Melbourne Energy Institute

Melbourne Energy Institute Symposium

December 8, 2023

Contents

Program

Date:	8 December 2023	**Time:**	8:30am – 4:30pm
Venue:	Melbourne Connect Forums 1-3, Mezzanine Floor, 700 Swanston Street, Parkville		
Registration:	https://events.humanitix.com/mei-symposium-23		
Cost:	Free	**Enquiries:**	mei-info@unimelb.edu.au

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

OPENING PLENARY	
	Forum 2 & 3
8:30-8:40am	**Welcome and opening of MEI Symposium 23** **Prof. Michael Brear**, *Director*, Melbourne Energy Institute
8:40-9:30am	**Prospective pathways to decarbonise heavy industry from Australian ores** **Prof. Graham (Gus) Nathan,** *Director, Centre for Energy Technology, Professor in Mechanical Engineering* University of Adelaide

	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 & 3	**Forum 1**
09:30-10:10am	**Keynote:** **Energy transition engineering science** **Prof. David Hill** *Prof Electrical Power and Energy Systems, Dept of Electrical and Computer Systems Engineering,* Monash University	**Keynote:** **CSIRO Manufacturing activities along battery value chain** **Dr Marzi Barghamadi** *Team Leader, Battery Materials and Design, Devices & Engineered Systems,* CSIRO Manufacturing
10:10-10:30am	**MORNING TEA**	
10:30-11:00am	**Advanced reactive power compensators: an introduction to Cascaded H-Bridge Low-Capacitance StatCom** **Dr Glen Farivar,** *Lecturer in Power Electronics, Electrical and Electronic Engineering,* University of Melbourne	**Investigating new emitter molecules for triplet-triplet annihilation (TTA) upconversion** **Dr Mina Barzegaramiriolya,** *Research Fellow in Exciton Science, Chemistry,* University of Melbourne
11:00-11:30am	**Making EVs and the grid work together: new challenges and opportunities** **Ms Jing Zhu,** *PhD student, Electrical and Electronic Engineering,* University of Melbourne	**Dynamic Topological Domain Walls Driven by Lithium Intercalation in Multilayer Graphene** **Ms Xue Yan**, *PhD student, Mechanical Engineering,* University of Melbourne
11:30-12:00pm	**A technical, economic & environmental assessment of clean marine fuel options for Australia** **Mr Nguyen Cao,** *PhD Student, Mechanical Engineering,* University of Melbourne	**Towards Autonomous Stealth Materials Design for Naval Vehicles** **Dr. Ellie Hajizadeh,** *Lecturer, Research & Teaching, Mechanical Engineering,* University of Melbourne
12:00-12:30pm	**Aggregated flexibility in integrated electricity-gas-hydrogen distribution systems** **Ms Antonella De Corato,** *PhD student, Electrical and Electronic Engineering,* University of Melbourne	**High efficiency perovskite solar cells for space applications** **Dr Shi Tang,** *Research Fellow, Optical Nanomaterials Synthesis, Chemistry,* University of Melbourne

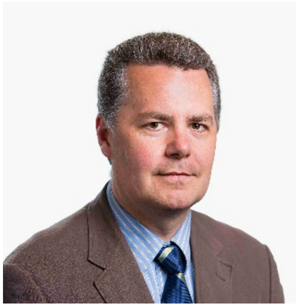
12:30-1:20pm	**LUNCH & POSTER COMPETITION** *(Launch pad zone)*	
	STREAM 1 (AFTERNOON) **Power Generation and Transport** **Chair: Dr Shiaohuey Chow on behalf of** Prof. Richard Sandberg, Program Leader	**STREAM 2 (AFTERNOON)** **Heavy Industry and Resources** Chair: A/Prof. Kathryn Mumford, *Program Leader*
	Forum 2 & 3	**Forum 1**
1:20-2:00pm	**Keynote:** **Get outta my dreams, get into my car: transitioning to sustainable mobility in a car-dependent world** **A/Prof David Keith** *A/Prof of Strategy and Faculty,* *Centre for Sustainability and Business,* *Melbourne Business School,* University of Melbourne	**Keynote:** **Direct air capture: a key technology to achieve net zero** **A/Prof Kathryn Mumford** *Head of Department,* *Chemical Engineering,* University of Melbourne
2:00-2:30pm	**High-fidelity computational studies of roughness effects on high-pressure turbine performance** **Dr Tom Jelly,** *Research Fellow in Extreme-Scale Cfd,* *Mechanical Engineering,* University of Melbourne	**Compatibility of plastic piping with future fuels** **Dr. Yuecheng Zhang,** *Graduate Researcher,* *Chemical Engineering,* University of Melbourne
2:30-3:00pm	**Better predictions of accidental cryogenic hydrogen release** Dr **Joe Berry,** *ARC Future Fellow,* *Chemical Engineering,* University of Melbourne	**Designing inherently stable PGM-free CO_2 electrolysis** **Dr Aaron Li,** *ARC Decra Fellow,* *Chemical Engineering,* University of Melbourne
3:00- 3.20pm	**AFTERNOON TEA**	
3:20- 3:50pm	**Forecasting offshore turbidity currents using deep learning models** **Dr. Negin Yousefpour,** *Senior Lecturer,* *Geotechnical Engineering, Infrastructure Engineering,* University of Melbourne	**Current status, challenges, and future prospects of liquid hydrogen infrastructure** **Dr. Shanaka Baduge,** *Research Fellow,* *Infrastructure Engineering,* University of Melbourne
3:50- 4:20pm	**Can machine learning help develop more efficient power generation?** **Ms Yuan Fang,** *PhD Student,* *Mechanical Engineering,* University of Melbourne	**Comparing powertrains for heavy-duty long-haul trucks and their implications for liquid hydrogen** **Dr. Zhenbiao Zhou,** *Research Fellow,* *Mechanical Engineering,* University of Melbourne
4:20-4:30pm	**THANK YOU AND CLOSE**	

Plenary

Welcome

Professor Michael Brear

Director, Melbourne Energy Institute



Professor 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.

Keynote: Prospective pathways to decarbonise heavy industry from Australian ores

Professor Graham (Gus) Nathan

Director, Centre for Energy Technology, Professor in Mechanical Engineering, University of Adelaide and Research Director, Heavy Industry Low-carbon Transition CRC

This presentation will focus on how to accelerate the transition to net-zero for the difficult-to-abate sectors of iron/steel, alumina and cement, considering both the path and the goal. The challenges to decarbonising these industries result both from the lack of commercially available net-zero technologies for Australian ores and the lack of sufficient energy infrastructure to fuel the anticipated future processes. Furthermore, while some steps can be made today, it is important to understand enough about the future system to avoid over-investing in technologies that may become redundant in the future. Professor Nathan presentation will also introduce new insights into the anticipated step-changes in technology that will be needed to increase circularity and lower the energy consumptions of future systems, which will thereby offer opportunity to lower the cost of the transition compared with simple substitution of current low-cost fossil fuels with more expensive, net-zero energy alternatives. These insights guide investments in how to achieve near-term reductions without compromising the net-zero technologies of 2050.

Gus Nathan is a Professor in Mechanical Engineering at the University of Adelaide, the inaugural Energy Professional of the Year from the Australian Institute of Energy, SA, a Fellow of both the Academy of Technological Sciences and Engineering and of the Combustion Institute, a recipient of a Discovery Outstanding Researcher Award from the Australian Research Council and an ATSE KH Sutherland medallist.

He was the bid leader for, and is now the Research Director of, the national Heavy Industry Low-carbon Transition Cooperative Research Centre, the HILT CRC. He has led the development of six technology platforms, three of which are in ongoing commercial use within high temperature processes such as iron pellets, cement and lime kilns and alumina calciners, while three are currently being upscaled to decarbonise heavy industry.

He has worked closely with industry throughout his career and is the founding chair of the international High Temperature Minerals Processing (HiTeMP) Forum. He has published some 300 papers in international journals, 250 in peer reviewed conferences, 50 commissioned reports and 13 patents.

Energy Systems

Chair

Professor Pierluigi Mancarella

Program Leader, Energy Systems, Melbourne Energy Institute

Professor Pierluigi Mancarella is the Chair Professor of Electrical Power Systems at the University of Melbourne, Australia, and Professor of Smart Energy Systems at the University of Manchester, UK. His key research interests include techno-economic modelling and analysis of multi-energy systems, grid integration of renewables and distributed energy resources, energy infrastructure planning under uncertainty, and security, reliability, and resilience of low-carbon networks.

Pierluigi is the Energy Systems Program Leader at the Melbourne Energy Institute, a Fellow of the IEEE (Institute of Electrical and Electronics Engineers), an IEEE Power and Energy Society Distinguished Lecturer, the Convenor of the CIGRE (International Council of Large Electric Systems) C6/C2.34 Working Group on “Flexibility Provision from Distributed Energy Resources”, holds the 2017 veski innovation fellowship for his work on urban-scale virtual power plants, and is a recipient of the international Newton Prize 2018 for his work on power system resilience in Chile. He is author of several books and over 300 research papers and reports, and is a Senior Editor of the IEEE Transactions on Power Systems, and the Oxford Open Energy journal.

Pierluigi is the Australian principal investigator of the US-UK-Australia Global Center in Climate Change and Clean Energy “EPICS” (“Electric Power Innovation for a Carbon-free Society”). In the past few years, he has supported the Finkel Review panel, the Australian Energy Market Operator, the Australian Energy Market Commission, and the Australian Energy Regulator on relevant research and consultancy projects on power system security, reliability, and resilience, and has led and been involved in several projects via the Australian Renewable Energy Agency, Cooperative Research Centres, and the Commonwealth Scientific and Industrial Research Organisation.

Keynote: Energy transition engineering science

Professor David Hill

Professor Electrical Power and Energy Systems, Department of Electrical and Computer Systems Engineering, Monash University

The talk will give a view of the Australian energy transition through the lens of an engineering scientist with an international outlook, but also one with insights obtained from consulting. There will be no more than one or two equations. The aim is to present the energy transition as a huge nation building engineering project that has an unacceptable level of risk of failing to meet declared goals in emissions, prices and reliability without more proactive action on current regulation, coordination, skills capacity and consumer social licence and energy resources. A major contribution could be made with higher level use of systems engineering and related sciences alongside social sciences.

David J. Hill holds the position of Professor of Electrical Power and Energy Systems at Monash University, Melbourne, Australia. He is also Professor Emeritus at The University of Sydney and The University of Hong Kong. He was Foundation Director of the Centre for Future Energy Networks at The University of Sydney.

Professor Hill is an elected Fellow of the IEEE, SIAM and IFAC professional societies and four learned academies in Australia, Sweden and Hong Kong. He has received numerous international awards for his research in control and power and energy systems.

Advanced reactive power compensators: an introduction to Cascaded H-Bridge Low-Capacitance StatCom

Dr Glen Farivar

Lecturer in Power Electronics, Electrical and Electronic Engineering, University of Melbourne

Static synchronous compensators (StatComs) can play an important role in the operation of transmission lines. Adding a StatCom to weak points of the transmission network provides voltage stability and increases the transmission line active power capacity. The main issue with widespread use of this technology is the cost. High power StatCom configurations are normally based on the cascade H-bridge (CHB) multilevel converters, which integrate many relatively large capacitors. Normally, the capacitors are sized to limit the magnitude of 2nd order capacitor voltages ripple to no more than 10%. Indeed, violating this threshold, i.e., further reducing the capacitance is achievable but comes with control challenges and compromise on stable operating region. In this presentation, firstly a brief background on significance of reactive power compensation in transmission lines followed by an overview of the conventional reactive power compensators will be provided. Then, pros and cons of operating a CHB StatCom with low capacitance values will be discussed.

Glen Farivar received a PhD in Electrical Engineering from the University of NSW, Sydney, Australia in 2016. He was a senior research fellow at the energy research institute at NTU (ERI@N) and a co-director of the Power Electronics and Application Research Lab at NTU, Singapore. Currently, he is a lecturer in Power Electronics at the Department of Electrical and Electronic Engineering, University of Melbourne, Australia. He is also a co-founder of SciLeap, a platform dedicated to promoting research integrity, accessibility, and openness. He is a Senior Member of IEEE and co-authored aver 100 papers in the areas of high-power multilevel converters and photovoltaic systems.

Making EVs and the grid work together: new challenges and opportunities

Ms Jing Zhu

PhD student, Electrical and Electronic Engineering, University of Melbourne

The growing adoption of electric vehicles (EVs) presents new technical/economic challenges to our grid, which were originally not designed with extra charging demand. If EV charging is managed well, it could mean more efficient grid, resulting in lower reinforcement costs and reduced charging delays. Furthermore, thanks to the development of vehicle-to-grid (V2G) technology, there are new opportunities as EV batteries can be discharged to support the grid. This talk will present the findings of EV impacts on distribution networks, the pros and cons of EV management strategies, and the availability of V2G technology. These findings aim to help distribution companies to discover optimal solutions that make EVs and the grid work together, thus moving towards a brighter, net-zero future.

Jing Zhu is a third-year PhD candidate at The University of Melbourne. Her PhD project is "EV and V2G Management Opportunities in Future Distribution Networks". Before pursuing her PhD, she worked as a control room operator in the State Grid Corporation of China for three years. She received a B.Eng. degree in Electrical Engineering from The University of Manchester, UK, and North China Electric Power University, China in 2018.

A technical, economic and environmental assessment of clean marine fuel options for Australia

Mr Nguyen Cao

PhD student, Mechanical Engineering, University of Melbourne

The recent update by the International Maritime Organisation (IMO) to their strategy regarding greenhouse gas (GHG) emissions aims to achieve near net-zero GHG emissions from international shipping by around 2050. This aspiration necessitates the eventual replacement or enhancement of ships using fuel oil, shifting them to lower emission fuels. Potential alternatives such as hydrogen, ammonia, methanol and liquified natural gas (LNG) are being considered. However, the adoption of any of these fuel options will inevitably impact vessel performance and capacity.

This research therefore presents an analysis of the associated trade-offs linked to typical merchant vessels that navigate routes between Australia and other nations. The study encompasses the computation of levelised shipping costs and the expenses linked to GHG emissions abatement for both newly built and retrofitted vessels operating on each of the potential fuel options. The costs of emission reduction are closely tied to the prevailing prices of crucial commodities and the existing shipping costs for these commodities.

Nguyen Cao is a PhD student at the University of Melbourne. Before commencing his PhD, Nguyen earned his Master of Energy Systems from the same university. During this period he participated in the Zero Emission Energy Laboratory Program, focusing on modelling solar photovoltaic energy systems. This valuable experience was made possible through a collaboration between the Melbourne Energy Institute (MEI) and their industry partner, Ekistica.

Prior to his master's degree, Nguyen worked as an engineer specialising in solar photovoltaic energy systems. He commenced his academic journey by completing a Bachelor of Engineering Honours in Mechanical Engineering at the University of Sydney.

Aggregated flexibility in integrated electricity-gas-hydrogen distribution systems

Ms Antonella De Corato

PhD student, Electrical and Electronic Engineering, University of Melbourne

The strategic aggregation and coordinated operation of distributed energy resources (DER) and flexible loads could help against the operational challenges in renewables-rich power systems by providing flexibility. In this context, distributed grid-connected hydrogen electrolyzers (HE) could be a valuable source of additional flexibility. This capability may be backed by locally injecting hydrogen in the gas network as a storage solution. However, because of hydrogen’s different properties compared to natural gas, it becomes crucial to ensure the compatibility of appliances and network’s components to the gas blend.

This presentation will introduce a multi-energy vector framework to quantify the steady-state aggregated flexibility from DER including multiple grid-connected HEs. The proposed methodology is then tested on a real-world integrated electricity-gas-hydrogen (IEGH) system, proving the capabilities of the framework to estimate the flexibility contribution from multiple HEs simultaneously injecting hydrogen at multiple locations while capturing the associated operational constraints.

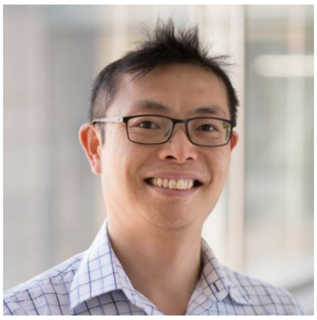
Antonella De Corato received her B.Sc. and M.Sc. degrees in electrical engineering from the Polytechnic University of Bari, Italy, in 2017 and 2019, respectively. She is in her final year of her Ph.D. degree in power systems at the University of Melbourne, under the supervision of Prof. Pierluigi Mancarella. Her research interests include modelling of distributed multi-energy systems and networks and grid integration of renewables and hydrogen technologies in low-carbon energy systems.

Energy Materials

Chair

Associate Professor Wallace Wong

Program Leader, Energy Materials, Melbourne Energy Institute



Associate Professor Wallace Wong is a Senior Lecturer in the School of Chemistry, the University of Melbourne, and leader of MEI's Energy Materials Research Program. He is a Chief Investigator and Research Theme leader in the ARC Centre of Excellence in Exciton Science.

Wallace has been an ARC Future Fellow (2014-2018) and an ARENA Research Fellow (2011-2014) and lead investigator on a number of organic solar cell projects including collaborative research programs with institutes in Germany and USA. The core expertise of this group is in the design and synthesis of organic materials with applications in light harvesting and solar energy conversion.

Keynote: CSIRO Manufacturing activities along battery value chain

Dr Marzi Barghamadi

Team Leader, Battery Materials and Design, Devices and Engineered Systems, CSIRO Manufacturing

Battery Materials and Design (BMD) Team at CSIRO Manufacturing is working on multiple multi-disciplinary battery projects in collaboration with other CSIRO teams, academia and industry sectors, both in Australia and overseas. Australia has a unique position in battery value chain due to its rich mineral resources. The major focus of BMD Team’s work is on the midstream of battery value chain where different electrodes and cells are manufactured and tested. These include materials for high power and high energy Li-ion batteries, as well as next generations battery technologies such as lithium sulfur and lithium air. During this seminar, an overview of battery research activities within BMD Team (and more broadly CSIRO Manufacturing Business Unit) will be presented. The discussion will also include how these activities are supporting a sustainable battery value chain with a few examples of CSIRO industry projects.

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 lithium ion / metal batteries to support Australian and international industries in solving their scientific and technical challenges, and to contribute to future scientists’ education in the area. Her research interests are electrolytes formulation and optimisation (including ionic liquids), modified separators, advanced electrode fabrication/ composition, cell electrochemical studies, and customised cell fabrication for both lithium metal (mainly Li-S) and lithium ion batteries. Marzi has received multiple prestigious awards such as 2023 David and Valerie Solomon Award, and 2020 L'Oréal-UNESCO For Women in Science Fellowship.

Investigating new emitter molecules for triplet-triplet annihilation (TTA) upconversion

Dr Mina Barzegaramiriolya

Postdoctoral Research Fellow, ARC Centre of Excellence in Exciton Science, School of Chemistry, Bio21 Institute, University of Melbourne

Photovoltaic (PV) technologies, despite a 50-year history, grapple with cost challenges due to low solar cell power conversion efficiency. This issue is largely caused by a mismatch between solar photon energy and semiconductor bandgaps.

1 Recent advances have produced luminescent materials that efficiently convert light into specific-wavelength photons, reducing energy losses in solar cell conversion. Upconversion (UC) of low-energy photons is a promising strategy to boost solar cell technology. Overcoming challenges like rapid quenching of triplet states by molecular oxygen and near-infrared (NIR) to visible light conversion is vital. The V79/PbS combination addresses these issues by transforming sub-bandgap photons into above-bandgap photons.
2 Our study focuses on improving V79's upconversion efficiency, modifying its structure to enhance quantum yield while maintaining oxygen stability.

Dr Mina Barzegaramiriolya earned her PhD in 2018 under the guidance of Professor Uta Wille at the University of Melbourne, Chemistry Department, focusing on the development of free radical sensors using organic fluorescent dyes. Her post-doctoral research in 2019 continued to emphasize precise detection, albeit through a distinct sensor architecture. Working under the supervision of Prof. Lloyd Hollenberg and A/Prof David Simpson at the School of Physics, she worked on pioneering diamond-based 'quantum sensors.' Utilizing the quantum properties of crystallographic defects in diamond to detect magnetic resonance signals. In 2022, she joined the Exciton Science team working under supervision of A/Prof Wallace Wong, concentrating on molecular structures to enhance upconversion process efficiency.

Dynamic Topological Domain Walls Driven by Lithium Intercalation in Multilayer Graphene

Ms Xue Yan

PhD student and research fellow in computational materials design in the Integrated Computational Materials Engineering (ICME) group, Mechanical Engineering, University of Melbourne

Atomic intercalation into van der Waals (vdWs) layered materials can modulate the stacking structure, thus enabling control over topological electronic phases at the atomic scale without highly technical protocols. The dynamics of intercalated atoms are crucial for controlling the intercalation and understanding how the topological microstructure evolves. Here, we present Li intercalation in a topologically-structured graphene/buffer system on SiC (0001), revealing dynamic topological domain wall (TDW) motions via in-situ aberration-corrected low-energy electron microscope (LEEM) and theoretical modelling. We observe a sequential Li-intercalation initiates at topological crossing points (AA stacking) and selectively extends to AB stacking domains. This locally changes the domain stacking to AA and consequently alters the neighbouring TDW stacking. Continuous intercalation drives the evolution of the whole topological structure network. Our work reveals moving TDWs protected by the topology regarding stackings during Li-intercalation and moreover lays the foundation for realizing intercalation-driven vdWs electronic devices and energy-storage-related applications.

Xue Yan obtained a B.Eng. in Materials Science and Engineering from Northwestern Polytechnical University (2015) and an M.Eng. in Materials Engineering from Tsinghua University (2018). Xue's research focuses on using molecular simulation for the rational design of materials for future energy storage and conversion applications. She has published several papers as the first or co-first author in high-impact journals, including Nature Nanotechnology, Nature Communication, Advanced Materials, and Advanced Functional Materials.

Towards autonomous stealth materials design for naval vehicles

Dr Ellie Hajizadeh

Lecturer, Research & Teaching, Mechanical Engineering, University of Melbourne

Defence is looking for accelerated outcomes in advanced materials technologies to provide the necessary asymmetric advantages in an era of fast-evolving threats. Nevertheless, the material design and development process, although guided by domain knowledge and explicit physical rules, is still largely a trial-and-error one, which is laborious time consuming, and resource-intensive.

We aim to establish an autonomous computational material design framework via integrating multiscale material simulation techniques with machine learning and statistical optimization techniques.

This research provides Defence with a highly sophisticated materials design engine, which can be used to design materials systems for any target performance requirement in a very short time.

Dr Ellie Hajizadeh is a Lecturer and Head of Soft Matter Informatics Research Group at the Department of Mechanical Engineering, University of Melbourne. Her vision is to enable accelerated and autonomous soft matter discoveries through contributing to 4 pillars of this emerging field, including physics-informed and interpretable ML for soft matter, integrated multiscale soft matter simulations, inverse design through statistical optimization, and high throughput robotic soft matter synthesis. Her research impacts several industries, including defence, medical, chemical, and modern manufacturing. Since 2018, she has raised $2m+ in funding and delivered several material design tools to national and international governments and industries.

High efficiency perovskite solar cells for space applications

Dr Shi Tang

Research Fellow, Optical Nanomaterials Synthesis, Chemistry, University of Melbourne

As commercial space activities surge, driven by declining launch and manufacturing expenses, there's a growing demand for cost-effective space solar cell technologies. Organometal halide perovskite solar cells (PSCs) stand out as a promising solution, given their high efficiencies, affordability in manufacturing, and radiation resistance. In this presentation, Shi will delve into the design and testing processes of PSCs tailored for space applications.

Dr Shi Tang is a research fellow at Exciton Science within School of Chemistry, Faculty of Science. He is now working on high-performance polaritonic devices for lighting. He holds a Ph.D. in Physics from the University of Sydney, where he developed perovskite solar cells for space applications in collaboration with Exciton Science, ANSTO and CSIRO.

Power Generation and Transport

Chair

Dr Shiaohuey Chow (on behalf of Professor Richard Sandberg, Program Leader)

Senior Lecturer in Geotechnical Engineering, Infrastructure Engineering, University of Melbourne

Shiaohuey Chow is a Senior Lecturer in the Department of Infrastructure Engineering at the University of Melbourne. She is an experimentalist in geotechnical engineering (laboratory soil element testing, laboratory 1g model testing, centrifuge modelling and field investigation) with research interests in offshore geotechnics.

Her expertise includes offshore geotechnical site investigation using free-fall penetrometers, anchoring solution in sand and strain rate effects in soil. 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 also a chief investigator on several research projects including three recent Australian Research Council Discovery Projects (Lead CI on two). She collaborates widely with both academic and industry partners nationally and internationally. She also enjoys engaging with the community to share her passion in geotechnical engineering and to promote more girls in STEM. She is an Associate Editor for the Géotechnique Letters and International Journal of Physical Modelling in Geotechnics, and a member in the Technical Committee 214 on Foundation Engineering for Difficult Soft Soil Conditions of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), and a Committee member in 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: Get outta my dreams, get into my car: transitioning to sustainable mobility in a car-dependent world

Associate Professor David Keith

Associate Professor of Strategy and Faculty, Centre for Sustainability and Business, Melbourne Business School, University of Melbourne

Our collective dependence on fossil fuel-powered, privately-owned, human-driven cars is responsible for multiple societal problems - including greenhouse gas emissions, urban air pollution, traffic congestion, and road deaths - that demand a sustainable mobility transition. Yet the reality is that consumer preferences for automobile ownership and use are at odds with many of the sustainable mobility solutions being proposed such as micro-mobility (scooters and bikes), on-demand mobility services, and pooled rides.

In this presentation I will introduce several studies of consumer mobility preferences that help us understand why we have the on-road fleet we have today. From these behavioural insights, I will suggest a mix of technologies and policies likely to be (relatively) more effective at reducing transportation externalities while providing consumers transportation solutions that are reliable, convenient, and flexible.

David Keith is an Associate Professor of Strategy at Melbourne Business School (MBS), and Associate Director - Innovation and Sustainability in the MBS Centre for Sustainability and Business. David is a leading researcher on the future of the automotive industry, exploring topics including consumer preferences for car ownership, EV adoption, and shared use; the dynamics of fleet turnover; platform competition in on-demand markets; and the development of robust EV charging infrastructure. Prior to joining MBS, David spent 9 years on the Faculty of the MIT Sloan School of Management, was co-founder and CEO of EV charging infrastructure financing platform Mobilyze.ai (acquired by FreeWire Technologies), has been a consultant to most global automakers, and worked in Product Planning for General Motors Holden.

High-fidelity computational studies of roughness effects on high-pressure turbine performance

Dr Tom Jelly

Research Fellow in Extreme-Scale Cfd, Mechanical Engineering, University of Melbourne

Gas turbines (GTs) are complex machines used to propel jet engines. As technology continues to advance, engineers want an estimate of how efficiently GT engines will perform. One of the main sources of GT performance degradation can be attributed to increases in surface roughness. GT blades in particular experience a substantial amount of surface degradation over their lifetime. To understand how roughness affects GT performance, we have performed high-fidelity computer simulations of flow over turbine blades with realistic levels of surface roughness in collaboration with the world's largest jet engine manufacturer, GE Aerospace. The simulation data have enabled us to explore the impact of surface roughness upon GT performance using a "digital wind-tunnel" operating at engine-relevant conditions.

Dr Tom Jelly currently works as a Research Fellow in Extreme-Scale Computational Fluid Dynamics at the University of Melbourne under the supervision of Professor Richard Sandberg. He has previously held research-focussed positions at the Universities of Cambridge and Glasgow, and holds a PhD in Mechanical Engineering from Imperial College London. His research employs high-fidelity computational methods to gain fundamental understanding of momentum and heat transfer phenomena in turbulent shear flows.

Better predictions of accidental cryogenic hydrogen release

Dr Joe Berry

ARC Future Fellow, Chemical Engineering, University of Melbourne

Uncontrolled release of hydrogen stored under pressure at cryogenic temperatures into ambient air is a complex process involving coupling of heat and mass transfer, phase change, and turbulent flow. New thermodynamic and phase behaviour knowledge developed from molecular simulations can be integrated into accurate computational fluid dynamics (CFD) simulations of cryogenic hydrogen plumes to inform development of low-order plume models necessary for safe process and plant design. Current simulation limitations will be critically assessed, as well as the steps necessary for accurate simulations of hydrogen plumes at cryogenic temperatures.

Dr Joe Berry is an ARC Future Fellow in the Department of Chemical Engineering at the University of Melbourne. His research focusses on the development and application of numerical models to solve complex, multi-disciplinary engineering problems in order to yield quantitative understanding directly relevant to industry. He has extensive experience in model development for research and industry, and was awarded the 2021 Barry Inglis Medal from the National Measurement Institute of Australia (an annual award recognising outstanding achievement in measurement research and excellence in practical measurements in Australia).

Forecasting offshore turbidity currents using deep learning models

Dr Negin Yousefpour

Senior Lecturer, Geotechnical Engineering, Infrastructure Engineering, University of Melbourne

Turbidity currents can pose a significant geohazard to offshore energy and subsea telecommunication infrastructures. We have explored novel methodologies to forecast turbidity currents on a real-time basis, leveraging on a novel approach combining both numerical modelling and deep learning techniques, validated based on laboratory and field measurements. A hybrid Convolutional Neural Network-Long Short-Term Memory (CNN-LSTM) model was trained to develop a real-time forecast model for turbidity current profiles. The deep learning models were trained using both synthetic and publicly available field data from an Acoustic Doppler Current Profiler (ADCP) deployed in the Congo Canyon, West Africa offshore region. The synthetic data generated through Computational Fluid Dynamics (CFD) analysis. Bayesian hyperparameter optimization techniques were implemented to find the best configuration for the DL models. The CNN-LSTM network is first trained using synthetic data generated by numerical models (CFD). Afterward, transfer learning techniques are applied by incorporating actual field data, leading to a 50 percent improvement in the model performance in predicting turbidity current profiles.

Dr Negin Yousefpour is a senior lecturer in the Infrastructure Engineering Department, specialised in data-driven and computational geotechnics. She joined the University of Melbourne winning the Doreen Thomas Fellow in 2020, and since then she has been leading collaborative, interdisciplinary research on geohazards and extreme events and application of AI-ML, data-driven and probabilistic methods, and advanced simulations for forecast/predictive maintenance, reliability assessment and design optimization, and development of early warning systems. Negin's research is applied and in close collaboration with industry and she is particularly passionate about application of her research in offshore renewable energy, infrastructure's resilience, and AI automation`. Prior to UniMelb Negin spent almost nine years working with Arup on cutting-edge projects across the globe.

Can machine learning help develop more efficient power generation?

Ms Yuan Fang

PhD Student, Mechanical Engineering, University of Melbourne

Industry consistently seeks more cost-effective and precise lower-order models in the early product design phase. A growing trend is shown in exploring machine learning (ML) techniques to develop these models. However, ML models often encounter challenges related to their ability to generalize and their compatibility when integrated into numerical solvers. To tackle these, we implement a symbolic regression algorithm (SRA) coupled with numerical solvers, applied across multiple scenarios. The outcomes reveal both improved model performance in and outside of the training dataset. Furthermore, the physical insights behind the models are explored by analysing the explicit expressions given by SRA.

Yuan Fang is a Ph. D student at the University of Melbourne's Mechanical Engineering Department, working under the guidance of Richard Sandberg, Andrew Ooi, and Yaomin Zhao. Her research focuses on enhancing the applicability of machine learning models in the field of computational fluid dynamics. Specifically, she is intrigued by the idea of utilizing machine learning, a technique heavily reliant on training data, to extract more comprehensive physical insights. Machine learning is used for training models that deliver accurate data-fitting outcomes across multiple datasets and we subsequently delve into the underlying physical principles behind models.

Power Generation and Transport

Chair

Associate Professor Kathryn Mumford, Program Leader

Program Leader, Heavy Industry and Resources, Melbourne Energy Institute

Kathryn Mumford is an Associate Professor in the Department of Chemical Engineering at The University of Melbourne.

Kathryn's research interests are in the areas of separations processes specifically ion exchange, solvent absorption and solvent extraction technologies. These interests range from the manufacture of novel materials, to the development of novel thermodynamic models to predict performance, and onto large scale implementation in the mining, energy, environmental and waste water processing fields.

Kathryn currently teaches in the Masters of Engineering (Chemical) program, namely Chemical Engineering Management and Heat and Mass Transport Processes subjects.

Keynote: Direct air capture: a key technology to achieve net zero

Associate Professor Kathryn Mumford

Program Leader, Heavy Industry and Resources, Melbourne Energy Institute

Recent simulations have indicated that in order to stay below the 1.5-2 °C threshold by 2100, negative emission technologies (NETs) with high CO2 removal capacity from the atmosphere will need to be widely deployed. Among various potential NETs, direct air capture (DAC), removing CO2 directly from the air and permanently storing it, has been gaining increasing attention compared to its competitors. This presentation will provide context for the recent and renewed interest in DAC systems, address technology developments, and future potential implementation pathways for DAC.

Compatibility of plastic piping with future fuels

Dr Yuecheng Zhang

Graduate Researcher, Chemical Engineering, University of Melbourne

Future fuels, methanol (CH3OH), ammonia (NH3) and dimethyl ether (DME), are attractive hydrogen alternatives that can potentially be distributed through natural gas pipeline networks. Compared with hydrogen, these future fuels have higher volumetric energy densities and safer material handling, ideal to replace natural gas. Polyethylene (PE) is the predominant pipeline material due to its corrosion resistance, flexibility and lightweight nature. However, the physical properties of future fuels, particularly their high condensability and solubility, means potential for stronger interactions with plastic piping and elastomers in the existing distribution network. This in turn, may result in high leakage rates accompanied by a decline in the mechanical properties of the plastic pipeline infrastructure. This work investigated the compatibility of liquid methanol, ammonia and dimethyl ether with the plastic pipeline and associated elastomers, including long-term performance changes. These future fuels compatibility is compared with methane, to highlight the impact these fuels will have on the natural gas infrastructure.

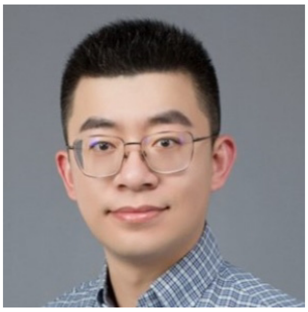
Yuecheng Zhang is a chemical engineering PhD student at the University of Melbourne, Australia. He is studying the compatibility of plastic pipelines with future fuels under the support of the Future Fuel Cooperative Research Centre. He enjoys learning new skills and collaborating with other researchers. He hopes to contribute to the development of clean and sustainable energy sources for the future.

Designing inherently stable PGM-free CO_2

Dr Aaron Li

ARC Decra Fellow, Chemical Engineering, University of Melbourne

CO_2 electrolysis is a promising electrochemical route to convert waste CO_2 into useful products such as CO, C2H4, 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 to enable stable PGM-free electrolysis cells for CO_2 electrolysis.



Dr Mengran (Aaron) Li is a lecturer and ARC DECRA in the Department of Chemical Engineering. After graduating with his PhD at UQ in 2016, he worked as a postdoc research fellow at UQ, working on the development of CO2 electrolysis technology for the iron-steel company for more than three years. In 2021 he joined the Delft University of Technology, the Netherlands, as another postdoc continuing his research on CO2 electrolysis supported by the EU Horizon Project. He then joined the Chemical Engineering Department at the University of Melbourne and was awarded ARC DECRA in 2023.

Current status, challenges, and future prospects of liquid hydrogen infrastructure

Dr Shanaka Baduge

Research Fellow, Infrastructure Engineering, University of Melbourne

Liquid hydrogen (LH2) is emerging as a prominent hydrogen storage medium in the global shift towards a hydrogen-based economy because of its compelling advantages of high volumetric energy density, purity, versatility, and ease of use. The worldwide demand for hydrogen is predicted to increase substantially, reaching approximately 180 million tons (MT) by 2030 and 500 MT by 2050, compared to 94 MT in 2021. The anticipated rapid expansion of the hydrogen industry necessitates extensive infrastructure development, including establishing large-scale storage systems to accommodate the global hydrogen supply chain. The NASA Kennedy Space Centre currently possesses the largest LH2 storage tank worldwide, located at the Rocket Launch Complex 39B, with a storage volume capacity of 4732 m3. However, given the accelerating growth of the hydrogen economy, it is imperative to research LH2 infrastructure to cater to the growing demand while ensuring a smooth energy transition.

The design and development of LH2 storage infrastructure require a specific focus on several critical aspects, including construction materials, thermally efficient structural designs, effective insulation systems, active boil-off management strategies, and hydrogen safety. While the space industry has made significant progress in overcoming various challenges related to LH2 storage, such as the utilisation of lightweight LH2 tank materials, the development of effective insulation materials like aerogel and glass bubbles, and the implementation of Integrated Refrigeration and Storage (IRAS) heat exchanger systems, there remains a substantial need for further research and innovation to address the existing hurdles in scaling up LH2 storage systems from small to mega-scale. With the efforts of Australia to position itself as a prominent global hydrogen exporter, and with Australia's noteworthy achievement in 2022 involving the successful shipment of LH2 to Japan as part of the pioneering Hydrogen Energy Supply Chain (HESC) Project, Australia possesses the potential to establish itself as a dominant player in the LH2 market. Currently, Australia faces challenges in the realm of LH2 infrastructure research and development, primarily due to its limited testing facilities in both academia and industry. This presentation aims to provide an insightful overview of the present state of LH2 infrastructure globally, focusing on the associated challenges in upscaling LH2 infrastructure. Furthermore, it will shed light on the forthcoming opportunities and emerging developments in this sector, both within Australia and globally.

Dr Shanaka Kristombu Baduge is a postdoctoral research fellow of the Department of Infrastructure Engineering with research interests in developing large-scale liquid hydrogen infrastructure and cryogenic testing capabilities. He received the prestigious Sir Winston Churchill Fellowship in 2022, focusing on "Design and Construction of H2 Storage Infrastructure". In his fellowship, he visited leading liquid hydrogen facilities worldwide, including the Cryogenic Testing Lab, Kennedy Space, NASA and the Linde LH2 liquefaction plant in Germany. He is currently leading projects to establish cryogen-free mechanical and thermal-conductivity testing cryostats to build cryogenic testing capabilities in Australia to enable large-scale LH2 storage and transport globally.

Comparing powertrains for heavy-duty long-haul trucks and their implications for liquid hydrogen

Dr Zhenbiao Zhou

Research Fellow, Mechanical Engineering, University of Melbourne

While heavy-duty long-haul trucks represent only 0.5% of the total vehicle population, they consume 13% of the total vehicle fuel in Australia. Therefore, the decarbonization of heavy-duty trucks has a significant impact on achieving net-zero targets. To understand the options and potentials, this presentation compares powertrains for heavy-duty trucks, including diesel, liquefied natural gas, hybrid electric, hydrogen combustion engines, and hydrogen fuel cells. Both efficiency and financial performance are assessed for long-haul applications. As indicated by this comparison, liquid hydrogen can be a promising alternative fuel, but its application necessitates the development of liquid hydrogen fuelling infrastructures. However, the safety codes for liquid hydrogen fuelling infrastructure remain incomplete and rely on subjective expert opinions rather than physical models. In an effort to advance the understanding of cryogenic hydrogen releases, a cryogenic hydrogen release system has been developed, and its current progress is introduced in this presentation.

Dr. Zhenbiao Zhou is a research fellow at the University of Melbourne, where he focuses on experimental research related to liquid hydrogen safety. He has developed a cryogenic hydrogen system and is using it to investigate the release characteristics of cryogenic hydrogen, with the aim of enhancing our understanding of liquid hydrogen leaks and improving safety codes for liquid hydrogen storage. He earned his PhD from the University of Melbourne in 2020. Before taking on his current role, he led the powertrain engineering efforts for fuel cell electric and battery electric trucks at Bosch Powertrain Solutions.
