list-style-type: none">Subtask C2 Automated Fault Detection, Diagnostics and Recommissioning Applications Led a team of about twenty international participants in the publication of a review paper on data-driven fault detection and diagnostics.Subtask C3 Building to Grid Applications Contributed to the development and testing of a Python package for energy flexibility KPIs.	

- **Fault Detection and Diagnostics Data Curation and Benchmarking**
 - Contributed to the LBNL Fault Detection and Diagnostics Datasets (<https://faultdetection.lbl.gov/data/>) that can be used to evaluate and benchmark the performance of fault detection and diagnostics algorithms or tools.
 - Generated annual ground-truth data on the presence and absence of various building faults in typical HVAC systems using HVACSIM+, including a fan-coil unit, a dual-duct system, a parallel fan-powered VAV system, and a series fan-powered VAV system.
 - Enhanced the HVACSIM+ models to ensure efficient, robust, stable, and accurate system simulation through the modification of control logic, tuning of PID parameters, resizing of system equipment, and elimination of numerical difficulties.
 - Developed rule-based and statistical-based data verification approaches to ensure data quality.
- **Advanced Solver Development for Large-scale Dynamic Building System Simulation**
 - Developed a new numerical solver based on a preconditioned Newton-Krylov method that significantly improved the computational efficiency of large-scale dynamic building system simulations using HVACSIM+, saving more than 90% of the computational time compared to the original solver while maintaining the same level of robustness.
 - Created AHU-VAV system models of various scales using HVACSIM+ to test the performance of the new solver, demonstrating a deep understanding of dynamic HVAC system modeling.
 - Developed a generic smoothing technique to improve the efficiency and robustness of building system simulations with discontinuities.
 - Investigated multiple strategies for constructing physics-based preconditioners to further improve the efficiency of dynamic building system simulations.

Missionary TECH Team, Longview, TX

06.2013-07.2013

- **Mechanical Design for Gowanda Free Methodist Church**
 - Developed HVAC and plumbing designs for a 12,000 square foot addition to the existing church facility.
 - HVAC design responsibilities included heating and cooling load calculations, DX split system equipment selection, ductwork layout and design, and hydronic piping layout and design.
 - Plumbing design responsibilities included plumbing fixture selection, domestic hot and cold water piping layout and design, waste and vent piping layout and design, and gas piping design.
 - Developed drawings for the designs in AutoCAD.

SELECTED PUBLICATIONS

Google Scholar Profile: <https://scholar.google.com/citations?user=NFKpwloAAAAJ&hl=en>

Journal Publications

- Granderson, J., Lin, G., Chen, Y., Casillas, A., Wen, J., **Chen, Z.**, Im, P., Huang, S. and Ling, J., 2023. A labeled dataset for building HVAC systems operating in faulted and fault-free states. *Scientific Data*, 10(1), p.342.
- **Chen, Z.**, O'Neill, Z., Wen, J., Pradhan, O., Yang, T., Lu, X., Lin, G., et al., 2023. A review of data-driven fault detection and diagnostics for building HVAC systems. *Applied Energy*, 339, 121030.
- Zhang, L., **Chen, Z.**, Zhang, X., Pertzborn, A., and Jin, X., 2023. Challenges and opportunities of machine learning control in building operations. In *Building Simulation* (pp. 1-22). Beijing: Tsinghua University Press.
- **Chen, Z.**, Wen, J., Kearsley, A., and Pertzborn, A., 2022. Evaluating the performance of an Inexact Newton method with a preconditioner for dynamic building system simulation. *Journal of Building Performance Simulation*, 15(1), 112-127.
- Chen, Y., Lin, G., **Chen, Z.**, Wen, J., and Granderson, J., 2022. A simulation-based evaluation of fan coil unit fault effects. *Energy and Buildings*, 112041.

Conference Publications

- **Chen, Z.**, Li, Y., Wen, J., Pertzborn, A., Payne, W. V., Lo, L. J., Grejowski, G., et al., 2023. A Simulation framework for analyzing the impact of stochastic occupant behaviors on demand flexibility in typical commercial buildings. In *2023 ASHRAE Annual Conference*.
- **Chen, Z.**, Wen, J., Bushby, S. T., Lo, L. J., O'Neill, Z., Payne, W. V., Pertzborn, A., et al., 2022. Development of a hardware-in-the-loop testbed for laboratory performance verification of flexible building equipment in typical commercial buildings. In *2022 ASHRAE Annual Conference*.
- Calfa, C., Yang, Z., Fu, Y., **Chen, Z.**, O'Neill, Z., Wen, J., 2022. Development of a water source heat pump hardware-in-the-loop (HIL) testing facility for smart building applications. In *2022 ASHRAE Annual Conference*.
- **Chen, Z.**, Wen, J., Bushby, S. T., Lo, L. J., O'Neill, Z., Payne, W. V., Pertzborn, A., et al., 2022. An analysis of the hybrid internal mass modeling approach in EnergyPlus. In *eSim 2022 Conference*.
- Phadhan, O., Hälleberg, D., **Chen, Z.**, Wen, J., Wu, T., Candan, K. S., and O'Neill, Z., 2022. Lagged-kNN based data imputation approach for multi-stream building systems data. *International High Performance Buildings Conference*. Paper 393.

- Casillas, A., Lin, G., Chen, Y., Granderson, J., Huang, S., and **Chen, Z.**, 2022. Modeling air handling units to create a diverse fault dataset for FDD innovation: Lessons learned and recommendations. *International High Performance Buildings Conference*. Paper 416.
- **Chen, Z.**, Wen, J., Kearsley, A. and Pertzborn, A., 2021. Smoothing techniques in dynamic building system simulation. In *2021 International Conference on Instrumentation, Control, and Automation (ICA)* (pp. 156-161). IEEE.
- **Chen, Z.**, Wen, J., Kearsley, A.J. and Pertzborn, A.J., 2017. Scaling methods for dynamic building system simulation in an HVACSIM+ environment. In *15th IBPSA conference*, San Francisco, CA, US (pp. 2059-2065).

Papers in Press, in Revision, or under Review

- Calfa, C., Yang, Z., Li, Y., **Chen, Z.**, O'Neill, Z., Wen, J., 2023. Performance Assessment of a Real Water Source Heat Pump within a Hardware-in-the-Loop (HIL) Testing Environment. *Science and Technology for the Built Environment*. In Press.
- Zhang, L., and **Chen, Z.**, Opportunities and Challenges of Applying Large Language Models in Building Energy Efficiency and Decarbonization Studies: An Exploratory Overview. *Renewable & Sustainable Energy Reviews*. Under Review.
- Phadhan, O., Hälleberg, D., **Chen, Z.**, Wen, J., Wu, T., Candan, K. S., and O'Neill, Z., Evaluation of Data Imputation Approaches for Multi-Stream Building Systems Data. *Science and Technology for the Built Environment*. Under Review.

PRESENTATIONS

2023 ASHRAE Annual Conference

- Seminar 62: Coupling Multiple Simulation Tools to Model Complex Building-Human Interactions for a Hardware-in-the-Loop Testbed
- Poster: A Simulation Framework for Analyzing the Impact of Stochastic Occupant Behaviors on Demand Flexibility in Typical Commercial Buildings

2022 ASHRAE Annual Conference

- Poster: Development of a Hardware-in-the-Loop Testbed for Laboratory Performance Verification of Flexible Building Equipment in Typical Commercial Buildings

2022 eSim Conference

- Presentation (virtual): An Analysis of the Hybrid Internal Mass Modeling Approach in EnergyPlus

2021 ASHRAE Annual Conference

- Presentation (virtual): A Hardware-in-the-Loop Approach for Laboratory Performance Verification of Flexible Building Equipment in a Typical Commercial Building

2021 International Conference on Instrumentation, Control, and Automation (ICA)

- Presentation (virtual): Smoothing Techniques in Dynamic Building System Simulation

2017 IBPSA Conference

- Poster: Scaling methods for dynamic building system simulation in an HVACSIM+ environment

TEACHING EXPERIENCE

Drexel University

Lecturer: AE 551 Building Energy Systems I	2021, 2022
Teaching Assistant: MEM 414 HVAC Equipment	2019
Teaching Assistant: MEM 413 HVAC Loads	2015, 2018

Mentor Experience

Yicheng Li, PhD Student, Drexel University	2020-2023
Jose Moussa, Master Student, Drexel University	2022-2023
Noreshvarman Manisagar, PhD Student, Drexel University	2022-2023

SERVICES

Reviewer

Building Simulation; DeCarbon; Science & Technology for the Built Environment;
 ASME Journal of Engineering for Sustainable Buildings & Cities;
 IEEE Transactions on Automation Science and Engineering;
 Reliability Engineering & System Safety;

Member

ASHRAE (Associate)