RESOURCES, SYSTEMS AND TECHNOLOGIES

Chaired by Dr Chris Briggs
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DEEPSyM-GriD: Digital tool for modelling energy demand, supply, and net-zero emissions

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Australia's Long-Term Emissions Reduction Plan sets a clear goal to reach net zero emissions by 2050, underpinned by a strong focus on technology to drive sustainability and economic growth. Towards this goal, it is imperative to address the power grid design, integrating a variety of anticipated technological innovations in power generation and storage options. Our collaborative research between the University of Sydney (USYD) and Mitsubishi Heavy Industries (MHI) investigates the design of efficient power grids, with focus on three areas: modelling future energy demand, optimising grid planning, and navigating mineral constraints for new energy technologies.

The transition to net-zero emissions requires accurate predictions and reliable tools for assessing future energy demand, yet such comprehensive tools are currently lacking. Although greenfield precincts present an opportunity to develop localized energy hubs and reduce infrastructure expansion costs, the absence of a multifaceted platform that integrates zone and sector typologies, historical national energy consumption data, and floor-area-based energy consumption studies hinders the progress toward carbon neutrality.

To address this gap, we introduce DEEPSyM-GriD, a digital planning tool developed through collaboration between USYD and MHI. Its core objective is to assess energy demand and estimate supply options, aligning with Australia's Net Zero-time horizon leading to 2050. A case study on the Aerotropolis site in Western Sydney and international examples demonstrate its utility. The platform accounts for dynamic demand changes as precincts transition from partial to full operation, including temperature-dependent fluctuations, capacity factors, and emissions reductions due to evolving technology.

This digital energy demand tool fills data gaps and provides realistic assessments ultimately informing decisions in energy, policy, and technology for greenfield and brownfield sites, and promoting stakeholder engagement for carbon-neutral developments.

Geotechnical research to unlock safe, cost-efficient foundations to underpin offshore wind in Australia

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Offshore wind is here and is set to dominate the offshore energy sector for the coming decades. Victoria has claimed 'first mover' status, with seabed surveys at the Star of the South project underway and award of the first lease areas to be announced shortly. New South Wales and Western Australia also have areas identified for future development of offshore wind.

However, while there is a well-established industry in Europe (and increasingly in other regions), will experience from other jurisdictions necessarily translate to success in Australia? In the case of offshore foundation design, history tells us that there are challenges ahead associated with the complex carbonate sediments found offshore Australia which have impacted offshore development over several decades.

Monopiles are the preferred option for offshore wind elsewhere, but can they be installed in variably cemented sediments? Will the noise generated from installing these foundations negatively impact the Australian-specific marine mammals and what options exist to mitigate this? Can we optimise site investigation activities to reduce cost, whilst still obtaining the quality of site knowledge needed to avoid failures during installation and optimise design?

The Centre for Offshore Foundation Systems ('COFS') at UWA was established in 1997 and has worked closely with the offshore sector to provide effective research that underpins safe and economic foundation design for conventional energy projects. Over the last decade, attention has shifted towards renewable energy – initially in support of developments overseas, but more recently for offshore wind and wave projects at home – with an extensive team working with partners in offshore wind to accelerate the energy transition. This presentation will overview recent and ongoing research including:

- The use of geological analogues to guide the early (concept select) development stage – what sort of seabed conditions do we expect at the locations of, as-yet unexplored, but proposed wind farms?;
- How do we best find out what the seabed is like by combining data science with limited offshore data?;
- Can we install monopiles in (variably cemented, carbonate) Australian seabeds?
- Can we install foundations quietly so as not to disrupt the marine environment?
- What are the best anchoring options for floating wind in carbonate sediments?

In addition, the talk will outline future challenges that must be addressed to provide safe, efficient and cost-effective foundations for the offshore wind sector in Australia.

The optimal infrastructure design for smart charging system: a case study based on the Monash microgrid

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Globally, the transport industry, responsible for approximately 23% of carbon dioxide emissions, ranks alongside electricity generation in environmental impact. Addressing this concern, prioritizing the electrification of the transport sector emerges as a critical strategy for establishing a carbon-neutral society.

As of 2019, Electric Vehicle (EV) sales in Australia represented 0.9% of total vehicle sales, trailing the global average of 2.6%. However, proactive measures toward decarbonization are anticipated to propel EV sales in Australia to comprise 70-100% of new vehicle sales by 2040, aligning with global trends. Notably, in 2019, Australia experienced a 200% surge in EV sales compared to the previous year, resulting in a more than twofold increase in EV charging activities.

Despite these positive developments, the uncontrolled or unsophisticated expansion of EV charging infrastructure poses a potential threat to electricity grid operations. Smart charging has emerged as a research focus to address this challenge, envisioning the EV fleet not merely as consumers but as prosumers capable of actively participating in various grid services.

In this research, innovative charging algorithms, including functionalities such as Grid-to-Vehicle (G2V), Vehicle-to-Grid (V2G), and Vehicle-to-Vehicle (V2V), are introduced to tackle the increasing demand for EV charging. The proposed algorithms are tailored for the aggregator, specifically Monash University and the optimization framework prioritizes both the secure operations of the microgrid and the enhancement of operating profits through the strategic arrangement of power trading of EV charging.

Furthermore, this study investigates the optimal infrastructure design and business models for the Monash microgrid through a comprehensive financial analysis. The presented algorithm utilizes an online charging strategy, incorporating Machine Learning algorithms to mitigate uncertainties. Also, it integrates a network-aware algorithm to manage node voltage issues within the microgrid. The effectiveness of the proposed approach is assessed through simulations conducted on the IEEE LV European test feeder system and MATLAB Simulink.

The outcomes of the simulation reveal that the introduced smart charging scheme successfully mitigates long-term grid violations. Additionally, the system ensures substantial financial gains, as evidenced by metrics such as Net Present Value (NPV) and Internal Rate of Return (IRR), surpassing those of the reference charging case.

Specifically, this research aims to offer comprehensive insights into optimal infrastructure configurations, encompassing the ideal quantity and optimal power ratio for EV chargers. Considering these factors, the study explores optimal investment strategies for the smart charging system, providing valuable guidance for the aggregator from a techno-economic perspective in G2V/V2G/V2V charging services.

Re-designing the energy transition based on circular economy principles: Materials constrained optimisation framework

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Australia has set a significant milestone in its commitment to combat climate change, aiming to achieve Net-Zero Emissions (NZE) by 2050, which will require the design and execution of an energy grid that incorporates renewable power generation and storage. Over the past years, researchers from the University of Sydney (USYD) and Mitsubishi Heavy Industries (MHI) have been actively engaged in a comprehensive study addressing three pivotal aspects of this endeavour: forecasting future energy demand, devising grid planning strategies that optimise renewable energy integration, and proactively considering potential constraints, including material shortages. As most nations also endeavour to achieve this NZE target, the collective rush towards sustainability raises concerns about the impending scarcity of critical materials.

To ensure a smooth energy transition, it is imperative to anticipate material shortages and strategically select alternative technologies that can mitigate these challenges, as mineral supply chains become of paramount importance. This, coupled with the lead-time required for mining operations to commence production, underscores the necessity of embracing Circular Economy concept. This approach enables the reuse of rare minerals and the repurposing of aging technologies to support and advance a more orderly energy transition.

An analysis of supply chains reveals that copper, nickel, lithium, cobalt, and silver are critical materials at risk of their demand exceeding their global reserves. Leveraging the University of Sydney's DEEPSyM-GriD (demand) and -Power (Supply planning) models, existing mineral reserves and production can be aligned with the demand for these minerals in energy transition technologies. A framework is proposed that integrates Circular Economy (materials) guidelines into transition modelling. This aims to retain these essential minerals at their peak value even after the technologies they're used in have become obsolete, thus easing limitations in the energy planning model. The framework assesses existing mineral reserves and aligns them with the projected exponential growth of production required to satisfy the demands for the energy transition. This framework incorporates anticipated pricing trends and trade dynamics, enabling an evaluation of how mineral scarcity may impact the optimal future energy mix and the meeting of net zero targets.