

# Mads Almassalkhi

## Curriculum Vitae

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[Website](#) and [LinkedIn](#) and [Google Scholar](#)

## Education

- 2008 - 2013 **Ph.D. in Electrical Engineering: Systems**, *Univ of Michigan*, Ann Arbor, MI.  
**Dissertation title:** Optimization & Model-Predictive Control for Overload Mitigation in Resilient Power Systems  
**Area of study:** Power Systems, Optimization, Predictive control  
**Advisor:** Professor Ian A. Hiskens
- 2008-2010 **M.S. in Electrical Engineering: Systems**, *Univ of Michigan*, Ann Arbor, MI.  
**Major:** Control Theory      **Minor:** Mathematics
- 2003-2008 **B.S. in Electrical Engineering**, *Univ of Cincinnati*, Cincinnati, OH.  
**Dual Degree:** Applied Mathematics  
Graduated Summa Cum Laude.

## Professional Appointments

### Academia

- 2021 - present **Associate Professor**, *Electrical Engineering*, Univ. of Vermont, Burlington, VT.  
◦ **Director of CORE (Control and Optimization of Renewable Energy) Systems Laboratory**  
- **Research themes:** optimization & control for grid resilience and clean energy systems integration
- 2021 - present **Otto Mønsted Visiting Professor**, *Center for Electric Power & Energy*, Technical University of Denmark, Denmark.  
◦ Funded professorship during my sabbatical at DTU Wind and Energy Systems (WES) and Aalborg University (AAU) Department of Electronic Systems.
- 2021 - present **Gund Fellow**, *Gund Institute for the Environment*, Univ. of Vermont, Burlington, VT.
- 2019 - present **Founding Director**, *VECTORS: Vermont's center for sustainable and resilient systems*, Univ of Vermont, Burlington, VT.  
◦ Lead and coordinate faculty efforts across the college to sustain and strengthen funded research and industry opportunities in the area of power and energy systems.
- 2014 - 2021 **Assistant Professor**, *Electrical Engineering*, Univ. of Vermont, Burlington, VT.
- 2009-2013 **Graduate Student Research Assistant**, *MPEL*, Univ. of Michigan, Ann Arbor, MI.  
*Advisor: Professor Ian A. Hiskens*  
◦ Studied optimization-based control for resilient energy systems with applications to transmission networks and energy storage. Supported by DOE (ARRA) and ARPA-E (GENI) funding.  
◦ Developed suitable convex power systems models within a bi-level predictive control scheme to mitigate effects of cascading failures in electric networks with renewables and energy storage.  
◦ Advanced the optimization of multi-energy systems (MES) within context of energy hubs.
- 2008-2009 **Graduate Student Fellow**, *MADCL*, Univ of Michigan, Ann Arbor, MI.  
*Supervisor: Professor Domitilla Del Vecchio*  
◦ Collaborated with group members on NSF-sponsored project on safety in a semi-autonomous systems by developing probabilistic human behavior models for the design of control algorithms.

### Government

- 2021 - present **Chief Scientist**, *Pacific Northwest National Laboratory (PNNL)*, Richland, WA.  
◦ Joint appointment in the Optimization and Control group within Electricity Infrastructure and Buildings Division in the Energy and Environment Directorate.  
◦ My responsibilities include proposing, leading, and supporting funded R&D&D projects with the U.S. Department of Energy and power/energy industry.

## Industry

- 2016 – 2022 **Co-founder, Packetized Energy**, Burlington, VT.
- Spun out company after ARPA-E NODES award
  - Working with technical and business team to develop technology partnerships with manufacturers to scale capability, deployment, and business models.
  - Representing company at investor and tech events and support fund raising.
  - Leading federal collaboration efforts directly resulting in >\$1M in DOE awards:
    - 2020-2022: Co-PI. ARPA-E PERFORM (sub: \$420,000). Lead: NREL.
    - 2020-2022: Co-PI. EERE/BTO BENEFIT (sub: \$100,000). Lead: Northeastern University.
  - Led technology collaboration with Enphase for working prototype of a packetized AC Battery with PE engineers. Team completed working prototype within one month of first contact.
- 2011 – 2014 **Lead Systems Engineer, Root3 Technologies**, Chicago, IL.
- Developed predictive energy analytics algorithms for SaaS platform for large C&I energy consumers.
  - Develop engineering analysis tools for economic viability studies of cogeneration, PV solar, and thermal storage systems.
  - Led development of energy asset plant models that are amenable to efficient optimization.
  - Worked closely with software team to deploy optimization algorithms and develop UI/UX.
- 2005–2008 **Junior Technical Associate, Etegent Technologies**, Norwood, OH.
- Collaborated with managers on NIH and DOD projects and SBIR proposals resulting in >\$1M in awards.

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## Externally Funded Projects (Total funding as PI > \$10M)

- 2023–2026 **PI, DOE EERE/SETO**, \$4,000,000.
- **Title:** Hybrid Energy System Platform for Cold Weather Climates
  - **Goal:** This project will enable a holistic techno-economic analysis of hybrid energy systems (HESs) in cold weather climates. The project's outcomes will be (1) advanced modeling, control, and optimization tools for HESs across a range of temperatures and timescales suitable for operation and planning; (2) testing of these new tools in a new accelerated testing laboratory (ATL) at UVM for hardware-enabled validation and data analysis and; (3) field validation of the tools at a new Hybrid Solar Test Center (HSTC) in Burlington, Vermont.
  - **Collaborators:** VEIC (techno-economic analysis) and CleanPowerResearch (forecasting)
- 2022–2024 **Co-I (PI: Bindu Panikkar), Sloan Foundation**, \$500,000.
- **Title:** Integrated renewable energy community microgrid transitions in remote rural and Indigenous communities in Alaska
  - **Goal:** Study rural energy communities in Alaska and the role of coordination/control architectures in enabling equitable electrification and renewable energy transition.
  - **Collaborators:** ACEP at Uni. of Alaska - Fairbanks
- 2022–2025 **PI, DOE PNNL**, \$600,000.
- **Title:** Coordinated Distributed Assets to Provide System Flexibility
  - **Goal:** Advance how transmission system operations can indirectly leverage distributed assets for improved grid reliability.
  - **Collaborators:** PNNL (simulations) and VELCO (grid data)
- 2021–2026 **PI, NSF CAREER (EPCN)**, \$500,000.
- **Title:** Enabling grid-aware aggregation and real-time control of distributed energy resources in electric power distribution systems
  - **Goal:** Intellectual: overcomes asymmetry of information and control between grid operator and DER aggregator using convex inner approximations of the distribution OPF to form dynamic hosting capacities and real-time grid-aware control of DERs. Broader: Positions the field of power systems as climate change mitigation technology to builds curriculum around climate change for STEM and non-STEM students using gamification.
  - **Collaborators:** PNNL (learning) and ConEdison (grid data)
- 2020–2023 **Co-PI, NASA EPSCoR**, \$750,000, (UVM Lead; Dr. Hamid Ossareh).
- **Title:** New Unified Framework for Scalable, Risk-Aware, and Resilient Estimation and Control of Satellite Swarms
  - **Goal:** Develop control and optimization algorithms to coordinate a swarm of small satellites.
  - **Partners:** Benchmark Space Systems, Swarm, JPL.

- 2020–2022 **Co-PI (w/ Packetized Energy)**, *DOE/BTO BENEFIT*, \$2,200,000 (PE sub of \$125,000).
- **Title:** Grid-interactive Efficient Building Equipment Performance Dataset.
  - **Goal:** Develop occupant-centric control algorithms that produce grid services from heat pumps.
  - **Partners:** Northeastern University (Lead; Dr. Michael Kane), NREL, ecobee.
- 2020–2022 **Co-PI (w/ Packetized Energy)**, *ARPA-E PERFORM*, \$3,408,526 (PE sub of \$420,000).
- **Title:** An Integrated Paradigm for the Management of Delivery Risk in Electricity Markets: From Batteries to Insurance and Beyond.
  - **Goal:** Technology to mitigate effects of uncertainty in DER aggregations for market participation
  - **Partners:** NREL (Lead; Dr. Elina Spyrou), EPRI, JHU, kWh Analytics.
- 2016-2021 **Lead PI**, *ARPA-E NODES*, \$3,400,000.
- **Title:** Packetized Energy Management: Coordinating Transmission and Distribution.
  - **Goal:** Develop technology to mitigate effects of DER uncertainty in aggregation and market participation
  - **Partners:** FIU, Packetized Energy, Green Mountain Power, VELCO, and NIST
  - **Key project outcomes:**
    - Co-founded and spun out company (*Packetized Energy*) to commercialize technology;
    - Successfully completed field demonstration of technology involving more than 150 VT homes.
    - Developed cyber-physical platform for real-time validation of DER coordination schemes;
    - Established & sustained an Industrial Advisory Board of more than 20 companies
    - Secured two years and \$1.5M in follow-on funding in 2019.
- 2017-2020 **Lead PI**, *DOE EERE ENERGISE*, \$2,500,000.
- **Title:** Robust and resilient coordination of feeders with uncertain distributed energy resources: from real-time control to long-term planning
  - **Goal:** Adapt wide-area control concepts to advanced distribution system operation to enable extreme solar PV penetration by optimizing control of energy-constrained DERs.
  - **Partners:** JHU, PNNL, NIST, ConEdison of NY, Orange & Rockland Utility
  - **Key project outcomes:**
    - Developed multi-timescale Grid+DER techno-economic optimization platform
- 2017-2020 **Co-PI**, *Vermont Electric Company (VELCO)*, \$297,000, (UVM Lead: Paul Hines).
- **Title:** Stochastic Receding Horizon Optimal Power Flow Given High-resolution Weather Forecasts
  - **Goal:** Demonstrate and validate how VT RPS affect transmission system reliability.
  - **Partners:** VELCO
- 2016-2017 **Co-I**, *UVM-GMP Industrial Partnership*, \$161,480, (UVM Lead: Paul Hines).
- **Title:** From Big Data to Actionable Insight: Using Smart Grid Data to Identify Geographic Locations for Targeted Investment
  - **Goal:** Build software and analytics tools to conduct hosting capacity with solar PV and battery storage.
  - **Partners:** Green Mountain Power (GMP)

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## Internally-funded Projects

- 2022–2024 **Co-PI (PI: Bindu Panikkar)**, *UVM's Gund Institute for Environment*, \$200,000.
- **Title:** Integrated renewable energy community microgrid transitions in remote rural and Indigenous communities in Alaska
  - **Goal:** Study rural energy communities in Alaska and the role of coordination/control architectures in enabling equitable electrification and renewable energy transition.
  - **Collaborators:** ACEP (data) and REAP (data)
  - **Follow-on:** Sloan Foundation funded expanded version of this project

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## List of Peer-Reviewed, Archived Publications

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Publications Under Review

- [1] M. Banaei, F. D’Ettorre, R. Ebrahimi, *et al.*, “Procuring Flexibility in Power Systems with Incentive-based Grid Access Requests,” (Under review in *Applied Energy*).

- [2] H. Basu, Y. Pedari, M. R. Almassalkhi, and H. R. Ossareh, “Computationally-Efficient Collision-Free Trajectory Planning of Satellite Swarms under Modeling Uncertainties and Perturbations,” (Under review in *Journal of Guidance, Control, and Dynamics*).
- [3] N. Qi, P. Pinson, M. R. Almassalkhi, *et al.*, “Chance-Constrained Economic Dispatch of Generic Energy Storage under Decision-Dependent Uncertainty,” (Under review in *IEEE Transactions on Sustainable Energy*).

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Published/Accepted Peer-reviewed Journal papers

- [1] S. Brahma, **A. Khurram**, H. Ossareh, and M. Almassalkhi, “Optimal Frequency Regulation using Packetized Energy Management,” *IEEE Transactions on Power Systems*, 2022, (Early Access).
- [2] **A. Khurram**, **M. Amini**, L. Duffaut Espinosa, *et al.*, “Real-time Grid and DER Co-simulation Platform for Validating Large-scale DER Control Schemes,” *IEEE Transactions on Smart Grid*, 2022, (Accepted).
- [3] S. Brahma, **N. Nazir**, H. Ossareh, and M. Almassalkhi, “Optimal and resilient coordination of virtual batteries in distribution feeders,” *IEEE Transactions on Power Systems*, vol. 36, no. 4, pp. 2841–2854, 2021. DOI: 10.1109/TPWRS.2020.3043632.
- [4] **M. Botkin-Levy**, A. Engelmann, T. Mühlfordt, *et al.*, “Distributed control of charging for electric vehicle fleets under dynamic transformer ratings,” *IEEE Transactions on Control Systems Technology*, 2021, (Accepted).
- [5] **N. Nazir** and M. Almassalkhi, “Grid-aware aggregation and realtime disaggregation of distributed energy resources in radial networks,” *IEEE Transactions on Power Systems*, vol. -, pp. -, 2021, (Early Access). DOI: 10.1109/TPWRS.2021.3121215.
- [6] —, “Guaranteeing a physically realizable battery dispatch without charge-discharge complementarity constraints,” *IEEE Transactions on Smart Grid*, pp. 1–5, 2021, (Early Access). DOI: 10.1109/TSG.2021.3109805.
- [7] —, “Voltage positioning using co-optimization of controllable grid assets in radial networks,” *IEEE Transactions on Power Systems*, vol. 36, no. 4, pp. 2761–2770, 2021. DOI: 10.1109/TPWRS.2020.3044206.
- [8] M. Almassalkhi, S. Brahma, **N. Nazir**, *et al.*, “Hierarchical, grid-aware, and economically optimal coordination of distributed energy resources in realistic distribution systems,” *Energies (Special issue: Building-to-Grid Integration through Intelligent Optimization and Control)*, vol. 13, no. 23, p. 6399, 2020, (Invited).
- [9] L. A. Duffaut Espinosa and M. Almassalkhi, “A packetized energy management macromodel with quality of service guarantees for demand-side resources,” *IEEE Transactions on Power Systems*, vol. 35, no. 5, pp. 3660–3670, 2020. DOI: 10.1109/TPWRS.2020.2981436.
- [10] L. A. D. Espinosa, **A. Khurram**, and M. Almassalkhi, “Reference-tracking control policies for packetized coordination of heterogeneous der populations,” *IEEE Transactions on Control Systems Technology*, pp. 1–17, 2020. DOI: 10.1109/TCST.2020.3039492.
- [11] **A. Khurram**, L. Duffaut Espinosa, R. Malhame, and M. Almassalkhi, “Identification of Hot Water End-use Process of Electric Water Heaters from Energy Measurements,” *Electric Power Systems Research*, vol. 189, p. 106625, 2020, (Note: paper was also presented at the 2020 Power Systems Computation Conference (PSCC) - 30% acceptance rate).
- [12] **M. Amini** and M. Almassalkhi, “Optimal corrective dispatch of uncertain virtual energy storage systems,” *IEEE Transactions on Smart Grid*, vol. 11, no. 5, pp. 4155–4166, 2020.
- [13] **N. Nazir** and M. Almassalkhi, “Stochastic multi-period optimal dispatch of energy storage in unbalanced distribution feeders,” *Electric Power Systems Research*, vol. 189, p. 106783, 2020, (Note: paper was also presented at the 2020 Power Systems Computation Conference (PSCC) - 30% acceptance rate).
- [14] **N. Nazir**, P. Racherla, and M. Almassalkhi, “Optimal multi-period dispatch of distributed energy resources in unbalanced distribution feeders,” *IEEE Transactions on Power Systems*, vol. 35, no. 4, pp. 2683–2692, 2020.
- [15] **Z. Hurwitz**, Y. Dubief, and M. Almassalkhi, “Economic efficiency and carbon emissions in multi-energy systems with flexible buildings,” *International Journal of Electrical Power and Energy Systems*, vol. 123, pp. 106–114, 2020.
- [16] S. R. Shukla, S. Paudyal, and M. R. Almassalkhi, “Efficient distribution system optimal power flow with discrete control of load tap changers,” *IEEE Transactions on Power Systems*, vol. 34, no. 4, pp. 2970–2979, 2019.
- [17] M. Almassalkhi and I. Hiskens, “Model-Predictive Cascade Mitigation in Electric Power Systems with Storage and Renewables Part I: Theory and implementation,” *IEEE Transactions on Power Systems*, vol. 30, no. 1, Jan. 2015.

- [18] —, “Model-Predictive Cascade Mitigation in Electric Power Systems with Storage and Renewables Part II: Case study,” *IEEE Transactions on Power Systems*, vol. 30, no. 1, Jan. 2015.

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Published/Accepted Peer-reviewed Conference papers

- [1] S. Brahma, H. Ossareh, and M. R. Almassalkhi, “Statistical Modeling and Forecasting of Automatic Generation Control Signals,” in *IREP Symposium - Bulk Power System Dynamics and Control*, Jul. 2022.
- [2] S. Chevalier and M. R. Almassalkhi, “Towards Optimal Kron-based Reduction Of Networks (Opti-KRON) for the Electric Power Grid,” in *IEEE Conference on Decision and Control*, (Accepted), Dec. 2022.
- [3] A. Khan, S. Paudyal, and M. Almassalkhi, “Performance Evaluation of Network-Admissible Demand Dispatch in Multi-Phase Distribution Grids,” in *IREP Symposium - Bulk Power System Dynamics and Control*, Jul. 2022.
- [4] O. Oyefeso, G. Ledva, I. Hiskens, *et al.*, “Control of Aggregate Air-Conditioning Load using Packetized Energy Concepts,” in *IEEE Conference on Control Technology and Applications (CCTA)*, Aug. 2022.
- [5] **A. Khurram**, M. Almassalkhi, and L. Duffaut Espinosa, “A Group-based Approach for Heterogeneity in Packetized Energy Management,” in *IEEE Conference on Control Technology and Applications (CCTA)*, Aug. 2022.
- [6] **H. Basu**, M. Almassalkhi, and H. Ossareh, “Fuel-Optimal Trajectory Planning of Satellites Using Minimum Distance Assignment and Comparative Analysis of Relative Dynamics under J2 and Air Drag,” in *American Control Conference*, Jun. 2022.
- [7] **N. Nazir** and M. Almassalkhi, “Market mechanism to enable grid-aware dispatch of Aggregators in radial distribution networks,” in *IREP Symposium - Bulk Power System Dynamics and Control*, Jul. 2022.
- [8] **N. Nazir**, I. A. Hiskens, and M. R. Almassalkhi, “Exploring reactive power limits on wind farm collector networks with convex inner approximations,” in *IREP Symposium - Bulk Power System Dynamics and Control*, Jul. 2022.
- [9] S. Brahma, M. Almassalkhi, and H. Ossareh, “Optimal Control of Virtual Batteries using Stochastic Linearization,” in *IEEE Conference on Control Technology and Applications (CCTA)*, Aug. 2021.
- [10] **A. Khurram**, L. Duffaut Espinosa, and M. Almassalkhi, “A Methodology for Quantifying Flexibility in a fleet of Diverse DERs,” in *IEEE PES PowerTech*, Jun. 2021.
- [11] L. Duffaut Espinosa, **A. Khurram**, and M. Almassalkhi, “A Virtual Battery Model for Packetized Energy Management,” in *IEEE Conference on Decision and Control*, Dec. 2020.
- [12] **H. Mavalizadeh**, L. Duffaut Espinosa, and M. Almassalkhi, “Decentralized Frequency Control using Packet-based Energy Coordination,” in *IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids (SmartGridComm)*, Nov. 2020.
- [13] **A. Khurram**, K. Desrochers, V. Hines, *et al.*, “Real-world, full-scale validation of power balancing services from packetized virtual batteries,” in *IEEE PES Conference on Innovative Smart Grid Technologies (ISGT)*, Washington, D.C., Feb. 2019.
- [14] **M. Amini**, **A. Khurram**, A. Klem, *et al.*, “A Model-Predictive Control Method for Coordinating Virtual Power Plants and Packetized Resources, with Hardware-in-the-Loop Validation,” in *IEEE PES General Meeting*, Atlanta, Georgia, 2019.
- [15] **N. Nazir** and M. Almassalkhi, “Convex inner approximation of the feeder hosting capacity limits on dispatchable demand,” in *IEEE Conference on Decision and Control*, Nice, France, 2019.
- [16] L. D. Espinosa, M. Almassalkhi, P. D. H. Hines, and J. Frolik, “System Properties of Packetized Energy Management for Aggregated Diverse Resources,” in *Power Systems Computation Conference*, Dublin, Ireland, 2018.
- [17] **M. Amini** and M. Almassalkhi, “Trading off robustness and performance in receding horizon control with uncertain energy resources,” in *Power Systems Computation Conference*, Dublin, Ireland, 2018.
- [18] **N. Nazir** and M. Almassalkhi, “Receding-horizon optimization of unbalanced distribution systems with time-scale separation for discrete and continuous control devices,” in *Power Systems Computation Conference*, Dublin, Ireland, 2018.
- [19] **S. Brahma**, M. Almassalkhi, and H. Ossareh, “A Stochastic Linearization Approach to Optimal Primary Control of Power Systems with Generator Saturation,” in *IEEE Conference on Control Technology and Applications*, Copenhagen, Denmark, 2018.
- [20] M. Almassalkhi, J. Frolik, and P. Hines, “Packetized energy management: asynchronous and anonymous coordination of thermostatically controlled loads,” in *American Control Conference*, 2017.
- [21] L. D. Espinosa, M. Almassalkhi, P. D. H. Hines, and J. Frolik, “Aggregate Modeling and Coordination of Diverse Energy Resources Under Packetized Energy Management,” in *IEEE Conference on Decision and Control*, Melbourne, Australia, Dec. 2017.

- [22] L. Duffaut Espinosa and Mads Almassalkhi and Paul Hines and **S. Heydari** and Jeff Frolik, “Towards a Macromodel for Packetized Energy Management of Resistive Water Heaters,” in *IEEE Conference on Information Sciences and Systems*, 2017.
- [23] M. Almassalkhi, Y. Dvorkin, J. Marley, *et al.*, “Incorporating storage as a flexible transmission asset in power system operation procedure,” in *Power Systems Computation Conference*, 2016.
- [24] M. Almassalkhi and **A. Towle**, “Enabling city-scale multi-energy optimal dispatch with energy hubs,” in *Power Systems Computation Conference*, Genoa, Italy, 2016.
- [25] **M Amini** and M. Almassalkhi, “Investigating delays in frequency-dependent load control,” in *IEEE Innovative Smart Grid Technologies Asia*, 2016.
- [26] M. Almassalkhi, B. Simon, and A. Gupta, “A Novel Online Energy Management Solution for Energy Plants,” in *IEEE Power Systems Conference*, 2014.
- [27] M. Almassalkhi and I. Hiskens, “Temperature-based Model-Predictive Cascade Mitigation in Electric Power Systems,” in *IEEE Conference on Decision and Control*, Dec. 2013.
- [28] —, “Impact of Energy Storage on Cascade Mitigation in Multi-energy Systems,” in *IEEE Power and Energy Society General Meeting*, Jul. 2012.
- [29] R. Hermans, M. Almassalkhi, and I. Hiskens, “Incentive-based Coordinated Charging Control of Plug-in Electric Vehicles at the Distribution-transformer Level,” in *IEEE American Control Conference*, Jun. 2012.
- [30] M. Almassalkhi and I. Hiskens, “Cascade mitigation in energy hub networks,” in *IEEE Conference on Decision and Control*, Dec. 2011.
- [31] —, “Optimization framework for the analysis of large-scale networks of energy hubs,” in *Power Systems Computation Conference*, Aug. 2011.

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#### Book chapters & magazine articles

- [32] M. Almassalkhi, J. Frolik, and P. Hines, *How to prevent blackouts by packetizing the power grid*, *IEEE Spectrum Magazine*, Feb. 2022.
- [33] M. Almassalkhi, L. Duffaut-Espinosa, P. Hines, *et al.*, “Asynchronous coordination of distributed energy resources with packetized energy management,” in *Energy Markets and Responsive Grids*, J. Stoustrup and S. Meyn, Eds., Springer, 2018.
- [34] M. Almassalkhi and I. Hiskens, “Impact of energy storage on cascade mitigation in multi-energy systems,” in *Energy Storage for Smart Grids: Planning and Operation for Renewable and Variable Energy Resources*, P. Du and N. Lu, Eds., Elsevier, 2015.

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#### Intellectual Property (IP) - Patents / Inventions / Disclosures

- [1] M. Almassalkhi, H. Mavalizadeh, and L. A. D. Espinosa, “Decentralized frequency control with packet-based energy management,” pat., (U.S. Patent Application No. 17/305,491), Jul. 2021.
- [2] J. Frolik, P. Hines, and M. Almassalkhi, “Packetized energy management control systems and methods of using the same,” pat., U.S. Patent No.: 11,150,618 B2 (Issued: Oct. 19, 2021), 2021. [Online]. Available: <https://patents.google.com/patent/US20190324415A1/>.
- [3] —, “Systems and methods for randomized, packet-based power management of conditionally-controlled loads and bi-directional distributed energy storage systems,” pat., U.S. Patent Application No. 15/712,089, 2016. [Online]. Available: <https://patents.google.com/patent/WO2018057818A1>.

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## Awards & Recognition

### University of Vermont

- Otto Mønsted Visiting Professorship, 2022
- National Science Foundation CAREER Award, 2021
- UVM Innovation Hall of Fame Award (for licensing IP), 2019
- IEEE GMS Faculty of the Year Award, 2019
- IEEE GMS PES Chapter Outstanding Young Engineer of the Year Award, 2019
- UVM College of Engineering and Mathematical Sciences Junior Faculty of the Year, 2016
- IEEE GMS PES Chapter Outstanding Young Engineer of the Year Award, 2015
- Nominated for the UVM Kroepsch-Maurice Excellence in Teaching Award, 2015

## University of Michigan

- o The Towner Prize for Distinguished Academic Achievement, 2013
- o CoE Graduate Symposium, 1st place in poster session, 2011
- o National Science Foundation GRFP Top Honorable Mention, 2009
- o Rackham Merit Fellow, 2008-2013

## University of Cincinnati

- o Jeanne Gulden Co-recipient (Top Department of Mathematics Award), 2008
- o National Tau Beta Pi Record Scholar, 2007
- o Alumni Foundation College of Engineering Scholar, 2007
- o Engineering Alumni Scholar, 2007
- o Hancock Scholarship Recipient, 2007
- o Hancock and Kieval Scholarships Recipient, 2006
- o Buck and Kieval Scholarships Recipient, 2005
- o Cincinnatus Scholar, 2003-2008

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## Professional Affiliations and Overviews

- Since 2019 **INFORMS Member**, *INFORMS*, Energy, Natural Resources, & the Environment Section (ENRE).
- Since 2007 **Senior IEEE Member**, *IEEE*, Control System (CSS) and Power & Energy (PES) Societies.
- Since 2006 **Lifetime Member**, *Tau Beta Pi*, U.S. national engineering honor society.

## Research Overview

- o **Lead externally funded research program in excess of \$6M as PI.**
  - Led team of more than 20 researchers across industry, national labs, and universities.
  - Past funders include: DOE/ARPA-E, EERE/SETO, NSF, and electricity industry partners.
  - Research translated to startup company, Packetized Energy, licensed IP, and software products.
- o **Current research group members:**
  - 2019 - present - PhD EE: Mr. Mavalizadeh – DER coordination and control.
  - 2022 - present - PhD EE: Mr. Owonikoko – Adaptive load shedding for transmission operations.
  - 2021 - present - BS EE: Ms. Rebecca Holt – Dynamic and equitable solar PV curtailment
- o **Student alumni**
  - 2017-21: PhD EE: Dr. A. Khurram – Modeling and control of Aggregated DERs.  
(Post-doctoral Associate at UCSD in San Diego, CA)
  - 2017-20: PhD EE: Dr. N. Nazir – Optimization of energy-constrained DERs in distr. networks  
(Post-doctoral Associate at PNNL in Richmond, WA)
  - 2014-19: PhD EE: Dr. M. Amini – Optimal dispatch of uncertain energy resources  
(Employed at National Grid in Boston, MA)
  - 2018-19: MS ME: Mr. Zach Hurwitz – Multi-energy system with flexible buildings  
(Employed at Siemens in Scarborough, ME)
  - 2017-19: MS EE: Mr. Micah Botkin-Levy – Optimal control of EV charging  
(Employed at eIQmobility/NextEra in San Francisco, CA)
  - 2015-17: MS EE: Mr. Lincoln Sprague – Distribution feeder modeling and inverters  
(Employed at Dynapower in South Burlington, VT)
  - 2020 - 2021 - BS EE: Mr. Sam Knox – Distribution Substation Transformer Thermal Modeling.
  - 2016: BS EE: Ms. Anna Towle – Multi-energy systems optimization  
(MS EE from KTH, Sweden. Employed at Fortum in Sweden)
- o **Post-doctoral and research scientist alumni**
  - 2020 - 2022 - Post-doc: Dr. Himadri Basu (Jointly advised with Prof. Hamid Ossareh) – Optimal trajectory assignment and collision avoidance
  - 2021: Post-doc: Dr. Nawaf Nazir – Grid-aware flexibility from DERs  
(Pacific Northwest National Lab)
  - 2017-20: Res. Faculty: Dr. Pavan Racherla – Three-phase distribution system modeling  
(Independent Power Systems Consultant)
  - 2016-19: Res. Faculty: Dr. Luis Duffault Espinosa – Modeling and control of DERs  
(Employed at UVM as TT faculty)

## Teaching Overview (rigorous courses in power systems, controls, optimization)

- o Spring 2021: *EE 303 - Convex Optimization* (3 hrs, 11 students, 4.8/5)
- o Fall 2020: *EE 215 - Power System Analysis* (3 hrs, 12 students, 4.1/5)
- o Spring 2020: *EE 113 - Electric Energy Conversion* (4 hrs, 25 students, 3.8/5.0)
- o Fall 2019: *EE 301 - Linear System Theory* (3 hrs, 19 students, 4.4/5.0)
- o Spring 2019: *EE 113 - Electric Energy Conversion* (4 hrs, 27 students, 4.1/5.0)
- o Fall 2018: *EE 395 - Convex Optimization* (3 hrs, 19 students, 4.1/5.0)
- o Spring 2018: *EE 113 - Electric Energy Conversion* (4 hrs, 18 students, 4.0/5.0)
- o Fall 2017: *EE 301 - Linear System Theory* (3 hrs, 21 students, 4.3/5.0)
- o Spring 2017: *EE 395 - Convex Optimization* (3 hrs, 17 students, 4.4/5.0)
- o Fall 2016: *EE 215 - Power System Analysis* (3 hrs, 11 students, 4.6/5.0)
- o Spring 2016: *EE/ME 210 - Control Systems* (3 hrs, 37 students, 4.6/5.0)
- o Fall 2015: *EE 301 - Linear System Theory* (3 hrs, 20 students, 4.5/5.0)
- o Spring 2015: *EE 113 - Electric Energy Conversion* (4 hrs, 10 students, 4.9/5.0)
- o Fall 2014: *EE 215 - Power System Analysis* (3 hrs, 16 students, 4.3/5.0)

## Service Overview

- 2022-present **Associate Editor**, *IEEE Transactions on Power Systems*.
- 2018-present **Member**, *Tech. Committee*, IEEE PES Smart Buildings, Loads, and Customer Systems.
- 2019-2021 **Chair**, *Loads Subcommittee*, IEEE PES Smart Buildings, Loads, and Customer Systems (SBLC), Successfully conducted SBLC's first IEEE Standards process.  
Organized and led SBLC's response for IEEE PES Trending Tech topic on Intelligent Electrification
- 2018-2021 **Vice-Chair**, *IEEE PES Green Mountain Section*, Vermont, USA.
- 2020-2021 **Graduate Program Director (EE)**, *Department of Electrical and Biomedical Engineering*, UVM.
- 2018-2020 **Founding Vice-Chair**, *IEEE CSS Green Mountain Section*, Vermont, USA.
- 2017-2021 **Faculty Advisor**, *Tau Beta Pi - Alpha Chapter*, Vermont, USA.

### External Case Reviewer

- o PhD Thesis (External reviewer) - Australian National University, Australia (2022)
- o PhD Thesis (External reviewer) - University of Melbourne, Australia (2020)
- o Tenure Promotion (External reference) - American University of Sharjah, UAE (2019)
- o MS Thesis (Committee member) - Michigan Technological University, USA (2018)

Funding Agency NSF EPCN (2015, 2016, 2021), Sloan Foundation (2018), NSF ESPCoR RII Track 2 (2020), Swiss NSF (BRIDGE 2021)

### Reviewer - Journals:

- Regularly:
- o \*IEEE Transactions on Power Systems (IF=6.8)
  - o \*IEEE Transactions on Smart Grid (IF=10.5)
  - o \*IEEE Transactions on Control Systems Technology (IF=4.9)
- Sporadically:
- o \*IEEE Transactions on Automatic Control (IF=5.1)
  - o IEEE Transactions on Sustainable Energy (IF=6.2)
  - o IEEE Access (IF=4.1)
  - o International Journal of Electrical Power & Energy Systems (IF=4.4)
  - o Electric Power Systems Research (IF=3.2)
  - o \*Applied Energy (IF=8.6)
- (\* flagship journal in respective field)

### Reviewer - Conferences:

- o \*Power Systems Computation Conference (PSCC): 2011-present
  - o \*IEEE Conference on Decision and Control (CDC): 2013-present
  - o \*American Control Conference (ACC): 2014-present
  - o IEEE Power & Energy Society General Meeting (PESGM): 2017-present [as TPC 2019-present]
  - o IEEE SmartGridComm (SGC): 2017-18 [as TPC in 2018]
  - o Sporadically: ISMA (2018), IEEE CCTA (2018, 2021), \*COMPEL (2020)
- (\* flagship conference in respective field)

### Workshops organized

- o Co-organizer of UVM-NIST Workshop on Smart Grid Testbeds (April, 2019, > 40 participants)
- o Co-organizer of UVM's Future of Energy Workshop (Sept. 2018; > 90 participants)



Panels organized  
or chaired

- o IEEE PES T&D 2022 - organized session on *Network-aware DER coordination* (Apr., 2022)
- o INFORMS 2020 - organized session on *Optimization of Networked Energy Resources* (Nov, 2020)
- o IEEE PES GM 2020 - organized and co-chaired panel: SBLC: BTM DER coordination (Aug, 2020)
- o IEEE PES GMS - organized virtual panel on *Effects of COVID-19 on the Electric Grid* (May, 2020)
- o IEEE PES GM 2019 - organized and chaired three panels: (1) AMPS: Unbalanced OPF, (2) SBLC: DER architectures, and (3) PSOPE: DER optimization and control (Aug, 2019)
- o IEEE CDC 2019 - Co-chair of session on *Energy Systems*
- o ACC 2017 - Chair of session on *Scalable Networked Control for Smart Grid Ancillary Services*

### Participation in conferences, workshops, and seminars

- May 2011 **Workshop on Dynamics, Control and Pricing in Power Systems**, Lund, Sweden, Invited Scholar.  
Spent three weeks at Lund University performing research, collaborating with faculty and other PhD students from around the world, gave a seminar (*Cascade Mitigation in Energy Hub Networks*), and attended workshop.
- August 2011 **INFORMS Midwestern Conference**, Columbus, Ohio, USA, Invited Speaker.  
Presented parts of two papers: *Optimization Framework for the Analysis of Large-scale Networks of Energy Hubs* and *Cascade Mitigation in Energy Hub Networks*.
- August 2011 **Power Systems Computation Conference**, Stockholm, Sweden, Speaker.  
Presented full paper *Optimization Framework for the Analysis of Large-scale Networks of Energy Hubs*.
- September 2011 **Energy Club Conference**, University of Michigan, USA, Poster.  
Cascade Mitigation in Multi-Energy Systems.
- October 2011 **Symposium on Emerging Topics in Control and Modeling of Cyber-Physical Systems**, University of Illinois at Urbana-Champaign, USA, Poster.  
Incentive-based Coordinated Charging Control of Plug-in Electric Vehicles at the Distribution-Transformer Level
- November 2011 **College of Engineering Graduate Symposium**, University of Michigan, USA, Poster.  
Incentive-based Coordinated Charging Control of Plug-in Electric Vehicles at the Distribution-Transformer Level (**Placed 1st in Power and Control session**)
- March 2012 **Conference on the Electricity Industry**, Carnegie Mellon University, USA, Poster.  
Robust Incentive-based Coordinated Charging Control of Plug-in Electric Vehicles at the Distribution-Transformer Level
- May 2012 **CNLS Annual Conference: Smart Grid**, Los Alamos National Lab, USA, Invited Speaker.  
Model-predictive cascade mitigation in electric power systems with energy storage and renewable generation.
- June 2012 **IEEE American Control Conference**, Montreal, Canada, Speaker.  
Co-presenter for paper on non-centralized Incentive-based MPC to solve PEV charging problem in a distribution-grid setting.
- July 2012 **IEEE PES General Meeting**, San Diego, USA, Invited Panel Speaker.  
Presented paper on the effects of energy storage sizing on performance of a model-predictive cascade mitigation scheme in a transmission systems.
- Nov 2012 **College of Engineering Graduate Symposium**, University of Michigan, USA, Poster.  
Model-predictive cascade mitigation in electric transmission networks with energy storage (**Placed 2nd in Energy session**)
- April 2013 **CEIC Seminar**, Carnegie Mellon University, Pittsburg, USA, Invited Speaker.  
Temperature-based Model-predictive cascade mitigation in electric power systems.
- Dec 2013 **Power Event**, Technical University of Denmark, Copenhagen, Denmark, Invited Speaker.  
Linear model-predictive cascade mitigation in AC electric power systems with energy storage.
- Nov 2014 **Storage in Sustainable Electric Energy Systems: Technology Push and Policy Pull**, McGill University, Montreal, CA, Invited workshop attendee.
- Summer 2015 **The Governor's Institute of Vermont, STEMBridge**, Burlington, VT, Invited speaker.  
Power and energy challenges in the 21st century
- Aug 2015 **LTU-IEEE Seminar, Webinar**, USA, Invited speaker.  
Enabling resilient control of power systems with distributed energy storage
- Oct 2015 **IEEE International Conference on the Edges of Innovation for Smarter Cities**, Burlington, USA, Invited speaker.  
Toward designing sustainable cities with energy hubs

- Dec 2015 **ECE Seminar**, *University of Connecticut*, Mansfield, CT, Invited speaker.  
Enabling resilient control of power systems with distributed energy storage
- May 2016 **IMA Annual Program Year Workshop - Control at Large Scales: Energy Markets and Responsive Grids**, *University of Minnesota*, USA, Invited workshop attendee.
- Mar 2017 **UVIG Spring Technical Workshop**, *Tucson, AZ, USA*, Invited panelist.  
Packetized Energy Management - A New Approach to DSM
- April 2017 **DOE panel at IEEE Innovative Smart Grid Technology Conference**, *Washington D.C.*, Invited panelist, Enabling Extreme Real-time Grid Integration of Solar Energy.
- June 2017 **Invited Seminar**, *Aalborg University*, Aalborg, Denmark, Invited Speaker.  
Towards a digital grid with packetized energy management
- July 2017 **Invited Seminar**, *Denmark's Technical University*, Lyngby, Denmark, Invited Speaker.  
Towards a digital grid with packetized energy management
- Aug 2017 **Autonomous Energy Grids Workshop**, *Golden, CO*, Invited workshop attendee.
- Sept 2017 **Rethinking Modeling, Simulations, and Control for the Changing Electric Energy Industry Workshop**, *MIT*, Boston, MA, Invited speaker.  
Packetized Energy Management: a new platform for coordinating distributed energy resources
- Oct 2017 **ECE Seminar**, *Rensselaer Polytechnic Institute*, Troy, NY, Invited speaker.
- Feb 2018 **Engineering Seminar**, *Michigan Technological University*, Houghton, MI, Invited speaker.  
Coordinating flexible energy resources with packetized energy management
- June 2018 **Lunch-and-Learn**, *Telefonica-Alpha*, Barcelona, Spain, Invited speaker.  
Packetized Energy Management
- Aug 2018 **ESIF Seminar**, *NREL*, Golden, CO, Invited speaker.  
Towards scalable integration of DERs to enable extreme penetration of renewable energy
- Aug 2018 **Lunch-and-Learn**, *Oersted*, Fredericia, Denmark, Invited speaker.  
Packetized energy management
- Oct 2018 **Innovation Panel**, *Wharton Energy Conference*, Philadelphia, PA, Invited panelist.  
Packetized energy management
- Nov 2018 **Trans-Atlantic Infraday Conference**, *FERC*, Washington, DC, Student presented.  
Three-phase OPF software for economic dispatch of continuous and discrete control assets
- Feb 2019 **PRECISE Seminar**, *University of Pennsylvania*, Philadelphia, PA, Invited speaker.  
Real-Time, Scalable Coordination of Smart Appliances with Packetized Energy Management
- Mar 2019 **ECE/FEEDER Seminar**, *University of Kentucky*, USA, Invited speaker.  
Real-Time, Scalable Coordination of Smart Appliances with Packetized Energy Management
- Mar 2019 **IEEE Conference on Information Sciences and Systems**, *Johns Hopkins University*, Baltimore, MD, Invited talk.  
Towards 100% renewable generation with flexible demand: control & optimization
- Apr 2019 **Autonomous Energy Grids**, *NREL*, Golden, CO, Invited participant.
- Apr 2019 **Young Professionals Webinar**, *IEEE PES*, Online (Global audience), Invited speaker.  
I'm an entrepreneurial electrical engineer (iEEE): from academia to startups
- May 2019 **SETO Planning & Operations Workshop**, *DOE*, Washington, DC, Invited speaker.  
Robust and resilient coordination of feeders with uncertain distributed energy resources
- May 2019 **Distribution System State Estimation Workshop**, *DOE/Northeastern University*, Boston, MA, Invited participant.
- Jun 2019 **ARPA-E PERFORM Pre-program workshop**, *DOE*, New York, NY, Invited participant.
- Aug 2019 **Panel on Enabling Advanced Grid Operations with DER coordination**, *IEEE PES General Meeting*, Atlanta, GA, Invited organizer and panelist.
- Oct 2019 **Challenges in Energy Systems Network Optimization Panel**, *INFORMS Annual Meeting*, Seattle, WA, Invited speaker.  
Optimization-based Spatial Disaggregation of Virtual Batteries Over Power Networks

- Oct 2019 **Seminar, Pacific Northwest National Laboratory**, Richland, WA, Invited speaker.  
Towards flexible distribution systems
- Nov 2019 **Trans-Atlantic Infraday Conference, FERC**, Washington, DC, Student presented.  
Enabling Real-time, Network-admissible Disaggregation of Market Services with Convex Inner Approximations
- Nov 2019 **Symposium on Machine Learning, Optimization and Security for Future Energy Delivery Systems, IEEE GlobalSIP**, Ottawa, Canada, Invited speaker.  
Enabling Real-time, Network-admissible Disaggregation of Market Services with Convex Inner Approximations
- Feb 2020 **IPAM Workshop on Learning, Control, and Optimization, UCLA**, Los Angeles, CA, Participant.
- Feb 2020 **Use of AI to Optimize Behind-the-Meter Resources, IEEE Innovative Smart Grid Technology Conference**, Washington D.C., Invited panelist (student presented in my place).  
Innovative methods in coordinating demand-side resources: From papers to practice
- Feb 2020 **EECS Seminar, MIT**, Boston, MA, Invited speaker.  
Unlocking demand-side flexibility with grid optimization and control
- May 2020 **Virtual Roundtable on Smart Energy Services, Consumer Technology Association**, Webinar, Invited Panelist.  
Experiences and recommendations for smart energy standards
- June 2020 **Solar & Storage Group, National Grid**, Online, Invited Speaker.  
Flexible Hosting Capacity
- Aug 2020 **Grid Modernization & Resilience with Energy Storage, NY BEST Annual Conference**, Online, Invited Panelist.  
Dynamic Hosting Capacity
- Aug 2020 **Architecture for DER Integration, IEEE PES General Meeting**, Online, Invited Panelist and Speaker.  
Utility and Aggregator interactions to support large-scale DER integration
- Aug 2020 **Optimal Power Flow Methods for Realistic Power Distribution Networks, IEEE PES General Meeting**, Online, Invited Panelist and Speaker.  
Real-time Control Methods for Balanced Power Distribution Systems
- Aug 2020 **Emerging issues on market-based coordination and control of BTM DERs, IEEE PES General Meeting**, Online, Invited Panelist and Speaker.  
Towards Decentralized Frequency Control with Packet-based Energy Coordination
- Nov 2020 **Market Models and Optimization in Active Distribution Networks, INFORMS Annual Meeting**, Washington, DC, Invited Speaker.  
To be or not to be a Utility: Allocating Flexible Resources Across a Network for Different Market Signals
- Feb 2021 **ECE Seminar, New York University**, Virtual, Invited Speaker.  
Towards scalable integration of distributed energy resources with packetized energy management
- Mar 2021 **Gund Institute for Environment Seminar, UVM**, Virtual, Invited Speaker.  
Mitigating Climate Change with Power Engineering
- Apr 2021 **IEEE PES Day, IEEE PES US & Canada Students**, Virtual, Invited Speaker.  
Engineering Innovation in Power and Energy Systems: from bulky MWs to nimble kW
- June 2021 **FERC, Technical Conference**, Virtual, Invited Panelist.  
Climate Change, Extreme Weather, & Electric System Reliability
- June 2021 **Google, Virtual**, Invited Participant, Carbon Aware Computing Workshop.
- June 2021 **Innovation Centre, Denmark**, Virtual, Invited Speaker.  
Towards large scale integration - energy islands and energy flexibility
- June 2021 **U.S. Department of Energy, Solar Energy Technologies Office**, Virtual, Invited Speaker.  
ENabling Extreme Real-time Grid Integration of Solar Energy (ENERGISE) Program Final Workshop
- Sept 2021 **Denmark's Technical University, Center for Electric Power & Energy**, Lyngby, Denmark, Speaker.  
Enabling flexible demand with distributed control of residential kW-scale devices
- Sept 2021 **Smart Energy Systems International Conference**, Copenhagen, Denmark, Speaker.  
Exploring reactive power limits on wind farm collector networks with convex inner approximations

- Oct 2021 **INFORMS Annual Meeting**, Anaheim, CA, Invited speaker.  
Guaranteeing a physically realizable battery dispatch without complementarity constraints
- Oct 2021 **INFORMS Annual Meeting**, Anaheim, CA, Invited speaker.  
Grid-aware aggregation and realtime disaggregation of distributed energy resources in radial networks
- Dec 2021 **Digital Tech Summit**, Copenhagen, Denmark, Invited speaker.  
New technologies, disruption and smart energy systems
- Jan 2022 **Young Professionals in Energy (Boston)**, *US-Denmark Green Transition*, Virtual, Invited speaker.  
Flexing the grid with intelligent electrification
- Feb 2022 **Innovation Centre Denmark**, *Transmission-Distribution interfaces, markets, and flexibility*, Virtual, Invited speaker.  
Indirect Control of Distributed Assets to provide System Flexibility
- Mar 2022 **Energinet seminar**, *Virtual*, Invited speaker, EV charging & internet ideas.
- Apr 2022 **IEEE PES T&D conference**, *New Orleans, LA*, Distribution Network-Aware Distributed Energy Resources Coordination., Co-chair.
- May 2022 **Aalborg University**, *Department of Electronic Systems*, Aalborg, Denmark, Invited speaker.  
Enabling a responsive grid and flexibility at scale
- May 2022 **Denmark Technical University**, *Department of Sustainability, Society, and Economics*, Lyngby, Denmark, Invited speaker.  
Enabling a responsive grid and flexibility at scale
- May 2022 **NSF Sponsored joint US-European workshop**, *Zagreb, CR*, Invited participant and Scribe.  
Grid at the Edge: towards the zero-carbon power grid with improved visibility, safety and reliability
- May 2022 **University of Manchester**, *Department of Electrical & Computer Engineering*, Manchester, England, Invited speaker.  
Enabling flexible demand with distributed control & optimization
- June 2022 **TU Dortmund**, *Institut für Energiesysteme, Energieeffizienz und Energiewirtschaft (ie<sup>3</sup>)*, Dortmund, Germany, Invited speaker.  
Enabling flexible demand with distributed control & optimization
- June 2022 **Innovation Centre Denmark**, *Virtual*, Co-organizer and moderator, Large-scale system integration.
- July 2022 **IEEE PES General Meeting**, Research and Educational Experiences of NSF CAREER Awardees in Power Systems, Invited panelist.  
Enabling grid-aware aggregation and real-time control of distributed energy resources in electric power distribution systems
- July 2022 **IREF 2022 Symposium**, *Banff, CA*, Vice-Chair and presenter.  
Session on microgrids and presenter of three accepted, co-authored papers
- Oct 2022 **DOE Wind Energy Technologies Office**, *Washington, DC*, Deep-dive workshop between Department of Energy and the Danish Energy Agency, Invited attendee.  
Transmission supporting broad-scale integration of Off-shore Wind
- Oct 2022 **Renewable Energy Vermont Conference 2022**, *Burlington, VT*, Invited panelist.  
Vermont Clean and Resilient Energy Consortium - Making Vermont a Leader in Renewable Energy Research
- Oct 2022 **Renewable Energy Vermont Conference 2022**, *Burlington, VT*, Invited moderator.  
The Future of Hydrogen in the Renewable Energy Landscape
- Dec 2022 **IEEE Conference on Decision and Control 2022**, *Cancun, MX*, Invited paper.  
Towards Optimal Kron-based Reduction Of Networks (Opti-KRON) for the Electric Power Grid