

Zhe WANG

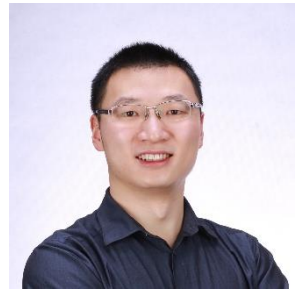
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INTRO

I am an Assistant Professor working with the Department of Civil and Environmental Engineering at The Hong Kong University of Science and Technology. My current research is about the application of artificial intelligence in smart building and low carbon city, majorly from two aspects. First, I am looking at how to leverage advanced control techniques (e.g. Reinforcement Learning, Model Predictive Control, etc.) to enhance building performance and building-grid interaction. Second, I am interested in how machine learning techniques could help to inform decision making on buildings and cities.

Prior to joining HKUST, I was the **youngest scientist** in Lawrence Berkeley National Lab working on smart building control; a Postdoctoral Scholar in UC Berkeley working on data-driven personal comfort models and devices; and an Energy Consultant in World Bank working on Urban Scale Building Energy Efficiency and Renewable Energy in China.

I published 65 articles in SCI journals, 21 as first author, 4 as corresponding author, 5 as co-first author, 2 as ESI highly cited paper. I was awarded the **National Science Fund for Excellent Young Scholars** (2021), **Second Class Award of State Science and Technology Prize** (2019); and was selected as a Schwarzman Scholar (2016, [covered by the New York Times](#)). I am now serving as an Associate Editor for *Frontiers in Built Environment* (SCI journal), as an Editor for *Building Simulation* (SCI journal) and *Building Energy Conservation* (Chinese journal), and is a [Fellow](#) of the George H. W. Bush Foundation for U.S.-China Relations. I have won the first prize in the **2022 Global AI Challenge for Building E&M Facilities** hosted by Hong Kong Electrical & Mechanical Services Department. Because of my achievements, I was invited to give a speech on the Seventh-Round High-level Consultation on U.S.-China People to People Exchange, chaired by U.S. Secretary of States John Kerry and Chinese Vice-Premier Yandong Liu, as the *only representative of Chinese young scholar* ([news coverage](#)).

EMPLOYMENT

- | | | |
|--------------------------|---|------------------|
| <i>2021.11 till now</i> | Hong Kong University of Science and Technology, Assistant Professor | Hong Kong |
| | <ul style="list-style-type: none">➤ Co-PI, Autonomous Cruise UVC Disinfection and Microclimate Air-conditioning Robot (6M RMB, SHCIRI-FSNH-2203)➤ PI, Smart Platform for Demand Response of Commercial Buildings (1M RMB, Midea Group) | |
| <i>2018.07 – 2021.10</i> | Lawrence Berkeley National Lab, Project Scientist | Berkeley |
| | <ul style="list-style-type: none">➤ Co-PI, AlphaBuilding – Reinforcement Learning for Building Control (0.2M USD, LBNL LDRD: BU21-036)<ul style="list-style-type: none">• Develop virtual testbeds to train and benchmark RL controllers for buildings• Design and implement multi-agent RL structure to enhance the scalability of RL controllers➤ Leading researcher, Sensor Data Integration - Integrating Sensor Data with Physics-Based Models (1.5M USD, US Department of Energy: EE-5B37579)<ul style="list-style-type: none">• Infer building thermal dynamics using connected smart thermostat data• Estimate demand response potential of US residential building stock➤ Key researcher, Hierarchical Occupancy Responsive Model Predictive Control at Room, Building and Campus Levels (3.0M USD, US Department of Energy: EE-5B24502)<ul style="list-style-type: none">• Develop, deploy, and test Model Predictive Control for buildings• Develop toolkits to simplify MPC controller development process➤ Key researcher, End-Use Load Profiles for the U.S. Building Stock (1.2M USD, US Department of Energy: EE-5B35033)<ul style="list-style-type: none">• Develop occupant behavior modelling toolkits to generate realistic building load shape• Develop and validate data-driven approach to generate building load using GAN | |

- 2017.10-2018.06 **UC Berkeley, Postdoc Researcher** **Berkeley**
- Key researcher, Data-driven personal comfort models and wearable comfort devices (0.5M USD, US National Science Foundation)
 - Develop data-driven models to predict individual comfort demands
 - Develop and test energy-efficient personal comfort wearables to address individualized demands
- 2016.12-2018.06 **World Bank, Energy Consultant** **Beijing/Berkeley**
- Joint research with Ministry of Housing, Urban and Rural Development: Urban Scale Building Energy Efficiency and Renewable Energy Project
 - Assist the project manager by overseeing the technical progress
 - Provide technical supports to the sub-contractors
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EDUCATION

- 2011.08-2017.07 **Tsinghua University** **Ph.D. in Building Science**
- Visiting scholar in *Harvard University*, 2015
 - Recipient of the *National Scholarship* (2012), *Boeing Scholarship* (2015), *Outstanding Graduate of Beijing* (2017)
- 2016.08-2017.07 **Schwarzman College, Tsinghua University** **Master in Public Policy**
- Invited to give a speech on the Seventh-Round High-level Consultation on U.S.-China People to People Exchange (Chaired by Chinese Vice Premier Yandong Liu and U.S. Secretary of State John Kerry), as the *ONLY* representative of Chinese young scholar
 - Selected as a Student Council Member (12 out of 110)
- 2013.10-2014.09 **University of Cambridge** **M.Phil. in Energy Technology**
- Recipient of the *Wing Yip Scholarship, Cambridge Overseas Trust* (2013)
- 2008.09-2011.07 **Tsinghua University** **Bachelor in Economics**
- Cumulative GPA 92.8/100, **ranking 1st /126**
- 2007.09-2011.07 **Tsinghua University** **Bachelor in Civil Engineering**
- Cumulative GPA 91.3/100, **ranking 1st /29**
 - Recipient of the *National Scholarship* (2009, 2010), *Boeing Scholarship* (2011)
 - Recipient of the *Outstanding Undergraduate of Beijing* (2011)
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OPEN-SOURCE TOOL

- MPCPy* Python-based open-source platform for model predictive control in buildings
<https://github.com/lbl-srg/MPCPy>
- Modelica Buildings Library* Dynamic simulation models for building energy and control systems
<https://github.com/lbl-srg/modelica-buildings>
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ACADEMIC SERVICE

- 2021 till now Associate Editor,
Frontiers in Built Environment
- 2020 till now Editor,
Building Simulation, Building Energy Conservation
- 2020 Grant Proposal Reviewer
The Dunhill Medical Trust, UK
- 2020, 2021 Member of Technical Program Committee,
First International Workshop on Reinforcement Learning for Energy Management in Buildings & Cities (RLEM), <https://rlem-workshop.net/>

2015 till now Reviewer,
Applied Energy, Energy, Building and Environment, Energy and Building, Journal of Building Engineering, Building Simulation, Environmental Science and Pollution Research, Science and Technology for the Built Environment, SoftwareX, Journal of Building Performance Simulation, Applied Thermal Engineering, Advanced Engineering Informatics, Frontiers in Built Environment, International Journal of Biometeorology, Journal of Asian Architecture and Building Engineering, Journal of the Taiwan Institute of Chemical Engineer, Sustainable Cities and Society, Engineering

AWARD

1. Key Technology for the Environmental and Energy-Efficient Design of Green Building, Second Class Award of 2019 Chinese State Science and Technology Prize, Award Number: 2019-J-22101-2-01-R09
2. First Prize, 2022 Global AI Challenge for Building E&M Facilities, hosted by Hong Kong Electrical and Mechanical Services Department (EMSD)
3. Key Technology for the Environmental and Energy-Efficient Design of Green Building, First Class Award of 2018 Beijing Science and Technology Prize
4. Environment Monitoring and Energy Conservation Technology of Large Commercial Buildings, First Class Award of 2020 Huaxia Construction Prize

PATENT

1. **Wang, Z.**, A Smart Thermostat for Demand Response in Residential Buildings. Chinese Patent Application Number: 202210667572.X
2. Lin, BR., Zhao, HT., and **Wang, Z.**, A Waste Heat Recovery System Designed for Dishwasher. Chinese Patent Number: ZL 201320328067.9

PUBLICATION

Google Scholar Citation: 2532; h-index: 29; i10-index: 49; ESI Highly Cited papers: 2

(#: contribute equally; *: corresponding author)

1. **Wang, Z.**, Chen, B., Li, H. and Hong, T., 2021. AlphaBuilding ResCommunity: A multi-agent virtual testbed for community-level load coordination. *Advances in Applied Energy*, 4, p.100061.
2. **Wang, Z.**, Hong, T. and Li, H., 2021. Informing the planning of rotating power outages in heat waves through data analytics of connected smart thermostats for residential buildings. *Environmental Research Letters*, 16(7), p.074003.
3. **Wang, Z.**, Hong, T., Li, H. and Piette, M.A., 2021. Predicting city-scale daily electricity consumption using data-driven models. *Advances in Applied Energy*, 2, p.100025.
4. **Wang, Z.** and Hong, T., 2020. Reinforcement Learning for Building Controls: The opportunities and challenges. *Applied Energy*, 269, p.115036.
5. **Wang, Z.**, Hong, T. and Piette, M.A., 2020. Building thermal load prediction through shallow machine learning and deep learning. *Applied Energy*, 263, p.114683.
6. **Wang, Z.** and Hong, T., 2020. Learning occupants' indoor comfort temperature through a Bayesian inference approach for office buildings in United States. *Renewable and Sustainable Energy Reviews*, 119, p.109593.
7. **Wang, Z.** and Hong, T., 2020. Generating realistic building electrical load profiles through the Generative Adversarial Network (GAN). *Energy and Buildings*, p.110299.
8. **Wang, Z.**, Hong, T., Piette, M.A. and Pritoni, M. 2019, Inferring occupant counts from Wi-Fi data in buildings through machine learning, *Building and Environment*, 158, pp. 281-294.
9. **Wang, Z.**, Parkinson, T., Li, P., Lin, B. and Hong, T., 2019. The Squeaky wheel: Machine learning for anomaly detection in subjective thermal comfort votes. *Building and Environment*, 151, pp.219-227.
10. **Wang, Z.**, Zhang, H., He, Y., Luo, M., Li, Z., Hong, T. and Lin, B., 2020. Revisiting individual and group differences in thermal comfort based on ASHRAE database. *Energy and Buildings*, 219, p.110017.
11. **Wang, Z.**, Wang, J., He, Y., Liu, Y., Lin, B. and Hong, T., 2020. Dimension analysis of subjective thermal comfort metrics based on ASHRAE Global Thermal Comfort Database using machine learning. *Journal of Building Engineering*, 29, p.101120.

12. **Wang, Z.**, Hong, T. and Piette, M.A., 2019. Predicting plug loads with occupant count data through a deep learning approach. *Energy*, 181, pp.29-42.
13. **Wang, Z.**, Warren, K., Luo, M., He, X., Zhang, H., Arens, E., Chen, W., He, Y., Hu, Y., Jin, L. and Liu, S., 2019. Evaluating the comfort of thermally dynamic wearable devices. *Building and Environment*, p.106443.
14. **Wang, Z.**, Hong, T. and Piette, M.A., 2019. Data fusion in predicting internal heat gains for office buildings through a deep learning approach. *Applied Energy*, 240, pp.386-398.
15. **Wang, Z.**, Hong, T. and Jia, R., 2018. Buildings. Occupants: a Modelica package for modelling occupant behaviour in buildings. *Journal of Building Performance Simulation*, pp.1-12.
16. **Wang, Z.**, Luo, M., Geng, Y., Lin, B. and Zhu, Y., 2018. A model to compare convective and radiant heating systems for intermittent space heating. *Applied Energy*, 215, pp.211-226.
17. **Wang, Z.**, de Dear, R., Luo, M., Lin, B., He, Y., Ghahramani, A. and Zhu, Y., 2018. Individual difference in thermal comfort: A literature review. *Building and Environment*, 138, pp. 181-193 (highly cited paper)
18. **Wang, Z.**, Zhao, Z., Lin, B., Zhu, Y. and Ouyang, Q., 2015. Residential heating energy consumption modeling through a bottom-up approach for China's Hot Summer–Cold Winter climatic region. *Energy and Buildings*, 109, pp.65-74.
19. **Wang, Z.**, Zhao, H., Lin, B., Zhu, Y., Ouyang, Q. and Yu, J., 2015. Investigation of indoor environment quality of Chinese large-hub airport terminal buildings through longitudinal field measurement and subjective survey. *Building and Environment*, 94, pp.593-605.
20. **Wang, Z.**, de Dear, R., Lin, B., Zhu, Y. and Ouyang, Q., 2015. Rational selection of heating temperature set points for China's hot summer–Cold winter climatic region. *Building and Environment*, 93, pp.63-70.
21. **Wang, Z.**, Lin, B. and Zhu, Y., 2015. Modeling and measurement study on an intermittent heating system of a residence in Cambridgeshire. *Building and Environment*, 92, pp.380-386.
22. Blum, D.*, **Wang, Z.***, Weyandt, C., Kim, D., Wetter, M., Hong, T. and Piette, M.A., 2022. Field demonstration and implementation analysis of model predictive control in an office HVAC system. *Applied Energy*, 318, p.119104.
23. Liu, S.*#, **Wang, Z.*#**, Schiavon, S., He, Y., Luo, M., Zhang, H. and Arens, E., 2020. Predicted percentage dissatisfied with vertical temperature gradient. *Energy and Buildings*, p.110085.
24. Wang, J.#, **Wang, Z.#**, Zhou, D. and Sun, K., 2019. Key issues and novel optimization approaches of industrial waste heat recovery in district heating systems. *Energy*, p.116005.
25. Wang, J.#, **Wang, Z.*#**, de Dear, R., Luo, M., Ghahramani, A. and Lin, B., 2018. The uncertainty of subjective thermal comfort measurement. *Energy and Buildings*, 181, pp.38-49.
26. Liu, Y.#, **Wang, Z.#**, Lin, B., Hong, J. and Zhu, Y., 2018. Occupant satisfaction in Three-Star-certified office buildings based on comparative study using LEED and BREEAM. *Building and Environment*, 132, pp.1-10.
27. Touzani, S.#, Prakash, A.K.#, **Wang, Z.#**, Agarwal, S., Pritoni, M., Kiran, M., Brown, R. and Granderson, J., 2021. Controlling distributed energy resources via deep reinforcement learning for load flexibility and energy efficiency. *Applied Energy*, 304, p.117733.
28. Luo, M., **Wang, Z.***, Ke, K., Cao, B., Zhai, Y. and Zhou, X., 2018. Human metabolic rate and thermal comfort in buildings: The problem and challenge. *Building and Environment*, 131, pp. 44-52
29. Luo, N., **Wang, Z.**, Blum, D., Weyandt, C., Bourassa, N., Piette, M.A. and Hong, T., 2022. A three-year dataset supporting research on building energy management and occupancy analytics. *Scientific Data*, 9(1), pp.1-15.
30. Pinto, G., **Wang, Z.**, Roy, A., Hong, T. and Capozzoli, A., 2022. Transfer learning for smart buildings: A critical review of algorithms, applications, and future perspectives. *Advances in Applied Energy*, p.100084.
31. Li, H., **Wang, Z.** and Hong, T., 2021. A synthetic building operation dataset. *Scientific data*, 8(1), pp.1-13.
32. Li, H., **Wang, Z.**, Hong, T. and Piette, M.A., 2021. Energy Flexibility of Residential Buildings: A Systematic Review of Characterization and Quantification Methods and Applications. *Advances in Applied Energy*, p.100054.
33. Li, H., **Wang, Z.**, Hong, T., Parker, A. and Neukomm, M., 2021. Characterizing patterns and variability of building electric load profiles in time and frequency domains. *Applied Energy*, 291, p.116721.
34. Wang, M., **Wang, Z.**, Geng, Y. and Lin, B., 2021. Interpreting the neural network model for HVAC system energy data mining. *Building and Environment*, p.108449.
35. Li, H., **Wang, Z.** and Hong, T., 2021. Occupant-Centric key performance indicators to inform building design and operations. *Journal of Building Performance Simulation*, pp.1-29.

36. Hong, T., **Wang, Z.**, Luo, X. and Zhang, W., 2020. State-of-the-art on research and applications of machine learning in the building life cycle. *Energy and Buildings*, p.109831.
37. Jiang, Y., **Wang, Z.**, Lin, B. and Mumovic, D., 2020. Development of a health data-driven model for a thermal comfort study. *Building and Environment*, p.106874.
38. Liu, Y., **Wang, Z.**, Zhang, Z., Hong, J. and Lin, B., 2018. Investigation on the Indoor Environment Quality of health care facilities in China. *Building and Environment*, 141, pp. 273-287
39. Luo, M., **Wang, Z.**, Zhang, H., Arens, E., Filingeri, D., Jin, L., Ghahramani, A., Chen, W., He, Y. and Si, B., 2020. High-density thermal sensitivity maps of the human body. *Building and Environment*, 167, p.106435.
40. Luo, M., **Wang, Z.**, Brager, G., Cao, B. and Zhu, Y., 2018. Indoor climate experience, migration, and thermal comfort expectation in buildings. *Building and Environment*, 141, pp. 262-272
41. Lin, B., **Wang, Z.**, Sun, H., Zhu, Y. and Ouyang, Q., 2016. Evaluation and comparison of thermal comfort of convective and radiant heating terminals in office buildings. *Building and Environment*, 106, pp.91-102.
42. Lin, B., **Wang, Z.**, Liu, Y., Zhu, Y. and Ouyang, Q., 2016. Investigation of winter indoor thermal environment and heating demand of urban residential buildings in China's hot summer–Cold winter climate region. *Building and Environment*, 101, pp.9-18.
43. Kim, D., Brugger, J., **Wang, Z.**, et al., 2022, Site Demonstration and Performance Evaluation of MPC for a Large Chiller Plant with TES for Renewable Energy Integration and Grid Decarbonization. *Applied Energy* (accepted)
44. Su, Y., Cheng, H., **Wang, Z.** and Wang, L., 2022. Impacts of the COVID-19 lockdown on building energy consumption and indoor environment: A case study in Dalian, China. *Energy and Buildings*, p.112055.
45. Guo, X., Lee, K., **Wang, Z.** and Liu, S., 2021. Occupants' satisfaction with LEED-and non-LEED-certified apartments using social media data. *Building and Environment*, p.108288.
46. He, Y., Zhou, Y., **Wang, Z.**, Liu, J., Liu, Z. and Zhang, G., 2021. Quantification on fuel cell degradation and techno-economic analysis of a hydrogen-based grid-interactive residential energy sharing network with fuel-cell-powered vehicles. *Applied Energy*, 303, p.117444.
47. Chen, B., Jin, M., **Wang, Z.**, Hong, T. and Bergés, M., 2020, November. Towards Off-policy Evaluation as a Prerequisite for Real-world Reinforcement Learning in Building Control. In *Proceedings of the 1st International Workshop on Reinforcement Learning for Energy Management in Buildings & Cities* (pp. 52-56).
48. Hong, T., Chen, C.F., **Wang, Z.** and Xu, X., 2020. Linking human-building interactions in shared offices with personality traits. *Building and Environment*, 170, p.106602.
49. Jiang, Y., Luo, Z., **Wang, Z.** and Lin, B., 2019. Review of thermal comfort infused with the latest big data and modeling progresses in public health. *Building and Environment*, 164, p.106336.
50. He, Y., Chen, W., **Wang, Z.** and Zhang, H., 2019. Review of fan-use rates in field studies and their effects on thermal comfort, energy conservation, and human productivity. *Energy and Buildings*, 194, pp. 140-162.
51. Geng, Y., Ji, W., **Wang, Z.**, Lin, B. and Zhu, Y., 2018. A review of operating performance in green buildings: Energy use, indoor environmental quality and occupant satisfaction. *Energy and Buildings*. 183, pp.500-514. (highly cited paper)
52. Lin, B., Liu, Y., **Wang, Z.**, Pei, Z. and Davies, M., 2016. Measured energy use and indoor environment quality in green office buildings in China. *Energy and Buildings*, 129, pp.9-18.
53. Cho, B., Dayrit, T., Gao, Y., **Wang, Z.**, Hong, T., Sim, A. and Wu, K., 2020, December. Effective Missing Value Imputation Methods for Building Monitoring Data. In *2020 IEEE International Conference on Big Data (Big Data)* (pp. 2866-2875). IEEE.
54. He, Y., Arens, E., Li, N., **Wang, Z.**, Zhang, H., Yongga, A. and Yuan, C., 2020. Modeling solar radiation on a human body indoors by a novel mathematical model. *Building and Environment*, p.107421.
55. Wang, Z., Yu, H., Luo, M., **Wang, Z.**, Zhang, H. and Jiao, Y., 2019. Predicting older people's thermal sensation in building environment through a machine learning approach: Modelling, interpretation, and application. *Building and Environment*, 161, p.106231.
56. Wang, J., Hua, J., Fu, L., **Wang, Z.** and Zhang, S., 2019. A theoretical fundamental investigation on boilers equipped with vapor-pump system for Flue-Gas Heat and Moisture Recovery. *Energy*, 171, pp.956-970.
57. Luo, M., Ke, Z., Ji, W., **Wang, Z.**, Cao, B., Zhou, X. and Zhu, Y., 2019. The time-scale of thermal comfort adaptation in heated and unheated buildings. *Building and Environment*, 151, pp.175-186.

58. Geng, Y., Yu, J., Lin, B., **Wang, Z.** and Huang, Y., 2017. Impact of individual IEQ factors on passengers' overall satisfaction in Chinese airport terminals. *Building and Environment*, 112, pp.241-249.
59. He, Y., Zhou, Y., Yuan, J., Liu, Z., **Wang, Z.** and Zhang, G., 2021. Transformation towards a carbon-neutral residential community with hydrogen economy and advanced energy management strategies. *Energy Conversion and Management*, 249, p.114834.
60. Chen, C.F., De Simone, M., Yilmaz, S., Xu, X., **Wang, Z.**, Hong, T. and Pan, Y., 2021. Intersecting heuristic adaptive strategies, building design and energy saving intentions when facing discomfort environment: A cross-country analysis. *Building and Environment*, 204, p.108129.
61. Li, Z., Lin, B., Zheng, S., Liu, Y., **Wang, Z.** and Dai, J., 2020, August. A review of operational energy consumption calculation method for urban buildings. *Building Simulation*, Vol. 13, No. 4, pp. 739-751
62. Hong, T., Macumber, D., Li, H., Fleming, K. and **Wang, Z.**, 2020, June. Generation and representation of synthetic smart meter data. *Building Simulation*, Vol. 13, No. 4, pp. 1205–1220
63. Ghahramani, A., Galicia, P., Lehrer, D., Varghese, Z., **Wang, Z.** and Pandit, Y., 2020. Artificial Intelligence for Efficient Thermal Comfort Systems: Requirements, Current Applications and Future Directions. *Frontiers in Built Environment*, 6.
64. Luo, M., Arens, E., Zhang, H., Ghahramani, A. and **Wang, Z.**, 2018. Thermal comfort evaluated for combinations of energy-efficient personal heating and cooling devices. *Building and Environment*, 143, pp.206-216.
65. Taylor, J., Liu, Y., Lin, B., Burman, E., Hong, S.M., Yu, J., **Wang, Z.**, Mumovic, D., Shrubsole, C., Vermeer, D. and Davies, M., 2018. Towards a framework to evaluate the 'total' performance of buildings. *Building Services Engineering Research and Technology*, p.0143624418762662.

Last Updated: June. 25, 2022