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GRID INNOVATION HUB

GIH 2023 Highlights

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Thank you

Thank you to our Grid Innovation Hub partners, Xelio and PSC for another busy, successful year of collaborative research and innovation. The funding that we received through highly competitive grant processes with ARENA, would not have been possible without the continued support of our partners. We thank you for your financial contributions as well as your personal engagement and commitment via Belinda Fan (Xelio) and Matt Robinson (PSC). Your time, enthusiasm, advice and questioning are appreciated.

Thank you of course too to our Chairman, Professor Tony Marxsen, whose time, advice and guidance was integral in the establishment of the GIH and its continued operation.

Project Highlights 2023

- Completion of 1 project worth $1.36M Titled: Stability-Enhancing Measures for Weak Grids
  Chief Investigator Associate Professor Behrooz Bahrani
- Commencement of another project titled: Management of Oscillations in Australia's National Grid
- Continuation of a third project titled: Integrating Energy Storage into the NEM
- GIH approved $47,000 funding for 2024, towards Dr Reza Razzaghi's project titled:
  Enhanced System Planning. This project received $180,000 from C4Net.

Future Partner Updates

- Conversations were held with staff from Acciona and EKS, about becoming GIH partners. Both organisations are very keen to do so.
- As at February 2024, Acciona's legal office are at final review stage of the GIH contract and partner agreement. We expect to receive the executed copy shortly.
- Eks were taken over by Hitachi late last year, so the contract is still at legal review stage with them. EKS have expressed their continued desire to become GIH partners.
  We look forward to welcoming both companies in early 2024.
- Discussions were also held with TILT renewables

Activities and News

- Pitched 3 proposals to Ms Nicole Iseppi, Bezos Earth Fund, Director of Energy Innovation: Advanced Grid-Forming Control: Type-3 and Type-4 Wind Turbines, A Rare-Earth-Free Solution: Innovative Axial Flux Machines, Controlling the Grid of the Future. Enthusiastically received by Nicole, but as yet not funded.
- A/Prof Behrooz Bahrani, along with colleagues from Monash and the University of Sydney, submitted a $3M AUD proposal to the Australian Government - International Clean Innovation Researcher Network. The proposal was supported by the GIH.
- A/Prof Bahrani presented at the APAC Offshore Wind Summit
- Dr Sarah Goodwin co-chaired the IEEE VIS 2023: Visualisation and Visual Analytics conference, with 800+ attendees.She also facilitated a series of workshops focusing on energy data challenges, including the 3rd international workshop on Energy Data Visualisation (https://energyvis.org/).
- A/Prof Guillaume Roger's book:On the Grid: Australian Electricity in Transition was published in July 2022
- Hao Wang, Sarah Goodwin & Reza Razzaghi collaborating with academics from RMIT won funding for PhD scholarships on AI for Clean Energy and Sustainability from the CSIRO Data61 Next Generation Graduates Program.

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(NSF Global Centres) EPICS program

Submitted 2 funding requests to the US Govt National Science Fund. A/Prof Behrooz Bahrani is part of one of the successful bids, a $118M National Science Foundation Global Centres in Climate Change and Clean Energy (NSF Global Centres) EPICS program

As part of this program, the Electric Power Innovation for a Carbon-free Society (EPICS) Centre was announced through a collaborative effort involving Australia, the United States, Canada, and the United Kingdom.

The EPICS Centre is positioned to become a worldwide leader in scientific advancements related to developing innovative computing technologies, economic strategies, engineering solutions, and progressive policies necessary for establishing a fully renewable energy grid. This project, led by Australia's national science agency CSIRO, the Australian Energy Market Operator, the University of Melbourne, and Monash University, represents a collective effort to drive this initiative forward.

Monash University played a crucial role in this ambitious global endeavour, reaffirming its commitment to combat climate change as outlined in its visionary Impact 2030 strategy. Monash is dedicated to being at the forefront of environmental sustainability efforts.

"Participating in the esteemed EPICS Centre, in collaboration with leading national and international institutions, highlights our shared dedication to pioneering solutions for a carbon-free society. Our focus on addressing challenges related to solid-state inverters not only aims to optimize the integration of renewable energy but also ensures a seamless transition to a 100 percent renewable energy mix."

"

Unlocking the potential of inverter-based resources, while addressing their inherent challenges, is critical for advancing the world's journey towards sustainable and equitable energy systems**.** This ground-breaking initiative champions both technical innovation and global cooperation as we progress in our mission towards a net-zero future," Dr. Bahrani stated.

The partnership between Monash University and its international collaborators reflects the growing global consensus on addressing climate change. By directing resources toward clean energy innovation and research, these institutions are making significant strides in reducing carbon emissions and mitigating the impacts of global warming.

Recognition

We celebrated our Co-Director Dr Behrooz Bahrani’s very well-deserved promotion to Associate Professor. Congratulations Behrooz!

Dr’s Hao Wang and Reza Razzaghi were awarded ARC DECRA Fellowships. Hao will investigate: Reliable Integration of Distributed Low-Carbon Energy Resources and Reza: Accurate Fault Location Methods for Complex Power Networks

Our GIH Chairman Prof Tony Marxsen was awarded an Honorary Fellow of the University in recognition of his service, mentoring and contributions to the GIH, Faculty and University. Wonderful news.

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Short courses - Grids, PSCAD

Grid Integration and GPS Studies of Renewables

Attendees learnt about timely topics in power engineering and grid integration of renewable energy resources, such as wind and solar. There was a focus on power electronic converters, their control, and PSCAD-related National Electricity Rules (NER) Clauses in generator performance standards (GPS). Attendees learnt to build and model the components for a grid-connected voltage source converter (VSC) in PSCAD, which shall progress into introducing and investigating the eight PSCAD-related NER Clauses found within the AEMO Connection

GPS 2024 Course Flyer
GPS 2024 Course Outline

PSCAD workshop

This 4-hour online workshop session was intended for PSCAD beginners, and aimed to teach basic techniques that will be useful throughout the course.
In this workshop, attendees stepped through introductory items in PSCAD such as setting up a basic network and running a simulation case, which was then be followed by simple exercises and demonstration and conclude with Q&A and some troubleshooting.

Grid Forming Inverters (July 2023)

This course is one of our "Grid Integration of Renewables" short course series, which was delivered by the expert team of Monash University researchers. This course primarily focused on grid forming inverters (GFMI) that have been hailed as a game changer across the energy industry in the transition to renewables-dominated power systems.
In this 4-day intensive course, there was an opportunity to learn about the fundamentals of different grid forming control topologies and their modelling. Attendees also learnt about GFMI capabilities and grid applications, and you will be able to analyse and interpret GFMI performance under various grid settings that will help you gain a competitive edge in the grid integration of renewables.

What was learnt

- Fundamentals of the grid-forming concept and how it compares with grid-following inverters
- Detailed modelling, control and tuning of droop-based and VSG-based grid- forming control
- An overview of alternative grid forming controls and novel control methods
- Testing GFMI capabilities and analyse dynamic performance in PSCAD
- GFMI grid-strengthening network capabilities
- The role of BESS in GFMI, and pilot projects, case studies and applications of GFMIs

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Project Updates

STABILITY-ENHANCING MEASURES FOR WEAK GRIDS

This project will assist both network owners and operators to ensure customers get the maximum value of these renewable farms located in weak parts of the grid. It will also increase the reliability and security of the grid in such areas.

The project comprised of three tasks.

- Task 1 | Weak grids classification and test-bed development

Explore and propose new measures to classify weak networks and will identify grid scenarios and value-range under which weak-grid-connected wind/solar farms will experience instability issues. Additionally, this task will develop a testbed, based on the North-western Victorian network (in collaboration with and based on the data provided by AEMO and AusNet Services). This testbed will be used in the following tasks to validate their findings.

- Task 2 | Grid-strengthening solutions

This task will propose two main grid-strengthening methods, i.e., SynCons and grid-forming inverters, and will explore their optimal allocation and sizing in weak networks. Additionally, alternative control strategies for these grid-strengthening assets with a focus on ultra-weak networks will be devised. Finally, the black-start capability of grid-forming inverters will be explored and outlined.

- Task 3 | Wind/Solar farms controls and their interactions with other PEC-connected assets

In this task, two internal controllers (PoC voltage controller and PLL) for grid-following converters with a focus on ultra-weak grids (SCR less than one) will be developed to guarantee robust performance and stability over a range of grid strength scenarios and specifically when the grid is very weak. Additionally, this task will investigate the interaction of various power-electronic converter (PEC)-connected assets in the network, with a focus on the existing grid following inverters, and will identify grid scenarios and value-ranges that lead to oscillatory modes.

- Total project cost $1.36Million AUD
- ARENA funded $559,000 AUD

Project Partners: AusNet Services, AEMO, ABB Australia

Project Knowledge

- Project reports
- ARENA media release 22/07/20
- Stability-Enhancing Measures for Weak Grids Study Report

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Further Information

https://www.monash.edu/energy-institute/grid-innovation-hub/home/stability-enhancing-project

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INTEGRATING ENERGY STORAGE INTO THE NEM: BIDDING, CLEARING, SETTLEMENT, DISPATCH AND ANCILLARY MARKETS

In the day-ahead market:

- Progress is being made on characterising the solution in the combinatorial model, which involves technically challenging coupled partial differential equations.

In the spot balancing market:

- The first paper has been submitted to a top journal in Economics.
- Work on a model of competing storage operators has been completed, revealing that collusion arises easily and can manifest in new forms, sometimes being the only equilibrium.
- Development of a model for the intraday cycle is ongoing, expected to progress rapidly with increasing experience.
- The work has attracted interest, with presentations made to ARENA and a White Paper written to provide a non-technical summary of the dynamics of storage.
- A knowledge-sharing event with PSC is scheduled for October 11, and there has been contact with AEMC regarding "The Future of the NEM."

- Total project cost $1.18 Million AUD
- GIH funded $135,000 AUD over 2022 & 2023 thanks to our partners X-ELIO & PSC
- ARENA funded $495,000 AUD

Project Knowledge

- Knowledge Sharing
- ARENA media release 25/07/22

Contact

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More Information

Monash University Integrating Energy Storage into the NEM Study

The Monash University Integrating Energy Storage into the NEM Study will investigate Australian electricity markets.

Australian Renewable Energy Agency

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MANAGEMENT OF OSCILLATIONS IN AUSTRALIA'S NATIONAL GRID

The project commenced in July 2023 and is currently in the literature review phase. Initial functionalities for the tool have been identified. No findings have been made yet for publication. Research staff have been hired, and efforts are underway to recruit a Python coding specialist with a background in power engineering.

- Total project cost $1.33M AUD
- GIH funded $150,000 over 2023 & 2024 thanks to our partners X-ELIO & PSC
- ARENA funded $500,000 AUD

The Project will investigate oscillatory issues in Australia's national grid and develop tools to identify the root causes of instability and help identify potential solutions.

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More Information

Monash Grid Oscillation Project (Study and Software Development)

The Project will investigate oscillatory issues in Australia's national grid and develop tools to identify the root causes of instability and help identify potential solutions.

Australian Renewable Energy Agency

Vale Professor Ariel Liebman

17 November 2023

It is with heavy hearts that we acknowledge the passing of Professor Ariel Liebman – a distinguished member of Monash, Director of the Monash Energy Institute, an academic of global esteem, a researcher committed to real-world impact and a beloved colleague and friend. We pay tribute to his legacy of impact and advocacy. Professor Liebman was committed to saving the world from the climate crisis, an endeavour he strived for throughout his extensive 25+ year career in the energy sector.

He held many leadership positions across the University, including Co-leader of the Australia Indonesia Centre Energy Cluster, Co-Director of the Monash Grid Innovation Hub and Deputy Director of the Monash Energy Materials and Systems Institute. This entity became the Monash Energy Institute, of which Professor Liebman was first Associate Director (Smart Energy Systems) and later Director from 2020.

Professor Liebman was a natural networker with a talent for bringing people of all backgrounds together to achieve his vision of a zero-carbon emissions future. Driven by this passion, he played a key role in establishing Net Zero by 2030 goal.
Working closely with interdisciplinary researchers, Professor Liebman was integral to many impactful and large-scale research initiatives, such as leading the RACE for Networks Program in the Reliable Affordable Clean Energy (RACE) for 2030 Cooperative Research Centre – Australia's largest CRC ever awarded. He was also an architect for the Monash Grid Innovation Hub and a lead researcher of Monash's Smart Energy City project.

As a friend and colleague, Professor Liebman was known for his collaborative and innovative spirit. Someone who was extremely knowledgeable about energy and technology and specialised in a non-traditional approach to academia and research. He was also a dedicated supervisor and mentor to numerous PhD and Masters students, student teams and junior colleagues.

Professor Liebman's humour, kindness, enthusiasm and welcome unconventionality will be fondly remembered by those who knew him. His legacy will be carried on by his colleagues and the generations of students, researchers and practitioners to come. Taken far too soon after a short illness, his was certainly a 'life well lived'. We extend our deepest sympathy and condolences to his children and extended family.

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Reports

Stability-Enhancing Measures for Weak Grids Study Report

Stability Enhancing Measures for Weak Grids Study

Knowledge Sharing Publications

A/Prof Behrooz Bahrani presented a webinar to ESIG
Stability Enhancement of Utility-scale Renewable Energy Plants in Weak Grids

Grid Forming Inverter Modelling, Control, and Applications

Power-Synchronized Grid-Following Inverter Without a Phase-Locked Loop

Optimal Allocation and Sizing of Synchronous Condensers in Weak Grids With Increased Penetration of Wind and Solar Farms

A Robust Exciter Controller Design for Synchronous Condensers in Weak Grids

H∞-Based Control Design for Grid-Forming Inverters With Enhanced Damping and Virtual Inertia

Generalized Virtual Synchronous Generator Control Design for Renewable Power Systems

Adaptive Virtual Resistance for Post-fault Oscillation Damping in Grid-forming Inverters

Small-Signal Synchronization Stability Enhancement of Grid-Following Inverters via a Feedback Linearization Controller

A Planning Method for Synchronous Condensers in Weak Grids Using Semi-definite Optimization

Comprehensive Modeling, Analysis, and Comparison of State-Space and Admittance Models of PLL-Based Grid-Following Inverters Considering Different Outer Control Modes

Comparison of PLL-Based and PLL-Less Control Strategies for Grid-Following Inverters Considering Time and Frequency Domain Analysis

Multivariable Control Design for Grid-forming Inverters with Decoupled Active and Reactive Power Loops

Online Grid Impedance Estimation-Based Adaptive Control of VSGs Considering Strong and Weak Grid Conditions

Integrating energy storage into the NEM: Bidding, clearing, settlement, dispatch and ancillary markets

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