Conference Schedule

Event Wifi Information
UW NetID: event0429
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Sponsors:

CLEAN ENERGY INSTITUTE
UNIVERSITY of WASHINGTON

FOM TECHNOLOGIES

Thursday, September 8

12:00 – 2:00 pm Arrival & Check-In

2:00 - 3:00 pm **MEM-C/CEI Professional Development Concurrent Sessions**
Interview Preparation and Practice with **Curtis Takahashi** and **Michael More**
Inclusive Mentoring: Considerations for Building Healthy Working Environments with **Tam'ra-Kay Francis** and **Christopher Arnette**

3:00 - 4:00 pm **MEM-C/CEI Professional Development Concurrent Sessions**
Networking and Professional Development with **Curtis Takahashi** and **Michael More**
Developing Strategies for Resilience & Well-Being with **Megan Kennedy**

4:00 - 5:00 pm Free Time

5:00 - 6:00 pm Welcome Address with **Daniel Schwartz**

6:00 – 7:30 pm Dinner in the dining hall

7:30 - 7:45 pm **César Omar Ramírez Quiroz**, FOM Technologies
The role of slot-die coating in the future of photovoltaics

7:45 – 8:00 pm **Jose Araujo**, University of Washington
Redox targeting of solid superionic conductors for high-energy-density batteries

8:00 – 9:00 pm Student poster session intro talks

Friday, September 9

7:45 – 8:15 am Breakfast in the dining hall

Session 1: AI & Machine Learning Session

8:30 - 9:05 am **Tonio Buonassisi**, Massachusetts Institute of Technology
Virtual Presentation *TBD*

9:05 - 9:40 am **Draguna Vrabie**, Pacific Northwest National Lab
Materials and chemistry of novel redox flow batteries

9:40 - 10:15 am **Hao Zhu**, University of Texas – Austin
Machine Learning for Integrating New Energy Resources at Grid Edge

10:15 am - 10:35 am 20-minute break

Session 2: Battery Technologies Session

10:35 – 11:10 am	**Linda Nazar**, University of Waterloo *All-Solid-State Batteries - a Step Change for Electrical Energy Storage*
11:10 – 11:45 am	**Jie Xiao**, Pacific Northwest National Lab *An Integrated Science and Engineering Approach for Next-Generation Battery Materials and Technologies*
11:50 - 12:00 pm	**Group Photo**
12:15 – 1:00 pm	**Lunch in the dining hall**
1:00 – 3:30 pm	**Free time**
3:40 – 4:15 pm	**Amy Prieto**, Colorado State University *Electrodeposition as a useful tool for next-generation anode materials for alkali metal rechargeable batteries*
3:40 – 4:15 pm	**Miaofang Chi**, Oak Ridge National Laboratory *Deciphering Complex Interfaces of Energy Materials Using Advanced Scanning Transmission Electron Microscopy*

Session 3: Solar Technologies Session

4:50 – 5:25 pm	**Thuc-Quyen Nguyen**, University of California – Santa Barbara *Organic Solar Cells Processed from Environmental Friendly Solvents*
5:25 – 6:00 pm	**Shane Ardo**, University of California – Irvine *Photovoltaics where H+ (and OH–) are the mobile charge carriers*
6:00 – 7:30 pm	**Dinner in the dining hall**
7:30 – 8:05 pm	**Dan Congreve**, Stanford University *Upconversion and Downconversion for Solar Energy Harvesting*
8:05 – 8:40 pm	**Matthew Beard**, National Renewable Energy Laboratory *Controlling charge, spin and light in Lead-Halide Inspired Hybrid Semiconductors*
8:40 – 10:00 pm	**Student poster session and conference social**

Saturday, September 10

7:45 – 8:15 am	Breakfast in the dining hall

Session 4: Grid Session

8:30 - 9:05 am	**Lang Tong**, Cornell University *Pricing Storage Operation in Real-time Markets under Uncertainty*
9:05 - 9:40 am	**June Lukuyu**, University of Washington *Off-grid Electricity for Rural Development in Africa*
9:40 – 10:00 am	20-minute break
10:00 - 10:45 am	**Alex Huang**, University of Texas – Austin *Power Electronics Energy System (PEES)*
10:45 – 11:30 am	**Johanna Mathieu**, University of Michigan *How Energy Storage Affects Grid Emissions: Empirical and Simulation Results*
11:30 am – 12:00 pm	Free time
12:00 – 1:00 pm	Lunch in the dining hall
1:00 pm	Conference end and departure

Speaker Abstracts

The role of slot-die coating in the future of photovoltaics

César Omar Ramírez Quiroz
FOM Technologies

High power conversion efficiency has never been as crucial as today, not only for accomplishing the global environmental targets but also for the survival itself of the PV industry. Concepts such as multijunction and tandem solar cells have been part of the PV technology roadmap for a long time. Two sub-cells of inexpensive solar absorbers with different bandgaps are combined. Several challenges are evident in accomplishing this, and strategic decisions regarding processing seem unclear. An overview of the performance-size evolution shows the multiple advantages of using slot-die coating. A clear path for scalability, potential short cycle times, and easy processing on non-flat substrates make slot-die coating a strategic choice for moving the field forward.

Redox targeting of solid superionic conductors for high-energy-density batteries

Jose Araujo
University of Washington

Long-duration energy storage is critical for the success of a sustainable clean-energy grid. Redox flow batteries (RFBs) are attractive for this purpose because of their scalability and ability to decouple energy storage from power generation. RFB deployment has been hampered by high costs and low energy densities, however. One strategy for improving energy density is to add redox-active solids to the electrolyte tanks, whereby these solids increase the electrolyte's volumetric capacity via "redox targeting". In aqueous RFBs, this approach has been almost exclusively limited to the catholyte side of batteries, and no good solutions for aqueous anolyte redox targeting have yet been identified. Here, we demonstrate a versatile redox-active solid that boosts the energy storage capacity of aqueous anolyte mixtures based on either organic or transition-metal redox shuttles. We show that addition of this solid to the anolyte tank can boost the capacity up to 400% of the electrolyte's capacity alone.

TBD

Tonio Buonassisi
Massachusetts Institute of Technology

Differentiable programming for modeling and control of energy systems

Draguna Vrabie
Pacific Northwest National Laboratory

I will introduce a differentiable programming-based method called differentiable predictive control (DPC) for learning domain-aware neural dynamical systems and constrained control laws for unknown nonlinear systems. The DPC method leverages deep neural networks as nonlinear function approximators for system identification and representation of explicit control laws. We capture domain knowledge by representing the system as a constrained neural state-space model, thus avoiding the requirements of intractably large datasets. Simulation case studies will illustrate the scalability, data efficiency, and constraints handling of the DPC method, including multi-zone building control and dynamic economic dispatch.

Machine Learning for Integrating New Energy Resources at Grid Edge

Hao Zhu
University of Texas - Austin

New energy resources including battery storage, renewable generation, and electrical vehicles (EVs) are increasingly transforming the electric grid infrastructure nowadays. Due to the small scale and large number of these grid-edge resources, they can use input signals from grid operators to provide grid services such as peak reduction and frequency regulation in a scalable fashion. However, the dynamics and uncertainty of these input signals are difficult to model and analyze, making a data-driven reinforcement learning (RL) approach attractive for determining the optimal operations of grid-edge resources. This talk presents two recent results on leveraging RL for enabling the grid-edge resources to support grid operations. First, we investigate the optimal battery control problem where the cycle-based battery degradation is difficult to represent under RL modeling. In addition to considering the energy arbitrage and frequency regulation performances, we develop an exact instantaneous model to represent battery degradation that is amendable for RL policy search, greatly improving the performance over existing linearized approximate model. Second, we focus on the optimal operations of EV charging station (EVCS), where the random EV arrival demands make the RL state representation time-varying and high-dimensional. We propose to reduce the state-action space by utilizing the laxity measure to capture the EV priority, leading to enhanced RL solution efficiency. The resultant algorithm has demonstrated performance improvement over existing heuristic approximation in terms of being more responsive to price peaks.

All-Solid-State Batteries - a Step Change for Electrical Energy Storage

Linda Nazar
University of Waterloo

All-solid-state lithium-ion batteries (ASSBs) have emerged as very promising alternatives to conventional Li-ion batteries for electrical energy storage, owing to their anticipated enhanced safety and higher energy densities. They are, however, still in their infancy. ASSBs are founded on high performance fast-ion conducting solid electrolytes, where the search for efficient materials hinges on understanding their intrinsic nature and gaining comprehensive knowledge of the factors that dictate facile Li-ion transport. Incorporating them into high functional ASSBs relies on mastering the interface of the solid electrolyte with the electrode materials. This presentation will outline our development of superionic Li solid electrolytes that show how cation disorder and a frustrated energy landscape impacts conductivity and activation energy. These materials are coupled to state-of-the art high voltage lithium metal oxide cathodes to enable ASSBs with capacities close to their liquid electrolyte counterparts over hundreds of cycles at room temperature owing to the low-resistance nature of the solid-solid interfaces.

An Integrated Science and Engineering Approach for Next-Generation Battery Materials and Technologies

Jie Xiao
Pacific Northwest National Laboratory

Electrochemical energy storage especially lithium-based battery technology enables electrification of the transportation sector and significantly improved stationary grid storage, hence is critical to developing clean-energy economy in the US. Today's batteries are, however, mostly manufactured outside the US. Developing IP-retaining next-generation battery materials and technologies provides a unique opportunity to establish a strong domestic manufacturing footing.

Identifying and addressing material challenges at industry-relevant scales and validation of new battery chemistries under realistic conditions critically determine the timeliness and success of materials development, manufacturing, and technology translation from academic research to industry applications in the US. There remains to be a large gap between academic research, materials scale-up/manufacturing, and device level performance optimization. This talk will review the challenges, opportunities, and approaches for accelerating R&D and manufacturing processes of next generation materials and battery technologies. I will highlight the importance of interdisciplinary research in electrochemical energy storage and emphasize the necessity to identify and address scientific challenges at relevant scales/conditions. Two specific examples will be discussed: (1) an integrated electrochemistry and engineering approach to utilize lithium metal anode and enable high-energy rechargeable lithium metal battery, (2) the study of single crystal Ni-rich cathode for Li-ion and Li metal batteries. Scaling up single crystal cathode will be used as an example to shed some light on the importance of integrated science and engineering methodology for battery materials development and manufacturing.

Electrodeposition as a useful tool for next-generation anode materials for alkali metal rechargeable batteries

Amy Prieto
Colorado State University

Antimony (Sb) based electrodes are promising anode materials for sodium-ion batteries. These anodes have high thermal stability, good rate performance, and good electronic conductivity, but there are significant limitations to the fundamental understanding of the phases present as the material is sodiated and desodiated, which limits further rational improvements to performance. Here we report that electrode fabrication techniques can dramatically impact the sodiation/desodiation reaction mechanisms observed due to the mechanical stability, morphology, and composition of the film. In addition, we show that solution additives typically used in industrial copper platting baths can influence the morphology and crystallinity of electrodeposited Sb anodes, which then also affect electrochemical performance.

Deciphering Complex Interfaces of Energy Materials Using Advanced Scanning Transmission Electron Microscopy

Miaofang Chi
Oak Ridge National Laboratory

Designing next-generation energy conversion and storage systems, such as solid-state batteries and fuel cells, faces numerous challenges, many of which are related to interfaces. Elucidating interfacial phenomena in energy systems requires knowledge, not only of atomic-scale structure and chemistry but also of correlated local charge distribution and ion diffusion that are difficult to probe with conventional techniques. Several new scanning transmission electron microscopy (STEM) techniques, such as four-dimensional (4D)-STEM, monochromated EELS (electron energy loss spectroscopy), atomic-scale cryogenic and in situ environmental microscopy, allow the behavior of electrons, ions, and atoms to be probed, opening opportunities to tackle complex dynamic interfacial questions. In this talk, I will demonstrate how we combine these techniques to reveal the origin of unexpected dendrite growth within all-solid-state batteries, probe local ion transport behavior at interfaces and grain boundaries, and map charge density in electrides and interfaces in heterogeneous catalysts. Perspectives for the future advancements of STEM techniques for energy materials research will also be provided.

Organic Solar Cells Processed from Environmental Friendly Solvents

Thuc-Quyen Nguyen
University of California – Santa Barbara

Organic solar cells (OSCs)npotentially can offer low cost, large area, flexible, light-weight, clean, and quiet alternative energy sources for indoor and outdoor applications. OSCs using non-fullerene acceptors (NFAs) have garnered a lot of attention during the past few years and shown dramatic increases in the power conversion efficiency (PCE). PCEs higher than 19% for single-junction systems have been achieved, but these high-performance organic photovoltaic cells are often processed with halogenated solvents. To accelerate the mass fabrication of OSCs, green solvent processing is crucial to reduce the harmful effect of halogenated solvents to human health and our environment. In this talk, I will discuss the molecular design, thin film property and performance of organic semiconductors processed from green solvents such as xylene and 2-methyl THF. A combination of characterization methods were employed to gain insight into the film morphology and solar cell performance.

Photovoltaics where H+ (and OH−) are the mobile charge carriers

Shane Ardo
University of California – Irvine

Generating electricity or driving redox reactions with sunlight requires (i) light absorption, (ii) charge separation, and (iii) charge collection. Numerous demonstrations of these processes exist for electronic charges, such a negatively-charge electrons in crystalline silicon, while near-zero demonstrations exist for protonic charges, such a positively-charged protons in liquid water.

My talk will focus on my group's development of energy materials and systems that rely on control of proton dynamics. These include demonstrations of near-ideal protonic diodes based on liquid or solid water, photogeneration of protons and the applicability Marcus theory to explain the driving-force dependence to their kinetics, detailed-balance (Shockley–Queisser) efficiency limits to light-to-protonic energy conversion, and catalysts that mediate proton-transfer reactions via Shockley–Read–Hall-type processes. I will also relate our new validated knowledge to applications of immediate global importance, including oceanic carbon capture, light-driven desalination, and local OH− sensing. Collectively, understanding the fundamental principles that dictate proton transfer will help facilitate the discovery of new innovations in clean energy and carbon capture.

Upconversion and Downconversion for Solar Energy Harvesting

Dan Congreve
Stanford University

Photon upconversion and downconversion allows us to convert between colors of light while conserving energy. We demonstrate that these processes could allow for huge advancements in photovoltaic technology by circumventing the single junction thermodynamic limit, achieving quantum efficiencies greater than 100% utilizing downconversion and sub-bandgap photon harvesting using upconversion. We will discuss the state-of-the-art of these technologies and the remaining hurdles to their full implementation.

Controlling charge, spin and light in Lead-Halide Inspired Hybrid Semiconductors

Matthew Beard
National Renewable Energy Lab

In this presentation I will discuss our studies of controlling the charge carrier dynamics, light/matter interactions, and spin populations in metal-halide organic/inorganic hybrid systems. In one effort we are exploring the use of novel organic hybrid systems at and near interfaces to control the carrier dynamics and reduce surface recombination while protecting grain boundary surfaces from degradation.

With respect to controlling spins we have recently studied and developed a novel class of chiral hybrid semiconductors based upon layered metal-halide perovskite 2D Ruddlesden-Popper type structures. These systems exhibit chiral induced spin selectivity whereby only one spin sense can transport across the chiral layer and the other spin sense is blocked for one handedness of the chiral perovskite layer. We show that chiral perovskite layers are able to achieve > 80% spin-current polarization. We have also studied spin-injection from the chiral-layer to a non-chiral perovskite layer and find high spin-injection efficiency. We developed novel spin-based LEDs using non-chiral perovskite NCs as the light emitting layer that promotes light emission at a highly spin-polarized interface. The LED spin-polarization is limited by spin-depolarization within the MHP NCs. In a separate effort we have explored the use of chiral copper-halide hybrid systems for circular light polarized detection. Chiral based copper-halide systems combined with highly conductive carbon nanotube networks can be employed to detect circular polarized light without the use of polarizers. Our chiral heterostructure shows high photoresponsivity of 452 A/W, a competitive anisotropy factor of up to 21%, a current response in microamperes, and low working voltage down to 0.01 V.

Finally, combining light and charge, we have developed novel photocatalyst based upon the unique properties of metal-halide semiconductor nanocrystals. We developed a novel photocatalyst the combines the properties of the perovskite NCs with a transition metal catalyst that is incorporated at the surface of the NCs. We show that such systems can drive multiple electron reactions. These results demonstrate that the emergent properties of organic–inorganic hybrid systems offer unique opportunities in controlling light, charge and spin.

Pricing Storage Operation in Real-time Markets under Uncertainty

Lang Tong
Cornell University

We consider the problem of pricing storage operation in the real-time market under demand and renewable forecast uncertainty. A widely adopted approach is the rolling-window look-ahead dispatch, where the operator sequentially optimizes the immediate dispatch decision based on forecasted demands and supplies. Such an approach provides a computationally tractable data-driven solution, exploiting that forecasts are more accurate for intervals close to the dispatch time. However, pricing multi-interval dispatch under uncertainty faces challenges arising from inaccurate and changing forecasts.   It can be shown that all uniform pricing mechanisms require discriminative uplift payments.
Such uplifts incentivize generators and storage participants to manipulate offers and bids to profit from uplift payments. We propose a simple generalization of the locational marginal pricing to include shadow prices for inter-temporal constraints. Referred to as temporal locational marginal pricing (TLMP), TLMP removes the need for uplifts under arbitrary forecasting errors and provides truthful bidding incentives for deterministic, stochastic, and robust rolling-window dispatch models.

Off-grid Electricity for Rural Development in Africa

June Lukuyu
University of Washington

Off-grid electricity systems, particularly mini-grids, have burgeoned across Africa recently as an essential driver of rural energy access, complementing grid extension. In contrast with traditional grid extension, planning for off-grid electrification in Africa has primarily been an informal, bottom-up, market-driven, and decentralized phenomenon dominated by the private sector. Mini-grids continue to face critical headwinds in gaining widespread traction because of a lack of investment capital, driven by concerns about high costs for construction and operation, as well as low electricity demand, limiting revenue potential. In turn, cost-reflective tariffs are often unaffordable for the low-income population they serve, stifling consumers from using electricity for economic purposes and, subsequently, rural development. In this talk, I discuss interventions aimed at facilitating climate-aware electricity use to enhance economic development in off-grid communities and strengthen private mini-grid business models. Further, based on our findings, I present policy recommendations for stakeholders working towards increasing electrification through adopting off-grid systems.

Power Electronics Energy System (PEES

Alex Huang
University of Texas - Austin

Driven by innovations in power semiconductor technology, decreased cost in solar, wind and energy storage technology, and the strong need to decarbonize every sector of our society, power electronics-based generations are positioned to replace today's synchronous generator as the governing generation technology in the future. Simultaneously, electrifications on the load side are also power electronics based, hence creating a power electronics energy system (PEES) that encompasses generation, transmission, distribution and load. Due to the flexible and fast controllability of power converters, PEES can potentially outperform today's energy system and achieve higher energy efficiency. A complete DC based PEES is also feasible. However, there are many challenges in designing and operating a PEES. This talk will provide an overview of power electronics technology, focusing on the state of the art from hardware and control point of view. New opportunities enabled by emerging power electronics technology in grid applications will be highlighted. The talk will also discuss gaps and research needs for a power-electronics based grid.

How Energy Storage Affects Grid Emissions: Empirical and Simulation Results

Johanna Mathieu
University of Michigan

In this talk I will discuss our recent interdisciplinary work to explore the effect of energy storage providing frequency regulation on CO_2 emissions. Leveraging PJM data, we show that energy storage providing frequency regulation can increase CO_2 emissions as unit commitment and fossil fuel generator operating points shift. We explore the mechanisms behind these results via simulation and show that the long-term emissions impacts can be positive or negative and in different directions than the short-term impacts. This is joint work with Catherine Hausman, Jesse Buchsbaum, and Jing Peng, and we gratefully acknowledge funding from the Alfred P. Sloan Foundation.
