# Kevin J. Kircher

Assistant Professor, Mechanical Engineering (2022–) Assistant Professor (by courtesy), Electrical and Computer Engineering (2023–) Purdue University 1022 Ray W. Herrick Laboratories https://kevinjkircher.com kircher@purdue.edu

# Research interests: Energy and algorithms

I work on control, optimization, and machine learning methods for energy systems, focusing on buildings and the power grid. I'm particularly interested in new technologies for efficient electric heating.

### Education

2019 - 2022	Postdoctoral Associate in Electrical Engineering and Computer Science,
	Massachusetts Institute of Technology
2019	PhD in Mechanical Engineering, Cornell University
2016	MS in Mechanical Engineering, <b>Cornell University</b>
2009	MEng in Engineering Physics, <b>Cornell University</b>
2008	BS in Applied Mathematics and Physics, University of Wisconsin–Milwaukee

# Publications

#### Journal articles

- 16. E.N. Pergantis, P. Dillhon, L.D. Reyes Premer, A.H. Lee, D. Ziviani, E.A. Groll and K.J. Kircher. "Humidityaware model predictive control for residential air conditioning: A field study." In review.
- 15. L. Semmelmann, M. Hertel, **K.J. Kircher**, R. Mikut, V. Hagenmeyer and C. Weinhardt. "The impact of heat pumps on day-ahead energy community load forecasting." In review.
- 14. G.P. Henze, **K.J. Kircher** and J.E. Braun. "Bridging the abyss from algorithms to applications: Synthesis of the 2023 Workshop on Intelligent Building Operations." In review.
- E.N. Pergantis, Priyadarshan, N. Al Theeb, P. Dillhon, J.P. Ore, D. Ziviani, E.A. Groll and K.J. Kircher. "Field demonstration of predictive heating control for an all-electric house in a cold climate." *Applied Energy* 360 (2024).
- 12. A.O. Aderibole, K.J. Kircher, E.K. Saathoff, S.B. Leeb and L.K. Norford. "Adaptive power line communication for low-data-rate control and sensing." *IEEE Transactions on Power Delivery* 38 (2023): 2213–2223.
- A.O. Aderibole, E.K. Saathoff, K.J. Kircher, A.W. Langham, L.K. Norford and S.B. Leeb. "Characterizing low-data-rate power line communication channels." *IEEE Transactions on Instrumentation and Measurement* 72 (2022): 1–12.
- Z. Zhang, K.J. Kircher, Y. Cai, J.G. Brearly, D. Birge and L.K. Norford. "Mitigating peak load and heat stress under heat waves by optimizing thermostat setpoint and fan speed schedules." *Journal of Building Performance Simulation* 16.4 (2022): 493–506.

- A.O. Aderibole, K.J. Kircher, S.B. Leeb and L.K. Norford. "Distributed load control using reliable lowbandwidth power line communication." *IEEE Access* 10 (2022): 50242–50253.
- 8. K.J. Kircher, A.O. Aderibole, L.K. Norford and S.B. Leeb. "Distributed peak shaving for small aggregations of cyclic loads." *IEEE Transactions on Power Delivery* 37 (2022): 4315–4325.
- A.O. Aderibole, E.K. Saathoff, K.J. Kircher, S.B. Leeb and L.K. Norford. "Power line communication for low-bandwidth control and sensing." *IEEE Transactions on Power Delivery* 37 (2021): 2172–2181.
- 6. **K.J. Kircher** and K.M. Zhang. "Heat purchase agreements could lower barriers to heat pump adoption." *Applied Energy* 286 (2021): 116489.
- 5. K.J. Kircher, W. Schaefer and K.M. Zhang. "A computationally efficient, high-fidelity testbed for building climate control." ASME Journal of Engineering for Sustainable Buildings and Cities 2 (2020): 1–22.
- 4. Z. Lee, K. Gupta, **K.J. Kircher** and K.M. Zhang. "Mixed-integer model predictive control of variable-speed heat pumps." *Energy and Buildings* 198 (2019): 75–83.
- 3. K.J. Kircher and K.M. Zhang. "On the lumped capacitance approximation accuracy in RC network building models." *Energy and Buildings* 104 (2015): 454–462.
- S.N. Palacio, K.J. Kircher and K.M. Zhang. "On the feasibility of providing power system spinning reserves from thermal storage." *Energy and Buildings* 104 (2015): 131–138.
- K.J. Kircher, X. Shi, S. Patil and K.M. Zhang. "Cleanroom energy efficiency strategies: Modeling and simulation." *Energy and Buildings* 42 (2010): 282–289.

#### Peer-reviewed conference proceedings

- 11. D. Mah, A. Tzempelikos and K.J. Kircher. "Real-time detection of internal and solar gains toward demanddriven building control using deep learning." ASHRAE Winter Conference, 2024.
- E.N. Pergantis, L.D. Reyes Premer, Priyadarshan, A.H. Lee, P. Dillhon, D. Ziviani, E.A. Groll and K.J. Kircher. "Latent and sensible model predictive controller demonstration in a house during cooling operation." ASHRAE Winter Conference, 2024.
- Priyadarshan, E.N. Pergantis, C. Crozier, K. Baker and K.J. Kircher. "EDGIE: A simulation test-bed for investigating the impacts of building and vehicle electrification on distribution grids." *Hawai'i International Conference on System Sciences (HICSS)*, 2024.
- E.N. Pergantis, A.S. Sangamnerkar, Priyadarshan, J.P. Ore, P. Dillhon, D. Ziviani, E.A. Groll and K.J. Kircher. "Sensors, storage and algorithms for practical optimal controls in residential buildings." ASHRAE Annual Conference, 2023.
- K.J. Kircher, Y. Cai, L.K. Norford and S.B. Leeb. "Controlling big, diverse, nonlinear load aggregations for grid services by adjusting device setpoints." *IEEE Conference on Decision and Control* (CDC), 2021.
- 6. Y. Cai, J. Burek, S. Das, J.R. Gregory, L.K. Norford, J. Wang and K.J. Kircher. "Reducing greenhouse gas emissions by optimizing room temperature set-points." *International Conference on Machine Learning* (ICML): Workshop on Tackling Climate Change with Machine Learning, 2021.
- 5. K.J. Kircher and K.M. Zhang. "Sample-average model predictive control of uncertain linear systems." *IEEE Conference on Decision and Control* (CDC), 2016.
- 4. K.J. Kircher and K.M. Zhang. "Testing building controls with the BLDG toolbox." American Control Conference (ACC), 2016. Invited paper.
- 3. K.J. Kircher and K.M. Zhang. "Model predictive control of thermal storage for demand response." *American* Control Conference (ACC), 2015. Invited paper.
- 2. K.J. Kircher, G. Ghatikar, S. Greenberg, D. Watson, R. Diamond, D. Sartor, C. Federspeil, A. McEachern and T. Owen. "Toward the holy grail of perfect information: Lessons learned from implementing an energy information system in a commercial building." *ACEEE Summer Study on Energy Efficiency in Buildings*, 2010.

 P.A. Mathew, R. Clear, K.J. Kircher, T. Webster, K.H. Lee and T. Hoyt. "Advanced benchmarking for complex building types: Laboratories as an exemplar." ACEEE Summer Study on Energy Efficiency in Buildings, 2010.

#### PhD thesis

K.J. Kircher. "Heat pump aggregation, optimization and control." Cornell University (2019).

This thesis develops an economic model that could accelerate adoption of efficient electric heat pumps for low-carbon heating and cooling. It also develops optimization and control methods that let heat pumps provide reliability services to the power grid, unlocking new revenues and facilitating renewable integration.

#### Course notes

- 5. K.J. Kircher and E.Y. Bitar. "Robust and stochastic optimization," based on Cornell ECE 6990.
- 4. K.J. Kircher and A.S. Lewis. "Convex analysis," based on Cornell ORIE 6328.
- 3. K.J. Kircher and D.P. Williamson. "Linear programming," based on Cornell ORIE 6300.
- 2. K.J. Kircher and S.G. Henderson. "Monte Carlo simulation," based on Cornell ORIE 6580.
- 1. K.J. Kircher and M.L. Psiaki. "Model-based estimation," based on Cornell MAE 6760.

### Patents

- K.J. Kircher, N. Al Theeb, A.A.M Bani Issa and E.N. Pergantis. "Comfort control system and method." US Patent App. 63/627, 421 (2024).
- S.B. Leeb, L.K. Norford, E.K. Saathoff, A.O. Aderibole and K.J. Kircher. "Power line communication for low-bandwidth control and sensing." US Patent 11,888,548 (2024).

# Funding

Total KJK share at Purdue: 3.5 student-years. Lifetime KJK share: 5.5 student-years.

- 8. "Optimization of low-cost predictive controls in residential buildings and the DC House." Co-authored with Eckhard Groll (PI) and Davide Ziviani. Center for High Performance Buildings (1/2024–1/2025).
- "Comparisons of occupant satisfaction and energy efficiency of comfort delivery approaches and heating equipment using the Human-Building Interactions Laboratory." Co-authored with Panagiota Karava (PI), James Braun, Travis Horton, and Davide Ziviani. Center for High Performance Buildings (1/2024–1/2025).
- "Technoeconomic decision-making framework for thermal and electric energy storage in net zero energy systems." Co-authored with Rebecca Ciez (PI), Eckhard Groll, and Davide Ziviani. Center for High Performance Buildings (1/2024–1/2025).
- 5. "Unlocking the potential of Ray W. Herrick Laboratories as a testbed for advanced whole-building HVAC control." (PI) Co-authored with Thanos Tzempelikos, Jie Ma, and James Braun. Center for High Performance Buildings. KJK share: **One-half student-year** (1/2024–6/2024).
- 4. "Improving air-source heat pump thermal comfort by modifying equipment and controls" (PI). Co-authored with Davide Ziviani. Carrier Global Corporation. KJK share: **One student-year** (1/2023–1/2024).
- 3. "Characterizing and mitigating the impacts of home and vehicle electrification on distribution grids" (PI). Co-authored with James Braun. Center for High Performance Buildings. KJK share: **Two student-years** (1/2023–1/2025).
- "Smart heat: Aggregating renewable-electric-heating-thermal-storage systems for grid services." Co-authored with K. Max Zhang (PI) and Justin Dobbs. NSF Energy, Power, Controls and Networks grant 1711546. (8/2017-8/2020).
- 1. Hydro Research Foundation fellowship. KJK share: Two student-years (6/2014-6/2016).

# Teaching

Sp24	Distributed Energy Resources course creator & instructor, Purdue University
F22, Sp23, F23	Thermodynamics I instructor, Purdue University
Sp14-Sp15	Teaching assistant trainer, Cornell University College of Engineering Trained hundreds of graduate student teaching assistants from 14 departments.
F13	Multivariable Calculus teaching assistant, Cornell University
Sp13	Dynamics teaching assistant, Cornell University
Sp07, Sp08	Physics in Everyday Life teaching assistant, University of Wisconsin–Milwaukee
F05-Sp07	Mathematics tutor, University of Wisconsin–Milwaukee

# Invited talks

- 27. Purdue University Institute for a Sustainable Future, West Lafayette, IN. *Decarbonizing Purdue*. February, 2024.
- 26. Hawai'i International Conference on System Sciences, Honolulu, HI. EDGIE: A Matlab toolbox for emulating the distribution grid impacts of electrification. January, 2024.
- 25. INFORMS Annual Meeting, Phoenix, AZ. Equity benefits of strategic home electrification. October, 2023.
- 24. Purdue University Herrick Energy Seminar, West Lafayette, IN. Thermal comfort and air-source heat pump controls. September, 2023.
- 23. Purdue University Institute for Control, Optimization, and Networks, West Lafayette, IN. Learning, optimization, and control for distributed energy resources. August, 2023.
- 22. Duke Energy and Itron, West Lafayette, IN. Data and decisions for distributed energy resources. August, 2023.
- 21. Princeton University ZERO Lab, Princeton, NJ. Demand peaks from electrification. November, 2022.
- 20. Purdue University School of Electrical and Computer Engineering, West Lafayette, IN. Reducing electricity demand peaks from populations of on/off loads. November, 2022.
- 19. Herrick Laboratories Industrial Advisory Committee, West Lafayette, IN. Toward smart electrification. October, 2022.
- 18. U.S. Department of Energy Loan Programs Office, Washington, D.C. Third-party ownership models for financing and aggregating electric heat pumps. March, 2022.
- 17. Carnegie Mellon University Department of Electrical and Computer Engineering, Pittsburgh, PA. Smart electrification: How control systems in buildings can accelerate decarbonization. March, 2022.
- 16. University of Vermont Department of Electrical and Biomedical Engineering, Burlington, VT. Smart electrification: How control systems in buildings can accelerate decarbonization. March, 2022.
- 15. Purdue University Department of Mechanical Engineering, West Lafayette, IN. Smart electrification: How control systems in buildings can accelerate decarbonization. February, 2022.
- 14. MIT Department of Mechanical Engineering and Schwarzman College of Computing, Cambridge, MA. Planet Earth has a fever... but better building control software can help. January, 2022.
- 13. IEEE Conference on Decision and Control, Austin, TX. A general, scalable grid-service control framework for aggregated electrical devices. December, 2021.
- 12. Tune-In on MIT's Climate Action Plan for the Decade, MIT, Cambridge, MA. *How artificial intelligence can reduce campus carbon emissions*. November, 2021.

- 11. MIT Department of Facilities, Cambridge, MA. Shifting electrical load by perturbing zone air temperature setpoints. February, 2020.
- 10. Schneider Electric, Cambridge, MA. Shifting load by perturbing temperature setpoints. January, 2020.
- 9. Cornell University Department of Mechanical and Aerospace Engineering, Ithaca, NY. Heat purchase agreements could lower barriers to heat pump adoption. July, 2019.
- 8. IEEE Conference on Decision and Control, Las Vegas, NV. Sample-average approximation in stochastic model predictive control. December, 2016.
- 7. HydroVision International, Minneapolis, MN. Operating a Hawai'ian microgrid without fuel. July, 2016.
- 6. American Control Conference, Boston, MA. Testing building controls in MATLAB with the BLDG toolbox. July, 2016.
- 5. Cornell University Economics and Engineering of Electricity Research Group, Ithaca, NY. Flexible demand from the building operator's perspective. October, 2015.
- 4. Cornell University Energy Seminar, Ithaca, NY. How can buildings help the grid? September, 2015.
- 3. HydroVision International, Portland, OR. Pumped hydro controls for a Hawai'ian microgrid. July, 2015.
- 2. American Control Conference, Chicago, IL. Economic MPC of thermal storage for demand response. July, 2015.
- 1. University of Hawaii at Hilo. A little island on the Big Island: UH-Hilo microgrid design. May, 2013.

# Media

February 2024	A market for $24/7$ clean power might look something like this. Heatmap News.
January 2024	Can this city's microgrid plan skirt the traditional utility model? Latitude Media.
November 2023	Heat pumps – The future of home heating and cooling. Her House, Her Home podcast.
July 2023	Europe struggles to heat homes without cooking the planet. Clean Energy Wire.
April 2023	6 things to know about heat pumps, a climate solution in a box. <b>NPR.org</b> .
March 2023	The new incentive for Americans to get heat pumps as a key climate solution. All Things
	Considered.
February 2023	Talking devices could reduce odds of electrical grid breakdowns. The American Society
	of Mechanical Engineers.
November 2022	Orchestrating chatter between appliances could save a surprising amount of energy. An-
	thropocene.
August 2022	Experts: Cash incentives in climate bill could revolutionize U.S. homes, 1 HVAC at a time.
	USA Today.
May 2022	The U.S. is addicted to gas heating. A new bill may make going electric the easy choice.
	HuffPost.
April 2022	How does a heat pump work? Carbon Switch.
April 2021	Unlocking home electrification with heat pumps. The Energy Gang podcast.

# Mentoring

### As a Purdue professor

- 2023– | Aaron Farha, PhD (co-chair with Eckhard Groll), Mechanical Engineering
- 2023– Arash Khabbazi, PhD (chair), Mechanical Engineering
- 2023– Nadah Al Theeb, PhD (chair), Mechanical Engineering
- 2022– Priyadarshan, PhD (chair), Mechanical Engineering
- 2022– Elias Pergantis, PhD (co-chair with Davide Ziviani), Mechanical Engineering
- 2023– Levi Reyes Premer, MS (co-chair with Davide Ziviani), Mechanical Engineering
- 2024– Andrew Beck, BS, Mechanical Engineering
- 2023– Sophia Evers, BS, Nuclear Engineering
- 2023– Jacob Aldridge, BS, Computer Science
- 2023– Justin Chang, BS, Mechanical Engineering
- 2023– Aadit Kumar, BS, Mechanical Engineering
- 2023– Brendan Corban, BS, Mechanical Engineering
- 2023– Alex Lee, BS, Civil Engineering and Computer Science
- 2023– Liam Johnson, BS, Mechanical Engineering
- 2023– Jude Lin, BS, Mechanical Engineering

**Committee memberships:** Tchato Vidal (ME PhD 2024–), Ranadip Saha (ME PhD 2023–), Feng Wu (ArchE PhD 2023–), Dongjun Mah (CE PhD 2023–), Aditya Nur (ME PhD 2022–), Ara Bolanger (ME MS 2022–), Ting-Chun Kuo (ArchE PhD 2022–)

### As an MIT postdoc

2021 - 2022	Morgan Santoni-Colvin, SM, Technology and Policy Program
2021-2022	Stella Zhujing Zhang, SM, Building Technology Next position: Civil engineering PhD student at EPFL
2021-2022	Julia Wang, SB/SM, Computer Science Next position: Machine learning engineer at Meta
2019-2022	Yuan Cai, SM, Computer Science and Building Technology Next position: Associate consultant at Bain & Company
2019-2022	Adedayo Aderibole, PhD, Electrical Engineering and Computer Science Next position: Systems engineer at Google

### As a Cornell PhD student

2017-2018	Kartikay Gupta, MS, Mechanical Engineering Next position: Flight dynamics engineer at SES Satellites
2016	Kevin Leong-Tiwanak, MEng, Systems Engineering Next position: Design engineer at SepiSolar
2015-2016	Sean Hidaka, MEng, Mechanical Engineering Next position: Mechanical engineer at Elara Engineering
2015	Walter Schaefer, MEng, Mechanical Engineering Next position: Project engineer at Energy and Resource Solutions
2015	Eric Hui Fat Tse, BS, Mechanical Engineering and Economics Next position: Business analyst at Indus Valley Partners
2015	Stefan Rauscher, BS, RWTH Aachen Mechanical Engineering Next position: Project engineer at TLK Energy
2014-2015	Julius Scheuber, BS, RWTH Aachen Mechanical Engineering Next position: Co-founder of ENLYZE
2014-2015	Siddharth Deshpande, MEng, Mechanical Engineering Next position: Energy analyst at EnerNOC

# Academic service

### Workshop organizing:

Julv 2024	Intelligent Building	g Operations Workshor	o co-chair. West	Lafavette. IN
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September 2023 Intelligent Building Operations Workshop co-chair, Boulder, CO

Seminar organizing: Herrick Energy Seminar creator and coordinator, Purdue University, 2023–24.

Society memberships: IEEE (Power & Energy Society and Control Systems Society), ASHRAE.

**Reviewing:** Applied Energy, IEEE Transactions on Power Systems, IEEE Transactions on Smart Grid, IEEE Transactions on Power Delivery, Electric Power Systems Research, Energy and Buildings, Journal of Building Performance Simulation, Journal of Cleaner Production, Control Engineering Practice, Science and Technology for the Built Environment, Earth's Future, IEEE Conference on Decision and Control, American Control Conference, Hawai'i International Conference on System Sciences.

### Select employment and volunteering

2009-2010	Building Technologies research associate, Lawrence Berkeley National Laboratory
	Deployed sensors throughout a 90,000 $ft^2$ office building to collect granular energy data.
2009	Volunteer, Amanecer solar oven project, Totogalpa, Nicaragua Designed and built solar ovens for smoke-free cooking with a rural women's cooperative.
2008	Volunteer, AguaClara water supply project, Cuatro Comunidades, Honduras Designed and built off-grid water filtration plants in remote villages.