Zhelun Chen, Ph.D.

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RESEARCH & TEACHING INTERESTS

Research Vision
Exploring the development and evolution of buildings and cities in response to global challenges: 1) environmental and climate change, 2) grid transformation, and 3) data explosion.

Research Interests
Computing and modeling for smart buildings and cities, with themes of 1) dynamic building system simulation; 2) artificial intelligence in buildings; 3) human-building interaction; 4) grid-interactive efficient buildings; 5) building energy modeling; 6) renewable energy integration in buildings; and 7) fault detection and diagnostics.

Teaching Interests
1) HVAC engineering; 2) data science in buildings; and 3) building energy modeling.

EDUCATION

Drexel University — Philadelphia, PA
Ph.D., Architectural Engineering, GPA: 4.0/4, Advisor: Prof. Jin Wen — 09.2015-09.2019
Dissertation: Advanced Solver Development for Large-scale Dynamic Building System Simulation

University of Pittsburgh — Pittsburgh, PA
M.S., Mechanical Engineering, GPA: 4.0/4 — 08.2012-12.2013

Beijing Institute of Technology — Beijing, China
B.S., Thermal Energy and Power Engineering, GPA: 3.0/4 — 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

PROJECT EXPERIENCE

Drexel University, Philadelphia, PA — 09.2015-Present

- **HILFT** *(Hardware-in-the-Loop Laboratory Performance Verification of Flexible Building Equipment in a Typical Commercial Building, https://research.coe.drexel.edu/caee/bseg/hilft-doe-benefit-9153/, part of DOE BENEFIT projects)*
  - Managed inter-institutional collaboration between National Institute of Standard and Technology, Texas A&M University, and Drexel, overseeing all testing activities to ensure consistency and alignment with project objectives.
  - 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 with consideration of occupant behaviors.
  - 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.
  - Led the data publication efforts, encompassing data postprocessing, Brick model development, data repository documentation, and in-depth data analysis and demonstrations.

- **ANNEX 81** *(IEA EBC - Annex 81 - Data-Driven Smart Buildings, https://annex81.iea-ebc.org/)*
  - **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 and 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

- 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*, pp.1-16.
- 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

- Li, Y., **Chen, Z.**, Wen, J., Fu, Y., Pertzborn, A., O'Neill, Z., 2023. A framework for calibrating and validating an air loop dynamic model in an HVAC system in Modelica. In *Building Simulation 2023*.
- **Chen, Z.**, Li, Y., Wen, J., Pertzborn, A., Payne, W. V., Lo, L. J., Grejawski, 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

- 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 Building Simulation Conference

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

2021 ASHRAE Annual Conference

- Presentation: 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: 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, Science & Technology for the Built Environment, Reliability Engineering & System Safety, ASME Journal of Engineering for Sustainable Buildings & Cities, DeCarbon, ASHRAE

Member

ASHRAE (Associate)