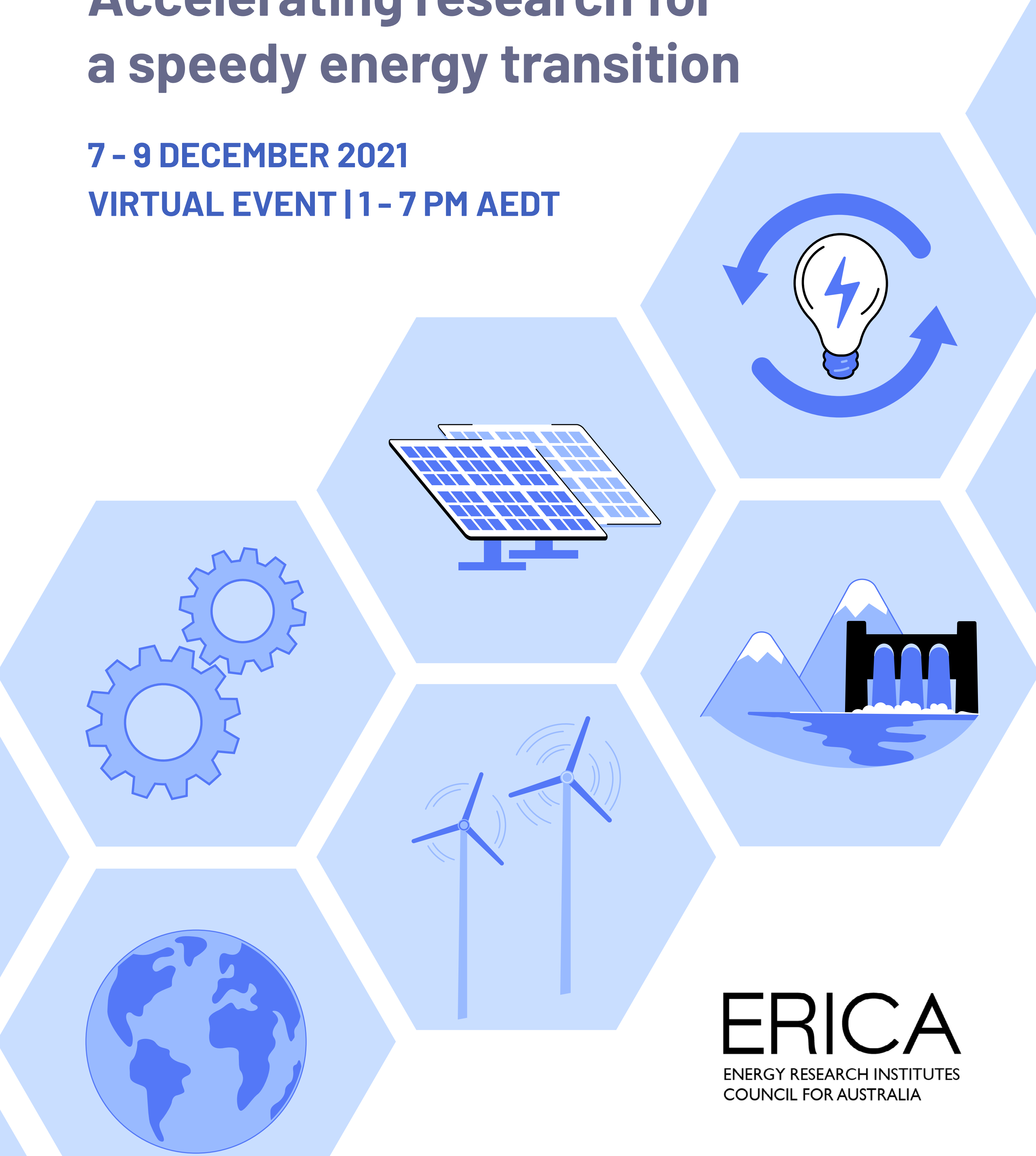
State of Energy Research Conference

Accelerating research for a speedy energy transition

7 - 9 DECEMBER 2021

VIRTUAL EVENT | 1 - 7 PM AEDT



ERICA

ENERGY RESEARCH INSTITUTES COUNCIL FOR AUSTRALIA

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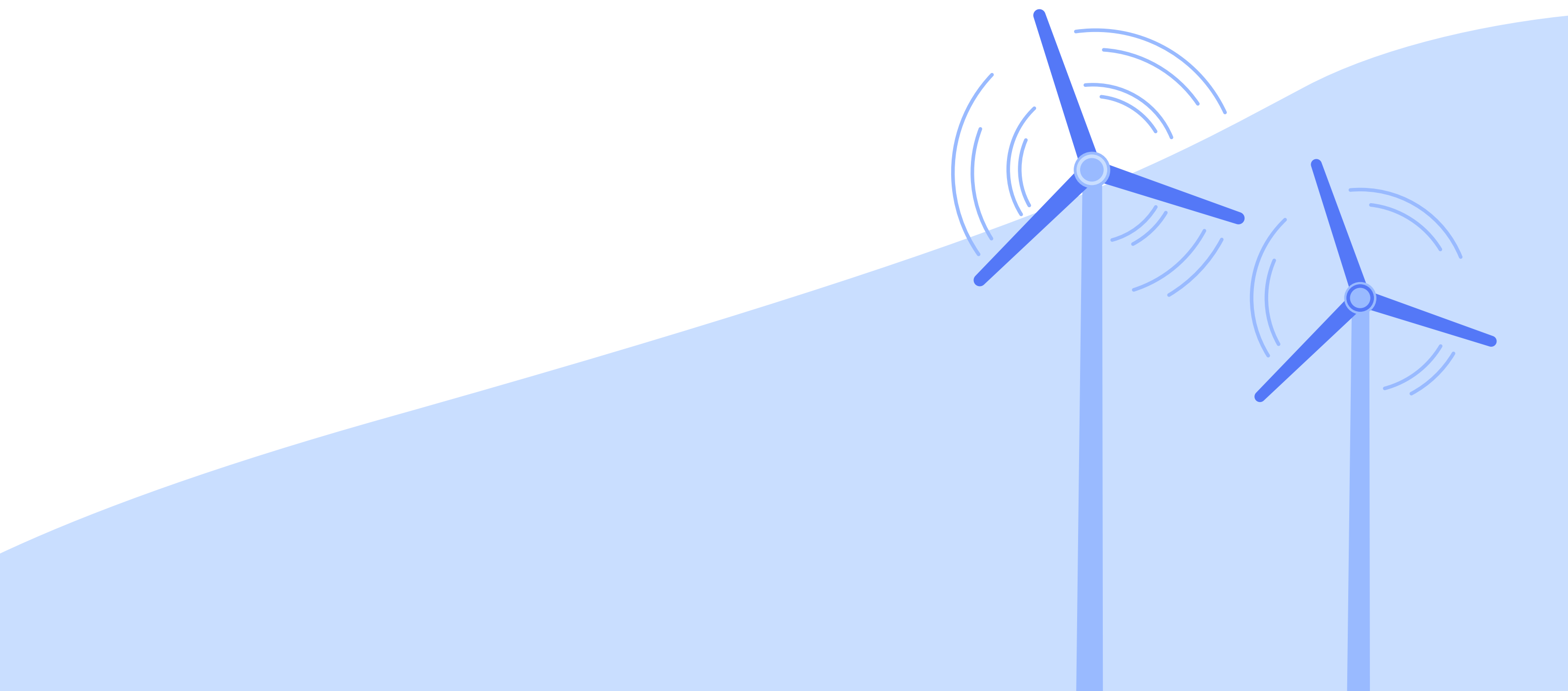

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ENERGY RESEARCH INSTITUTES COUNCIL FOR AUSTRALIA (ERICA)

ERICA is a council of university energy research institutes which collectively aim to provide:

- National capacity across a broad spectrum of cutting-edge energy research, in both specialised and inter-disciplinary fields;
- High-level, evidence-based, energy policy advice to government;
- An over-the-horizon perspective on future energy opportunities and challenges that can only be informed by cutting-edge research;
- A research touch point for industry and government on energy issues of national and international significance; and
- A research-led education network for students and young researchers.

As active members of ERICA, participants agree to:

- Meet at least once per year in person;
- Attend teleconference meetings to discuss intervening and time-dependent issues requiring a collective response;
- Provide sufficient resources to enable part-time administrative support for ERICA, including a website and organisation for an annual Energy Research conference;
- Contribute to specific projects on an 'as needs' basis.

Membership

Membership of ERICA by any organisation is by invitation through the agreement of existing members, and membership can be requested at any time.

The membership is non-binding, and the consensus views represented by the Council are those of the ERICA representatives and not of their parent universities.

The ERICA secretariat will move from one member institute to the other, each year.

Monash University is the secretariat for the current year (2021).

ERICA MEMBERS

THE UNIVERSITY of ADELAIDE

THE UNIVERSITY OF SYDNEY

Curtin University

UNIVERSITY of TASMANIA AUSTRALIA

MONASH University

THE UNIVERSITY OF QUEENSLAND AUSTRALIA CREATE CHANGE

DEAKIN UNIVERSITY

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Institute for Climate, Energy & Disaster Solutions

UTS

THE UNIVERSITY OF MELBOURNE

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CHAIR'S FOREWORD

Welcome to ERICA's second State of Energy Research Conference, **SoERC2021**! The community of researchers and their industry partners that gather here this week represent hope and dedication to the most urgent and critical challenge facing humanity to date: anthropogenic climate change.

The societal impacts of runaway climate change are unimaginable.

At **Paris COP21** it was agreed that to avoid famine and water shortage based geopolitical instability, which would cause massive population displacement and consequent war and suffering, we must limit warming to **1.5 degrees**. This requires halving global emissions by 2030! As the world gathered for COP26 in Glasgow last month, the stark realities of the challenge ahead have become painfully clear.

While significant progress has been made in putting the world on the path to 1.5 degrees through new policies and technologies, much work still remains. SoERC2021 provides an opportune time to revisit the leading role the research sector must play in addressing the challenge.

However, there is hope on the horizon.

Mass-scale renewable **solar** and **wind** technologies are more competitive than fossil sources, even in Australia where fossil power is amongst the cheapest in the world.

Technologies such as batteries, rooftop solar PV and electric vehicles, have a complete set of building blocks for mass decarbonisation of the electricity and transport sectors, accounting for up to two-thirds of the world's energy-based carbon emissions.

However, in this transition there are emerging challenges that cannot be overlooked. For example, with the proliferation of large-scale solar, together with the world's highest per capita deployment of rooftop solar PV, Australia is seeing the emergence of phenomena like the 'Minimum Net System Load' during high solar production, leading us into uncharted grid control territory.

Many of the solutions needed are still not available "off the shelf". While wind and solar electricity generation has won the race against other sources of electricity generation, both young and old, there is still work to be done. This conference allows us to get together and discuss some of the key questions still to be answered, such as:

- How do we progressively integrate renewable and disruptive technologies, such as electric vehicles, into a power grid that was built for fossil fuels?
- How will people's decisions and expectations impact the pace and scale of the energy transition?
- What energy market design will serve consumers better, while at the same time accelerating the update of renewables?
- How can green hydrogen and its derivatives such as ammonia help make the entire global supply chain and transport sectors carbon-free?

The questions that need to be answered keep coming.

This are far from normal times for researchers, industry, and the Australian communities we serve. I believe this conference will provide a reset to our research ambitions in support of climate change mitigation through an accelerating energy transition.

We at ERICA are particularly excited to acknowledge the excellent work being done by the Australian Council of Learned Academies' (**ACOLA**) on the Australian Energy Transition Research Plan, led by our first keynote speaker, **Drew Clarke AO**.

Mr Clarke, as both the plan's architect and Chair of the Australian Energy Market Operator, is uniquely placed to guide the Australian Energy Transition research community on a path to an accelerated research effort in support of a speedy energy transition.

The magnitude of this challenge requires collaboration. The research sector, including universities and the CSIRO, is more critical than ever to the future needs of Australian and global society. We stand ready and are humbled by the enormity of the task ahead.

I believe and trust that this second ERICA State of Energy Research Conference heralds a new era of scaled-up collaboration between researchers, industry and government across Australia.

I'm pleased and honoured that so many researchers, both early career and experienced, have agreed to share their research during SoERC2021 as well as to have industry leaders share their hope for the growth of a vibrant collaborating research community. The future of global society and its well being is in your hands.

Professor Ariel Liebman
Chair, ERICA
Director, Monash Energy Institute

From 2020 onwards, Ariel has been Director of the Monash Energy Institute and leads the RACE for Networks Program in the Reliable Affordable Clean Energy (RACE) for 2030 CRC. Ariel's current research in Energy sector focuses on optimisation and ML-based decision support tools for operation and planning of smart-grids, microgrids and large-scale energy systems. Internationally, Ariel led the Australia Indonesia Centre Energy Cluster directing a $2.8M research program in Microgrids and Energy System transition to tackle the challenge of integrating distributed storage and renewables into new system planning and investment. Ariel has been an architect of the 6 mil. Monash Grid Innovation Hub and is lead researcher in the 3 mil. Monash's Smart Energy City supported by Australian Renewable Energy Agency. Both of these initiatives are undertaken under the broader Net Zero Initiative, tasked to eliminate university's emissions and reduce energy costs by 2030.

PROGRAM // 7 DECEMBER 2021

DAY ONE

1.00 pm **Welcome to Country**
Uncle Tony (Wurundjeri Elder)

1.05 pm **Official Conference Opening**
Prof Margaret Gardner (President and Vice-Chancellor, Monash University)

1.15 pm **Keynote Speaker:** Update on the ACOLA Australian Energy Transition Research Plan
Drew Clarke AO (Chair of Australia's Energy Transition Research Plan, Australian Council of Learned Academies)

2.00 pm **Plenary speaker:** The scientific basis for rapid climate action
Prof Mark Howden (Director, Institute for Climate, Energy & Disaster Solutions, Australian National University)

2.45 pm **Panel Discussion:** Climate 101 | Decarbonising hard to abate sectors: Hydrogen, Ammonia and CCUS
A/Prof Sven Teske (Institute for Sustainable Futures, University of Technology Sydney)
Prof Emeritus Mike Young (Energy, Water and Environmental Policy, University of Adelaide)
Dr Emma Aisbett (School of Regulation and Global Governance, Australian National University)
Hosted by: Dr Emi Gui (ClimateWorks Australia)

3.35 pm **Afternoon tea**

	PEOPLE, SOCIETY, AND INSTITUTIONS	RESOURCES, SYSTEMS, AND TECHNOLOGIES	MARKETS, POLICY, AND REGULATION
3.50 pm	**JUST TRANSITIONS** Dr Rebecca Pearse (Fenner School of Environment & Society and School of Sociology, Australian National University)	**RENEWABLE ENERGY INTEGRATION** A/Prof Anna Bruce (School of Photovoltaic and Renewable Energy Engineering, UNSW)	**MODELLING OF SNOWY HYDRO MARKET POWER WITH SNOWY 2.0** Dr Ross Gawler (Department of Data Science and Artificial Intelligence, Monash University)
4.15 pm	**REBUILDING CONSUMER TRUST** Prof Chris Riedy (Institute for Sustainable Futures, University of Technology Sydney)	**PROSUMER-CENTRIC DISTRIBUTED ENERGY SYSTEMS** A/Prof Gregor Verbic (School of Electrical and Information Engineering, The University of Sydney)	**HOUSEHOLD WEALTH AND ROOFTOP SOLAR IN AUSTRALIA** Dr Kelly Burns (Victoria Energy Policy Centre, Victoria University)
4.40 pm	**ASPECTS OF SOLAR SHARING AND STORAGE** Prof Greg Morrison (Sustainability Policy Institute, Curtin University)	**POTENTIAL FOR BATTERY MANUFACTURING IN VICTORIA** Prof Maria Forsyth (Institute for Frontier Materials, Deakin University)	**LEGAL MECHANISMS FOR PROMOTING CORPORATE ENERGY TRANSITION** Prof Jacqueline Peel (Melbourne Climate Futures, University of Melbourne)
5.05 pm	**HOUSEHOLD ENERGY, EQUITY AND DEMAND RESPONSE** Dr Larissa Nicholls (Emerging Technologies Research Lab, Monash University)	**OVERVIEW OF HYDROGEN PRODUCTION TECHNOLOGIES** Prof Greg Metha (Department of Chemistry, University of Adelaide)	**CERTIFYING SUSTAINABLE HYDROGEN** Prof Fred Gale (School of Social Sciences, University of Tasmania)

6 - 6.30pm **Special Guest Speaker:** Moving the needle towards global net zero
Laura Cozzi (Chief Energy Modeller at International Energy Agency (IEA), Head of Division at World Energy Outlook)

5.30 - 7pm **Posters and Networking session**

7pm **END OF DAY ONE**

PROGRAM // 8 DECEMBER 2021

DAY TWO

1.00 pm **Opening remarks**
Prof Peta Ashworth (Director, Andrew N. Liveris Academy for Innovation and Leadership; & Chair, Sustainable Energy Futures, University of Queensland)

1.15 pm **Keynote:** The secret to great energy research? We don't know
Lynne Gallagher (CEO, Energy Consumers Australia)

2.00 pm **Plenary speaker:** RACE for 2030 CRC innovation for the energy/decarbonisation transformation
Dr Katherine Woodthorpe AO (Deputy Chair, RACE for 2030 CRC)
Jon Jutsen (CEO, RACE for 2030 CRC)

2.45 pm **Panel discussion:** Energy Justice | Implications of decarbonisation on employment and productivity
Dr Chris Briggs (Institute for Sustainable Futures, The University of Sydney)
Dr Lily O'Neill (Centre for Aboriginal Economic Policy Research and Energy Change Institute, Australian National University)
Prof Greg Morrison (Sustainability Policy Institute, Curtin University)
Hosted by: Prof Peta Ashworth (Director, Andrew N. Liveris Academy for Innovation and Leadership, & Chair, Sustainable Energy Futures, University of Queensland)

3.35 pm **Afternoon tea**

	PEOPLE, SOCIETY, AND INSTITUTIONS	RESOURCES, SYSTEMS, AND TECHNOLOGIES	MARKETS, POLICY, AND REGULATION
3.50 pm	**SOCIETAL ATTITUDES ON FUTURE FUELS** Dr Belinda Wade (Sustainability and Strategy, University of Queensland)	**BATTERY STORAGE REQUIREMENTS** A/Prof Evan Franklin (School of Engineering, UTAS)	**MODELLING THE NEM TO SUPPORT INCREASED VRE UPTAKE TO 2050** Dr James Foster (Energy Systems Research Program, CSIRO)
4.15 pm	**COLLABORATIVE LEARNING FRAMEWORK FOR DEMAND-SIDE ENERGY SYSTEMS** Dr Fengji Luo (Faculty of Engineering, The University of Sydney)	**FLEXING OUR ENERGY** Dani Alexander (Institute for Sustainable Futures, University of Technology Sydney, RACE for Business, RACE for 2030 CRC)	**BUILD OWN OPERATE TRANSFER HITS THE RETAIL MARKET** Prof Bruce Mountain (Victoria Energy Policy Centre, Victoria University)
4.40 pm	**DIGITAL TWINS TO MODEL HOME ENERGY EFFICIENCY** Dr Susannah Soon (School of Electrical Engineering, Computing and Mathematical Sciences, Curtin University)	**RENEWABLE ENERGY RESOURCES GRID INTEGRATION CHALLENGES** Dr Behrooz Bahrani (Faculty of Engineering, Monash University)	**PV POWER UNCERTAINTY: TRADE-OFF BETWEEN OPERATIONAL SYSTEM COSTS AND SECURITY** Dr Maria Vrakopoulou (Electrical and Electronic Engineering, University of Melbourne)
5.05 pm	**EVALUATING SOCIAL LICENCE FOR HYDROGEN TECHNOLOGIES** Dr Virginia Weber (Deakin Business School, Deakin University)	**DISRUPTIVE BATTERY TECHNOLOGIES** Dr Mahdokht Shaibani (Mechanical and Aerospace Engineering, Monash University)	**MEASURING WINDFALL PROFITS TO COAL-FIRED ELECTRICITY GENERATORS FROM FREE EMISSION PERMIT ALLOCATIONS** Dr Alastair Fraser (School of Economics, University of Sydney)

6 - 6.30pm **Special Guest Speaker:** Renewable energy as a key performance indicator
Rana Adib (Executive Director, Renewable Energy Policy Network for the 21st Century REN21)

5.30 - 7pm **Posters and Networking session**

7pm **END OF DAY TWO**

PROGRAM // 9 DECEMBER 2021

DAY THREE

1.00 pm **Opening remarks**
Prof Bruce Mountain (Victoria Energy Policy Centre, Victoria University)

1.15 pm **Keynote:** The drums of change
Dr Alan Finkel AO (Chair, The Technology Investment Advisory Council)

2.00 pm **Plenary speaker:** The importance of basic systems research for the energy transition
Prof David Hill (Energy Systems, University of New South Wales)

2.45 pm **Panel discussion:** Competition between central and decentralised energy supply
A/Prof Penelope Crossley (The University of Sydney Law School)
Dr Gabrielle Kuiper (Institute for Energy Economics and Financial Analysis)
Dr Naomi Stringer (School of Photovoltaic and Renewable Energy Engineering; & Collaboration on Energy and Environmental Markets, UNSW)
Hosted by: **Prof Bruce Mountain** (Director, Victoria Energy Policy Centre, Victoria University)

3.35 pm **Afternoon tea**

	PEOPLE, SOCIETY, AND INSTITUTIONS	RESOURCES, SYSTEMS, AND TECHNOLOGIES	MARKETS, POLICY, AND REGULATION
3.50 pm	**HOW WILL WE LEARN ABOUT HYDROGEN?** Loren Tuck (Training and Industry, Hycel, Deakin University)	**MACHINE LEARNING AND HOME AUTOMATION FOR ENERGY OPTIMISATION** Dr Jessica Breadsell (Sustainability Policy Institute, Curtin University)	**CONSUMER-CENTRIC ENERGY MARKETS: CHALLENGES AND OPPORTUNITIES** Dr Rowena Cantley-Smith (Institute for Sustainable Futures, University of Technology Sydney)
4.15 pm	**INDIGENOUS STAKEHOLDERS IN THE ENERGY TRANSITION** Luke Blackbourn (InterContinental Energy)	**DESIGN ELECTROCATALYST MATERIALS BY MOLECULAR MODELLING** A/Prof Yan Jiao (Centre for Energy Technology, University of Adelaide)	**BUSINESS FLEETS AND EVS** Dr Diane Kraal (Senior Lecturer, Business Law & Taxation, Monash Business School, Monash Unviersity)
4.40 pm	**INTERSECTION OF CONSUMER REPRESENTATION, SOCIAL JUSTICE AND ENERGY MANAGEMENT SYSTEMS** Dr Phillipa Watson (Syndicate of Technology, Environments and Design, University of Tasmania)	**LIQUID HYDROGEN GENERATION, STORAGE AND TRANSPORT FOR DOMESTIC APPLICATIONS** Prof Paul Webley (Monash Energy Institute, Monash University)	**TRANSPORT FUTURES: THE ROLE OF MICRO-MOBILITY** Prof Mark Stevenson (Melbourne Energy Institute, University of Melbourne)
5.05 pm	**TRUSTWORTHY AGGREGATORS** Dr Declan Kuch (UNSW Energy Institute, University of New South Wales)	**WIND VARIABILITY AND VOLATILITY IN SE AUSTRALIA** Dr Claire Vincent (School of Geography, Earth and Atmospheric Sciences, University of Melbourne)	**SYSTEM RESILIENCE IN EXTREME WEATHER EVENTS** Prof Rosemary Lyster (Climate and Environmental Law, The University of Sydney)

5.30 pm **Closing remarks:** Awards for Virtual Student Poster presentation
Ariel Liebman (Chair, ERICA 2021)

5.40 pm **Posters and Networking session**

7pm **END OF CONFERENCE**

DAY ONE // KEYNOTE SPEAKER

Drew Clarke AO PSM

Non-Executive Independent Chairman, AEMO Board of Directors

Mr Drew Clarke AO is Chair of the Australian Energy Market Operator (AEMO), a Director of CSIRO and of NBN Co., and has served in energy policy leadership roles since 2003. He led the Commonwealth's actions in the creation of the National Energy Market Rules and the three NEM market bodies, served as Chair of the Senior Committee of Officials under the COAG Ministerial Council on Energy, led the establishment of the Australian Renewable Energy Agency and the Global Carbon Capture and Storage Institute, and was Australia's member on the Governing Board of the International Energy Agency.

TITLE

Update on the ACOLA Australian Energy Transition Research Plan

ABSTRACT

Australia's energy system is transforming. We all acknowledge the imperative to address climate change through a 'speedy energy transition' with a goal to reach 'net zero emissions' by 2050, but way earlier if we can. ACOLA presented the first iteration of the Research Plan in June 2021. It identifies the urgent and strategic research priorities (and critical gaps) that require research for a successful Australian energy transition. The presentation will outline the Research Plan and describe developments since its release.

DAY ONE // PLENARY SPEAKER

Professor Mark Howden

Director, Institute for Climate, Energy & Disaster Solutions, Australian National University

Professor Mark Howden is Director of the Institute for Climate, Energy & Disaster Solutions at The Australian National University, and a Vice Chair of the Intergovernmental Panel on Climate Change (IPCC) and is the Chair of the ACT Climate Change Council. Mark has worked on Climate Change issues for over 30 years. Issues he has addressed include agriculture and food security, the natural resource base, ecosystems and biodiversity, energy, water and urban systems.

TITLE

A climate science update: implications for the energy transition!

ABSTRACT

GHG emissions and atmospheric concentrations are at record levels causing substantial warming globally and overall net negative impacts. Meeting the Paris Agreement temperature goals and avoiding very problematic climate impacts requires keeping CO_2 emissions to a stringent budget – approximately ten times less than the current annual emissions. Doing this will require very rapidly reducing emissions (approximately a 45 to 50% reduction by 2030), reaching net zero around 2045 to 2050 and then going below zero. The costs of emission-reduction are likely to be much lower than the costs of climate impacts (which range from about USD70 to 800 per tonne of CO_2). Energy transitions will themselves need to take into account climate change impacts and adaptations.

Lynne Gallagher

Chief Executive Officer
Energy Consumers Australia

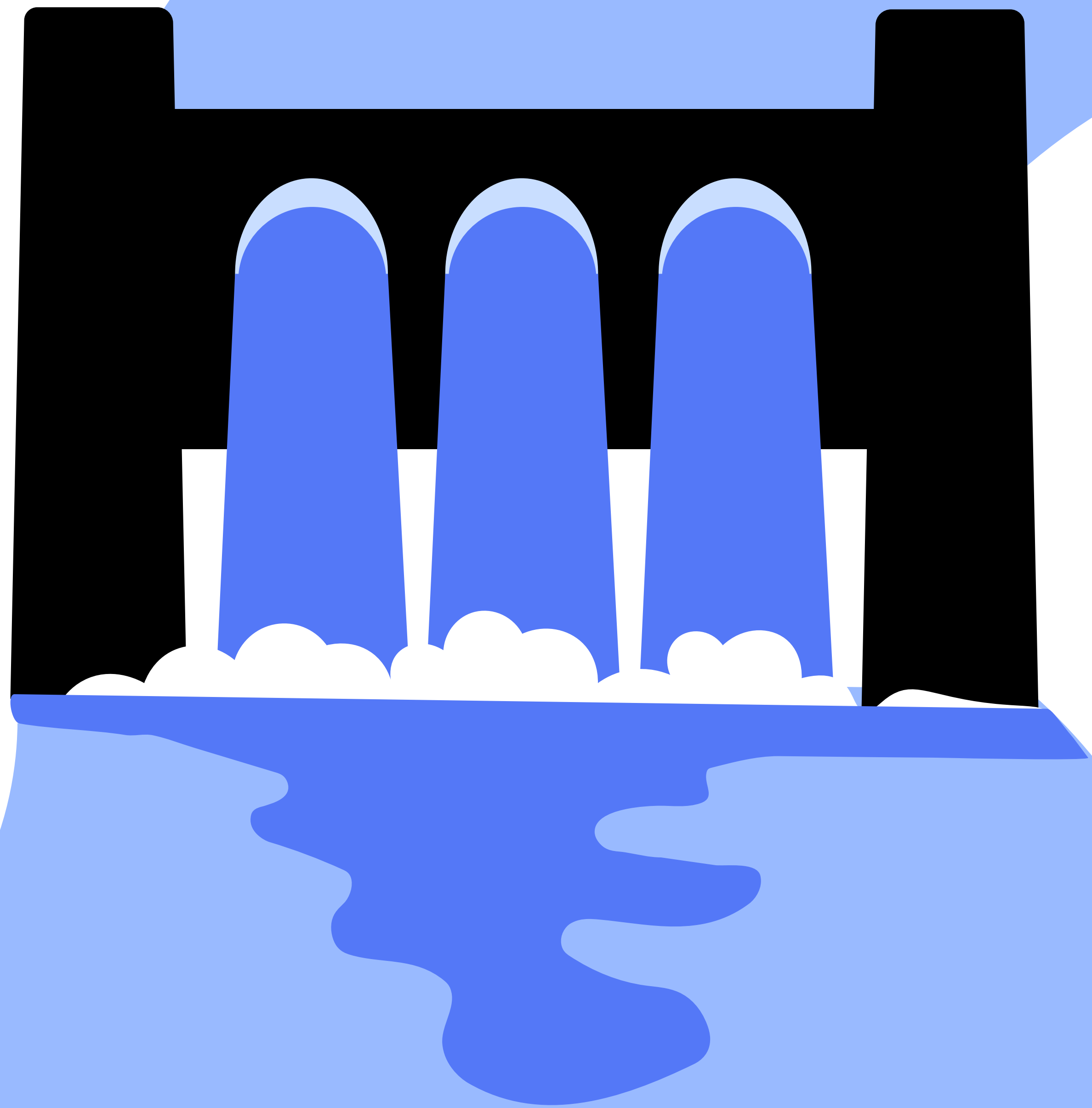
Lynne Gallagher is an economist/econometrician by qualification and has substantial experience in economic modelling and policy reform processes, including working with the Council of Australian Governments, and in strategic issues management in the corporate sector. She spent 15 years in a technical environment, followed by 12 years in practice and as an adviser. Prior to her appointment as ECA's Director of Research, Lynne was Executive Director, Industry Development at Energy Networks Australia. Lynne brings to ECA strong insights, a strategic focus and a consumer advocacy perspective.

TITLE

The secret to great energy research? We don't know

ABSTRACT

There is little point attempting to accelerate energy research unless we are confident we are pointing in the right direction. It's time for some course correction. By engaging earlier and more meaningfully with consumers, researchers can grasp an opportunity to create far greater real-world impact for their ideas and work. Doing this is essential if we are to tackle the complex problems underlying our energy system and its transition. This keynote address will map out some of the flaws in current thinking when it comes to researching from a starting point of consumer needs, values and expectations, and will chart a better way forward, based on securing social licence.



DAY TWO // PLENARY SPEAKERS

Dr Katherine Woodthorpe AO

Deputy Chair, RACE for 2030 CRC

Dr Katherine Woodthorpe FAICD AO is an experienced Chair and Non-Executive Director serving for more than 20 years on the boards of a variety of organisations including listed entities, government boards and for-purpose organisations. She has a strong track record in a broad range of innovation-dependent industries including healthcare, renewable energy, and environmental and climate science. Amongst her current appointments, she is a Director of Anteotech Ltd. Vast Solar Pty Ltd and Chairs the Natural Hazards Research Australia Ltd.

Jon Jutsen

CEO, RACE for 2030 CRC

Jon Jutsen is the CEO of the RACE for 2030 CRC, addressing the energy and carbon transition, focusing on the customers. Jon has been a leader in energy and carbon management for over 40 years. He was co-founder and led the Australian Alliance for Energy Productivity. He founded and led Energetics. He also had a stint on the Board of the Australian Renewable Energy Agency. He is a Chemical Engineer with a Masters degree in Energy Technology.

TITLE

RACE for 2030 CRC innovation for the energy/decarbonisation transformation

ABSTRACT

RACE (Reliable, Affordable, Clean Energy) for 2030 is the CRC for the energy/carbon transformation. In this paper, Katherine Woodthorpe (Deputy Chair) provides an overview of the historical challenge of decarbonisation that RACE is addressing, the urgency of the mission, the great opportunities that this powerful collaborative of over 70 organisations across the energy value chain can capture, and the research strategy RACE will apply. Jonathan Jutsen (CEO) demonstrates the research program in action in RACE's second year of a 10-year planned operation. This includes a focus on the 4 strategic challenges being addressed in 2022-23 — the minimum demand challenge (or how to get the best value from rooftop solar), EVs and the grid with a focus on V-X/2-way charging, pathways to net zero C business, and millions of homes – how to retrofit at scale for decarbonising homes, reducing bills and increasing comfort. Jon also provides some brief project case examples.

DAY THREE // KEYNOTE SPEAKER

Dr Alan Finkel AO

Chair, The Technology Investment Advisory Council

Dr Alan Finkel AO is a neuroscientist, engineer and entrepreneur. He was Australia's chief scientist from 2016 to 2020, where he led the National Electricity Market Review, the development of the National Hydrogen Strategy, and the panel that advised the Australian Government on the 2020 Low Emissions Technology Roadmap. He is currently Chair of Stile Education, Chair of the Australian Government's Technology Investment Advisory Council, and Special Adviser to the Australian Government on Low Emissions Technologies.

TITLE

The Drums of Change

ABSTRACT

In his speech to the 2021 State of Energy Research Conference, Dr Alan Finkel proposes that the only solution to the challenge of climate change is to replace high emissions technologies with clean alternatives. Through a discussion of effective contributions and the importance of goal setting, Dr Finkel outlines the challenges we face along the road to Net Zero with a focus on the opportunities they present for Australian researchers. Taking the Low Emissions Technology Roadmap as a guide, he makes practical suggestions to inform the research decisions that will change the way our energy is supplied.

DAY THREE // PLENARY SPEAKER

Professor David Hill

Professor of Energy Systems, University of New South Wales

Professor David Hill has been the Chair of Electrical Engineering and Director of the Centre for Electrical Energy Systems at The University of Hong Kong. He has been a part-time Professor at The University of Sydney and is now Professor Emeritus. He was Foundation Director of the Centre for Future Energy Networks at The University of Sydney, he led a HK RGC project on Sustainable Power Delivery Structures for High Renewables (A$7M) and also a project on Future Grid Modelling and Security within the CSIRO Future Grid University Cluster (A$13M). David's work focuses on achieving secure power delivery with high penetration of renewables.

TITLE

The importance of basic systems research for the energy transition

ABSTRACT

Looking back over the history of electrical power delivery there have been prior momentous transitions which have raised new system dynamics and control problems to solve. Now we face an even bigger transition where the word 'complexity' appears frequently. This talk aims to motivate a new level of systems and control thinking that can address the harder problems underpinning the achievement of a secure transition to a decarbonised electricity supply system. Reference will be made to recent work at UNSW with the NSW Government where a clear need for a whole new suite of modelling, analysis, and tools for planning and operation became clear. The recent Energy Security Board (ESB) advice to Energy Ministers locally and the G-PST program globally also serve to identify a very substantial systems program that needs more support in Australia.

SPECIAL GUEST SPEAKERS

Laura Cozzi

Chief Energy Modeller,
International Energy Agency

Laura Cozzi is the Chief Energy Modeller at the International Energy Agency. Ms Cozzi oversees the Agency's work on outlooks and is also Head of the Demand Outlook Division with responsibility for producing the annual World Energy Outlook, the IEA flagship publication. The Division produces medium to long term energy demand, efficiency, power generation, renewables and environmental analysis for the World Energy Outlook and other publications. Ms Cozzi also co-directed the IEA's recently released Net Zero by 2050 report.

TITLE

Moving the needle towards global net zero

ABSTRACT

The IEA's Net Zero by 2050 roadmap for the global energy sector provides clarity on what is needed from the energy sector to reach the goal of global net zero by 2050. Informed by detailed analysis of energy markets and policies today, technology availability and costs, the report sets out key milestones on the path to net zero. The recently published World Energy Outlook 2021 highlights progress made in recent years, but also the major increase in ambition and policy implementation required to reach net zero. Rapid scaling up of clean energy investment flows is required, yet current investment commitments fall short.

Rana Adib

Executive Director, Renewable Energy Policy Network for the 21st Century (REN21)

Rana Adib is the Executive Director of REN21, the Renewable Energy Policy Network for the 21st Century. REN21 is the only global renewable energy community of actors from science, governments, NGOs and industry, headquartered at the United Nations Environment Programme in Paris, France. Previously, Rana was REN21's Research Coordinator developing the international expert community and leading the REN21 Renewables Global Status Report series to become an international reference.

TITLE

Renewable energy as a key performance indicator

ABSTRACT

The global energy transition is underway. Solar and wind make up the lowest-cost electricity in history and are rapidly growing share in power systems around the world. But the transition needs help: the share of renewable energy in heating & cooling and in transport is still low. It's no longer enough to track renewable energy targets, policies and investment. Real progress can be measured by a simple indicator: the share of renewable energy. This key performance indicator reflects the share of renewable energy developments in energy demand, energy conservation, energy efficiency and emissions, renewable energy uptake and the reduction of fossil fuel use. It lets people measure progress and ensure engagement globally, nationally, in regions, in cities, in any economic sector and even in businesses.

PANEL ONE //
Climate 101 | Decarbonising hard to abate sectors: Hydrogen, Ammonia and CCUS

This first SoERC2021 Panel Discussion, hosted by Dr Emi Gui (System Lead - Energy, ClimateWorks Australia), will outline how Australia's transition towards zero emissions could work over the next decade and what's happening now.

Join our Panel Discussion to discuss the need for a rapid and global energy transition in support of the climate challenge. Our experts are familiar with how countries, including Australia, are phasing out fossil fuels and the challenges ahead. They will discuss the various approaches to decarbonisation, the possible net zero trajectories, the regional and national implications of transitioning to net zero emissions, the policies in place and the importance of resilience and supply security during the transition.

A/Prof Sven Teske (Research Director, UTS) will discuss the global carbon budget, give a broad overview of renewable energy systems and market integration and will stress the need for net zero emissions by 2030, as even without new fossil fuel projects, global warming will still exceed 1.5C.

Dr Emma Aisbett (Fellow, School of Regulation and Global Governance and Associate Director, Research, Zero-Carbon Energy for the Asia-Pacific Grand Challenge, ANU) will talk about embedded emission accounting and certification to support the export of embedded renewable energy in products like hydrogen and ammonia.

Prof Emeritus Mike Young (Future Fuels CRC, Global Centre for Food and Resources, Centre for Energy Technology, UoA) will examine the regional and national implications of transitioning to net zero emissions by 2050.

PANEL ONE // SPEAKERS

HOST: Dr Emi Gui

System Lead – Energy,
ClimateWorks Australia

Dr Emi Gui leads the development of initiatives and programs in energy system decarbonisation, electricity sector transitions and net zero energy planning in Australia and Southeast Asia. Emi joins ClimateWorks with 15 years' experience in energy consulting and research, including policy design, the electricity market, energy infrastructure planning and renewable energy market research. Emi has a PhD in Energy Policy and Energy Economics from the University of New South Wales, an MBA from Melbourne Business School in Australia and a Master of Engineering from Nanyang Technological University in Singapore.

Dr Emma Aisbett

Research Fellow, School of Regulation and Global Governance,
Australian National University

Dr Emma Aisbett is a Fellow at the School of Regulation and Global Governance and Associate Director (Research) for the Zero-Carbon Energy for the Asia Pacific Grand Challenge at the Australian National University. Emma works across disciplines and sectors on questions at the intersection of international economic regulation and the environment. Her current research on trade-related climate policies explores how international trade and investment frameworks and Green Industrial Policy can be made mutually supportive of each other, and of the net zero transition.

Professor Emeritus Mike Young

Professor Emeritus in Energy,
Water and Environmental Policy,
University of Adelaide

Professor Mike Young is a Fellow of the Academy of Social Sciences in Australia, and a Distinguished Fellow of the Australian Agricultural and Resource Economics Society. Mike recently led an assessment of the economic feasibility attaining net zero emissions under stated government policy commitments and, in earlier life, led teams responsible for the development of several water, fishery and greenhouse gas emissions trading systems. He is currently involved in a constructive assessment of opportunities to improve the EU's carbon border adjustment mechanism.

Associate Professor Sven Teske

Research Director,
Institute for Sustainable Futures,
University of Technology Sydney

Associate Professor Sven Teske is Research Director at the Institute for Sustainable Futures at the University of Technology Sydney with a research focus on energy decarbonisation pathways for specific industry sectors and regions. 100% renewable energy concepts are required to achieve the Paris Climate Agreement. This includes technical analysis of power grids regarding integration of solar electricity, onshore and offshore wind power generation and electricity and heat storage systems. Sven also has over 20 years of experience in the renewable energy market and policy analysis.

PANEL TWO //
Energy Justice | Implications of decarbonisation on employment and productivity

This second SoERC2021 Panel Discussion, hosted by Professor Peta Ashworth (Director Andrew N. Liveris Academy for Innovation and Leadership; & Chair, Sustainable Energy Futures University of Queensland), will explore the goal of reducing carbon dioxide emissions to improve productivity and create employment opportunities under an energy justice lens.

Join our Panel Discussion to discuss the challenges and opportunities of decarbonising our economy. The point of our energy system is to provide people with resources (electricity, fuel for vehicles etc.), so they can go about our daily activities of carrying out work, studies and social activities. What are the prospects for job creation through clean energy and transitioning coal workers? What is the impact of the energy transition for the coal mining communities? Thinking about the growing awareness of the human impact on the environment but also the crisis of livelihoods and labour: what coal miners are facing with the future of coal increasingly in question. Also, what are the constraints that could emerge for the build-out of renewable energy and transmission from skill shortages?

Dr Chris Briggs (Research Director, ISF, University of Technology; Technical Director, Business Renewables Centre) will discuss the challenges and opportunities for managing growth in clean energy and transition for coal regions.

Dr Lily O'Neill (Research Fellow at the Centre for Aboriginal Economic Policy Research, working on the ANU Grand Challenge project 'Zero-Carbon Energy for the Asia-Pacific'), will focus on how clean energy stakeholders can assess whether and how First Nations communities will fairly share the costs and benefits of large-scale clean energy projects on their land.

Professor Greg Morrison (Curtin University Sustainability Policy Institute, School of Design and the Built Environment, Faculty of Humanities, Curtin University) will also join the discussion by generally focussing on the implications of decarbonisation on employment and productivity.

PANEL TWO // SPEAKERS

HOST: Professor Peta Ashworth

Director, Andrew N. Liveris Academy for Innovation and Leadership; & Chair, Sustainable Energy Futures, University of Queensland

Professor Peta Ashworth is Director of Andrew N Liveris Academy for Innovation and Leadership and Chair in Sustainable Energy Futures at UQ. Peta is well known for her expertise in the integration of science and technology in society through dialogue and engagement. Peta has been researching public attitudes to climate and energy technologies (wind, CCS, solar PV, geothermal, battery storage and hydrogen) and was recently appointed by the Palaszczuk Government to chair an expert task force charged with fast tracking the establishment of a sustainable hydrogen supply chain in Queensland.

Dr Chris Briggs

Research Director, Institute for Sustainable Futures, University of Technology Sydney; Technical Director, Business Renewables Centre

Dr Chris Briggs is a Research Director at the Institute for Sustainable Futures (ISF), University of Technology. Chris has a combination of climate, energy and labour market expertise developed over 20 years of experience working in roles as a political adviser, policymaker, program leader and researcher. At ISF, Chris specialises in clean energy transition projects including clean energy employment, energy fairness and just transition, renewable energy power purchase agreements and the role of demand-side flexibility to integrate renewable energy into markets, networks and businesses.

Dr Lily O'Neill

Research Fellow, Centre for Aboriginal Economic Policy Research and Energy Change Institute, Australian National University

Dr Lily O'Neill is a Research Fellow at the Centre for Aboriginal Economic Policy Research and the Institute for Climate, Energy and Disaster Solutions. She is a lawyer and legal researcher examining agreement making and dispute resolution processes in relation to natural resources, climate change and the energy transition, environmental law and native title. Her work on the Grand Challenge Project 'Delivering zero-carbon energy to the Asia-Pacific' examines whether and how First Nations communities can best benefit from renewable energy generation in north-west Australia.

Professor Greg Morrison

Curtin University Sustainability Policy Institute, School of Design and the Built Environment, Faculty of Humanities, Curtin University

Professor Greg Morrison was a professor for close to 30 years at Chalmers University of Technology in Gothenburg, Sweden until 2015. He started at Curtin in 2015 and has been carrying out research on renewable energy systems and Living Labs. He is a co-founder of Climate-KIC Australia and a Director of the Board. Greg is also Program Leader for RACE for Everyone in the RACE for 2030 CRC.

PANEL THREE //
Competition between centralised and decentralised energy supply

This third SoERC2021 Panel Discussion, hosted by Prof Bruce Mountain (Director of Victoria Energy Policy Centre at Victoria University), will explore the nascent rivalry between distributed and centralised electricity supply.

Within a few years' time, Australia will have as much electricity production on the roofs of homes and businesses as it has in large coal generators. Central and distributed generation are quite different but they compete at times. The rise of distributed storage will present an enormous opportunity and massively change the competition between central and decentral production.

This session brings leading researchers in law policy and engineering to debate these developments.

Dr Gabrielle Kuiper (Institute for Energy Economics and Financial Analysis) will share her work on Distributed Energy Resources.

Dr Naomi M Stringer (Research Associate, School of Photovoltaic and Renewable Energy Engineering (SPREE) and Collaboration on Energy and Environmental Markets (CEEM) at UNSW Sydney, Australia) will talk about the practical differences that currently exist between distributed and centralised generation and what it means, and how we manage the different behaviours.

A/Prof Penelope Crossley (Centre for Future Energy Networks, University of Sydney) will give an overview on the role of governance and legislation in the energy transition. Penelope will use the case study of energy storage to explore the regulatory trends affecting the deployment of decentralised energy resources and what this means for consumers.

PANEL THREE // SPEAKERS

HOST: Professor Bruce Mountain

Director, Victoria Energy Policy Centre, Victoria University

Professor Bruce Mountain is the inaugural Director of the Victoria Energy Policy Centre at Victoria University. Bruce is an energy economist with a particular interest in the political economy of energy supply and in the economics of regulation. Before joining academia Bruce was a consulting economist in Australia and internationally. Over the course of his career, he has worked on policy and economics problems in many parts of the electricity supply chain. His particular interests now are in decentralised production and in the economics of electricity storage.

Associate Professor Penelope Crossley

Associate Professor and SOAR Fellow (2020-2022),
University of Sydney Law School

Associate Professor Penelope Crossley researches the complex legal issues associated with the energy transition, including renewable energy and energy storage law, and electricity market governance. Previously, she worked as an international project finance lawyer, and global in-house counsel for BP Alternative Energy. This commercial and practical legal experience informs her academic research, ensuring that her research focuses on real-world problems and identifies innovative solutions that can be easily translated and applied.

Dr Gabrielle Kuiper

Energy Professional, Institute for Energy Economics and Financial Analysis

Dr Gabrielle Kuiper is an energy, sustainability and climate change professional with over twenty years' experience in the corporate world, government and non-government organisations and academia. She was previously the DER Strategy Specialist with the Energy Security Board. Prior to that Dr Kuiper held senior executive or senior advisory energy-related positions in the Office of the Australian Prime Minister, at the Public Interest Advocacy Centre (PIAC) and in the NSW Government.

Dr Naomi Stringer

Research Associate, School of Photovoltaic and Renewable Energy Engineering (SPREE) and Collaboration on Energy and Environmental Markets (CEEM), University of New South Wales

Dr Naomi Stringer's research is concerned with the integration of Distributed Energy Resources in the electricity sector. Her work is undertaken in close collaboration with electricity industry stakeholders and includes the development of open source analytical techniques to leverage real-world operational data sets. Naomi is currently leading ARENA-funded Project MATCH in partnership with the Australian Energy Market Operator (AEMO) and Solar Analytics. Prior to entering academia, Naomi worked as a consultant with AECOM.

Dr Rebecca Pearse

Lecturer, Fenner School of Environment & Society and School of Sociology, Australian National University

Dr Beck Pearse is a sociologist whose teaching and research focuses on inequalities and environmental policy. Beck's current projects investigate the possibilities for just sustainable transitions, with particular focus on rural land and labour relations. She is a Chief Investigator on two ARC Discovery Projects: Decarbonising Electricity (Goodman et al. 2018-21) and Environmental Justice and the Making of Just Food and Energy Policy (Schlosberg, Pearse, Rickards 2020-22).

TITLE

Just rural transitions: the case of renewable energy zones

ABSTRACT

The transition to renewable electricity is a spatial shift. Electricity infrastructure is being built in new parts of rural Australia that have not hosted energy utilities at this scale before. There are major economic opportunities for rural development, as well as unexpected effects to manage. This paper sketches the social and economic dimensions of NSW's first trial Renewable Energy Zones. The case of enhanced regional economic planning and national industrial policy is made.

Professor Chris Riedy

Professor of Sustainability Transformations, Institute for Sustainable Futures, University of Technology Sydney

Professor Chris Riedy's research focuses on co-production of knowledge to support transformative change towards sustainable futures, particularly in the energy sector. He draws on sociological and political theory, narrative theory and futures thinking to design, facilitate and evaluate sustainability interventions. His most recent project was a review on trust building for collaborative win-win customer solutions.

TITLE

Rebuilding consumer trust in the energy sector

ABSTRACT

In surveys of consumer trust, the utilities sector in Australia regularly rates towards the bottom of the list. Consumers are confused by the options available in a competitive energy market, sensitive to rising energy bills and worried about how energy businesses use and secure their data. This presentation will review what we know about consumer trust in the Australian energy sector and introduce tools and practices that show the most promise for building (or rebuilding) consumer trust. The presentation draws on work for the RACE for 2030 Cooperative Research Centre on trust building for collaborative win-win customer solutions.

Professor Greg Morrison

Curtin University Sustainability Policy Institute, School of Design and the Built Environment, Faculty of Humanities, Curtin University

Professor Greg Morrison was a professor for close to 30 years at Chalmers University of Technology in Gothenburg, Sweden until 2015. He started at Curtin in 2015 and has been carrying out research on renewable energy systems and Living Labs. He is a co-founder of Climate-KIC Australia and a Director of the Board. Greg is also Program Leader for RACE for Everyone in the RACE for 2030 CRC.

TITLE

Aspects of solar sharing and storage

ABSTRACT

Solar sharing is a phenomenon that is increasingly common at a strata level due to the penetration of PV on roofs. We have studied the governance of solar-battery energy storage systems on strata in the White Gum Valley in Fremantle. Sharing solar allows local use but is still limited in winter due to poor building envelope performance. Further improvements in energy efficiency are enabled through understanding everyday practices and using the data to provide Machine Learning (ML) algorithms diurnal automation control. The phenomenon of solar sharing was also studied for peer-to-peer trading across the network between prosumers and consumers in Fremantle with the results demonstrating the institutional and early adopter uptake of the system.

Dr Larissa Nicholls

Human Centred Computing, Monash Emerging Technologies Research Lab, Monash University

Dr Larissa Nicholls' human-computer interaction research includes smart home, distributed electricity generation, and other digital technologies. Her applied research projects involve in-home ethnographic research to explore interactions between energy (technologies, usage, pricing, communications) and social, physical and financial wellbeing. Larissa specialises in bringing deeper understandings of household practices and concerns into Australia's ongoing policy debates about energy affordability, sustainability and reliability. Her industry research supports consumer advocacy and energy organisation decision-making towards better outcomes for households.

TITLE

Emerging household energy, demand response and equity issues amid disruptions

ABSTRACT

As we transition to a grid powered by renewables, demand response can play an important role in stabilising the electricity system. As the recent bushfire crisis and COVID pandemic have shown, all electricity stakeholders need to be flexible and able to adapt to shocks. Research from the Digital Energy Futures project highlights key new household trends and vulnerabilities. This presentation considers a range of demand management implications from emerging household trends and constraints. It also discusses opportunities to work better with households to deliver demand response that is productive for the grid, engaging and healthy for households, and avoids disadvantaging households already experiencing vulnerability.

Dr Belinda Wade

Lecturer, Sustainability and Strategy,
Business School,
The University of Queensland

Dr Belinda Wade is a lecturer in sustainability at the UQ Business School and leader of the Business Sustainability Initiative research area. Continuing from her industry career Belinda's research examines organisational adaptation to sustainability issues with a key focus on decarbonisation and transitions under climate change challenges. Recent academic works have been published in Journal of Business Ethics, and Nature Climate Change.

TITLE

Societal attitudes on future fuels in Australia's future energy mix

ABSTRACT

Public engagement is an important aspect for increasing societal understanding of the trade-offs associated with the implementation of new technologies. This session will present the findings from three citizens' panels, as a form of deliberative engagement, used to explore the Australian public's perspectives about the role of future fuels in the future energy mix. It will share key insights gained in relation to the Australian public's perceptions and priorities towards future fuels in the low-carbon energy transition.

Dr Fengji Luo

Academic Fellow and Lecturer, Faculty of Engineering, The University of Sydney

Dr Fengji Luo received his bachelor and master degrees in Software Engineering from Chongqing University, China in 2006 and 2009. He received his PhD degree in Electrical Engineering from The University of Newcastle, Australia, 2014. Currently, he is a Lecturer and Academic Fellow in Faculty of Engineering, The University of Sydney, Australia. His research interests include energy demand side management, smart grid, active distribution networks, and energy informatics. He received the Pro-Vice Chancellor's Research and Innovation Excellence Award of The University of Newcastle in 2015 and ATSE's Australia-Japan Emerging Research Leader Program in 2016.

TITLE

Collaborative learning framework for demand-side energy systems

ABSTRACT

It is expected that in coming years the combined effects of population growth, urbanisation, global warming and income growth will have an enormous impact on an increase of energy demand. Extensive research is underway to develop sustainable and flexible methodologies to facilitate effective energy demand side management. This contribution intends to present a computational framework, which rely on: (i) implementation of collaborative filtering strategies to assist end energy users in supporting energy-efficient behaviours and adopting energy-efficient products/services; and (ii) setting up of a federated learning approach to enhance the short-term power load forecasting. An effective implementation of these approaches needs to consider the specific customers' needs within their urban and climatic context.

Dr Susannah Soon

Research Fellow, Computing, School of Electrical Engineering, Computing and Mathematical Sciences, Curtin University

Dr Susannah Soon is a Research Fellow in Computing at Curtin University. She specialises in AI, human computer interaction (HCI), human factors, simulation and modelling, and VR. Susannah conducts research in energy and sustainability, defence, health, and transport. Susannah also manages the Optus 5G lab within the Optus Centre for AI at Curtin, engaging researchers, and industry in demand-driven technology research in AI, HCI, and 5G.

TITLE

Using digital twins to model residential energy efficiency

ABSTRACT

We develop a methodology to model micro-level residential energy efficiency of individual homes using IoT sensors (temperature, light, humidity, CO2) to measure building conditions in real-time. Predictive modelling simulates future building behaviour which is visualised in a customised digital twin and dashboard Building Management System. This technology better informs residents to retrofit their homes with energy efficient solutions. Further, we perform machine learning over Geographical Information System data such as aerial photography to categorise residences as having differing energy efficiency, forming a macro-level understanding of groups of residences. We then synthesise our understanding of both micro- and macro- level analyses.

Dr Virginia Weber

Lecturer, Deakin Business School, Deakin University

Dr Virginia (Gini) Weber is a Lecturer in the Deakin Business School and Course Director for the Bachelor of Marketing (Psychology). Their research centres on consumer psychology, investigating how consumers are influenced by their social environments and how they cope with negative experiences. Gini's research also focuses on sustainability, and they work with the Better Consumption Lab to examine drivers of environmental action and consumer perceptions toward new energy technologies.

TITLE

Evaluating Social Licence for Hydrogen Technologies

ABSTRACT

The Better Consumption Lab at Deakin University conducted a survey evaluating the current social licence for developing and using hydrogen technology in the Warrnambool/Portland region of Victoria. The work was undertaken to inform the community engagement activities being undertaken through Deakin's Hycel initiative. As part of this work, the team evaluated community perceptions toward developing and using hydrogen technologies in their community, as well as the perceived benefits for adopting these technologies. Through this, the team has identified certain strategies that could be adopted to further enhance and solidify hydrogen's current social licence in the region.

Loren Tuck

Coordinator Education, Training and Industry, Hycel, Deakin University

Loren Tuck's involvement in national projects about hydrogen workforce planning and education programs includes representation on the Australian Hydrogen Skills and Training Steering Committee, BIC's Zero Emissions Bus Committee, convening 10 TAFEs driving a national hydrogen microcredential and development of industry training at Deakin Warrnambool's Hydrogen Testbed Facility. Combining project and education experience broad industry insights, Loren leads Deakin's hydrogen education program, spanning projects in the school, vocational and tertiary sectors.

TITLE

School, apprenticeships and degrees – how will we learn about hydrogen?

ABSTRACT

As Australia's hydrogen industry evolves, so too does our understanding of the skills and jobs required to meet the hydrogen tasks of the future. This session explores jobs and roles - existing and new – that will feature across a thriving hydrogen supply chain, and the training we'll need to get there.

Luke Blackbourn

External Relations Director, InterContinental Energy

Luke Blackbourn joined InterContinental Energy from the Pilbara operations of the Norwegian firm Yara, developing a green ammonia project that received ARENA funding in 2021. Prior to this, Luke held global social performance roles, including for the $54 billion Gorgon Project. This included the establishment of Aboriginal engagement and employment functions across the business. Luke has worked in North America, Africa, Europe and Asia, including community infrastructure projects in post-conflict Liberia and Eastern Europe.

TITLE

Indigenous Stakeholders in the energy transition

ABSTRACT

With a global focus on large-scale decarbonisation, the need for renewables-based energy supply is apparent. This 'green wave' of development will be assessed, quantified and certified to ensure it is indeed renewable and free of carbon. It will also need to be assessed against its impact on stakeholders, and in areas where Indigenous peoples have connections to country, they will be key partners in the development.

Dr Phillipa Watson

Research Fellow, Syndicate of Technology, Environments and Design (TED), University of Tasmania

Dr Phillipa Watson works to support smart, ethical, and sustainable change for people and the buildings and technologies they use. She has worked in applied research (UQ, CSIRO and UTAS), sustainable building consultancy (Brisbane City Council and RED sustainability consultants), and housing design (private practice). Her interdisciplinary research includes focus on socio-technical transitions, housing quality, household experiences, social equity and distributed energy resource use and the intersections between these.

TITLE

Where consumer representation, social justice and energy management systems technology meet

ABSTRACT

Contemporary electricity management technologies and systems, and recent advances in their application, are driving the evolution of electricity provision in Australia. Customer relationships and customer opportunities are necessarily evolving in conjunction. Over recent decades recognition of customers as critical actors in energy systems and of the need for social justice and energy equity has grown. This presentation considers the emerging intersection between customers, new energy management, and evolving electricity grids, asking, 'are customers and social justice issues being effectively considered as new energy management systems are developed and applied?'

Dr Declan Kuch

VC Research Fellow, Institute for Culture and Society, Western Sydney University

Dr Declan Kuch is a social scientist with some 15 years experience working on energy and climate issues with campaigners, governments and industry. He is the author of the Rise and Fall of Carbon Emissions Trading (Palgrave) and has consulted on public engagement emerging technologies to the Australian Council of Learned Academies and recently co-led the Social License to Automate Task under the IEA's User-Centred Energy Systems Technology Collaboration Program, the first TCP with an explicit social science focus in the history of the IEA. He likes riding bicycles.

TITLE

Who's a trustworthy aggregator? Evidence from international demand-side management projects

ABSTRACT

Who would you trust to control your air conditioner, electric vehicle, battery or washing machine? Network businesses and aggregation firms are trialling automation technologies to shave peak demand, manage frequency and voltage and bid into markets in residential settings. This paper examines how problems are framed as well as users enrolled in trials involving some 26 projects involving third party automated control over batteries, heat pumps, EVs and other energy appliances across Australia, Austria, the Netherlands, Norway, Sweden and Switzerland. I examine the role of problem framing, level of automation, appliances automated and forms of actors involved to draw out lessons for scaling up automated DSM.

Associate Professor Anna Bruce

Associate Professor, School of Photovoltaic and Renewable Energy Engineering, University of New South Wales

Assocaite Professor Anna Bruce leads CEEM's research theme in distributed energy systems, including 'smart grids' and 'smart' homes, distributed generation and demand-side participation. Her research focuses on modelling, analysis and integration of renewable energy and distributed energy resources into electricity industries, energy access in developing countries, and energy policy and regulation. Anna contributes to the International Energy Agency's PV Power Systems programmes Task 18 (Off-grid and Fringe of Grid) and Task 14 (High Penetration PV in electricity networks) and leads the Australian PV Institute's Solar Mapping project.

TITLE

High PV Penetrations in the NEM: How big a challenge for System Services?

ABSTRACT

The variability, uncertainty and controllability characteristics of utility scale PV present challenges, but also opportunities for ensuring power system security and reliability. This presentation summarises some key CEEM work exploring the characteristics of utility scale PV and modelling of future requirements for system services in the NEM.

Associate Professor Gregor Verbič

School of Electrical and Information Engineering, The University of Sydney

Associate Professor Gregor Verbič is with the School of Electrical and Information Engineering at the University of Sydney, where he is Director of the Centre for Future Energy Networks. His expertise is in power system dynamics, control and operation, and electricity markets, with the research focus on future prosumer-centric sustainable energy systems.

TITLE

Prosumer-centric distributed energy systems

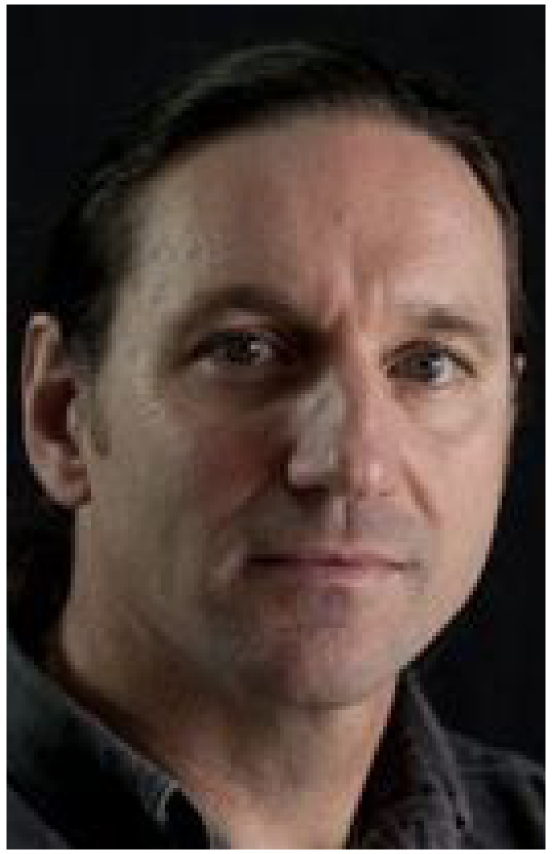
ABSTRACT

This talk will discuss approaches for facilitating the grid integration of small-scale distributed energy resources (DER) in the context of the emerging prosumer-centric sustainable energy systems. We focus on three transactive energy approaches: (i) uncoordinated approaches that only consider energy management of an individual user; (ii) coordinated approaches that orchestrate the response of several users by casting the energy management problem as an optimisation problem; and (iii) peer-to-peer energy trading that aims to better utilise the DER by establishing decentralised energy markets.

Professor Maria Forsyth

Director, ARC ITTC for Future Energy Storage Technologies (storEnergy)
Institute for Frontier Materials,
Deakin University

Professor Maria Forsyth "FAA" (Fellow Australian Academy of Sciences) is an Alfred Deakin Professorial Fellow at Deakin University and an Ikerbasque Visiting Professorial Fellow at University of the Basque Country. Professor Forsyth has worked at the forefront of energy materials research since her Fulbright Research Fellowship in 1990 and has consistently made breakthrough discoveries, including in polymer electrolytes, ionic liquids and organic plastic crystals. Her research has focused on understanding the phenomenon of charge transport in these materials and at metal/electrolyte interfaces present in all electrochemical applications.



Professor Greg Metha

Department of Chemistry,
University of Adelaide

Professor Greg Metha is a professor in the Department of Chemistry and an executive member of the Centre for Energy Technology (CET) at the University of Adelaide. He studies the interaction of photons and matter using light sources across the entire electromagnetic spectrum, from lasers to synchrotrons to solar radiation, investigating a range of molecular phenomena. His most recent work involves using light to produce chemical fuels directly from sunlight such as hydrogen from water-splitting, and hydrocarbons from CO2 reduction.

TITLE

The potential for battery manufacturing in Victoria

ABSTRACT

We are seeing a worldwide explosion of battery manufacturing to supply to anticipated global demand for Lithium ion batteries for EVs in particular. There are more than 180 Gigafactories planned across Europe, UK, USA, China and South East Asia and all jurisdictions are developing plans for increased production. Several companies have initiated their plans for Gigafactories in Australia with Energy Renaissance in NSW, Magnus Energy in Qld. There are smaller companies that consider alternative technologies, eg. Gelion and Redflow with Zn based systems, as well as a multitude of SMEs and start-ups looking at pack assembly for bespoke applications. Does it make sense to establish a sovereign battery manufacturing capability in Australia and particularly, in Victoria? What are the advantages and what are the roadblocks?

TITLE

Overview of the most promising and emerging hydrogen production technologies

ABSTRACT

The recent Hydrogen Production Technology forum HyPT-2 considered a broad suite of current and emerging CO2-free hydrogen production technologies such as: (i) large scale electrolysers; (ii) emerging electrolysis, (iii) hydrogen from natural gas, (iv) thermochemical processes, (v) hydrogen from bioresources & waste, (vi) photoelectrochemical & photocatalysis. The forum explored and appraised, with industry and academic experts, these various options with a view to understanding each technology's projections, limitations, challenges, and barriers to provide cheap hydrogen at large scale. This talk will summarise the discussions and highlight the most promising technologies identified from the forum.

Associate Professor Evan Franklin

Renewable Energy and Power Systems,
School of Engineering,
University of Tasmania

Associate Professor Evan Franklin is an Associate Professor in the Centre for Renewable Energy and Power Systems and Co-director of the Future Energy group at the University of Tasmania. Evan's research interests include renewable energy technologies, the integration of renewables into distribution networks and power systems, and the role of energy storage in future energy systems. Evan is a member of Engineers Australia and IEEE, and a regular collaborator with industry.

TITLE

Battery storage requirements for frequency control in 100% renewable systems

ABSTRACT

As power systems transition towards being based on variable renewable energy sources, conventional synchronous generators are being displaced and system inertia and system strength are subsequently reduced. As a result, the power system will become more exposed to frequency stability risk, among other things. Battery energy storage systems, meanwhile, are rapidly entering the market, primarily to provide energy arbitrage and smoothing capability. Battery systems also offer the ability to rapidly absorb or inject power upon demand and have been shown already to successfully provide primary frequency response in the Australian market. If well managed and with appropriate settings, battery storage can not only replace the functionality of conventional generators but can potentially improve frequency stability of power systems.

Dani Alexander

Research Director, UTS Institute for Sustainable Futures, RACE for Business Program Leader, RACE for 2030 CRC

Dani Alexander is a research director at the UTS Institute for Sustainable Futures who is passionate about reshaping our energy system to be clean, affordable, reliable and equitable. Dani specialises in understanding game-changing energy technologies, with a focus on distributed energy resources to promote energy system flexibility. Dani is also the RACE for Business Program Leader at the Reliable Affordable Clean Energy for 2030 Cooperative Research Centre (RACE for 2030 CRC). The vision for RACE for 2030 CRC is flourishing low carbon Australia, where energy research improves quality of life and boosts energy productivity. Outside her research, Dani is also a mother, ultimate frisbee athlete and C40 Woman4Climate.

TITLE

Flexing our energy – opportunities to maximise flexible demand in Australian businesses

ABSTRACT

The energy market is being reshaped to support the growth of renewable energy. This is being both driven by customers (e.g. by many businesses purchasing off-site renewables) and through regulatory reform. Many regulatory changes are being pursued to facilitate more demand flexibility to support the increased variability in renewable energy supply. This session will outline new research topics that could unlock swathes of flexible demand, based on an opportunity assessment undertaken by RACE for 2030 CRC. Three real-world opportunities for flexible demand will also be presented, based on case study research undertaken by the UTS Institute for Sustainable Futures and Flow Power.

Dr Behrooz Bahrani

Senior Lecturer, Faculty of Engineering/ Department of ECSE Director, Grid Innovation Hub, Faculty of Engineering, Monash University

Dr Behrooz Bahrani is a Senior Lecturer in the Electrical and Computer Systems Engineering department and the director of Grid Innovation Hub at Monash University. Prior to joining Monash, he was a postdoctoral fellow at several institutions including EPFL, Purdue University, Georgia Institute of Technology, and the Technical University of Munich. His research interests include control of power electronic systems, applications of power electronics in power systems, and grid integration of renewable energy resources.

TITLE

Renewable energy resources grid integration challenges in weak grids

ABSTRACT

On the way to a zero net emissions future, Australia's electricity network roadmap is to replace the critical role of synchronous generator-based plants such as coal-fired power plants with low-emission renewable, power electronic converter (PEC) connected energy resources. Retiring conventional synchronous generators and their substitution with PEC-connected generators creates a power system with a lower level of native inertia leading to a weaker electricity network with a lower system strength. Additionally, with the majority of optimal sites for renewable energy generation and stiffer connection points already utilised, future developments need to focus on less favourable locations leading to the connection of future farms into weaker grid points with lower system strength. This presentation will present several solutions for the grid integration of renewable energy resources into weak areas of the grid using enhanced grid following inverters and also grid forming inverters.

Dr Mahdokht Shaibani

VC Research Fellow, Institute for Culture and Society, Western Sydney University

Dr Mahdokht Shaibani is an energy storage researcher, inventor, and solution provider. She has a Ph.D. in Mechanical Engineering, focusing on energy storage from Monash University, Australia. Mahdokht has expertise in materials synthesis, engineering, and scale-up for next-generation energy storage systems, including lithium-sulfur batteries, silicon anodes, flow batteries, supercapacitors, and lithium-ion capacitors. She has conducted pioneering research in developing practical graphene-based protection technologies and expansion-tolerant architectures for stabilizing lithium-sulfur batteries.

TITLE

Disruptive battery technologies

ABSTRACT

The rising environmental and resource availability concerns regarding the production of the seriously mineral-intensive Li-ion battery technology and the rapid expansion of battery manufacturing capacity driven by transportation electrification could result in disruptive changes in the type of minerals used in today's batteries. Replacing the graphite anode, which has served the Li-ion battery for 30 years, with ultra-high capacity Lithium metal or silicon anodes is one such scenario. Another game-changer scenario could be substituting the high-capacity yet mineral-intensive nickel/cobalt-based cathodes with the older and lower-capacity lithium iron phosphate cathodes, which uses naturally-abundant iron. Such battery technologies and their potential effect on materials resource availability will be discussed.

Dr Jessica Breadsell

Research Associate, Sustainability Policy Institute, Curtin University

Dr Jessica Breadsell is a social scientist studying how emerging technologies intersect with the practices of everyday life. This work is undertaken through longitudinal, multidisciplinary living laboratory research projects that develop an understanding of everyday practices, how technology fits into these and where improvements can be made to increase broader societal uptake.

TITLE

Machine learning and home automation for energy optimisation

ABSTRACT

Machine learning algorithms can be used to identify the different clusters and routines that homes follow in their energy use and interact with automation systems. The utilisation of the K-means clustering technique demonstrates the energy profiles of households over three Living Laboratories followed over a year. These energy profiles provide insight into the practices and routines of the residents and their use of solar PV, battery and air-conditioning systems. These results are discussed through the lens of Social Practice Theory to understand how energy is consumed in the everyday activities of the homes and how future automation systems may work.

Associate Professor Yan Jiao

School of Chemical Engineering and Advanced Materials, University of Adelaide

Associate Professor Yan Jiao is an ARC Future Fellow working at the University of Adelaide. She received her PhD in Chemical Engineering from UQ in 2012. Jiao is an expert in the field of computational electrochemistry and materials design for clean and sustainable energy conversions. She was recognized as a Highly Cited Researcher by Clarivate Analytics. She has attracted more than one million Australian dollars in research grants.

TITLE

Design electrocatalyst materials for clean energy conversion by molecular modelling

ABSTRACT

The increasing impact of climate change urges us to establish energy supplies with zero carbon emissions. The large scale production of green electricity from renewable energy resources (such as solar, wind, tide, and geothermal) is now commercially available. However, these renewable energy resources are often intermittent and are not in concert with the need for electricity. By electrochemical methods, we can store as generated electricity in the format of green chemicals and fuels. These electrical-chemical energy conversion processes require electrocatalyst materials, and molecular modelling is a great way to design new efficient materials for these energy conversion processes.

Professor Paul Webley

Director, Woodside Monash Energy Partnership, Monash University

Professor Paul Webley has over 15 years' industry and academic experience in the development and management of clean energy technologies, specifically carbon capture. Professor Webley leads the Woodside Monash Energy Partnership to progress energy solutions for a lower carbon future. Aligned to the United Nations Sustainable Development Goals, the research and development initiatives of the partnership will focus on leadership and novel technologies in the hydrogen value chain and carbon abatement. Professor Webley's principal research interest has seen him at the cutting edge in supporting Australia's lower-carbon energy transition.

TITLE

Liquid hydrogen generation, storage and transport for domestic applications

ABSTRACT

The emergence of a hydrogen economy has prompted renewed efforts to improve the technology for hydrogen generation, storage, and delivery. At atmospheric pressure, hydrogen is a liquid at 20K, requiring advanced insulation to avoid excessive boil off during storage and delivery. Almost 30% of the embedded energy is needed to liquefy hydrogen. However, there are significant benefits such as higher density, more than twice that achievable with high pressure compressed hydrogen. In addition, cryopumps can be used to provide high-pressure hydrogen with substantially lower energy penalty than gas compressors. We present some advanced concepts in liquid hydrogen which will provide opportunities for its use both in export and domestic applications.

Dr Claire Vincent

Senior Lecturer, School of Geography, Earth and Atmospheric Sciences, University of Melbourne

Dr Claire Vincent is a Senior Lecturer in the School of Geography, Earth and Atmospheric Sciences and a CI in the ARC Centre of Excellence for Climate Extremes. Her research interests include tropical variability, extreme rainfall and wind energy meteorology. She has worked on problems including heavy tropical rainfall in the Maritime Continent, high-resolution modelling of tropical islands, wind variability over the North Sea and wind power forecasting in southeast Australia.

TITLE

Wind variability and volatility in SE Australia

ABSTRACT

The wind resource varies on multiple scales, from turbulent eddies to interannual or even longer time-scales. In this talk, I will discuss the drivers of offshore and onshore wind variability, with reference to wind power forecasting and predictability. I will focus on case studies of LIDAR-based wind forecasting in SE Australia, and the spatial and temporal variability of offshore wind patterns in offshore and coastal regions.

Dr Ross Gawler

Senior Research Fellow, Department of Data Science and Artificial Intelligence, Monash University

Dr Ross Gawler graduated with Bachelor and PhD degrees in electrical engineering from Monash University. From 1978, at the State Electricity Commission of Victoria, he made innovative contributions to transmission and generation planning. From 1993, his major consulting work has been in electricity price and revenue forecasting for investment in generation and transmission, and emission abatement in electricity markets. His current work involves decarbonisation of electricity markets including electric vehicles.

TITLE

Modelling of Snowy Hydro Market Power with Snowy 2.0

ABSTRACT

Snowy 2.0 is a major investment in hydro pumped storage which will support ongoing investment in renewable energy resources in the National Electricity Market. The impact of Snowy 2.0 on the market power of Snowy Hydro has been evaluated using a PLEXOS Model based on the 2020 AEMO data for the Integrated System Plan. The Nash-Cournot game in PLEXOS was calibrated using 2019 calendar year NEM spot prices. The market power of Snowy Hydro was tested in selected years of the 2030s and 2040s. It was found that Snowy Hydro's market power is indicated as moderate without Snowy 2.0. In the event that it became a matter of concern, then disaggregating Snowy Hydro into 2 or 3 portfolios would have a material effect in moderating its market power.

Dr Kelly Burns

Senior Research Fellow, Victoria Energy Policy Centre, Victoria University

Dr Kelly Burns (PhD, B.Eco (Hons), LLB (Hons), PS146) is an energy economist at the Victoria Energy Policy Centre, Victoria University. Kelly has a multidisciplinary background in economics, finance and law, and extensive experience in retail energy markets, distributed energy resources, demand responsiveness, and energy modelling and forecasting more broadly. Kelly is also the elected council member for the International Association of Energy Economics (IAEE), representing the Asia-Oceania region.

TITLE

The relationship between household wealth and rooftop solar in Australia

ABSTRACT

Previous studies suggesting wealthier homes are more likely to install rooftop solar are not robust when the data are appropriately segmented to account for the interrelationship between solar and wealth, building form and ownership. After controlling for these factors (as well as prices and consumption), our results suggest that wealthier, fully-detached and owner-occupied homes may be less likely to install solar compared to their poorer counterparts. We demonstrate the relationship between household wealth and rooftop solar in Australian is not well understood because it is difficult to model robustly using available data.

Professor Jacqueline Peel

Director, Melbourne Climate Futures, University of Melbourne

Professor Jacqueline (Jackie) Peel is a Professor of Law at the Melbourne Law School and the Director of the Melbourne Climate Futures initiative at the University of Melbourne. She is a globally renowned expert in the field of environmental and climate law with several books and numerous articles published on these topics. Amongst other roles, Jackie is co-chair of the American Society of International Law's Signature initiative on Climate Change, is a founder of the Women's Energy and Climate Law Network and is a Lead Author on the Intergovernmental Panel on Climate Change, Working Group III for its Sixth Assessment Report.

TITLE

Legal mechanisms for promoting corporate energy transition

ABSTRACT

Clean energy transition by the private sector to address climate change is no longer a matter of what or why, but how. Legal mechanisms and regulatory frameworks have an important role to play, particularly in governing company disclosures of climate risk, duties of Boards to manage those risks and, as a last resort, litigation to hold underperforming corporate actors to account. This presentation will discuss how these legal mechanisms are developing in Australia and what they mean for corporate action to address climate change.

Professor Fred Gale

VC Research Fellow, Institute for Culture and Society, Western Sydney University

Professor Fred Gale in an interdisciplinary scholar researching the discipline of political economy from a sustainability perspective. He has undertaken empirical studies on forestry, fisheries, fair trade, free range, and organic certification schemes. In his recent book, The Political Economy of Sustainability (Edward Elgar 2018), he explores the concept of sustainability value for political economic theory and practice, highlighting the implications for deliberative, participatory, and post-party approaches to governance.

TITLE

Certifying sustainable hydrogen: from a techno-economic to an eco-social approach

ABSTRACT

As governments, corporations and civil society actors gear up for the switch from fossil fuels to renewable energy, attention is turning to hydrogen as a potential scalable solution, especially in manufacturing, long-haul transportation and heating. Not all hydrogen is equal, however, and a narrow techno-economic focus on production is leading to weak hydrogen certification schemes that fail to pass the sustainability test. In this presentation, I will outline what sustainability means and how it needs to be operationalised and explain why there is a need to transition from narrow techno-economic approaches to the emerging hydrogen market to an eco-social approach that ensures all those with an interest in H2 production are fully included in the decisions taken.

Dr James Foster

Research Scientist, Energy Systems Research Program, CSIRO

Dr James Foster is a member of the Energy Economic Modelling team, within the Energy Systems research program. He is a specialist in mathematical optimisation and data analytics applied to energy systems, and as a member of the Energy Economic Modelling team performs research on the production, transport and consumption of energy on national or global scales, providing insights to help industry and government make strategic decisions about the future state of the economy.

Professor Bruce Mountain

VC Research Fellow, Institute for Culture and Society, Western Sydney University

Professor Bruce Mountain is the inaugural Director of the Victoria Energy Policy Centre at Victoria University. Bruce is an energy economist with a particular interest in the political economy of energy supply and in the economics of regulation. Before joining academia Bruce was a consulting economist in Australia and internationally. Over the course of his career he has worked on policy and economics problems in many parts of the electricity supply chain. His particular interests now are in decentralised production and in the economics of electricity storage.

TITLE

Modelling the NEM to support increased VRE uptake to 2050.

ABSTRACT

A question of current interest is how much energy storage and transmission is needed in the NEM to support increased variable renewable energy (VRE) uptake to 2050. Our model of the NEM, STABLE, looks to address this question and forms a key part of the GenCost project, a collaboration between CSIRO and AEMO to deliver an annual process of updating electricity generation and storage costs. I will discuss our NEM model as it relates to insights into potential balancing costs in a system with expected increasing VRE.

TITLE

Build Own Operate Transfer hits the retail market: is major disruption on the way?

ABSTRACT

Innovative retailers are now offering build-own-operate-transfer solar and battery bundles. This looks like an incredibly compelling proposition. I will explore the model and talk about the impact I think it will have in the market.

Dr Maria Vrakopoulou

Lecturer, Power and Energy Systems, Electrical and Electronic Engineering, University of Melbourne

Dr Maria Vrakopoulou is a Lecturer in the Power and Energy System group at the Department of Electrical and Electronic Engineering, at the University of Melbourne. She holds a diploma in Electrical and Computer Engineering from the University of Patras (Greece) and a PhD from ETH Zurich (Switzerland). She was awarded a Marie-Curie post-doctoral fellowship and conducted research at the University of Michigan, Ann Arbor (MI, USA), at the University of California, Berkeley, CA, USA, and ETH Zurich. Her research focuses on the optimisation and analysis of planning problems for power systems under uncertainty.

TITLE

PV power uncertainty impact on operational cost and security trade-offs

ABSTRACT

The talk is motivated by the future operation of distribution systems with high PV power penetration. Operation schemes of distribution systems while participating in energy and reserve markets will be discussed. Special focus will be given on the impact of the PV power uncertainty on the trade-off between operational system costs (both energy and reserves) and security. The analysis of the operational schemes will provide insights into future market structures.

Professor Frank Jotzo

Director, Centre for Climate and Energy Policy, Australian National University

Professor Frank Jotzo is Head of Energy at the ANU Institute for Climate Energy & Disaster Solutions and a Professor at the ANU Crawford School of Public Policy. He is an environmental economist. His research is on climate change and energy economics and policy, in the context of economic reform and development. He is joint editor-in-chief of the journal Climate Policy and a Lead Author with the IPCC. He has advised national and state governments, international organisations and businesses.

TITLE

Coal exit trajectories and models for orderly coal power exit

ABSTRACT

Closure of coal fired power plants is a vital part of decarbonisation of electricity supply, which in turn allows low-emissions electrification across the economy. Coal power in Australia is declining as renewable energy generation is increasing, leaving less demand to be filled by coal. Some plants have closed and others will close as market pressures mount. However the process is haphazard and future exits might come suddenly or be delayed through subsidy arrangements. International practice shows that regulatory and policy mechanisms can be used to make coal plant exit more predictable, for better outcomes for communities and electricity markets, and to accelerate the process for lower emissions.

Dr Rowena Cantley-Smith

Senior Lecturer and Barrister, Faculty of Law, University of Technology Sydney

Dr Rowena Cantley-Smith (BEc, LLB, GCLT, LLM, LLD) is a Senior Lecturer, Faculty of Law, University of Technology Sydney and Barrister (The Victorian Bar). Rowena has 20+ years' experience in energy and climate change law, regulation, and policy. Her international, European, and Australian legal expertise encompasses energy policy, law, and regulation, climate change law, legal rights, consumer protections, and dispute resolution. Her international interdisciplinary research focuses on the energy-environment-human nexus and related issues. This canvasses sustainable energy market transitions, climate change, energy justice, energy security of supply risks, and emergent international legal rights.

TITLE

Consumer-centric energy markets: challenges and opportunities

Dr Diane Kraal

Senior Lecturer, Business Law & Taxation, Monash Business School, Monash University

Dr Diane Kraal is a taxation law lecturer and researcher with the Monash Business School. Her expertise has been applied to investigate the facilitation of greater uptake of electric vehicles in business fleets. This 2021 project between Monash and Griffith universities is funded by the 'Reliable Affordable Clean Energy (RACE) for 2030', Co-operative Research Centre. Recent research compares the taxation legislation for gas in Australia and the Netherlands; mineral extraction industry tax incentives; and energy policy inquiries into Australia and south-east Asian countries.

TITLE

Business Fleets and EVs: Taxation incentives for home charging and affordability

ABSTRACT

Business car fleets have a low uptake of battery electric vehicles (BEVs), and key associated problems are scarce business site charging facilities, and affordability. Nonetheless, business fleets are seen as an effective pathway for early adoption of BEVs, given high numbers of fleet petrol vehicles of which up to 47% are reported as home garaged. An immediate solution is to charge BEVs at individual fleet employees' homes, which can include the use of smart meters. The research asks whether taxation changes can provide solutions to affordability and inadequate business charging infrastructure — by using fleet employees' homes for BEV charging.

Professor Mark Stevenson

Melbourne Energy Institute,
University of Melbourne

Professor Mark Stevenson is an epidemiologist and Professor of Urban Transport and Public Health at The University of Melbourne. He has worked on numerous national and international projects that have influenced transport policy and worked with both Federal and State Governments in Australia and internationally. He has led many research groups and is internationally recognised in the field of transport and public health. Professor Stevenson is the director of the Transport, Health and Urban Design Research Lab at The University of Melbourne.

TITLE

Transport futures: the role of micro-mobility

ABSTRACT

The transport sector currently accounts for approximately 19% of Australia's total greenhouse gas emissions and the sector has one of the fastest growth rates in emissions. Current Australian and State-based strategies continue to rely on energy inefficient motorised vehicles. Despite these challenges, cities are re-thinking their transport plans with respect to reductions in CO 2 emissions but also to reduce congestion and other negative externalities arising from our current transport system. This brief presentation will explore micro-mobility as an important component in a transition to an efficient low emission future transport system.

Professor Rosemary Lyster

Climate and Environmental Law, The
University of Sydney

Professor Rosemary Lyster is Professor of Climate and Environmental Law at the University of Sydney Law School and a Fellow of the Australian Academy of Law. Rosemary's research expertise covers Climate Justice and Disaster Law, Energy and Climate Law, and Water Law. She has extensive publications in these areas. Rosemary is currently the holder of an ARC Discovery Grant 'A legal framework for resilient electricity infrastructure in Australia' with Associate Professor Gregor Verbic and two experts in the United States.

TITLE

How to build system resilience to extreme weather events

ABSTRACT

Climate-induced disasters have overwhelmed many parts of the world. Thinking about the resilience of electricity infrastructure is not just some kind of technical engineering exercise. Here, I shine the light on the ways in which electricity infrastructure has been impacted in Australia, and ask whether governments and utilities have either planned for and responded to the challenges, at least in the short term, or have failed to do so. I propose the kinds of legal strategies that will need to be adopted in future. One of the uplifting messages of this presentation is that while renewable energy generation is generally considered to be an emissions mitigation strategy it is also vital for resilience. Another intriguing aspect is that where electricity markets have been deregulated largely for competition reasons, renewable generation and the 'prosumer' have so disrupted the market that the owners and operators need to find new ways of being relevant. In other words, the 'market' has taken on a life of its own and is thriving far beyond the imaginings of its original architects.

VIRTUAL POSTERS //

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PEROVSKITE-SILICON TANDEM ABSORBERS BASED DIRECT SOLAR HYDROGEN GENERATION

Astha Sharma, Doudou Zhang, Siva Karuturi, Kylie Catchpole, Fiona Beck

INTRODUCTION

Direct solar hydrogen generation (DSHG) is a promising method for renewable hydrogen generation, where solar energy drives the generation of hydrogen and oxygen by molecular dissociation of water on a catalytic/semiconductor surface. Developing. Developing DSHG systems with high efficiencies and low-costs is critical to achieving commercial viability. With realised power conversion efficiencies (PCE) of 30%, and potential to reach up to 35%, perovskite-Si tandems are a promising candidates or DSHG.

SUMMARY

High-performance Si photocathodes, with an half-cell STH of over 10% are demonstrated, enabling overall STH efficiencies of 17% when integrated in tandem with perovskite PV cells.
Current and voltage mismatch due to sub-optimal system configuration is one of the largest losses in the system.
An unassisted solar hydrogen generation system using perovskite-Si tandem PV and Ni based earth abundant catalytic system in PV-EC configuration with an unprecedented efficiency of 20%.

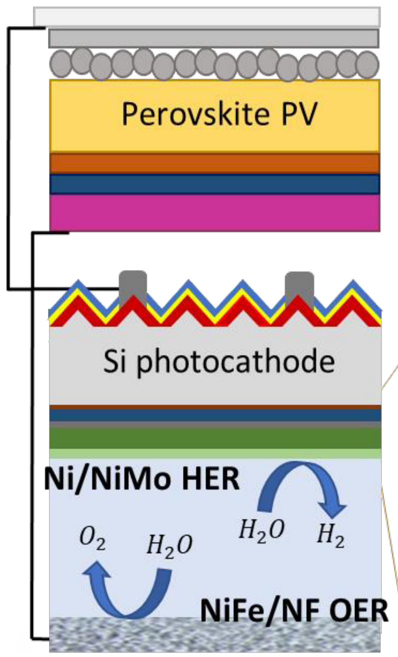
TEAM


PROJECT LINK

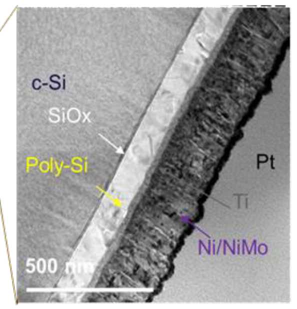
https://cecs.anu.edu.au/research/research-projects/solar-hydrogen

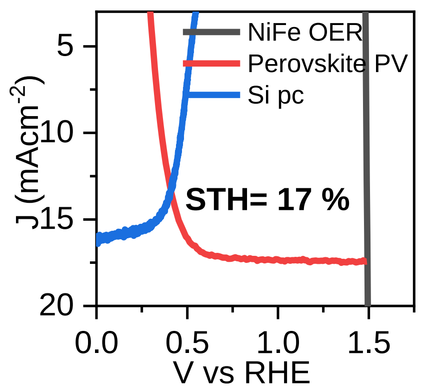
KEY RESULTS AND HIGHLIGHTS

I. Direct solar to hydrogen conversion enabled by silicon photocathodes with carrier selective passivated contacts

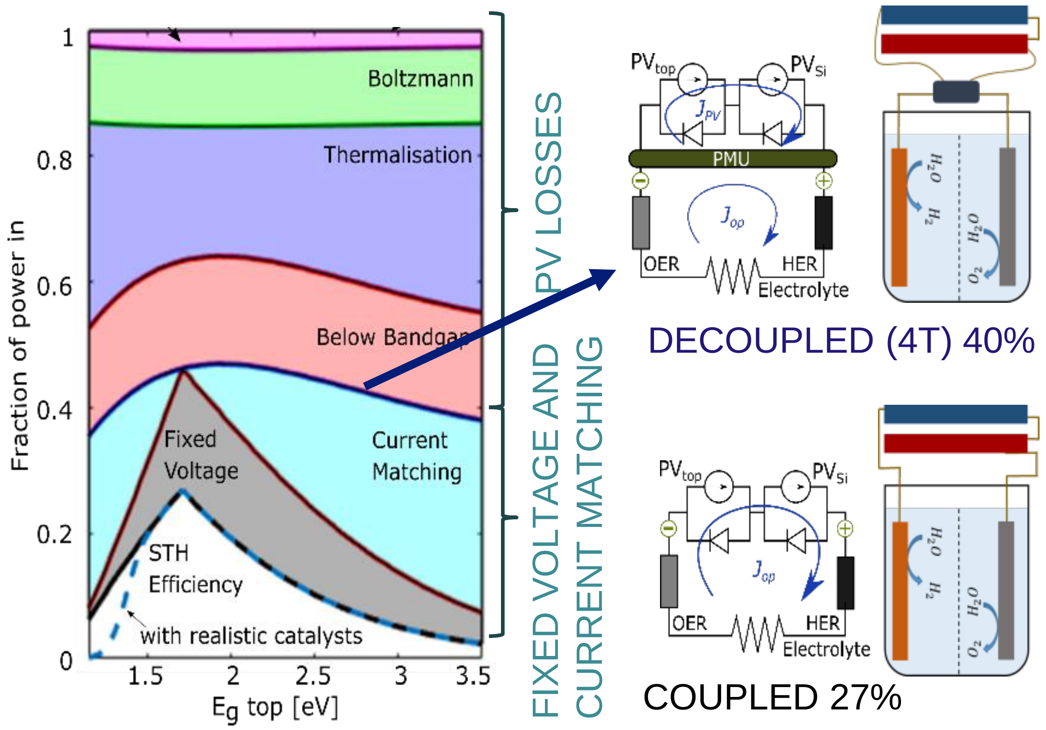


- Si photocathodes with carrier selective passivated contacts
- All low cost, earth abundant catalysts using industrially compatible fabrication techniques
- Photocathode half-cell STH = 10.5%
- Stand alone STH = 17%

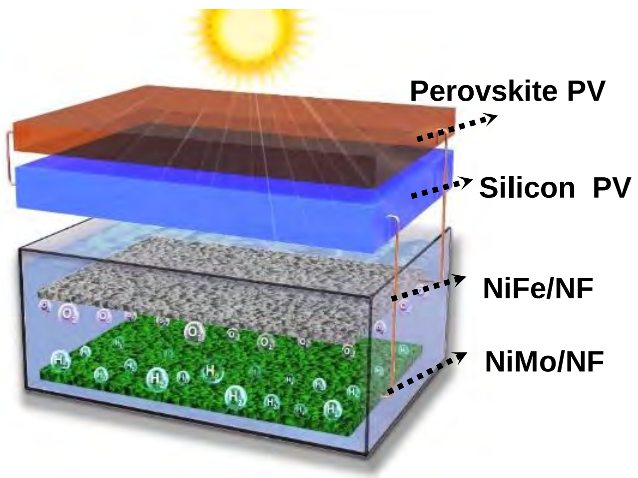


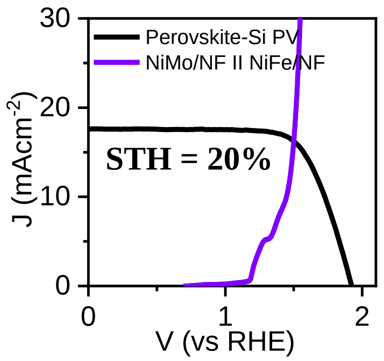


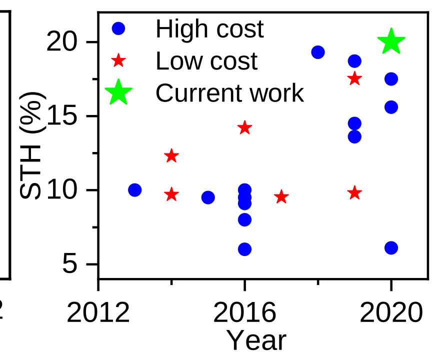
II. Quantifying and Comparing Fundamental Loss Mechanisms to Enable STH Efficiencies above 20% Using Perovskite–Silicon Tandem Absorbers

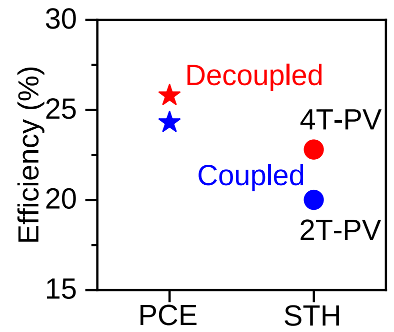


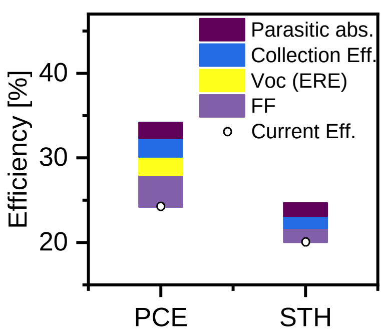
III. Direct Solar Hydrogen Generation at 20% Efficiency Using Low-Cost Materials











- 20 % STH efficiency using all low-cost materials based system
- Meets the US DoE STH efficiency target for 2020
- Potential to achieve 25% STH efficiency

https://cecs.anu.edu.au/research/research-projects/solar-hydrogen

WATCH PRESENTATION ONLINE

Natural LOHCs based on computational chemistry

Chunguang Tang[1, 2] and Yun Liu[1,2]
[1] Research School of Chemistry, The Australian National University
[2] Institute for Climate, Energy & Disaster Solutions, The Australian National University
Email: chunguang.tang@anu.edu.au or yun.liu@anu.edu.au

Australian National University

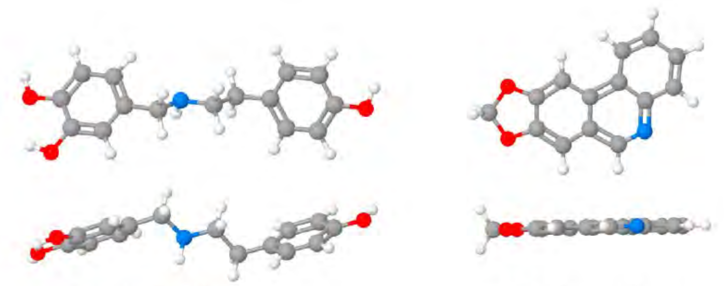
Background

Liquid organic hydrogen carriers (LOHCs) are promising candidates hydrogen storage materials [1]. To date,the typical LOHCs, except N-ethylcarbazole, have high dehydrogenation enthalpy (ΔH_{dh}). It's desirable to find more LOHC systems with relatively low ΔH_{dh}.
Also, the production of LOHCs from fossil-based materials is not green or sustainable. On the other hand, natural molecules out of plants represent an unexplored mine of possible LOHC candidates.

In this work we explore the potential LOHCs from alkaloids out of Amaryllidaceae plants. This plant family contains ~1600 species in tropical and subtropical areas, including many garden plants and vegetables.

Snowflake plant

Specifically, we study the energy of dehydrogenation of perhydro-norbelladine and perhydro-trisphaeridine based on the first principles computations. These two molecules have low weights and high hydrogen storage capacity (4% and 5.91%, respectively).



norbelladine trisphaeridine

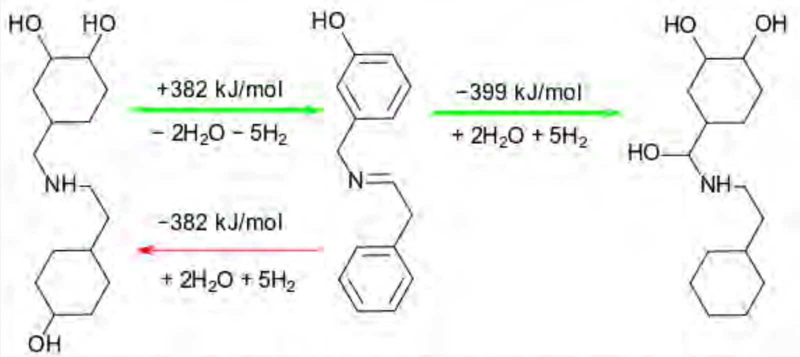
Methods

We examine the energy of dehydrogenation through various reaction paths for

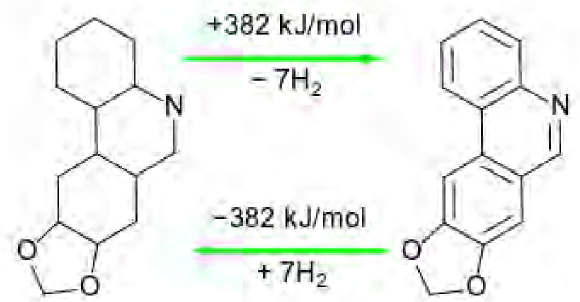
$$H_{H-rich\ molecule} + \Delta H_{dh} \rightarrow H_{H-lean\ molecule} + H_{nH_2}$$

For details, see Ref [2].

Main results



Irreversible dehydrogenation of perhydro-norbelladine



Reversible dehydrogenation of perhydro-trisphaeridine

Comparison of ΔH_{dh} (in unit KJ/mol-H_2) with other LOHC molecules

system	ΔH°_{cal}	ΔH°_{expt}
Perhydro-norbelladine ($C_{15}H_{29}NO_3$)	75.33	
Perhydro-trisphaeridine ($C_{14}H_{23}NO_2$)	54.54	
Cyclohexane (C_6H_{12})	67.56	68.7
Trans-Decalin ($C_{10}H_{18}$)	70.93	66.3
Perhydro-N-ethylcarbazole ($C_{14}H_{25}N$)	52.02	53.2
Methylcyclohexane (C_7H_{14})	74.82	68.3

Conclusions

- A first attempt exploring bio-based LOHCs
- Norbelladine as a potential LOHC with low ΔH_{dh}

Other computational projects

- Catalytic reactions of LOHCs
- Database of potential LOHCs
- Hydrogen behaviour in metals

References

1. Abdin Z, Tang C, Liu Y, and Catchpole C, "Large-scale stationary hydrogen storage via liquid organic hydrogen carriers", *iScience*, **24**, 102966 (2021)
2. Tang C, Fei S, Lin G D, and Liu Y, "Natural liquid organic hydrogen carrier with low dehydroenation energy: A first principles study", *Int J Hydrogen Energy*, **45**, 32089 (2020)

WATCH PRESENTATION ONLINE

RACE for 2030

Final Report
RACE for Networks Program
Theme N1: Electric Vehicles and the Grid
Business Fleets and EVs: Taxation changes to support home charging from the grid, and affordability

Project Code: 21.N1.00146

ISBN: 978-1-922746-08-5

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Citation

Mortimore, A.; Kraal, D., Lee, K-H., Klemm, C., Akimov, A. (2021). Business Fleets and EVs: Taxation changes to support home charging from the grid, and affordability. Fast track project for RACE for 2030.

Acknowledgments

The authors would like to thank the many stakeholders involved in the development of this report. In particular, interviewees and the Industry Reference Group members, which includes the Australasian Fleet Management Association. All have been generous with their time. Many thanks also to Lex Fullerton and the research assistants, Kelly Hodson, Ben Grunberg, Sanuri De Silva Wimalatunga, Melchor Raval, and Nuwan Gunarathne.

Whilst their input is very much appreciated, any views expressed here are the responsibility of the authors alone.

What is RACE for 2030?

The Reliable Affordable Clean Energy for 2030 Cooperative Research Centre is a 10-year, $350 million Australian research collaboration involving industry, research, government and other stakeholders. Its mission is to drive innovation for a secure, affordable, clean energy future.

Project Partners

Griffith University, Monash University, Victoria State Government, NSW Government, agl, Government of South Australia

What is the report?

This fast track report reflects tax changes investigated to accelerate business fleets uptake of battery electric vehicles (BEVs) in Australia. The tax changes address affordability and support for home charging of business fleet vehicles at fleet employees' place of residence. The project recommends 17 tax changes. The short-term and long-term fringe benefits tax (FBT) and income tax changes draw on overseas literature and the project's research to address fiscal barriers to BEV fleet vehicle affordability and home charging.

Why is it important?

Business fleets are seen as an important, effective pathway for early adoption of BEVs but their uptake of BEVs, and site charging infrastructure is low. Up to 47% of fleet vehicles are home garaged, providing an opportunity for business fleet BEVs to be home charged using smart meters, and optimising CO_2 emission reduction.

What did we do?

The fast-track project research included:

1. Fleet manager interviews.
2. Fleet manager and fleet employee test surveys.
3. FBT case studies that explore short-term tax changes for home charging of BEVs.
4. An income tax literature and legislation discussion for short-term tax changes.
5. Modelling of Total Cost of Ownership for both BEV and ICEVs
6. FBT and income tax changes for the long-term, based on tax literature from overseas jurisdictions.

What difference will it make?

The critical difference in this research is the identification of short-term and long-term tax changes and other fiscal incentives to both address affordability arising from the price premium on BEVs; and current tax barriers inherent in establishing home charging of fleet vehicles.

What's next?

The results of this fast-track project have provided the basis to address the following areas in future research:

- Further FBT and income tax changes, both short-term and long-term.
- Further modelling of proposed tax changes to support business fleets accelerated uptake of BEVs.
- Quantitative surveys of fleet managers and fleet employees to accelerate uptake of BEVs and to promote home charging of fleet BEVs.

WATCH PRESENTATION ONLINE

AUSTRALIA: THE RENEWABLE ENERGY EXPORT POWERHOUSE

Australian National University

P.J. Burke, F.J. Beck, E. Aisbett, K.G.H. Baldwin, M. Stocks, J. Pye, M. Venkataraman, J. Hunt, X. Bai

ANU Grand Challenge: *Zero-Carbon Energy for the Asia-Pacific*

WATCH PRESENTATION ONLINE

Advancing a Hydrogen Economy in Australia: Industry Perceptions Compared to Reported Community Concerns

Authors: Dr Kim Beasy, Dr Stefan Lodewyckx & Ms Sylvia Gray

By conducting a thematic analysis of stakeholder submissions to key national and Victorian hydrogen white papers, we investigate the ways in which community and their concerns are identified and conceptualised by community stakeholders compared with industrial stakeholders.

Introduction

This study addresses the lack of existing research exploring Australian community concerns regarding hydrogen technologies. The advancement of the hydrogen economy depends upon partnerships between industry and community. Establishing mutual understanding and productive relationships are imperative[1]. Little research exists comparing reported community concerns with industry perceptions of community concerns.

Methodology

Research Question: How do industries conceive of community perceptions of hydrogen technologies, and how do they compare with those reported by the Victorian public?

Method: Inductive thematic analysis[2] of 89 publicly-available submissions received in 2019 for the National Hydrogen Strategy, predominantly from industry; 85 public submissions received in 2019–2020 for the Victorian Green Hydrogen Discussion Paper, predominantly from the community.

Findings

Industry Perceptions of Community Concerns: Industry predicted technological and logistical implementations (i.e. safety) and the environmental 'credentials' of hydrogen technologies as primary community concerns (Figure 1). Unlike community submissions, industry respondents illustrated an unwavering trust in technology to advance a hydrogen economy and the technical readiness of hydrogen-related technologies to assure community trust. Further, some industry submissions reflected openness to working with community and viewed industry as part of community. However, the dominant perspective positioned community as a separate entity and a barrier to development.

"The community will also need to be informed about the use of hydrogen to ensure acceptance."

Figure 1. Word cloud of industry perceptions of community concerns about hydrogen technologies (left) community perceptions about hydrogen technologies (right).

swinburne.edu.au

Community Concerns: Broader objectives for hydrogen technologies and their ability to address local and global challenges (i.e. climate change) were primary concerns for the community. Additionally, industry accounts lacked acknowledgement of the emotional investment observed among community responses.

"Don't risk the health of citizens. Make the right choice for our children and future generations."

The differences may be due to industry motivations and worldviews which privilege technological determinism[3], compared to communities, where worldviews centre environmental and social wellbeing[4].

Implications and Future Work

Findings suggest multiple implications for the emerging Australian hydrogen economy. First, hydrogen will not be immune to challenges faced by other sustainable energy sources; thus, a robust plan for community engagement that considers a range of complex, contextual factors is required. Second, there is an opportunity for mutual identity formation, which integrates industry and community goals and values. Third, industry may benefit from viewing the community as an under-utilised, valuable partnership or resource rather than a hinderance. Mutual identity formation and co-design may be critical to furthering the hydrogen agenda. Further research is needed to understand the intersections of industry/community.

Limitations

- Data was not purposefully collected for this project.
- Findings are not generalisable and reflects industry and community who have some knowledge of hydrogen.
- While the data was collected in the same year, the two datasets are from different consultation periods.
- Findings presented here are based on preliminary results.

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WATCH PRESENTATION ONLINE

Green steel in cars is affordable

Mousami Prasad[1], Frank Jotzo[1] and John Pye[2]

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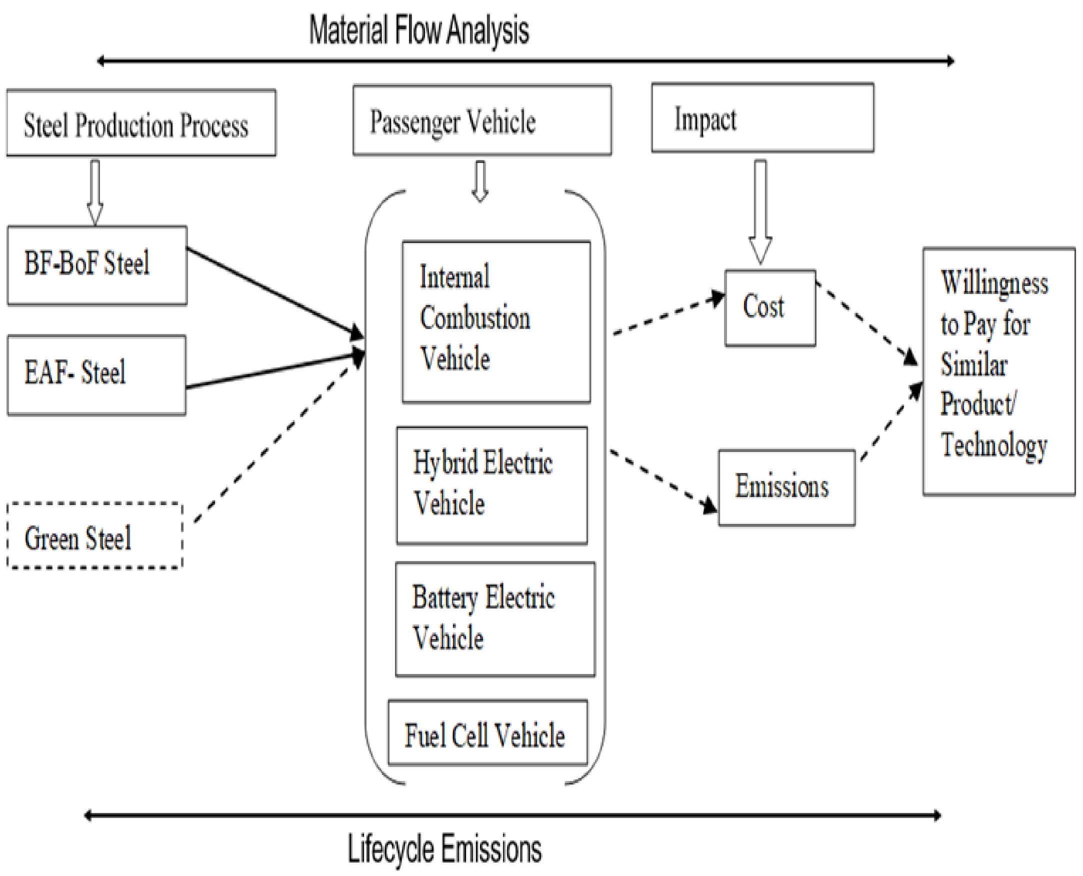
2 Research School of Electrical, Energy and Materials Engineering, ANU

ZERO CARBON ENERGY FOR THE ASIA-PACIFIC

Introduction

- Green steel is important for industrial decarbonisation.
- Current technology costs for producing green steel imply premium over conventional steel.
- Green steel is costly to produce.
- The cost differential for green steel is much higher than the typical carbon prices.
- The car industry has the potential to be an early market for green steel.

Methodology



Bold Lines: Existing routes. Dotted Line: Future routes

Results

- Reduces lifecycle emissions by 0.3-14%
- If green steel costs 26-41% higher than conventional steel
- Increases cost :95-439 USD per car or 0.1-1.6% of typical retail prices.
- Extra cost is within range of consumers' indicative willingness to pay

Acknowledgements

We are grateful for funding under the Australian National University Zero-Carbon Energy for the Asia-Pacific Grand Challenge project

WATCH PRESENTATION ONLINE

Charging Pools of Electric Vehicles

Ning Ruan[1], Lachlan H. Andrew[2], Hai L. Vu[1]

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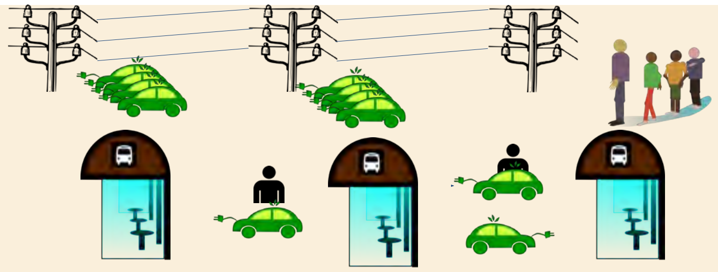
Why charge pools of EVs?

Pools of autonomous electric vehicles may replace public transport.
Electric vehicles, need regular charging.
Electric vehicles can also provide grid support while plugged in.

Need to balance:

1. Getting vehicles to the start of a journey in time for customer.
2. Minimizing "dead-heading" (travel with no passenger).
3. Risk of running out of storage on a journey.
4. Maximizing grid support.



Contributions

1. Consider battery usage/drainage and minim charge level for EV operation.
2. Reduce the computation cost by considering different look-ahead for MPC and different integer constraints.
3. Compare energy used and average delay for customers when choosing different fleet size.
4. Consider location dependent charging rate.

Model

1. **Obj**: min $\sum_t [\, d(t) + \varrho_1 t_{ij}\, w(t) + \varrho_2\, (\, (e(t)-\eta g(t))m(t) + \omega\, g(t)\,)\,]$
(waiting time + rebalancing + cost related to charging)

St. state of vehicle, variable bound constraint, and battery constraints.

State variables:
number of waiting people (d) , vehicle locations (p) , vehicle waiting at stations (u), state of charge (q),

Control variables:
vehicle carrying a passenger (v), vehicle driving empty (w), energy charged (e), energy discharged (g)

2. Battery constraints include the following:
Battery level is sufficient for mobility,
Stationary time is sufficient for charging/ grid support,
Charging is sufficient for mobility + grid support.

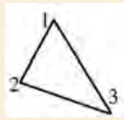
Method

Model Predictive Control (MPC) is a control technique whereby an optimization problem is solved at each time step to yield a sequence of control action up to a fixed horizon, and the first control action is executed.

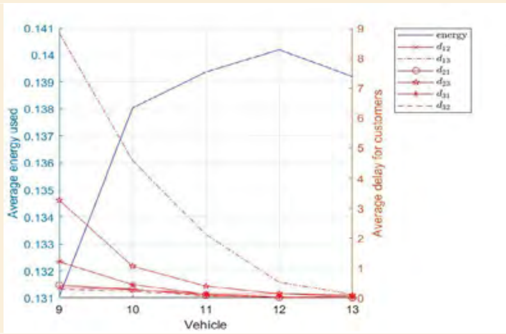
Results and Conclusions

Parameters:
travel time t_{12}=2, t_{23}=3, t_{13}=5, total time T=300, price of electricity m=0.2, charge used per travel time α_d=0.05, charge rate α_c=0.2, V2G rate α_{v2g}=0.1, V2G efficiency η=0.53, cost of cycling battery ω=0.6, ϱ_1=0.01, ϱ_2=0.001.

Network

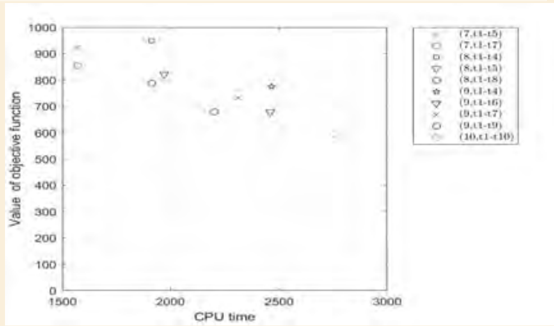


A. There is a tradeoff between delay and energy consumption as we vary the number of vehicles.



A1. In the legend, d_{ij} means that average delay (in time steps) for customers on path (ij), i.e, from station i to station j.

B. Choose smaller horizon time and relax integer variable, we can decrease computation time.



B1. The problem is an integer problem,
B2. We try relaxing some of the ones at future times, to reduce computation,
B3. In the legend, (7, t1--t5) means that we used a horizon of 7, and the first five steps had integer constraints.

Conclusion

Model predictive control provides an adequate method for scheduling charging and motion of a pool of EVs serving as public transport. This study has identified an unexpected non-monotonic dependence of energy consumption on the number of vehicles in the system.

References

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MONASH University Engineering

THE UNIVERSITY OF MELBOURNE

Acknowledgements

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WATCH PRESENTATION ONLINE

Will investment in blue hydrogen result in significant early retirement of SMR with CCS plants?

Reza Fazeli [1], Thomas Longden [2], Fiona J. Beck [1], Matt Stocks [1]

[1] The Australian National University, College of Engineering and Computer Science

[2] The Australian National University, Crawford School of Public Policy

Abstract

Hydrogen can help tackle various critical energy challenges, since it offers ways to decarbonise a range of hard-to-abate sectors.

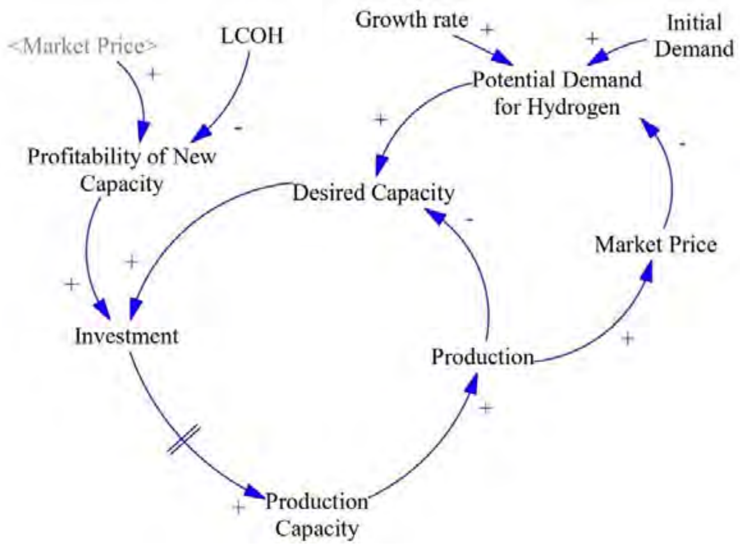
However, developing hydrogen supply chains on the basis of fossil fuels, as many national strategies suggest, may be inconsistent with decarbonisation targets and raise the risk of stranded assets.

Research Question

- Will investment in blue hydrogen in the short-term result in a delay in renewable hydrogen investment? (lock-in) or significant early retirement of SMR and CCS plants (stranded assets)?

Methodology

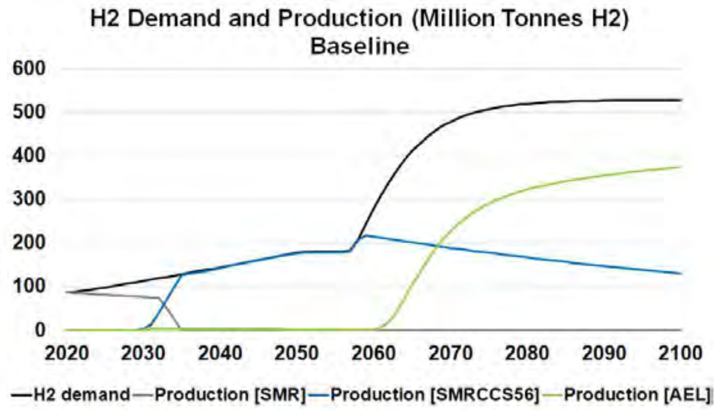
System Dynamics is a powerful methodology and computer simulation modelling technique for understanding complex issues and has been widely used to analyse a range of systems in, e.g. business, ecology, medical and social systems as well as engineering.



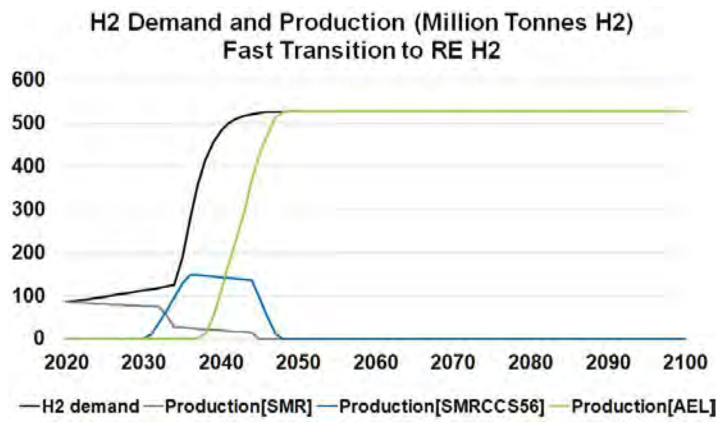
For further details of the modelling: Recognizing the role of uncertainties in the transition to renewable hydrogen (*dx.doi.org/10.13140/RG.2.2.13610.13768*)

Results

Figure illustrates the development of hydrogen supply driven by the projected growth in demand in the baseline case:



In the case of rapid decline in the cost of electricity and the capital cost of electrolysers, the expansion of hydrogen supply industry can be very different:



Conclusion

- In the baseline scenario, the SMR with CCS can contribute significantly to hydrogen production and, can delay the investment in RE hydrogen, mainly because the Desired new Capacity (the difference between demand & supply) will be very small.
- However, in the “Fast Transition to RE H2” scenario, the RE hydrogen can take over the majority of demand and thus force early retirement of SMR with CCS plants at ~18 yrs.
- The sensitivity of findings will be explored using Monte-Carlo analysis.

Acknowledgements

We are grateful for funding under the Australian National University Zero-Carbon Energy for the Asia-Pacific Grand Challenge project.

ANU COLLEGE OF ENGINEERING AND COMPUTER SCIENCE

WATCH PRESENTATION ONLINE

Market Power of Snowy Hydro with Snowy 2.0 in Service

Dr Ross Gawler - Senior Research Fellow   Prof Ariel Liebman
Faculty of Information Technology - Monash University
Prof Frank Jotzo   Dr Mousami Prasad
Crawford School of Public Policy - Australian National University

MONASH ENERGY INSTITUTE

Australian National University

PLEXOS BY ENERGY EXEMPLAR

The Questions

- Will Snowy 2.0 enhance the market power of Snowy Hydro in the National Electricity Market?
- Is it significant? If so what can be done to mitigate it?
  - Split Snowy Hydro into 2 or 3 separate companies?
  - Force Snowy 2.0 to be dispatched on marginal value?

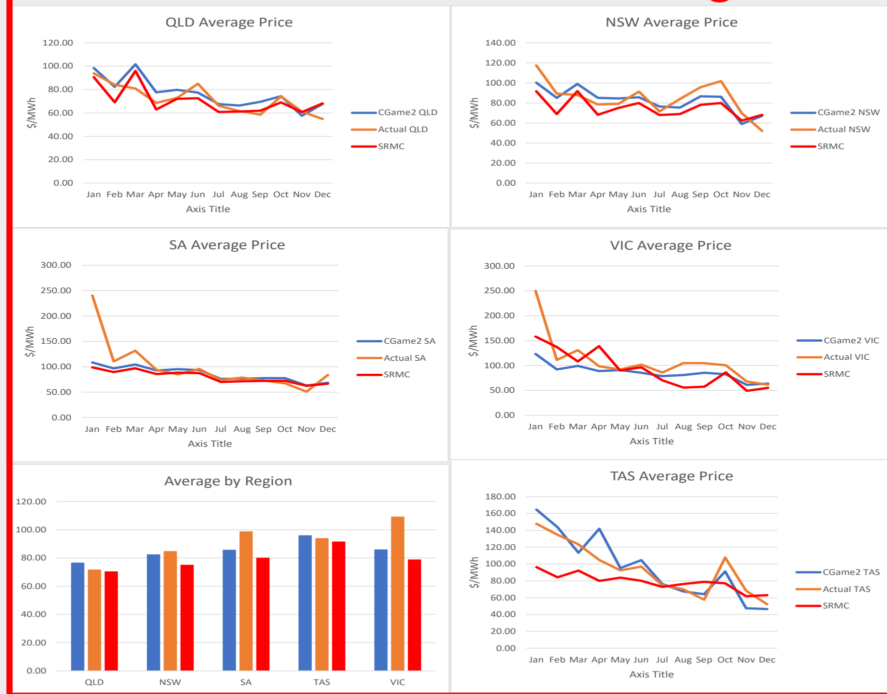
The Method

- NEM Model using PLEXOS based on AEMO's Detailed Long-term Model updated to 2019 data
- Benchmark calendar 2019 actual NEM dispatch and price to estimate **% capacity for strategic bidding** of dominant companies for Nash Cournot volume/price gaming
- Test future gross profit for Snowy Hydro assuming gaming patterns unchanged with Snowy 2.0 for various combinations of mitigation
  - No gaming – Short-run Marginal Cost bidding
  - With gaming – Snowy Hydro as one portfolio
  - With gaming – Snowy 2.0 as a separate portfolio
  - With gaming – Snowy Hydro, Snowy Thermal and Snowy 2.0 as separate entities
  - Central and Step Change Scenarios were tested
  - Gaming with and without Snowy 2.0
- Recommend mitigation strategies if market power is deemed to undermine market efficiency.
- All values in 2019 dollar prices for 2029-2031 and 2039-2041 financial years ending June

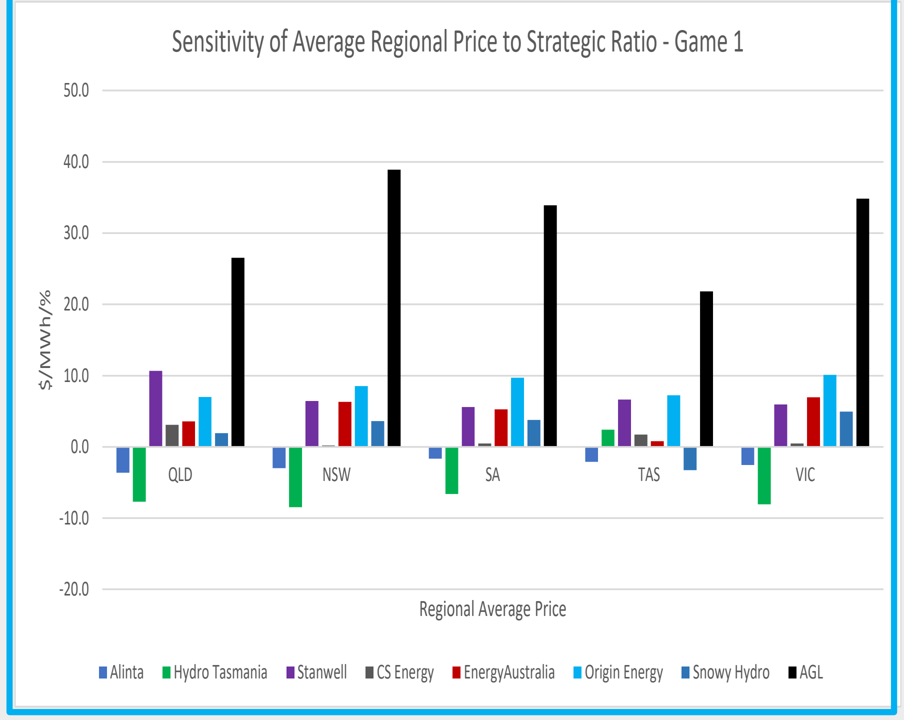
Acknowledgements

The work was co-funded by ANU and Monash University and was based on prior PLEXOS modelling work funded by Ausnet Services.

2019 Price Benchmarking

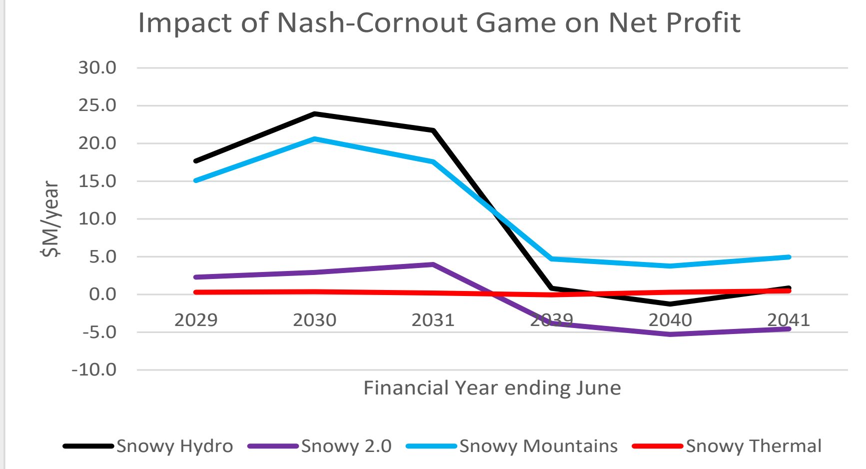


2020 Market Power



Key Observations – Market Power 2019

- AGL is by far the dominant NEM portfolio
- Origin Energy and Energy Australia – moderate influence
- CS Energy and Stanwell have influence outside QLD
- Snowy Hydro not very influential



Key Observations – Snowy Hydro Market Power 2019

- Snowy 2.0 supports extra 680 MW of wind power in NSW but displaces other pumped hydro and battery storage capacity that would otherwise be efficient
- Snowy 2.0 does not generate market benefits commensurate with its costs including transmission – net NEM economic loss of $230 to $370 m pa
- Market power mitigation:
  - Efficient bidding of Snowy 2.0 is more effective than either company disaggregation option in Central Scenario
  - Two-company split is more effective for Step Change Scenario but the impacts are more variable over time, so the best method may change according to growth in storage and renewables.

‘Clean’ hydrogen? – Comparing the emissions and costs of fossil fuel versus renewable electricity based hydrogen

Thomas Longden, Fiona J. Beck, Frank Jotzo, Richard Andrews, Mousami Prasad
Australian National University Zero-Carbon Energy for the Asia-Pacific (ZCEAP) Grand Challenge

Abstract

Hydrogen produced using fossil fuel feedstocks causes greenhouse gas (GHG) emissions, even when carbon capture and storage (CCS) is used. By contrast, hydrogen produced using electrolysis and zero-emissions electricity does not create GHG emissions.
Several countries advocating the use of ‘clean’ hydrogen put both technologies in the same category.

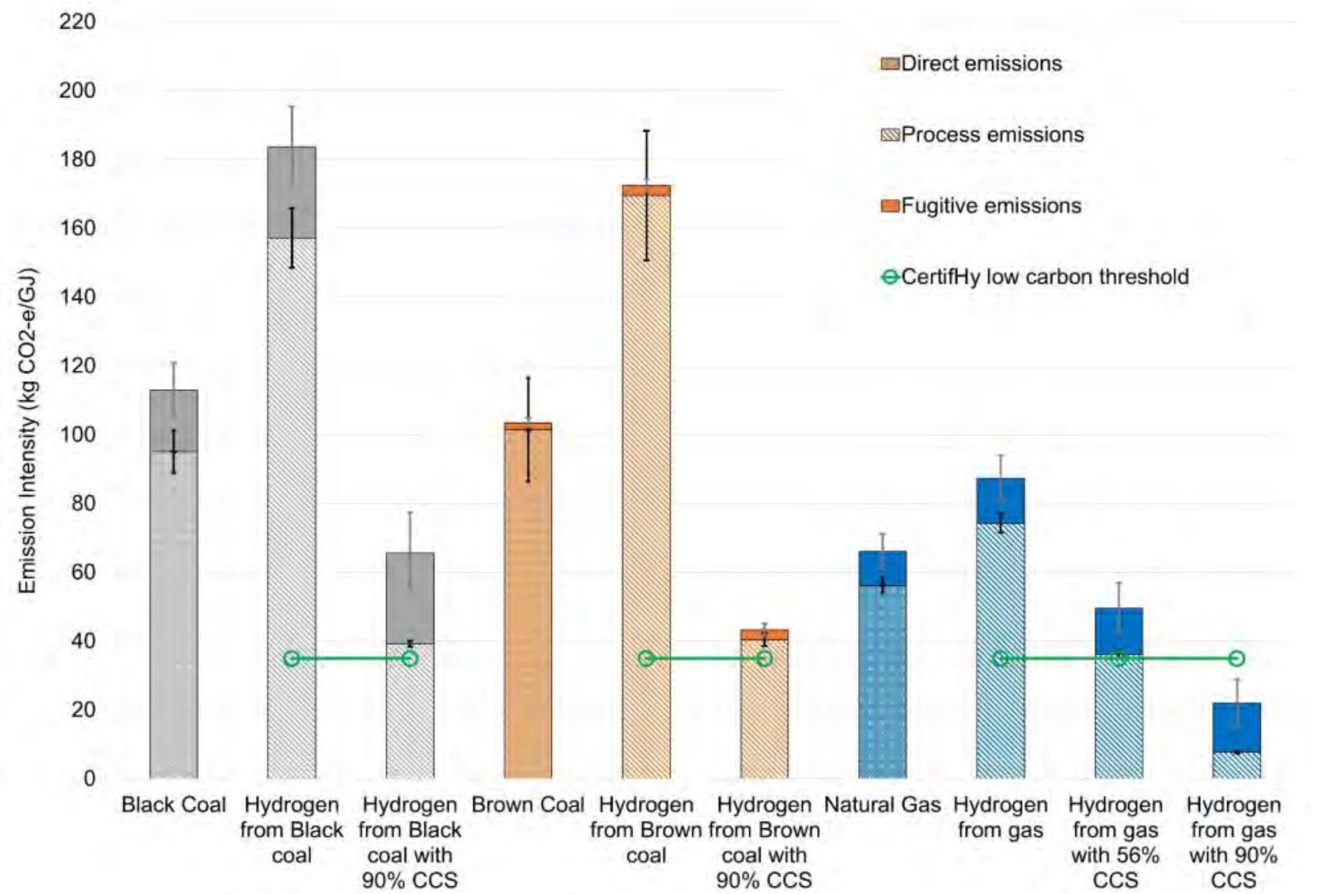


Fig. 1. Total emissions intensity of different fuels, including direct emissions from the combustion of brown/black coal and natural gas, process emissions associated with the production of hydrogen from these fossil fuels, and fugitive emissions from fossil fuel extraction.

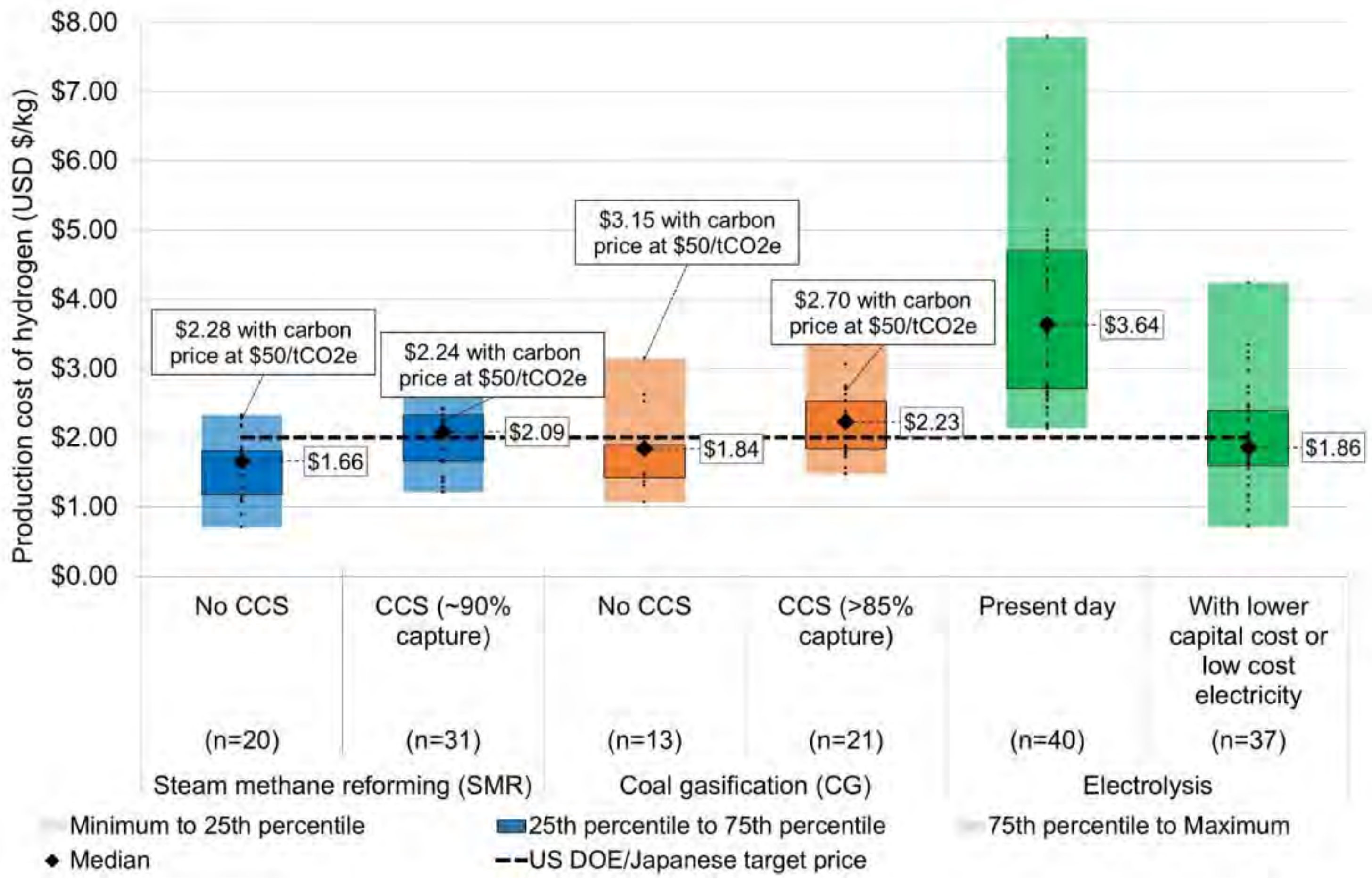


Fig. 2. Estimated production cost of hydrogen for different production technologies, which were collated using 97 estimates from 16 studies (black dots). The median cost estimate for each technology type is given (black diamond). The 25th-75th percentile range is shown as a darker coloured box. The impacts of a carbon price of $50/tCO2e are also given and were computed using the median cost estimate and the total emission intensities shown in Figure 1.

- Emissions from gas or coal based hydrogen systems are substantial even with CCS,
- Electrolysis with renewable energy could become cheaper than using fossil fuels with CCS to produce hydrogen.

WATCH PRESENTATION ONLINE

Optimal Energy Storage Configuration in Indonesia

MONASH University

PhD Student : Ahmad Amiruddin

Supervisor : Dr. Roger Dargaville and Prof Ariel Liebman

Background

4 big Electricity system in Indonesia

- Increasing Demand and Electricfication Ratio in Indonesia
- Emission Reduction Target
- Renewable Energy Target 23% in 2025
- Variable Renewable Energy (VRE) power plants are constrained by the grid's reliability

Literature Review

- The integration of VRE will bring intermittency
- The electricity systems need to be flexible
- Energy storage is one of a flexible choice
- A decline in the price of batteries in the world
- ES grid scale has been applied in many countries but not in Indonesia.
- Studies Shown limited penetration RE in Indonesia

Research Gap

Previous Studies **not considering energy storage** as one of the emerging options like the flexibility tool in Indonesia the power system.

Research Question

What is the **optimal mix of storage technologies, size, location, and deployment** strategy for Indonesia for a range of market conditions?

Methodology

Select the appropriate mix of technologies

↓

Optimize the size and location of technology based on technical and economic

↓

Build a framework to deploy the technology

Energy modelling PLEXOS BY ENERGY EXEMPLAR

Conclusion

- The research would bring impact to the optimal configuration of energy storage in Indonesia
- Could boost the penetration of renewable energy in Indonesia
- Provides a recommendation to the decision maker
- Avoid the negative impact on the environment

WATCH PRESENTATION ONLINE

An Electrical Model-Free Optimal Power Flow for PV-Rich Low Voltage Distribution Networks

Angela Simonovska, Vincenzo Bassi, Arthur Gonçalves Givisiez, Luis (Nando) Ochoa, Tansu Alpcan

1) Introduction

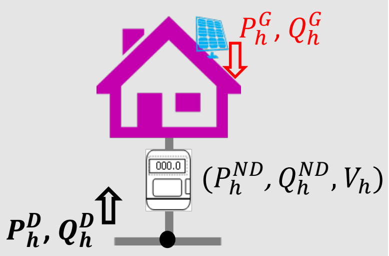
- The rapid uptake of solar PV in low-voltage (LV) networks is creating **voltage rise issues**.
- One potential **solution** is the **DER orchestration**, such as the **active management of PV systems**, curtailing generation as needed.
- Conventional techniques, such as the AC Optimal Power Flow (OPF) require detailed three-phase LV network **models** that are **not** always **available**.

2) Methodology

- This work proposes the **optimal calculation of PV settings** using, instead of power flow equations, a neural network trained to capture the nonlinear relationships among historical smart meter data (P, Q, V). In other words, an **electrical model-free OPF**.

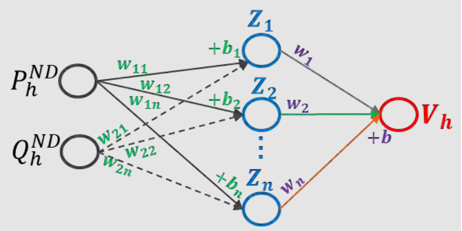
Smart Meter Data

Household $h \in H$



$$P_h^{ND} = P_h^D - P_h^G, \forall h \in H$$
$$Q_h^{ND} = Q_h^D - Q_h^G, \forall h \in H$$

Neural Network



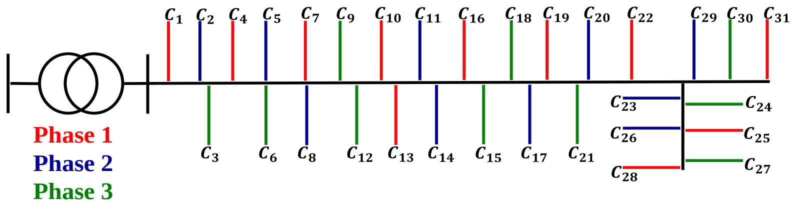
$$Z_n = \varphi_1\left(\sum_{h\in H, n\in N} P_h^{ND}|Q_h^{ND} \times w_{hn} + b_n\right)$$
$$V_h = \varphi_2\left(\sum_{n\in N} Z_n \times w_n + b\right)$$

Electrical Model-Free OPF

$$Max \sum_{h\in G\in H} P_h^G$$
$$0 \le P_h^G \le P_h^{avail}, \forall h \in G \in H$$
$$V_h = \varphi_2\left(\sum_{n\in N} Z_n \times w_n + b\right), \forall h \in H$$
$$Z_n = \varphi_1\left(\sum_{h\in H, n\in N} P_h^{ND}|Q_h^{ND} \times w_{hn} + b_n\right)$$
$$(P_h^{ND})^2 + (Q_h^{ND})^2 \le (S_h)^2, \forall h \in H$$
$$V_h^- \le V_h \le V_h^+, \forall h \in H$$

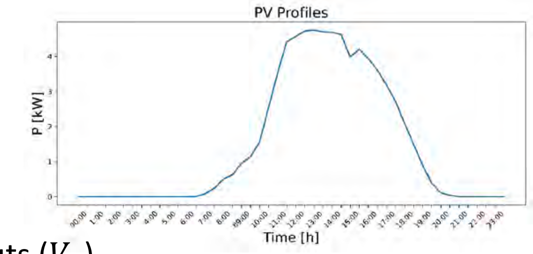
3) Case Study

- **LV feeder**
  - 22/0.433 (kV/kV) 500kVA Transformer
  - Voltage Bases 22.0kV, 400V
  - 31 single phase customers (C1 to C31)



- **Data Sets:**
  - Training data: 60% PV Penetration (3 weeks in Dec, **no** voltage issues)
  - Testing Data 1: 60% PV Penetration (3 weeks in Jan, **no** voltage issues)
  - **Testing Data 2**: **70%** PV Penetration (3 weeks in Jan, **voltage issues**)

- PV systems: **5kW** per customer
  - Installed Capacity: 22 customers $x\ 5kVA = 110kVA$
  - Selected day: Summer weekday in January
  - Chosen time interval: $10{:}00h\ - 18{:}00h$



- **Neural Networks' characteristics**
  - 62 inputs (P_h^{ND} and Q_h^{ND} of all 31 customers), 31 outputs (V_h)
  - 1 **hidden** layer – $\boldsymbol{Tanh}$ activation function, 248 neurons
  - Output layer – **Linear** activation function

4) Results

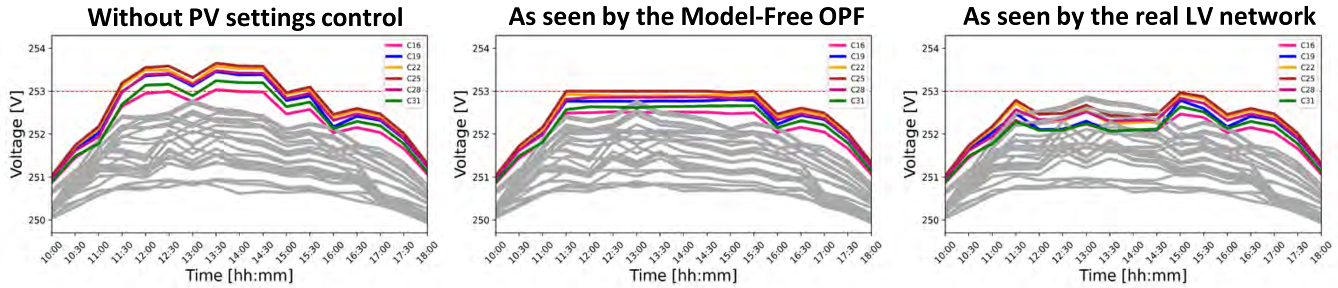
NN's performance	MSE (V^2)	Av. Deviation (V)	Max. Deviation (V)
Training Data	0.00012	0.00671	0.15834
Testing Data 1	0.00041	0.01192	0.39344

NN achieves a **very accurate** performance!

- **Calculated PV settings** (Comparison between Model-Free OPF & AC OPF)

Model-Free OPF underestimates the PV generation (curtails more) than the AC OPF (up to 4.56%)

- **Voltage profiles** of the selected day with 70% PV Penetration



Voltage violation **solved;** The approach underestimates the voltages → lower curtailment.

5) Conclusions

- The proposed electrical model-free OPF shows **promising results** and can be used by distribution companies to perform DER orchestration, **without the need** for LV network models.

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WATCH PRESENTATION ONLINE

Towards Real-Time DER Orchestration in Australian HV-LV Networks via Distributed Optimisation

Arthur Gonçalves Givisiez, Michael Z. Liu, Luis(Nando) Ochoa

1. Introduction

- Increasing penetration of distributed energy resources (**DER**) are causing **voltage and congestion problems** on distribution networks.
- To **efficiently orchestrate DER**, a **real-time approach** is **preferred**.
- This can be achieved by a **three-phase AC optimal power flow (3ph AC OPF)**, which is appropriate for distribution networks. However, **it may not be scalable** (i.e., fast enough) **for real-time orchestration of DER** on its conventional formulation as a single problem (HV-LV networks) and nonconvex equations.

2. Methodology

- **To improve scalability**, two main techniques are proposed:
  1) Reformulate the **nonconvex 3ph AC OPF** formulation **into** a **linear 3ph AC OPF** (LOPF);
  2) Split the **single problem into smaller ones** and **solve via** the **distributed algorithm** alternating direction method of multipliers (**ADMM**).

A Reformulate the nonconvex 3ph AC OPF problem into a linear 3ph AC OPF

B Split the single HV-LV problem into HV network and LV networks problems

C Create split variables and add consensus constraints to them

D Write the augmented Lagrangian L_ρ

E Solve the split problems via the ADMM algorithm

F Validate and compare results: ADMM-based LOPF vs Conventional 3ph AC OPF

E ADMM Algorithm

1) $x^{k+1} := \underset{x}{\operatorname{argmin}}\left(L_\rho(x, z^k, y^k)\right)$

2) $z^{k+1} := \underset{z}{\operatorname{argmin}}\left(L_\rho(x^{k+1}, z, y^k)\right)$

3) Check convergence criteria ☆

4) $y^{k+1} := y^k + \rho * (x^{k+1} - z^{k+1})$

Residues

$$r^{k+1} = x^{k+1} - z^{k+1}$$
$$s^{k+1} = -\rho * (z^{k+1} - z^k)$$

☆ Convergence

$$\left\|r^{k+1}\right\|_2 \le \varepsilon^{primal}$$
$$\left\|s^{k+1}\right\|_2 \le \varepsilon^{dual}$$

3. Case Study

- **Real Australian HV feeder** with 22kV/0.433kV distribution transformers and **realistically modelled LV networks** (400V nominal).
- Total of **4,603 single-phase** connected **customers**, all with **5kW** PV systems (**100% PV penetration**).
- Simulation for a **summer weekday** for 24h with **control cycles every** of **5 minutes**.

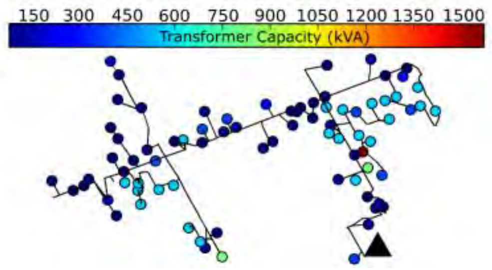

Fig. 1. Real Australian HV feeder (22kV).

4. Results

- **Total generation mismatch** and **maximum voltage mismatch** between conventional and distributed approaches are **below 1%**.
  - Results for **conventional and distributed approaches match**.
- The **ADMM-based LOPF** is **faster than** the **conventional 3ph AC OPF** in all control cycles (Fig. 2).
  - In **average** it is **186 times faster**.
- **Before DER orchestration** (Fig. 3, left), **voltages** are **above limits**, achieving up to 1.2 p.u. (276V).
- **After DER orchestration** (Fig. 3, right), **all voltages** are **within limits** (0.94 p.u. and 1.1 p.u.).

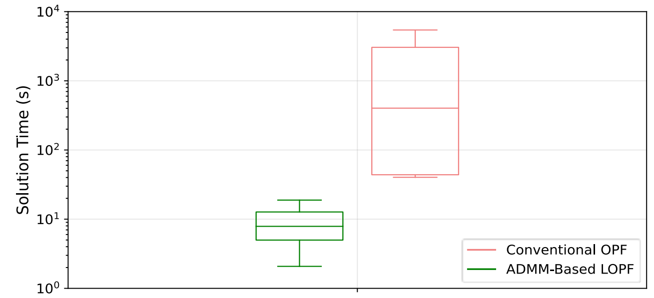

Fig. 2. Solution time for conventional and distributed approaches.

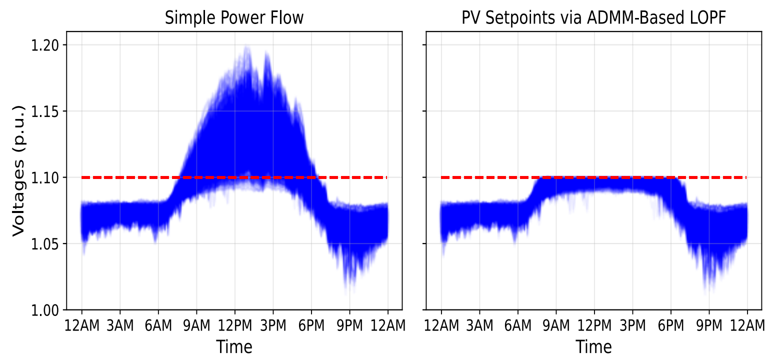

Fig. 3. Voltages at residential customers with and without DER orchestration.

5. Conclusions

- The proposed **ADMM-based LOPF** shows **significant scalability improvement**.
- The **distributed optimisation** has **adequate accuracy** and kept **voltages within limits**.
- **Real-time DER orchestration** enables an **efficient use** of **existing infrastructure, allowing more DER** to be **connected to** the **distribution network**.

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Network-Aware Value Stacking for Electric Vehicles in Transactive Energy System

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MONASH University

1. Introduction

Due to the reduced cost of renewable energy systems and the advancement of battery technology, electric vehicles (EVs) have become more popular worldwide. The high uptake of EVs poses challenges to the network but also brings opportunities.

- Uncoordinated EV charging may cause peak load on distribution networks, resulting in transformer overloading.
- EVs can enable bidirectional power flows between the grid and EVs, which serve as storage to provide services to the grid and create benefits to EVs themselves.

2. Motivation

Trend: Recent studies suggested the optimal scheduling of EV charging and discharging to interact with smart homes, the local energy market, and the grid to maximize the value of EVs.
Problem: The values of V2G and energy trading among EVs can be restricted by local network constraints, and the results are not convincing if such constraints are not considered.
Objective: We are motivated to develop a value-stacking optimization problem to maximize the value of EVs while maintaining the local grid voltage within limits.

Figure 1. Value stacking model of EVs.

3. System Model

In the system model, we consider a system with multiple prosumers having EVs in smart homes connected through a local grid.

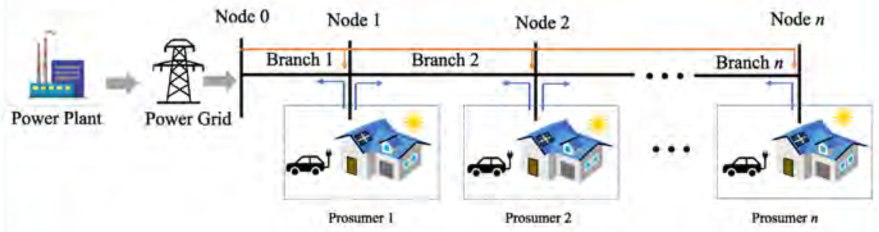


Figure 2. Coordination of Prosumers in a Local Network

Figure 2 illustrates a radial power network, where each node has only one parent node and connects to one prosumer. The orange bold line represents the power from the main grid, and the blue line represents the power flow of V2G and energy trading in the local network.

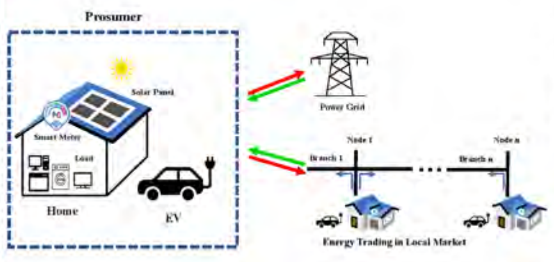


Figure 3. The operation of the proposed value stacking model.

The proposed value stacking model is shown **Figure 3**. We consider multiple value, including V2H, V2G, and energy trading in the local market. The prosumer optimizes its EV discharging to leverage the multiple value streams.

4. Simulation Results and Performance Evaluation

- We consider 10 prosumers in a local grid, and every one of them own EVs. We use real market data in NEM and first evaluate TOU and TPT separately. To evaluate the contribution of each value stream, we consider V2G, V2H, and EV energy trading in the local grid alone, respectively.
- Moreover, We evaluate the marginal contribution of each value stream in different markets, namely NEM, ISO-NE, and NY-ISO. The marginal contribution is calculated as the relative difference of cost reductions between value stacking and baseline problems excluding one value stream.

Figure 4. The left is the comparison of prosumers' total cost reduction under two tariffs, e.g., TOU and TPT in four scenarios with V2G, energy trading, V2H, and full value stacking. The right is the comparison of marginal contribution of V2G, energy trading, and V2H in the value stacking problem for Australia's NEM, ISO-NE, and NY-ISO in the US.

5. Conclusion

In conclusion, we proposed an EV value-stacking optimization problem considering local network constraints to maximize the value of EVs.

In addition, we used real data from different markets and evaluated the two prosumer tariffs in NEM in Australia.

Moreover, the marginal contributions of three value streams in NEM, ISO-NE, and NY-ISO were also studied. The results are as follows:

1. The value-stacking model achieves better performance when TOU is used.
2. V2H contribute the most to cost reduction in NEM and ISO-NE. In contrast, energy trading contribute most to cost reduction in NY-ISO.

6. References

[1] Donovan Aguilar-Dominguez, Jude Ejeh, Alan DF Dunbar, and Solomon F Brown. Machine learning approach for electric vehicle availability forecast to provide vehicle-to-home services. *Energy Reports*, 7:71–80, 2021.

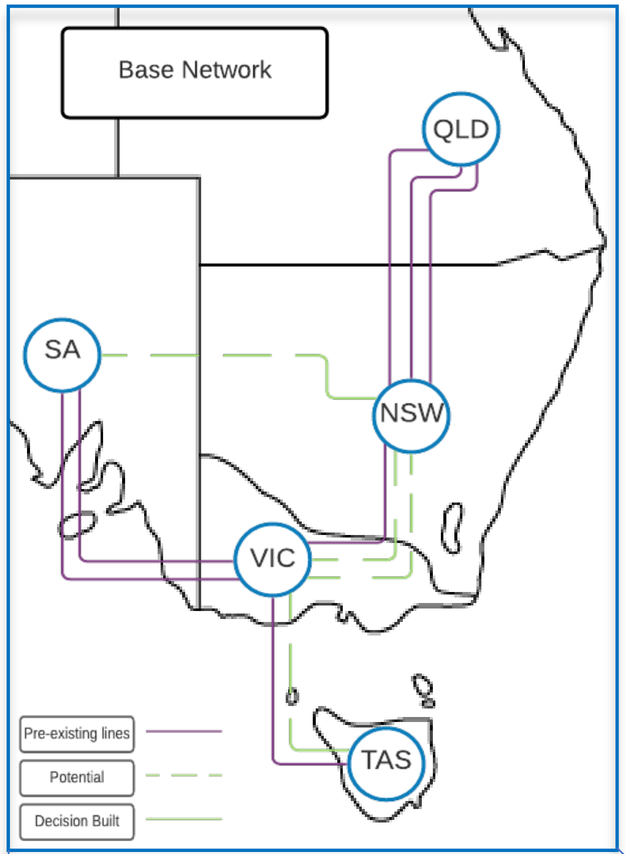
[2] Qing Yang and Hao Wang. Distributed energy trading management for renewable prosumers with hvac and energy storage. *Energy Reports*, 7:2512–2525, 2021.

[3] Qing Yang and Hao Wang. Cooperative energy management of hvac via transactive energy. In *2020 IEEE 16th International Conference on Control & Automation (ICCA)*, pages 1271–1277. IEEE, 2020.

WATCH PRESENTATION ONLINE

Julia integrated Generation, Storage, Transmission Expansion Planning, (JiGSTEP*) applied to the Australian National Energy Market (NEM).

*This work is an implementation based on the core methodology/code developed by Dr. Semini Wijekoon (2020) DOI: 10.26180/5eddb6216e35f



Problem description

Efficiently planning an electricity generation/transmission network capable of meeting predicted demand for the future.

Data from the Australian Energy Market Operator's (AEMO) 2020 Integrated System Plan ISP).

Justification

Sustainable, ethical, and economically efficient energy production is one of modern society's most pressing issues.

To plan a transmission and generation network capable of meeting uncertain demand in the future we must be able to solve the expansion planning problem efficiently and intelligently.

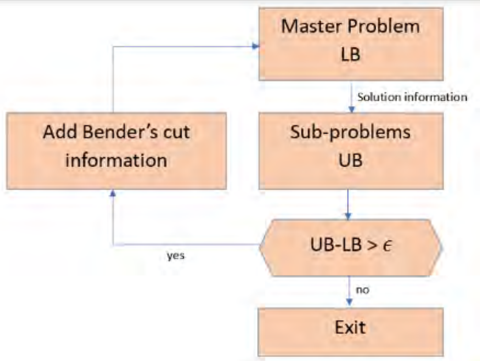
Key

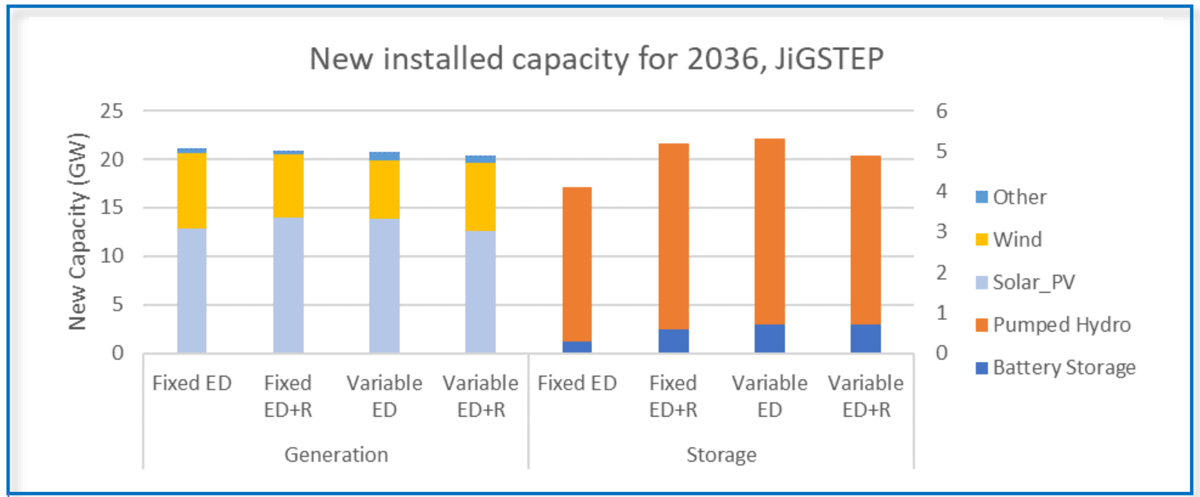
ED – Economic Dispatch
ED+R – ED with Ramping constraints
LP – Linear Program
NEM – National Energy Market
Fixed vs Variable – Transmission forced to be built vs as a decision variable for the model to choose.

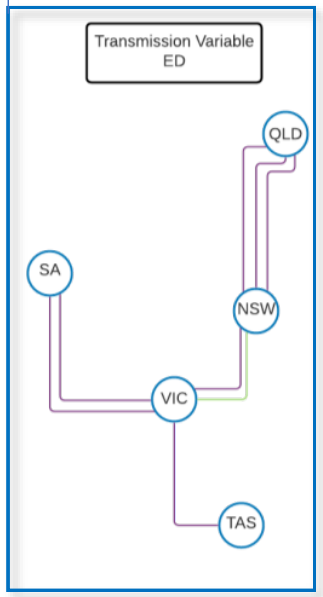
Methodology

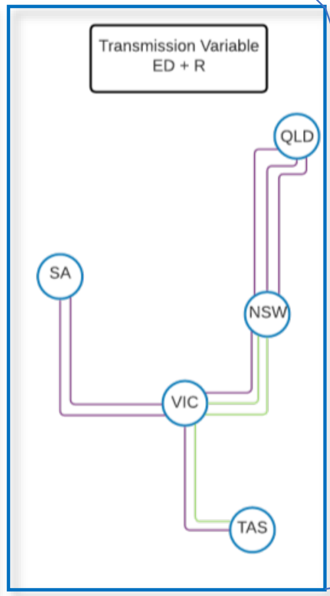
The GSTEP problem is formulated as a Mixed-Integer Linear Program with decision variables for building generators, storage, and transmission lines. Constraints form around nodal balance and generation/storage limits.

To solve this LP a Bender's Decomposition method is used: the main problem uses binary investment decision variables, and the sub problem deals with generation and nodal balance.









Transmission variant 'Line' decisions

The results from solving both fixed and variable transmission scenarios for demand 2036 leads to these two transmission networks.

We see that more transmission is required when incorporating ramping constraints to the economic dispatch model (ED+R).

Transmission variant generation and storage decisions

We see when planning across the NEM there is consistency between the different transmission variant scenarios. All scenarios require additional ~25GW of capacity to be built to meet demand in the target year (2036).

We see a substantial investment across all scenarios into Wind, Photovoltaic Solar for generation and Pumped Hydro for storage.

Future work

Complete the same tests for 2050 and analyse the impact of retirements of current generators as well as build limits on unserved demand.

Consider how resolution of the sub problem affects the solution mix and coupled network components.

Design intelligent method of picking sub problem resolution to minimise solver time.

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Supervisors: Andreas Ernst, Ariel Liebman, Pierre Le Bodic (Monash University), Simon Dunstall (CSIRO)

MONASH University

WATCH PRESENTATION ONLINE

Opportunities and costs of planning and operating a power system with high shares of Variable Renewable Energies (VRE)

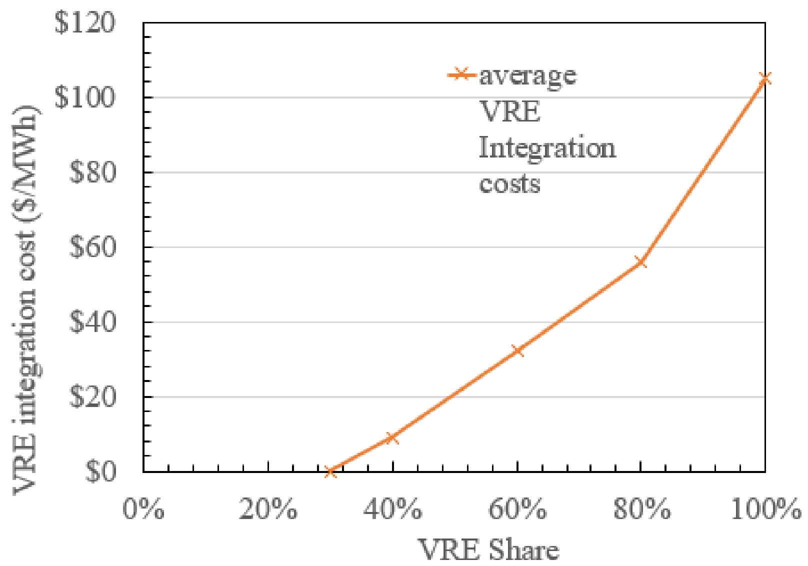
Gabriel Rioseco | PhD Energy Systems © | University of Queensland

CONTEXT

- Variable renewables energy (VRE), as solar PV and Wind are key for decarbonising electricity systems.
- Higher shares of VRE can causes additional challenges and costs at the whole System level → **VRE integration costs**

AIM OF THIS STUDY: Capture and quantify VRE integration costs for the NEM, how they vary with higher VRE shares, and to define the least-cost system configuration to minimize them.
METHOD: **Novel capacity-planning model with an embedded short-term unit-commitment formulation**. Investment, unit commitment, flexbility and dispatch decisions are captured for a whole year (2040), with hourly time steps.

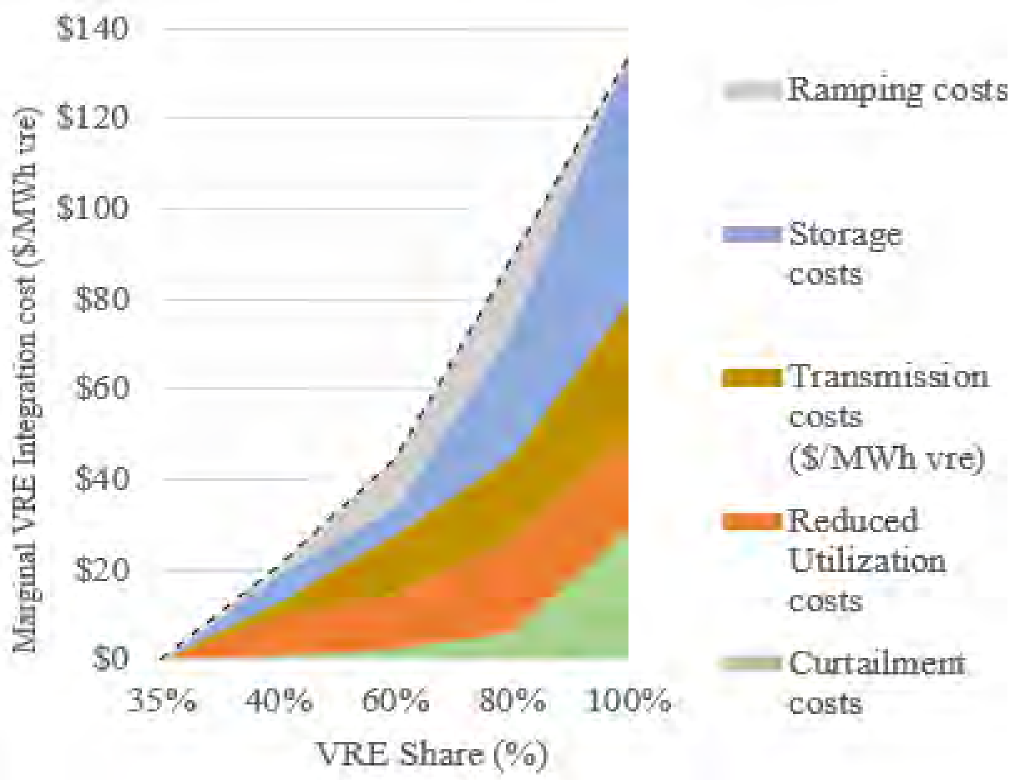
RESULTS AND CONCLUSIONS



Optimum VRE share: 35%

Above this level, VRE integration cost increase:

- **$12/MWh at 40% VRE share, reaching..**
- **$105/MWh at 100% VRE share.**



Main causes of VRE integration costs:

- Reduced utilization of dispatchable plants in the system.
- VRE curtailment costs, but relevant in high VRE scenarios only.
- Storage costs: A 55 % reduction in batteries CAPEX can reduce significantly these costs.
- Ramping and cycling of thermal plant not highly relevant (Technical constraints in the model prevents excessive ramping)

An holistic approach should be considered when analyzing systems with high VRE penetration. This whole system analysis permits to identify key research areas for mitigating the challenges of VRE integration

WATCH PRESENTATION ONLINE

Multi-Agent Reinforcement Learning for Electric Vehicle Coordination

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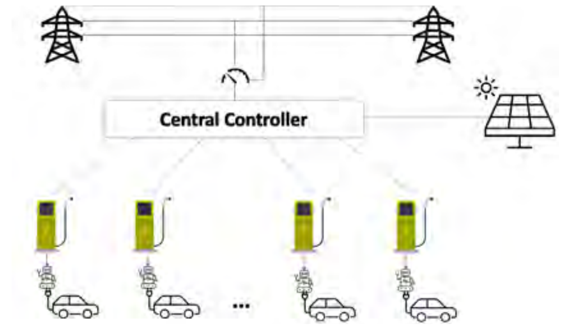
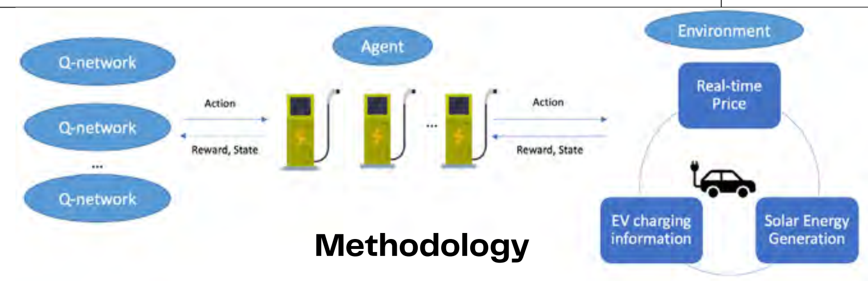
Introduction and Motivation

- A large number of electric vehicles have brought challenges to the management and scheduling of charging stations.
- There are two objectives of the project which are minimize charging cost and maximize user satisfaction.
- Uncertainties are a challenge of the problem that include EV arrival time, solar energy generation and real-tme price.
- This research is to design a multi-agent algorithm to schedule EV charging under uncertainty.



EV Charging Station System Overview

- Each EV will connect to a smart charging port, which can monitor the charging status and execute the charging decision.
- We used Vehicle-to-grid(V2G) technology for flexible control and reduced the cost by discharging during high price periods.
- We also consider battery degradation cost during discharge.
- The energy supply of the charge station includes the solar energy and grid.
- The central controller can coordinate all resources and make decisions based on our algorithm.



Methodology

- Each charging port is an agent and the multi-agent Q-network is used to maximize the quality of decision.
- Agents can receive the state and reward from the environment(Charging data).
- Then, Q-networks can update their parameters by Temporal difference (TD) learning.
- After the training process, the Q-network has good performance for action evaluation, which can tell agents which action(charging rate) is better under current situations.

Experimental Result

- Satisfaction rate is to evaluate the EV user satisfaction rate of the charging service.
- we assume that the user is satisfied when more than 80% of the charging task is completed.
- The experiment results show that our developed MARL algorithm can reduce the total cost by up to 20% and achieve the charging satisfaction rate of 94%.
- Our algorithm can improve the solar energy usage by up to 23%.

	1st month	2nd month	3rd month
Satisfaction rate	94.81%	94.01%	93.6%
Cost Reduction	12.8%	17.6%	15.2%
Solar energy usage growth rate	19%	22%	23%

Limitations:
- Centralized algorithm led to high communication cost which will cause the delay of the decision.
- The performance of multi-objective optimization is low.

Future work:
- A decentralized algorithm is necessary.
- The model should integrate the ability of multi-objective optimization.

Conclusion

- This research proposed a multi-agent reinforcement learning to solve the problem of EV charging scheduling under uncertainty.
- We used a deep Q network to approximate an evaluator which can evaluate the quality of each action and select the best charging rate for the decision.
- The experimental result showed that the algorithm is effective to reduce the monthly charging cost and satisfy charging demand of users.
- The future work should focus on decentralized execution and multi-objective optimization.

Assessing the EV Hosting Capacity of Australian Urban and Rural MV-LV Networks

Jing Zhu, William Nacmanson, Luis(Nando) Ochoa

1. Introduction

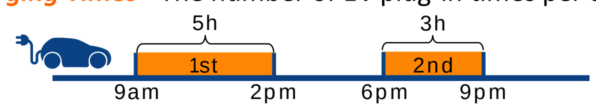
- Many countries have seen a growing uptake of **electric vehicles** (EVs) which is expected to surge over the next two decades.
- Since most EV charging might take place at home, the additional demand can lead to **technical impacts** on the very infrastructure EV chargers are connected to: **the distribution network**.
- This work proposes a comprehensive **EV modelling process** and an **EV hosting capacity assessment** during the peak demand day.

2. EV Modelling

Key modelling parameters:

Charging Start Time and Duration - The timeframe from charging beginning to end.

Daily Charging Times - The number of EV plug-in times per day.



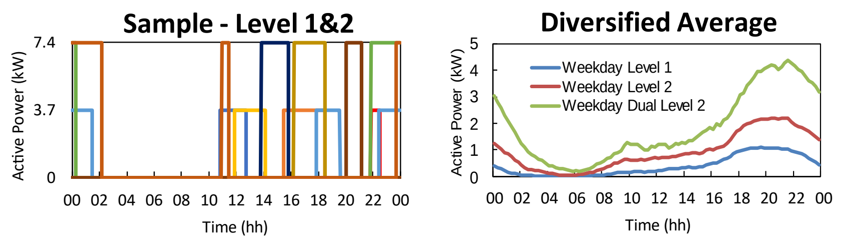
Daily Plug-in Factor - The percentages of EVs charged for a certain day.

EV Charger Sizes - Decide the actual demand. In Australia, there are normally two types of EV chargers: Level 1 and Level 2. The estimated market share is 20% and 80% in 2050, respectively.

Power Factor - The ratio of P to S drawn by EV chargers due to an AC/DC converter embedded, which can range from 0.98 to 1.0.

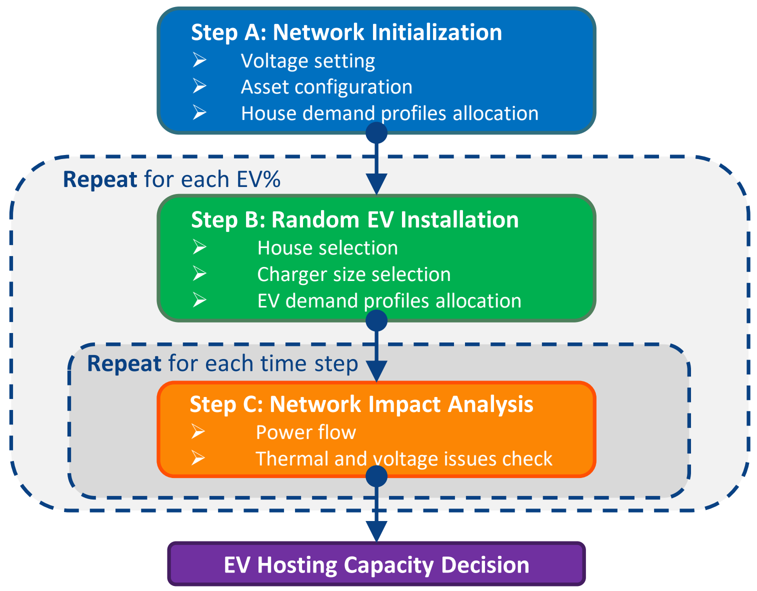
EV demand profiles:

Based on data analysis on **30,000+** unmanaged EV charging events, here are weekday EV demand profiles used in the study.



3. EV Hosting Capacity Assessment

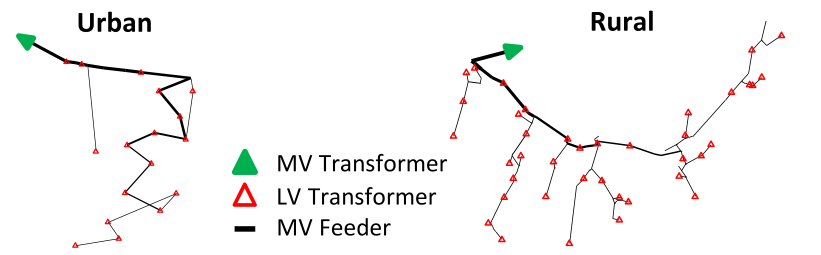
EV hosting capacity -The largest EV penetration that does not have **asset congestion** or **voltage issues**.



4. Case Study: Urban and Rural Networks

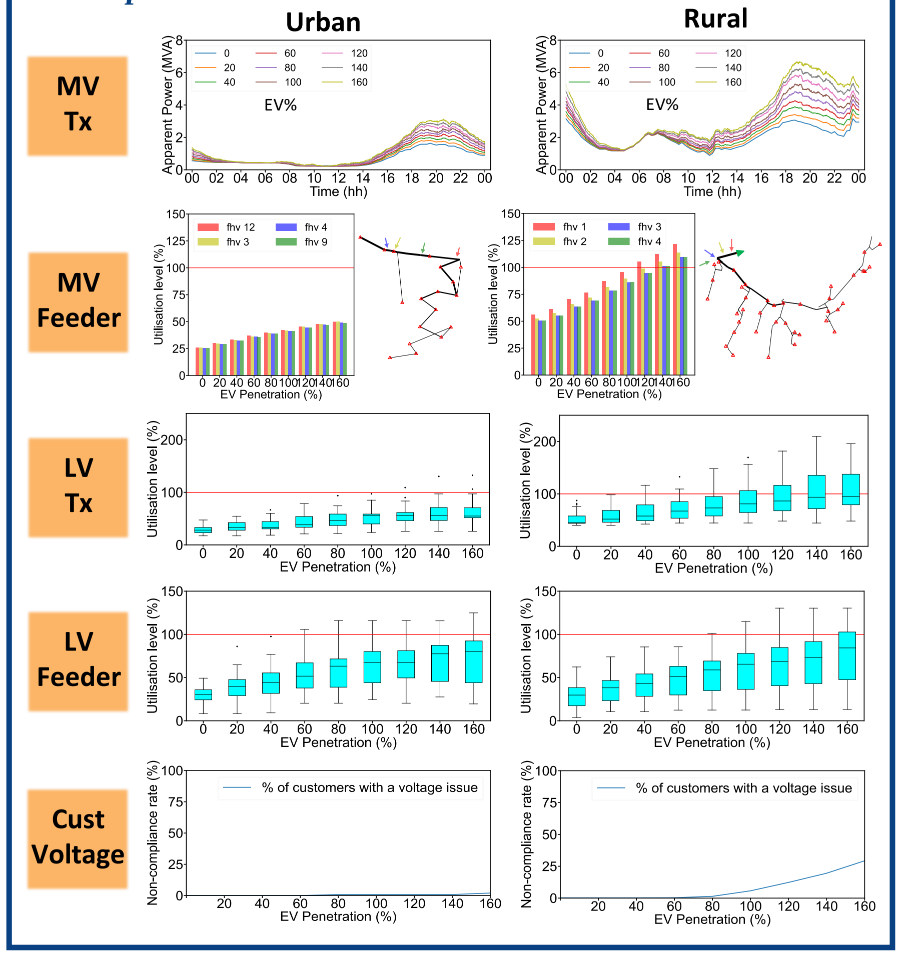
Network Technical Information

Network Name	Voltage Levels	No. of Cust	No. of LV Tx	MV Feeder Length	PV Penetration and Size
Preston (urban)	33/11/0.4 kV	598	17	6km	30% (Avg 5.8kW)
Hazelbrook (rural)	66/11/0.4 kV	1362	39	20km	24% (Avg 3.8kW)



5. Results

EV Impacts on Australian MV-LV networks



6. Conclusions

- **Asset congestion** is the main limiting factor for both urban and rural networks considered in this study.
- **Voltage issues** in rural feeders can be quite significant despite no or limited voltage issues seen in urban feeders. Furthermore, mitigation of voltage issues due to solar PV can exacerbate voltage drop from EVs.
- The EV hosting capacity of the urban and rural networks is assessed to be **40% and 20%**, respectively.

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EV Integration
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Distribution network congestion and voltage management with transactive aggregated EVs

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Department of Electrical and Computer Systems Engineering, Faculty of Engineering, Monash University

Background and Motivation

- Electric vehicles (EVs) with G2V and V2G capabilities provides opportunities and challenges in power networks.
- A coordinated EV charging/discharging schedule is required in an LV PDN with high EV penetration.
- The transactive energy (TE) concept has been applied in networks with high penetration of DERs, such as EVs.
- The TE concept provides a jointly economic and control mechanism for energy trading in the market among independent agents.

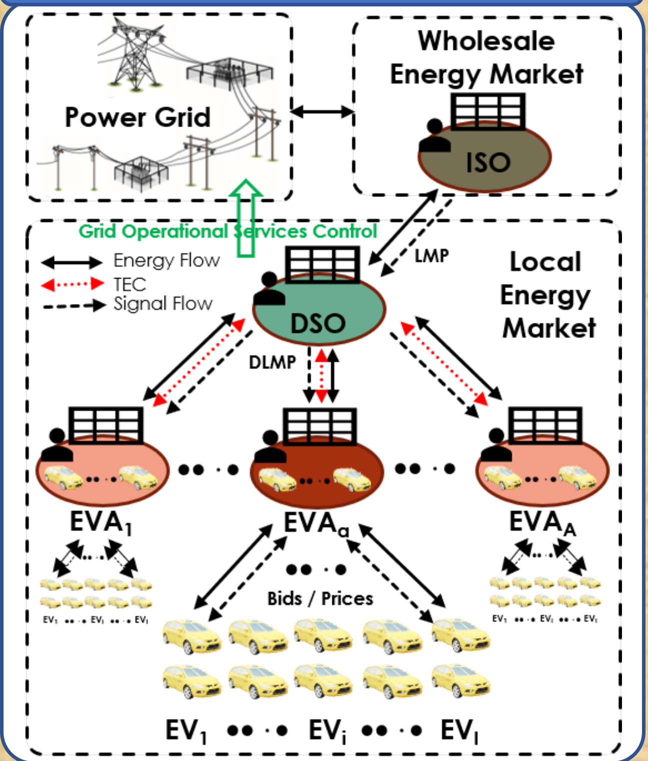
Problem Statements

- Uncoordinated EV charging/discharging can reduce EV penetration or charging failure.
- It can produce network operational problems such as **line congestion** and **voltage violation**.
- The conventional coordination control may not provide robust solution for EV integration management.

Objective

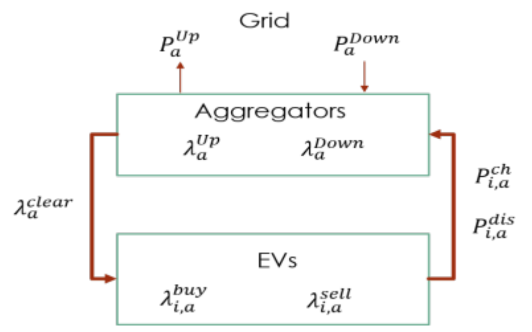
✓ To devise a new aggregated EV coordination technique with TE concept managing the network operational services.

The Proposed System Architecture

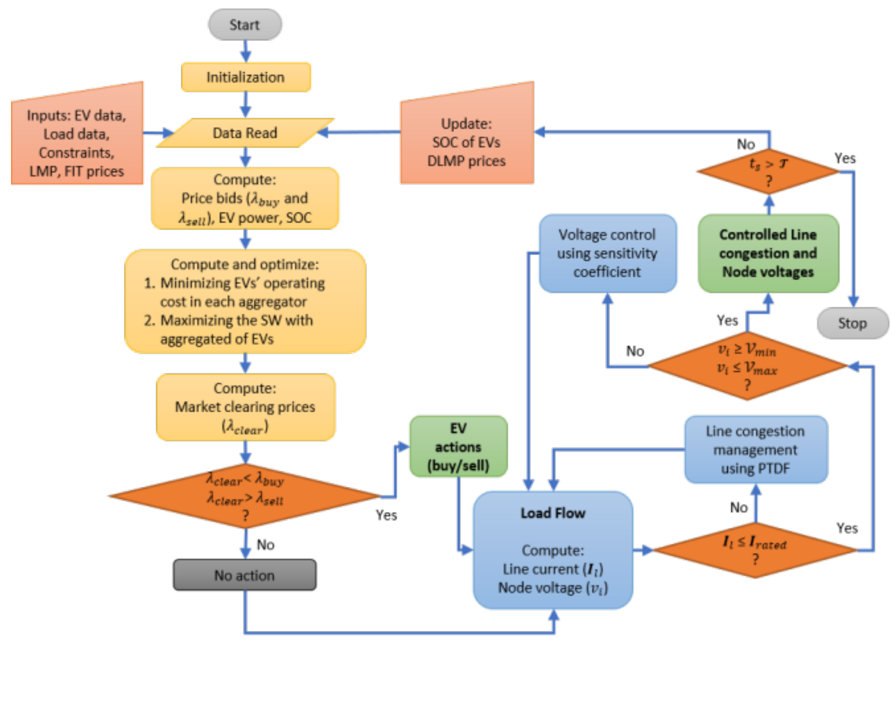


Market Clearing Mechanism

- Aggregator coordinates EVs for managing their participations in the energy market.
- Aggregator optimises the EVs' charge/discharge requirements by minimizing the operating cost of EVs.
- Aggregators communicate to the DSO with their aggregated amount of EVs' charge/discharge requirements for generating market clearing prices by maximizing the SW.



The proposed Method- Algorithm Flow



Control Models

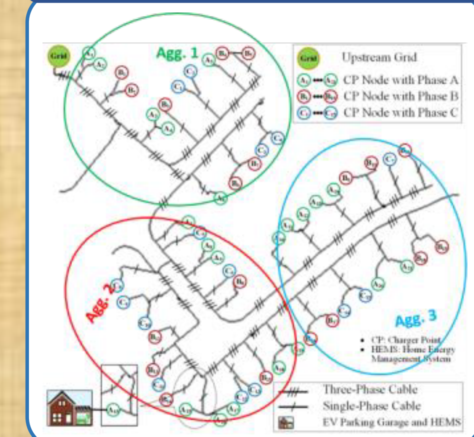
Node voltage control

$$\mathcal{P}_i^{EV} = \mathcal{P}_i^{EV} \mp n\alpha \times \mathcal{P}_i^{EV}$$

Line congestion management

$$\mathcal{P}_i^{EV} = \mathcal{P}_i^{EV} \mp \mathrm{PTDF}_{l,i} \times \Delta\mathcal{P}_l$$

Test Network



EV Model and SOC update

$$SOC^{cur}_{i,a}(t+\Delta\mathcal{T}) = SOC^{cur}_{i,a}(t) + \frac{\eta^{ch}\mathcal{P}^{ch}_{i,a}(t)\Delta\mathcal{T}}{\mathcal{E}_{max}} - \frac{\mathcal{P}^{dis}_{i,a}(t)\Delta\mathcal{T}}{\eta^{dis}\mathcal{E}_{max}}$$

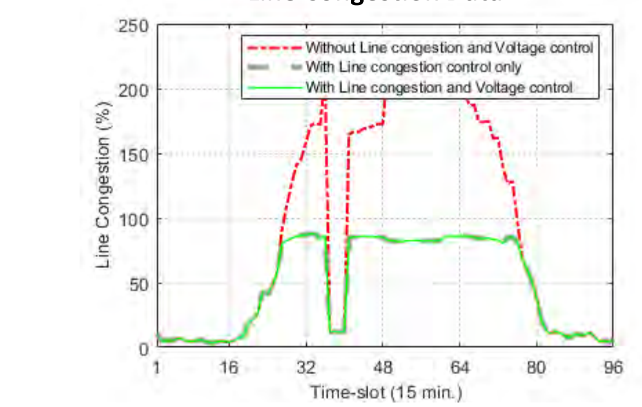
SOC Update | Current SOC | SOC for Charging | SOC for Discharging

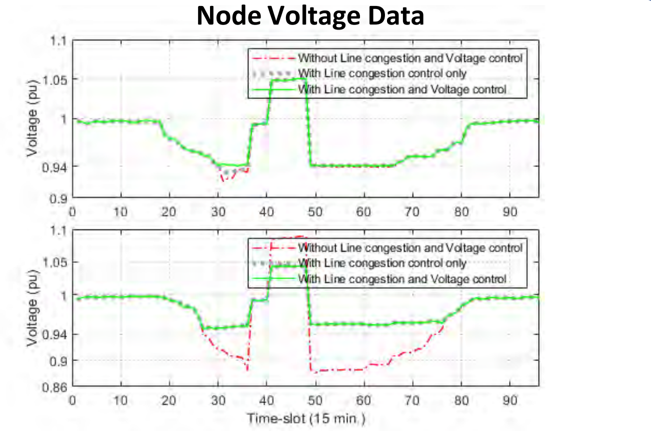
Constraints

Line congestion: $|I_l(t)| \le I_{rated}$

Node voltage: $\mathcal{V}_{min} \le |v_i(t)| \le \mathcal{V}_{max}$

Results





Voltage Sensitivity Coefficients

$$\Delta\mathcal{V}_i = \sum_{j\in\mathcal{I}} \frac{\partial\mathcal{V}_i}{\partial\mathcal{P}_j}\Delta\mathcal{P}_j + \sum_{j\in\mathcal{I}} \frac{\partial\mathcal{V}_i}{\partial\mathcal{Q}_j}\Delta\mathcal{Q}_j$$

Voltage sensitivity coefficients

Power Transfer Distribution Factors

$$\Delta\mathcal{P}_l = \sum_{i\in\mathcal{I}} \frac{\partial\mathcal{P}_l}{\partial\mathcal{P}_i}\Delta\mathcal{P}_i + \sum_{i\in\mathcal{I}} \frac{\partial\mathcal{P}_l}{\partial\mathcal{Q}_i}\Delta\mathcal{Q}_i$$

Power transfer distribution factors (PTDF)

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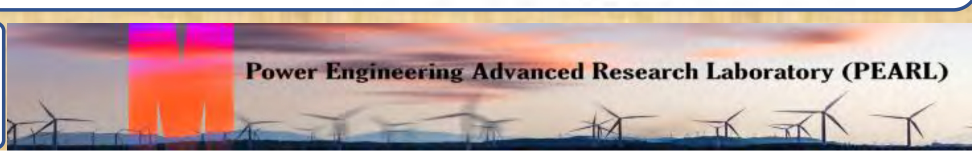
Date: 7-9 December 2021



WATCH PRESENTATION ONLINE

Designing Future-Proof Residential LV Networks

Muhammad Zulqarnain Zeb, Michael Z. Liu, Luis(Nando) Ochoa

1. Introduction

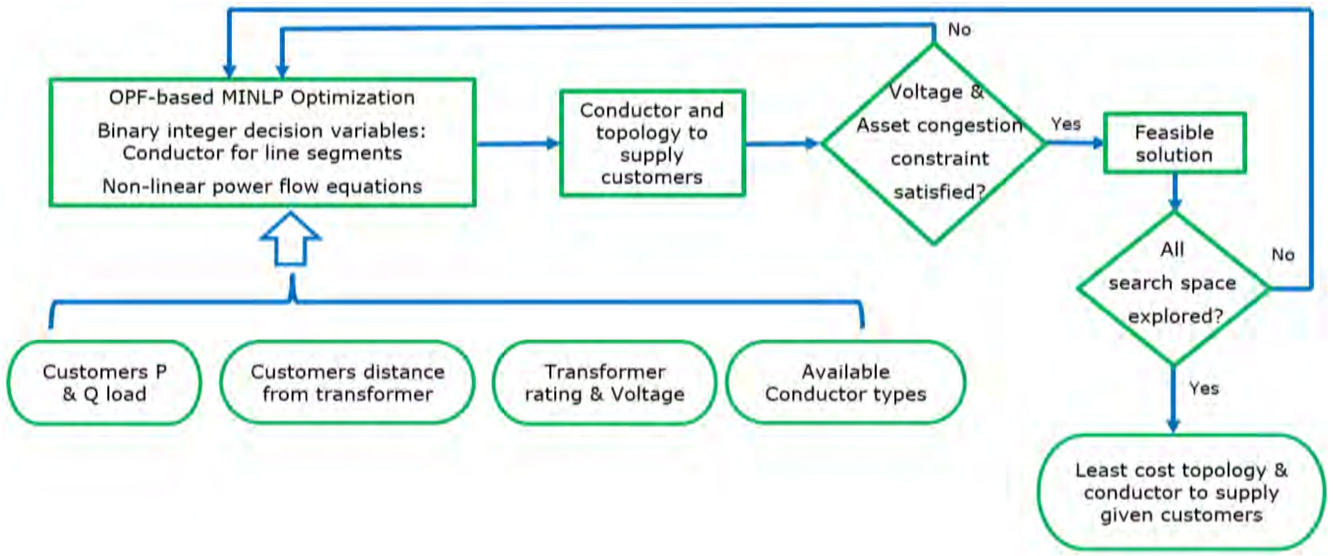
- Our **existing residential low voltage (LV)** were not designed to have **Distributed Energy Resources (DERs)** which can lead to **voltage** and **asset congestion** problems
- Different **solutions** can be adopted:
  - On-Load Tap Changer (OLTC)
  - Off-load Tap Changer
  - Storage management
  - Demand side management (DSM)
  - Active and Reactive power curtailment

But

- Can we **design future-proof DER-rich** LV networks?
- What will be the **most cost effective** DER-rich LV design?

2. Methodology

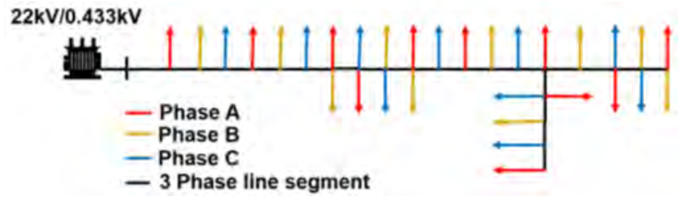
- At this stage, the **methodology** focuses on **conductor types** for the lines of the network and used **Mixed Integer Non-Linear Programming (MINLP)-based Optimal Power Flow (OPF)**



- **The approach finds the least-cost conductor type** able to supply customers without any voltage or asset congestion problems
- **Warm start** conditions are used for **computational efficiency**

3. Case Study

- Real 31 customers residential LV network supplied by 22/0.433kV transformer
- Formulated as **3Φ unbalanced** network in **AIMMS**
- 2 conductor options are given to solver **(AIMMS Outer Approximation)** for **3Φ** lines including 185 sq m with ampacity of 280A and 240 sq m with ampacity 325A
- **After Diversity Maximum Demand (ADMD)** per single phase customer is 4kW and 2.2kVar



4. Results

- For feeder with 31 customers, **185 sq m conductor** is decided by optimizer for all **3 phase line segments**
- Voltages and lines utilization are within limits and verified by OpenDSS
- $V_{max} = 1.1\,pu, V_{min} = 0.94\,pu$
- $S_{185sqm}^{max} = 64.4kVA$

Total Customers	Voltage End Customer (pu)	Voltage End Customer in OpenDSS (pu)	Error (pu)	Max. Power per phase (kVA)	Max. Power per phase kVA (OpenDSS)	Error (kVA)
1	0.998	0.998	0.000	4.56	4.56	0.00
5	0.997	0.997	0.000	9.14	9.10	0.04
10	0.995	0.994	0.001	18.26	18.20	0.06
20	0.987	0.986	0.001	32.24	32.10	0.14
31	0.973	0.972	0.002	51.20	51.00	0.20

5. Conclusions

- MINLP based OPF methodology can be successfully used to **design residential LV network**
- **Future work** include considering **DER** and a **comparison** of presented methodology with practiced design methodology and different **solutions** for increased **DER penetrations**

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THE UNIVERSITY OF MELBOURNE

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ELECTRICITY MARKET AND MAJOR ENERGY POLICY CHALLENGES IN NEPAL

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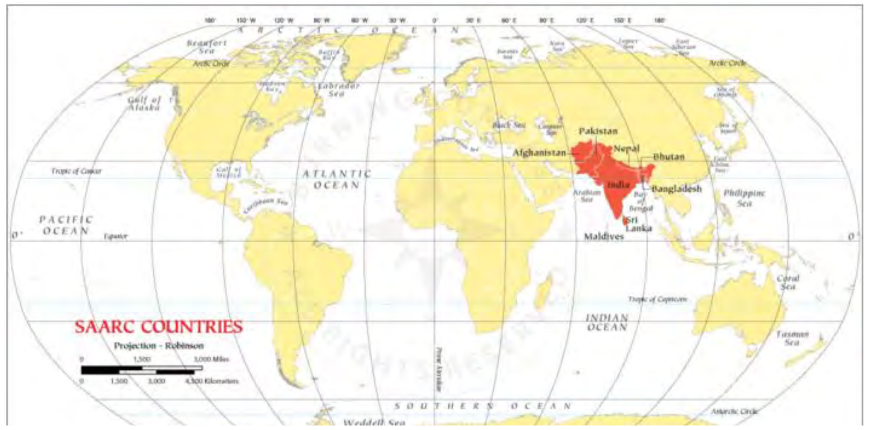
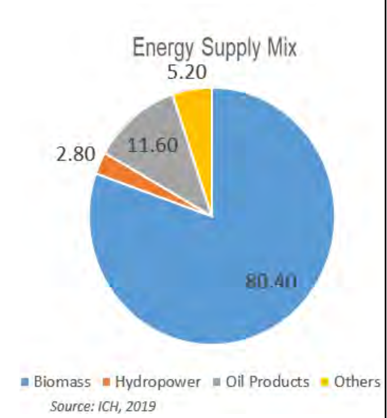
Future PhD Candidate, Victoria Energy Policy Center, Victoria University
Supervisor: Prof. Bruce Mountain

1. Nepal: Geographical Location and Hydropower Potential



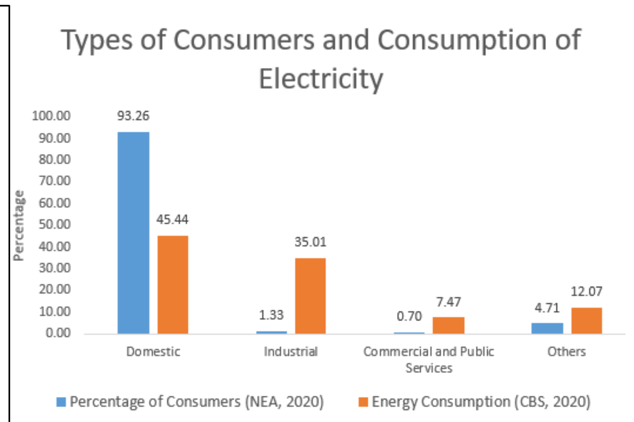
- More 6000 Rivers-Capacity of 83000 MW Hydropower
- **Energy system dominated by Hydropower**
- Installed capacity: Only 2000 MW (recently)
- Hovered about 700-1200 MW for many years
- Upto 12 hrs load shedding 4 years ago
- Energy Surplus (Supply>Demand)

2. Energy Supply and Consumption Mix in Nepal



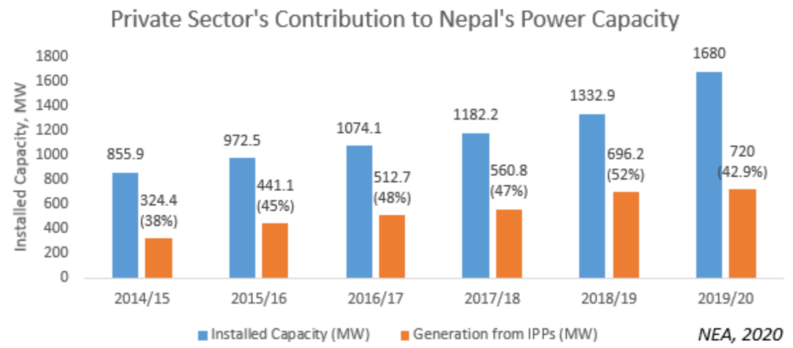
SN	Indicators	Present Status
1	Electrification (% of Households)	94%
2	Per Capita Electricity Consumption (kWh)	267
3	Share of Renewable Energy in Total Mix (%)	6
4	Installed Capacity (MW)	2000

- One third of population uses LPG as cooking fuel
- In rural areas, 66% of population uses firewood for cooking
- Only 72% population is supplied with reliable and uninterrupted electricity (WB, 2019)
- 33% of households do not get stable electricity



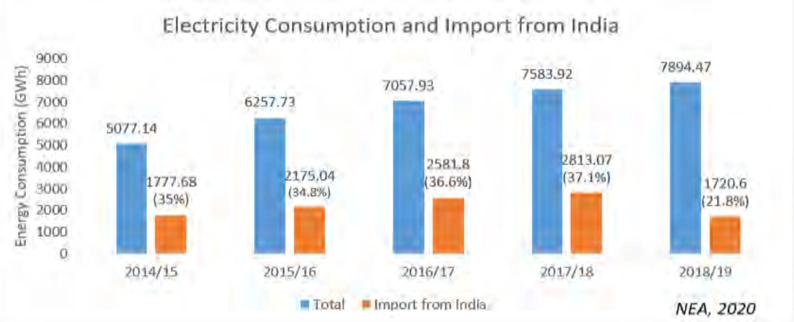
3. Energy Market: Internal (Domestic Market)

- Electricity Generation is increasing rapidly as compared to demand
- Considerable contribution by the Private Developers (IPPs)
- Energy surplus in monsoon (Jun-Oct) after biggest 456 MW Upper Tamakoshi HPP came under operation from July 2021
- But, huge deficit (500-800 MW in the dry season)
- NEA is the sole off taker of electricity
- No competitive energy wholesale/retail markets
- New PPAs for ROR projects not being executed
- Chronic situation of Transmission Lines not being completed in time



3. Energy Market: Regional and International Trade

- **Major energy markets for Nepal: India and Bangladesh**
- Upto 1000 MW of electricity can be traded via 400 kV DM Cross-border Transmission Line
- Bangladesh interested to buy 9000 MW of electricity from Nepal
- Several bilateral and regional agreements signed between Nepal, India and Bangladesh
- Nepal recently started selling 39 MW of electricity to India (too little)
- India reluctant to buy Nepal's electricity (if projects are financed by any nation other than Nepal or India and Provide its land for trading between Nepal and Bangladesh



4. Major Energy Policy Challenges

A. <u>Structural Rigidity of NEA and Lack of Competitive Electricity Market</u>

Unbundling of NEA to deregulate the energy market.

Key questions to be answered:

- *Timeline and steps of deregulation*
- *Structure of transitional and final market#*
- *setup of trading market*
- *Determination of trading prices, wheeling charge*
- *Market regulation and retail energy pricing mechanism*
- *Price Discrimination*
- *Adjustment of localized market and off-grid generations*
- *Measurement of efficiency of new companies after deregulation*

B. <u>Unavailability of Energy Mix</u>

Only 60 MW out of 2000 MW installed capacity comes from solar and wind.

Major challenge to meet demand in the dry season (October to March) when actual generation falls to a third of the installed capacity.

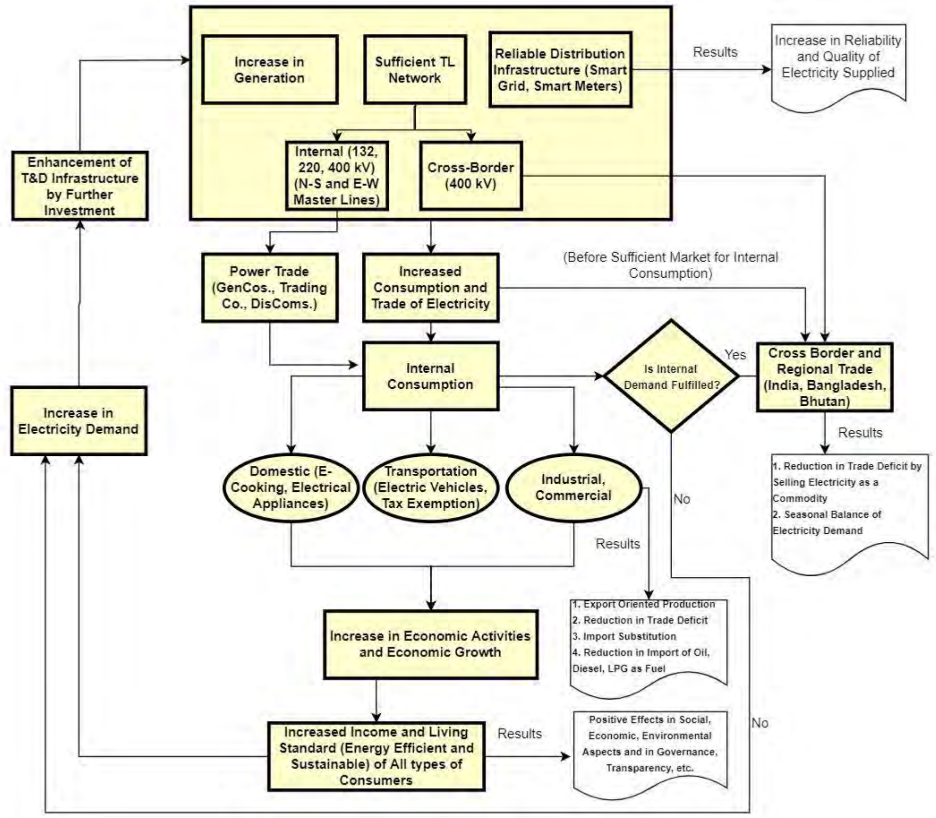
Key questions to be answered:

- *Optimum Energy Mix for the next 10, 20, 40 years?*
- *Future and possibility of renewables (except hydro)?*
- *National policies to increase the share of renewables?*
- *Effect on retail price?*

C. <u>How to Deal with Excess Energy?</u>

- There is urgent need of increasing electricity consumption to use up the excess electricity produced in the monsoon. **Sell excess energy to India?**
- Energy supplied is insufficient in the dry season. Need to address this seasonal imbalance by means of energy **storage (reservoir plants/hydrogen as energy carrier).**

5. Way Forward



6. Conclusion

- Provide Sufficient sustainable energy funding
- Enhance internal energy consumption
- Develop Solar Power Projects and Reservoir Based HEPs
- Open electricity market to private sector for free market and competition
- Develop real time electricity trading market
- Ease regulatory hurdles
- Ensure equal and fair treatment in bipartite and tripartite agreements
- Treat electricity as good (commodity), not service
- **ULTIMATE GOAL: 'RELIABLE, SAFE, QUALITY AND SUFFICIENT ELECTRICITY TO THE CONSUMERS' AND 'ECONOMIC GROWTH BY INTERNAL CONSUMPTION + ENERGY EXCHANGE BETWEEN NEPAL, INDIA AND BANGLADESH'**

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EV Charging Optimisation for Grid to Vehicle

Soobok Yoon, Civil Engineering, Monash University

Abstract

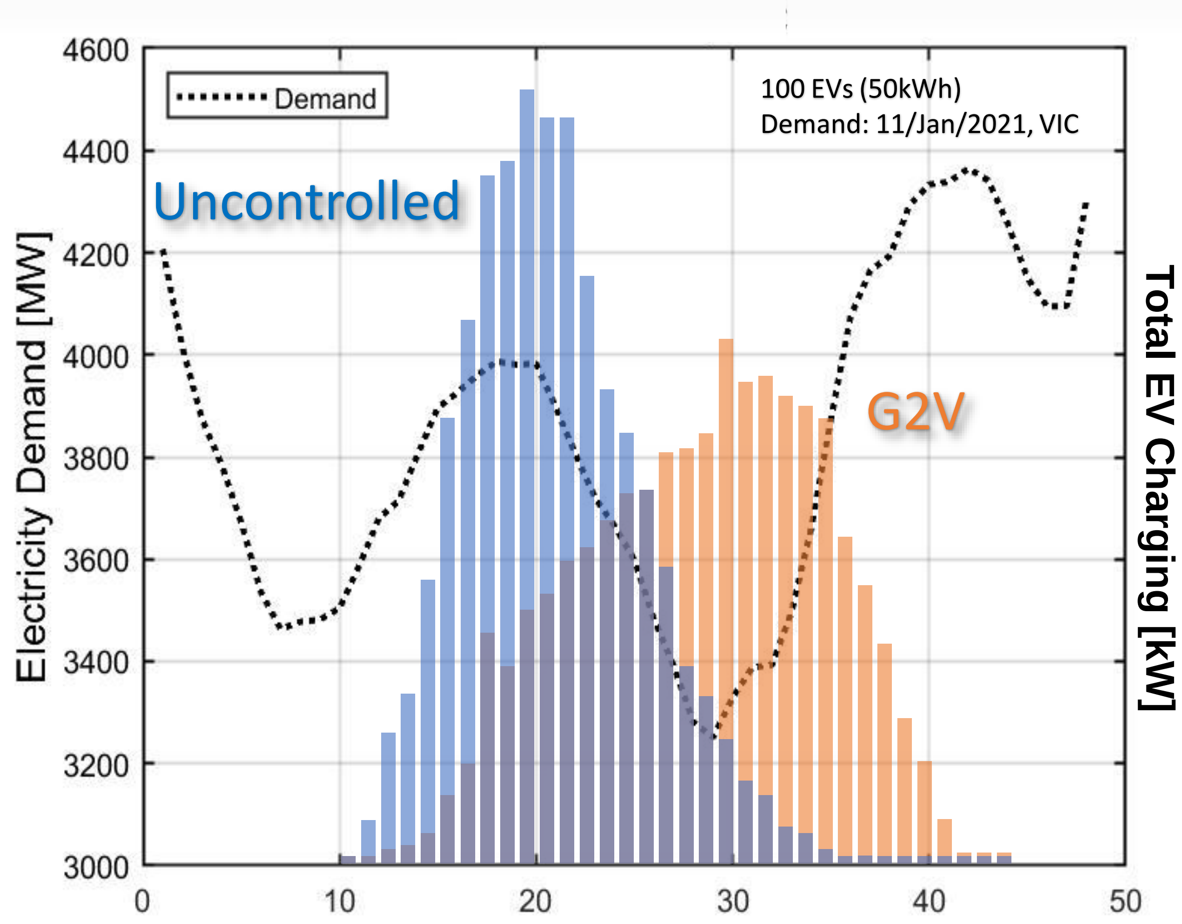
As of 2019, the sales of Electric Vehicles (EVs) in Australia accounted for 0.9%, lagging behind the global average of 2.6%. Nonetheless, it is predicted to reach up to 70-100% of new vehicle sales by 2040 with the strong initiatives towards the decarbonisation along the global trend.

However, the rapidly increased need for charging EVs, if done in an uncontrolled way, will result in significant complication in terms of the electricity operations. Many of the existing research showed that the electricity grid can only accommodate EVs when they represent as low as approximately 10-20% of the total number of vehicles, warning that the EV boom could require massive investment in the grid infrastructure.

This study proposes the Grid to Vehicle (G2V) algorithm which employs genetic algorithm to optimise the charging schedule. The simulation uses 100 electric vehicle supply equipment (EVSE), while the proposed algorithm was designed for the centralised parking system for the aggregator.

The cost function is set to maximize the utilisation of the solar PV system installed in the parking system and to minimize the purchased amount of the electricity from the grid, while guaranteeing the most profits to the aggregator. At the same time, the cost function focuses on the long-term optimisation to ensure a consistent performance under the extremely unstable grid condition.

In addition, the proposed G2V algorithm shows the simulation results of the essential information necessary to design the business model of the (centralised) parking system such as the optimal EVSE combination (charging power), charging price design, and the size of solar PV system in a long-term perspective.



-43.2% Peak Demand

-13.4% Fluctuation

-32.5% Stress Index

+$15 Profits

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Extracting the Physics of Electrical Networks Using Smart Meter Data: Towards Model-Free Voltage Calculations

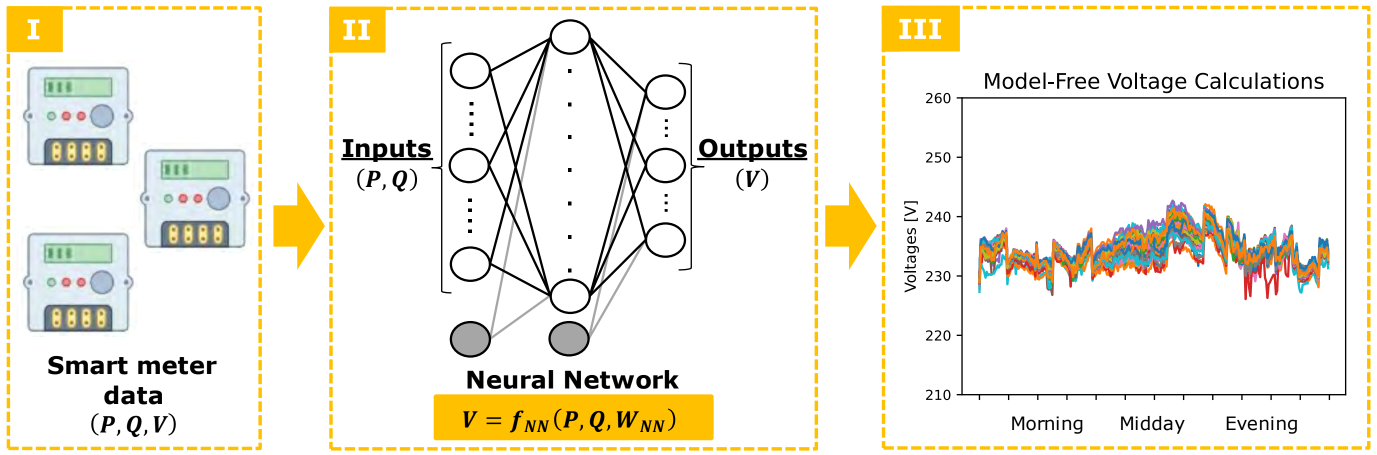
Vincenzo Bassi, Luis (Nando) Ochoa, Tansu Alpcan, Dillon Jaglal

1) Introduction

- Increasing residential PV systems adoption rates → voltage rises.
- To understand the corresponding impacts → voltage calculations.
- However, voltage calculations need accurate low voltage (LV) network models, **which are not readily available in most cases.**

2) Methodology

- **Data-driven approach to calculate voltages without electrical models.**
  - Part of the **"Model-Free Operating Envelopes at NMI Level"[1]** project funded by the Centre for New Energy Technologies, C4NET.
  - I. Collect historical data of customers (P, Q and V).
  - II. Tailored Neural Networks (NNs) are trained to learn the relationships among the historical data and the studied LV network. Selection → K-fold cross validation.
  - III. Model-free voltage calculations for any kind of what-if scenario of customers.



W_{NN} → Weights & biases of the NN

3) Case Study

- Real LV network located in Victoria
  - 26 residential customers (1ϕ)
  - 2 C&I customers (3ϕ)
- Smart meter data (P, Q and V)
- 5 minutes resolution

January 2021 | **February 2021** | **March 2021**

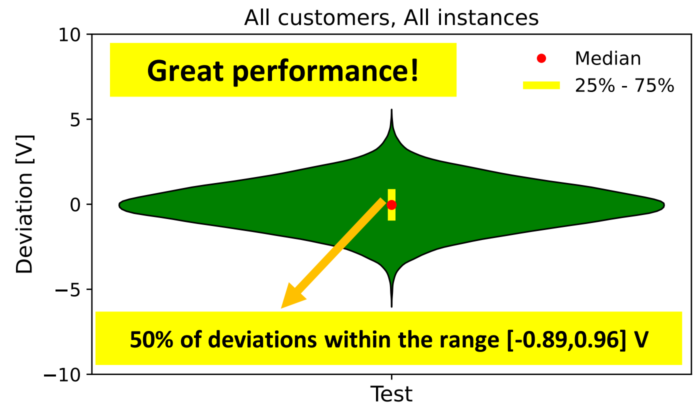
Training: Eq. 6 weeks | **Test: Eq. 3 weeks**

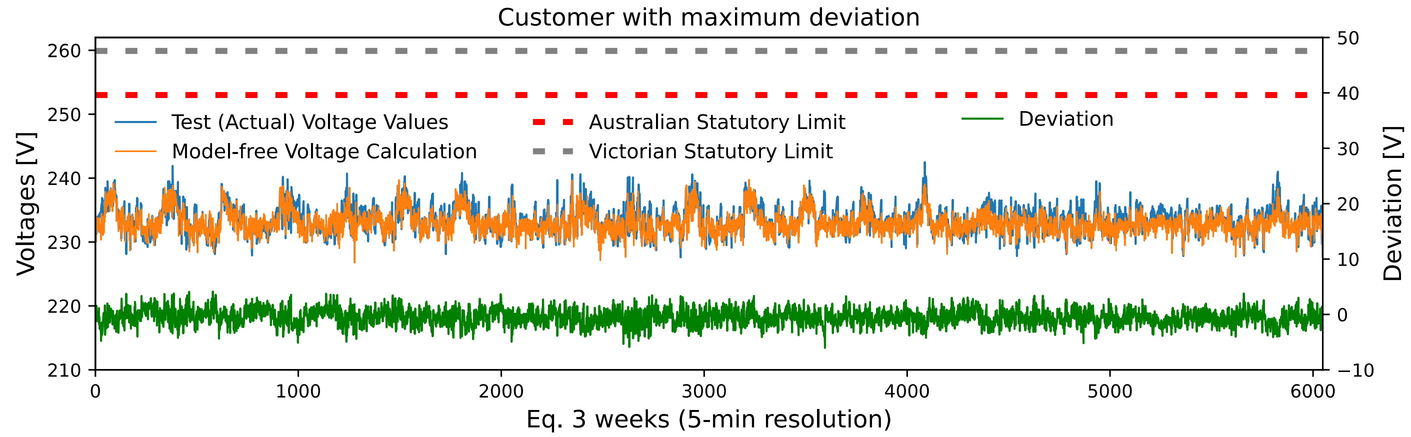
K-fold cross validation → Selected NN							
Inputs	Hidden layers	Neurons	Activation function	Outputs	Learning Rate	Batch size	Epochs
64 (P, Q)	1	32	Tanh	32 (V)	1e-2	72 (Eq. ¼ day)	2,000

4) Results

- Promising results achieving an average deviation of **1.1041 V** (≈ **0.48%** of the nominal voltage).

Voltage calculations (All customers)	
RMSE (V)	1.3910
Av. Dev. (V)	1.1041
Max. Dev. (V)	6.0383





5) Conclusions

- The approach shows promising results that **demonstrate distribution companies with smart meter data can calculate voltages without LV network electrical models**, reducing the associated time, cost and inaccuracies.

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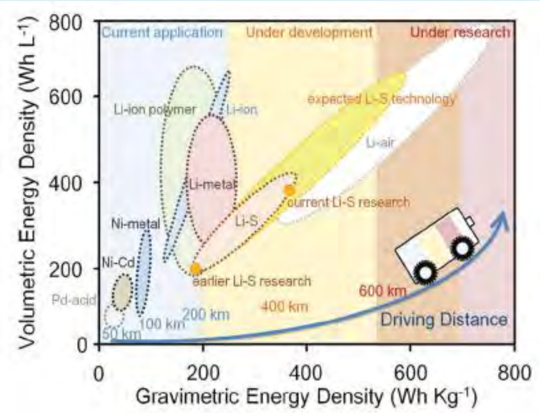
[1]Visit our project website

WATCH PRESENTATION ONLINE

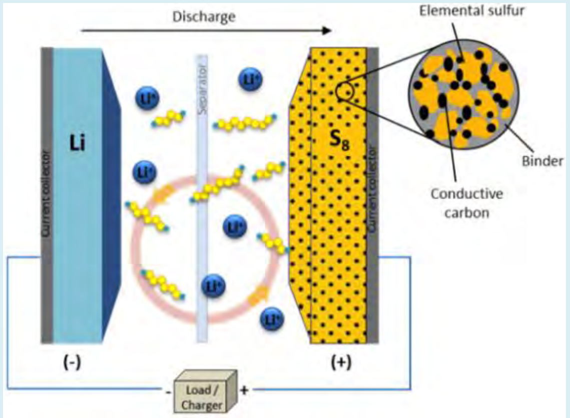
A saccharide-based binder for efficient polysulfide regulations in Li-S batteries

Yingyi Huang
Supervisors: Prof. Mainak Majumder
Prof. Matthew R. Hill
Dr. Mahdokht Shaibani

Background

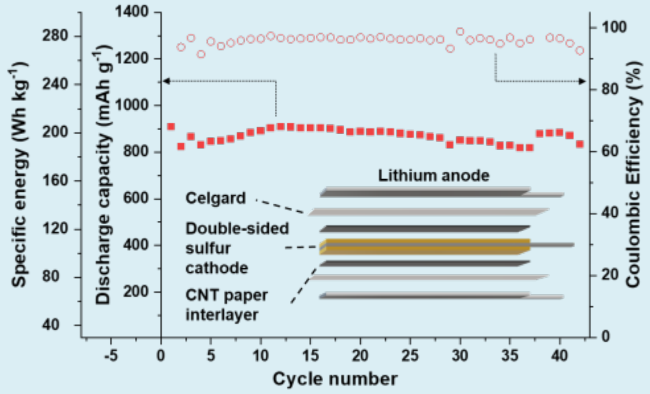


Batteries for future market



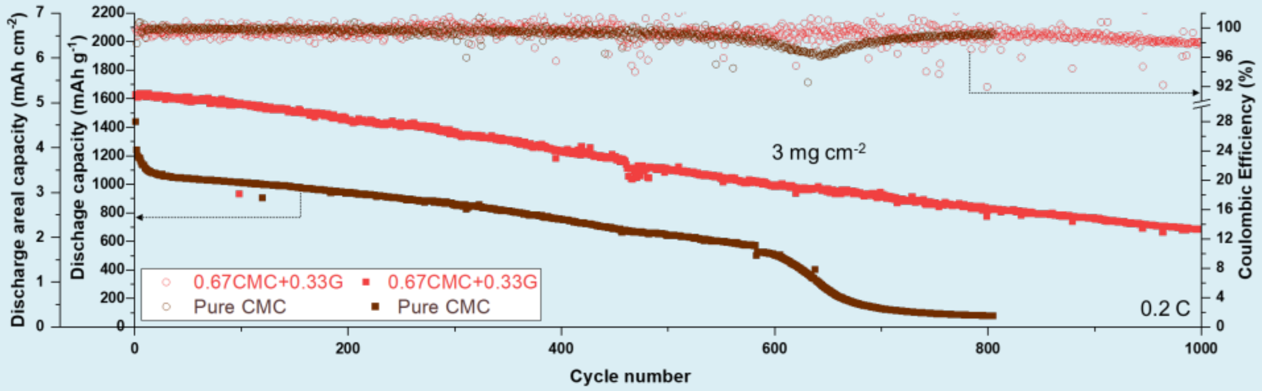
Li-S cell diagram

Battery Performance



Cycling performance of Pouch cell

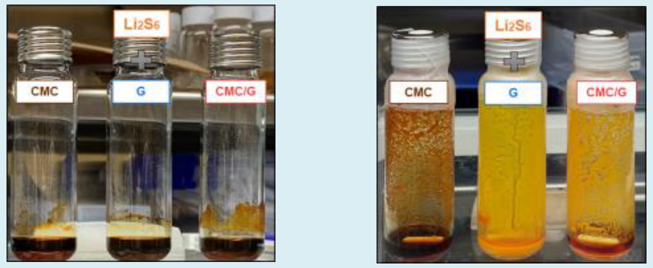
Pouch cell prototype



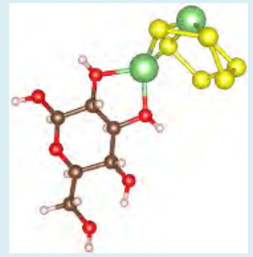
Cycling performance comparison between CMC cathode and CMC/G cathode

Rosenman, Ariel, et al. Advanced Energy Materials 5.16 (2015): 1500212.
https://www.greencarcongress.com/2018/03/20180302-oxis.html

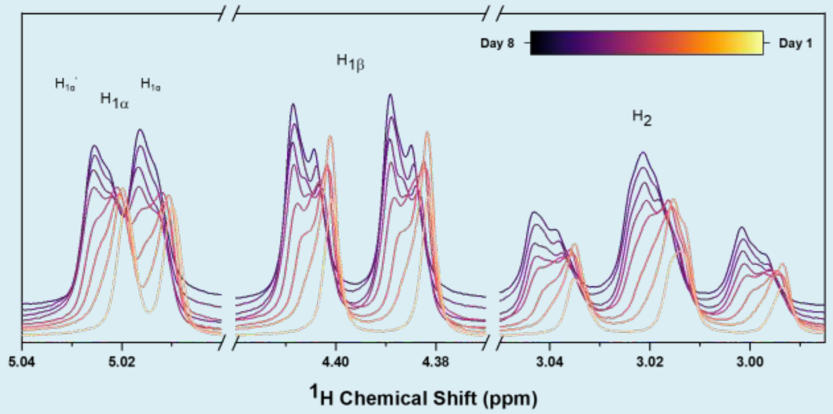
Effect of glucose on the polysulfide regulation



Evolution of polysulfide in different binder systems

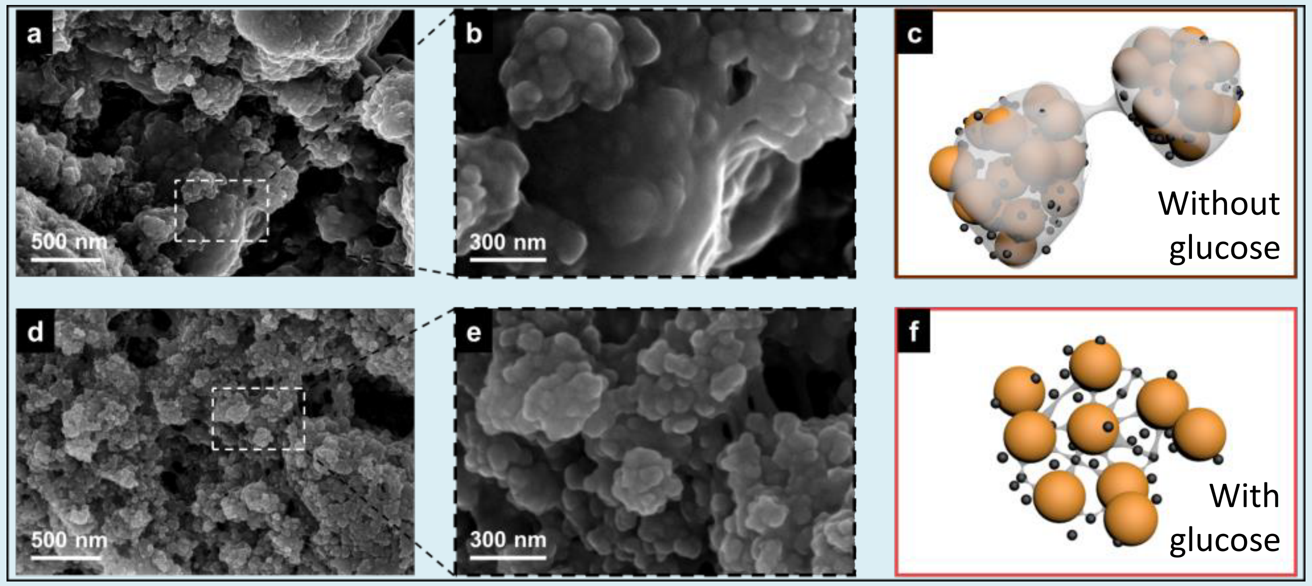


Glucose-Li_2S_6 (0.95 eV)



^{1}H NMR analysis probing the glucose-Li_2S_6 interactions

Microstructural study of sulfur electrodes



Huang, Yingyi, et al. Nature communications 12.1 (2021): 1-15.

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Residential PV Hosting Capacity, Voltage Unbalance, and Power Rebalancing: An Australian Case Study

Yushan Hou, Michael Z. Liu, Luis (Nando) Ochoa

1. Introduction

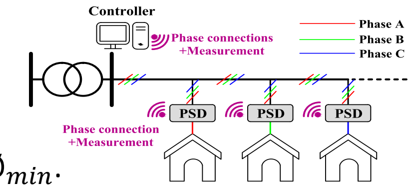
- Residential **PV systems** are mostly **single-phase installations**. This inherently **increases unbalance** among phases and **exacerbates voltage rise** issues on certain phases.
- The aim of this work is to 1) **investigate the effects of unbalance on PV hosting capacity** and 2) propose a practical **rule-based power rebalancing algorithm**.

2. Unbalance Metric

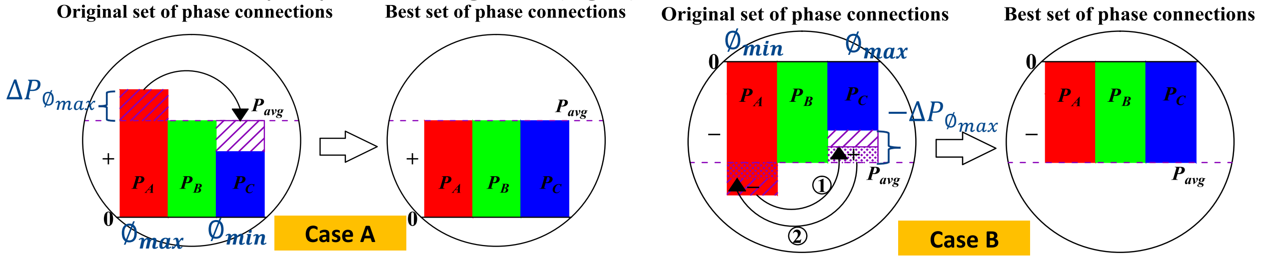
- The metric **Power unbalance (PWU)** is proposed.
  - $PWU = Max(P_A, P_B, P_C) - Min(P_A, P_B, P_C)$, where P_A, P_B, P_C are total net demand per phase.
  - Can work as well as voltage-based metric (e.g., voltage unbalance factor).
  - Easier to calculate and has less requirement for measurement than voltage-based metric.

3. Power Rebalancing Algorithm

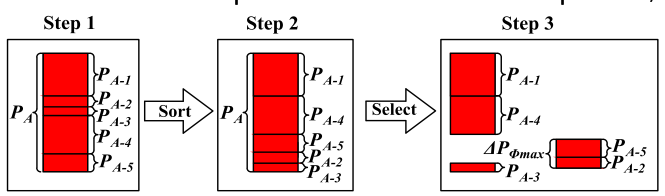
- **Aim:** determine the **best set of phase connection of customers** that minimizes PWU
  - Algorithm is used to control phase switching devices (PSD).



- **General principles**
  - Move the customer with positive net demand on phase $\emptyset_{max}$ (phase with the maximum total net demand) to phase $\emptyset_{min}$.
  - Move the customer with negative net demand on phase $\emptyset_{min}$ to phase $\emptyset_{max}$.
- **Examples** to get best set of phase connections
  - **Case A**: when the total net demand per phase is positive (left) and **Case B**: when the total net demand per phase is negative (right)

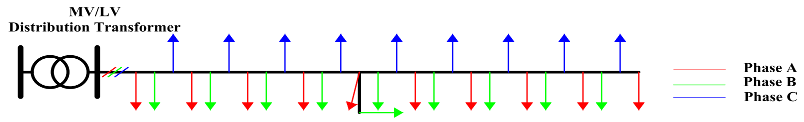


  - **Three steps** to select specific appropriate customers for Case A
    Step 1: put the customers with positive net demand on phase $\emptyset_{max}$ into a pool.



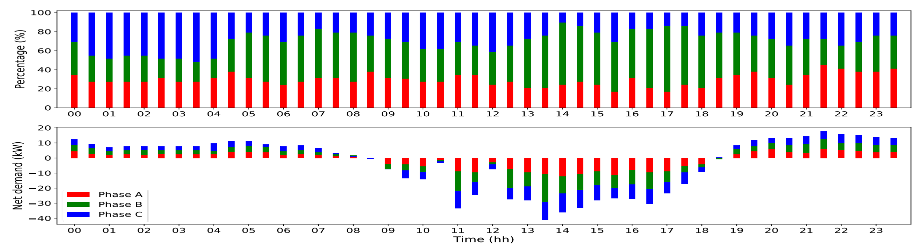
4. Case Study

- Australian LV Feeder
- 3φ $500kVA$, $22kV/0.433kV$ TR
- 29 single-phase customers
- Randomly vary PV locations and sizes and select load profiles from a pool (342 daily profile)
- 2900 scenarios for Monte Carlo-Based Assessment

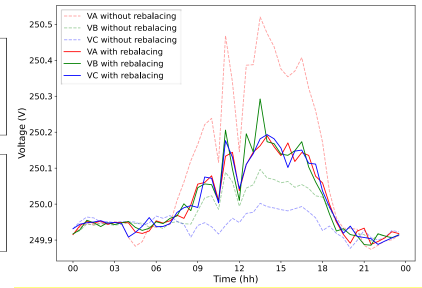


5. Results

- **Single-day Results (41 % PV penetration level)**
  - Percentage of customers and total net demand of each phase with rebalancing (left) and voltage at the head of feeder (right)

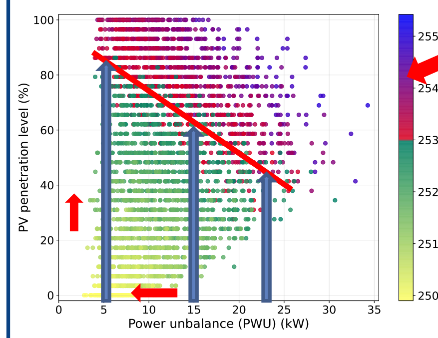


Rebalancing the net demand among phases will result in an unequal number of customers in each phase



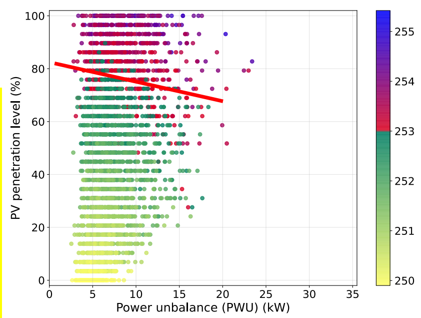
With rebalancing, the voltage unbalance is smaller

- **Monte Carlo-Based Assessment**
  - Sensitivity diagram for the case **without rebalancing (left)** and **with rebalancing (right)**



Max customer voltage

Unbalance decrease → PV hosting capacity increase (blue arrow)



Unbalance decrease, maximum customer voltage decrease! For most scenarios, **PV hosting capacity can reach up to 70%**

6. Conclusions

- **Large unbalance** can significantly **limit residential PV hosting capacity**.
- The proposed **rebalancing algorithm** can **effectively mitigate unbalance**. **More PV systems** can be **accommodated** without PV generation curtailment.

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