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Abstract book

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Advanced Power and Renewable Energy Systems

Plenary Session

The solar revolution: the fastest energy change in history

Andrew Blakers*
Australian National University, Australia

Abstract

The fastest energy change in history is underway. New solar photovoltaic capacity is being deployed several times faster than everything else put together. In comparison with solar and wind, global construction of new fossil, hydro, nuclear and other generation technologies are cottage industries. Global solar deployment is doubling every three years. This exponential growth is sufficiently fast to fully decarbonise the global economy by 2040, in combination with electrification of transport, heating, industry and aviation. Solar is unconstrained by availability of solar energy, land or raw materials. It has the lowest environmental and social impact of any energy technology, and has the lowest utility for warfare or terrorism. It provides the cheapest energy in history, for the next 5 billion years. Energy storage to support solar (and wind) is a solved problem via pumped hydro and batteries. This talk will expand on these themes.

Biography:

Andrew Blakers is Professor of Engineering at the Australian National University. He was joint winner of the Queen Elizabeth Prize for Engineering in 2023 for PERC technology, which comprises half of all solar panels ever made and is mitigating 3% of global greenhouse gas emissions through displacement of coal. Prof Blakers engages in analysis of 100% renewable energy systems supported by storage for which he was joint winner of the 2018 Eureka Prize for Environmental Research. His team developed a global atlas of a million off-river pumped hydro energy storage sites which is influential in the renewable energy storage industry.

Leveraging AI and Machine Learning for Smart Grid Management

Xinghuo Yu*
RMIT University, Australia

Abstract

Smart Grids are becoming increasingly complex and dynamic, requiring advanced technologies to manage and optimize their operations. This talk will explore how Artificial Intelligence (AI) and Machine Learning (ML) can enhance the efficiency and effectiveness of the smart grid management. We will delve into the essence of AI and ML, show their potential, and examine the challenges and opportunities. Several case studies such as using generative AI and large language models in the control room operations will be used to inform the discussions.

Biography:

Xinghuo Yu is a Distinguished Professor, a Vice-Chancellor's Professorial Fellow, and an Associate Deputy Vice-Chancellor at RMIT University, Melbourne, Australia. His research interests are in control systems, intelligent and complex systems, and power and energy systems. He received a number of awards and honours for his contributions, including 2018 M A Sargent Medal from Engineers Australia, 2018 Australasian Artificial Intelligence Distinguished Research Contribution Award from Australian Computer Society, and 2013 Dr.-Ing. Eugene Mittelmann Achievement Award from IEEE Industrial Electronics Society. He has been named a Highly Cited Researcher by Clarivate since 2015 (consecutively). He is a Fellow of Australian Academy of Science, an Honorary Fellow of Engineers Australia, and a Fellow of the IEEE, Australian Computer Society and Australian Institute of Company Directors. He was the President of IEEE Industrial Electronics Society in 2018 and 2019.

Session: Advanced Power and Energy Systems

Keynote Talk

The Accelerating Energy Capacitance of Oceans and Landscapes: A Quantum Thermodynamic Perspective

G. B. Smith*
University of Technology Sydney, Australia

Abstract

The energy stored within environmental systems heated by solar and atmospheric radiation is rising at a faster rate than expected from the rate at which incident atmospheric intensities are rising. Ocean temperatures are advancing at accelerating rates especially close to the surface where total radiant loss to the atmosphere and to outer space is usually in balance over time, with the total heat gain from solar energy and the incoming thermal radiation from the atmosphere. If the content of greenhouse gases in the atmosphere was to stabilise a new but historically warmer overall thermal balance could emerge for earth's environments. A quantum basis for an accelerating temperature has now been identified from an extension of our recently published model (1) of the spectral composition of exit radiation when applied to water. Exit photons carry information (not heat) on the oscillation modes of polar bonds in water. This photon excitation source is distinct from the excitations associated with heat capacitance. It occurs at specific local sites along photon modes, where resonant optical delay results from pairing with a molecule's oscillations to form short-lived hybrid pairs. Many such pairs are present at any instant. The heat capacitance acts as an "internal heat bath" whose temperature is needed to excite the energy capacitance set by hybrid pairs. Their energy capacitance is thus sensitive to T and mass density. The combined capacitance slows the exponential rate of temperature change dT/dt, following switches in external heating rate. Since time to cool overnight Is fixed it appears stored energy and T will continue to accelerate over time unless atmospheric emissions cease rising.

Biography:

Geoff Smith is Emeritus Professor of Applied Physics at UTS in Sydney Australia. His current research is directed to developing a new quantum physics approach to the thermal response of all matter to external heating when internal photons are included. This is the culmination of his long career in energy science and technology involving solar energy, and materials physics that began in the 1970s. His key research contributions include new spectral selective coatings for solar collectors and windows, improved approaches to radiative cooling, innovative daylighting solutions and building materials development that improves energy efficiency and human comfort.

Invited Talk

Strategies Enabling Efficient and Stable Perovskite PV Devices

Xu Liu*
University of New South Wales, Australia

Abstract

Rapid improvements in device performance over the past decades have made perovskite solar cells (PSCs) one of the most promising photovoltaic technologies. The breakthroughs on the synthesis of carrier-transport-layers, the development of surface/interface passivation and the optimization of perovskite bulk are regarded as the keys for state-of-art PSCs. Here, we present our work on the fabrication of efficient and stable PSCs. We explored inorganic binary alkaline halide KCl to passivate the SnO_2/perovskite interface and found that it can significantly suppress the recombination at interface, contributing to an increase in the open-circuit voltage, the fast response of steady-state efficiency, the elimination of hysteresis and improved stability. Then, we developed a facile approach based on the incorporation of 1-dodecanethiol (DDT) in the hole-transport-layer (HTL). We discovered that DDT provides a more efficient and controllable doping process with significantly reduced doping duration, enabling the HTL to achieve comparable performance before air activation. The coordination between DDT and LiTFSI increases the concentration of dopants in the HTL bulk, reduces their accumulation at interfaces, and enhances the structural integrity of the HTM under wetting, heat and light stress. The best devices exhibit an efficiency of 24.6% and retain 90% of peak performance under continuous illumination for 1,000 h. We also revealed the great influences of DMSO-molecule-control on the enhancement of perovskite absorber, including the crystal orientation, grain size, surface roughness, photo-response, carrier lifetime, contact potential difference superior charge transport as well as reduced carrier recombination and decreased trap densities. Because of these step-by-step works, we recently obtained big breakthroughs on the synthesis of perovskite bulk. The associated PSCs deliver 25% efficiency without post-passivation treatment and retained 90% of peak performance after 2 years in ambient air.

Biography:

Dr. Xu Liu obtained his PhD in the School of Photovoltaic and Renewable Energy Engineering of UNSW in 2018, and the ACAP Research Fellow, currently DECRA Fellow and Postdoctoral Fellow at UNSW. Dr. Xu Liu has focused his research on low-cost, high-efficiency thin film solar cells and tandem solar cells for more than eight years, researching on various energy materials, initially using earth-abundant chalcogenides semiconductor materials, and then inorganic-organic perovskite materials for solar photovoltaic applications.

Invited Talk

Enabling Future Distributed Energy Systems using Data

Reza Razzaghi*
Monash University, Australia

Abstract

Low Voltage (LV) distribution networks are undergoing unprecedented changes with energy users rapidly adopting rooftop solar systems, energy storage technologies, and electric vehicles. Switching from traditional one-way networks to bidirectional ones, necessitates a more detailed understanding of the capacity of assets at the LV level and a better visibility into these networks. However, in general, LV networks are characterised by low levels of visibility due to limited access to and existence of network data and network connectivity models. The lack of LV visibility can result in uncertainty in network operation and planning decisions, leading to conservative capacity management practices and inefficient utilisation of Distributed Energy Resources and network infrastructure.

This talk will present findings of our recent industry-supported research projects on low-voltage network visibility. It will cover applications of smart meter data analytics to estimate network topology and impedances, fault detection, and distribution transformer monitoring.

Biography:

Dr Reza Razzaghi leads the Distributed and Intelligent Power Systems group of Monash University. His research aims to develop smart grid solutions to deliver sustainable, affordable and secure electricity supply efficiently. He is particularly interested in two overarching research areas: (1) Smart and sustainable energy systems, and (2) Improving the reliability of power supply for communities. Dr Razzaghi has secured more than $24M AUD research funding from a combination of Australian Research Council, Australian Renewable Energy Agency and industry. He has been the recipient of the prestigious Discovery Early Career Research Award fellowship from Australian Research Council, the 2019 Best Paper Award of the IEEE Transactions on Electromagnetic Compatibility and the Basil Papadias Best Paper Award from the IEEE PES Power Tech conference. He received the PhD degree in Electrical Engineering from the Swiss Federal Institute of Technology of Lausanne (EPFL), Lausanne, Switzerland in 2016.

Invited Talk

Controlling Power Systems in the Transition to Net-Zero: A Paradigm Shift using Negative Imaginary Systems Theory

Elizabeth Ratnam*
Monash University, Australia

Abstract

The electric grid that we have known for more than a century must transform to meet the global challenge of climate change. The global transformation of power systems is underpinned by the need to displace fossil fuel-fired generation with renewable energy technologies (e.g., solar and wind technology backed by batteries) and to electrify everything where possible (e.g., the transportation sector starting with electric vehicles). This transformation of power systems is in the face of the requirement to continue operating safely, reliably and stably and achieving this in an economic way. Future electric grids must also be able to withstand more severe and frequent weather events resulting from climate change. In this presentation, we explore this problem through new approaches in control engineering that overcome unnecessary limitations on infrastructure utilisation.

Biography:

Dr Ratnam was awarded a BEng (Hons I) degree in Electrical Engineering in 2006, and a PhD degree in Electrical Engineering in 2016, from the University of Newcastle, Australia. She subsequently held postdoctoral research positions with the Center for Energy Research at the University of California San Diego, and at the University of California Berkeley in the California Institute for Energy and Environment (CIEE). During 2001–2012 she held various positions at Ausgrid, a utility that operates one of the largest electricity distribution networks in Australia. From 2018, Dr Ratnam held a Future Engineering Research Leader (FERL) Fellowship at The Australian National University (ANU), where she was a Senior Lecturer in the ANU School of Engineering, and was a Sub-Dean for Educational Programs at the College of Engineering & Computer Science. From 2024, Dr Ratnam is an Associate Professor at Monash University in the Department of Electrical and Computer Systems Engineering. She is also a Senior Member of IEEE and a Fellow of Engineers Australia. Her research interests are in developing new paradigms to operate power systems with a strong focus on creating a resilient carbon neutral power grid.

Oral Talk

Substrate Optimization for Reproducible and Efficient p-i-n Perovskite Solar Cells

Yihao Wang[1]*

University of New South Wales, Australia

Abstract

We would like to introduce easy and effective methods for optimizing substrates in p-i-n perovskite solar cells (PSCs). We optimize the transparent conductive layers, use new hole transport strategies, and add interfacial layers to address the reproducibility issue of high-efficiency inverted perovskite solar cells. For example, with the $Cu_2(Tu)Br_2$ interfacial layer on PTAA, perovskite can be processed without additional DMF prewetting step, which not only improves the processing reproducibility and scalability, but further improves perovskite absorber uniformity, thickness, and structural and electrical properties. This, in turn, resulted in much better device performance, especially on the open circuit voltage, increasing from 1.07 ± 0.08 V to 1.17 ± 0.05 V. As a result, the substrate-optimized devices achieved 25.5% efficiency on 1.53 eV bandgap perovskite absorber and non-doped PTAA. Compared with control devices, substrate-optimized ones had significantly improved uniformity and reproducibility with much narrower device performance variation and high yield. Moreover, it was found that our new interfacial layer materials, such as the $Cu_2(Tu)Br_2$, also facilitated to tuning of the perovskite bottom and top surface favorably towards an improved charge carrier extraction at the HTL/absorber and absorber/ETL side.

In addition, the added interfacial layers had negligible harm to the device's long-term stability. Unencapsulated devices retained 95% of their initial efficiency after 1000 hours at 85 °C, and 100% of their initial efficiency after 1000 hours of light soaking under the open circuit condition. Having all these merits, the proposed new strategies for inverted PSCs effectively tackle one of the most critical reproducibility issues in p-i-n PSCs and may facilitate the upscaling development of high-efficiency and high-yield p-i-n PSCs for the industry.

Biography:

Dr. Wang Yihao Graduated from UNSW, with the specialties including Energy research of Silicon and Perovskite Solar Cells.

Plenary Talk

Electrochemical water splitting catalysis on 2D nanomaterials

Ziqi Sun*

Queensland University of Technology, Australia

Biography:

Prof. Ziqi Sun, a Fellow of the Higher Education Academy and Fellow of the Royal Chemical Society, is currently a full professor, ARC Future Fellow, and ARC Industry Mid-Career Fellow at Queensland University of Technology (QUT), Australia. His research interests include the rational design of multiscale-ordered metal oxide nanomaterials and bio-inspired inorganic smart nanomaterials for sustainable energy and environmental technologies, such as rechargeable batteries, oil-water separation, and catalysis.

Prof. Sun received his PhD in advanced structural ceramics from the Institute of Metal Research, Chinese Academy of Sciences, in 2009. After a year as a NIMS Postdoctoral Fellow in Japan, working on solid oxide fuel cells, he joined the University of Wollongong (UOW), Australia, in 2010, and then moved to QUT as a faculty member in 2015. He has published over 200 peer-reviewed articles in leading journals, including Nature Nanotechnology, Nature Communications, Journal of the American Chemical Society, and Advanced Materials.

Prof. Sun serves as the Editor-in-Chief of Sustainable Materials and Technologies (Impact Factor 9.6), Principal Editor of the Journal of Materials Research (MRS), and Handling Editor of Physics Open.

Session: Renewable Energy Systems and Standards

Keynote Talk

Design and Development of Next Generation Light-Driven Biotechnologies: From Atomic to Industrial Scale

Ben Hankamer*

The University of Queensland, Australia

Abstract

The international community is facing combined challenges of operating within our planetary boundaries, meeting the UN SDG 2030 targets, and delivering net-zero emissions by 2050. The cost of delivering CO_2 neutrality alone is estimated to be ~US$144 Trillion by 2050 or >US$5.5 trillion per year. Yet failure to solve these challenges risks economic, social, political, climate, food, water, and fuel security. This highlights the importance of fast-tracking new robust, circular economy solutions. The Centre for Solar Biotechnology is developing next-generation light-driven biotechnologies that tap into the vast energy resource of the sun to produce a broad range of products. Biotechnologies designed to simultaneously deliver economic, social, and environmental benefits are identified using integrated Techno-Economic and Lifecycle Analysis (TELCA). These are refined further through simulation guided design. Facilities simulated include 500 ha renewable fuel processes and multiproduct biorefineries, through to 1 ha high value recombinant protein production facilities. This *simulation guided design* approach informs process optimization work including atomic resolution cryo-electron microscopy and sequential CRISPR focused on the development of next-generation cell lines with improved light capture efficiency, light-driven recombinant protein and small molecule synthesis, high-throughput robotic nutrient and light optimization, bioprocess optimization and pilot scale trials to fast-track systems optimization, de-risk scale up and develop robust business cases for the chosen products and services.

Biography:

Prof. Ben Hankamer is a renowned scientist with a PhD from Imperial College of Science, Technology and Medicine, London, UK, completed in 1994. Following his PhD, he held a Postdoctoral Fellowship and Research Lectureship at the same institution. Since 2002, Prof. Ben Hankamer has been a Chief Investigator at the Institute for Molecular Bioscience, The University of Queensland. In 2009, he was honoured as an Eisenhower Fellow. From 2013 to 2015, he received the prestigious ARC Discovery Outstanding Research Award Fellowship.

In 2017, Prof Ben Hankamer became the Director of the Centre for Solar Biotechnology, where he leads pioneering research initiatives in next-generation light-driven biotechnologies.

Invited Talk

Micro-Hydropower Energy Recovery in Existing Infrastructure: Concept, Resource Assessments & Pilot Demonstrations

*Aonghus McNabola**
RMIT University, Australia

Abstract

Existing infrastructure systems with significant water consumption are associated with large energy resource demands. These include drinking water supply systems, irrigation systems, energy production facilities, wastewater treatment facilities, and mining operations, among others. This paper outlines the development of a concept for the low-cost recovery of hydraulic energy lost within existing infrastructure systems, and its conversion to micro-hydropower to reduce net energy demands and related emissions. The paper outlines an assessment of available hydropower energy resources of this nature at national level in the EU, and the demonstration of the technology across numerous differing infrastructure systems. The result of the technology demonstrations show that micro-hydropower energy recovery can be implemented using pump-as-turbine systems across a wide range of settings at 5-15 times less than conventional hydropower machinery. The results also demonstrate that the technology can reduce local energy consumption significantly. At national level the scale of these available energy resources were assessed as ranging between 482.3 and 821.6 GWh divided across Ireland, Northern Ireland, Scotland, Wales, Spain, and Portugal. These energy resources were also and distributed across the drinking water (43–67%), irrigation (51–30%), and wastewater (6–3%) sectors. Micro-hydropower energy recovery in existing private industrial settings in Spain were estimated to possess 3.31 and 3.54 MW. This research highlights that economically viable savings in energy consumption can be achieved using pump-as-turbine based micro-hydropower technology, and that the available geographic locations and setting types for the implement of same is widespread.

Biography:

Prof. Aonghus McNabola graduated from Trinity College Dublin with a bachelor degree in Civil and Environmental Engineering, and a PhD in applied fluids mechanics and air pollution. He specializes in research addressing energy efficiency and environmental impact within the built environment and applied fluid mechanics domains. He has been awarded >40 research contracts in Europe including several as coordinator from Horizon Europe. He worked as a Professor in Energy and the Environment at Trinity College Dublin for >16 years. He is presently the Deputy Dean International and Professor of Energy and Environmental Engineering at RMIT University, Melbourne.

Invited Talk

Pulping Modification on Ordered Conversion of Biomass in Supercritical Water: The Systematic Study of Experiment Evaluation, Sulfur and Heavy Metals Transformation, and Thermodynamic Analysis

Bin Chen*

Xi'an Jiaotong University, China

Abstract

The environmental pollution caused by the overuse of fossil fuels has been hindering social development. Under this background, a green and low-carbon energy revolution to reduce dependence on fossil fuels and promote sustainable economic and social development is crucial. Biomass is second only to coal, oil and natural gas in the global energy supply. The development of biomass energy can reduce the dependence on fossil fuels, which has become one of the strategic directions of energy technology development. However, biological methods and traditional thermochemical technologies, such as pyrolysis, gasification, and hydrothermal liquefaction, exhibited low utilization efficiency and severe environmental impacts. Supercritical water gasification (SCWG) has significant advantages in efficiently producing high value-added products without drying process and without producing NO_x, and SO_x. Our team explored the effects of different operating conditions on the characteristics of biomass SCWG. Through the characterization of the three-phase products after gasification, a biomass supercritical water conversion mechanism based on the three-phase products was constructed. However, lignocellulosic biomass have low density and high hydrophilicity. Free water is fixed in the cell structure of biomass, increasing the viscosity of slurry reduce the pulping property. High concentration slurry is the key factor to realize self-heating in SCWG hydrogen production system. Therefore, we firstly discussed the possibility of preparation of high concentration slurry by alkaline and salt method and found that the molecular structure of biomass can be reshaped by alkali and salt pulping. In addition, the transformation path in pulping process was constructed and discussed by using the method of kinetics. Secondly, the kinetic model of gasification process was established to clarify the specific reaction path and transformation mechanism, which was helpful to clearly regulate the specific product in the situ. Moreover, sulfur is widely present in all kinds of biomass, which seriously restricts the clean utilization of fuel. Based on the research idea of combining experiment and DFT, the migration and transformation mechanism of sulfur-containing compounds in the SCWG was revealed, the role of supercritical water in the organic sulfur transformation was found, and the competitive reaction mechanism of H_2O, H_2, ·H/·OH in the organic sulfur transformation during the supercritical water gasification process was clarified. It is also worth noting that heavy metals are the most harmful polluting components in organic solid waste and are easily ignored factors in the SCWG. The forms of heavy metals in the gasification process are constantly changing, so it is very important to study the stabilization technology of heavy metals from liquid state to solid state and from active state to stable state for realizing the harmless treatment and resource utilization of supercritical water of biomass. Finally, through thermodynamic modeling and analysis, the most suitable thermal recycling scheme of biomass was analyzed from the perspective of energy and effective energy to achieve the maximum utilization of exergy, and the life cycle analysis and comprehensive economic calculation of the system were carried out. It is of great significance to realize the economic output of the system and promote the industrial application. The above studies fill some gaps in the current knowledge about biomass SCWG and aim to provide valuable insights into the clean utilization of biomass.

Biography:

Prof. Bin CHEN received his Ph.D degree in thermal engineering at Xi'an Jiaotong University, 2002. During 2002-2004, he worked as JSPS (Japan Society for Promotion Science) postdoc research fellow in Tokyo University. Now he is full professor, working as vice-director of State Key Laboratory of Multiphase Flow in Power Engineering, Xi'an Jiaotong University. For more than decades, he has devoted his efforts to the research of heat transfer and fluid flow in efficient and clean utilization of fossil energy as well as large-scale and low-cost conversion of renewable energy, especially in supercritical water gasification for hydrogen production by biomass and organic wastes. Up to now, he has published over 150 peer-reviewed journal papers and was invited for more than 30 keynote speeches.

Keynote Talk

Renewable Energy Systems: Current Status in the World and Prospects

*Soteris A. Kalogirou**
Cyprus University of Technology, Cyprus

Abstract

This presentation examines the current status of renewables in the world. The presentation starts with some facts about the climate change, global warming and the effects of human activities such as the burning of fossil fuels on the climate problem. It then examines the current status of conventional resources of energy such as oil, coal and natural gas and their reserves based on current consumption and known resources, followed by a general outline of the status of renewables in the world, which includes the shares with respect to conventional fuel use for electricity and power and jobs created. Then the basic forms of renewables are examined in some detail, which include solar thermal, both for low and high temperature applications, photovoltaics, hydro power, onshore and offshore wind energy systems and biomass/biofuels. In all these the basic technology is presented followed by the current status as well as the prospects of the technology and new research findings.

Biography:

Professor Soteris Kalogirou is a distinguished faculty member in the Department of Mechanical Engineering and Materials Sciences and Engineering at the Cyprus University of Technology, Limassol, Cyprus. He holds both a Ph.D. and the title of D.Sc., and he is a Fellow of the European Academy of Sciences, a Founding Member of the Cyprus Academy of Sciences, Letters and Arts, a Member of Academia Europaea, and a Fellow of the International Artificial Intelligence Industry Alliance. With over 35 years of experience, Professor Kalogirou has been actively engaged in research across various areas of solar energy, including flat plate and concentrating collectors, solar water heating, solar steam generating systems, desalination, photovoltaics, geothermal energy, and absorption cooling.

He has authored numerous publications, including books, book chapters, and articles in international scientific journals and refereed conference proceedings. Professor Kalogirou serves as Editor-in-Chief of *Renewable Energy* and Honorary Editor of *Energy*, and is a member of the editorial boards of twenty other journals. He is the editor of *Artificial Intelligence in Energy and Renewable Energy Systems* (Nova Science Inc.), co-editor of *Soft Computing in Green and Renewable Energy Systems* (Springer), and editor of *McEvoy's Handbook of Photovoltaics* (Academic Press of Elsevier). Additionally, he is the author of *Solar Energy Engineering: Processes and Systems* and *Thermal Solar Desalination: Methods and Systems*, both published by Academic Press of Elsevier.

Session: Policy, Economics, and Commercialization

Invited Talk

Emerging Technologies and Pathways to Decarbonise Australian Heavy Industry

Alfonso Chinnici*
University of Adelaide, Australia

Abstract

The talk will showcase prospective pathways and emerging technologies poised to accelerate Australia's heavy industries towards a net-zero future. Recent R&D activities at the University of Adelaide, supported by the Heavy Industry Low-carbon Transition CRC, will be synthesized to elucidate how common challenges across iron/steel, alumina/aluminium, and cement/lime industries are being leveraged for technology acceleration and enhanced circularity in lowcarbon production processes. Exploration of utilisation opportunities for alternative energy carriers like hydrogen through emerging beneficiation, calcination, and direct reduction technologies will be discussed, together with novel thermal-based processes aiding in developing alternative carbon capture, utilisation, and storage solutions. Fundamental challenges associated with hydrogen utilisation as a fuel or reductant will also be briefly discussed, along with recent research efforts to overcome these obstacles. Overall, the talk aims to provide insights into the transformative potential of emerging technologies in driving sustainable practices and achieving net-zero emissions across Australia's heavy industries.

Biography:

Dr. Alfonso Chinnici is a distinguished Senior Lecturer in Sustainability, Net-Zero, and Energy Innovation at the University of Adelaide and an executive member of its Centre for Energy Technology. Utilizing cutting-edge research methodologies and fundamental engineering principles, he advances ground-breaking clean energy technologies, with a focus on transitioning to a net-zero economy. His work centers on the production and application of hydrogen and alternative energy carriers, as well as the decarbonization of carbon-intensive industries, energy networks, and transportation systems.

Dr. Chinnici's expertise spans sustainable heat and mass transfer, reaction engineering, combustion science, solar thermal energy, circular economy practices, and environmentally friendly metal and mineral processing techniques. He has published over 80 papers in leading international journals, holds four patents, authored 20 commissioned industry reports, and secured over $10 million in R&D funding. Currently, he holds a leadership role in the Australian Heavy Industry Low-Carbon Transition CRC, working closely with industry leaders on impactful net-zero initiatives. Previously, he was an investigator at the Future Fuels CRC and has contributed to international initiatives such as the Mission Innovation ARENA program on green fuels and the Global Net Zero Industries Mission. In addition to his academic work, Dr. Chinnici has served as a high-profile consultant for organizations like the International Energy Agency and the Government of South Australia, providing expert advice on hydrogen, ammonia, green metals, and critical mineral supply chains.

Oral Talk

Identifying Challenges of the Hydrogen Economy: A Global Approach to Low-Carbon Strategies

Minhee Son *

National University of Singapore, Singapore

Abstract

Hydrogen is currently considered an important energy source for low-carbon strategies, as many countries have announced their own national hydrogen strategies and roadmaps. National policies for promoting the hydrogen economy vary based on each country's hydrogen production methods and low-carbon strategies. Hydrogen can be classified into green, blue, and white hydrogen based on its production method, and most technologies for reducing carbon emissions are still in the early stages. Additionally, the hydrogen economy requires international collaboration for the production and distribution of hydrogen. The methodology of this study is based on a historical policy literature review from the IEA Energy Policy Database. It aims to provide an initial proactive mapping of the status of hydrogen economy development in each country, categorized by the type of hydrogen and applications (such as vehicles, power generation). The analysis revealed that hydrogen-related policies began in the 1990s with the aim of reducing air pollution. These policies eventually promoted the commercialization of hydrogen fuel cell vehicles in many countries, particularly in Japan and South Korea. However, while the production and development of green and blue hydrogen, as well as white hydrogen, are being pursued in many countries, practical examples are still limited due to various challenges. In conclusion, feasible policies and clear R&D targets are necessary to actively implement hydrogen. This study helps understand the status of hydrogen applications in countries promoting the hydrogen economy as part of their global low-carbon strategies and provides insights into how to introduce hydrogen in a sustainable way.

Biography:

Dr. Minhee Son graduated from Graduate School of Energy and Environment (KU-KIST GREEN SCHOOL) of Korea University in Seoul, South Korea with specialties including energy policy research with cost bene-fit analysis and life cycle assessment. Currently, she is working at the Energy Studies Institute at the National University of Singapore as a research fellow, focusing on projects related to decarbonization strategies and carbon accounting.

Invited Talk

Outcomes of Time-Matching in Renewable Energy PPAs and Implications for Planning and Policy

Anna Bruce*

University of New South Wales, Australia

Abstract

Businesses and coalitions aiming to provide leadership in renewable energy procurement are going beyond net 100% targets and committing to renewable energy matched every hour with demand ('24/7 Carbon Free Energy' (CFE)). However, the costs, emissions and risk implications of this novel approach are not well understood. It is anticipated that 24/7 CFE procurement would drive additional investment in the storage and demand side flexibility needed to support renewables integration, but this has not previously been tested for Australia. This presentation will assess the opportunities and challenges of 24/7 CFE in the Australia context through: 1) stakeholder engagement on the role of time matching and certification in Australia, in particular under the new Renewable Energy Guarantee of Origin scheme; 2) analysis of cost, emissions and risk outcomes of time-matched renewable energy contracting; and 3) modelling of the impact of time-matched PPAs on investment in clean firming in the Australian National Electricity Market.

Biography:

Dr. Anna Bruce is an Associate Professor in the School of Photovoltaic and Renewable Energy Engineering and Joint Director (Engineering) at the Collaboration on Energy and Environmental Markets (CEEM) at UNSW Sydney. She leads CEEM's research theme in Distributed Energy Systems, distributed generation and demand-side participation. Her research includes modelling, analysis and integration of renewable energy and distributed energy resources into electricity industries; energy access in developing countries; and energy policy and regulation. Anna is currently leading one of five subprojects in the ARC Hub for Integrated Storage Solutions, the Racefor2030 24/7 TRUZERO Project, and the Sun Spot Solar Assessment Tool upgrade. Other recent projects include Energy Data for Smart Decision Making through the Australian Government's Smart Cities and Suburbs Program, and Integrated Smart Home Energy Management Technologies through the CRC-P program. Anna contributes to the IEA's PV Power Systems programmes and leads the APVI's Solar Mapping and Data project.

Invited Talk

Legal and Economic Aspects of the Energy Transition in Poland, Especially in the Context of EU Regulations

Aneta Suchoń*

Adam Mickiewicz University, Poland

Abstract

Poland is a country where the energy market has undergone major changes in recent years. There is a growing interest in renewable energy sources. Not only state authorities, but also entrepreneurs and individuals are involved in the transition. The article assesses whether, and to what extent, regulatory policies encourage investment in renewable energy, energy storage and energy efficiency. It will also assess the energy transition and identify directions for the further development of renewable energy in Poland and the European Union. First, however, a brief overview of the development of European Union legislation on renewable energy and energy efficiency will be given. Reference will be made to Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources, Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast), Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency states that increasing the EU's energy efficiency target can lead to lower energy prices and can also have a decisive impact on the reduction of greenhouse gas emissions (a reduction of these gas emissions of at least 55% below 1990 levels is to be achieved in the coming years). It is worth mentioning that Article 194 of the Treaty on the Functioning of the European Union stipulates the need to ensure security of energy supply in the European Union, to promote energy efficiency and energy saving and to develop new and renewable forms of energy. The paper then focuses on Polish legislation. The Europeanisation of legislation is evident in certain legal solutions. Reference is made to the Polish Act of 20 February 2015 on Renewable Energy Sources, the Act of 20 May 2016 on Energy Efficiency Financing of Renewable Energy Enterprises. The issue of energy cooperatives and civil energy communities is considered.

The author concludes that the energy transition has made significant progress in recent years in Poland. The participation of prosumers, in the energy market is increasing. Undoubtedly, the support of renewable energy investments from EU funds should be evaluated positively. Wind and solar energy could become increasingly popular thanks to innovative solutions and the possibility of installing them on roofs or in open spaces. An opportunity for the development of biogas plants is provided by the Act of 13 July 2023 on Facilitating the Preparation and Realisation of Investments in Agricultural Biogas Plants and their Operation.

Biography:

Aneta Anna Suchoń is a Polish lawyer and professor at the Department of Agricultural Law, Faculty of Law and Administration, Adam Mickiewicz University in Poznań. She holds a PhD in legal sciences and has expertise in the legal aspects of agriculture and cooperatives. She graduated from Adam Mickiewicz University in 1997 and earned her habilitation in 2016 with a thesis on agricultural cooperatives. Her research focuses on agricultural land leases, real estate management, and legal instruments in agriculture. Professor Suchoń also lectures on agricultural law and environmental protection and has taught internationally through the Erasmus program.

Day 2, 14th Novemeber, 2024

Innovations in Energy Storage and Sustainability

Plenary Session

State-of-the-Art and Emerging Materials for Energy Storage Technologies

Marzi Barghamadi*
CSIRO, Australia

Abstract

Lithium batteries are a crucial component of the electronic devices used in our everyday life, from small devices to EVs. The need for reliable renewable energy sources to meet net-zero targets has increased the demand for safe, high energy, and long-lasting batteries. This is demonstrated by the cathode materials market growing from $28.44B to $32.02B (USD) in only the past year, with forecasted growth to 2030 reaching $67.25B. This trend is similarly reflected in predicted growth in the anode materials market, which is anticipated to reach $41.08B by 2030.

Electrode materials impact all battery specifications. While some of the new advanced electrodes offer higher capacity, the safety and cycle life, due to materials degradation, is yet to be fully addressed. Additionally, more sustainable and environmentally friendly production is becoming more important due to enhanced customer environmental awareness and stricter regulations. During this session, an overview of the current and emerging battery electrode materials technology, including their advantages and challenges, will be discussed.

Biography:

Dr. Marzi Barghamadi is a Research Scientist at CSIRO Manufacturing, leading the Battery Materials and Design Team. The team includes scientists, postdoctoral fellows, and students working on different aspects of battery materials. They support Australian and international industries in solving scientific and technical challenges and contribute to the education of future scientists in this area. Her research interests include electrolyte formulation and optimisation (including ionic liquids), advanced electrode fabrication/composition, cell electrochemical studies, and customised cell fabrication for both lithium metal and lithium-ion batteries. Marzi has received multiple prestigious awards, such as the 2023 ATSE David and Valerie Solomon Award and the 2020 L'Oréal-UNESCO For Women in Science Fellowship.

Nanocarbon Materials for Emerging Battery Electrodes and Real-time Characterization of Reaction Kinetics

Jang-Kyo kim*

University of New South Wales, Australia

Abstract

This talk reports the recent development of novel electrodes for high-performance rechargeable batteries, such as Li-ion, Li-sulfur, Li-metal, Na-ion and Na-metal batteries. An in-depth discussion is made of the synthesis of composite electrodes consisting of active materials and nanocarbon supporters and substrates, including graphene, carbon nanotubes and electrospun carbon nanofibers. The influences of essential structural and functional parameters, such as pores and cavities of various sizes and distributions, surface area, graphitizing sacrificial metals, activation and functionalizing agents, on the characteristics of nanocarbon materials and the electrochemical performance of the electrodes and batteries are discussed. Special focus is placed on in-depth demonstration of the underlying reaction mechanisms and the kinetics probed by real-time characterization, including in-situ TEM and in-situ XRD, depth profiling XPS and SIMS, together with theoretical analyses based on the density functional theory and molecular dynamic simulations.

Biography:

Graduated from the University of Sydney with PhD in Mechanical Engineering (1991), Prof. Kim has well over 30 years of dedication to academic excellence, initially with ANU and until recently at HKUST and now UNSW. Kim served as Associate Dean of Engineering (Research and Graduate Studies), Director of Finetex-HKUST R & D Center and Director of Advanced Engineering Materials Facilities while at HKUST. Kim was the Editor of Composites Part A (2012-23) and is currently Associate Editor of Aerospace Science & Technology and Energy Materials & Devices, apart from sitting in the editorial/advisory boards of 12 refereed journals in advanced materials, including Nanoscale Horizons, Energy Storage Materials, and Nano Materials Science. Kim was the President of the Asian-Australasian Association for Composite Materials (2009-10). He has been honored with many awards, including the Tan Chin Tuan Exchange Fellowship, numerous Best Paper Awards from international conferences together with graduate students, HKUST President Cup Silver Medal, and the Life-long AchievementAward.

As an internationally renowned scholar, Kim is one of the leading authorities in the field of nanocomposites and nanostructured energy materials. He has pioneered in the development of multifunctional composites made with 2D and nanocarbon materials for polymer dielectrics, EMI shielding, flexible electronics, sensors, cooling aerogels, and emerging rechargeable batteries and supercapacitors. In particular, his group was among the first who devised in-situ TEM to probe real time the electrochemical reactions taking place in battery electrodes. In recognition of his scholarly achievements and outstanding contributions to professional societies, Kim has been elected as Fellows of prestigious academy and learned societies, including the HKAES, the RAeS, the RSC and the HKIE. The 2023 Stanford University's Top 2% Scientists List identified him as the top 0.05% most influential scientist in the subfield of Materials in both career total and single year. Kim has been named the Highly Cited Researcher by Clarivate.

Graphene-coated Ni-Cu Alloys for Durable Degradation Resistance of Bi-polar Plates for Proton Exchange Membrane Fuel Cells

Raman Singh*
Monash University, Australia

Abstract

Bipolar plates, a critical component, of proton exchange membrane fuel cell (PEMFC) are constructed out of alloys of Ti, Pt, Cr, or graphitic materials that have limitations. Electrical conductivity, cost and corrosion resistance are among the critical considerations for bi-polar plate material. Graphene, which possesses impressive conductivity and toughness, is an attractive option as coating on metallic substrates of PEMFC bipolar plates. This study investigated corrosion resistance and its durability due to graphene developed by chemical vapour deposition on a pure Ni-Cu alloy and a commercial Ni-Cu alloy in 0.5 M H_2SO_4 environment, with a view to exploring use of graphene coated Ni-Cu alloys for the construction of PEMFC bipolar plates. The graphene coating on the pure alloy showed remarkably superior corrosion resistance than the commercial alloy which is attributed to the former's ability to develop considerably defect-free graphene.

Graphene has triggered unprecedented research excitement for its exceptional characteristics. The most relevant properties of graphene as corrosion resistance barrier are its remarkable chemical inertness and impermeability and toughness, i.e., the requirements of an ideal surface barrier coating for corrosion resistance, thus, an interest in graphene coating as a disruptive approach to corrosion mitigation. However, the extent of corrosion resistance due to chemical vapour deposition (CVD) graphene coatings has been found to vary considerably in different studies. The author's group demonstrated the ultra-thin graphene coatings developed on copper and nickel by CVD to improve corrosion resistance of the metals by two orders of magnitude in aggressive aqueous chloride environments. In contrast, other reports suggest the graphene coating to actually enhance corrosion rate of copper, particularly during extended exposures. Author's group has investigated the reasons for such contrast in corrosion resistance due to graphene coating as reported by different researchers, and on the basis of the findings, they have succeeded in developing multilayer graphene coatings that conferred durable corrosion resistance to copper and nickel in the aggressive chloride environment. However, developing graphene coating on the most common engineering alloy, mild steel by CVD is a non-trivial challenge. The presentation will discuss the challenges, and their successful circumvention that enabled graphene coatings on mild steel, and presents results demonstrating durable and remarkable corrosion resistance of graphene-coated mild steel.

Biography:

Professor Raman Singh's primary research interests are in the relationship of Nano/microstructure and Environment-assisted degradation and fracture of metallic and composite materials, and Nanotechnology for Advanced Mitigation of such Degradations. He has worked extensively on advanced materials (e.g., graphene) for corrosion mitigation, stress corrosion cracking, and corrosion-mitigation. He is a senior professor at Monash University, Australia. He is/was a Guest Professor at ETH Zurich, Switzerland (2020, 2023, 2024), US Naval Research Lab, Indian Institute of Science, and University of Connecticut. Prof Singh's professional distinctions and recognitions include: Guest Professor of ETH Zurich, Editor of a book on Cracking of Welds (CRC Press), Lead Editor of a book on Non-destructive Evaluation of Corrosion (Wiley), Editor-in-Chief of an Elsevier and two MDPI journals, leader/chairperson of a few international conferences and numerous plenary/keynote lectures at international conferences, over 285 peer-reviewed international journal publications and 15 book chapter, and several competitive research grants. He has supervised 60 PhD students.

Session: Advanced Materials for Energy Storage

Keynote Talk

What's Hot and What's Not: Thermal Batteries Powering the Future

Gary Rosengarten*

RMIT University, Australia

Abstract

As we strive to decarbonise our energy systems, the biggest and -as yet- unsolved challenge lies in efficiently managing, utilising and delivering heat. Heating and cooling accounts for about half of the global final energy consumption and more than 40% of global energy-related carbon dioxide emissions. As we fully electrify our energy distribution and conversion systems, it makes sense to be able to store energy, which has an end use as heating or cooling, in thermal batteries. Thermal batteries are not only considerably cheaper than electrochemical batteries, but also have significantly lower embodied energy due to the use of basic abundant materials. In this presentation I will discuss some of the technology we have worked on to create renewable and reliable thermal energy for domestic and industrial applications. These include cheap and safe thermal batteries coupled to heat pumps for residential and commercial applications, and solar PV driven sustainable high temperature thermal storage for industrial heat up to 700°C.

Biography:

Professor Gary Rosengarten is Director of the Sustainable Technologies and Systems Enabling Impact Platform at RMIT University, and leader of the Laboratory for Innovative Fluid Thermal Systems in Mechanical Engineering. Before deciding on an academic career, he spent 3 years at Australia's National research laboratory, CSIRO, and 2 years as an Engineering consultant in sustainable building design. He completed a double honours degree in Physics and Mechanical Engineering at Monash University and a PhD in Mechanical Engineering at the University of New South Wales. He applies his research expertise in thermos fluids and energy systems, to help solve a wide variety of problems, particularly in energy storage, solar energy, thermal control, energy efficiency, and biosystems, working closely with interdisciplinary teams from academia and industry. He has developed solar absorbers using radiative selective surfaces and is one of the pioneers of solar spectral splitting using volumetric absorbers. His current research project focus includes collaborating with industry to develop distributed thermal batteries coupled to heat pumps for domestic thermal loads, large scale thermal storage for industrial heat, and droplet/surface interactions for high heat flux applications. He has attracted over 20 million dollars of research funding, published over 200 refereed journal articles, and has 6 patents.

Keynote Talk

Interfacially Engineered Graphene Inks for Energy Applications

Namita Roy Choudhury*
RMIT University, Australia

Abstract

The use of graphene has facilitated many unique features to energy devices, from transparent batteries to flexible solar cells and hyper-long-life supercapacitors. Due to the high specific area and hydrophobic nature of graphene, it is extremely difficult to fabricate graphene based inks without the re-stacking and re-aggregation of graphene sheets. Moreover, due to the lack of scalable and cost-effective fabrication techniques, it is still a great challenge to bring any advanced graphene-based technologies from laboratories to practical applications. This talk will cover a promising and versatile platform for the production and patterning of graphene inks into functional energy devices based on the interfacial engineering approach such as exfoliation-induced non-covalent functionalization [1-7] of graphene. Aqueous dispersions of pristine graphene are produced via the scalable liquid-phase exfoliation process, employing various types of electroactive materials as dispersing agents. These electroactive dispersants non-covalently functionalize the exfoliated graphene flakes and offer synergistic effects for stabilizing graphene dispersions (to formulate printable inks) and inducing intermolecular charge transfer (to improve its electrochemical properties). Dispersant–assisted and dispersant–free graphene inks have been successfully produced and printed into functional energy devices, including conductive circuits for flexible electronics, printed electrodes for supercapacitors, and electrocatalyst layers for fuel cells applications. The interfacial interaction between graphene and different amphiphilic electroactive dispersants has been investigated using various advanced characterization techniques, wherefrom, a fundamental understanding of the surface interactions between graphene and amphiphilic molecules is developed for engineering of stable graphene aqueous dispersions with printability. This work shows significant promise of printable graphene inks for potential practical applications.

Biography:

Prof. Namita Choudhury joined the School of Engineering of the RMIT University in 2018. Prior to that Choudhury was a Professor at University of Adelaide and University of South Australia for last 20 years. Her expertise lies at the interface of polymer science and nano/biomaterials with a focus on both fundamental and applied research. She conducts interdisciplinary research on engineered biomimetic materials, ion conducting hybrids, graphene based hybrids and tunable gels for energy and health applications. She has won many grants and currently is the Chief Investigator of major collaborative projects including Industry Hubs with interdisciplinary team of national, international and industry partners. An author/co-author of >300 publications, including 5 recent patents, she has trained 30 PhD students and mentored a large cohort of ECRs.

Invited Talk

Fighting Urban Overheating Using Advanced Super Cool Materials

Mattheos Santamouris*
University of New South Wales, Australia

Abstract

Counterbalancing the effects of urban heat island is a major priority for the scientific community. Several techniques have been proposed, developed and applied with quite high success. Proposed mitigation techniques and technologies involve the use of the so called cool materials presenting a high reflectivity in the solar spectrum together with a high thermal emissivity value, able to amortize and dissipate solar and thermal energy, the development of smart materials presenting high optical and thermal performances, the use of green spaces in the urban environment involving appropriate landscaping and design of urban green modules, the use of appropriate heat sinks presenting low temperature to dissipate the excess ambient heat involving the use of the ground, ambient air and water, appropriate shading and solar control of urban surfaces, and the use of cool and green roofs in urban buildings.

The present paper aims to analyze the actual developments in the field of urban heat island and local climatic change in cities and also present the development and the characteristic of new advanced urban mitigation techniques designed to counterbalance the phenomenon.

Biography:

M. Santamouris is a Scientia, Distinguished, Professor of High Performance Architecture at UNSW, and past Professor in the University of Athens, Greece. Visiting Professor : Cyprus Institute, Metropolitan University London, Tokyo Polytechnic University, Bolzano University, Brunnel University, Seoul University National University of Singapore, and UITM Univ Malaysia. Past President of the National Center of Renewable and Energy Savings of Greece. Editor in Chief of the Energy and Buildings Journal, Past Editor in Chief of the Advances Building Energy Research, Associate Editor of the Solar Energy Journal, E- Prime, Journal of Low Carbon and Sustainable Energy, and Member of the Editorial Board of 24 Journals. Editor of the Series of Book on Buildings, published by Earthscan Science Publishers. Editor and author of 20 international books published by Elsevier, Earthscan, Springer, etc. Author of 412 scientific articles published in journals. Reviewer of research projects in 29 countries including USA, UK, France, Germany, Canada, Sweden, etc. Ranked as the top world cited researcher in the field of Building and Construction by the Stanford University ranking system, for 2019-2022. Highly Cited Researcher in the Clarivate ranking for 4 continuous years. Ranked as no 538 researcher in the world in all scientific disciplines in the list prepared by Stanford University in 2021 for the 200000 more influential researchers. He has received many international awards.

Invited Talk

Metal-Air Batteries for Sustainable Energy Storage

Bing Sun*

University of Technology Sydney, Australia

Abstract

Owing to the superior high energy density, metal air batteries (e.g. lithium–oxygen batteries and sodium–oxygen batteries) have been considered promising advanced battery systems to meet today's stringent requirements as the power source for electric vehicles (EVs) and renewable energy storage. However, the development of metal air batteries is still constrained by several serious challenges, including uncontrolled side reactions, low energy efficiency and poor cycling life. The electrochemical performances of lithium/sodium–oxygen batteries await dramatic improvement in the design of porous oxygen cathodes, efficient electrocatalysts and stable metal anodes. Herein, we present the research outcomes from our group on materials innovation for rechargeable metal air batteries. First, the family of metal air batteries will be introduced. Second, the design of porous carbon-based materials and redox mediators for high-performance air (oxygen) cathodes will be discussed. Third, facile and effective methods to enhance the electrochemical performance of lithium/sodium metal anodes will be presented, including electrolyte optimization, three-dimensional current collector design, and dual interface engineering on lithium/sodium metal anodes.

Biography:

Dr Bing Sun is a senior lecturer at University of Technology Sydney (UTS). He completed his Ph.D. at UTS in 2012 and started his postdoctoral research in the Centre for Clean Energy Technology at UTS. His research interests focus on developing next-generation battery materials and technology for high-energy-density batteries. He is the recipient of ARC DECRA and ARC Future Fellowship. Dr Sun has published more than 120 peer-reviewed articles, including *Nat. Energy.*, *Chem. Rev.*, *Joule*, *Nat. Commun.*, *Sci. Adv.*, *Adv. Mater.*, *JACS*, *Angew Chem*., etc., with more than 10,100 citations and an h-index of 59.

Invited Talk

Lithium Metal Capacitors: High Energy and High Power for Next-Generation Energy Storage

Md. Joynul Abedin*
Monash University, Australia

Abstract

Lithium-ion capacitors (LICs) have long promised the best of both worlds—high energy and power density, coupled with long operational life. However, their widespread adoption has been hindered by the complexities of the pre-lithiation process. Lithium metal capacitors (LMCs), which replace the graphite anode with lithium metal, present a compelling alternative for next-generation energy storage—especially when the lithium metal is stabilized by a robust solid-electrolyte interface (SEI). Via a specialized formation process, the well-explored synergetic reaction between the $LiNO_3$ additive and controlled amounts of polysulfides in an ether-based electrolyte stabilizes the SEI on the lithium metal electrode. This innovation eliminates the need for pre-lithiation, delivering over 55 mAh g^{-1} at a 30C discharge rate with an activated carbon cathode, retaining 95% of their capacity after 8,000 cycles. Compared to commercially available LICs, LMCs demonstrate competitive—and potentially superior—performance with a far simpler manufacturing process. This approach opens up new possibilities for practical, high-performance energy storage by supporting versatile cathode chemistries and scalable production.

Biography:

Dr. Md Joynul Abedin earned his PhD in Mechanical & Aerospace Engineering from Monash University in 2020. His research integrated machine learning to advance the understanding of structure-processing-property relationships in one- and two-dimensional colloidal particles. Focusing on their use in thin films and electrodes, his work has significant implications for energy storage and thermal management technologies, positioning him at the forefront of innovative solutions in these critical areas.

Following his PhD, Dr. Abedin joined the Nanoscale Science and Engineering Lab (NSEL) at Monash University as a Research Fellow. In this role, he focuses on the development of high-performance lithium metal-based batteries and hybrid energy storage devices. Collaborating closely with both academic and industry partners, Dr. Abedin is dedicated to advancing these cutting-edge prototypes toward commercialization by improving their Technology Readiness Levels (TRL), bridging the gap between research and practical, real-world applications.

Recently awarded an AEA Accelerator Seed Grant, Dr. Abedin continues to push the boundaries of innovation in lithium metal-based hybrid energy storage systems. With over 40 peer-reviewed articles to his name, his research has garnered significant attention, amassing over 3,700 citations, and an h-index of 27.

Oral Talk

Developing High-Energy Density Magnesium-ion Batteries Through Hybrid Electrolyte Advancements

Sarah K. W. Leong*
University of Hong Kong, Hong Kong

Abstract

Magnesium-ion (Mg-ion) batteries offer a promising alternative to lithium-ion technology due to the material abundance and high theoretical energy density. However, conventional Mg-ion batteries with organic electrolytes often suffer from slow kinetics, safety concerns, and high costs. On the other hand, aqueous electrolytes exhibit a narrow electrochemical stability window that would lead to instability and parasitic side reactions. In this study, novel hybrid aqueous/organic electrolytes were developed to mitigate these limitations, facilitating dual Mg-ion storage at the cathode for high battery performance. First, we designed a quasi-solid-state $MgCl_2$-PEO electrolyte that suppresses proton insertion into the copper hexacyanoferrate (CuHCF) cathode by immobilizing the electrolyte's water network. The electrolyte exhibits a widened electrochemical stability window and a high ionic conductivity of 1.24 mS cm^{-1}. This results in an exceptional energy density of 264 Wh kg^{-1}, voltage up to 2.6 V, and remarkable low-temperature performance over 900 cycles. Subsequently, another hybrid $MgCl_2$-ChCl electrolyte was developed and used with a carbon nanotube (CNT) cathode, which further promoted the dual ion intercalation of Mg^{2+} and $MgCl_3^-$ and dramatically enhanced the energy density to 2100 Wh kg^{-1}. This work provides fundamental insights into Mg ion storage mechanisms and hybrid aqueous/organic electrolyte design. The success of these high-performing Mg-ion batteries holds promise for the development of next-generation multivalent metal-ion battery technologies.

Biography:

Sarah Leong is currently a PhD student in the Department of Mechanical Engineering at the University of Hong Kong (HKU). She obtained a Master of Engineering degree from UC Berkeley in 2018 and a Bachelor of Science degree from Columbia University in 2017. Her research interests revolve around the development of next-generation aqueous rechargeable metal-ion batteries through novel electrolyte design and the study of electrode-electrolyte interfaces. Sarah will pursue postdoctoral research at the Department of Materials Science and Engineering at Massachusetts Institute of Technology (MIT) starting in 2025.

Invited Talk

Advanced Ionic Materials for Energy Storage Applications

Mega Kar*

Deakin University, Australia

Abstract

There is a critical need to design inexpensive, non-flammable and stable materials for the next generation of rechargeable batteries to overcome the variability of renewable energy in Australia. Metal have come a long way since the 1920's since the progression in non-aqueous electrolytes have been employed to overcome safety concerns with moisture and air-sensitive metals, i.e. Li. Recently, advanced electrolytes based on liquid salts have garnered enormous interest in the field of electrochemistry for energy storage technologies. Herein the design of a series of weakly-coordinating borate based electrolytes[1-3], with low-volatility and high oxidative stability, is reported. Such materials make them immensely attractive for high-voltage cathodes. Moreover, their electrochemical compatibility with a number of various metals including lithium (Li), sodium (Na) and magnesium (Mg) is demonstrated, making them highly appealing for a number of emerging rechargeable metal battery technologies such as high-energy density batteries based on Li as well as affordable, safer alternatives such as sodium and magnesium.

Biography:

Dr. Mega Kar completed her undergraduate degree with honor at The University of Melbourne, Australia, in 2008. She then pursued her PhD at Monash University from 2012 to 2015, supported by the Australian Research Council's Centre of Excellence for Electro-materials Science (ACES). Following her doctoral studies, Dr. Kar served as an Alfred Deakin Research Fellow at Deakin University from 2021 to 2023, where she investigated novel, low-cost, and safe materials for energy storage devices. Recently, she received the Australian ARC DECRA Fellowship to continue her research at Deakin University, focusing on the development of new materials for advanced sodium technology. Her primary research interests include designing innovative ionic liquid and solid-state electrolytes for rechargeable lithium, sodium, magnesium, and zinc batteries.

Invited Talk

Multifunctional Li+-Containing Organic Ionic Plastic Crystals for Advanced Rechargeable Batteries

Hiroyuki Ueda*

Deakin University, Australia

Abstract

Solid-state batteries (SSBs) employ thermally stable solid electrolytes rather than flammable liquid electrolyte solutions as lithium-ion batteries (LIBs) do, helping overcome some performance limitations of LIBs. Solid electrolytes contribute to determining the SSB performance because they transport ions between both sides of electrodes for reversible electrochemical reactions. To secure ideal ion-transport networks, using soft solid electrolytes is beneficial as they can be easily integrated into electrodes and the interlayer between them.

We are studying an emerging class of soft solid electrolytes called organic ionic plastic crystals (OIPCs) to realise high-performing SSBs. So far, we have created many OIPC-containing electrodes/electrolytes and demonstrated their promising electrochemical performance. In our presentation, we first focus on graphite–OIPC anodes and explain how incorporating an OIPC electrolyte improves the rate and cycle performance. Secondly, our recent work on polymer-binder-free $LiFePO_4$–OIPC cathodes is introduced, where an attractive binding ability of OIPC electrolytes supports electrode coating up to 3.74 mAh/cm^2 as well as fast lithiation/delithiation of $Li_{1-x}FePO_4$ ($0 \le x \le 1$) particles. Thirdly, highly ion-conductive OIPC-electrolyte membranes ($\le 10^{-3}$ S cm^{-1} at 50 °C) are presented, and we disclose a seminal work on full cells comprising OIPC-containing electrodes/electrolytes manufactured at our Australian battery-technology research and translation facility, Battery Research and Innovation Hub.

Biography:

Dr Hiroyuki Ueda is an Alfred Deakin Postdoctoral Research Fellow at Deakin University. Dr Ueda is currently working on the development of advanced electrodes and electrolytes for battery applications, especially focusing on the realization of practical solid-state batteries using plastic crystals as promising solid electrolytes. Dr Ueda studied various electrochemical phenomena in ionic liquids and received his PhD degree (Doctor of Engineering) in 2016 from Kumamoto University. After graduation, he worked as a battery development engineer in the industry for approximately 4 years. Since 2020, Dr Ueda has led many industry collaborations at the Battery Research and Innovation Hub, Deakin University.

Invited Talk

Understanding Liquid Metal Systems for Renewable Energy Synthesis and Storage

Andrew Christofferson*
RMIT University, Australia

Abstract

One of the main challenges faced by current technologies for synthesis and storage of renewable fuels is the lack of efficient catalytic materials and materials for electrodes. In recent years, liquid metals have emerged as a new class of materials with superior catalytic activities and intriguing properties for energy storage. However, in order to understand both current and future applications of these materials, an atomistic description of the behaviour and interactions of these systems is highly desirable. We therefore developed a multiscale modelling protocol to describe the dynamics of liquid metal alloys, the formation of oxide layers at the alloy surface, and the interactions between liquid metal alloys, their oxide layers, and materials and molecules of interest for energy synthesis and storage applications. Quantum chemical calculations were used to develop force field parameters for classical molecular dynamics simulations, which enabled the exploration of length scales and time scales beyond the reach of *ab initio* methods. To date, this novel modelling protocol has been used to explore the mechanisms in liquid metal catalysis, and describe liquid metal nanostructure, in atomistic detail. While this work has been carried out in close collaboration with experimental researchers, many challenges and opportunities remain in the growing field of liquid metal modelling, including the potential application of machine learning to optimize processes.

Biography:

Andrew received a bachelor’s degree in chemistry from Montana State University, USA, and a PhD in chemistry with a focus on computational chemistry from the University of Birmingham, UK. Following postdoctoral work at the National Institute of Biological Sciences in Beijing, China, he joined RMIT University as a research fellow in 2012. In his current position at RMIT he uses molecular dynamics simulations and quantum chemical calculations to complement the experimental data of his collaborators to determine atomistic models of self-assembled materials, polymers, biomaterials, liquid metals, and ionic liquids. Applications of his work include novel catalysts and energy storage materials.

Invited Talk

Moving Ions and Molecules Across Sheets of Atoms for Low-Carbon Manufacturing

Chi Cheng*

University of New South Wales, Australia

Biography:

Dr. Chi (David) Cheng is a Senior Lecturer and ARC Future Fellow in chemical engineering at UNSW Sydney, where he established the Nanofluidics and Advanced Separations Laboratory in 2023. Prior to this, he was a Postdoctoral Scholar followed by a Research Scientist appointment in the department of mechanical engineering at MIT from 2017 to 2022. Dr. Cheng received his Ph.D. in materials science and engineering from Monash University in 2014 and a B.Eng. in polymer materials and engineering from Wuhan University of Technology in 2010. From 2016 to 2017, he worked in the R&D division of DuluxGroup Australia, developing functional coatings. In 2017, Dr. Cheng was awarded the Australian Endeavour Research Fellowship, and in 2021, he received an Australian Research Council Future Fellowship. He served as the Alumni Committee Chair for the MIT Postdoctoral Association from 2018 to 2019 and an MIT Communication Lab Fellow in 2019. His research and teaching focus on transport phenomena, membrane science, and nanopore technology for advanced bio/chemical separations, addressing critical societal challenges in resource and energy security.

Session: Sustainability and Environmental Impact

Keynote Talk

Wave-Energy Converters: Controlling Coastlines and Generating Electricity

Richard Manasseh*

Swinburne University of Technology, Australia

Abstract

Wave-Energy Converters (WECs) machines that extract renewable energy from ocean waves. They have been developed for many decades, but remain an expensive energy source relative to the most popular renewables. We discuss a unique dual-use opportunity that only WECs can offer: they can also protect coastlines from wave-induced environmental and infrastructural damage such as erosion and flooding, and protect ports and harbours from wave-induced economic losses. Since WECs remove energy from waves in order to convert it to electricity, arrays or 'farms' of WECs may also remove damaging wave energy. Coastlines, ports and harbours are traditionally protected by fixed structures such as walls, but these have permanent impacts on the marine ecosystem, and may shift problems further down the coast. They are also sunk costs. If WECs could be properly designed for coastal protection, they would offer the ability of control: they could reduce damaging wave conditions while allowing wave conditions that are environmentally beneficial. Furthermore, the machines would deliver revenue paying for the protection from sales of renewably-generated electricity. We show via theoretical modelling, numerical simulations, and laboratory modelling how arrays of WECs can be designed specifically for coastal protection.

Biography:

Richard Manasseh is a mechanical engineer with a PhD in applied mathematics, specialising in fluid dynamics. He is a professor at Swinburne University of Technology and earlier worked for CSIRO on R&D and technology commercialisation. His research over the past 30 years has focused on wave modes and oscillators in fluids and their interactions. He has applied this fundamental research to diverse industries in Australia and abroad, including the space, minerals, biomedical, water, food and defence sectors. He has worked on ocean wave power since 2010. Together with colleagues in other research organisations and Australian wave-power companies, he has been working on arrays of ocean wave-energy converters since 2014.

Invited Talk

Pathways to Decarbonise the Alumina Industry

Woei Saw*
University of Adelaide, Australia

Abstract

The Heavy Industry Low-carbon Transition Co-operative Research Centre (HILT CRC) is addressing the need to de-risk relatively high TRL technologies that can be incorporated as a retro-fit to reduce emissions from current alumina refineries and advance novel technologies needed to unlock a step-change in increased efficiency and reduced cost in next generation alumina refineries.

HILT's projects are focussing on electrification of calcination process and recovery of waste heat from calcination to the Bayer process to achieve these aims. The results of these projects including a study technical and economic feasibility of retrofitting an alumina calcination process using hydrogen (H2) or electrification to enable steam recovery. This evaluation demonstrated both pathways can provide approximately 30-40% of the steam required for the digestion process, leading to a substantial energy savings of 20-30% compared with the existing steam production with natural gas boilers.

Biography:

Dr Woei Saw is a Senior Lecturer in the School of Chemical Engineering at the University of Adelaide (UA). He has demonstrated a good track record in the development and demonstration of novel technology in the decarbonisation of high-temperature industrial processes. Currently, he is leading several Heavy Industry Low-carbon Transition Corporate Research Centre (HILT-CRC) funded project aimed at de-risking the retro-fitting of relatively high technology readiness level (TRL) emissions reduction technologies to existing industrial processes.

In addition, he has research and hands on experience in designing and operating pilot scale systems, and expertise relevant to thermal conversion technologies. Furthermore, he is working towards on a transformation of agricultural waste through the development of technologies to produce value-adding energy co-products. He is also target on the development of solar gasification technologies that convert agricultural products to solar syngas or solar fuels that can be transported as liquids (green biodiesel). These technologies are delivering a low-cost route to a sustainable and carbon neutral fuel to replace both conventional diesel and kerosene.

Invited Talk

Generationally Sustainable Renewable Energy

Andreas Helwig*
University of Southern Queensland, Australia

Abstract

This review sets the scene of pollution globally and ranks the issues facing the G20 nations, particularly that energy generation still contributes nominally 25% of GHG pollution. It describes where Australia is in terms of training professional engineers and technologists for sustainable design and end of life design for entry into circular economy, while looking at the current regulatory framework that is currently beginning to develop. It examines a few case study summaries of renewable energy technologies where they currently badly miss the requirement for sustainable design, development, and circular economy. It indicates principles for future development of generationally sustainable renewable energy generation design and investment for our Australian NEM grid development.

Biography:

Alumni UniSQ 1978; Qld Rail 1974-1996 Engineering Cadet career developed into specialist engineer for applied research in carbon brushes/battery technology/electrical insulation systems/traction application bearing, remanufacturing maintenance/overhaul and reliability engineering specialist. This included new traction vehicle drive system specification as Electrical Engineering Rollingstock Maintenance; Type Test Engineer Witness for Queensland Tilt-train in Hitachi City Japan. 1997-2011 Director/Senior Engineer/Industry Engineering trainer running I H S & Helwig Engineering Consultants in rail/mining traction technology; Become a fulltime family carer in 2010, and then moved careers in 2013 UniSQ Lecturer Electro-Mechanical Engineering to AProf. Position 2022. UniSQ researcher in renewable energy, sustainable energy storage; sintering technology; axial flux/conventional electrical machines development/characterisation, resource recovery and circular economy techno-economic-impact business modelling. This is the 51st year in an engineering career.

Invited Talk

Management of Local Ionic Transport for Stable CO_2 Electrolysis

Mengran Li*
University of Queensland, Australia

Abstract

CO_2 electrolysis is a promising electrochemical route to convert waste CO_2 into useful products such as CO, C_2H_4, or ethanol. Research efforts over the past decades have greatly improved its reaction rate close to the industrially applicable rate through catalyst development, electrode innovation, and cell configuration re-design. The state-of-the-art electrolysis cells are built based on monopolar ion-exchange membranes and are designed to achieve a pH-neutral or alkaline local reaction environment at the cathode, which is the centre for CO_2 reduction to take place. However, these cell designs are inherently unstable, causing either significant salt precipitation that blocks CO_2 at the cathode or dissolution of the PGM-free catalysts that destabilise the anode. This talk will report our recent work to address this critical stability issue by applying bipolar membranes and careful management of the local ionic transport in the electrolysis system.

Biography:

Dr. Mengran Li is a lecturer and ARC DECRA fellow at the Department of Chemical Engineering, University of Melbourne (UoM). After obtaining his PhD from the University of Queensland (UQ) in 2016, he spent over three years as a postdoctoral research fellow at UQ, working on developing CO_2 electrolysis technology for the iron and steel industry. In 2021, Dr. Li joined the Delft University of Technology in the Netherlands as a postdoctoral researcher. There, he continued his work on CO_2 electrolysis in collaboration with other European institutes and companies, supported by the EU Horizon Project SELECTCO2. He then joined UoM in 2023, the same year he was awarded the ARC DECRA fellowship. At UoM, Dr. Li is leading the Li Energy Lab, which focuses on advancing electrochemical technologies crucial for the global energy transition towards a greener future. His research includes CO_2/water electrolysis, reactive carbon capture, fuel cells, and hydrogen separation and compression.

Oral Talk

Electrification of Dry Reforming of Methane

Hamza Asmat*
Monash University, Australia

Abstract

Carbon dioxide accumulation in the Earth's atmosphere due to anthropogenic emissions is a major cause of climate change. Carbon capture and storage (CCS) is not viable or uneconomical in many parts of the world. Carbon capture and utilisation (CCU) is a better alternative, in which CO_2 is converted into value-added chemicals or fuels using renewable energy. Due to the high endothermicity, the reaction occurs at temperatures above 800 °C. Like steam reforming of methane, the heat required for DRM reaction is provided by combusting methane / natural gas in a firebox. Therefore, electrification of the DRM process is essential to make it viable at a large scale with a low carbon footprint in syngas production. A clean energy-based process is required to produce syngas ($CO + H_2$) via dry reforming of methane, which is essential for the production of valuable chemicals through Fischer Tropsch synthesis. One of the most attractive options for CO_2 utilisation into chemicals is through the conversion of CO_2 into synthesis gas ($CO + H_2$) via dry, bi-, or tri-reforming of methane. Syngas produced as a result of DRM reaction can be used to produce a range of valuable products. In this study, we demonstrated the viability of electrification as a source of heat provision for DRM reaction. Structured reactors coated with metal catalysts show high stability and great catalytic activity. No signs of significant coking were discovered from SEM/EDS imaging. Catalyst particles were promoted to grow on the surface of the substrate using the dip coating technique, which eliminates the use of powder catalysts. Transition metals were used to synthesise the precursor solutions for the dip coating of the catalysts onto the monoliths. The dip coating technique involved precursor solutions being coated and dried simultaneously. After a certain number of cycles, the substrate was calcined at a high temperature to remove impurities and binding agents used in the synthesis of the precursor solution. The catalytic activity of the 3D catalyst was carried out in a continuous flow reactor setup. Heat energy supplied was purely electric involving renewable energy. DRM reaction was carried out at a fixed feed ratio of CO_2:CH_4. The reaction studies showed that the reactant conversion, H_2/CO ratio, product yield and selectivity were significantly higher in the case of sandwiched Catalyst compared to other tested catalysts. The reactions were run at various Weighted Hourly Space Velocities (WHSVs). Sandwiched Catalyst showed a high conversion of 98% and 100% for CO_2 and CH_4, respectively. The catalyst was promoted to lower temperatures up to 700 °C to test coking resistance. It remained active and stable in both cases with 102 h of activity time on stream and showed no signs of deactivation or carbon deposition. In addition to this, no pressure drop was detected across the monolith reactors.

Biography:

Dr. Hamza Asmat completed his PhD in Chemical Engineering at Monash University, Australia, in October 2024. His research expertise spans heterogeneous catalysis, advanced reaction engineering, nanomaterials and carbon capture, conversion, and utilisation. Dr. Asmat has been leading innovative projects in methane dry reforming, utilising novel 3D-printed structured reactors coated with supported Ni catalysts. Dr. Asmat is the Lead Inventor of the Electrified Reformer technology, a groundbreaking advancement in syngas production. He is an alumnus of Lancaster University, United Kingdom, and COMSATS University Islamabad, Pakistan, where he earned a First-Class Honors in Chemical Engineering.

Invited Talk

Mimicking a Cell Plasma Membrane to Regulate Dynamic Polysulfide Chemistry for a Practical Lithium-Sulfur Battery

Petar Jovanović*
Monash University, Australia

Abstract

Lithium-sulfur batteries are compelling candidates for overcoming the resource and sustainability limitations of current batteries. Regulating complex polysulfide chemistry is a critical challenge in achieving a practical lithium-sulfur battery with high cycle life and minimal electrolyte weight. Drawing inspiration from cell biology, here we propose the concept of bespoke membranes for making practical lithium-sulfur batteries. The membrane devised herein utilizes conductive reduced graphene oxide as a brick-like framework, with an elastic polymer liquid—rich in ion hopping and lithiophilic sites—as the mortar. The membrane mimics cell plasma membranes by integrating rapid and permselective Li^+ channels alongside catalytic electrochemical reactions. Employing our reactive permselective membranes, we attain areal capacities of 4.8–8.1 mAh cm^{-2} with 450 stable cycles in coin cells and 202 Wh kg^{-1} with over 100 stable cycles in pouch cells. This behaviour is achieved with efficient electrolyte/capacity ratios (4.9–5.3 µL mAh^{-1}).

Biography:

Dr Petar Jovanović finished his PhD from the Mechanical & Aerospace Engineering at Monash University in 2022, where he worked on applying polymer complexes into separator and binder formulations for advanced lithium-sulfur battery applications. Since then, he joined the Nanoscale Science and Engineering Laboratory (NSEL) in 2023 at Monash University as part of the ARC Research Hub for Advanced Manufacturing with 2D Materials. He is working on bridging the gap between academia and industry to advance the Technology Readiness Level (TRL) for various energy storage technologies.

Session: Materials for Renewable Energy Applications

Invited Talk

Drilling Solutions for Offshore Wind Foundations and Export Cable Landfalls

Marc Peters*
Herrenknecht AG, Germany

Abstract

The development of renewable energies is the focus for future energy supply. Large offshore wind farms are to be constructed and connected to a high-capacity transmission grid. Due to the public environmental awareness, smart installation methods are required for fast and safe construction of offshore foundations and the eco-friendly landfall installation for the export cables, with minimal impact on surroundings.

The installation of offshore foundations requires drilled installation methods, especially in non-drivable soil conditions. Furthermore, conventional pile-driving has a deep environmental impact, causes high noise emissions and reaches its limits with increasing turbine sizes. Based on 40 years of drilling experience, Offshore Foundation Drilling (OFD) machine has been designed with a partial-face or full-face cutting system. For the installation of conical piles like large monopiles, the full-face concept is used for socket drilling (e.g. in St. Nazaire Project, France) and the partial-face solution for drive-drill-drive methods or as a backup. Smaller cylindrical piles for jacket foundations or floating anchors use the full-face drilling machine concept.

Furthermore, offshore wind farms have to be connected to onshore grid. These landfall sections of export cables are usually located in sensitive coastal areas where the operation of heavy construction equipment is not possible due to environmental protection requirements. Also, when dyke structures have to be crossed, this sets further increased demands on the respective installation methods. Trenchless solutions like Horizontal Directional Drilling (HDD) and slurry microtunnelling methods offer a wide range of environmental and safety benefits and a high degree of flexibility for project planners.

Biography:

Dr. Marc Peters has a degree of civil engineering and Phd of the University of Aachen, Germany. Since 2004, he is working for Herrenknecht AG. He started as personal assistant of the Board of Directors and was responsible for research and development for Utility Tunnelling from 2006 to 2017. In this position, his focus was the further development of existing technologies in the fields of utility tunnelling, pipeline construction, shaft sinking and renewable energies. Since 2011, he is Director of the Business Division Energy within the Utility Tunnelling Department, where he is in charge of worldwide Business Development in the Energy sector.

Invited Talk

Supported Single Site Cobalt-Based Molecular Catalysts for CO_2 Conversion

Oliver J. Conquest *
University of Sydney, Australia

Abstract

Carbon dioxide (CO_2) is a greenhouse gas, the most common product of combustion reactions,and possibly the largest single driver of climate change. The development of technologies that convert of CO_2 into valuable hydrocarbon products offer not only an environmental incentive, but also an economic incentive to industries, to capture and convert their CO_2 product. This means CO_2 would become a reaction feedstock in the creation of hydrocarbon fuels, which can be reused, potentially closing the industrial carbon cycle. The electroreduction of CO_2 coupled with renewable energy is one possible route to achieving this, driven by metal-organic catalysts with exceptional product selectivity and catalyst stability.[1] Using density functional theory (DFT) calculations we have studied single site cobalt metal-organic catalysts for CO_2 electroreduction (CO2ERR). Our DFT calculations involve environmental contributions such as implicit water, temperature and solvation corrected entropies which we have previously benchmarked.[2,3] We have investigated the active site tuning of cobalt-phthalocyanine via various atomic linkers and found the N, S and P atomic linkers have the most favorable CO2ERR free energy reaction pathways for CO production[4]. Furthermore, we have investigated two-dimensional cobalt tetracyanoquinodimethane (CoTCNQ) metal-organic frameworks as potential single site CO2ERR catalysts that can go beyond CO production to produce HCHO and HCOOH products.

Biography:

Dr. Oliver J. Conquest received his Bachelor of Science and Master of Research degrees from Macquarie University. He then worked in industry for a year before starting his PhD with the Condensed Matter Theory (CMT) group, supervised by Prof. Catherine Stampfl, in the school of physics at the University of Sydney in 2019. He completed his PhD in 2023 and is continuing his work as a postdoctoral research associate with the CMT group.

Invited Talk

The Power of Physics-Informed Machine Learning in Solving Nanoscale Challenges

Sherif Abdulkader Tawfik *
Deakin University, Australia

Abstract

At the heart of the flourishing field of machine learning potentials are graph neural networks, where deep learning is interwoven with physics-informed machine learning (PIML) architectures. Various PIML models, upon training with density functional theory (DFT) material structure-property datasets, have achieved unprecedented prediction accuracy for a range of molecular and material properties. A critical component in the learned graph representation of crystal structures in PIMLs is how the various fragments of the structure's graph are embedded in a neural network. Several of the state-of-art PIML models apply spherical harmonic functions. Such functions are based on the assumption that DFT computes the Coulomb potential of atom-atom interactions. However, DFT does not directly compute such potentials, but integrates the electron-atom potentials. We introduce the direct integration of the external potential (DIEP) methods which more faithfully reflects that actual computational workflow in DFT. DIEP integrates the external (electron-atom) potential and uses these quantities to embed the structure graph into a deep learning model. We demonstrate the enhanced accuracy of the DIEP model in predicting the energies of pristine and defective materials. By training DIEP to predict the potential energy surface, we show the ability of the model in predicting the onset of fracture of pristine and defective carbon nanotubes.

Biography:

Sherif is a Research Fellow at the Applied Artificial Intelligence Institute (A2I2). He joined Deakin University in 2021 as awardee of the Alfred Deakin Postdoctoral Research Fellowship at the Institute for Frontier Materials. Sherif works at the cross-roads of material science, physics, chemistry and AI, and leverages the AI expertise at A2I2 for solving challenging problems in material science. He was awarded his PhD degree in Physics in 2017 from the University of Sydney, and has since worked as a Postdoctoral Research Fellow at University of Technology Sydney, RMIT University until he moved to Deakin University.

Invited Talk

Enhancing Efficiency in Perovskite-Si Tandem Solar Cells through Quantum Interference at the Recombination Junction

Zijun C. Zhao*

University of Western Australia, Australia

Abstract

In this talk I will give an overview of our recent publications about Quantum Interference at the Recombination Junction of Perovskite-Si Tandem Solar Cells Improves Efficiency. We show quantum interference effects can enhance coherent electron transmission in perovskite tandem solar cells using ultrathin indium tin oxide (ITO) layers. We develop a model for the behavior of the power conversion efficiency based on a finite difference time domain solution of the time-dependent Schrödinger equation. The modeled potential includes an imaginary part to simulate probability loss by incoherent scattering. The results agree with observations of efficiency as a function of ITO thickness, suggesting an optimized design.

Biography:

Dr. Zhao researches quantum technologies to test fundamental physics and search for dark matter. For example, she's working towards uncovering new physics using precision measurements of crystals in cryogenic environments. She is also interested in using quantum technologies in the application for renewable energy. Dr. Zhao is currently based at our University of Western Australia node, working with CI Professor Michael Tobar in the Quantum Technologies and Dark Matter Lab. Dr. Zhao obtained a PhD from the University of Sydney in 2020. She joined EQUS (ARC Centre of Excellence for Engineered Quantum Systems) in 2020.

Session: Renewable Energy Fuels and Future Directions

Keynote Talk

Ion Specific Separators and Their Role within Energy Storage Devices

Matthew R. Hill*
Monash University, Australia

Abstract

One of the great global scientific challenges is the availability of energy at low cost, to all. Whilst the ability to generate power from renewable sources, and from a distributed grid, progressed remarkably over the last 15 years, it can only be fully exploited if usage can be decoupled from generation.

Electrochemical energy storage technologies such as batteries and supercapacitors are the primary mechanism to break this link. Developments in the performance of new storage media, whilst maintaining an economical aspect, are crucial for making the use of self-generated renewable energy viable in many more instances.

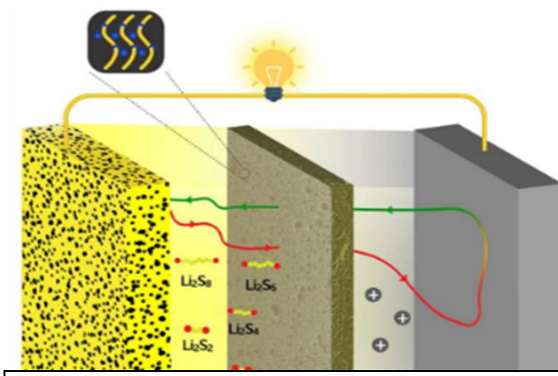

Figure 1. Lithium-Sulfur Batteries offer tantalizing global potential, should endemic limitations be overcome.

One of the most tantalizing battery chemistries is Lithium-Sulfur (Li-S). With a gravimetric storage potential around 10 times higher than Lithium ion, Li-S batteries are also manufactured from cheap, safe and stable materials, amenable to their widespread deployment. However, Li-S batteries have inherent challenges of stability with cycling, accessing their full storage potential, and obtaining charge-discharge at requisite rates. Many of these inherent challenges are due to slow, or non-selective transport, and porous materials offer the potential to address this behaviour.

In this presentation, recent breakthroughs in addressing these challenges inherent to Li-S will be presented. We have been able to develop Li-S cells with some of the best performances yet reported, and under conditions practical to their wide deployment. This is due to new forms of transport, and the mechanisms behind how porous materials within Li-S cells achieved this, discussed. Recent developments with related separators and their potentials in flow batteries will also be highlighted.

Biography:

Professor Matthew Hill PSM GAICD is currently Head of Department - Materials Science and Engineering at Monash University. He is a technical leader in the field of clean and renewable energy research with 18 years experience delivering technical solutions to government and industry, across 54 projects worth $ 38M AUD. Matthew completed his PhD in the chemical vapour deposition of perovskite thin films under the supervision of Professor Robert Lamb at UNSW in 2006. He subsequently joined the CSIRO Division of Materials Science and Engineering, with Dr Anita Hill, to develop applied research into porous materials. In 2016, Matthew began a joint appointment with Monash Chemical and Biological Engineering where he served as deputy head of department from 2021-24.

Matthew has received several awards for his research, most notably the ATSE Solomon Award for Industry-Research Collaboration, ARC Future Fellowship, the Public Service Medal, and the Prime Minister's Prize for Science - Physical Scientist of the year. He has contributed to over 160 papers, 20 patents and 44 commercial reports, having accrued over 11,000 citations with an h-index of 55.

Current research efforts include high cycle life lithium-sulfur and organic redox flow batteries, hydrogen purification membranes, ion-selective membrane transport, direct air oxygen capture, porous liquids, magnetic induction swing adsorption, reverse electrodialysis, plastic upcycling, liquid organic hydrogen carriers and direct air carbon dioxide capture. Research hypotheses in these areas are inspired by problem definition derived from industry projects in chemical production, hydrogen economy, space, carbon utilisation, circular economy, and defence.

Invited Talk

Future Directions for Silicon Solar Cells in Mass Production – Beyond 27% Efficiency

Daniel MacDonald*

Australian National University, Australia

Abstract

The efficiency of industrial silicon solar cells has continued to increase at an impressive rate over the past five years, recently exceeding 26% for both silicon heterojunction and poly-silicon contacted solar cells. However, this performance is rapidly approaching the theoretical limit for single-junction silicon cells of just over 29%. In this talk we will review and assess the most likely technologies for achieving over 27% in mass production in the near-term, considering both performance and cost. Looking beyond the single-junction limit, we will also consider likely future directions for silicon-based tandem cells with efficiencies above 30%.

Biography:

Professor Daniel Macdonald completed his PhD in silicon solar cells in 2001 and has over 20 years' experience in silicon solar cell research, spanning materials, device design, fabrication, and advanced characterisation. He currently leads a team of 25 postdoctoral fellows and research students, has published over 400 papers in the field, and has led research projects valued at over AU$20 million, including multiple large industry-supported projects. He has held three ARC Fellowships and is a leading expert in n-type silicon solar cells and their commercialisation.

Invited Talk

100% Renewable Energy Systems Research

Muhammad Zeeshan*
University of Lahore, Pakistan

Abstract

Research on 100% renewable energy systems is a relatively recent phenomenon. It was initiated in the mid-1970s, catalyzed by skyrocketing oil prices. Since the mid-2000s, it has quickly evolved into a prominent research field encompassing an expansive and growing number of research groups and organizations across the world. The main conclusion of most of these studies is that 100% renewables is feasible worldwide at low cost. Advanced concepts and methods now enable the field to chart realistic as well as cost- or resource-optimized and efficient transition pathways to a future without the use of fossil fuels. Such proposed pathways in turn, have helped spur 100% renewable energy policy targets and actions, leading to more research. In most transition pathways, solar energy and wind power increasingly emerge as the central pillars of a sustainable energy system combined with energy efficiency measures. Cost-optimization modeling and greater resource availability tend to lead to higher solar photovoltaic shares, while emphasis on energy supply diversification tends to point to higher wind power contributions. Recent research has focused on the challenges and opportunities regarding grid congestion, energy storage, sector coupling, electrification of transport and industry implying power-to-X and hydrogen-to-X, and the inclusion of natural and technical carbon dioxide removal (CDR) approaches. The result is a holistic vision of the transition towards a net negative greenhouse gas emissions economy that can limit global warming to 1.5°C with a clearly defined carbon budget in a sustainable and cost-effective manner based on 100% renewable energy-industry-CDR systems. Initially, the field encountered very strong skepticism. Therefore, this paper also includes a response to major critiques against 100% renewable energy systems, and also discusses the institutional inertia that hampers adoption by the International Energy Agency and the Intergovernmental Panel on Climate Change, as well as possible negative connections to community acceptance and energy justice. We conclude by discussing how this emergent research field can further progress to the benefit of society.

Biography:

Prof. Muhammad Zeeshan Graduated from LUT University in Finland, with the specialties including Sustainable Energy Systems. Later on I obtained my post-graduation from KTH Royal Institute of Technology in Renewable Energy. Now I am professor in the field of renewable energy at University of Lahore.

Invited Talk

Assessment of a Sustainable Bioethanol Plant in Dubai

Gaurav CJK*
Rochester Institute of Technology, UAE

Abstract

This study evaluates the techno-economic feasibility of a solar-powered bioethanol plant in Dubai. The feedstock is date seeds. The objective is to leverage UAE's Energy Strategies by encapsulating on the availability of its 2 most abundant resources, Sun and Dates. Dubai has recorded a significant growth in the market of personal vehicles for transport. While affordable electric vehicles are steadily encroaching the market, the purpose of this study emanated as an attempt to aid existing owners of petrol-engine vehicles. Bioethanol can blend seamlessly in proportions of 5-15% with conventional fuel without modifications to the engine. While there has been research in UAE inclined towards biofuel from dates, it is restricted to aviation and solid fuel (biochar). The model explored is compounded of a fast pyrolysis plant processing grinded powder from date seeds blended with iron nitrides. The system is powered by a heating system with a compound parabolic collector (CPC) and a flat-plate PV system with battery storage. Data for the pricing of each component is predominantly derived from research focused on the Middle East. The period of the economic cycle is 10 years. Results showed that the dependency of the plant on non-renewable sources is considerably decayed by 78%. Furthermore, the Net Present Value (NPV) at the end of the cycle is $12.36 Million with a simple payback period of approximately 3 years. The proposed model proves to be a formidable steppingstone for UAE's road to a sustainable future.

Biography:

Gaurav CJK graduated with a BS in Mechanical Engineering from the Rochester Institute of Technology, Dubai, specializing in Energy and Environment. Presently, he is pursuing a master's degree from the same university, where he is also working as a Teaching Assistant for Psychology and Creative Writing. During his undergraduate years, he worked as an intern with Emerson Automation Solutions, supporting the Inside Sales Engineers. He was a recipient of the RIT Dubai President's Cup, awarded to one undergraduate student per year for prowess in academia, extracurricular activities and leadership. He aspires to pursue his PhD in the field of sustainability.