

Changhong Zhao

Assistant Professor
Department of Information Engineering
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PhD: Electrical Engineering, Caltech, 2016
BE: Automation, Tsinghua University, 2010

Appointments

- Assistant Professor, 8/2019 – present
Department of Information Engineering, CUHK
- Research Engineer, 8/2016 – 7/2019
National Renewable Energy Laboratory, US

Selected awards

- Prize Paper Award (coauthor), IEEE Power & Energy Society, 2021
- Early Career Award, Research Grants Council of Hong Kong, 2020
- PhD thesis: Demetriades Prize, 2016; Wilts Prize, 2017, Caltech

Teaching and mentoring

- Second runner-up, *IE Department Best Teaching Award*, 2023
 - IERG2051 Signals and systems (four times), 2019 –
 - IERG3280 Networks: technology, economics & social interactions (three times), 2022 –
 - Graduate topics: control and optimization in networked systems (three times), 2020 –
- Current students:
 - PhD: Bohang Fang (2021), Heng Liang (2021), Yujin Huang (2023)
 - MPhil: Runjie Zhang (2023)

Service

- External:
 - Poster and demo co-chair, ACM e-Energy, 2022
- Internal:
 - Deputy Director, IDA Double Major Program, CUHK & CUHK(SZ), 8/2023 – 7/2025
 - Chair, IE Department Curriculum Committee, CUHK, 8/2021 – present

Projects

- RGC General Research Fund 14212822, “Optimizing fast frequency response of distributed energy resources under distribution network constraints,” 1/2023 – 12/2025, USD 95,586.
- RGC Early Career Scheme 24210220, “Optimizing multiphase power flow via exact convex relaxation and distributed feedback design,” 1/2021 – 12/2023, USD 100,190.

Book

- F. Liu, Z. Wang, C. Zhao, and P. Yang, *Merging Optimization and Control in Power Systems: Physical and Cyber Restrictions in Distributed Frequency Control and Beyond*. John Wiley & Sons, 2022.

Book chapters

- C. Zhao, V. Gupta, and U. Topcu, “Distributed load management,” *Advanced Data Analytics for Power Systems*, pp. 431–454. Cambridge University Press, 2021.
- Y. Li, C. Zhao, H. Jiang, Y. Zhang, and E. Muljadi, “Introduction,” *New Technologies for Power System Operation and Analysis*, pp. 1–21. Academic Press, 2020.

Journal papers

1. W. Huang (postdoc) and C. Zhao, “Improved successive branch reduction for stochastic distribution network reconfiguration in the presence of renewables,” *CSEE Journal of Power and Energy Systems*, accepted.
2. W. Huang (postdoc) and C. Zhao, “Deep-learning-aided voltage-stability-enhancing stochastic distribution network reconfiguration,” *IEEE Transactions on Power Systems*, 39(2):2827–2836, 2024.
3. W. Lin (postdoc), Y. Chen, Q. Li, and C. Zhao, “An AC-feasible linear model in distribution networks with energy storage,” *IEEE Transactions on Power Systems*, 39(1):1224–1239, 2024.
4. W. Lin (postdoc), C. Zhao, M. Gao, and C. Y. Chung, “Data-driven static equivalence with physics-informed Koopman operators,” *CSEE Journal of Power and Energy Systems*, 10(1):432–438, 2024.
5. [Letter] Z. Yuan (intern), C. Zhao, and J. Cortés, “Reinforcement learning for distributed transient frequency control with stability and safety guarantees,” *Systems & Control Letters*, 185:105753, 2024.
6. [Letter] Z. Sun (intern), Z. Yuan, C. Zhao, and J. Cortés, “Learning decentralized frequency controllers for energy storage systems,” *IEEE Control Systems Letters*, 7:3459–3464, 2023.
7. W. Lin (postdoc) and C. Zhao, “Improved characterization for AC-feasible power transfer regions of virtual power plants,” *International Journal of Electrical Power & Energy Systems*, 152:109260, 2023.

8. W. Lin (postdoc) and C. Zhao, “Cost functions over feasible power transfer regions of virtual power plants,” *IEEE Systems Journal*, 17(2):2950–2960, 2023.
9. [Chinese] S. Fang (postdoc), C. Zhao, Z. Ding, S. Zhang, and R. Liao, “Port integrated energy systems toward carbon neutrality I: typical topology and key problems,” *Proceedings of the CSEE*, 43(1):114–134, 2023.
10. [Chinese] S. Fang (postdoc), C. Zhao, Z. Ding, S. Zhang, and R. Liao, “Port integrated energy systems toward carbon neutrality II: flexible resources and key technologies in energy-transportation integration,” *Proceedings of the CSEE*, 43(3):950–968, 2023.
11. S. Fang (postdoc), C. Wang (intern), R. Liao, and C. Zhao, “Optimal power scheduling of seaport microgrids with flexible logistic loads,” *IET Renewable Power Generation*, 16(12):2711–2720, 2022.
12. S. Fang (postdoc), C. Wang (intern), Y. Lin, and C. Zhao, “Optimal energy scheduling and sensitivity analysis for integrated power–water–heat systems,” *IEEE Systems Journal*, 16(4):5176–5187, 2022.
13. T. Wu (coadvised), C. Zhao, and Y. J. A. Zhang, “Privacy-preserving distributed optimal power flow with partially homomorphic encryption,” *IEEE Transactions on Smart Grid*, 12(5):4506–4521, 2021.
14. T. Wu (coadvised), C. Zhao, and Y. J. A. Zhang, “Distributed AC-DC optimal power dispatch of VSC-based energy routers in smart microgrids,” *IEEE Transactions on Power Systems*, 36(5):4457–4470, 2021.
15. C. Zhao, E. Mallada, S. H. Low, and J. Bialek, “Distributed plug-and-play optimal generator and load control for power system frequency regulation,” *International Journal of Electrical Power & Energy Systems*, 101:1–12, 2018.
16. C. Zhao, U. Topcu, N. Li, and S. H. Low, “Design and stability of load-side primary frequency control in power systems,” *IEEE Transactions on Automatic Control*, 59(5):1177–1189, 2014.
17. C. Zhao, U. Topcu, and S. H. Low, “Optimal load control via frequency measurement and neighborhood area communication,” *IEEE Transactions on Power Systems*, 28(4):3576–3587, 2013.
18. Y. Chen and C. Zhao, “Improved approximation of dispatchable region in radial distribution networks via dual SOCP,” *IEEE Transactions on Power Systems*, 38(6):5585–5597, 2023.
19. Y. Chen, C. Zhao, S. H. Low, and A. Wierman, “An energy sharing mechanism considering network constraints and market power limitation,” *IEEE Transactions on Smart Grid*, 14(2):1027–1041, 2023.
20. Y. Guo, X. Zhou, C. Zhao, L. Chen, G. Hug, and T. Summers, “An online joint optimization-estimation architecture for distribution networks,” *IEEE Transactions on Control Systems Technology*, 31(6):2303–2318, 2023.
21. Y. Guo, X. Zhou, C. Zhao, L. Chen, and T. Summers, “Optimal power flow with state estimation in the loop for distribution networks,” *IEEE Systems Journal*, 17(3):3694–3705, 2023.

22. Q. Wang, H. Chen, C. Zhao, Y. Li, P. Popovski, and B. Vucetic, "Optimizing information freshness via multiuser scheduling with adaptive NOMA/OMA," *IEEE Transactions on Wireless Communications*, 21(3):1766–1778, 2022.
23. Y. Chen and C. Zhao, "Review of energy sharing: business models, mechanisms, and prospects," *IET Renewable Power Generation*, 16(12):2468–2480, 2022.
24. X. Chen, C. Zhao, and N. Li, "Distributed automatic load frequency control with optimality in power systems," *IEEE Transactions on Control of Network Systems*, 8(1):307–318, 2021.
25. Y. Chen, C. Zhao, S. H. Low, and S. Mei, "Approaching prosumer social optimum via energy sharing with proof of convergence," *IEEE Transactions on Smart Grid*, 12(3):2484–2495, 2021.
26. Y. Chen, T. Li, C. Zhao, and W. Wei, "Decentralized provision of renewable predictions within a virtual power plant," *IEEE Transactions on Power Systems*, 36(3):2652–2662, 2021.
27. [Brief] Z. Wang, W. Wei, C. Zhao, Z. Ma, Z. Zheng, Y. Zhang, and F. Liu, "Exponential stability of partial primal–dual gradient dynamics with nonsmooth objective functions," *Automatica*, 129:109585, 2021.
28. [Letter] X. Zhou, C.-Y. Chang, A. Bernstein, C. Zhao, and L. Chen, "Economic dispatch with distributed energy resources: co-optimization of transmission and distribution systems," *IEEE Control Systems Letters*, 5(6):1994–1999, 2021.
29. X. Zhou, Z. Liu, Y. Guo, C. Zhao, J. Huang, and L. Chen, "Gradient-based multi-area distribution system state estimation," *IEEE Transactions on Smart Grid*, 11(6):5325–5338, 2020.
30. X. Zhou, Z. Liu, C. Zhao, and L. Chen, "Accelerated voltage regulation in multi-phase distribution networks based on hierarchical distributed algorithm," *IEEE Transactions on Power Systems*, 35(3):2047–2058, 2020.
31. X. Chen, E. Dall’Anese, C. Zhao, and N. Li, "Aggregate power flexibility in unbalanced distribution systems," *IEEE Transactions on Smart Grid*, 11(1):258–269, 2020.
32. [Letter] Z. Wang, F. Liu, C. Zhao, Z. Ma, and W. Wei, "Distributed optimal load frequency control considering nonsmooth cost functions," *Systems & Control Letters*, 136:104607, 2020.
33. E. Weitenberg, Y. Jiang, C. Zhao, E. Mallada, C. De Persis, and F. Dörfler, "Robust decentralized secondary frequency control in power systems: merits and tradeoffs," *IEEE Transactions on Automatic Control*, 64(10):3967–3982, 2019.
34. A. S. Zamzam, E. Dall’Anese, C. Zhao, J. A. Taylor, and N. D. Sidiropoulos, "Optimal water–power flow-problem: formulation and distributed optimal solution," *IEEE Transactions on Control of Network Systems*, 6(1):37–47, 2019.
35. Z. Wang, F. Liu, S. H. Low, C. Zhao, and S. Mei, "Distributed frequency control with operational constraints, part I: per-node power balance," *IEEE Transactions on Smart Grid*, 10(1):40–52, 2019.

36. Z. Wang, F. Liu, S. H. Low, C. Zhao, and S. Mei, “Distributed frequency control with operational constraints, part II: network power balance,” *IEEE Transactions on Smart Grid*, 10(1):53–64, 2019.
37. H. Jiang, Y. Zhang, Y. Chen, C. Zhao, and J. Tan, “Power-traffic coordinated operation for bi-peak shaving and bi-ramp smoothing—a hierarchical data-driven approach,” *Applied Energy*, 229:756–766, 2018.
38. J. Wang, C. Zhao, A. Pratt, and M. Baggu, “Design of an advanced energy management system for microgrid control using a state machine,” *Applied Energy*, 228:2407–2421, 2018.
39. A. Bernstein, C. Wang, E. Dall’Anese, J.-Y. Le Boudec, and C. Zhao, “Load flow in multiphase distribution networks: existence, uniqueness, non-singularity and linear models,” *IEEE Transactions on Power Systems*, 33(6):5832–5843, 2018.
40. S. S. Guggilam, C. Zhao, E. Dall’Anese, Y. C. Chen, and S. V. Dhople, “Optimizing DER participation in inertial and primary-frequency response,” *IEEE Transactions on Power Systems*, 33(5):5194–5205, 2018. **Best Paper** and **PES Prize Paper Award**.
41. S. S. Guggilam, C. Zhao, E. Dall’Anese, Y. C. Chen, and S. V. Dhople, “Optimizing power–frequency droop characteristics of distributed energy resources,” *IEEE Transactions on Power Systems*, 33(3):3076–3086, 2018.
42. K. Baker, A. Bernstein, E. Dall’Anese, and C. Zhao, “Network-cognizant voltage droop control for distribution grids,” *IEEE Transactions on Power Systems*, 33(2):2098–2108, 2018.
43. Y. J. A. Zhang, C. Zhao, W. Tang, and S. H. Low, “Profit-maximizing planning and control of battery energy storage systems for primary frequency control,” *IEEE Transactions on Smart Grid*, 9(2):712–723, 2018.
44. E. Mallada, C. Zhao, and S. H. Low, “Optimal load-side control for frequency regulation in smart grids,” *IEEE Transactions on Automatic Control*, 62(12):6294–6309, 2017.
45. N. Li, C. Zhao, and L. Chen, “Connecting automatic generation control and economic dispatch from an optimization view,” *IEEE Transactions on Control of Network Systems*, 3(3):254–264, 2016.
46. K. Nakayama, C. Zhao, L. F. Bic, M. B. Dillencourt, and J. Brouwer, “Distributed power flow loss minimization control for future grid,” *International Journal of Circuit Theory and Applications*, 43(9):1209–1225, 2015.

Conference papers

1. B. Fang (PhD), C. Zhao, and S. H. Low, “Convergence of backward/forward sweep for power flow solution in radial networks,” tutorial paper, IEEE Conference on Decision and Control (CDC), 2023, Singapore, pp. 4034–4039.
2. W. Lin (postdoc), C. Y. Chung, and C. Zhao, “Relaxing complementarity constraints of energy storage with feasibility and optimality guarantees,” IEEE PES General Meeting, 2023, Orlando, pp. 1–5.

3. J. Su (intern), C. Zhao, and D. Wang, “Differentially private stochastic convex optimization in (non-)Euclidean space revisited,” Conference on Uncertainty in Artificial Intelligence, 2023, Pittsburgh, pp. 2026–2035.
4. H. Liang (PhD), X. Zhou, and C. Zhao, “Hierarchical optimal power flow with improved gradient evaluation,” American Control Conference (ACC), 2022, Atlanta, pp. 4547–4552.
5. C. Zhao, E. Dall’Anese, and S. H. Low, “Convex relaxation of OPF in multiphase radial networks with delta connection,” IREP 2017, Espinho, pp. 1–7.
6. C. Zhao, E. Mallada, S. H. Low, and J. Bialek, “A unified framework for frequency control and congestion management,” Power Systems Computation Conference, 2016, Genoa, pp. 1–7.
7. C. Zhao, E. Mallada, and F. Dörfler, “Distributed frequency control for stability and economic dispatch in power networks,” ACC 2015, Chicago, pp. 2359–2364.
8. C. Zhao, E. Mallada, and S. H. Low, “Distributed generator and load-side secondary frequency control in power networks,” Conference on Information Sciences and Systems, 2015, JHU, pp. 1–6.
9. C. Zhao, M. Chertkov, and S. Backhaus, “Optimal sizing of voltage control devices for distribution circuit with intermittent load,” Hawaii International Conference on System Sciences, 2015, Kauai, pp. 2680–2689.
10. C. Zhao and S. H. Low, “Optimal decentralized primary frequency control in power networks,” CDC 2014, Los Angeles, pp. 2467–2473.
11. C. Zhao, U. Topcu, and S. H. Low, “Swing dynamics as primal-dual algorithm for optimal load control,” IEEE SmartGridComm, 2012, Tainan, pp. 570–575.
12. C. Zhao, U. Topcu, and S. H. Low, “Fast load control with stochastic frequency measurement,” IEEE PES General Meeting, 2012, San Diego, pp. 1–8.
13. C. Zhao, U. Topcu, and S. H. Low, “Frequency-based load control in power systems,” ACC 2012, Montreal, pp. 4423–4430.
14. X. Zhou, Y. Chen, Z. Liu, C. Zhao, and L. Chen, “Multi-level optimal power flow solver in large distribution networks,” IEEE SmartGridComm, 2020, online, pp. 1–6.
15. Y. Guo, X. Zhou, C. Zhao, Y. Chen, T. Summers, and L. Chen, “Solving optimal power flow for distribution networks with state estimation feedback,” ACC 2020, Denver, pp. 3148–3155.
16. P. Munankarmi, X. Jin, F. Ding, and C. Zhao, “Quantification of load flexibility in residential buildings using home energy management systems,” ACC 2020, Denver, pp. 1311–1316.
17. W. Liu, F. Ding, and C. Zhao, “Dynamic restoration strategy for distribution system resilience enhancement,” IEEE ISGT 2020, Washington DC, pp. 1–5.
18. K. Utkarsh, F. Ding, C. Zhao, H. Padullaparti, and X. Jin, “A model-predictive hierarchical-control framework for aggregating residential DERs to provide grid regulation services,” IEEE ISGT 2020, Washington DC, pp. 1–5.

19. X. Zhou, Z. Liu, W. Wang, C. Zhao, F. Ding, and L. Chen, "Hierarchical distributed voltage regulation in networked autonomous grids," ACC 2019, Philadelphia, pp. 5563–5569.
20. X. Chen, C. Zhao, and N. Li, "Distributed automatic load frequency control with optimality in power systems," IEEE Conference on Control Technology and Applications, 2018, Copenhagen, pp. 24–31. **Best Student Paper Finalist.**
21. E. Weitenberg, Y. Jiang, C. Zhao, E. Mallada, F. Dörfler, and C. De Persis, "Robust decentralized frequency control: a leaky integrator approach," ECC 2018, Limassol, pp. 764–769.
22. L. Guo, C. Zhao, and S. H. Low, "Graph Laplacian spectrum and primary frequency regulation," CDC 2018, Miami, pp. 158–165.
23. L. Guo, C. Zhao, and S. H. Low, "Cyber network design for secondary frequency regulation: a spectral approach," Power Systems Computation Conference, 2018, Dublin, pp. 1–7.
24. S. S. Guggilam, C. Zhao, E. Dall'Anese, Y. C. Chen, and S. V. Dhople, "Engineering inertial and primary-frequency response for distributed energy resources," CDC 2017, Melbourne, pp. 5112–5118.
25. S. S. Guggilam, C. Zhao, E. Dall'Anese, Y. C. Chen, and S. V. Dhople, "Primary frequency response with aggregated DERs," ACC 2017, Seattle, pp. 3386–3393.
26. A. S. Zamzam, C. Zhao, E. Dall'Anese, and N. D. Sidiropoulos, "A QCQP approach for OPF in multiphase radial networks with wye and delta connections," IREP 2017, Espinho, pp. 1–8.
27. K. Baker, A. Bernstein, C. Zhao, and E. Dall'Anese, "Network-cognizant design of decentralized volt/var controllers," IEEE ISGT 2017, Washington DC, pp. 1–5.
28. Z. Wang, F. Liu, S. H. Low, C. Zhao, and S. Mei, "Decentralized optimal frequency control of interconnected power systems with transient constraints," CDC 2016, Las Vegas, pp. 664–671.
29. N. Li, L. Chen, C. Zhao, and S. H. Low, "Connecting automatic generation control and economic dispatch from an optimization view," ACC 2014, Portland, pp. 735–740.
30. E. Mallada, C. Zhao, and S. H. Low, "Optimal load-side control for frequency regulation in smart grids," Allerton 2014, Illinois, pp. 731–738.
31. K. Nakayama, C. Zhao, L. F. Bic, M. B. Dillencourt, and J. Brouwer, "Distributed real-time power flow control with renewable integration," IEEE SmartGridComm, 2013, Vancouver, pp. 516–521.