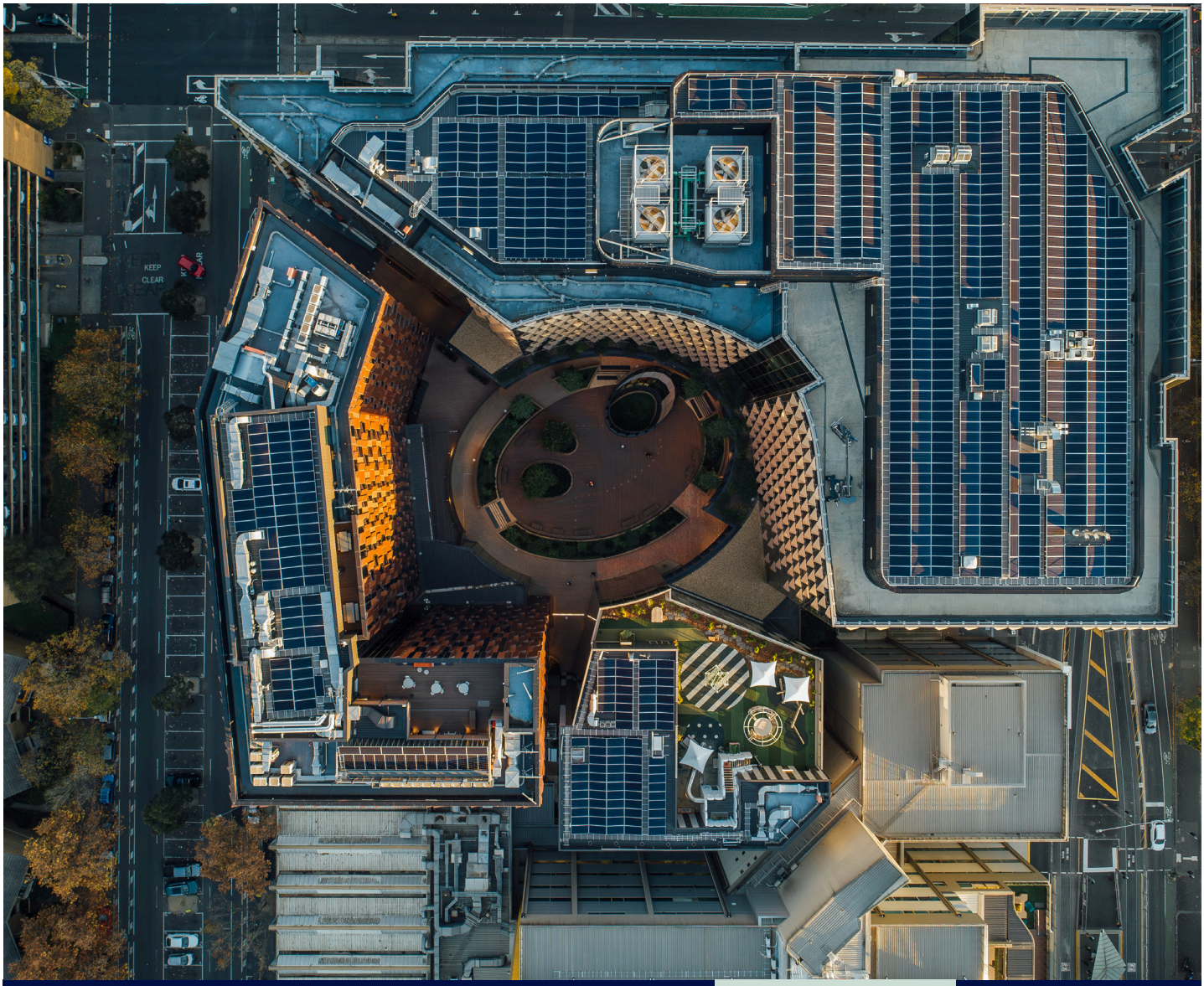


Melbourne
Energy
Institute

THE UNIVERSITY OF
MELBOURNE

MEI Symposium 24

Full program

22 November 2024

Table of Contents

Program

Date:	22 November 2024	**Time:**	8:00am – 4:30pm
Venue:	Melbourne Connect Forums 1-3, Mezzanine Floor, 700 Swanston Street, Parkville		
Registration:	https://events.humanitix.com/mei-symposium-24		
Cost:	Free	**Enquiries:**	mei-info@unimelb.edu.au

8:00-8:30am	**REGISTRATION AND COFFEE**

OPENING PLENARY	
8:30-8:40am	**Welcome and opening of MEI Symposium 24** **Prof. Michael Brear,** *Director*, Melbourne Energy Institute
8:40-9:25am	**Opening Plenary: Matching ambition by design: aligning the energy system with renewable superpower expectations** **Anna Skarbek,** *Chief Executive Officer*, Climateworks Centre

	STREAM 1 (MORNING) **Energy Systems** **Chair: Prof. Pierluigi Mancarella, *Program Leader***	**STREAM 2 (MORNING)** **Energy Materials** **Chair: A/Prof. Wallace Wong, *Program Leader***
	Forum 2 and 3	**Forum 1**
09:30-10:10am	**Keynote:** **OPTIMISATION TO SUPPORT DECISION MAKING IN ENERGY SYSTEMS** **Prof. Kate Smith-Miles** AO FAA *Pro Vice-Chancellor (Research Capability)* *Melbourne Laureate Professor, School of Mathematics and Statistics* *Director, OPTIMA* University of Melbourne	**Keynote:** **IMPROVING BATTERY STORAGE PERFORMANCE THROUGH, PROCESSING, ADDITIVES AND CHEMICAL MODIFICATION** **Prof. Amanda Ellis** *Head of School* *Chemical and Biomedical Engineering* University of Melbourne
10:10-10:30am	**MORNING TEA**	
10:30-11:00am	**Techno-economic assessment of inertia measurements: Australian case** **Dr. Bastian Moya Ureta,** *Research Fellow, Electrical and Electronic Engineering*	**A general nucleation model for semiconductor nanocrystals** **Dr. Zifei Chen** *PhD Graduate, ARC Centre of Excellence in Exciton Science, School of Chemistry*
11:00-11:30am	**On the stability of negative imaginary systems theory for future electric grid stability** **Dr. Yijun Chen** *Research Fellow, Electrical and Electronic Engineering*	**New cell architectures in the photovoltaics market** **Dr. James Bullock** *Senior Research & ARC Decra Fellow, Electrical and Electronic Engineering*

11:30-12:00pm	**Assessing strategies to promote residential energy decarbonisation** **Dr. Andrea Vecchi** *Research Fellow - Clean Energy and Clean Transport, Mechanical Engineering*	**Unveiling material dynamics: Advancing spectroscopic techniques for next-generation applications** **Dr. Nina Novikova** *Research Fellow in Optical Nano & Spectroscopy, Chemistry*
12:00-12:30pm	**Future electricity and hydrogen systems: Long-duration storage options for Australia** **Dr. Sleiman Mhanna** *Senior Research Fellow, Electrical and Electronic Engineering*	**Nonconfinement promotes the proton transport: A computational study** **Dr. Yuxiang Wang** *Research Fellow, Computational Materials Engineering, Mechanical Engineering*
12:30-1:20pm	**LUNCH AND POSTER COMPETITION *(Launch pad zone)***	
	STREAM 1 (AFTERNOON) **Power Generation and Transport** **Chair: A/Prof. Shiaohuey Chow on behalf of Prof. Richard Sandberg, *Program Leader***	**STREAM 2 (AFTERNOON)** **Heavy Industry and Resources** **Chair: A/Prof Colin Scholes on behalf of A/Prof. Kathryn Mumford, *Program Leader***
	Forum 2 and 3	**Forum 1**
1:20-2:00pm	**Keynote:** **TECHNOLOGY PATHWAYS FOR SUSTAINABLE ENERGY SYSTEMS** **Dr. David Harris** *Chief Research Consultant* CSIRO Energy	**Keynote:** **CARBON CAPTURE AND STORAGE – A PATHWAY TO A LOW EMISSION FUTURE** **Barry Hooper** *Executive Director* KC8 Capture Technologies Ltd
2:00-2:30pm	**Geothermal: Our under-utilised renewable resource** **Prof. Rachel Webster** *Redmond Barry Distinguished Professor* *School of Physics*	**A high pressure, high temperature electrolysis rig with optical access for bubble imaging** **Dr. Andre Chambers** *Postdoc Research Associate, High Press Hightemp Electrolysis, Mechanical Engineering*
2:30 3:00pm	**Gradient enhanced deep Gaussian processes for multi-fidelity surrogate modelling** **Dr. Viv Bone** *Research Fellow, Electrical and Electronic Engineering*	**Development of equations of state at cryogenic conditions by molecular dynamics simulations** **Jiaou Song** *PhD student, Chemical Engineering*
3:00- 3.20pm	**AFTERNOON TEA**	
3:20- 3:50pm	**Assessment of long-term trends and variability of wind energy density off the coast of Australia** **Dr. Rui Li** *Research Student, Infrastructure Engineering*	**Carbon-negative ammonia production from the air** **Dingqi Wang** *PhD student, Chemical Engineering*
3:50- 4:20pm	**Pushing the frontiers of supercomputing for next-generation aircraft engines** **Marco Rosenzweig** *PhD Student, Mechanical Engineering*	**Green hydrogen production from the air** **Dr. Mandy Men** *Postdoc Research Engineer, Chemical Engineering*
4:20-4:30pm	**WRAP UP AND CLOSE**	

Welcome

Professor Michael Brear

Director, Melbourne Energy Institute

University of Melbourne

Prof. Michael Brear is a mechanical engineer and the Director of the Melbourne Energy Institute (MEI) at the University of Melbourne. MEI facilitates the University's research on the technical, economic, environmental and social impacts of energy.

Michael is a Fellow of the Australian Academy of Technology and Engineering, the Combustion Institute, Engineers Australia and the Australian Institute of Energy. He previously established the University's multi-disciplinary degree, the Master of Energy Systems. Prior to commencing at the University of Melbourne, Michael worked for ICI Australia (now Orica), and then undertook graduate studies at Cambridge University and post-doctoral research at the Massachusetts Institute of Technology.

Plenary

Matching ambition by design: aligning the energy system with renewable superpower expectations

Anna Skarbek

Chief Executive Officer

Climateworks Centre

Australia's 'renewable superpower' ambition is clear and the energy system has a critical role to play. The nation has the potential to take this from ambition to reality. But what does that look like in practice? What are the major technological, governance, policy and financing changes underway to drive this and what more would help the electricity and energy system planning match the ambition for Australia's future economic prosperity in a net zero world?

For 15 years, Climateworks Centre has led scenario modelling that demonstrates Australia's sector pathways for achieving climate goals with other benefits - informing policy and practice for implementation.

Climateworks CEO Anna Skarbek will outline the energy sector pathway's role in the net zero transformation, the latest policy and financing developments, and how energy system planning can align.

Anna Skarbek is CEO of Climateworks Centre, leading the organisation's work in Australia and Southeast Asia with decision-makers who have power to reduce emissions at scale. Anna has led Climateworks since its creation in 2009. Co-founded by philanthropy and Monash University, Climateworks bridges the gap between research and climate action, operating as an independent not-for-profit within the Monash Sustainable Development Institute.

Anna is an Asia Pacific Advisory Board member for GFANZ (the Glasgow Financial Alliance on Net Zero), a member of the Nature Finance Council, a board director of SEC Victoria, the Green Building Council of Australia, and the Centre for New Energy Technologies.

Anna was a founding board director of Australia's Clean Energy Finance Corporation and the Carbon Market Institute and has held other board directorships ranging from impact investing to human rights organisations.

Melbourne Energy Institute

THE UNIVERSITY OF MELBOURNE

Research Program: Energy Systems

CHAIR: Professor Pierluigi Mancarella

Chair Professor of Electrical Power Systems

Energy Systems Program Leader, Melbourne Energy Institute

University of Melbourne

Prof. Pierluigi Mancarella is Chair Professor of Electrical Power Systems at the University of Melbourne, Australia, and Professor of Smart Energy Systems at the University of Manchester, UK. He obtained the PhD degree in Power Systems from the Politecnico di Torino, Italy, did his post-doc at Imperial College London, UK, and has held visiting research positions at Sintef/NTNU in Norway and NREL in Colorado, as well as visiting professorships at Ecole Centrale de Lille in France, the Universidad de Chile, and Tsinghua University in China.

Keynote: Optimisation to support decision making in energy systems

Professor Kate Smith-Miles AO FAA

Pro Vice-Chancellor (Research Capability)
Melbourne Laureate Professor, School of Mathematics and Statistics
Director, OPTIMA
University of Melbourne

Optimisation is the branch of mathematics underpinning large-scale complex decision making, and such decisions are plentiful in the energy sector. This talk will provide an overview of the work undertaken in OPTIMA to develop powerful techniques to support decision making focusing on several case studies in energy systems: policy development, market operations, infrastructure design, and wind farm energy production.

Prof. Kate Smith-Miles AO FAA is a Melbourne Laureate Professor of Applied Mathematics, Pro Vice-Chancellor (Research Capability), and Director of the ARC Training Centre in Optimisation Technologies, Integrated Methodologies and Applications (OPTIMA). As an applied mathematician she has collaborated with many industry partners and interdisciplinary researchers over the last 30 years. She has published over 300 refereed articles, supervised over 30 PhD students to completion, and been awarded over $30m in competitive research funding. She has been awarded several medals and prizes for her research, and was appointed Officer of the Order of Australia in the 2024 King's Birthday Honours.

Techno-economic assessment of inertia measurements: An Australian case

Dr. Bastian Moya Ureta

Research Fellow, Electrical and Electronic Engineering, *University of Melbourne*

As renewable energy penetration increases, system stability becomes more challenging, leading system operators to investigate the role of Frequency Control Ancillary Services (FCAS) and inertia. In Australia, inertia concerns have led to the implementation of an inertia market in the Wholesale Electricity Market (WEM) and a very Fast FCAS market in the National Electricity Market (NEM).

This study leverages a novel technology to assess the value of accurate inertia measurement within the NEM. The data analysis reveals correlations between renewable penetration, demand and system inertia. Additionally, a techno-economic assessment highlights potential benefits of inertia measurement in system operation and planning.

Dr. Bastian Moya Ureta received his B. Sc. And M. Sc. Degrees in electrical engineering from the University of Chile, Santiago, Chile in 2018 and 2021, respectively. His research interests include operation and planning of low inertia power systems.

On the stability of negative imaginary systems theory for future electric grid stability

Dr. Yijun Chen

Research Fellow, Electrical and Electronic Engineering, *University of Melbourne*

The transition to renewable energy sources, like solar and wind, requires a fundamental rethinking of power system stability and control. Traditional approaches to grid expansion are no longer sufficient. This talk introduces negative imaginary (NI) systems theory as a novel method for enhancing grid stability through the integration of large-scale batteries. By improving the control of voltage, frequency, and power angles, NI systems can help optimize existing grid infrastructure, ensuring resilience and reliability in the face of growing renewable energy use.

Dr. Yijun Chen is a Department Research Fellow at the University of Melbourne, focusing on control and power systems. She completed her PhD at the University of Sydney in 2023 and subsequently held a postdoctoral position at the Australian National University. Yijun's research interests lie primarily in multi-agent systems, intersecting with control theory, game theory, network science, and optimization. She was honoured as one of the five finalists for the IFAC Congress Young Author Prize for her paper titled "Dynamic Game for Regional Climate Mitigation Control.

Assessing strategies to promote residential energy decarbonisation

Dr. Andrea Vecchi

Research Fellow - Clean Energy and Clean Transport, Mechanical Engineering, *University of Melbourne*

Household thermal demand supply through electricity, particularly when this is locally generated with rooftop photovoltaics, is a primary pathway to cut emissions from buildings. However, it could also compromise the operation of the electricity distribution network upstream. In this presentation, strategies that could ease this change by containing the electricity load and volumes to be handled by the upstream network are discussed. These are 1) suitable electricity tariffs; and 2) smart thermal comfort management. Their effect is characterised when used individually and in combination across various building types, vintage and local climates.

Dr. Andrea Vecchi holds a PhD in Engineering jointly awarded by the University of Birmingham (UK) and The University of Melbourne (AU). Before undertaking post-graduate research, Andrea received a Bachelor's and Master's Degree in Energy Engineering from Politecnico di Torino (Italy) and gained industrial experience as an R&D Engineer. He has been part of the modelling team in the Net Zero Australia project and is currently a research fellow at the Department of Mechanical Engineering. His research addresses energy system decarbonisation through the rational use of energy and energy storage.

Future electricity and hydrogen systems: Long-duration storage options for Australia

Dr. Sleiman Mhanna

Senior Research Fellow, Electrical and Electronic Engineering, *University of Melbourne*

Increasing uptake in variable renewable energy (VRE) will require commensurate acceleration in the update of various forms of energy storage systems to support their variability and improve system reliability. Clean fuels will also play a central role in the context of energy system decarbonisation but, as of today, is it unclear to what extent they can competitively provide security, resilience, and reliability. This talk will provide insight into how the levelised cost of storage of an underground hydrogen storage system compares to that of pumped-hydro energy storage system under stringent resilience requirements against prolonged VRE droughts and other disruptive events.

Dr. Sleiman Mhanna received his PhD in electrical engineering from the University of Sydney in 2016 with emphasis on fast distributed methods in power systems and demand response pricing mechanisms. For the subsequent three years he was a research fellow at the same institution, working mainly on the award-winning CONSORT project funded by ARENA, where he developed fast distributed optimisation methods and nonlinear pricing structures for load-side distribution network support.

He is working on designing mathematical models and scalable algorithms for the operation and planning of integrated electricity, gas, and hydrogen systems. The studies he has conducted over the past three years, which include electrification of residential heating demand and modelling of hydrogen blending in gas transmission networks, are currently used by Future Fuels Cooperative Research Centre (FF CRC) and its industry partners in their policy initiatives and decarbonisation roadmaps.

Melbourne Energy Institute

THE UNIVERSITY OF MELBOURNE

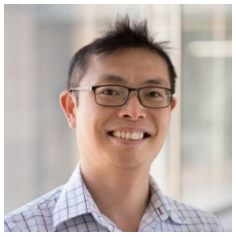
Research Program: Energy Materials

CHAIR: Associate Professor Wallace Wong

Associate Professor, Chemistry

Energy Materials Program Leader, Melbourne Energy Institute

University of Melbourne



A/Prof. Wallace Wong is an Associate Professor in the School of Chemistry, the University of Melbourne, and leader of MEI's Energy Materials Research Program. He is a Chief Investigator and Deputy Director of the ARC Centre of Excellence in Exciton Science
Wallace has been an ARC Future Fellow (2014-2018) and an ARENA Research Fellow (2011-2014). The core expertise of his group is in the design and synthesis of organic materials with applications in energy conversion, electronics, and chemical sensing.

Keynote: Improving Battery Storage Performance Through Processing, Additives and Chemical Modification

Professor Amanda Ellis

Head of School, Chemical and Biomedical Engineering, *University of Melbourne*

The first part of the talk will showcase work on spheronisation of natural graphite and its carbon-coating as an active material in anodes for improved performance in lithium-ion batteries (LIBs). We show improved yields of in spec. graphite anode material using a Nara hybridiser (dry-powder milling) as opposed to traditional mill-trains and how this can be facilely carbon-coated using technology developed in our labs.

The second part of the talk will address some current issues of cathode electrodes such as poor rate performance and failure mechanisms, namely using nickel manganese cobalt oxide (NMC) as active materials. The talk will focus on improving the performance of both the conductive additive, carbon black (CB), and the active material in the cathodes of LIBs. By modifying CB with carbonyl moieties, the energy barrier for lithium-ion movement at the electrode-electrolyte interface was shown to be reduced, resulting in lower overpotentials and faster charge/discharge reactions. In addition, NMC particles have been modified with self-assembled supramolecular nanolayers of an iron-based metal phenolic network (MPN) with electrochemical impedance spectroscopy (EIS) showing improved lithium-ion accessibility to the NMC. This accessibility improves electrochemical kinetic processes within the cathode electrode, achieved through (1) improved passage of the ions in the electrolyte that penetrates the porous electrode structure (ionic transport), (2) improved passage of the ions through the cathode-electrolyte interphase, (3) improved charge-transfer reactions, and (4) improved passage of the ions in the NMC (solid-state diffusion). As a result, the cathode electrode showed reduced interfacial resistance and a more efficient NMC structural phase transition, with uniform (de)intercalation of lithium-ions on the surface. Overall, the chemical modifications of the CB and NMC lower the battery overpotential and thus the

battery energy requirements, resulting in more efficient batteries. This work paves the way for improving battery materials via eco-friendly strategies.

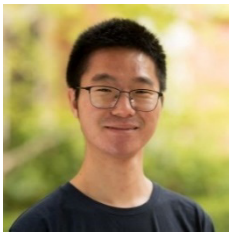
Prof. Amanda Ellis is the Head of the School of Chemical and Biomedical at The University of Melbourne. Her research work focuses on carbon and DNA nanomaterials, polymer science and energy harvesting/storage devices. She graduated with a Ph.D (Applied Chemistry) from the University of Technology, Sydney in 2003. She has undertaken postdocs in the US (Rensselaer Polytechnic Institute and New Mexico State University) and NZ (as a Foundation of Research Science and Technology Research Fellow at Callaghan Innovations). She has secured over $38 M in funding from the ARC and non-ARC sources as well as publishing over 195 peer-reviewed publications and holds 6 patents. She is currently the President-Elect of the Royal Australian Chemical Institute (RACI) (President Nov 2024).

A general nucleation model for semiconductor nanocrystals

Dr. Zifei Chen

PhD Graduate, ARC Centre of Excellence in Exciton Science, School of Chemistry, *University of Melbourne*

Understanding the formation mechanism is a central goal in designing energy materials. Here, we introduce a nonclassical model for nanocrystal nucleation in solution which centres on the dynamic interplay of chemical bond breakage and formation coupled with the desolvation of precursor molecules1. This model is applied to CdSe nanocrystal formation and showcase its efficacy in predicting solvent dynamics, precursor characteristics, crystal phase, stoichiometry, and transition states. We show that it is possible to derive reaction pathways by reducing the calculations to algebraic approximations for the nucleation energy. This allows nanocrystal nucleation and growth to be conceptualized as a straightforward chemical reaction.



Dr. Zifei Chen completed his PhD at the University of Melbourne in 2024, working with Professor Paul Mulvaney and Prof. Salvy Russo. His research mainly focuses on experimental and theoretical investigation of mechanical, optical properties and formation mechanism in semiconductor materials.

New cell architectures in the photovoltaics market

Dr. James Bullock

Senior Research and ARC Decra Fellow, Electrical And Electronic Engineering, *University of Melbourne*

The fast-growing terrestrial solar cell industry has begun ramping up production of architectures which employ ‘passivated contacts’. These are specialised contact interfaces that reduce interfacial defects, decreasing carrier recombination, and enabling device voltages close to the fundamental limits. In this talk, I will discuss the current technological status of the photovoltaics industry with a particular focus on the Tunnel Oxide Passivating Contact, or TOPCon, architecture. In the second half of this talk I will detail some of our recent projects exploring possible iterations beyond the current TOPCon architecture

Dr. James Bullock completed his PhD in Engineering, as an Australian Renewable Energy Agency Fellow, at the Australian National University. Following that he was a postdoctoral researcher in the Electrical Engineering and Computer Sciences department at Berkeley and an affiliate in the Materials Sciences Division at the Lawrence Berkeley National Laboratory. James now heads the Electronic Materials and Devices (EMaD) group in the Electrical and Electronic Engineering Department at the University of Melbourne. This group focuses on the design and fabrication of next-generation photovoltaic devices.

Unveiling material dynamics: Advancing spectroscopic techniques for next-generation applications

Dr. Nina Novikova

Research Fellow in Optical Nano and Spectroscopy, School of Chemistry, *University of Melbourne*

Time-resolved spectroscopy and microscopy techniques are incredibly useful for the characterization of advanced materials used in energy storage and conversion. These techniques enable real-time observation of electronic and molecular dynamics, guiding our understanding of the photoactive processes within these materials, and providing essential insights into their efficiency, stability, and overall performance. I will discuss several studies conducted at UoM to illustrate how these methodologies can contribute to the development of next-generation energy technologies and solutions.

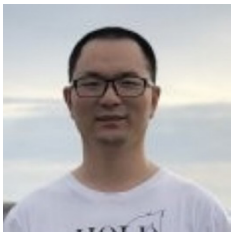
Dr. Nina Novikova is a Research Fellow at the University of Melbourne, specializing in optical and nano-spectroscopy. With a PhD in Chemistry completed in 2019 from the University of Auckland, her research focuses on understanding and harnessing light-matter interactions in molecular systems. She has extensive experience in ultrafast spectroscopy and the development of advanced spectroscopic and analytical techniques for application-driven research.

Nonconfinement promotes the proton transport: A computational study

Dr. Yuxiang Wang

Research Fellow, Computational Materials Engineering, Mechanical Engineering, *University of Melbourne*

Nanosheet-based membranes with tunable intersheet spacings, achieved by incorporating phosphoric acid (PA) to separate individual nanosheets, have been experimentally shown to significantly enhance proton conductivity at high temperatures. To uncover the mechanisms behind this exceptional performance, we employed computational techniques. Our findings reveal that hydrogen bond distributions, influenced by nanoconfinement, are closely correlated with the experimentally observed improvements. Additionally, temperature-induced ring deformations in the nanosheets (graphene and hBN) appear to directly facilitate possibility of proton transport through the rings. While uncertainties remain, this computational study provides critical insights into the underlying mechanisms and opens the door for further exploration.



Dr. Yuxiang Wang received his PhD at Monash University in 2019. Thereafter, he joined Deakin University as a research associate (2020 to 2023),working on cellulose-based materials; then as a research fellow at Monash University from early 2023 to 2024, he mainly worked on a proton exchange membrane project, focusing on the mechanism exploration by using computational techniques. Currently he is a research fellow at The University of Melbourne, continuing working with the proton exchange membrane project and several other projects.

Power Generation and Transport

MEI Symposium 24

Melbourne Energy Institute

THE UNIVERSITY OF MELBOURNE

Research Program: Power Generation and Transport

CHAIR: Associate Professor Shiaohuey Chow

(on behalf of Professor Richard Sandberg, Program Leader)

Associate Professor in Geotechnical Engineering, Infrastructure Engineering

Director, Australian Centre for Offshore Wind Energy

University of Melbourne

A/Prof. Shiaohuey Chow is an Associate Professor in Geotechnical Engineering at the University of Melbourne. She is also the Director of the Australian Centre for Offshore Wind Energy, and a member of the Executive Committee for the Melbourne Energy Institute. Her research interests include offshore geotechnical site investigation, anchoring solution in sand, strain rate effects in soils and sample disturbance effects on soft soils. Her works have received several international best paper awards, including the Telford Premium Prize in 2016 and Manby Prize in 2014 from the Institution of Civil Engineers (ICE), UK. Shiaohuey is an Associate Editor for the Géotechnique Letters and International Journal of Physical Modelling in Geotechnics. She is also a member of the ISSMGE TC214 on Foundation Engineering for Difficult Soft Soil Conditions, and Secretary of the Australian Geomechanics Society (Victorian Chapter).

Shiaohuey obtained her PhD at the University of Sydney in 2013, and her MEng degree in geotechnical engineering from the Nanyang Technological University, Singapore in 2003. Prior to her appointment at Melbourne, she was a Research Fellow at the Centre for Offshore Foundation Systems (COFS) at the University of Western Australia.

Keynote: Technology pathways for sustainable energy systems

Dr. David Harris

Chief Research Consultant, *CSIRO Energy*

Net-zero policies and strategies are driving industrial sectors worldwide to develop, demonstrate and implement new business and operating models that support significant reductions in emissions and environmental impacts. Many industrial sectors are now seeking step changes to deploy technologies and systems to support sustainable energy, transport, manufacturing and industrial operations at the local, national and international scale. At the local scale, there are near term opportunities for technology adaptations, demonstrations and deployments directly aligned with 'in-business' sustainability challenges. At the grander scale, there are opportunities to demonstrate and establish entire new industry sectors leveraging the transition of global energy and fuels platforms required to maintain viable international energy and transport systems.

Dr. David Harris leads the development of major industrial scale projects which leverage state-of-the-art technologies across vital energy value and supply chains. The focus is to support development, demonstration and deployment of practical, sustainable energy technologies that enable large scale renewable energy production, storage, transport and utilisation. In his previous role as Research Director for CSIRO's Energy Technologies Program, David led CSIRO's low emissions and hydrogen-based energy research programs for more than 25 years. He has strong personal and professional networks across the major energy research, manufacturing, transport, government and infrastructure sectors in Australia and internationally. These partnerships are key enablers in ensuring Australian energy initiatives are appropriately positioned to enable success of the crucial first-of-a-kind technology demonstrations currently being developed across clean energy supply chains underpinning major energy sector transitions that are now well underway at global scale.

Geothermal: Our under-utilised renewable resource

Professor Rachel Webster AO FAA

Redmond Barry Distinguished Professor, School of Physics, *University of Melbourne*

Geothermal provides a renewable energy resource which is complementary to other variable sources. The potential of geothermal is being realised in all major economies across the globe. This talk will describe the local opportunities for geothermal to deliver industrial heat as gas replacement at an economical cost. In addition, the future opportunities for geothermal electricity generation will be outlined.

Prof. Rachel Webster has had a distinguished career in astrophysics at the University of Melbourne. In addition, for over fifteen years, she has been investigating the potential of Australia's geothermal resources to be part of our renewable energy mix. Recently she has led a project to understand the geothermal resources in Victoria's Latrobe Valley and to develop designs for use cases that ensure the long-term sustainability of these resources. She is working with key researchers and government to realise these opportunities.

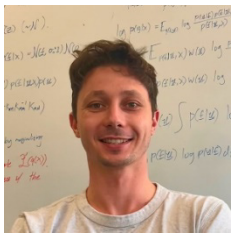
Gradient enhanced deep Gaussian processes for multifidelity surrogate modelling

Dr. Viv Bone

Research Fellow, Electrical and Electronic Engineering, *University of Melbourne*

Multifidelity surrogate models integrate data from multiple sources to produce a single approximator for the underlying process at lower computational expense than single-fidelity models.

Deep Gaussian processes are an attractive architecture for multifidelity modelling as they are non-parametric, naturally yield uncertainty bounds, and can capture nonlinear input-dependent relationships between data of different fidelities. This talk focuses on extending deep Gaussian processes to incorporate gradient information. We show that this information, which can be cheaply obtained from adjoint solutions or automatic differentiation tools, can significantly improve the predictions of these models. We demonstrate on two computational fluid dynamics examples: a hypersonic waverider and the ONERA M6 wing.



Dr. Viv Bone's research interests include thermofluids, model-based control and optimization, machine learning, and optimal control, with applications in aerospace and renewable energy.

Assessment of long-term trends and variability of wind energy density off the coast of Australia

Dr. Rui Li

Post Doc Researcher, Infrastructure Engineering, *University of Melbourne*

Wind energy has emerged as a crucial and sustainable source of renewable energy, showcasing significant environmental benefits and fostering economic growth. This study focuses on assessing long-term trends in wind energy off the coast of Australia. By calculating the extreme values of Wind Energy Density (WED) using 10 meter wind speed, the study reveals maximum values of 918.9 W/m² and 1200.0 W/m² for the northeastern and western coasts of Australia over a 40-year period. Additionally, the study compares the differences in wind energy calculated from 100 meter wind speed versus 10 meter wind speed, finding that wind energy at 100 meters is not always greater than at 10 meters off the coast of Australia. Furthermore, the study selects and analyses four specific points along the Australian coast to understand their time-series variations, identifying a five-year period in the offshore wind field of Australia. The zonal WED in the Southern Ocean exhibits an upward trend, primarily influenced by the westerly wind belt. The study also calculates the long-term return period values and variation index of wind energy. Ultimately, the findings of this study are expected to facilitate informed decision-making regarding offshore wind development in Australia.

Dr. Rui Li is a postdoctoral researcher in the Ocean Engineering Group at the University of Melbourne, specializing in physical oceanography. With a Ph.D. from Ocean University of China, Rui's research focuses on ocean waves, marine hazards, climate change and wind energy. Rui has published multiple papers in leading journals such as Journal of Geophysical Research: Oceans and Remote Sensing.

Pushing the frontiers of supercomputing for next-generation aircraft engines

Marco Rosenzweig

PhD Student, Mechanical Engineering, *University of Melbourne*

Australia's international connectivity in travel and trade relies on long-haul aircraft which will be powered by gas turbines for the foreseeable future. Consequently, next-generation aircraft engines must be more efficient and less noisy to meet environmental and economic demands. Current industrial design cycles use low-fidelity models, which, while being computationally cheap, often fail to predict the complex airflow through the engine dictating performance and efficiency. High-fidelity simulations, solving physical equations, can provide accurate results but at a high computational cost. This talk explores combining low- and high-fidelity simulations to balance accuracy and cost, using Australia's supercomputing resources to improve aircraft engine design cycles.

Marco Rosenzweig is a third-year Ph.D. student at the University of Melbourne. In 2022, he obtained his M.Sc. degree in Aerospace Engineering at the Technical University of Munich and has two years of industrial work experience at MTU Aero Engines AG. Marco's research expertise is in the turbomachinery flows critical to aircraft engines with a focus on low-pressure turbines. To date his research interests have included modelling of multi-stage component interactions, the evaluation of standard industrial design methods and scale-resolving, numerical methods. His most recent work focuses on performing multi-fidelity simulations on the latest supercomputing architectures.

Heavy Industry and Resources

MEI Symposium 24

Melbourne Energy Institute

THE UNIVERSITY OF MELBOURNE

Research Program: Heavy Industry and Resources

CHAIR: Associate Professor Colin Scholes

(on behalf of Professor Kathryn Mumford, Program Leader)

Associate Professor, Chemical Engineering, *University of Melbourne*

A/Prof. Colin Scholes is the head of the Scholes Research Group at the University of Melbourne. His research is focused on developing solutions in the clean energy and future fuels sector, including developing novel separation processes involving membranes and assisting industry's undertake carbon emission abatement. This research is primarily achieved by working with industry partners on technology development. His goal is to implement technology solutions in Australia and international industry that will facilitate the transition to a clean energy future, reduce CO2 emissions and decrease the energy intensity of industry.

Keynote: Carbon capture and storage – A pathway to a low emission future

Barry Hooper

Executive Director, *KC8 Capture Technologies Ltd*

The low emission journey is complex and expensive. Barry's journey started over 20 years ago and continues with CCS as relevant now as then - an important abatement tool for Heavy Industry and Resources.

This presentation will explain and de-mystify CCS, look at past milestones and discuss future emission reduction. It was never to be the dominant tool in climate wars nor will it be in the future - a balanced approach was advocated. What happened?

The company's work in the cement and power industries, supported by investors, industry and government both in Australia and the US, is a clear indication of the pathways for CCS.

Barry Hooper is Executive Director of KC8 Capture Technologies Ltd, an Australian company commercialising CCS and capture technology IP globally. He has over 40 years' experience in design, operations and management roles in the refining, chemical processing and CCS industries. Prior to his current position he was Corporate Engineering and Manufacturing Manager at Orica and the Chief Technologist at CO2CRC from 2003 to 2014.
He has held an honorary appointment in Chemical Engineering at The University of Melbourne since 2002.

A high pressure, high temperature electrolysis rig with optical access for bubble imaging

Dr. Andre Chambers

Postdoc Research Associate, High Press Hightemp Electrolysis, Mechanical Engineering, *University of Melbourne*

To fulfill the potential of green hydrogen, reducing production costs is essential, particularly by improving the electrolysis efficiency. Gas bubbles are a significant source of efficiency losses by limiting the electrolysis reaction rate. Understanding bubble formation and transport under industrial conditions is crucial to mitigate these effects. In this work, we developed a novel, optically accessible, laboratory scale electrolyser that can characterise device performance, including imaging bubble formation, at temperatures up to 200°C and pressures up to 200 bar. Preliminary results demonstrate the strong effect of elevated temperatures and pressures.

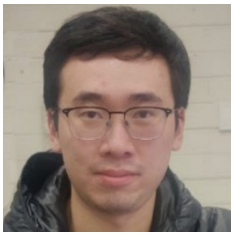
Dr. Andre Chambers is a Postdoctoral Research Fellow at the University of Melbourne, working on electrolyser design and optimisation. Completing his PhD in Physics at the University of Melbourne in 2023, his research focussed on theoretical and experimental aspects of semiconductor electrochemistry for both biomedical and energy storage applications. His current research focus is high temperature, high pressure electrolysis. Completing his PhD in 2023, he has received multiple awards for his research, including the Klein Prize in Experimental Physics, the Kenneth Head Award, and the Borland Forum Award.

Development of equations of state at cryogenic conditions by molecular dynamics simulations

Jiaou Song

PhD Student, Chemical Engineering, *University of Melbourne*

Molecular Dynamic (MD) computer simulations were applied to generate precise density-pressure-temperature (ρPT) data for gas mixtures under cryogenic conditions. By simulating binary and ternary mixtures of hydrogen, helium, and air, we observed metastable phase transitions and the non-ideal effects on mixture densities. A new Equation of State (EOS) model, based on the MD simulations, was developed to improve the inaccuracies otherwise predicted by traditional models. The newly developed model has shown its potential in computational fluid dynamics (CFD) simulations to enhance the design and efficiency of processes in areas such as pollution control and engine development.



Jiaou Song earned a Bachelor of Science in Chemical Systems and a Master of Engineering in Chemical Engineering at the University of Melbourne, where he is currently pursuing a Ph.D. in Chemical Engineering under the supervision of Dr. Eirini Goudeli and Dr. Joseph Berry.

Carbon-negative ammonia production from the air

Dingqi Wang

PhD student, Chemical Engineering, *University of Melbourne*

Ammonia holds paramount importance for production of fertilisers and hydrogen carriers, but its conventional synthesis via Haber-Bosch process significantly contributes to greenhouse gas emissions. Here, we present a carbon-negative ammonia synthesis process that not only produces ammonia from the air but also directly captures the atmospheric CO2. Under ambient conditions, this process utilizes lithium to cleavage the nitrogen gas and yield ammonia upon exposure to atmosphere moisture and promote spontaneous absorption of CO2 with an exceptional capacity. This proof-of-concept of ammonia production from air coupled with DAC paves a new way for the development of sustainable and negative-emission technologies.

Dingqi Wang, obtained his bachelor's degree from Fudan University major in Pharmacy, and completed his master's degree from The University of Melbourne in Chemical Engineering. He is currently a PhD candidate at Clean Energy Lab under supervision of A/Prof. Gang Kevin Li at University of Melbourne. His research topic is about "integrated lithium cycle for combined gas processing".

Green hydrogen production from the air

Dr. Mandy Men

Postdoc Research Engineer, Chemical Engineering, *University of Melbourne*

Green hydrogen produced via water electrolysis is one of the most promising energy carriers for the low-carbon economy. However, a major challenge lies in the geographic mismatch between the distribution of renewable energy sources and freshwater availability, which limits hydrogen production. To mitigate the freshwater shortage for electrolysis, a novel hydrogen production from air has been developed and tested. Freshwater is captured in situ from the atmosphere via a hygroscopic electrolyte, followed by electrolysis to produce hydrogen. This method offers a potential solution to the freshwater scarcity in hydrogen production, enabling more sustainable and geographically flexible energy generation.

Dr. Mandy Men obtained her PhD from the University of Melbourne, specializing in CO2 capture and utilization. After her role as a laboratory manager, she joined the Clean Energy Laboratory at the University of Melbourne as a Postdoctoral Research Engineer working on Thin Air Fuel Project, aiming at producing hydrogen from air applicable to desert and other water scarce regions. She involved in scaling up advanced laboratory technologies to pilot-scale production.

THE UNIVERSITY OF MELBOURNE

Contact us

Melbourne Energy Institute
The University of Melbourne
Level 1, Melbourne Connect
700 Swanston Street, Carlton VIC 3053

mei-info@unimelb.edu.au
energy.unimelb.edu.au
Melbourne Energy Institute