Woodside Energy

THE UNIVERSITY OF WESTERN AUSTRALIA

2023
Annual Report

The University of Western Australia acknowledges that its campuses are situated on Noongar land, and that Noongar people remain the spiritual and cultural custodians of their land, and continue to practise their values, languages, beliefs and knowledge.

Table of Contents

Executive Summary

Woodside FutureLab at The University of Western Australia (UWA) plays an integral role in addressing challenges and opportunities within Woodside Energy and the broader energy industry. Operating with a focus on impact, the FutureLab facilitates ideation sessions, rapid prototyping projects, student programs, and extensive industry collaborations. These efforts are all aimed at delivering valuable outcomes and enhancing capabilities for both Woodside Energy and UWA. This collaborative approach aligns with Woodside Energy's goals to innovate, explore ideas, and find creative solutions to provide reliable, affordable and lower carbon energy today and into the future.

Woodside Future Lab at UWA has two key hubs: OceanWorks and TechWorks, both dedicated to driving research aimed at improving safety, reliability, efficiency, and environmental performance. OceanWorks concentrates on ocean engineering, fostering collaboration among experts in oceanography, ecology, engineering, resource management, and governance. TechWorks focuses on technology-based solutions to enhance operational safety and cost-effectiveness, with a core emphasis on 3D Additive Manufacturing.

In the past year, OceanWorks prototypes addressed challenges related to swell events, wave dynamics, subsea calcification, and decommissioning polyurethane. Employing the 'Think Big, Prototype Small, Scale Fast' approach, the team explored opportunities in marine energy and the use of algae for commercial CO2 capture and utilisation. Now in its eighth year, this report details instances where OceanWorks prototypes have led to rapid and effective implementation after prototype validation.

Established in May 2021, TechWorks has made significant strides. This year, TechWorks introduced an awareness level course on 3D Additive Manufacturing, delivering professional development to Woodside engineers and fulfilling competency requirements. This year, the TechWorks lab performed tests on novel solutions ranging from 3D printed threads to evaluating an innovative Woodside solution for lifting components at height. TechWorks has been influential in identifying risks and supporting decision-making, as well as reverse engineering and producing optimal parts in response to parts failure.

A central aspect of the partnership involves engaging the next generation and encouraging them to pursue careers in the energy sector. This year 21 final year engineering students participated in 13 RiverLab research projects, focussing on offshore wind, wave energy, anchors, and pipeline fatigue. FutureLab-supported outreach activities for school-aged students including the Emerging Engineers Competition and Future Engineers Program, aimed at inspiring female students towards engineering courses and careers in the energy sector.

This report also provides progress updates on Woodside Energy/UWA's industry-level collaborations supported by the Australian Government, including Transforming energy Industry through Digital Engineering (TIDE), Future Energy Exports Co-operative Research Centre, and the Australian Research Council Linkage Projects. Achievements from the Woodside Chair in Leadership and Management and the Long Subsea Tiebacks Laboratory are also highlighted. We extend our appreciation to the 150+ UWA researchers and Woodsiders involved in these extensive partnerships for their commitment to collaboration and co-creation, strong progress on projects, and enthusiasm to explore new opportunities. The discretionary effort on both sides has been outstanding. Reflecting Woodside Energy's transition to a truly global business, this year saw the welcoming of many Houston-based Woodsiders to campus, providing them with insights into the FutureLab facilities and potential engagement opportunities.

The achievements in 2023 underscore the power of the long-term partnership between Woodside and UWA, showcasing mutual benefits from the deep understanding of Woodside Energy's business by UWA researchers, and the exposure of Woodsiders to UWA's expertise, capabilities, and infrastructure.

As we reflect on a productive year for Woodside FutureLab at UWA, we look toward 2024 with optimism, with major activities already in progress across ocean operations, underwater detection, new energy, optimising 3DAM Support Structures, and in-situ decommissioning.

OceanWorks

Since its establishment in 2016, OceanWorks has kick-started 138 research projects, ranging from predicting swell arrival times on the Northwest Shelf, to model scale testing of innovative subsea vehicles. Many of these projects have followed a similar timeline, being seeded as ideas developed in the OceanWorks space or via the OceanWorks network, and then incubated as part of a prototype or RiverLab project, or as part of a student internship.

OceanWorks is unique because it enables rapid research, turning ideas into research projects in a matter of weeks. It fills a gap in conventional research programs, embodying the 'Think Big, Prototype Small, Scale Fast' approach to exploring ocean engineering solutions.

Located in the Indian Ocean marine Research Centre, the OceanWorks space is used to host events led by both industry and researchers, aiming to share skills and knowledge, build networks, support innovation, and promote collaboration across Ocean Engineering. As a versatile space, it was used to support more than 80 engagements ranging from 'challenge' sessions to industry tours and Woodside away days. This level of engagement is almost unmatched across the University, having brought together a community of more than 200 Woodside engineers, UWA academics and UWA students to engage in open innovation.

The OceanWorks prototype fund provides rapid access to small scale funding (A$5k – A$10k) to progress projects from ideation through to investigation. More than 8 prototypes are initiated per year, with some generating immediate value, and others growing into larger-scale research projects. Valuation of prototype projects in 2019 indicated a greater than 1:10 return on investment. To provide an example, one prototype project successfully reproduced – in the laboratory – scour observations around the Xena midline connector structures, providing unique insight into the observations and informed mitigation solutions. Another prototype explored if machine-learning and offshore wave buoys could correct swell forecasts – following successful demonstration, this work has now been pursued in collaboration with the Bureau of Meteorology to improve commercial forecast models.

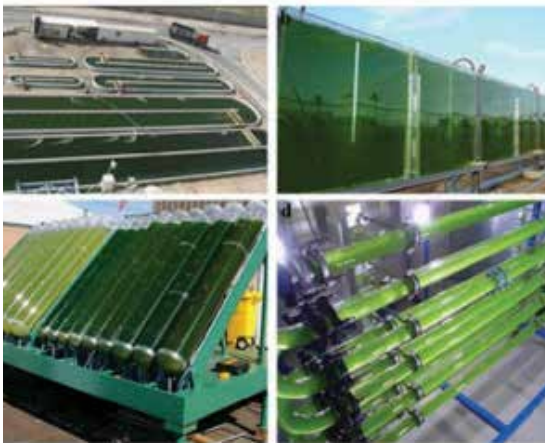
Some project ideas require field testing in a marine environment. In response to this, RiverLab was developed to bring together researchers and students and provide them with state-of-the-art equipment to use the Swan River as an analogue for the Ocean environment. In this way RiverLab provides a testing ground for new offshore engineering concepts, sensors and tools, which circumvents the need for costly ocean trials or international wave basins. The RiverLab program has seen enormous success, with over 140 students now having completed hands-on research across 92 different projects. This has resulted in award-winning research, invitations to speak on national radio, and publications in the Woodside Trunkline magazine. Valuation of the program has also indicated return on investment in excess of 1:10. An example project includes the application of Fibre Reinforced Polymer to repair corroded members – an idea that was adopted for repair of the KGP jetty. A second example is the demonstration of the Smart Marine Transport technology live in the river to an industry group – this provided motivation for industry to adopt alternative means to install subsea structures offshore.

In addition to developing novel ideas, OceanWorks has been committed to providing training programs and internships. OceanWorks also recognises that diversity and communication are vital ingredients for innovative engineering. It is therefore involved in two flagship outreach programs, created to address the need for greater gender diversity in engineering. The first is the Emerging Engineers Competition, a 20-week competition run in collaboration with UWA Girls in Engineering, which aims to engage young women in high school to the future challenges facing Ocean engineers. The second is the Future Engineers Program, run in collaboration with Women in Subsea Engineering to educate young women and explores opportunities to pursue a STEM career in the blue economy.

Prototypes

Exploring microalgae for commercial CO_2 capture and use

How might we commercially capture CO_2 using biological (microalgae) systems?



Microalgae are photosynthetic microorganisms responsible for about 50% of global photosynthesis, with their photosynthetic efficiency ranging from 10-20%, while most terrestrial plants have 1-2% efficiency. This project examined the main microalgae species, seeking to identify the ones with high growth rates and resistance to contaminants and CO_2 concentrations. We evaluated the advantages and disadvantages of the most recent culturing systems and proposed a model for further studies. We recommended a species and system (shallow graded raceway ponds) with relatively low cost of installation and operation. Selling biomass alone was uneconomic, but cost reduction of using on-site power (solar PV) and revenue increase by providing wastewater treatment indicated a Net Present Value (NPV) positive outcome.

Exploring macroalgae for $C0_2$ sequestration

How might we commercially capture CO_2 using biological (macroalgae) systems?

Macroalgae (kelps) have potential to transport carbon to the ocean interior, where sequestration will depend on the retention time of carbon from the ocean-atmosphere interface. This study investigated the export rates of seaweeds across continental shelves & resolved the fraction entering the deep ocean. Work from multiple studies was integrated (including RiverLab initiatives), and coastal flow modelling done to identify key parameters to size the potential of the opportunity. Indicatively 19-33% of detritus in Australia may be exported to deep ocean where it should sequester >100 years. Conserving existing seaweed forests has environmental benefits; small scale farms could have carbon benefit; however large farming requires very large areas to generate significant sequestration and may involve large social, economic and ecological risks.

Structure from Motion: Using ROV video to recover seabed profiles

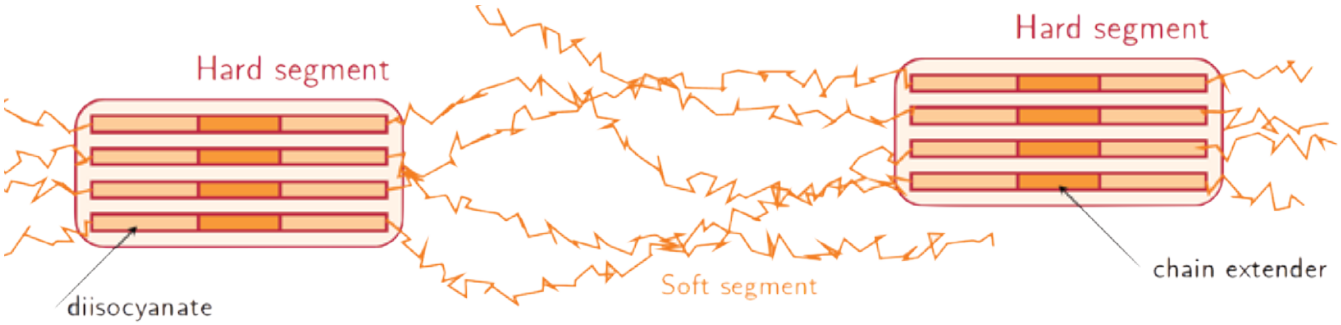
How might we dimension structures and seabed using existing conventional video?

Significant cost saving may be realised if Woodside is able to generate 3D seabed profiles around subsea structures using existing ROV video and structure from motion (SFM) algorithms instead of relying on expensive sonar survey campaigns. This project is investigating the feasibility of this alternative approach using ROV video sourced from a recent offshore operation (picture right) and a range of different SFM software available in the public domain. The work is focused on unlocking crucial understanding of how seabeds have evolved around structures to optimise management and maintenance of subsea infrastructure. Recommendations will be made in regards to the video quality and video content required to achieve an accurate profile.

Recycling the Nganhurra riser turret mooring polyurethane

How might we effectively and responsibly dispose of bulk decommissioned plastic (polyurethane)?

A systematic review of the literature has been conducted to explore the recycling of polyurethane. In addition, a market analysis has been conducted to assess the viability of potential recycling solutions. The results of this research revealed promising recycling techniques based on mechanical, chemical, thermal and biological approaches. The market model showed that pyrolysis and mechanical recycling can be cost-effective if optimal parameters are selected



Marine energy using uni-directional and bi-directional turbines

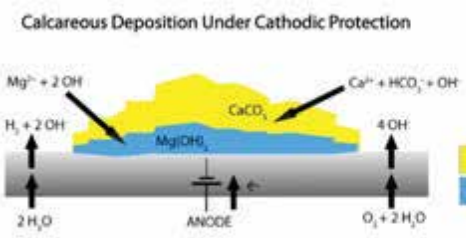
How might we harvest energy from the ocean (marine currents)?

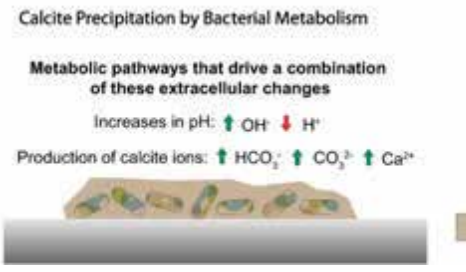
Marine currents can be a large source of low carbon electricity. Open-ocean flows may be insufficient, however prevailing coastal longshore currents and tidal flows combined with regional topography/bathymetry may concentrate flows to a level where bottom-fixed or floating systems could economically exploit these flows. This first-phase study involves a literature review to understand the state of the art, the power yield from horizontal axis and vertical axis turbines (across a range of flows), the leading success factors for economic development, and a high-level economic assessment for an indicative concept.

Subsea calcification, replication & investigation

How might we better understand the subsea calcification process?

This project aims to replicate/study the calcification phenomena on subsea hydraulic couplers and electrical connectors, using the unique facilities at the IOMRC Waterman's Bay. Calcification is currently managed by subsea intervention and component replacement. This project involves designing a prototype test cell, proving the concept (replication calcification in the lab). Once replicated, future phases can examine means of disrupting/avoiding it. This research can provide a sound understanding of the subsea calcification process in a controlled environment, with a high level of realism. The facility/test-set-up can be used for equipment supplier design testing and optimization. Maturation of solutions could substantially reduce subsea intervention costs on legacy assets and in new designs.





Education & Training

Offshore Wind Energy (delivery globally, initiating locally)

How might we bring our personnel on the energy transition journey (offshore wind)?

Offshore renewable energy resources are underpinning one of the world's fastest growing energy industries. At UWA our experts, supported by our state-of-the-art facilities, provide world-leading research to support offshore wind energy developers around the world. This presentation provided an overview of the offshore wind energy landscape, insight to the research capabilities at UWA (equipment and facilities, ways of working together, offshore energy expertise) and research underway in key enabling areas (social and legal context, social licence to operate, marine spatial data planning, development of national assessment standards, underwater cultural heritage, environment [eg birds and whales], supply chain and supporting infrastructure, and overcoming science and engineering challenges [geotechnical, hydrodynamic etc]).

Celebrating Linguistic Diversity

How might we better understand the merits of linguistic diversity?

Woodside's Cultural and Linguistic Diversity (CALD) employee impact group is charged with championing Woodside's multi-racial, multi-ethnic, multi-faith, multicultural, and multilingual workforce. Linguistic week is designed to raise awareness of linguistic diversity and celebrate a multi-language workforce. Dr Micelli presented an overview of her research into bi-lingualism and the anti-doppel bias, which seeks to identify why diversity occurs in some geographical hotspots and not others. Her research highlights the issues shared words between languages cause in the brain and the impact bilingualism has on cognitive performance. This event highlighted the importance of publishing academic research to reduce discrimination and close the gap to combat linguistic exclusion.

Industrialisation of native seeding for greening or restoration

How might we improve greening and site restoration economics?

Successful seeding has the potential to substantially reduce cost compared to individual plantings. Accurately and efficiently using wild-collected native seeds to initiate plant establishment is a critical challenge to large scale ecological restoration. The UWA Centre for Engineering Innovation (Agriculture & Ecological Restoration) aims to optimize and deploy seed enhancement techniques (e.g. coating, flaming, pelleting, etc.) and seed distribution mechanisms. Our work focuses on field-based tests and optimization. In this presentation you'll learn about the Restoration Engineering Seed Technology Deployment Program, the Australian Seed Scaling Initiative and other research underway that could enhance Woodside's greening projects (terrestrial CO_2 sequestration) or reduce Woodside's cost of site restoration post-operations.

Outreach

Emerging Engineers Competition

How might we increase the participation of women in engineering?

This competition is supported by OceanWorksand UWA Girls in Engineering to engage young women in the future challenges facing ocean engineers. With an emphasis on problem-solving, project-based work, and communication skills, the Emerging Engineers Competition offers primary and secondary students a chance to work on a real problem from ocean industries. This year's theme was "how to design a low-carbon footprint home in 2040". 14 teams from 8 different schools participated in the competition and saw the students take a holistic approach to energy-reduction strategies as well as innovative house design and power concepts.

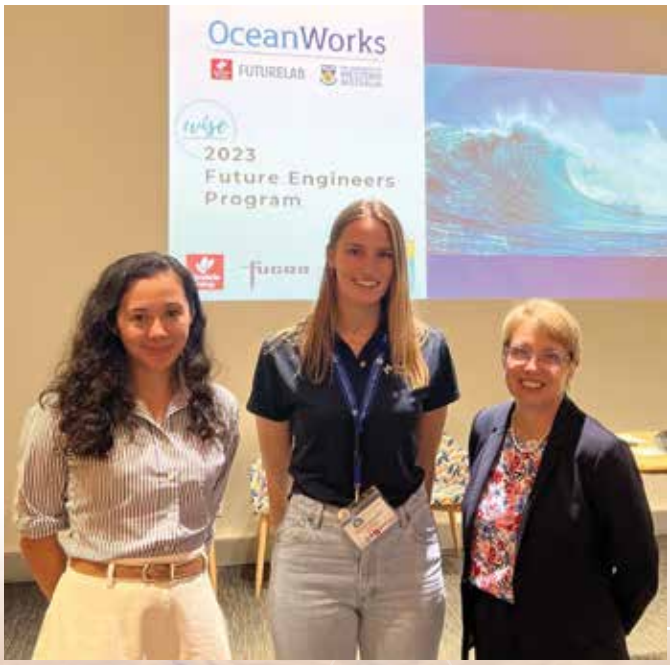
5 teams were short-listed in the Finals, and the winning solution –Solar-Powered Aqua Panels (harnessing microbial fuel cells to generate electricity in homes) was well-researched, comprehensive and well presented by the team from All Saints' College.

"My daughter participated in the competition last year - she had absolutely no interest in engineering. However, she was inspired by seeing the types of problems engineers solve (especially the micro-plastics challenge last year), so she now has engineering as the number one thing she wants to do. So the program is clearly working..."

Future Engineers Program

How might we increase the participation of women in engineering?

This is a week-long school holiday STEM program for High School girls in Years 8-12 designed to educate young girls about where our energy comes from and explore the opportunities to pursue a STEM career in the subsea and ocean-based industries. OceanWorkswere pleased to host the final day of activities at UWA, as well as host the final presentation event in the Indian Ocean Marine Research Centre with industry sponsors WISE Professional Network, Subsea Energy Australia, Engineers Australia, Woodside and Fugro.



RiverLab


Woodside
FUTURELAB
Connected thinking. Accelerating innovation.

RiverLab projects are chosen based on their alignment to Woodside Energy's strategic priorities, as well as their viability, potential to deliver significant value and their suitability for testing in the river. In total 13 new projects were initiated in 2023 using this assessment scheme, as summarised in the list adjacent. These projects bring together a community of engineering students and academics from multiple schools and discipline areas across the University.

RiverLab projects generally fall into one of three research themes: decarbonisation, decommissioning and remote operations. Amongst these themes, threads of research have naturally emerged, with multiple RiverLab projects providing complementary pieces of insight into a new research area. Example threads have included: the repair of corroded steel members submerged using fibre reinforce polymer (a technique which was adopted on the KGP jetty); better understanding the vibration potential of spanning subsea pipelines (which has motivated a larger research program within TIDE); and the development of novel, dynamically installed anchors (which has resulted in research findings that are influencing design guidance).

In this report we have chosen to highlight an emerging thread of research centred on floating offshore wind (FOW). The focus of this RiverLab research has been the development of a model scale floating wind turbine (possibly the first FOW turbine in Australia!), which has been deployed and tested in various conditions on the river to investigate the research questions indicated in the picture on the right. For example, in 2023 RiverLab students investigated non-linear loading on offshore wind infrastructure in long-period wave conditions unique to Australia, and they refined model instrumentation and numerical tools to resolve the combined effects of wave and wind forces on the turbine. Holistically, this thread of RiverLab research – which was motivated by discussion with the floating structures group within Woodside - is enabling new understanding of FOW and identifying opportunities for knowledge translation from conventional oil and gas design and operations. This knowledge and understanding are available for Woodside to adopt in future business activities.

2023 RiverLab Projects

1. Stabilising cables for offshore applications including wind farms using optimal arrangements of rock bags
2. Automated eFoil
3. Ocean based carbon capture and sequestration using the D-spar
4. Testing fixed offshore wind structures in Australian wave conditions
5. Scour growth and vortex induced vibration of subsea pipelines in sandy rivers and seabed
6. Investigating wave effects on floating solar
7. Yanchep lagoon, a natural water flume
8. Coastal Particle Dynamics
9. Free fall cone penetrometer to dynamically installed fish anchor direct design approach
10. Floating wind – modelling and integration
11. Microplastics in swan river via raman spectroscopy
12. Coupled balloon wave energy device
13. Hydrodynamics of a near-wall pipeline covered with soft marine growth

TechWorks

TechWorks was established in 2021 and is the second dedicated FutureLab HUB at UWA. It comprises a laboratory space, world-class 3D scanning and printing capabilities including a state-of-the-art EOS M290 metal 3D printer and a professional space for Woodside personnel to collaborate and experiment with real-world production technology. Through the specialist team of materials and mechanical engineers, Woodside Energy personnel are able to access to the expertise of the entire University.

We work with academics from across the University to promote innovation and engagement through prototyping and testing activities to drive improved production, maintenance and operation outcomes.

One of the central cores to the Techworks Futurelab is our 3D Additive Manufacturing program. We are working closely with Woodside Energy to make 3D Printing a business-as-usual activity. This not only involves developing a detailed understanding of the properties of the printed parts, but also 3D scanning, design or redesign of parts for 3D printing, in situ defect monitoring and upskilling of Woodside Energy personnel.

Alongside our advanced metal printing capabilities, we have extensive polymer printing equipment, 3D scanning equipment capable of 25μm accuracy, access to world-leading microscopy facilities including CT scanning and an advanced fabrication workshop which supports this work.

"Our TechWorks collaboration gives us great access to diverse engineering and scientific expertise and facilities at UWA. They're readily accessible, capable and responsive to our needs".

Dr Lee Djumas, Additive Manufacturing Lead, Woodside Energy

Design & Prototype

This program includes:

- 3D scanning
- Design optimisation for 3D printing
- Functional & mechanical testing
- Printing & testing of pre-qualification parts

High pressure coating pump bushings

How might we increase reliability of coating pump bushings?

The ball valve seat bushings in some of Woodside Energy's high pressure coating applicator pumps have been failing prematurely. The replacement parts are sourced from the manufacturer in Germany and there are no OEM-options for more robust materials. Techworks was approached to reverse engineer the bushings and to produce parts from different materials. Three types
of replacement bushing were produced, with 2 being additively manufactured to allow for faster procurement in a break-down situation. The three materials are machined PEEK, and 3D printed PEKK-C and Inconel 625. These parts are currently undergoing performance testing by Woodside.

Replacement Interlock keys

How might we cease replacing interlock systems because the key has broken?

This project explored the use of 3D scanning and additive manufacturing to reproduce broken interlock keys. There is an ongoing issue with the interlock keys failing. Upon failure the manufacturer requires all keys and barrels to be replaced rather than supplying a replacement key. Techworks 3D scanned a broken key profile, and then printed the replacement. The key was functional without any post processing. Techworks received the broken key, scanned, printed and redelivered the replacement in 2 days. The main takeaway was the ability of additive manufacturing, with the use of supporting technology, to be extremely reactive and able to remanufacture parts to significantly reduce procurement times.

Understanding 3D Printed Thread

How might we make more efficient components by printing threads?

Techworks is exploring the performance of additively manufactured threads. Typically, threads are post-machined but when the part geometry is complex, this can greatly increase the machining costs. We have demonstrated that we can successfully print the thread-form and testing is ongoing to determine whether the resulting threads have acceptable mechanical performance. Our preliminary results have indicated static performance is maintained, however the fatigue performance may be slightly reduced. Further testing is required to gain a full understanding of the mechanical performance however printed threads look promising.

Deluge Nozzle Redesign

How might we replace an obsolete sprinkler with an enhanced 3D printed one?

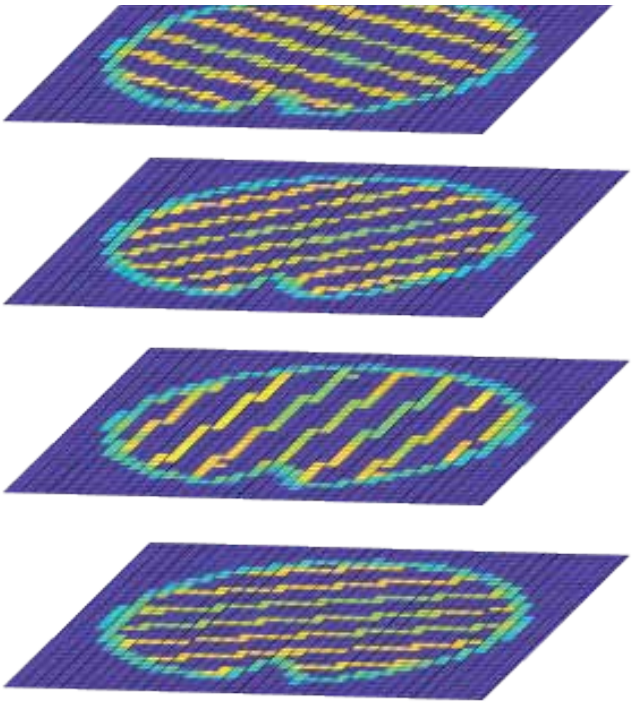
Techworks explored additive manufacturing as an alternative method for producing obsolete parts. The deluge nozzles were originally produced from three separate castings. However, the OEM no longer exists and there is a need to produce several hundred replacement parts. Techworks redesigned the components, making them easier to print while not impacting the function. A hexagonal nut was added to the parts for easier installation and the thread was printed to reduce post-print machining costs. Although the decision was ultimately made to stay with the conventional manufacturing process, this project proved AM was a competitive process with the expected cost being less than the conventionally produced parts. AM also proved to be more adaptable as changes could be quickly made to the design without the need to reinvest in specific tooling to suit.

In Situ Monitoring & Defect Detection

The aim of this program is to understand the effect of build defects on both the static and dynamic properties of AM parts and how we can detect the formation of these defects using advanced in situ monitoring. These two combined will provide an increased confidence in the quality of the printed part, assisting in the acceptance within Woodside Energy of AM as a viable manufacturing process for end use parts.

How might we reliably detect defects?

This research aims to advance knowledge in defect detection during 3D Printing. The EOS powder bed fusion (PBF) metal printer is equipped with an in situ monitoring package which measures the thermal history of the materials using two methods (a localised system and an area-wide system). This research combines the outputs of these systems on a layer-by-layer basis with machine learning to predict both the location and size of the defects. The detection algorithm is being developed by creating test samples with embedded defects (created by adjusting laser energy density outside the optimal process range) and analysing the relationship between the captured sensor data and the actual porosity within the part, as determined by micro-computed tomography (uCT).



Conventional detection methods are costly and have lower limits on the size of defect they can measure, especially as the section size increases. The in situ monitoring process appears able to detect defects down to ~150μm and this limit is theoretically independent of the section size. This places in situ monitor at a distinct advantage over conventional techniques.

Awareness Course

This program is delivering professional development training courses to meet Woodside Energy's competency requirements.

How might we educate our people to better identify additive manufacturing-based solutions within Woodside?

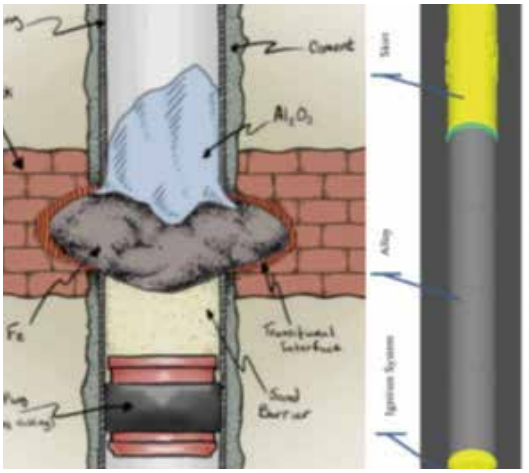
The TechWorks lab has developed and has commenced delivering Awareness-level courses in additive manufacturing (AM). The course comprises of three main components: a general introduction to AM, insight into how AM solutions may be incorporated within Woodside Energy and case studies demonstrating previous examples of its implementation across the business' operations.

After completing the course participants will have upskilled their knowledge base, be better able to identify opportunities and realise the potential that AM can provide to Woodside Energy. This initiative enables the required competency development to deliver AM as a cost and time efficient solution for replacement parts. Higher level courses (Knowledge and Skilled) are in preparation and are expected to be rolled out in 2024.

Projects

Performance of shales at elevated temperatures

How might we identify the risks associated with novel well P&A methods?



The project examined the current state of knowledge in rock mechanics in relation to the application of thermite- and bismuth-based technologies to plug and abandon oil and gas wellbores. These technologies use elevated temperatures during installation (above ~200°C for the Bismuth-based system and above ~1,500°C for thermite-based methods). Under these elevated temperatures, hydrocarbon leakage may be caused by thermal damage/cracking of the shale cap-rock and/or from the resultant metal-to-rock interface bond. There are many non-trivial physical processes to consider, including: crack initiation and propagation; thermo-hydro-mechanical coupling; three-phase modelling which captures phase changes; and material anisotropy (thermal, hydraulic, and mechanical). Structured identification of these knowledge gaps supported Woodside Energy's risk identification and decision-making.

Pyrolysis of Polyurethane to manage decommissioned subsea assets

How might we effectively and responsibly dispose of bulk decommissioned plastic (polyurethane)?

Pyrolysis-based thermal processing is considered a cost effective and simple means to thermally decompose composite plastic waste without the formation and release of freons. It also offers an opportunity for metal and energy recovery. Phase 1 of this project seeks to screen Woodside Energy's decommissioned/waste products (e.g. polyurethane foam, composite umbilicals & flowlines) to identify their yields in energy and solids (residues, steel etc); to perform preliminary economic analysis considering both centralised plant and mobile unit. The expected outcomes include preliminary process flowsheets (with simple mass and energy balance and identification of technology readiness level); preliminary economic analysis and performance evaluation of the centralised and remote scenarios; and identified knowledge gaps for further R&D in Phase 2 & beyond.

Kevlar cord embedment in epoxy

How might we create a lifting point to retrieve a component at height?

An innovative solution is being sought to lift a sheet metal component at height. The solution prototype is focussed on creating a lifting point which is deployable and liftable by drone. The solution needs to allow for in-place challenges including inclination and curvature. A solution has been developed by Woodside Energy and is being tested by UWA. The initial prototype requires the embedment of high-strength Kevlar cord into epoxy for lifting purposes. Techworks has undertaken two testing phases (Kevlar cord-
to-plate; and plate-to-plate) to provide datasets to inform Woodside Energy and enable prototype improvement and decision-making. Full-scale prototype trialling, involving the drone service-provider, is planned. Prototype success will be followed by site trialling.


EMO

Contract Research

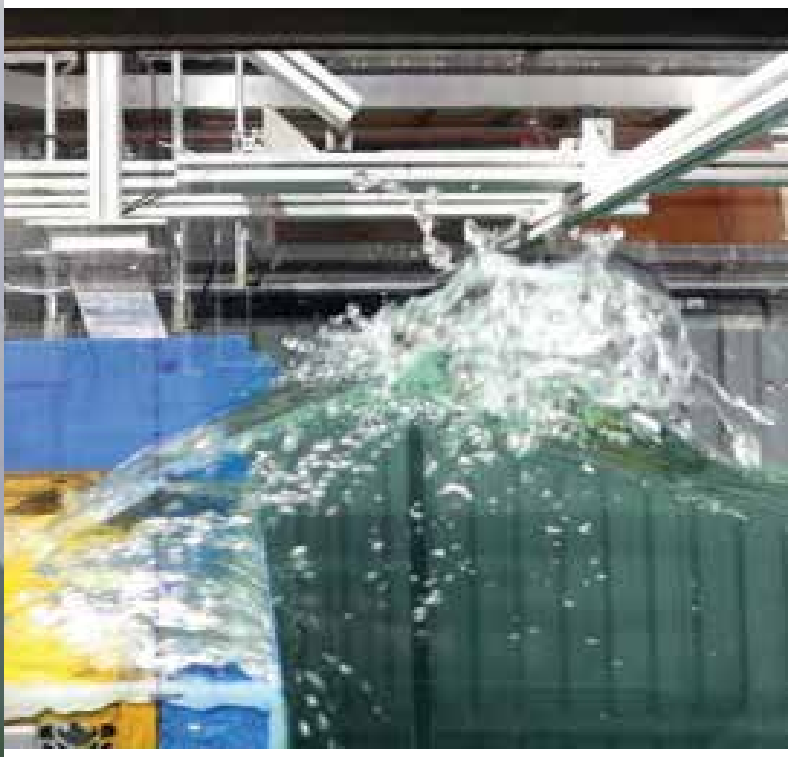
New research can be organised under our multi-project Framework Agreement, which creates shared value by supporting long-term research growing excellence in academia and industry practices. Under the Agreement, Cost Time Resource sheets (CTRs) are a mechanism designed to support larger scale research projects, sometimes following prototype validation. Well-framed CTRs help Woodside engineers collaborate with academics and experts across a range of technical fields and access a depth of expertise across the University.

CTRs are beneficial for their speed to action, as agreed academic rates have been negotiated and approved, and IP terms are defined (with options to own IP). Woodside is regularly invited to propose research projects under the CTR mechanism, and to work with academics to deliver valuable outcomes. CTRs are reviewed and approved by both parties.

Shaping Australia's Hydrogen Market

How might we better understand the demand for domestic hydrogen as a clean energy source?

This study Investigated the development of hydrogen markets in Australia, focusing on the forces influencing business customers' hydrogen energy and technologies adoption and the potential role of hydrogen hubs. A text analysis of academic, industry and media reports was completed, followed by in-depth interviews with 34 interviews with Australian industry, government and thought leadership stakeholders. Several specific drivers and barriers were identified, as well as participant plans for energy transition and potential solutions to barriers. Insights were also captured around the perceived role and performance of government, as well as four contrasting perspectives of the future of the Australian hydrogen sector.



Greenwater loading on deck for an FPSO with sponson

How might we better understand the merits of sponsons in FPSO design?

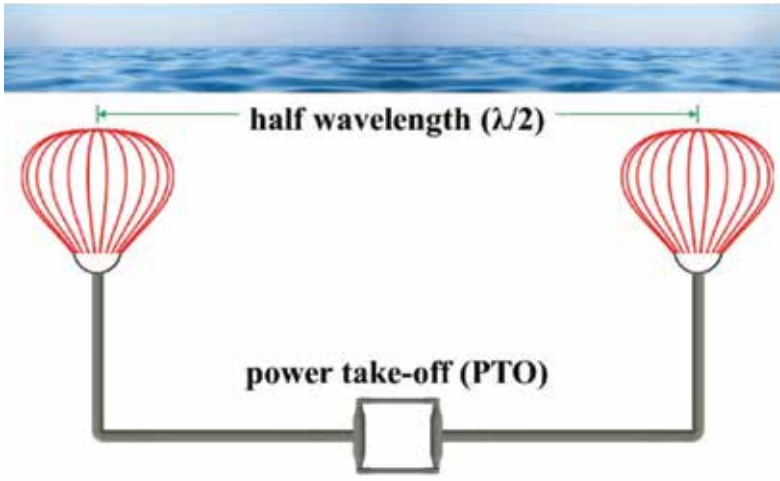
Experimental testing was undertaken in the 54 m long wave flume at the Coastal and Offshore Research Laboratory (CORL) to investigate green water loading on topside modules for the Browse FPSO. In the experiments, a fixed 1:100 scale model cross-section of the FPSO hull –including a sponson - was placed across the width of the flume, and an impermeable box was supported from above to represent a simplified topside module. Focused wave groups incident from the beam were simulated with underlying spectra chosen to represent realistic design sea states around the North West Shelf of Australia.

The work undertaken in this project leveraged Min Gao's PhD (part of TIDE). Detailed load time series and coincidental wave measurements were obtained from the experiments, which will be used to validate consultant's design models.

Coupled Balloon Wave Energy Device

How might we harvest energy from the ocean (waves)?

This project seeks to evaluate the performance and feasibility of a coupled balloon wave energy prototype. It will involve development of numerical models of increasing complexity (if justified by results from the previous stage) to capture interaction of waves with the balloons and the dynamics of the air pumped between volumes, including power take-off. Previous work has shown that coupled submerged rigid volumes with membrane 'lids' perform well as a wave energy converter, however, in practice there would be a large capital cost associated with the rigid chamber. If much of the performance could be maintained with balloons the cost may be substantially decreased.



Reliability-Based Assessment of Drag Anchor Capacity

How might we better assess drag anchor capacity?

Drag anchors are often used in offshore floating facility moorings. The standard drag anchor design is based on a deterministic Load and Resistance Factor Design framework that considers characteristic design 'low' and 'high' estimates of soil strength and other geotechnical parameters, combined with code-specified partial factors. A disadvantage of this approach is that anchor designs may not achieve a consistent level of reliability. We addressed this limitation by developing a generalised drag anchor probability of failure analysis framework for inclusion in a Reliability Based Assessment (RBA). Results from the first stage (focussed on capacity) will be published in 2024. In the next stage this will be combined with a rapid prediction of mooring line tension (using a trained ANN based on Orcaflex simulation data) to develop an overall RBA.

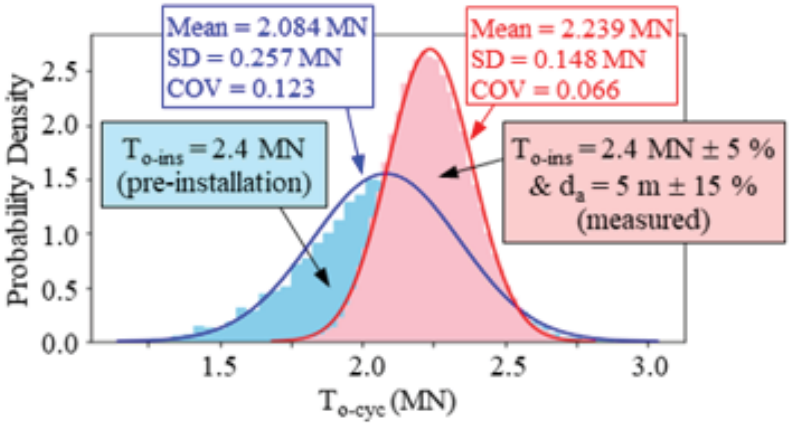


Figure: Histograms and Normal Distribution Fits to Anchor In-Place Cyclic Capacity

Using decommissioned materials for public art (circular economy)

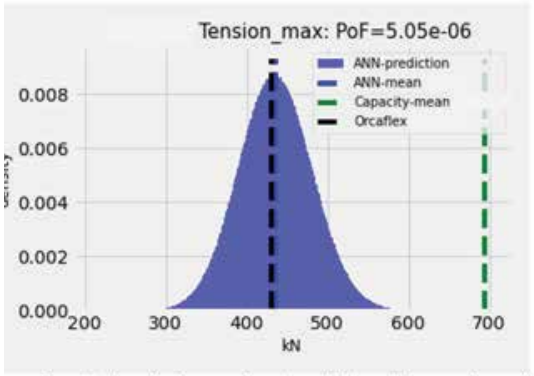
How might we re-use (rather than recycle) decommissioned products?

The project analysed 22 case studies to examine the repurposing of decommissioned materials into public art. It aimed to identify sustainable circular economy practices in the resource industry's nascent decommissioning market, worth around $60 billion. The research's critical findings indicated that public art not only fosters community engagement and identity but also serves as a narrative for resource conservation and circularity. The study provided a systemic analysis of the opportunities and barriers faced in Western Australia, offering valuable insights into the integration of circular economy principles in public art and the reception of such art by the public.

Rapid Post-Cyclonic Integrity Assessment of Flexible Risers

How might we minimise assessment/inspection by rapidly confirming flexible riser integrity post-cyclone?

This project seeks to identify ways to rapidly confirm the integrity of a flexible riser and thus expedite the resumption of production following exposure to an extreme cyclonic event. An efficient risk-based tool for rapidly assessing the post-cyclonic response structural integrity of flexible risers has been developed. Leveraging Machine Learning (ML) technology via an Artificial Neural Network (ANN), the predictive tool was trained using synthetic data to provide a near-instantaneous integrity assessment. The tool was validated using operational data from the Ngujima-Yin FPSO to demonstrate the effectiveness of using an ANN as a surrogate model. The tool uses a probabilistic framework for the assessment of structural failure risk and is currently in use within Woodside.



ıre: Empirical pdf of max tension obtained by monte-carlo ılation compared with Orcaflex

Reliability-Based Fatigue Analysis of Flexible Risers

How might we minimise intervention by better assessing riser fatigue capacity?

Recent studies suggest the deterministic conventional methods for the fatigue design of flexible risers are conservative and there's potential reserve fatigue capacity. This project seeks to quantify this benefit for life extension of aging risers. A novel method was developed to enable full Monte-Carlo (MC) simulations for quantification of the probability of failure in the fatigue assessment. The method employs ANN technology for rapid response prediction to enable the MC simulation results to be determined, and the performance of the method was successfully evaluated and verified. The methodology has been adopted by Woodside Energy for structural integrity management of two operating flexible risers on the Ngujima-Yin FPSO.

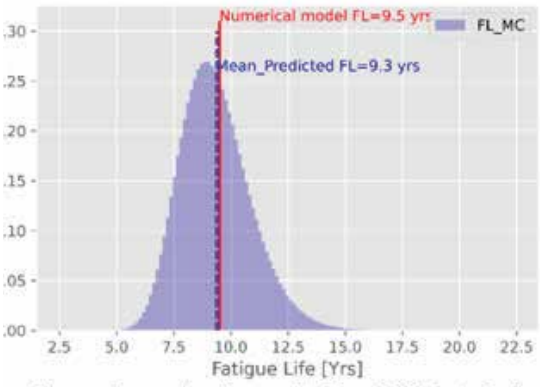


Figure: Comparing the results from 10^7 Monte Carlo runs with ANN results

Regional collapse of coral fringing reefs within Exmouth Gulf

How might we better understand coral reef lifecycle?

An extensive reef system extends 80 km along the Eastern side of Cape Range. Inspection revealed a broad reef terrace formed of dead coral framework and coral rubble. A systematic habitat survey at three locations found live coral cover was < 3% (dominated by turbid water species). A focused survey sampled coral diversity. The dead coral had high diversity (19 unique coral genera). Radiocarbon dating of 37 samples identified mass mortality events in three age clusters. Corals within the cemented reef had infinite ages (indicating last interglacial age). Corals on the reef surface were aged 6400-6900 yrs (mid-Holocene). Other corals returned modern ages (post 1950 AD). Planned uranium series dating should provide a more precise timing of the event(s), increasing our understanding of the sensitivity of coral reefs to environmental impacts.

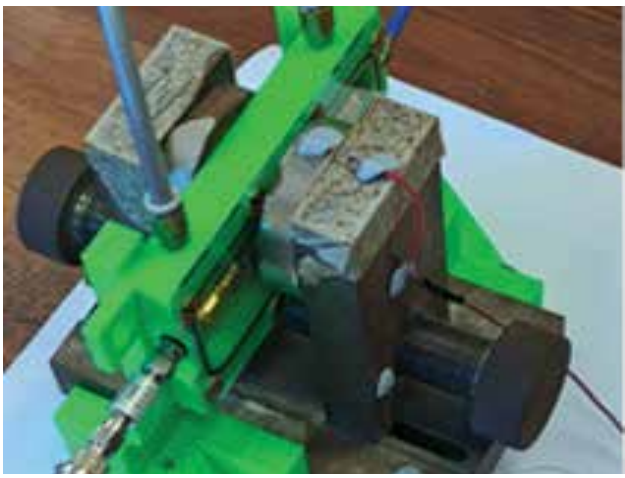
Taking a bite out of plastic pollution

How might we dispose of plastics using biological solutions (worms)?

This study aims to contrast the degradation of commercial expanded polystyrene (EPS) with that of pure EPS by superworms (Zophobas atratus larvae). We are testing the worms' ability to decompose both forms of polystyrene. The pure EPS serves as a control. The commercial EPS, however, contains various additives. The current stage of our research involves detailed observation and analysis of the larvae's efficacy in degrading these materials. The results promise to provide groundbreaking insights into the adaptability of superworms in recycling EPS waste and to assess whether commercial additives present in EPS alter the degradation efficiency. The findings may materially improve bioremediation strategies and contribute to the development of more sustainable approaches to managing polystyrene waste.

Magnetic Hydrogen Gas Sensor

How might we reliably detect hydrogen across a wide concentration range?

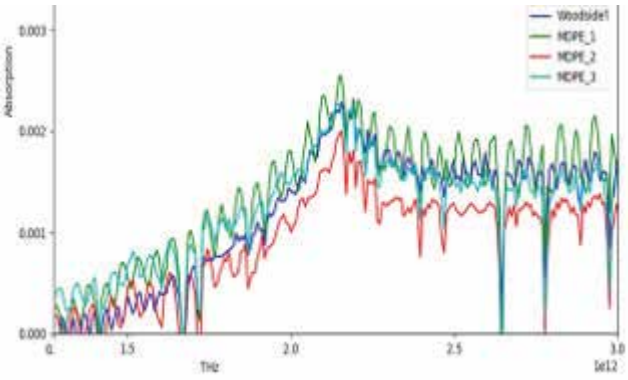


This project sought to develop an integrated, stand-alone device-prototype of a hydrogen (H2) gas sensor based on a palladium-containing magnetic film. The sensor was to be tested in a hydrogen gas concentration range from 0.5% to 100%. The sensor was to be benchmarked against existing commercially available sensors The goals of the research were achieved in full. A stand-alone prototype sensor based on the physical effect of Ferromagnetic Resonance (FMR) was developed. We demonstrated successful detection of 0.5% to 10% of H2 gas in nitrogen (as a proxy for air). The repeatability of the detection was very good. The sensor response time to the presence of 0.5% of H2 is comparable to commercial hydrogen gas sensors. The prototype would fulfil many criteria for H2 safety sensors. Currently seeking funding for further maturation.

Assessing degradation of plastics used in subsea equipment

How might we support decommissioning decisions (plastics)?

This project evaluated the use THz-TDS in assessment and characterisation of plastic degradation in seawater using accelerated ageing experiments. The research found that HDPE has unique THz spectral features which allows for easy identification of samples. THz absorption was shown to increase in seawater, due to water diffusion into the sample, but there was very little change in refractive index which means that reliable thickness measurements can be made over the lifetime for a sample, and any change would be due to material loss into the environment. This approach can inform decommissioning decisions as to whether the plastics have degraded or remain fully intact.



THz absorption spectrum of HDPE, with a characteristic peak at 2.2 THz

CEEDWA

Cooperative Education for Enterprise Development

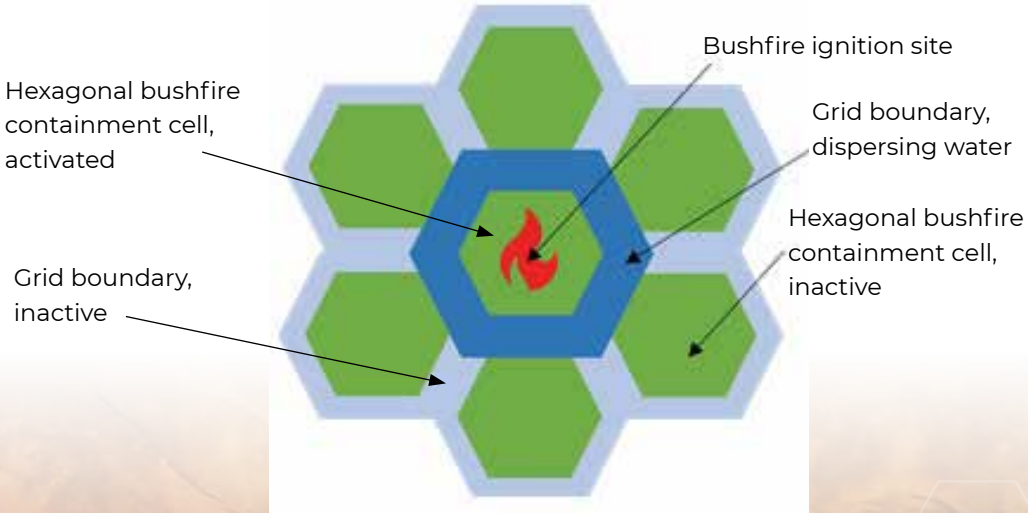
CEED Projects are Industry Sponsored Student Research Projects, in which Woodside Energy defines the project topic and deliverables, and mentors the student in partnership with an academic supervisor as they complete the project for academic credit.

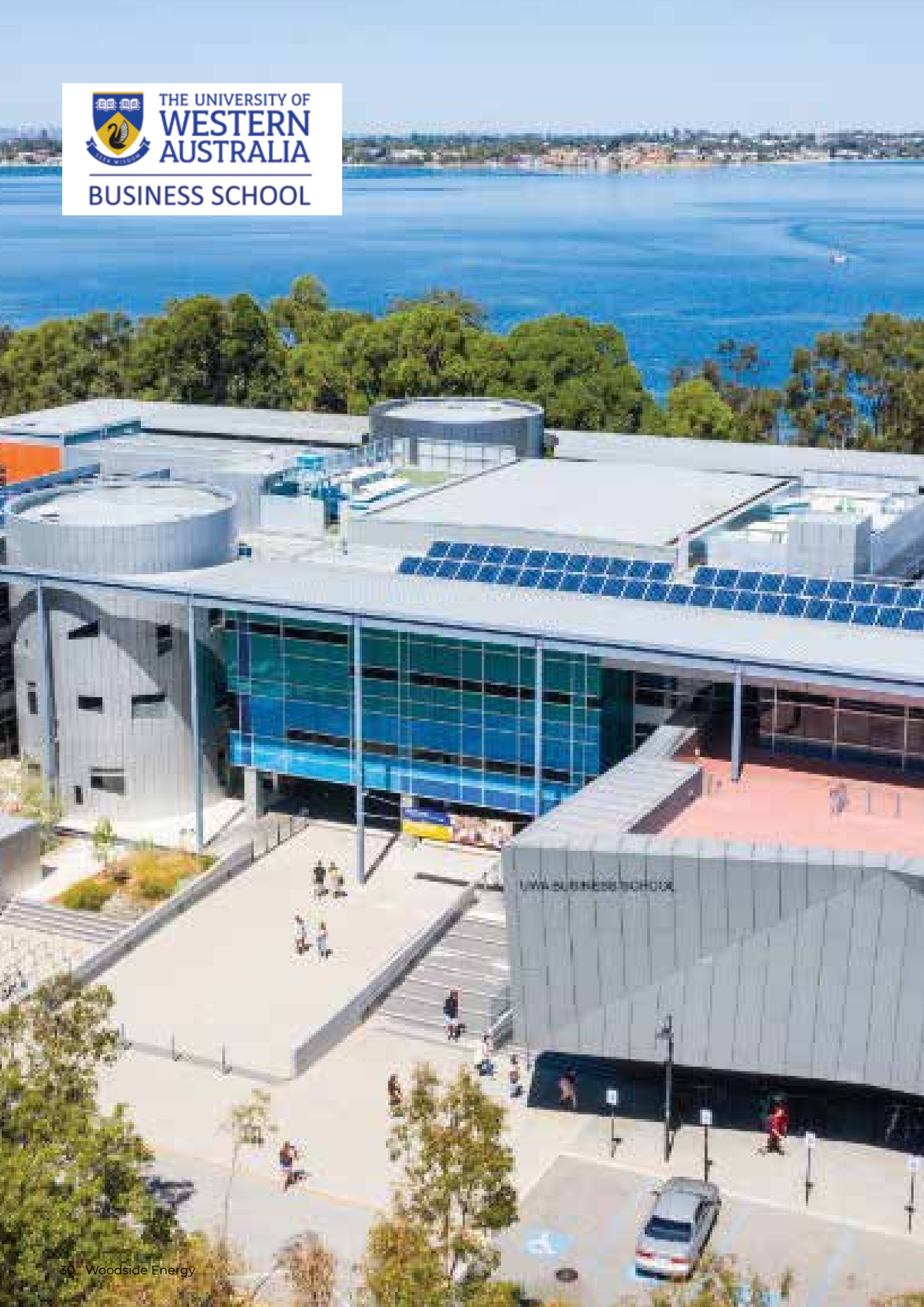
- CEED has been a long-term partner of Woodside Energy and Futurelab
- The extension of CEED from UWA to include Curtin was pioneered in partnership with Woodside Energy
- Many CEED alumni have gone on to join Woodside Energy as graduates (including students sponsored by other clients)
- CEED can access any discipline that has a suitable research project unit.
- Successful past CEED projects have included:
  - Hydrodynamic Forces on Subsea Pipelines
  - The development of torpedo anchors for offshore wind structures constructed from decommissioned flexible pipe
  - Determining the critical velocity for transport of sand particles in stratified gas/condensate/water flows for varying pipe inclines and roughness
  - How a Lessons Learned Strategy can be Successfully Designed and Implemented within a Technical Engineering Environment
- 3 CEED projects are currently in development for 2024

Controlling Bushfires – A Feasibility Study

How might we re-use (rather than recycle) decommissioned products?

Rural Australian communities face a significant risk of losing lives or property to bushfires. As the climate trends warmer, there is an expected increase in the incidence of weather in which extreme fires occur. Simultaneously, multiple oil/gas extraction operations on state, national and global scales must either dispose of or reuse decommissioned flexible flowlines. These flowlines consist of high-quality materials and can transport fluids at high pressures even after decommissioning. Thus, there is an opportunity to investigate whether these flowlines can be used in combatting the increasing threat of bushfires. This project examines the technical feasibility of using these flowlines to produce a fixed bushfire containment grid. On ignition of a fire within the grid, each grid cell disperses water to ensure containment of the fire within a single grid cell. To determine this feasibility of this grid, modelling was conducted starting from a set of environmental conditions, then working out the expected severity of the bushfire under these conditions, the volumetric flowrate required to contain the fire at the grid boundary, to arrive at a required peak and total flowrate of water for containment. It was found that the proposed grids could feasibly protect against highly severe bushfires.




THE UNIVERSITY OF
WESTERN
AUSTRALIA
BUSINESS SCHOOL

Woodside Energy Chair in Leadership & Management

Gillian Yeo is Professor and Woodside Energy Chair in Leadership and Management in the Department of Management and Organisations at the UWA Business School. The Woodside Energy Chair aspect of her role is targeted at building research capacity, with a particular focus on facilitating industry engagement and collaborative research, both at Woodside Energy and beyond. Initiatives include "Research & Reflection" events (e.g., with Woodside Energy on International Women's Day), career development workshops with early career researchers, industry grants (e.g., with MATES in Construction WA to examine suicide prevention, and the Australian Research Council to address fire safety), and planned "Open Fishbowl" panel discussions amongst researchers and practitioners.

2023 International Women's Day: Women in the Workplace

How might we develop a more inclusive workforce?

Professor Gillian Yeo, and her team of researchers from the UWA Business School developed a "Research & Reflection" event to present a range of gender-diversity research initiatives currently being investigated at UWA, with a focus on potential implications for employees and managers. This event provided an opportunity for Woodsiders to reflect on how these findings, along with related research implications can be incorporated into Woodside Energy's ideal work experiences. Topics included:

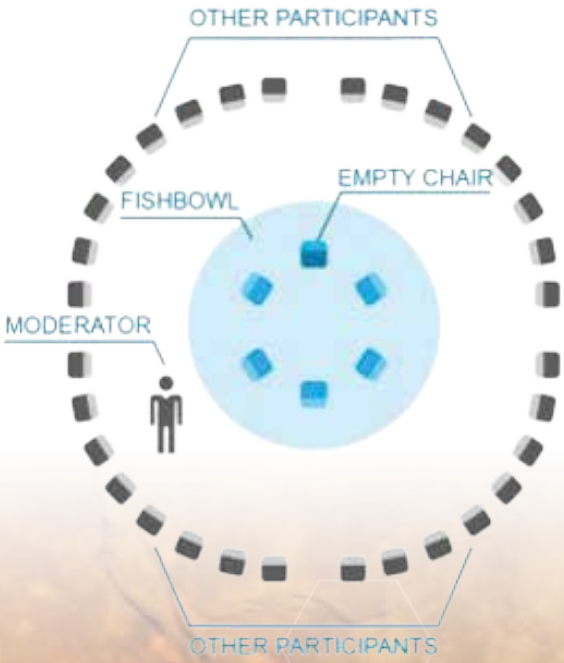
- The Mental Load
- Presenteeism (turning up to work sick)
- Job Performance
- Career Success

2024 Open Fishbowl Conversations

How might we apply inclusion & diversity research findings in practice?

One of Professor Yeo's initiatives is targeted at early career researchers, to assist them in strengthening their links with industry. As part of this, she plans to run some "Open Fishbowl" sessions, in which she will invite panel members from a range of organisations and facilitate an informal, open discussion amongst practitioners and researchers on a timely topic. Possible topics include:

- The Mental Load
- The "3 M's" (Menstruation, Maternity and Menopause)
- Regulatory Changes for Reducing Carbon Emissions
- The Power of Social Networks
- Potential Benefits of "Doing Nothing"



Industry Research Collaborations

Industry-research collaborations bring together multidisciplinary teams to tackle complex industry or global challenges through formal partnerships. Companies, universities, and government agencies contribute cash and in-kind, and the collaborations address critical problems, provide research data, and facilitate knowledge exchange and professional development. The Australian Government provides several funding mechanisms to support long-term strategic research alliances that bridge the industry-academia gap.

ARC Linkage Projects
The Australian Research Council (ARC) is a Commonwealth entity within the Australian Government. The ARC Linkage Projects scheme promotes national and international research partnerships between researchers and business, industry and community organisations. The Linkage Projects scheme provides project funding of $50,000 to $300,000 per year for two to five years.

Joint Industry Projects
Joint Industry Projects offer a way of bringing together unique knowledge within a partnership. Joint Industry Projects are too complex or too costly to be handled by one party and they require specific knowledge, equipment which is not at hand in one company. Joint Industry Project partners cooperate, share costs and benefits.

Industry-funded centres
Industry-funded centres can spearhead research for new technologies in a specific sector, fostering collaborative opportunities to address real-world challenges and unlock new prospects. Joint centres are established where the participating companies share mutual interests, such as increasing a shared region or asset's market competitiveness, and are usually founded following successful collaborations.

Research Consortium
A research consortium generally involves several companies in a specific industry sector funding universities to address a common set of questions or goals using a defined structure and governance model. In return, the university will research solutions to critical problems identified by the companies and provide critical research data.

Industrial Transformation Research Hubs
Industrial Transformation Research Hubs are an initiative of the Australian Research Council (ARC) to fund collaborative research projects that benefit industry partners in targeted industry sectors. The Hubs undertake cutting-edge research on new technologies and economic, commercial and social Itransformation. Funding of between $500,000 and $1 million per annum for between 3 to 5 consecutive years may be awarded for each Industrial Transformation Research Hub.

Co-operative Research Centres
The Cooperative Research Centres (CRC) Program is an Australian Government initiative that funds industry-led collaborations between industry, researchers and end users. CRC grants support medium to long term industry-led collaborations through multi-million-dollar funding for up to 10 years, and typically result in the creation of a not-for profit entity.

Australian Government
Australian Research Council

ARC Linkage

Working in co-design - Indigenous and western knowledge systems

Desert to the Sea: Managing Rock Art, Country and Culture

How might we enable efficient and effective cultural surveys and estate management?

This Project will expand our understanding of Aboriginal settlement of Australia's deserts by exploring how mythological narratives and rock art enable knowledge transmission. It brings together Indigenous and western scientific knowledge systems to develop improved management outcomes for vast cultural estates.

This significant collaboration with Murujuga, Jamukurnu Yapalikurnu and Mungarlu Ngurrarankatja Rirraunkaja Aboriginal Corporations is focusing on four research nodes including, exploring connections between water, rock art and mythological narratives through intergenerational and two-way knowledge transfer; making wood and plant reference collections and managing fire regimes to protect rock art site; repatriating museum and private collections to communities; and developing databases and curriculum for Indigenous rangers managing significant cultural heritage estates.

Start
2019

End
2023

Dating Murujuga's Rock Art: new scientific approaches

How might we enable efficient and effective cultural surveys and estate management?

The land and seascape of Murujuga is of national scientific and cultural significance but we still know little about its local palaeo-climate, or age of rock art production. This project is developing innovative scientific approaches to direct-date engravings and stone structures, exploring age of desert varnish (with U-series and dNA of microbiome) and through luminescence rock surface dating; reconstruct climate from geological proxies – i.e. carbonate tufas (including modelling hydrology, pollen and isotope analyses); claypan and dune cores; and model voyaging opportunities as this cultural landscape transformed to a seascape.

This significant collaboration with Murujuga Aboriginal Corporation will improve the conservation and management of one of Western Australia's premier cultural heritage places.

Australian Government
Australian Research Council

ARC Linkage

Building a CO_2 Foundry

How might we capture and use carbon commercially?

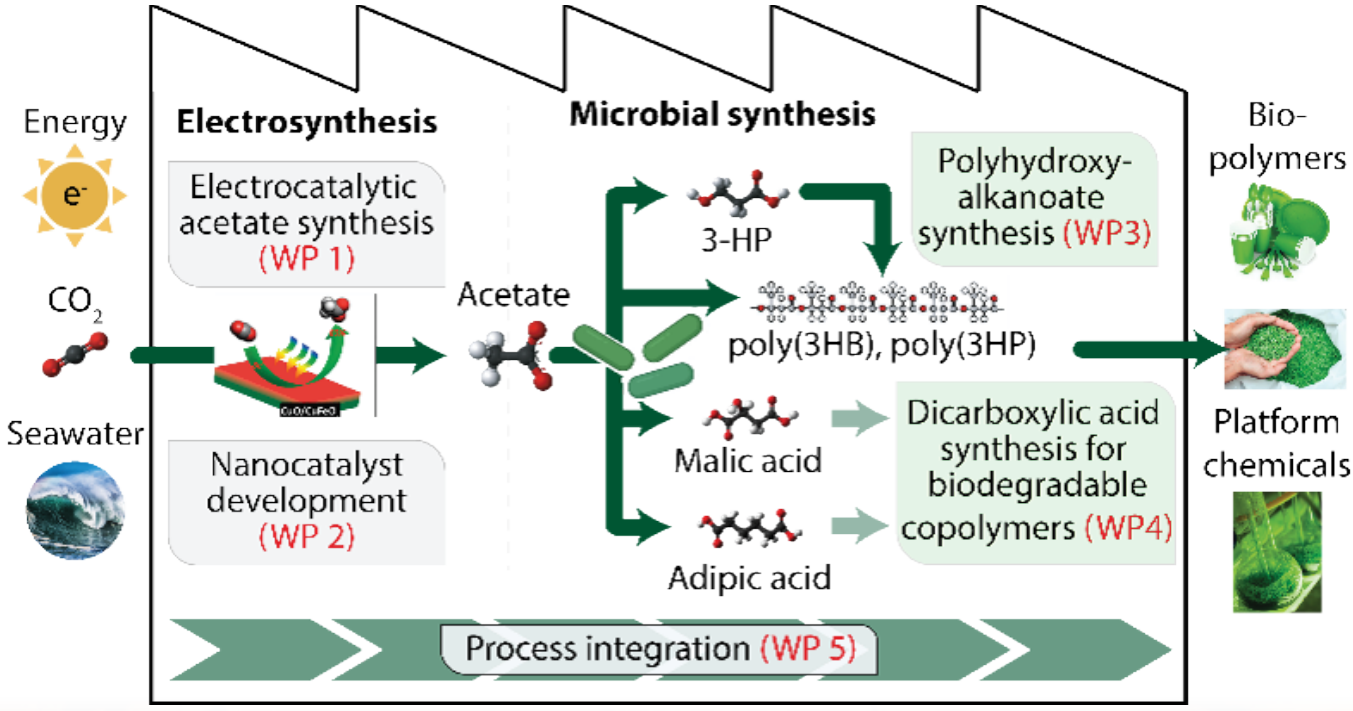
This project seeks to develop an innovative carbon capture and utilisation technology fusing synthetic biology with inorganic chemistry. The technology utilises nano-structured copper electrocatalysts to efficiently convert CO_2 from industrial emissions into the C2 feedstock acetate, and genetically-engineered microbes to rapidly transform acetate into platform chemicals and biopolymers.

Excellent international staff have been recruited and will commence their work in Nov 2023 and Jan 2024.

The CO_2 foundry is designed around the genuine needs, restrictions, and opportunities of Woodside Energy, including the availability of high-purity CO_2 from gas plants and renewable energy from Woodside Energy's photovoltaics investment in Western Australia's Karratha region.

The project follows five independent work packages (WPs):

- WP 1: Optimising parameters for electrocatalytic CO_2 reduction to acetate.
- WP 2: Developing enhanced nanocatalysts to maximise acetate synthesis rates.
- WP 3: Engineering bacterial production pathways for biopolymer synthesis from acetate.
- WP 4: Engineering fungal production pathways for dicarboxylic acid synthesis from acetate.
- WP 5: Integrating chemical and microbial synthesis in a laboratory-scale demonstration plant.



Start
2023

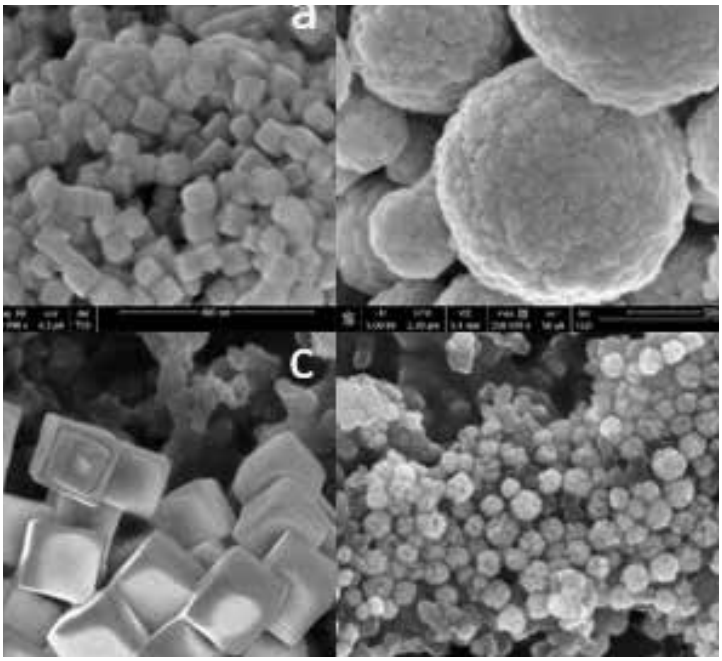
End
2026

Key findings

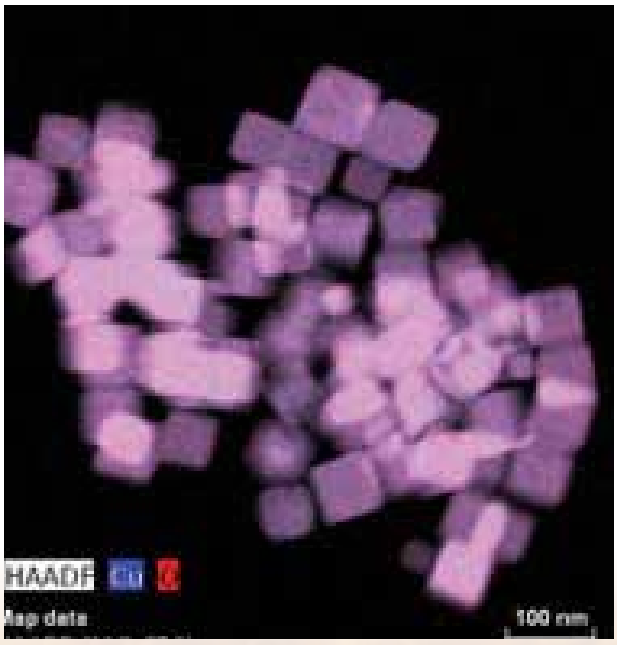
- Synthesis of Cu_2O nanoparticle electrocatalysts with controllable sizes, shapes under different experimental conditions, including CO_2 directed 'evolution' of surface structures
- Electrosynthesis of oxygenated hydrocarbons, including formate, acetate, and ethanol.
- Engineering of microbial platforms to turn over acetate to poly(3-hydroxypropionate) (PHP) and poly(3-hydroxybutyrate) (PHB)
- First evidence of CO_2 to PHB conversion in V.alginolyticus bioplatform

Current work

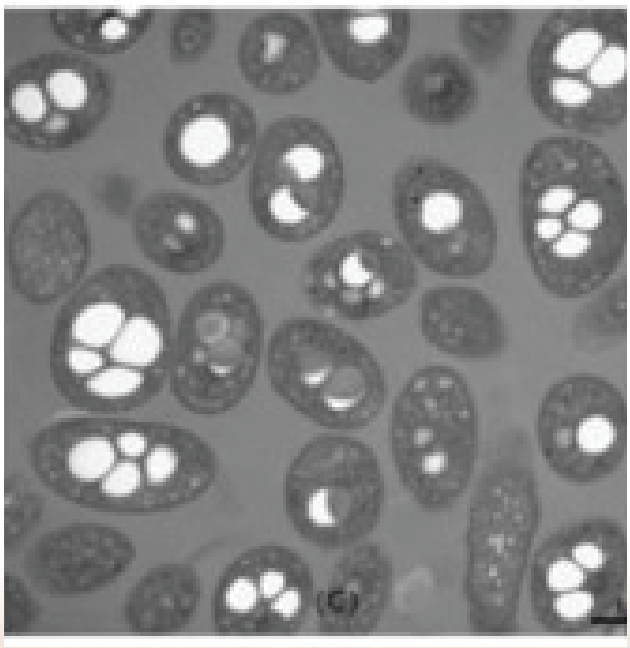
- Tailored nanoparticle synthesis under CO_2/CO to create surface structures optimised for CO_2 /CO binding and increased faradaic yield of acetate (WP1/WP2).
- Optimizing media and conditions for maximized microbial biopolymer production (WP3/WP4)



SEM images of synthesized nanoparticles with different morphology



TEM Image showing distribution of elements in cubic nanoparticles


PHB production in V.alginolyticus

TASER - Transforming Australian Subsea Equipment Reliability

How might we <insert>?

The SEAR-JIP Transforming Australian Subsea Equipment Reliability (TASER) project has seen the deployment of subsea testing structures (STS) within the oceanic waters of the Australian North West shelf for the assessment of marine fouling on materials and equipment that will see use in offshore operations. STS 1 (Gorgon) and STS 2 (Jansz) were retrieved after nearly 5 years of deployment, fitted with innovative coatings, materials, and technologies to assess their performance against calcareous deposition and biological growth. The STS were called “Living Laboratories” for their ability to deploy directly within the marine environment to provide ecological and physicochemical conditions typical of maritime operations.

Innovative approaches in the form of environmental DNA and RNA sequencing were used to assess the biodiversity and biological activity of biospecimens collected from across the different material and equipment samples. These “sampling sites” across both STS showed a highly diverse range of taxa, with nearly 10000 species of prokaryotes, and over 2000 species of eukaryotes (consisting of sessile marine invertebrates and algae) uncovered from the DNA data. However, as roughly 90% of the DNA data was unable to be classified due to a lack of matching DNA sequences from current scientific databases, the true levels of biodiversity within this biofouling communities are expected to be far greater. Nevertheless, the community compositions of biodiversity were scrutinised for any differences – significant deviations in sampling sites when compared to the baseline material meant the tested material/equipment in question was able to exert considerable ecological influence and could be shortlisted for further testing. The RNA data from select sites showed the potential of the environmental sequence approach to discern effective anti-fouling effect. Testing was able to identify material that was less likely to promote the expression of gene groups that are involved in biofilm formation – a crucial step in the development of biofouling communities.

The “dark matter” or yet unobserved biodiversity in the DNA data was processed further, via the reconstruction of prokaryotic genome from environmental data to produce explicit microbial candidates. The genomes of the reconstructed candidates screened for proteins involved with microbially induced calcite precipitation (MICP), a process where calcareous deposition occurs biologically. We discovered that nearly 90% of the recovered genomes had MICP potential, indicating that the prokaryotic population within the NW Shelf have a high potential to contribute to hard fouling. The MICP proteins were predominately related to nitrogen metabolism, indicating that the process is likely due to nutrient cycling and energy production, offering a potential target for further study for the disruption of ecological processes in biofouling communities.

In summary, the environmental sequencing approach utilized in the TASER project has delivered value in investigating fouling biodiversity on a large scale and have enabled cross sample assessment on the effectiveness of anti-fouling materials and coatings for applications in subsea operations.

Start
2022

End
2024

Industry Funded Centre

2023-2024 Theme: Technology to Reduce Capital and Carbon Intensity

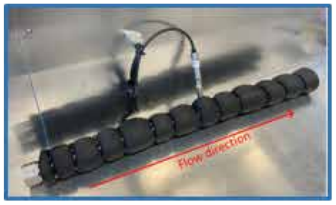
A new JT Expansion Loop at UWA: 100 bar drop across a 60o choke

How might we test hydrate formation across a choke to validate our simulations?

Designed to interrogate fluid behaviour and hydrate formation under extreme expansion

- 2023 scoping campaign completed to update UWA's Hydrate Extension (for OLGA, Virtuoso)
- 2024-2025 industry campaigns underway to study MEG reduction during restart across choke
- Collaboration (A/Prof. Paul Stanwix) on new, non-invasive deposition sensor (microwave cavity)

Controllable JT Valve



Detachable Test Section (0.83" ID)

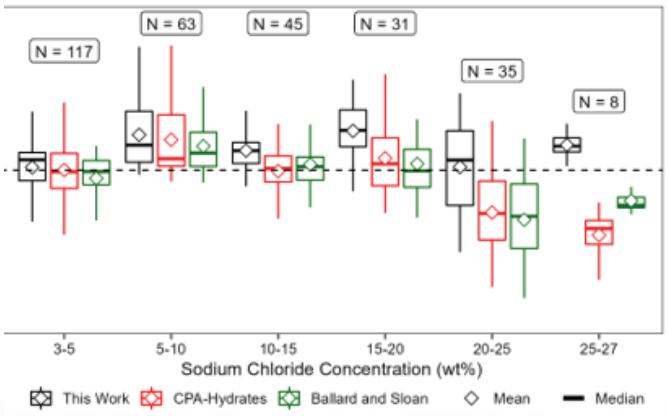
Post-experiment Visual Inspection

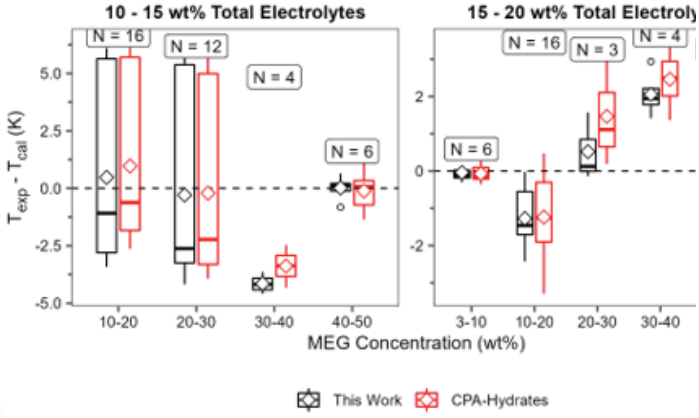
Hydrate Thermodynamics with Gibbs Energy Minimization

How do we improve the reliability of predicting hydrate thermodynamics?

3rd-generation GEM tool (ThermoFAST) published in 2023 with best-in-class phase prediction

- Hydrate phase boundary/properties with 60% parameter reduction from existing GEM methods
- Simultaneous hydrocarbon VLE, SLE with automated and tuneable pseudo-components;
- Integrated complex electrolyte model (no additional parameters), as accurate as Multiflash 7





CENTRE FOR LONG SUBSEA TIEBACKS

Start 2019 — 2022 — End 2023

Pseudo Dry Gas (PDG) High-Pressure Flowloop Campaign (at NEL)

How might we leverage UWA's modelling capabilities to enable pseudo-dry-gas?

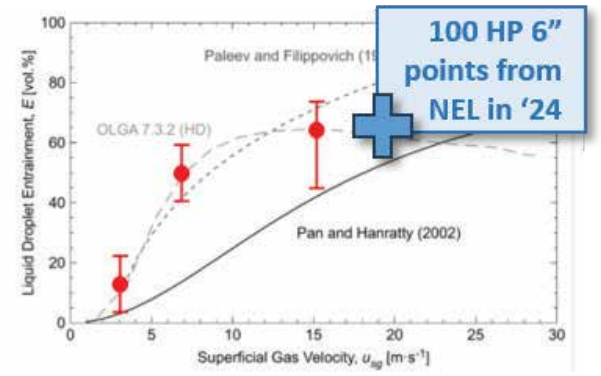
UWA is the key academic research partner supporting Intecsea's international operator consortium

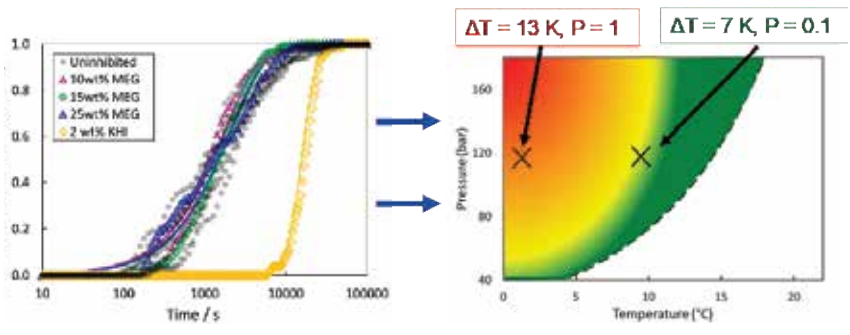
- Responsible for developing OLGA extension for operators to "try" PDG units (90% complete)
- Experimental design and support for successful 2023 HP flowloop campaign at NEL (100+ cases)
- Alongside confidential performance data, captured hundreds of HP, large ID (6") entrainment points: analysis and update ofentrainment models underway

Updates to the UWA Hydrate Extension: Entrainment, Nucleation

How might we deliver our state-of-the-art hydrate knowledge into industry software?

Now deployed with OLGA (Schlumberger), Virtuoso (Wood), and as a steady-state implementation in Maximus (KBC) to support tieback design/scoping





Improved entrainment predictions

- Critical to hydrate kinetics, ToL
- Dataset enables entrainment and uncertainty prediction

First integration of nucleation probability

- Built through 10,000 HPS-ALTA points (above, left)
- Sensitivity to composition and PT conditions,enabling dynamic probability map (above, right)

Research Consortia

Quantitative Seismic Stratigraphy & Reservoir Analogues (QRA)

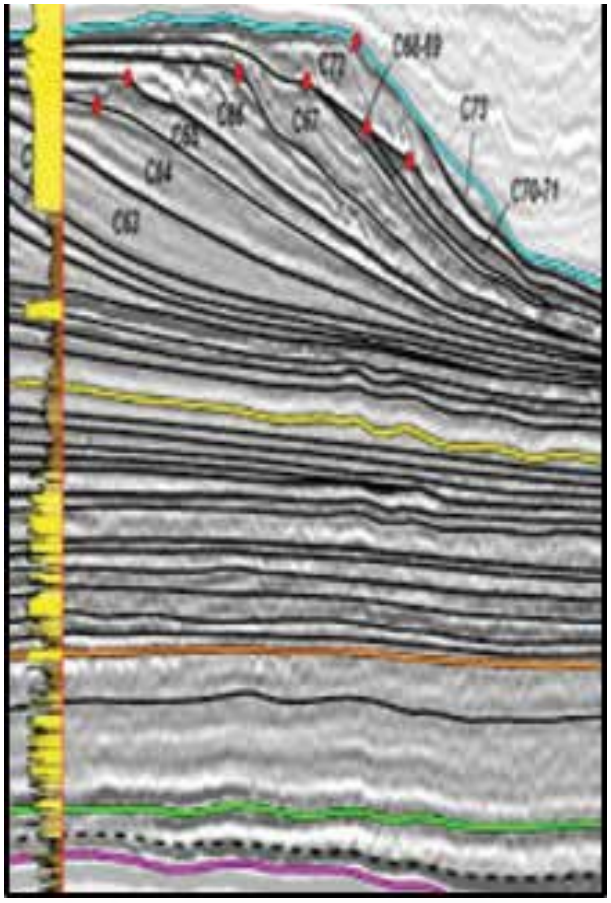
How might we support technical excellence in geoscience?

The QSS & RA projects (multi-company consortia) were developed as part of a Woodside-UWA Partnership from 2020 to 2022. Sponsors recommended they now be merged into a single consortium (QRA) for the next phase (2024-2026). The projects had close shaping from Woodside to meet their exploration, CCS and subsurface modelling objectives. These have delivered significant impact for Woodside Energy via workshops, field-based staff training, modelling guidance and confidential consulting.

ELEMENT COMPLEXES

Reservoir analogues developed from seismic interpretation of ancient examples, and field mapping of modern depositional systems, form a key resource for geoscientists as an aid to exploration, field development/production, subsurface reservoir modelling (including CCS) and shallow hazard analysis. Analogues offer vital quantitative data for comparison with sponsor datasets and enable projection into areas never drilled. They underpin risking protocols by predicting lithology and the presence and effectiveness of reservoir and seals (containment).

For QSS, large multiclient and propriety seismic datasets from a global range of basin types are interpretated specifically to investigate the linkage between paleo- shallow marine and fluvial processes on the shelf margin to their time-equivalent deepwater basin floor deposits. The focus is on shelf margin clinoforms from a range tectonic and climatic basin settings, mapped using full-volume 3D-interpretation workflows from seismic data correlated to existing well data where possible. For RA, three modern deltas spanning increasing tidal range were mapped at element complex scale using LIDAR, drones, with ground-truth, and the development of a new, automated satellite bathymetry map of much of the Australian shelf margin.



CLINOFORMS

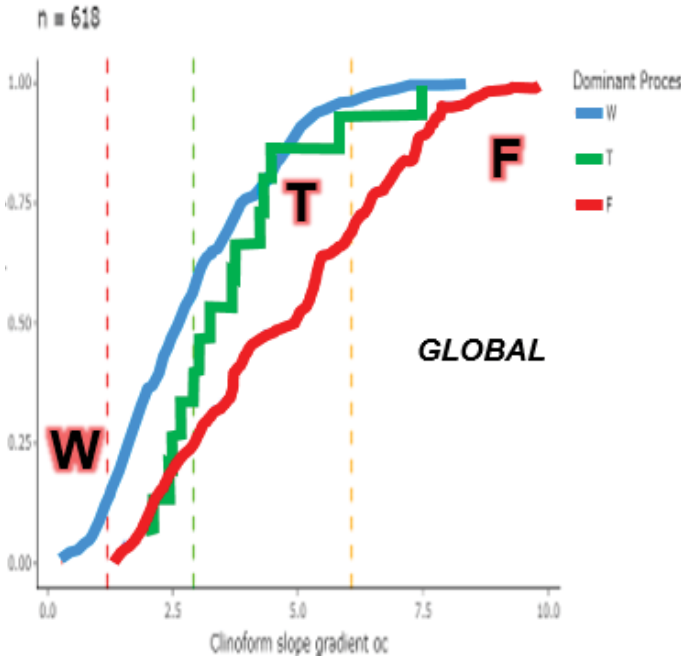
QSS &RA1
2020-2022

2023

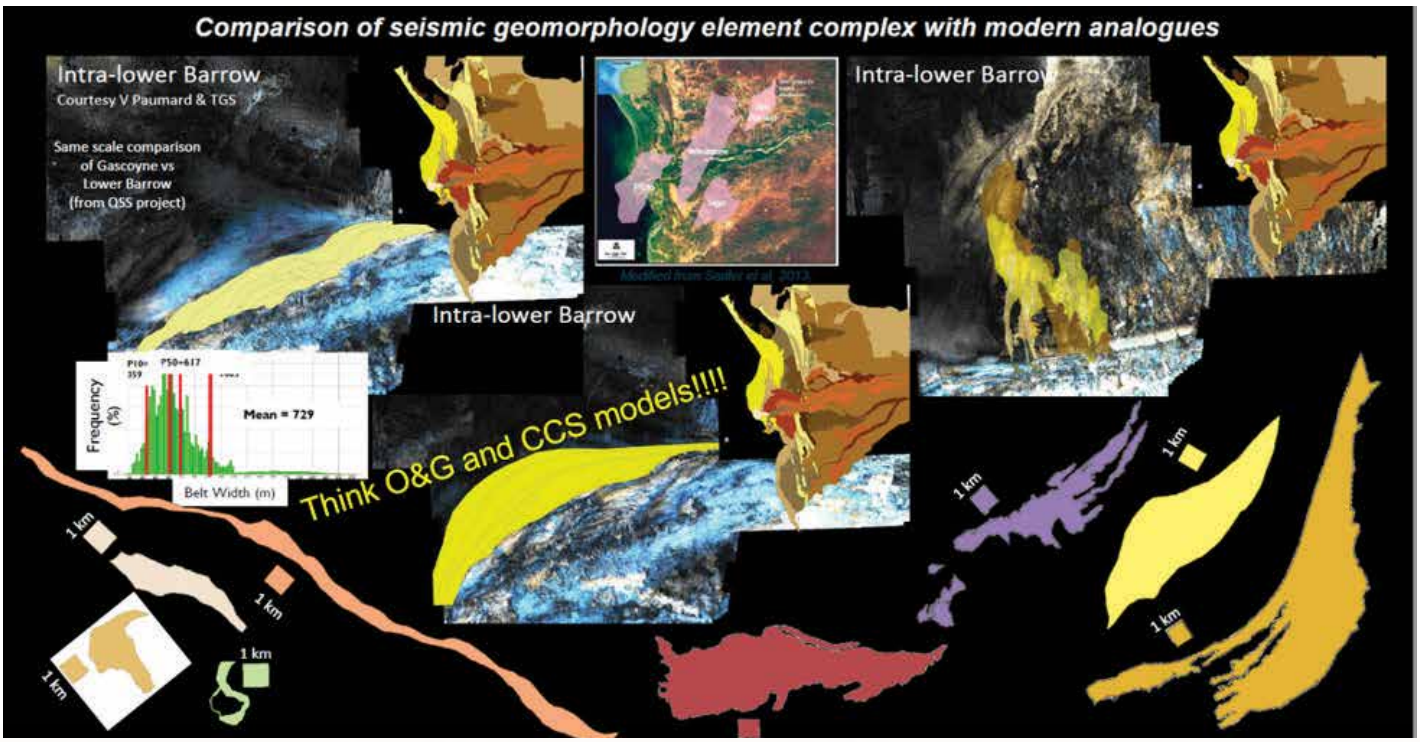
QRA
2024-2206

Key findings amongst many include recognition of twice-steeper clinoforms associated with fluvial and to a lesser extent tidal dominance at the shelf break and longer run-out distances for deepwater channel complexes. Tidal processes magnify the size and can improve connectivity of river mouth bars, whereas waves improve reservoir quality, and increase asymmetry. Morphometrics of element complexes and juxtaposition provide key data for scaling (e.g. channel belt and bar statistics).

Deployment is via bi-annual workshops, field training courses, and confidential call-off workshops. Metrics and predictive tools are deployed via virtual dashboards that contain the two databases (QSS metrics & Element Complexes).



GLOBAL



Australian Government
Australian Research Council

Industrial Transformation Research Hub

Transforming engery Infrastructure through Digital Engineering

Applied Theme 1

How might we use data to create better forecasting tools for ocean and seabed?

TIDE AT1 focuses on characterising the ocean environment using sparse and uncertain data.

- Employs observations, statistical techniques and physics-based modelling to build forecast models that characterise the ocean environment, with appropriate quantification of uncertainty in these predictions.
- Recent work includes a major 2023 fieldwork campaign in the Browse Basin which utilised SWOT satellite data to inform predictive modelling systems to better understand dynamic ocean processes.
- Other activity includes deployment of drifting wave buoys to improve wave forecasts through data assimilation; and the study of various data science approaches to predict ground conditions at unsampled locations.

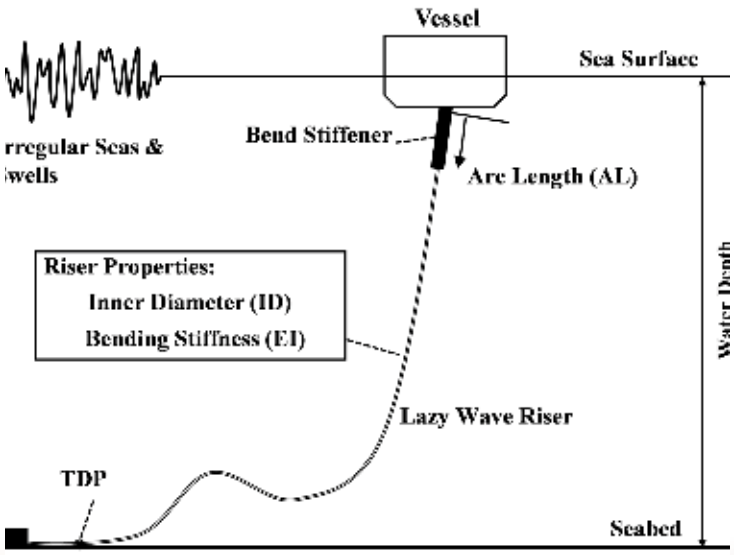
Deployment of wire walker mooring to profile the water column on RV Solander.

Applied Theme 2

How might we improve our assessment of ocean-structure interaction to optimise design?

TIDE AT2 studies environmental effects on structures at the sea surface for enhanced decision-making. It is improving the design of infrastructure located at the sea surface by:

- Predicting vessel motion across various time-scales, covering individual events, operational windows and installation periods. This includes developing field-verified engineering models capable of predicting vessel motions and resulting stresses.
- Improving the modelling of loads associated with extreme events to reduce damage and downtime.
- Application of Response Based Analysis methods to improve the prediction of extreme response / capacity of key offshore infrastructure e.g. steel catenary risers, flexible risers, drag anchors, FPSO motions, etc. Includes the use of AI to enable rapid assessment of response prediction.



Overall view of a flexible riser system

Start
2021

2023

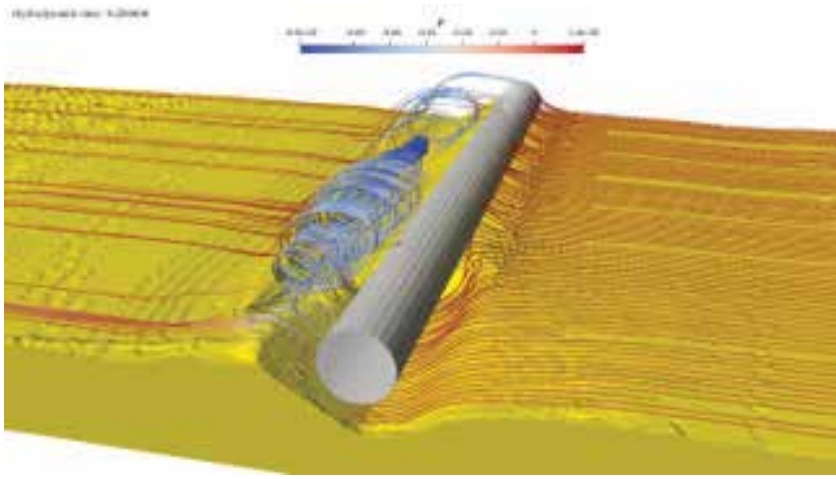
End
2026

Applied Theme 3

How might we reduce operational costs through data informed prediction of complex seabed interactions?

TIDE AT3 seeks to optimise the management of infrastructure on an evolving seabed, including through improved understanding of how seabed changes impact the response of infrastructure.

- Working with observations gathered from offshore pipelines (and over extended periods) to inform future design practice, and support better operational design making.
- Using of numerical simulations, physical experiments and field data to reveal key physics for pipeline freespans – with the goal to reduce costs associated with inspection and remediation activities.
- Developing tools to predict and mitigate scour around subsea infrastructure, by combining numerical and experimental assessments, supported by field data.



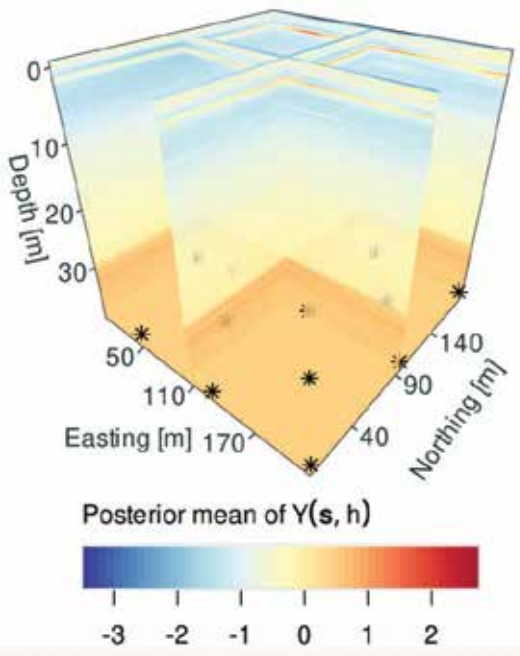
Simulated three-dimensional scour development of a free spanthe water column on RV Solander.

Enabling Theme

How might we use statistics and data science improve our understanding of physical processes?

TIDE ET is integrated into all applied themes, providing expertise in data science and the handling/ analysis of big data – which is key to enabling insights and inferences on critical processes in offshore engineering.

- Deliver statistical spatio-temporal modelling, statistical and AI forecasting, Bayesian optimisation and emulation to facilitate design/ decision-making in uncertain environments.
- Focus on developing tools for analysis/ evaluation of time-series data; both stationary and non-stationary, in the time and spectral domains, and with engineering applications.



3D simulation of CPT data using GeoWarp

Australian Government
Australian Research Council

Co-operative Research Centre

Future Energy Exports CRC

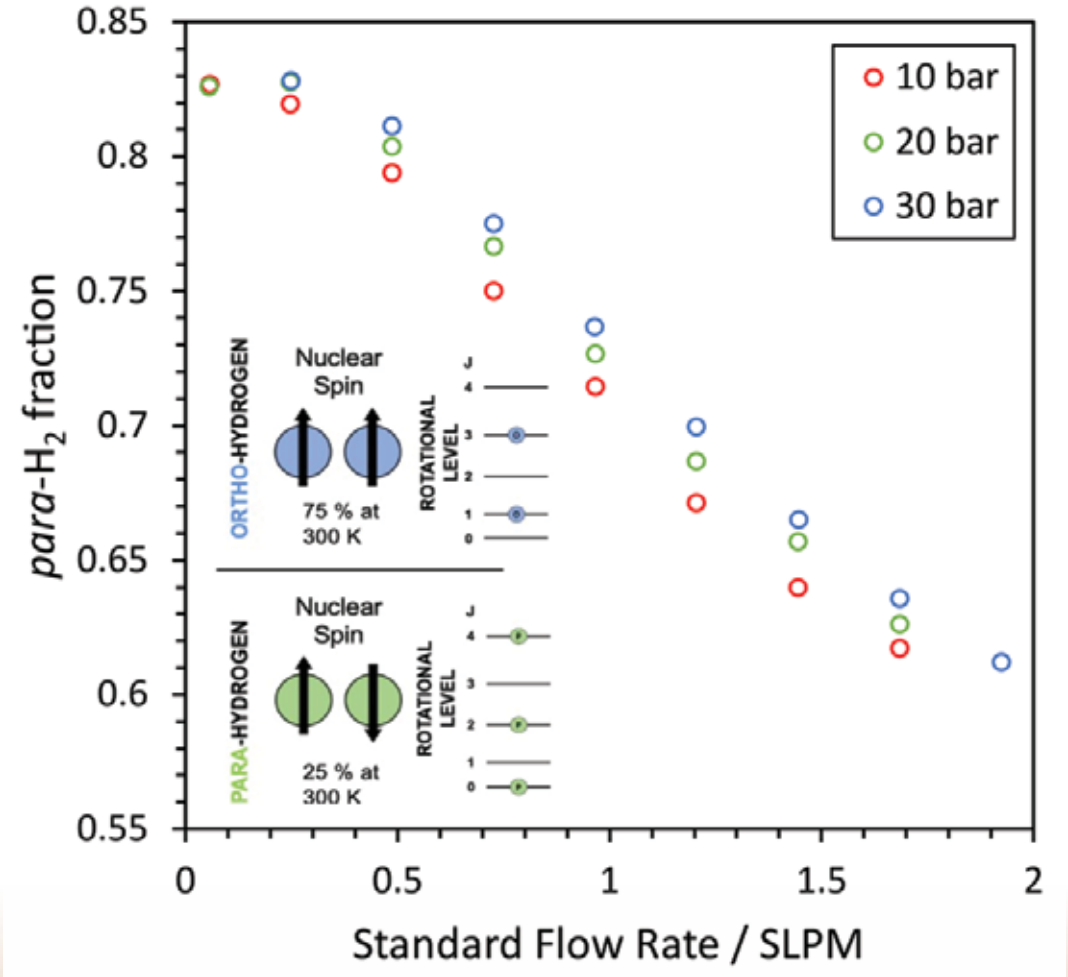
Simulation and testing cryogenic ortha para conversion in hydrogen liquefaction process

How might we improve the efficiency of hydrogen liquefaction?

This project seeks to account for ortho-para (OP) conversion in the simulation and design of catalyst lined plate-fin heat exchangers. It will:

- Develop a process simulation block within Aspen HYSYS for catalyst lined PFHX incorporating OP conversion
- Establish experimental capability for evaluating and characterising OP catalyst performance
- Compare the performance of different catalyst activation procedures, reactors, and levels of impurities.

This project will address the requirement for an accurate way of simulating and facilitating the development of efficient large-scale hydrogen liquefaction systems.



FUTURE ENERGY EXPORTS
Cooperative Research Centre

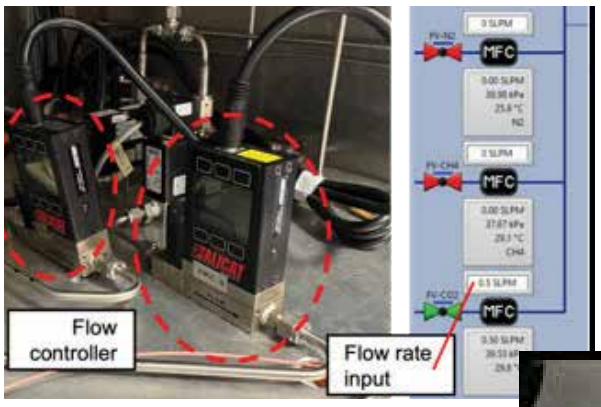
Start 2020 — 2023 — End 2030

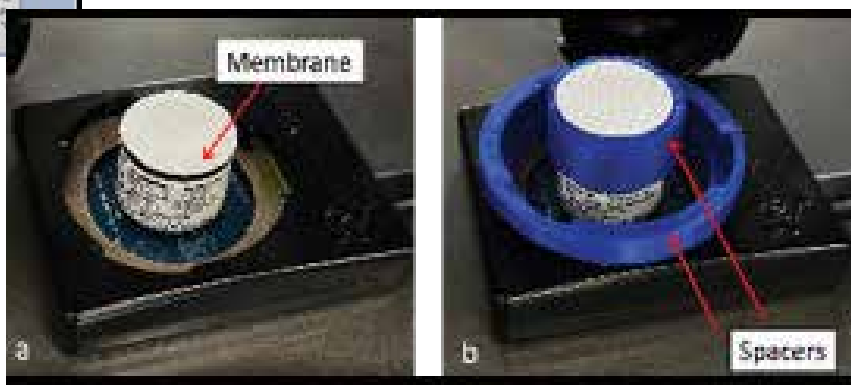
Feasibility Study of a Fugitive Methane Emissions Sensor

How might we reliably detect methane emissions?

A variety of methane detection sensors exist on the market. However, many were tested in a specific environment, which is unsuitable for on-site uses. Therefore, it is critical to conduct a comprehensive feasibility test of a methane sensor to guarantee reliable monitoring of methane emissions in industrial plants.

- Large-scale measurements need to be accompanied by small-scale monitoring to estimate methane emissions better.
- The University of Western Australia has lab capabilities to test the feasibility of nominated methane sensors (detection technologies) in controlled environments
- The test campaigns include (i) signal stability (signal-to-noise ratio), (ii) response to methane fraction change, and (iii) repeatability tests, to evaluate the reliability of measurement using a methane sensor.





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