Woodside Energy | FutureLab

THE UNIVERSITY OF WESTERN AUSTRALIA

ANNUAL REPORT 2024

A diverse and thriving ecosystem of industry, academia and students to collaborate and co-create to solve challenges today, and into the future.

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.

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2024
The Year in Review

Working in partnership to build capability and co-create solutions for decommissioning, decarbonisation, new energy, and offshore operations.

For almost 50 years, Woodside Energy ("Woodside Energy Technologies Pty Ltd") and UWA ("The University of Western Australia") have partnered together to deliver projects of major significance to the people of Western Australia and the nation. We are proud of this partnership and very pleased to present the 2024 annual report to showcase our diverse research portfolio at UWA.

Our business has changed over the years and as we transition to a lower-carbon energy landscape, UWA has demonstrated their ability to respond to our changing needs.

Our research portfolio spans across 10 different schools and we have created a purposeful, vibrant and thriving ecosystem of industry-academic-student relationships to collaborate and co-create solutions to our challenges today and into the future.

The adjacent page demonstrates the variety of research entities we have established at UWA from small-scale, rapid prototyping models and student programs, to direct research contracts and ARC-partnered collaborations.

In March this year we completed a high level evaluation that demonstrated an estimated 'Return on Investment' for the period of 2018 – 2023 and we are extending this to include the portfolio of projects of 2024 – this value is very conservative but exceeds tens of millions of dollars.

Woodside Energy has grown into a global company and the FutureLab brand now sees us expanding our network of partnerships. This presents opportunities for UWA to collaborate with our international partners and to solve challenges on a global scale. 2024 has seen examples of UWA working closely with our Houston colleagues - especially International Operations.

At the heart of our partnership are the relationships between our organisations - Woodside people who understand the capability at UWA, and UWA Academics who understand our business. As we look to the future, we are excited to continue to engage with UWA and grow our network of domestic and international university and Woodside Energy connections.

I would like to thank the team at UWA for their expertise, tenacity and patience to work with Woodside Energy in 2024.

Voula Terzoudi

Head of Partnerships Australia Technology & Innovation - TED

Woodside Energy

Woodside Energy and UWA at Subsea Controls Down Under (SCDU 2024) engaging with vendors and industry on improving subsea electrical systems reliability.

Woodside Energy | FutureLab

THE UNIVERSITY OF WESTERN AUSTRALIA

OceanWorks

TechWorks

RiverLab

CEEDWA

THE UNIVERSITY OF WESTERN AUSTRALIA
BUSINESS SCHOOL

Australian Government
Australian Research Council

CO_2 Foundry

Dating Murujuga's Dreaming
CLIMATE · CULTURE · CHRONOLOGY

THE UNIVERSITY OF WESTERN AUSTRALIA | Centre for Rock Art Research + Management

Long Subsea Tiebacks Laboratory

QRA QUANTITATIVE RESERVOIR ANALOGUES

TIDE BEYOND THE NUMBERS

FUTURE ENERGY EXPORTS
Cooperative Research Centre

OceanWorks

After 8 years, OceanWorks continues to demonstrate our ability to think big, prototype small and deliver value to Woodside Energy.

"This year the Geo-metocean team worked with OceanWorks to investigate scour of subsea structures to inform a potential life extension project. The outcomes of the testing go a long way into removing uncertainty associated with empirical calculation approaches and best represent the risk attributed to undermining by local scour and to plan field management in a manner commensurate with this. We will surely leverage this collaboration in other projects!"

Antonio Borges Rodriguez
Geotechnical Engineer | Operations Support - Woodside Energy

OceanWorks draws together research capability and partnerships spanning ocean engineering, oceanography, ecology, resource management and governance to develop solutions to new and existing challenges. It leverages high-quality facilities, including the unique OceanWorks collaborative space located in the Indian Ocean Marine Research Centre, the Coastal and Offshore Research Laboratory, the National Geotechnical Centrifuge Facility and the Watermans Bay research facility. The capabilities in Oceans research at UWA are recognised as the best in Australia.

OceanWorks is structured to enable new research rapidly, 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.

In 2024, OceanWorks supported: 7 research prototypes on topics such as scour assessment of subsea structures and subsea calcification; an ARC Linkage proposal to quantify the long-term endurance of subsea pipelines and the ecological benefits they provide; and further explored a 2023 research initiative to understand the economic and ecological opportunities to sequester carbon in micro-algae by building this research into our Environmental Engineering Design courses.

We have continued to work closely with Woodside Energy to support their decommissioning journey, and this year expanded our relationships across the FutureLab partnership, spending time at Monash and Curtin Universities to explore opportunities to work together to achieve greater impact.

This year also saw us build relationships with NOPSEMA, NDRI, AIMS, SUT, Engineers Australia, SICA, CODA and other operators as our prototype research grows into larger programs of research.

To demonstrate the direct impact and ROI that our research had on Woodside Energy’s operations we undertook a valuation of the OceanWorks program.

As we look towards 2025 and beyond, OceanWorks is well placed to partner with Woodside Energy to explore lower carbon energy, solutions to decommissioning, operational efficiencies and renewable energy opportunities.

Prototypes

Improving subsea electrical connector reliability will materially reduce maintenance costs

UWA Indian Ocean Marine Research Centre, Watermans Bay

Subsea Calcification Replication and Investigation

How might we improve subsea connector reliability in Australian conditions?

Using UWA's Indian Ocean Marine Research Centre (IOMRC) facilities at Watermans Bay, we have demonstrated that we can replicate calcification deposits and biofilm in the laboratory. The calcification deposits were significant and representative of immersion in the field.

The project involved immersing three (3) subsea hydraulic couplers in each of three (3) test tanks. One tank with no cathodic protection (CP), one tank with sacrificial anode CP and impressed potential CP. The seawater and the connector surface potential have been tested periodically to understand changes, as well as the biofilm on the connector surfaces and in the tank. We also took the opportunity to retrieve one coupler from each test tank and pull-test them to understand the increased tension after six months of immersion.

This project is now looking to understand the evolution of calcification and biofilm on the subsea electrical connector surfaces. This may lead us to an understanding of the subsea electrical connector degradation mechanisms.

This research is important because if we can better understand the degradation processes that all three subsea electrical connector vendors experience in Australian waters, we can develop solutions in collaboration with the vendors and the operators.

If we solve premature degradation by design (or new industry standards), intervention costs will be materially reduced or eliminated.

Tensile test

UWA Materials Testing Laboratory

Modeling of Polymer Degradation in Subsea Environments

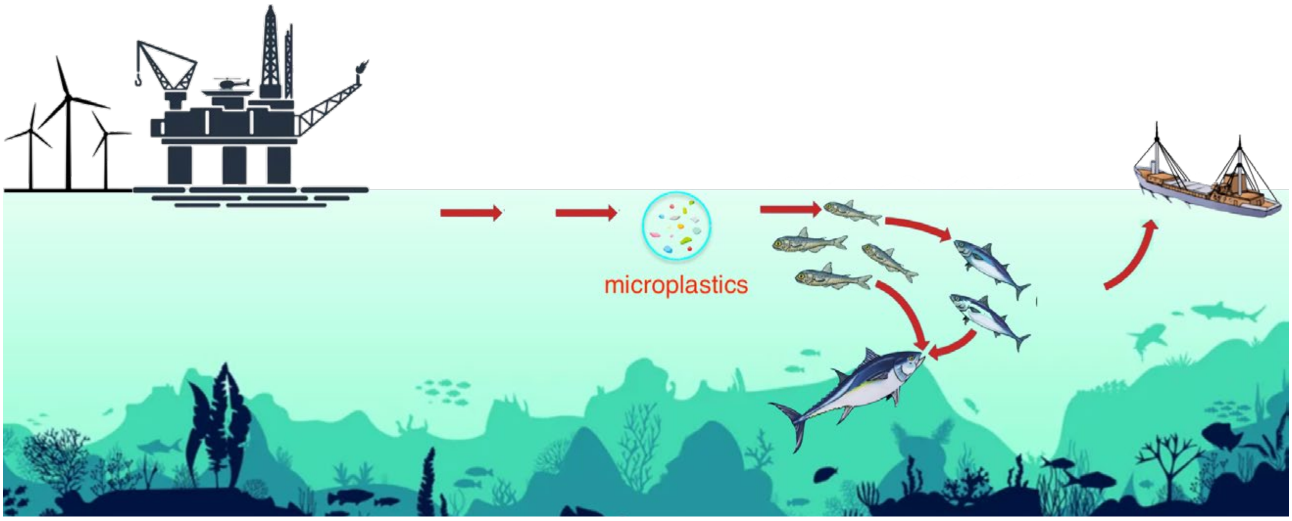
How might we better predict plastic degradation accounting for marine growth?

The degradation of plastics in the ocean is a concern for numerous stakeholders and policy makers, however conventional plastics continue to be used in offshore applications (e.g. for protective coatings, insulation, etc.) as biodegradables cannot replace them.

This project investigated the mechanisms of degradation and provided new insights into the degradation behaviour of plastic coatings in subsea environments, particularly in the presence of marine growth (MG). Marine growth significantly accelerates the degradation of Polyurethane (PE) coatings due to its higher susceptibility to biological degradation. As MG coverage increases, the lifetime of PE coatings decreases, with a pronounced effect at lower MG coverage levels.

In contrast, MG coverage provides a protective effect for PP coatings by reducing exposure to physical degradation forces. This results in an extended lifetime for PP coatings as MG coverage increases, with the most substantial protective effect observed at 75% coverage. With Polypropylene (PP) as the outer layer and PE as the inner layer, MG coverage delays the degradation of the outer PP layer, significantly extending its lifetime. However, once the inner PE layer is exposed, its degradation is accelerated by MG due to biological activity.

The findings suggest that neglecting MG effects could lead to underestimations of degradation rates, particularly for materials like PE that are more susceptible to biological degradation.

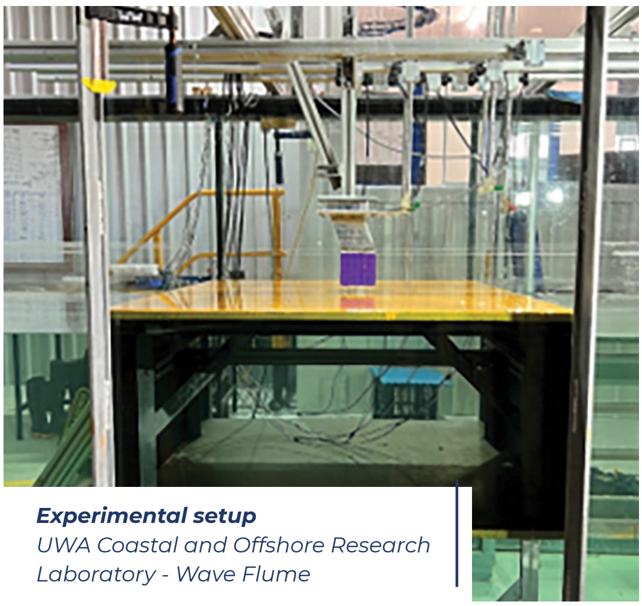


Greenwater Testing on Porous Structures

How might we better design FPSO topside structures?

Concerns around greenwater loading on topside modules can influence the design size of FPSO hulls. Current practice is to size FPSO hulls to avoid greenwater loading on modules in the 1,000-year or 10,000-year conditions by selecting a suitably large freeboard. This adds significant CAPEX as it requires a larger hull and turret mooring system.

This research is investigating green water loads on porous structures, to better predict loads on topside structures. These findings may be applied to reduce the size and hence CAPEX of FPSO currently being considered for future development opportunities by Woodside Energy.



Experimental setup
UWA Coastal and Offshore Research Laboratory - Wave Flume

Experimental setup
UWA Coastal & Offshore Research Laboratory - Large O Tube

This has better defined the site-specific scour risk, which valuably informs the field management plan

Investigating Scour of Subsea Structures to Inform Life-Extension

How might we predict scour around subsea structures placed on complex marine sediment?

Without knowledge of the expected scour around sleds proposed to be placed around the offshore jacket structure, the design of scour protection or prediction of structure settlement is difficult. It is also difficult to determine an ideal scour monitoring and management plan. O-Tube testing in UWA's Coastal and Offshore Research Laboratory (CORL) was undertaken to investigate the erosion properties of seabed sediment recovered from close to an offshore fixed platform, as well as to explore scour around the sled structures.

Reduced scale model testing of individual and multiple subsea sleds revealed the likely extent of scour and undermining, providing unique insight into scour development around the specific sled geometry. Combining these results with the erosion test results enabled better estimates of the likely rate of scour development in the field. It enabled a scour assessment accounting for the specific sled geometry and seabed sediment properties. The experimental findings can also be compared to observations of scour around existing nearby infrastructure to develop a more complete picture of scour risk at this site.

The findings from this research may feed into the future scour management design and planning. Comparison of the testing results with future observations of the sled structures will provide an opportunity for validating lab-based scour prediction.

Modeling Energy Recovery from Ocean Waves

How might we power FPSOs in later life using renewable energy?

This research project developed a model to assess wave energy recovery from prevailing waves at a location on the North West Shelf.

The work leveraged UWA's expertise in hydrodynamic modeling of offshore structures, including the assessment of Wave Energy Converters through its Great Southern Marine Research Facility, located in Albany.

This project combined joint occurrence tables of wave conditions on the North West Shelf with the power matrix of a wave energy device to estimate annual ocean wave power generation offshore.

This model can be used for an initial assessment of locally developed concepts and for comparison with other wave energy devices. In due course, an economic analysis of different wave energy converters could be undertaken, identifying those with minimum cost-per-kW delivered.

This modeling can support decision-making on a renewable power solution which could reduce operational expenses and concurrently reduce carbon emissions.

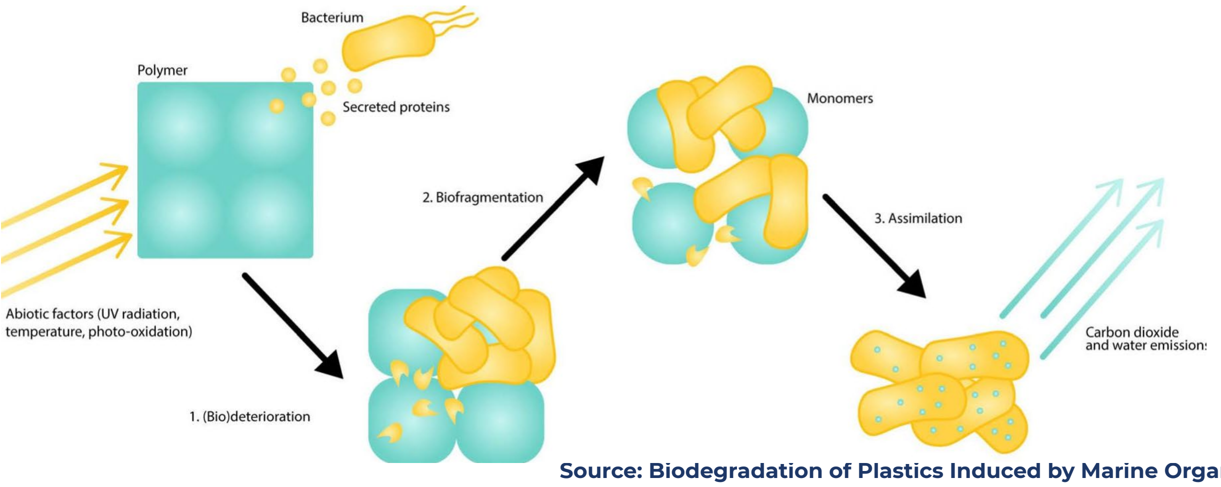
Understanding the Fate of Marine Plastics

How might we use our understanding of marine plastics to make decommissioning decisions?

Unlike other types of waste, plastics don't readily decompose. In offshore decommissioning, decisions need to be made on the acceptability of leaving plastics in place (typically attached as coatings on marine structures/pipelines) or removing the structure/pipeline in order to remove the plastic from the ocean.

In the marine environment, plastics may degrade in a manner that generates no, or minimal, toxic residue given the many potential degradation initiators which could enable marine organisms from bacteria and upwards from progressing/advancing plastic degradation.

This research is investigating the bacteria/organisms that degrade plastic, and their prevalence in the ocean to provide a sound synthesis of current knowledge. There may be sufficient understanding of natural processes that may justify leaving plastics in place, with minimal eco-tox consequence.



Source: Biodegradation of Plastics Induced by Marine Organisms: Future Perspectives for Bioremediation Approaches; Polymer 2023; Viel T et al

UVC emitters (germicidal lamps in HVAC service)

Eliminating Marine Biofouling Using UV-C Light

Can UV-C materially reduce or eliminate biofouling at critical locations?

Marine biofouling can adversely affect subsea operations (inefficiencies due to cleaning downtime) and has potential to affect safety (fouling of firewater intake systems).

This project looks to identify critical systems in Woodside's underwater facilities where marine biofouling cleaning is a regular high-cost activity to ensure equipment reliability or is a safety task. The project also looks to identify ways to deploy UV-C at critical locations, including ways to power the emitters (e.g. via spare electrical connectors at umbilical terminations, or via small-scale marine renewable energy which trickle charges batteries etc). If successful, this research could improve operations by eliminating biofouling cleaning tasks.

Student Internship

OceanWorks supports high-achieving students at UWA to work on a 10-week research project aimed at solving key industry challenges.

Open-Source Wave Energy Data

How might we help establish a wave energy test site in Albany by public sharing of data from M4?

The 'Moored MultiMode Multibody' (M4) Wave Energy Demonstration Project has been developed as part of the Blue Economy CRC and seeks to demonstrate the future potential of the wave resources in the Great Southern to power the local economy and develop an export industry.

While at sea, the M4 is producing data 24 hours, 7 days a week from more than 40 different data channels. The opportunity to interpret this data while it is being produced is a unique one, and is time critical. OceanWorks supported a talented student to participate in this opportunity.

Wave energy converters (WECs) have significant potential benefits when supplying power along with wind and solar. The persistence, predictability and different temporal profile of the power they can deliver are key reasons for these benefits. Wave energy also has the ability to supply isolated communities and facilities, including offshore production platforms and subsea production systems.

In Albany, a test site has been developing over several years, through discussion with the Southern Ports Authority. This test site can play a key role in future projects.

In November, 2024 the M4 WEC started producing its first data. This internship project provided internal checking, screening and assessment of data that is being released to the public, to ensure that what is being released is correct and easily interpretable by a general audience. This data analysis will also help to inform internal operational decision making for the M4, to ensure the best chance of project success.

Local public interest in the project is high, but it is very important that there is trust in the data that is shared. Establishing this trust can serve the wave energy industry well for future deployments in Albany and WA.

***M4** scale prototype deployed in King George Sound, Albany*

RiverLab

RiverLab was developed in 2016 by UWA in collaboration with Woodside Energy as a solution to two problems: (i) increased demand from students to work on practical ocean engineering problems, and (ii) no deep-water wave basins in Australia for Woodside Energy to trial new offshore engineering concepts.

RiverLab solves these problems by providing resources and training to empower students to conduct industry-relevant research in the Swan River, which serves as an affordable and accessible analogue of the open-ocean environment.

Each research project is offered to Engineering, Earth Science and Biology students in the form of a "final" year research project that they complete over two semesters (or 10 months). In 2024, 22 students completed 11 projects.

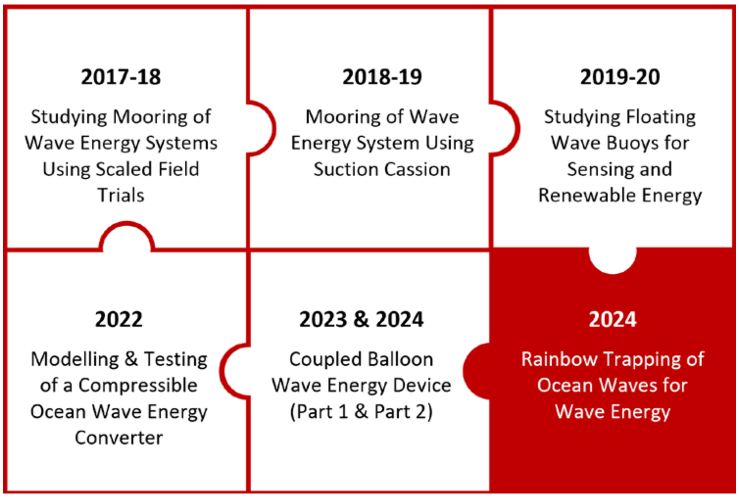
2024 RiverLab Projects

1. Microplastics & Muck in the Swan River
2. Model testing the coupled balloon wave energy device (Part 2)
3. Effect of soft/hard marine growth on response of vortex-induced vibration of a pipeline near a plane wall
4. Testing fixed offshore wind structures in Australian wave conditions
5. Hydroski – 3rd generation controller and new prototype autonomous vessel
6. Rainbow trapping in oscillating water column (OWC) arrays
7. Investigating wave loads on floating solar facilities
8. Using wind energy to power sensors offshore
9. Measuring hydrodynamic forces on subsea mattresses
10. Yanchep Lagoon, a natural water flume
11. Effects of soft/hard marine growth on responses of VIV of a pipeline near a plane wall

RiverLab students work on practical projects include trialling ocean sensors, building and testing offshore systems, collecting data, and developing novel design methods.

RiverLab Supporting Wave Energy Research

Dr Hugh Wolgamot, Dr Jana Orszaghova and Dr Adi Kurniawan have been working with students in the RiverLab program since 2018. They have developed theoretical and numerical models of wave energy conversion (WEC) and have built and tested many kinds of WEC devices.



RiverLab Projects *that have built capability in wave energy at UWA with 12 students working across 7 different year-long research projects.*

How might we use rainbow trapping to improve the performance of an array of wave energy converters?

Ocean waves are a largely untapped energy source and wave energy converter (WEC) technologies have the potential to play an important role in the global transition to renewable energy. However, large variability in ocean wave conditions makes designing WECs that perform well over a large bandwidth of frequencies a challenge.

Rainbow trapping is a wave control technique that spatially confines different frequencies in different locations. Using this technique to design a graduated formation of barriers with an array of WECs has been shown theoretically to achieve excellent power absorption across a broad range of ocean wave frequencies.

This project investigated a potential practical implementation of this rainbow-trapped array using submerged, pressure differential flexible membrane wave energy converters. The prototype device consisted of two submerged air-filled chambers sealed with upwards facing flexible membranes that move with the pressure differential in the wave field to drive air through a power take off mechanism.

This involved theoretical, numerical and experimental investigation at UWA's Coastal and Offshore Research Laboratory, aimed primarily at determining whether the resonant frequency of this device could be tuned, and hence determining its feasibility in a rainbow-trapped array.

Our experiments showed that the resonant frequency of the device can be tuned by increasing the mean pressure in the chambers. This suggests that the submerged pressure differential flexible membrane WEC is a feasible candidate for use in a rainbow-trapped array.

If the mechanism of controlling the resonant frequency by adding pressure can be realised in an array, it would be possible for a rainbow-trapped array of such devices to be live tuned according to wave conditions which is a promising method of addressing the challenge of variable ocean conditions in wave energy conversion.

"Working with OceanWorks as a summer intern and as a RiverLab student this year, I've gained hands-on research and data analysis skills in wave energy technology. I'm excited to use this experience to drive innovations in renewable technology and contribute to the energy transition in Western Australia".

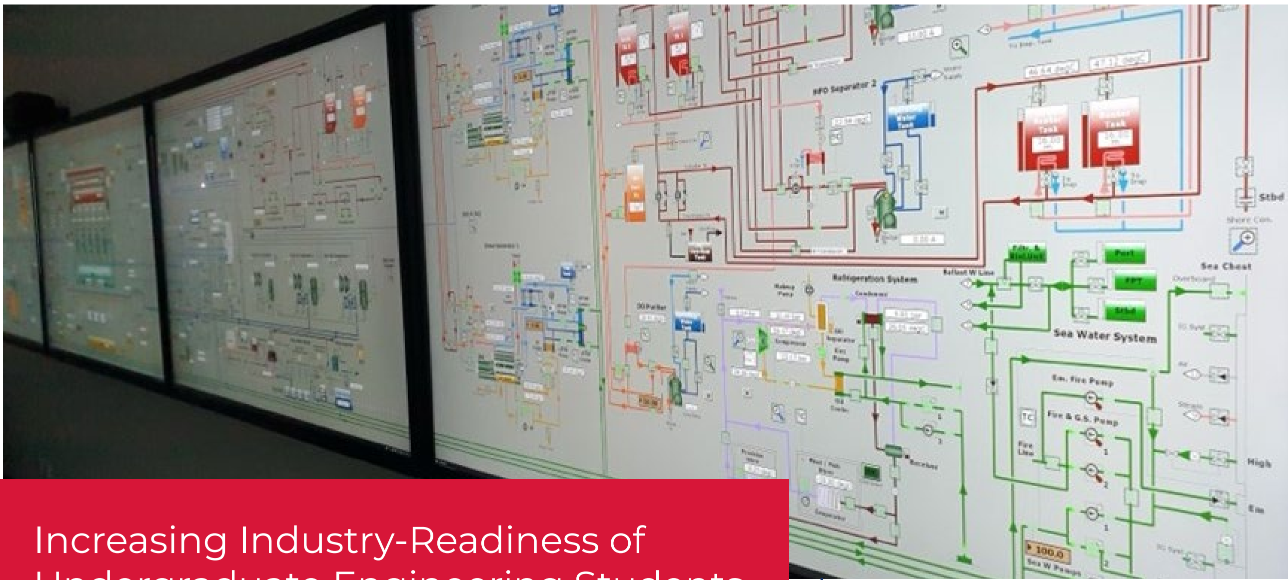
Megan McDougall
Bachelor of Philosophy (Honours) Student (Physics)

Rainbow Trapping of Ocean Waves for Wave Energy
Experimental setup of two submerged air-filled chambers sealed with upwards facing flexible membranes that move with the pressure differential in the wave field to drive air through a power take off mechanism.

UWA Coastal and Offshore Research Laboratory - Wave Flume

Studying Floating Wave Buoys for Sensing and Renewable Energy
Building on the knowledge of past projects, 2020 saw Dr Jana Orszaghova investigate how to design a small wave energy converter to operate in swell waves. This work also has application to swell measurement and prediction, a key area of interest to offshore operators on the NWS.

Education & Training



Increasing Industry-Readiness of Undergraduate Engineering Students

K-Sim Lab
(Built by Kongsberg, owned and operated by South Metropolitan TAFE)

This project provides a new opportunity for undergraduate Chemical Engineering students to develop new practical, hands-on skills using an advanced Kongsberg K-Sim digital laboratory at South Metropolitan TAFE.

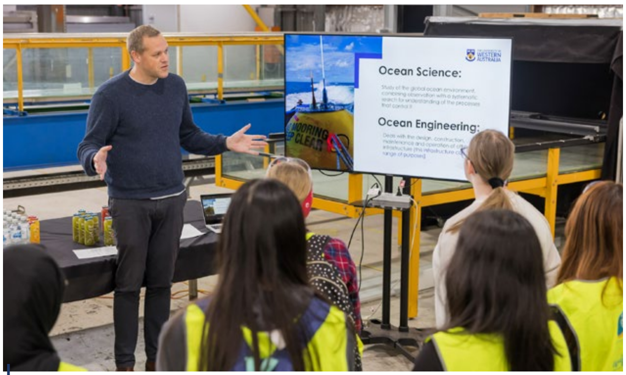
This world-class facility provides students with a number of transient operations, a subset of which have been selected for use as a real-time digital laboratory activity. Students will first be presented with an introduction to the gas turbine system, where they will collect transient data to build a thermodynamic performance envelope. They will then work on a second simulation task, in migrating an engine system between two fuel sources to assess the real-time impact on performance. Each digital laboratory experience will conclude with a safety demonstration on both electrical faults and engine fire suppression led by SM TAFE.

OceanWorks sponsored the inaugural 2024 UWA Early and Mid-Career Researchers Network Symposium. The symposium is themed on cross-discipline collaboration to foster new collaborations and promote the exchange of innovative research ideas among EMCRs at UWA.

This one-day-event featured a series of abstract and poster presentations by EMCRs, keynote talks from prominent experts, panel discussions, workshops.

Outreach

Inspiring the next generation to learn about our grand ocean challenges, pursue STEM subjects at school, and choose a career in ocean science and engineering



Professor Scott Draper presenting to the Future Engineers at UWA's Coastal & Offshore Research Laboratory. How can ocean science and ocean engineering help solve our grand challenges?

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 Students 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.

This year, OceanWorks was pleased to host the girls at UWA's Coastal & Offshore Research Laboratory and National Geotechnical Centrifuge Facility. In addition to our supportive team of Academics each year, it was great to have two of our RiverLab students present to the girls on their research projects at UWA.

Rose Lehane - 2024 RiverLab student presenting to the Future Engineers at UWA's National Geotechnical Centrifuge Facility about how studying engineering at UWA has helped her solve many challenges.

This event is run in conjunction with industry sponsors WISE Professional Network, Subsea Energy Australia, Engineers Australia, Woodside Energy and Fugro.

2024 Future Engineers Program - Industry sponsors and students.

TechWorks

High quality, experimental research facilities and an expert team allow us to co-create solutions in collaboration with Woodside Energy to trial new innovations in engineering and 3D additive manufacturing.

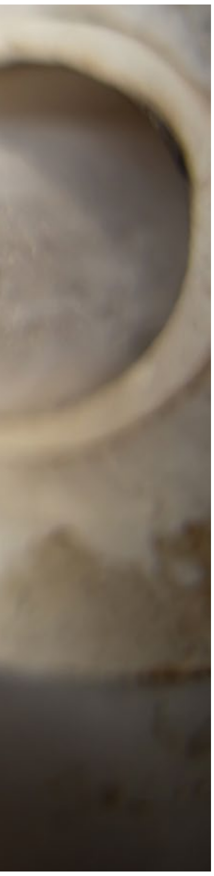
TechWorks is dedicated to fostering innovation and engagement through cutting-edge research, rapid prototyping, and testing. Our mission is to enhance production, maintenance, and operational outcomes for Woodside Energy.

In collaboration with the FutureLab team, we identify opportunities, refine designs through iterative processes, and deliver solutions that have been tested and proven on site.

Our laboratory features an EOS M290 metal 3D printer and supports an additive manufacturing program which is aimed at harnessing the full potential of this disruptive technology. In 2024, we supervised 12 Masters students, working on a range of projects from FDM of high performance polymers, to the printing of threaded features and developing an understanding on how to manipulate the strength of the support structure.

This year, our team has also collaborated with academics from UWA, Monash University, and Curtin University, as well as third-party vendors, to explore innovative approaches to decommissioning. We are excited to continue these collaborations, working together to co-create impactful solutions for Woodside Energy and the broader industry.

> *"The TechWorks team have been instrumental in helping Woodside Energy trial new innovations in 2024 that have realised significant operational savings."*
>
> **Andy Watt**
> Innovation Advisor, Woodside Energy



***TechWorks Team**: Dr Bobby Ghillham, Research & Innovation Manager and Dr Jincheng Wang, Research Associate*

3DAM at UWA

The 3DAM program at UWA seeks to build an understanding of and confidence in key material properties and processes to expand the use of additively manufactured parts across the Woodside Energy business, including in-critical service.

Design & Prototype

This focuses on the production of pre-qualification parts. Part production may be preceded by preparation steps that are tailored towards the AM workflow including 3D scanning of an object for the purpose of reverse engineering, or the design optimisation to enhance 3D printability, functional and mechanical testing.

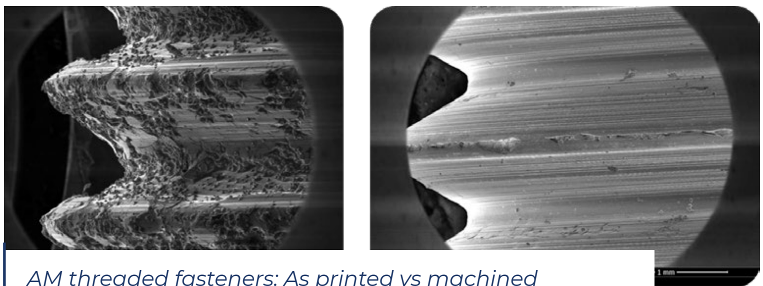
Threaded Fasteners

How might we incorporate threaded features into 3D Printed parts?

In 2024, several final-year students undertook projects to investigate the mechanical behavior of 3D-printed threaded fasteners. This research was motivated by the growing need to incorporate complex geometries that can only be produced using additive manufacturing (AM) techniques. When threaded features are integrated into these designs, it becomes critical to understand how AM processes might influence their mechanical performance.

The students conducted a series of tests to evaluate the impact of the inherently rough surface finish characteristic of AM on the static and dynamic properties of threaded fasteners. The insights gained from this research will be instrumental in determining whether AM-produced threads can achieve mechanical performance comparable to their conventionally manufactured counterparts.

This work lays the groundwork for advancing the understanding of AM-produced threads, contributing to the broader adoption of additive manufacturing for complex, high-performance applications.



AM threaded fasteners: As printed vs machined surface finish

Inconel Probe Holders

How might we prolong service life of parts to reduce operational downtime?

Previously manufactured plastic probe holders were prematurely failing and the customer was seeking a more robust solution. To address this, parts were produced using IN625 alloy through the Laser Powder Bed Fusion (LPBF) process, offering significantly enhanced strength and superior resistance to environmental exposure compared to their plastic counterparts.

3D printing enabled the efficient production of these complex geometries without the need for costly tooling or fixtures. Following several design iterations, a total of 40 sets of probe holders and flange nuts were successfully manufactured. meeting the customer's requirements for durability and performance.

Probe holders and flange nuts 3D printed in IN625

Quality Assurance

Metal additive manufacturing (AM) offers significant advantages in rapid prototyping and small-scale production of complex parts. However, the process is susceptible to the stochastic formation of defects, posing challenges for quality assurance (QA). Traditional QA methods, such as ultrasonic testing or radiography, are costly and often struggle to detect small defects in intricate geometries.

To address this, the metal AM industry is shifting towards in-situ monitoring, introducing a "qualify as you build" paradigm. This approach enables the detection of sub-optimal manufacturing conditions and potential defects during the build process, theoretically independent of part size or complexity.

The 3DAM program is at the forefront of this innovation, focusing on developing in-situ defect detection methods and establishing critical thresholds for defect characteristics that influence mechanical performance. This research utilizes an EOS M290 Laser Powder Bed Fusion (L-PBF) metal printer equipped with an in-situ monitoring system that captures infrared thermal radiation emitted during printing.

As part of the study, samples with intentionally seeded porosity of varying severity and locations have been printed. These samples are analyzed using X-ray computed tomography (X-CT) to extract detailed information about pore geometries, clustering, and subsurface depth. The X-CT data serves as "ground truth" for training machine learning algorithms, allowing patterns in-situ thermal data to be correlated with the locations and characteristics of porosity. Early findings demonstrate a 97% accuracy in detecting pores between 50 and 300 µm in diameter.

In parallel, mechanical testing is conducted on similar samples to evaluate how defect severity and location impact static and dynamic properties. This helps define the threshold at which porosity begins to degrade performance, providing critical benchmarks for defect detection algorithms to meet reliably.

This pioneering work not only advances defect detection capabilities but also paves the way for more efficient, reliable, and scalable quality assurance in metal AM.

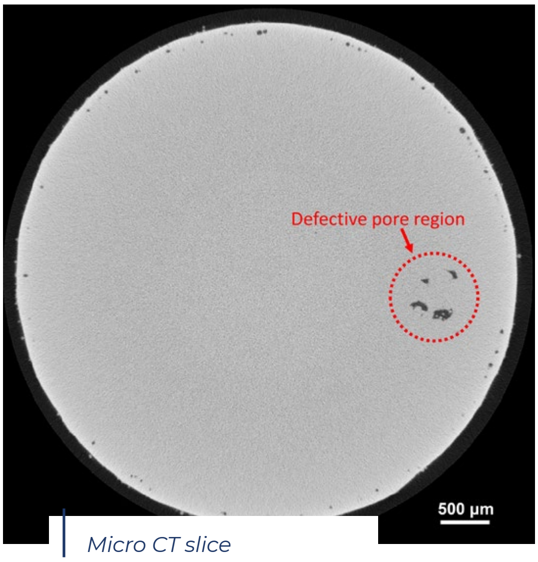
An in-situ monitoring system coupled with a quality assurance framework informed by machine learning will help unlock wider utilisation of 3D printed components

The micro-CT slice shown below shows a component with a deliberately introduced porous region. These CT images were combined with in-situ monitoring signals and fed into a machine learning algorithm. The goal is to identify the porous areas from the in-situ monitoring detectors, enabling quality assessment of the component without the need for post-build quality assurance processes.

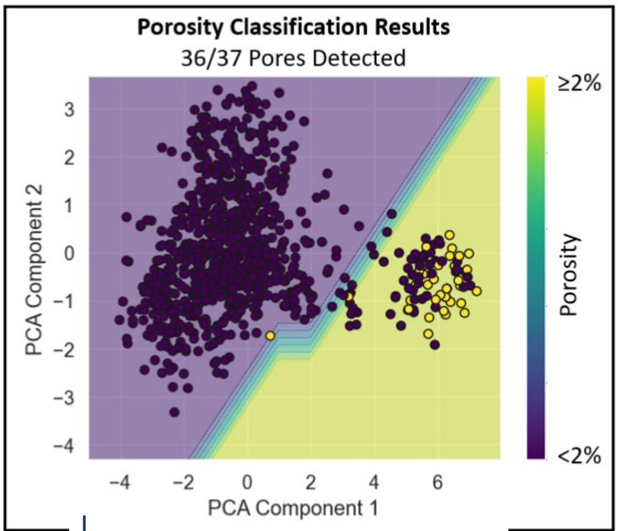
The accompanying graph (on the right) presents a classification of porous and non-porous regions using a Support Vector Machine (SVM). The sample includes a volume intentionally designed to be porous.

In the graph, the background colors indicate the machine learning algorithm's classification: yellow represents porous regions, and purple represents non-porous regions. Overlaid dots represent the actual porosity determined by micro-CT imaging. There are some instances where non-porous regions were misclassified as porous (purple dots in yellow areas), but there are very few cases where porous regions were misclassified as non-porous (yellow dots in purple areas).

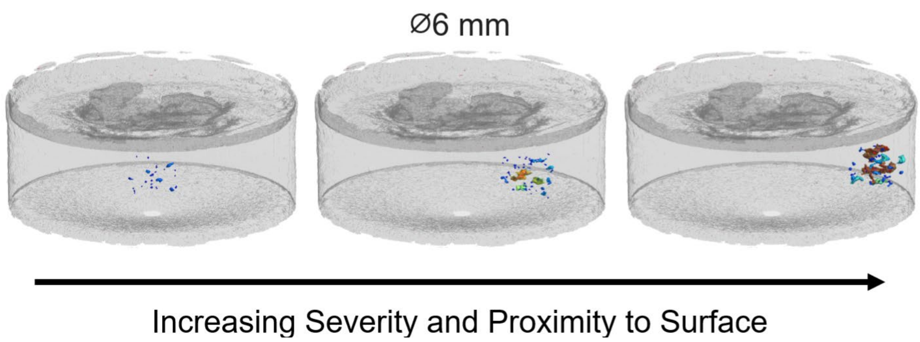
This demonstrates that while the algorithm produced some false positives, it was highly effective at detecting porosity, with minimal instances of undetected porous regions.



Micro CT slice



Classification of porous and non-porous areas via SVM



Sustainable 3DAM

Recycling of Plastics for Use in Manufacturing

How might we recycle material from the oil & gas waste stream?

This project brings together UWA, Hyperion Systems, and Monash University to evaluate the feasibility of reprocessing hard-to-recycle plastics for reuse in 3D additive manufacturing.

By investigating methods to salvage materials from the oil and gas waste stream, the research aims to support Woodside in showcasing the wide-ranging opportunities that effective and responsible decommissioning activities can offer. The initiative focuses on transforming waste disposal costs into revenue-generating streams through material reuse.

By promoting a circular economy, the project not only creates economic value but also emphasizes environmental sustainability and resource conservation.

Decommissioned flowlines

Training & Education

To increase the uptake of 3DAM across the Woodside Energy business, UWA has designed a range of training courses to up skill employees' understanding of AM practices.

These courses cover fundamental concepts of 3DAM as a manufacturing technique and delve into key considerations for proposing AM-based solutions within the business. The curriculum is designed to empower employees with the expertise needed to identify and implement AM opportunities effectively.

In 2024, Dr Lee Djumas, 3D Additive Manufacturing Lead at Woodside Energy, presented the Awareness level course to Woodsiders in the Houston office.

There is enormous opportunity to share this knowledge in 2025 to a broader cohort of personnel as the qualification process to use 3DAM parts is developed within the organisation.

TechWorks Projects

Hole Saw Fitting

How might we more safely inspect inner pipelines for corrosion under insulation?

Installing water-under-insulation sensors is an innovative approach for conducting essential inner pipeline inspections. However, the process demands highly precise hole drilling, especially in vibration-intensive environments, to avoid damaging the inner pipeline wall.

This project investigated several design iterations of a cladding hole saw, leveraging additive manufacturing techniques to produce a single FDM-printed component. The design provides both enhanced positional stability and precise depth control during drilling operations.

The resulting prototype is more durable, cost-effective, and easily replaceable compared to the previous solution. Technology qualification is currently underway to integrate this product into Woodside's part catalog, paving the way for its adoption in field operations.

Original Machined Design

3D Printed Replica Design Multiple Materials & Parts

Prototype Single Print TPU Hole Saw

Heat Sink Performance Testing

How might we use test data to better inform our decision making?

Significant heat transfer performance improvements have been claimed for a graphene based coating applied to fin-fan coolers.

This project is analysing the performance of coated and uncoated transmission coolers under steady-state temperature to characterise the coating's performance. These findings will provide Woodside with the data to inform decision making as to whether the performance increase of the coatings is demonstrated.

Fin fan coolers

Experimental Heat Sink coated in graphene

Scaling up Pyrolysis to Decompose Plastic Waste

How might we decommission thousands of kilometers of subsea flowlines and umbilicals?

This project explores the use of simple physical pre-treatment methods to recover metals from decommissioned subsea flowlines and umbilicals, followed by high-temperature pyrolysis, which efficiently remove the polymers. The pyrolysis process generates a gas that can serve as fuel to offset onsite utility needs, leaving minimal solid residue, thereby providing an environmentally responsible solution.

The proposed method leverages pyrolysis as a cost-effective, scalable approach to recover valuable metals and eliminate polymers with minimal environmental impact. A preliminary cost-benefit analysis has demonstrated the process's efficiency and economic feasibility. Laboratory tests on actual samples from Woodside have been conducted to evaluate pyrolysis behavior, assess the impact of contaminants, and optimize operating conditions for upcoming pilot-scale trials. Initial results from pyrolysis at 700°C are promising, yielding less than 20% solid residue, approximately 50% gas production, and the remainder as a pyrolysis liquid.

Building on these findings, a pilot-scale test program is underway, with plans for a large-scale demonstration under development. The system has been conceptually designed as a containerized, self-sufficient, and mobile platform, enabling flexible deployment across decommissioning sites.

This work highlights significant opportunities for metal recovery, sustainable waste management, and reduced environmental impact in subsea decommissioning. Key achievements of the project include:

1. Validated Pyrolysis Effectiveness: Established confidence in pyrolysis as a highly effective and environmentally responsible method for polymer elimination and metal recovery.

2. Proven Technology Attributes: Demonstrated pyrolysis as a simple, robust, fast, scalable, and low-cost technology capable of decomposing plastic waste, recovering valuable metals as saleable by-products, and preventing the formation and emission of harmful toxins.

3. Developed a Mobile Pyrolysis Unit: Conceptualized a portable, self-sufficient pyrolysis system that uses gas and liquid fuels produced during the process to offset power requirements, enabling efficient remote operations.

This project underscores the potential of pyrolysis to revolutionize subsea decommissioning, offering a sustainable, economically viable solution for metal recovery and polymer elimination while reducing environmental impact.

Capturing Carbon from Food Waste as Limestone

Can CO_2 from food waste be stored in limestone?

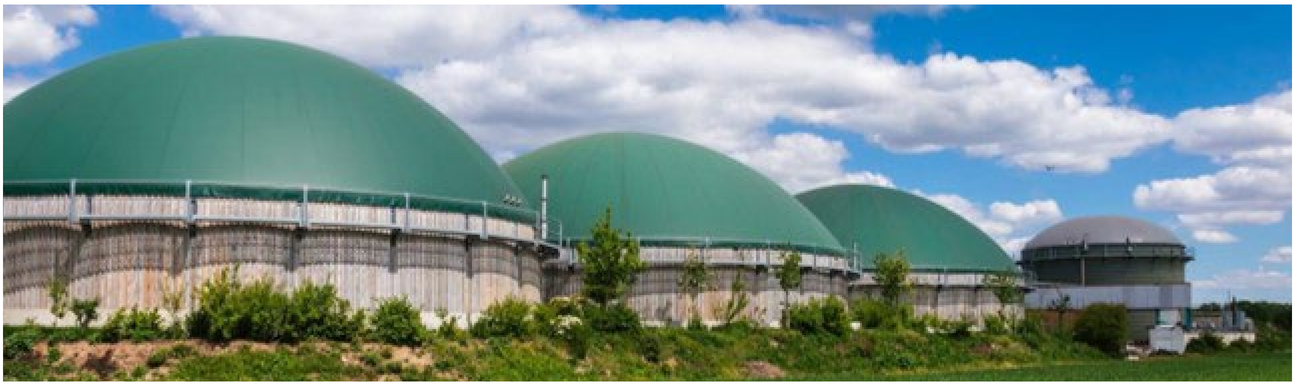
This project employs anaerobic digesters and bacteria to capture carbon from food waste as limestone, presenting a permanent negative-carbon removal strategy for atmospheric CO_2.

For billions of years, microbes have utilized microbial sulfate reduction to transform plant-captured CO_2 into limestone. This research aims to upscale this natural process to mitigate anthropogenic CO_2 emissions while reducing food waste sent to landfills. Preliminary laboratory experiments have validated that organic materials subjected to sulfate reduction produce substantial quantities of bicarbonate, mirroring naturally observed phenomena.

In a benchtop demonstration using anaerobic digestate from the Richgro facility in Perth, researchers have demonstrated that adding gypsum to bicarbonate-rich digestate rapidly precipitates limestone. Further work aims to quantify the yield of carbon captured as limestone and sulfur generated during sulfate reduction of food waste. Additionally, the project seeks to design a digestor system for economic evaluation of this innovative process.

By addressing two pressing environmental challenges—CO_2 emissions and waste management—this project transforms municipal organic waste into a dual-purpose solution. It mitigates greenhouse gas emissions, diverts waste from landfills, and generates valuable byproducts, including sulfur. As fossil fuel-derived sulfur supplies decline, this byproduct offers an increasingly important resource.

This approach represents a sustainable, scalable pathway to simultaneously combat climate change and improve waste management practices, with significant environmental and economic potential.



Trusted partners working together to create opportunities to challenges today and into the future.

CEED Projects

CEED Projects are Industry Sponsored Student Research Projects, in which the client (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.

Machine Learning Options for Magnificent Frigate Bird Detection and Counting using CCTV

How can machine learning be adapted to identify and count birds effectively using existing CCTV system?

Advanced object detection models, combined with image processing techniques like tiling and augmentation (random flipping, scaling, and photometric distortion), enhance the model's ability to detect small birds in video footage.

The project developed a machine learning prototype to detect and count Magnificent Frigate Birds on offshore Wellhead Protector Platforms (WPPs) in Trinidad and Tobago, where bird activity poses significant personal safety and operational risks, especially for helicopter operations. By leveraging CCTV footage from these platforms, the prototype applies advanced object detection models, including Faster R-CNN, RetinaNet, and YOLOv8. To improve performance in real-world conditions, techniques such as image tiling and data augmentation were used during training, enhancing the model's ability to generalize across varying weather and lighting conditions. The models achieved a count accuracy of up to 97.1%. After thorough evaluation, YOLOv8 was selected as the optimal model, offering both high detection precision and a fast CPU inference speed of 21 frames per second, making it well-suited for real-time applications in challenging offshore environments.

The machine learning system enhances operational safety on offshore platforms by automating bird detection and counting, enabling real-time monitoring, and providing systematic data that can inform the design and evaluation of deterrence mechanisms. By utilizing existing CCTV resources, the project demonstrates how machine learning can autonomously monitor bird activity, improving operational efficiency and safety with minimal human intervention and hardware upgrades. This approach not only supports immediate safety efforts but also lays the foundation for scalable, data-driven solutions in environmental monitoring and management.

CEEDWA

Options for Dissuading Magnificent Frigate Birds from Resting and Nesting on Offshore Platforms

How might we design effective bird deterrents to suit the offshore platforms while ensuring they are safe for the birds?

This project validated that it would be technically feasible to integrate a laser deterrent system with real-time tracking powered by the CCTV machine learning tool developed in a parallel project.

To develop humane and effective techniques, a combination of comprehensive research and physical prototyping was conducted. Through an extensive literature review and method evaluation, laser and audio deterrent systems were identified as the most promising solutions for this project.

A prototype integrating a pan-tilt laser system with real-time object detection and tracking capabilities was developed, demonstrating the potential for precise and responsive bird management in offshore environments

The successful implementation of effective bird deterrent systems will enhance operational safety, reduce downtime, and align with environmental and regulatory compliance. The project also offered valuable insights into humane wildlife management on offshore platforms, providing a blueprint for addressing similar challenges globally.

CEED Projects

Robotic Perception of Industrial Safety Barriers and Behaviour Planning Using a Quadruped Robotic Platform

Can Spector's perception be enhanced to perceive and navigate partial industrial safety barriers?

This project investigated the ability to autonomously detect and navigate SWAs by implementing a machine learning pipeline that leveraged equirectangular image inputs and computational geometry for boundary tracing.

To increase the autonomy of Spector, an autonomous robot currently reliant on local object detection for obstacle avoidance, a machine learning and computer vision pipeline was developed to enable Safety Work Area (SWA) detection. The pipeline employs equirectangular inputs and consists of three main stages: 2D machine learning object detection, depth estimation, and SWA boundary tracing. Distortion handling strategies were tested to address spatial distortions from equirectangular projection, with YOLOv5m proving the optimal architecture for detection using 2D cube map projections. This model achieved a peak precision of 95.9% and recall of 87.5% in detecting obstacles.

To improve depth estimation, an RGB-D camera was used in conjunction with HSI colour histograms, enabling efficient location of cones and bollards in 3D space. Finally, the Monotone Chain algorithm was identified as the most effective boundary tracing method. End-to-end testing yielded an average execution time of 12.38 seconds on a CPU, meeting real-time requirements and demonstrating the pipeline's feasibility in enhancing Spector's autonomy in recognizing SWAs.

This project demonstrates a significant advancement in the autonomy of industrial robots, allowing Woodside's Spector to identify SWAs and navigate safely without remote monitoring. By enabling Spector to detect partial barriers and trace boundaries autonomously and independently, the pipeline reduces the risk of robot damage and improves on-site personnel. The techniques developed, particularly for handling spatial distortions in equirectangular projections and boundary tracing, offer a scalable approach that could enhance similar autonomous robots deployed in Woodside's industrial plants.

Woodside Chair in Leadership & Management

Professor Gillian Yeo from the UWA Business School is the Woodside Chair in Leadership and Management. This Chair position was created to support and foster research capacity in the Business School, with a particular focus on supporting junior colleagues. This involves collaborative industry research as well as industry engagement, both with industry personnel from Woodside Energy and more broadly across WA. The role also involves supporting their academic career trajectories more broadly. The UWA Business School is very grateful for this support and wishes to share some of this year's highlights that have been made possible by this position.

With regard to supporting early career research trajectories, Professor Yeo began the monthly "Early Career Researcher Hour" in July this year, for (currently) 17 postdoctoral fellows or Level B ("lecturer") academics to discuss pressing topics (e.g., juggling multiple projects, applying for promotion), receive peer feedback (e.g., on grant applications and project pitches) and roll out initiatives (e.g., "three week writing challenge", "research incubation workshop"). Through this mechanism, Professor Yeo, in collaboration with her junior colleagues, has recently begun developing an early career mentoring programme which is due to launch next year.

Professor Gillian Yeo (UWA Business School) is the Woodside Chair in Leadership and Management

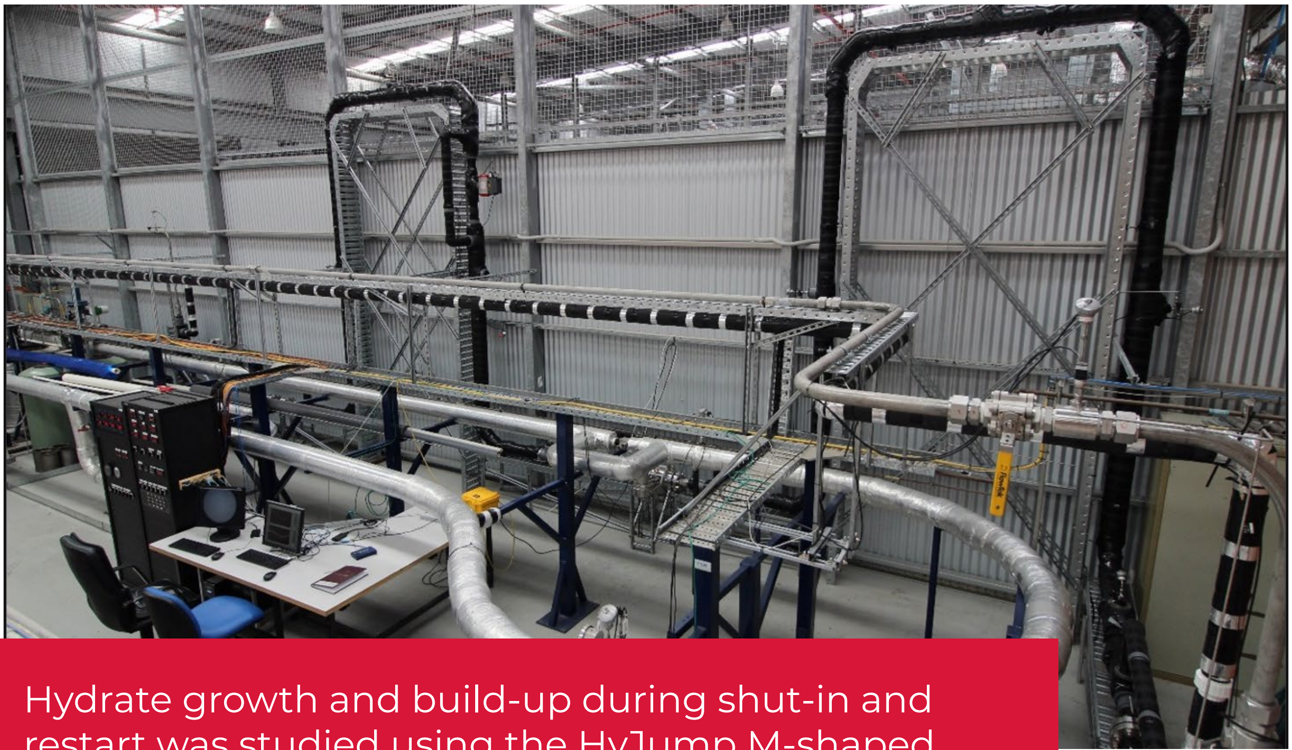
With regard to collaborative industry research, Professor Yeo has been mentoring Dr. Joseph Carpini (along with Drs. Michael Kyron and Lisette Kanse from the School of Psychology) in his capacity as chief investigator of a research project with MATES in Construction WA, which is a statewide effort aimed to assess the extent of suicide risk and identify risk protective factors. Also, as one of the theme leaders of an ARC Industrial Transformational Hub Grant (investigating fire safety and resilience), Professor Yeo is mentoring Drs. Ron Maas and Yifan Zhong in recruiting a PhD student and (soon to be) supervising that PhD, which will focus on identifying regulatory conditions that support compliance with fire safety regulations.

With regard to Woodside Energy more specifically, Professor Yeo (along with her PhD student Emma Stephenson and colleagues from UWA Psychology, USA and Netherlands) is in the process of seeking funding for research on "The Mental Load (the thinking work done to support family or work team goals) and Work", with keen interest in collaborating from colleagues at Woodside Energy. Professor Yeo has also enjoyed engaging with a range of Woodside Energy staff at formal events (e.g., The Breakfast by the Bay Event on Menopause; and a meet-and-greet with Sven Bolte [leading researcher on a neurodiversity] and Woodside's ADAPT group at the Business School), along with various informal conversations regarding shared interests ranging from leader identity to organisational culture.

Professor Yeo looks forward to continuing these engagements and starting new projects and initiatives in the year to come.

Industry Funded Centre

Static Hydrate Formation



Hydrate growth and build-up during shut-in and restart was studied using the HyJump M-shaped jumper (in black), which will be used to validate the updated UWA Hydrate Extension.

This project seeks to improve simulation of hydrate kinetics to predict growth rate during shut-in and start-up.

The UWA Hydrate Extension for OLGA has been successfully deployed to predict the growth rate and severity of hydrate build-up in gas-dominant systems. However, the current Extension limits hydrate growth kinetics to liquid water droplets entrained in the gas phase, based on previous studies led by UWA and CSIRO in the Hytra horizontal flowloop. Additional flowloop trials in a M-shaped jumper ("HyJump") suggested different build-up mechanisms, which involve both hydrate formation on the static liquid water pool (prior to restart) and on entrained bubbles during restart.

This project will deliver new hydrate kinetic predictions in the Extension. In addition to growth on entrained water droplets, the Extension will be updated to predict hydrate formation from dissolved and entrained gas in the liquid water phase, alongside wall growth from dissolved water in the gas phase. In addition, the updated Extension will describe the hydrate particle deposition rate in the liquid phase, which is important during periods of low flowing shear stress (e.g., during shut-in and restart).

The improved UWA Extension will be validated against a suite of published data from the HyJump flowloop, where hydrate formation was studied during shut-in and restart. In addition, an updated

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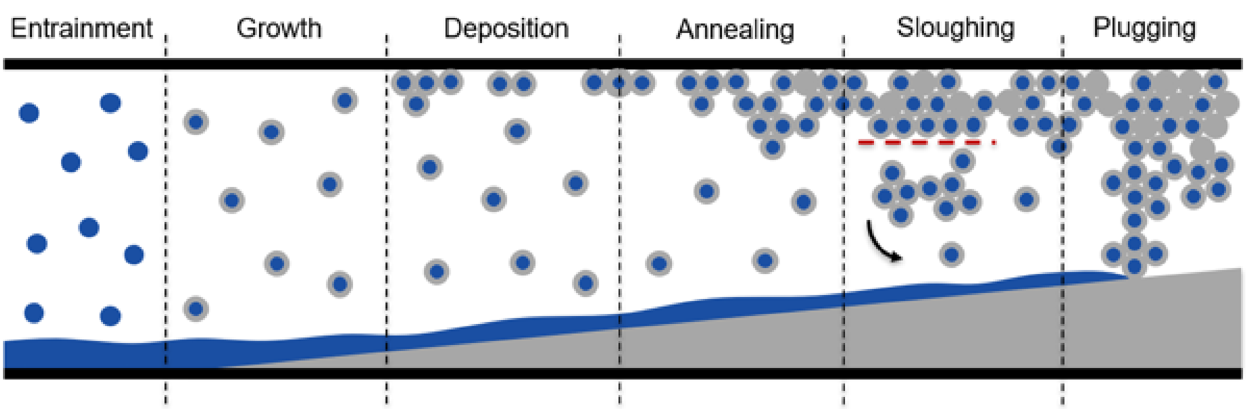
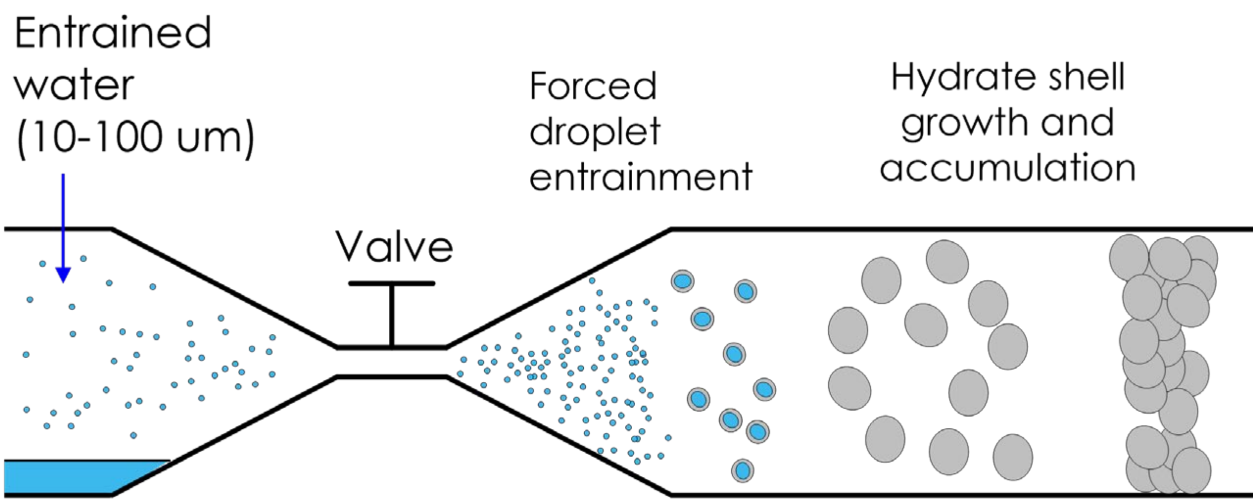
growth model for entrained liquid water droplets will be included and validated against data from a new Joule-Thomson Hydrate Flowloop built by UWA in 2021: hydrate formation was studied in this flowloop by expanding gas and water across a choke with a pressure differential of up to 80 bar.

While the current Extension describes the rate of hydrate growth and build-up during steady-state operation, it is limited in its ability to predict growth and build-up during shut-in and restart. By increasing the interfaces available for hydrate growth, and the mechanisms by which hydrates may build up on the pipeline wall, this improved transient simulation capability will be better suited for risk assessments and flow assurance solutions during transient operations.



In the UWA Hydrate Extension, growth on hydrodynamically (above) or forcibly (below) entrained water droplets leads to one build-up mechanism. This project will incorporate additional growth and deposition mechanisms in the continuous liquid phase, alongside updating growth rates for entrained droplets.



Australian Government
Australian Research Council

ARC Linkage

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

To understand deep time Aboriginal knowledge about water, rock art and song lines in arid north-west Australia

This projects focuses on bringing Indigenous and Western knowledge systems into conversation; Digital+ 3D recording platform; Developing mechanisms for intergenerational knowledge sharing. Four research nodes have seen important progress over two years:

1: Rock art, Stories and Water; data auditing of 600 rock art panels and recording in two new art provinces; in-field pigment colour analysis and identification of pigment sources; water mapping and sampling; modeling and mapping historical water sources (Martu and European).

2: Plants and Fire; Tree-ring analysis Callitris spp.; plant reference collections around rock art sites; anthracological (charcoal) analysis; experimental controlled fire experiments known tree species.

3: Collections; audit and digitisation of the donated Mark de Graaf collection (maps, notebooks, documents, transparencies, film, audio, objects).

4: Heritage training and data; Repatriation of Canning Stock Route Database (25,000 images, 800 sites) to three Aboriginal partners and on-Country heritage actions with all Ranger groups.

Three PhDs are now employed on the project, researching water, pigments, and residue analysis. One honours student is studying the charcoal from Wirrili shelter.

Desert to the Sea is now into its third year. The collaboration involves ten researchers from five universities, three partner Aboriginal Corporations, three industry partners and collaborators from the WA Museum and DBCA. Four project staff are employed by the grant and there will be four PhD students and several Honours projects. We have completed 12 fieldwork trips (culture camps, archaeological recording and ranger heritage training), and have recorded 127 sites, 1,495 rock art images, 1,071 stone artefacts and 46 stone structures. These trips have facilitated 740 on-Country days for Traditional Owners and Rangers, 496 researcher days, 363 project staff days, and 59 industry partner days.

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Dating Murujuga's Rock Art: New Scientific Approaches

How old is Murujuga's rock art and how has the changing environment influenced rock art production?

The Dating Murujuga's Dreaming research team have deployed new scientific methods to direct-date rock engravings and stone structures, with local environmental proxies contextualising the changing landscape and resource use over the period of Murujuga's human occupation.

The project is investigating a range of novel techniques to approach absolute dating of rock art and stone structures, exploring the age of desert varnish (with U-series, 14C and DNA of microbiome) and through luminescence rock surface exposure and burial dating.

The project foci is on records of past environmental and climatic conditions that enabled and constrained human occupation and associated art production. During the last glacial period, sea level was lower and Murujuga was ~160 km inland. Rapid sea level rise after ~14 ka , transformed Murujuga from an inland range to a coastal archipelago ~7 ka. Climate proxies from freshwater tufa, sediments and shells, provide environmental information on a range of temporal scales and inform on local conditions and resource availability.

Water availability and changing hydroclimate through the Holocene impacted humans accessing the islands. Modern collection with MAC Rangers of Tegillarca granosa shells, (found in many Murujuga Holocene middens), is allowing us to understand seasonality of occupation.

This significant collaboration with Murujuga Aboriginal Corporation will improve the conservation and management of one of Western Australia's premier cultural heritage places. Key outcomes for dating rock art and stone features will have global implications. Developing new climatic records will enhance the accuracy of predicting and measuring the impact of environmental changes.

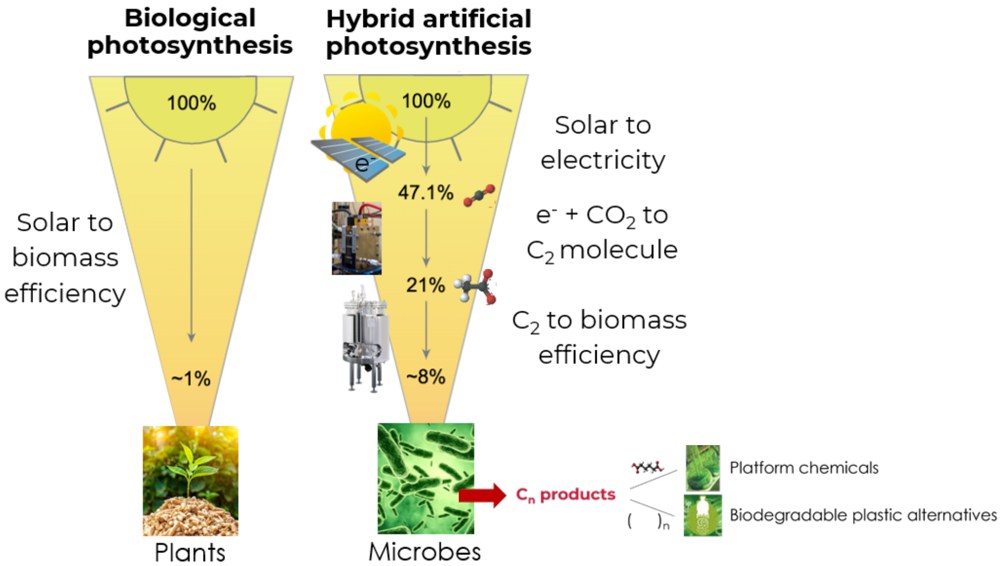
A total of 460 researcher days have been spent in the field, collecting and measuring geological, water and soil samples. Community engagement has involved Ranger participation and 27 meeting with Murujuga's Circle of Elders and/or Board, for permissions and reporting back on fieldwork and laboratory results.

Australian Government
Australian Research Council

ARC Linkage

Building a CO_2 Foundry

Developing carbon solutions to enable Woodside's base business, support growth, and deliver future values.



Hann, et al. *Nature Food* (2022)

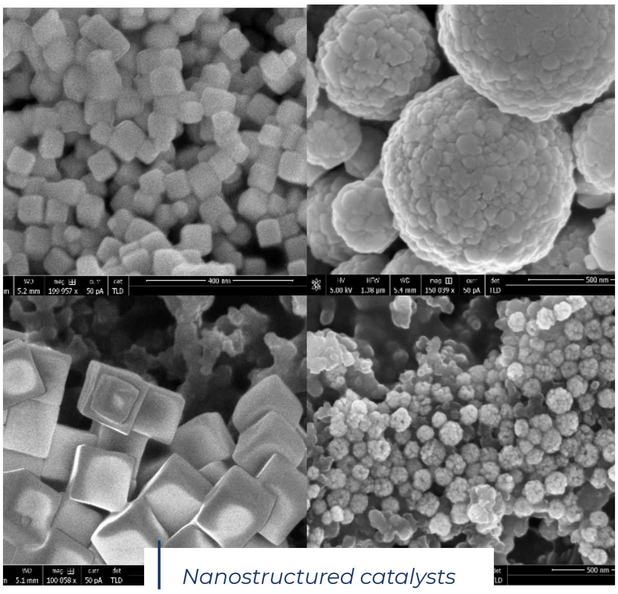
Can a hybrid electrochemical/biological system serve as an efficient carbon capture and utilisation technology?

This project aims to develop an integrated carbon capture and utilization (CCU) platform that transforms CO_2 emissions into valuable bioproducts, contributing to sustainable industry practices and CO_2 reduction. By combining electrocatalysis and synthetic biology, the project converts CO_2 into acetate for further processing into biopolymers and platform chemicals, supporting eco-friendly alternatives to petrochemicals.

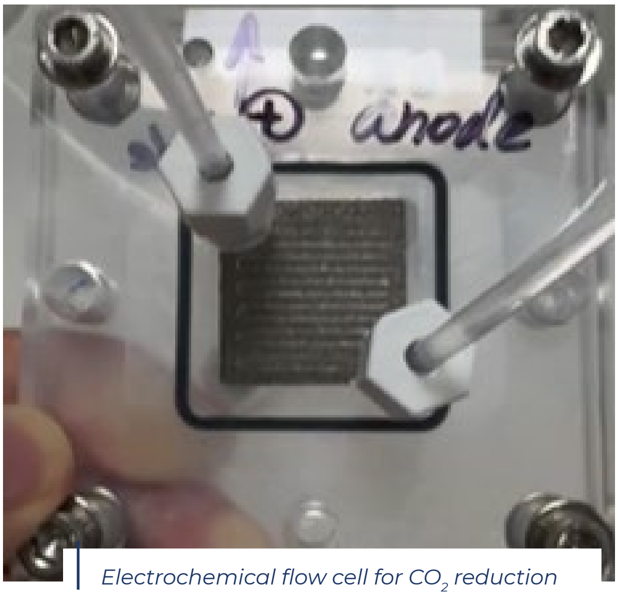
In 2024, significant progress was made. The electrocatalysis team optimized nanostructured catalysts, boosting the selectivity and efficiency of CO_2 reduction to acetate, creating a strong foundation for scalable CO_2 capture. The microbial engineering team advanced *Vibrio natriegens* to rapidly metabolize acetate and produce high yields of PHB biopolymers, using innovative genome editing techniques. The fungal bioconversion team adapted *Aspergillus oryzae* to tolerate high

acetate levels and convert it into malic acid, with early success in dicarboxylic acid synthesis. These achievements lay the groundwork for future industrial-scale applications of this sustainable CCU technology.

The CO_2 Foundry project incorporates groundbreaking innovations drawn from the combination of cutting-edge research in electrocatalysis, nanotechnology, and synthetic biology. The project employs highly efficient catalyst designs and genetically engineered microbes that enable an 8-10x increase in CO_2 conversion rates compared to traditional photosynthesis, achieving transformation speeds 30-40 times faster than plants. The innovative integration of these technologies offers a scalable solution that positions the CO_2 Foundry as a leader in transforming emissions into economically viable, carbon-negative products.



Nanostructured catalysts



Electrochemical flow cell for CO_2 reduction

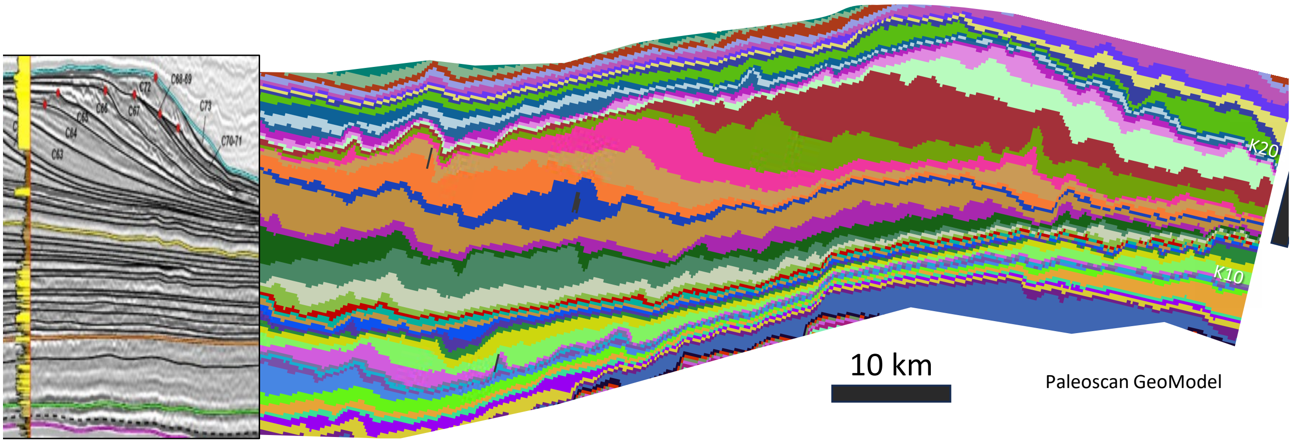
Genetically engineered bacterium

Bioprocess for PHA bioplastic production

Research Consortia

Quantitative Seismic Stratigraphy & Reservoir Analogues (QRA)

Can high-resolution seismic stratigraphy and modern depositional systems provide better quantitative measures to improve subsurface geological models?



Shelf-Margin Seismic Scale Clinoforms in the Carnarvon Basin
Late Jurassic to Early Cretaceous (Lower Barrow Group K10-K20)

This project uses high resolution seismic stratigraphy for quantitative measures of element complex scale seismic geomorphologic features, and relates these to measurements from outcrops or depositional modern systems to build better subsurface reservoir models.

QRA – the Quantitative Reservoir Analogues project, is now a multi-company research consortium that was shaped from a 3-year Woodside-UWA Partnership Agreement (2020-2022) based on the need for quantitative measures for modeling subsurface reservoirs and seals using data from seismic, outcrop and modern depositional systems. The project applies innovative quantitative 3D seismic interpretation ('QSS' workflows) to reveal seismic geomorphic features at the reservoir compartment scale (element complex) and deploying knowledge from 3D geometries of potential reservoir/seals from the spatial mapping and vertical drilling of modern and ancient reservoir analogues.

QRA investigates the linkages between shelf-margin architecture, hydrodynamic processes along fluvio-deltaic shorelines down into equivalent shelf/slope and deep-water setting, underpinned by state-of-the-art, full volume, semi-automated 3D

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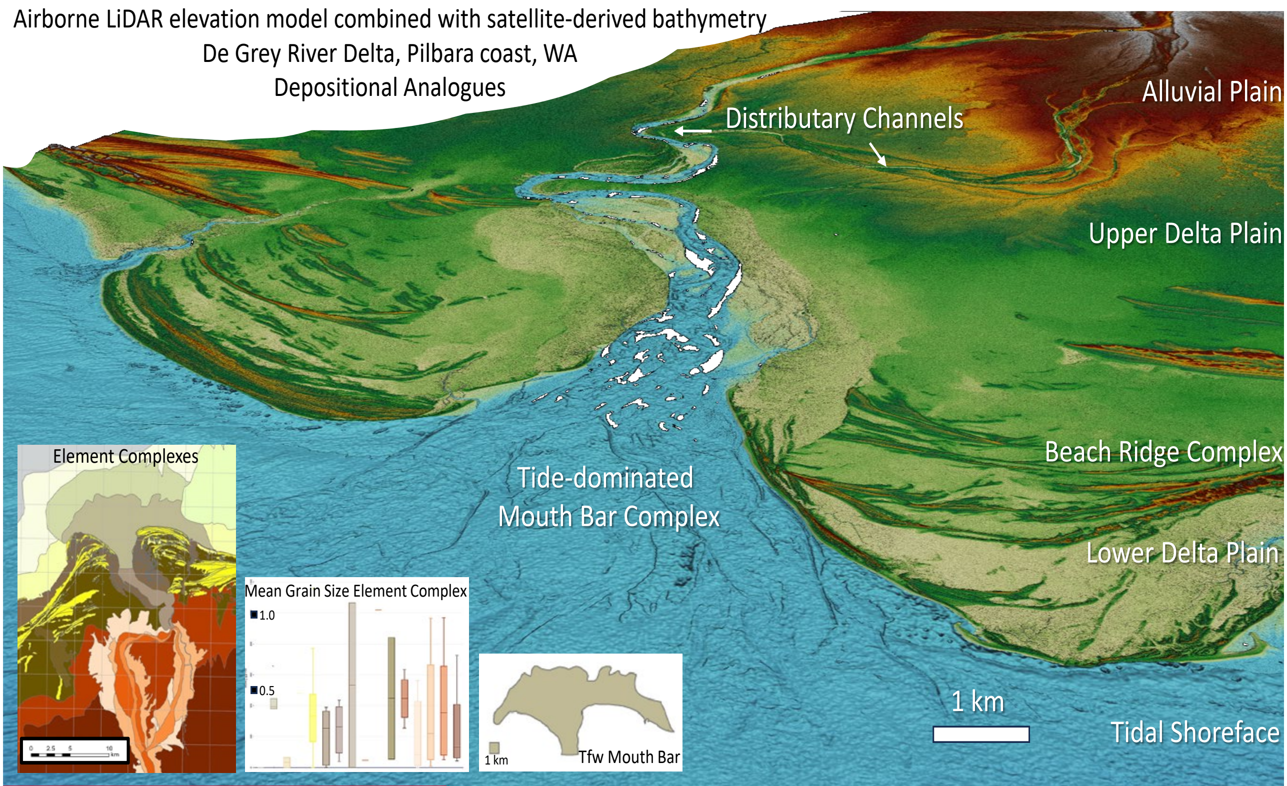
seismic interpretation methods that enable very high-resolution seismic stratigraphic analysis of large open file or donated proprietary/multi-client datasets to date from Australasia, SE Asia, Gulf of Mexico, Alaska and Europe. The focus has been on the inter-field to reservoir "element complex" scale (rock type, spatial geometry and especially thickness, and 3D architectural connectivity) in a variety of tectonic and climatic settings. This phase of the study is specifically focused on datasets with well-log and core-log data to link the vertical thickness and rock types with the seismic attributes and continues to investigate modern fluvial-deltaic systems of the Pilbara coast that provide high-resolution detail on processes that control facies juxtaposition and potential reservoir quality, that are training datasets for prediction and geostatistical distribution of facies properties below the seismic scale.

Key findings delivered by a live online database relating numerous measures extracted from clinoforms and mapping of element complexes from seismic geomorphology, especially associated with coastal-deltaic systems with varying fluvial-, wave- and tidal dominance, that influence run-out distances for deepwater channel complexes. Morphometrics of element complexes and juxtaposition from the various modern and ancient analogues provide key data for scaling (e.g. channel belt and bar statistics).

Deployment via bi-annual workshops, field training courses (Gascoyne delta & Kennedy Range in 2024), and confidential call-off workshops.



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Industrial Transformation Research Hub

Transforming energy Infrastructure through Digital Engineering

Spotter Buoy deployments for AT1-B in the Southern and Indian Ocean.

Applied Theme 1

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

TIDE AT1 uses sparse data, statistical methods, and physics-based models to forecast and characterise the ocean environment, with quantified uncertainty.

AT1-A is enhancing marine forecasting by characterising the predictability of nonlinear internal waves and eddy fields on the NWS through the fusion of advanced in situ and satellite data with physics-based models.

AT1-B is improving regional operational wave forecasts through assimilation of satellite and buoy wave observations, and site-specific forecasts using machine learning.

AT1-C is using machine learning and statistics to predict ground conditions at unsampled locations, and also compiling a unique database for carbonate sediments from project site investigations.

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Applied Theme 2

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

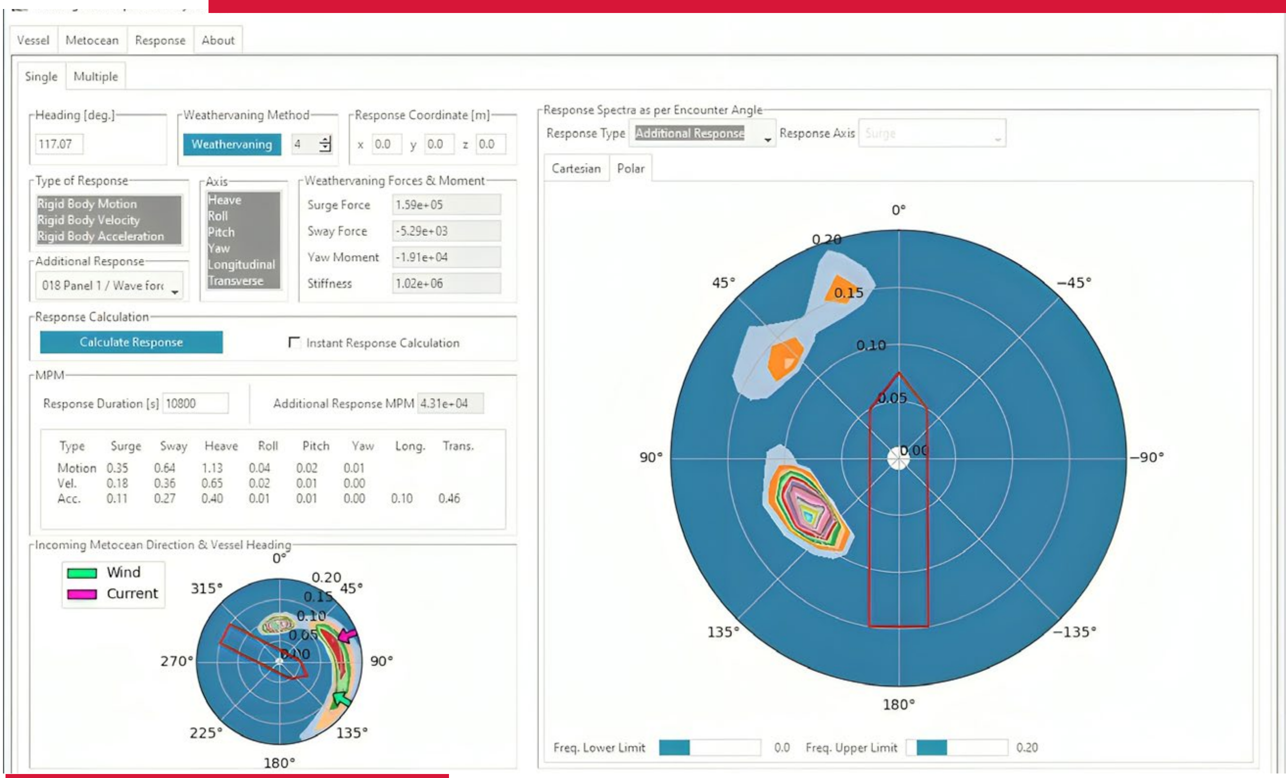
TIDE AT2 studies environmental effects on structures at the sea surface for enhanced decision-making. It is improving the design of infrastructure located at the sea surface.

AT2-A is developing frameworks to quantify and reduce uncertainty in wave forecasts, integrating machine learning and field data to enhance decision-making in operational sea states.

AT2-B is advancing reliability of offshore design by refining wave field representation in cyclonic conditions, and by improving load prediction for lightweight structures under multivariate extremes.

AT2-C is focused on enhancing the reliability and design of flexible risers, moorings, and vessel responses in extreme metocean conditions using machine learning and probabilistic models for improved safety and operational efficiency, and physical modeling.

TIDE AT2-B is developing software for efficient analysis of weathervaning behaviour and wave-induced responses of a ship unit, applicable to a large number of metocean combinations



Industrial Transformation Research Hub

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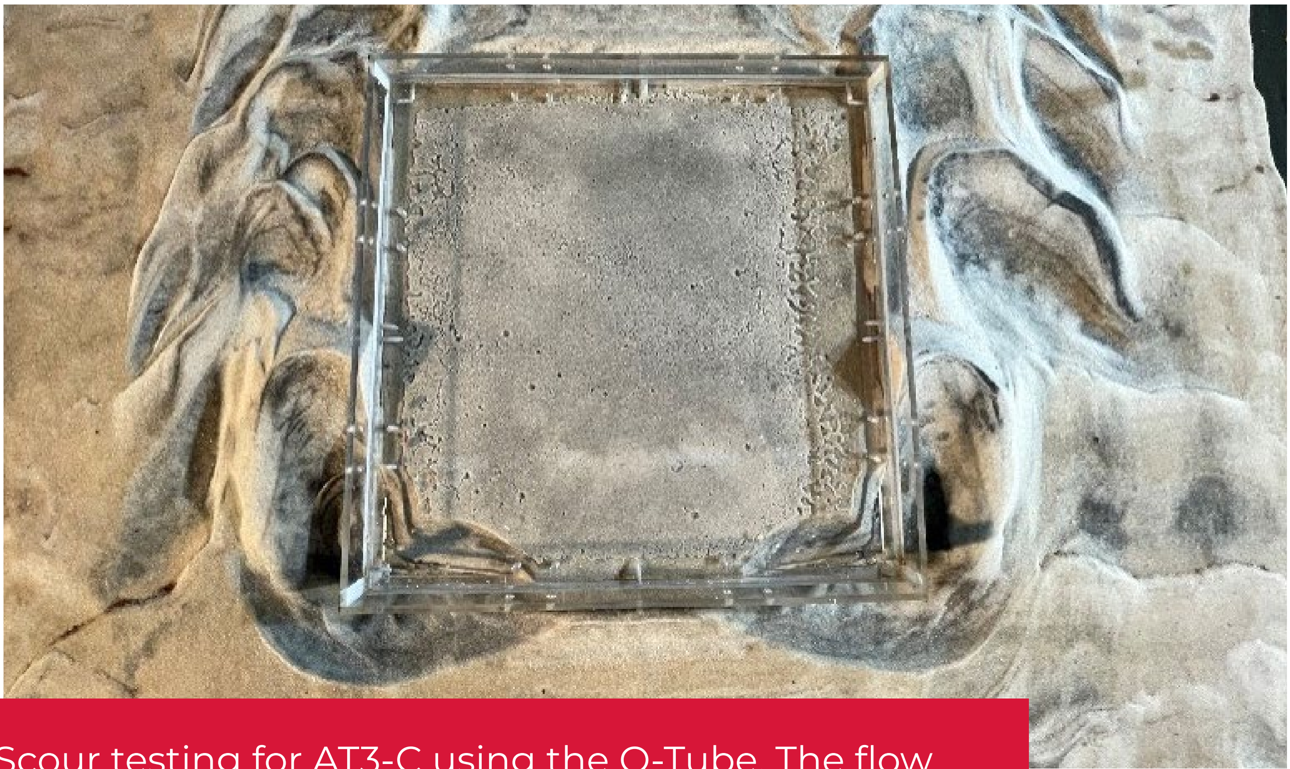
Transforming energy Infrastructure through Digital Engineering (continued)



Scour testing for AT3-C using the O-Tube. The flow direction is from bottom to top. The structure is squat with a skirt, and undermining is observed around the upstream corner

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.

AT3-A is working with observations gathered from offshore pipelines (and over extended periods) to inform future design practice, and support better operational design making.

AT3-B is using numerical simulations, physical experiments and field data to reveal key physics for pipeline freespans – with the goal to reduce the cost associated with inspection and remediation activities.

AT3-C is developing tools to predict and mitigate scour around subsea infrastructure, by combining numerical and experimental assessments, supported by field data.

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Enabling Theme

How might we use statistics and data science to 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.

The ET team delivers statistical spatio-temporal modeling, statistical and AI forecasting, Bayesian optimisation and emulation to facilitate design/ decision-making in uncertain environments.

They also develop tools for analysis/evaluation of time-series data; both stationary and non-stationary, in the time and spectral domains, and with engineering applications.

TIDE member Adam Sykulsku (Imperial College London) delivered a master class on space-time statistical modeling, including a discussion on the frequency-direction spectrum associated with ocean waves.

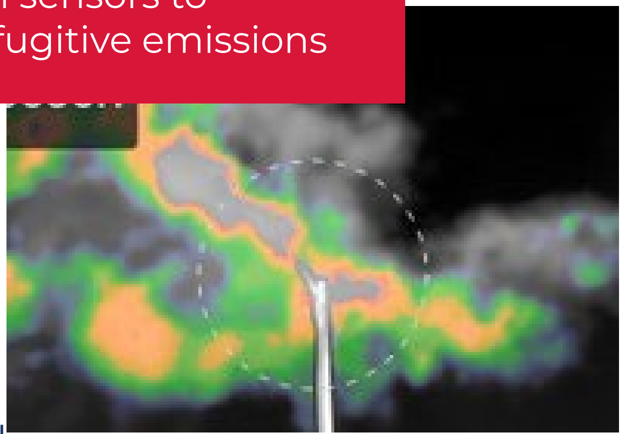
Australian Government
Australian Research Council

Co-operative Research Centre

Future Energy Exports CRC

Building WA capability for evaluating the performance of methane detection sensors to support local industry in reducing fugitive emissions

Test methane release from UWA's Shenton Park facility under ideal conditions. Methane is released at a known rate as measured using a set of Alicat flow controllers, which is used to benchmark candidate detection technologies. .



Test methane release from UWA's Shenton park facility with background interference. Understanding environmental factors is critically important when trying to quantify the release of methane.

Test Bed for Fugitive Methane Emission Sensors

Reducing greenhouse gas emissions is an ongoing challenge for all industries, and a particular focus for Australia's future energy exports. Decarbonisation of the energy industry requires effort across the whole value chain, including production and processing, in addition to capturing combustion emissions. Throughout the LNG ecosystem, so-called fugitive emissions can result from incomplete combustion, venting and methane slip. The ability to measure the magnitude and location of these fugitive emissions is crucial to efficiently allocating resources for mitigation.

This project makes use of a new test apparatus designed to evaluate different sensor technologies and establish the efficacy of each, to quantify which of these tools is fit for any given situation. The test rig is a benchtop-scale controlled release system supplied with bottle methane, with flowrates to be precisely controlled. Detection apparatus to be tested include a FLIR GFx620 camera (Teledyne FLIR), GMP02 QOGI Camera (Konica Minolta), GFM 2.0 High Volume Sampler (Add Globe) and Semtech Hi Flow 2 Sampler (Sensors Inc).

The work is critical in meeting legislated emissions reporting requirements for the Australian energy industry, and will enable such reporting to be performed in a reliable and cost-effective manner. Further, the testing of small-scale detection technologies is critical for site inspections in minimising the overall emissions from facilities, and may help inform replacement of "emissions factors" with more quantitative metrics.

The project has seen the commissioning of a capability for testing candidate sensor efficacy in detecting emissions, but, more importantly, serves as a launch pad to expand this initiative in future. At present, a pilot test facility at the UWA Shenton Park Campus may be used for large scale releases, with future plans to shift to the Kwinana Energy Transformation Hub when it becomes available in 2025-26.

Woodside Energy

START 2020 — 2024 — END 2030

How can we lower the hydrogen liquefaction process's power consumption and cost?

Development and demonstration of safe, efficient hydrogen liquefaction through optimised mixed refrigerants and plant design

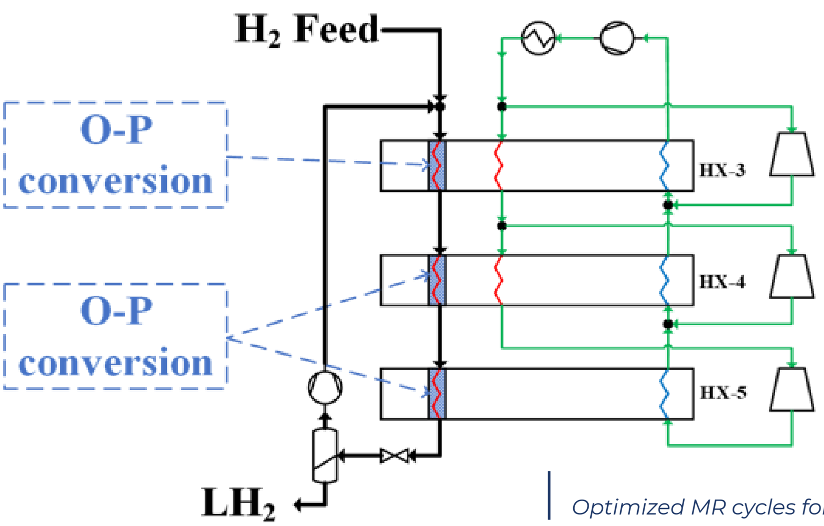
This project aims to provide significantly lower hydrogen (H2) liquefaction costs with novel mixed refrigerant (MR) cycles and smaller, safe plant layouts through the development of validated numerical tools. We will achieve this by completing three carefully designed and integrated core research programs delivering:

A novel demonstration and testing facility for liquid hydrogen (LH2) production using MR (lowering power consumption and cost)

New tools for understanding the thermodynamics and fluid dynamics of cryogenic hydrogen to optimise LH2 process design, efficiently scale-up turbomachinery, and to better predict release incidents

Fit for purpose safety codes for LH2 plants and associated infrastructure design so hydrogen liquefaction can be cost competitive without compromising safety,

This combined experimental and simulation approach will enable a more straightforward and streamlined liquefaction process, with simpler process configurations and a smaller plant footprint, collectively resulting in lower capital costs. Upon completion of the project a total hydrogen specific liquefaction cost (SLC) of 1-2 US$/kg will be targeted. This approximately 50% total cost reduction over the current state-of-the-art will be composed of both reduced power consumption and a cheaper compression inventory for both the refrigerant and process fluids, coupled with more precise design tools featuring significantly reduced uncertainty, in the process curtailing current excessively conservative design practices with respect to LH2 process plant safety. The improved knowledge regarding cost-reduction, safety and dispersion will foster further development of hydrogen liquefaction technologies and facilitate the up-scaling of LH2 production and storage facilities.



Optimized MR cycles for H2 liquefaction

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ANNUAL REPORT 2024

A diverse and thriving ecosystem of industry, academia and students to collaborate and co-create to solve challenges today, and into the future.

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.

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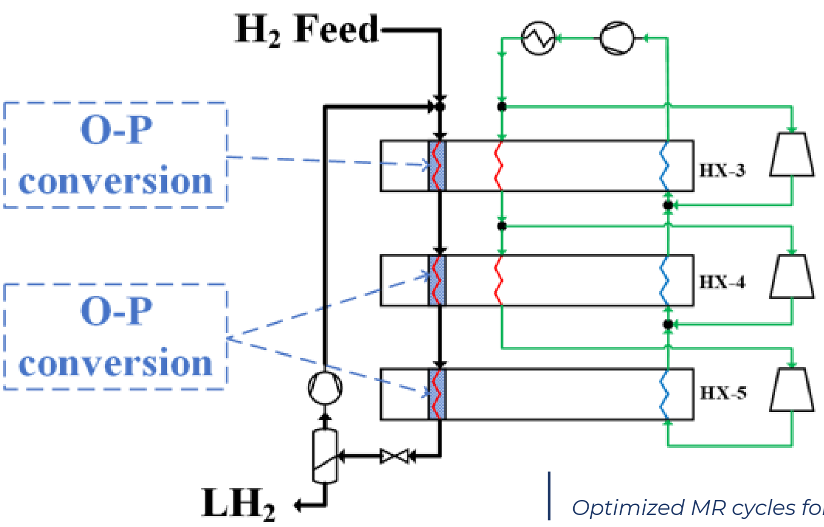

Optimized MR cycles for H2 liquefaction