2022 Annual Report

Woodside Energy

FUTURELAB
at UWA

"An environment where industry, academia and Government can collaborate on problem solving is essential to realise truly impactful solutions."

Voula Terzoudi
Head of Partnerships - Australia, Woodside Energy

"OceanWorks and TechWorks provide a rich opportunity for students and academics to partner with Woodside Energy to apply their learning and expertise to Industry challenges."

Prof. Anna Nowak
Deputy Vice Chancellor (Research), The University of Western Australia

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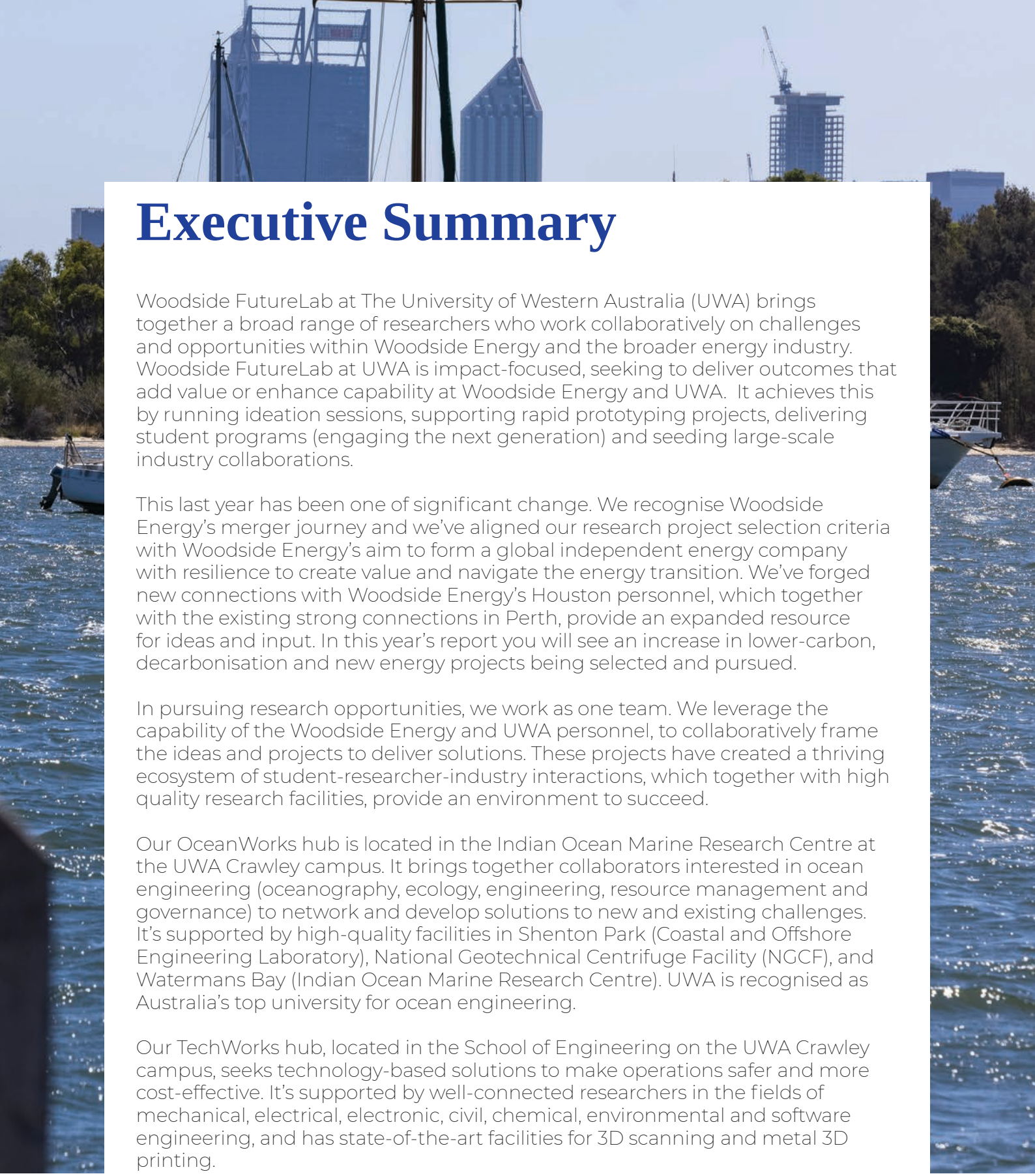


Executive Summary

Woodside FutureLab at The University of Western Australia (UWA) brings together a broad range of researchers who work collaboratively on challenges and opportunities within Woodside Energy and the broader energy industry. Woodside FutureLab at UWA is impact-focused, seeking to deliver outcomes that add value or enhance capability at Woodside Energy and UWA. It achieves this by running ideation sessions, supporting rapid prototyping projects, delivering student programs (engaging the next generation) and seeding large-scale industry collaborations.

This last year has been one of significant change. We recognise Woodside Energy's merger journey and we've aligned our research project selection criteria with Woodside Energy's aim to form a global independent energy company with resilience to create value and navigate the energy transition. We've forged new connections with Woodside Energy's Houston personnel, which together with the existing strong connections in Perth, provide an expanded resource for ideas and input. In this year's report you will see an increase in lower-carbon, decarbonisation and new energy projects being selected and pursued.

In pursuing research opportunities, we work as one team. We leverage the capability of the Woodside Energy and UWA personnel, to collaboratively frame the ideas and projects to deliver solutions. These projects have created a thriving ecosystem of student-researcher-industry interactions, which together with high quality research facilities, provide an environment to succeed.

Our OceanWorks hub is located in the Indian Ocean Marine Research Centre at the UWA Crawley campus. It brings together collaborators interested in ocean engineering (oceanography, ecology, engineering, resource management and governance) to network and develop solutions to new and existing challenges. It's supported by high-quality facilities in Shenton Park (Coastal and Offshore Engineering Laboratory), National Geotechnical Centrifuge Facility (NGCF), and Watermans Bay (Indian Ocean Marine Research Centre). UWA is recognised as Australia's top university for ocean engineering.

Our TechWorks hub, located in the School of Engineering on the UWA Crawley campus, seeks technology-based solutions to make operations safer and more cost-effective. It's supported by well-connected researchers in the fields of mechanical, electrical, electronic, civil, chemical, environmental and software engineering, and has state-of-the-art facilities for 3D scanning and metal 3D printing.

OceanWorks TechWorks

THE UNIVERSITY OF WESTERN AUSTRALIA

Woodside Energy FUTURELAB

Professor Tim Sercombe
TechWorks Chair
Head of School of Engineering, UWA

Voula Terzoudi
Head of Partnerships - Australia
Woodside Energy

Nicole Austin
Curator
OceanWorks & TechWorks

Assoc. Professor Scott Draper
OceanWorks Chair
Head of Department of Civil, Environmental & Mining Engineering, UWA

Leadership Team

OceanWorks and TechWorks are the two flagship programs that form the Woodside FutureLab at The University of Western Australia (UWA). Both programs act to generate, incubate, and deliver innovative, impactful outcomes for Woodside Energy. The programs focus on Ocean- and Technology-themed initiatives and are governed collectively under the UWA-Woodside Framework Agreement.

In 2022, OceanWorks enabled 22 new research projects investigating solutions ranging from carbon sequestration using micro algae through to efficient offshore data acquisition. The projects are undertaken as rapid prototype studies; final year student projects within the unique RiverLab program; and multi-disciplinary internships. OceanWorks also coordinates education and training modules to Woodside Energy personnel and delivers an engaging annual Outreach program to encourage young women to pursue a STEM career in ocean engineering.

TechWorks saw the delivery of the EOS M290 Metal 3D Printer in May and with this, a growth in the 3D Additive Manufacturing capability at UWA. The team was impacted by a range of staff changes in 2022. Joss Doak-Smith commenced as the TechWorks Manager in March, while June saw several Woodside Energy Technology team changes as part of the restructure process. Finally in September, Joss took on the role of the UWA Woodside Energy Robotics Laboratory liaison, which will bring close alignment of the robotics and automation activities at Woodside Energy and the capability at UWA.

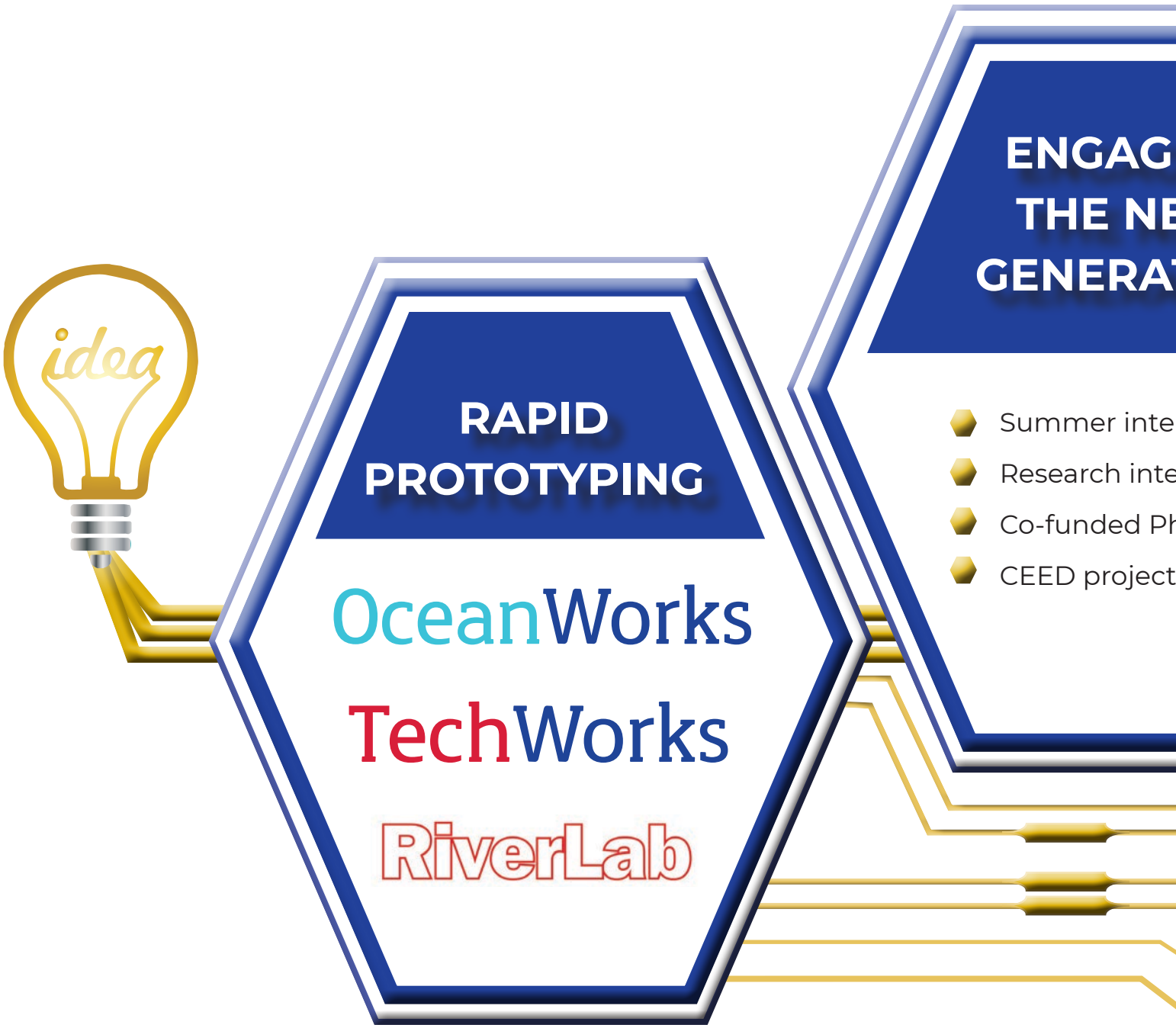
The long-standing UWA-Woodside Energy partnership is a testimony to the relationships and trust between key personnel that has been built through open collaboration. This has resulted in the generation of new ideas, rapid and reliable testing methods to prove new concepts, and a culture of growing proven concepts into larger programs of work that deliver demonstrated value to Woodside Energy.

We would like to thank the Woodside Energy and UWA staff who have contributed to the collective success of the FutureLab at UWA in 2022 and especially the OceanWorks and TechWorks Advisory Committees. Collectively Woodside FutureLab at UWA has included more than 80 UWA researchers, staff and students over the last 12 months.

Looking ahead, we are excited to welcome Voula Terzoudi back to the team and to use our collaborative partnerships and capability to innovate across the Woodside Energy organisation in 2023.

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.

Woodside FutureLab Value Chain



Woodside FutureLab at UWA is designed to encourage people to “Think Big, Prototype Small, Scale Fast” and apply these learnings to Woodside Energy projects.

OceanWorks and TechWorks provide opportunities for Woodside Energy personnel to connect with the University and its researchers. They provide a means to explore new ideas through rapid prototyping and student research projects. Successful prototypes and projects then deliver immediate impact to Woodside Energy or seed larger research collaborations. The examples on the following pages demonstrate some sample pathways that have unlocked this value chain.

THE UNIVERSITY OF WESTERN AUSTRALIA

ING EXT TION

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INDUSTRY - GOVERNMENT RESEARCH

- Cooperative Research Centre
- Australian Research Council
- Industry Fellowships
- Joint Industry Project
- Program Chair

IMPACT

Value & Enhanced Capability

- Cost reduction (problem solved)
- Competitive advantage
- Talent acquisition
- Internal development (skills, systems)
- Increased efficiency, safety & reliability
- Business transformation
- Supply chain partnership
- Commercial opportunities (Licensing, start ups)

Research Showcases

Using micro-biology to solve macro-problems: tackling plastic pollution and $C0_2$ emissions head on

OceanWorks Prototype - VibrioPET to Degrade PET Plastics (Phase 1)

In 2020, Georg Fritz completed an OceanWorks prototype to test the use of synthetic biology tools to degrade PET (polyethylene terephthalate) which account for up to 30% of microplastic pollution found in our metropolitan marine environments. This work aligns with Woodside Energy's wider interest in helping to find solutions to reduce the abundance of marine plastics in our oceans.

The project equipped the world's fastest-growing, non-pathogenic bacterium *Vibrio natriegens* with the enzymatic machinery to break the PET polymer into its non-toxic monomeric building blocks. The project confirmed the effect of PETase and MHETase to degrade the PET polymer into terephthalic acid (TPA) monomers but further research was required to develop a marine bacterium to serve as a fast-growing chassis organism to produce and excrete key enzymes for the bio-degradation of PET plastics in marine environments.

VibrioPET to Degrade PET Plastics (Phase 2)

In 2021, Georg completed a second proof of concept to engineer the ultra-fast growing marine bacterium *Vibrio natriegens* into a microbial platform for rapid bio-degradation of polyethylene terephthalate (PET) plastics. This demonstrated that the bacterium can grow on the PET breakdown products protocatechuic acid (PCA) and to a minor extent on terephthalic acid (TPA).

Towards Building a $C0_2$ Foundry (Phase 1)

Georg was subsequently engaged by Woodside Energy to develop a proof-of-concept and preliminary experimental evidence for an innovative carbon capture and utilisation technology fusing synthetic biology with inorganic chemistry. The technology utilises nano-structured copper electrocatalysts to efficiently convert $C0_2$ from industrial emissions into the C_2 feedstock acetate, and genetically-engineered microbes to rapidly transform acetate into platform chemicals and biopolymers.

The project successfully established an electrochemical flow cell for the $C0_2$ conversion reaction into acetate, and produced the first generation of copper nano-cubes as catalysts. The ultra-fast-growing bacterium *Vibrio natriegens* was successfully adapted for rapid growth on acetate (4x faster than usual *E. coli* cells), and the production of the bioplastic poly-hydroxybutyrate (PHB) was demonstrated qualitatively during growth on acetate. The research outcomes formed the basis for a joint UWA-Woodside Energy Australian Research Council (ARC) Linkage project application (Phase 3).

Towards Building a CO_2 Foundry (Phase 2)

This project seeks to advance experimental results in the $C0_2$ foundry project, by expanding the diversity of nano-structured copper surfaces with enhanced electrocatalytic efficiencies, and by quantifying and optimising the microbial conversion of acetate utilisation to PHB and other bioplastics

This ongoing project has successfully produced copper surfaces in the form of roughly structured nano-films, smooth nano-sheets, as well as nano-cubes with different geometries, forming the basis for new catalysts for the $C0_2$ to acetate reaction. Preliminary results during growth on acetate suggest that microbes accumulate significant PHB titres that could result in economically viable bioplastic production processes.

OceanWorks Prototype - Microalgae for CO_2 Valorisation (Phase 1)

In 2022 Georg was further engaged by Woodside Energy to apply his skills to explore the application of microalgae in carbon sequestration technologies. Georg and his team are currently reviewing and critically analysing available microalgal strains, their features and possible farming methods to be used for $C0_2$ valorisation in Western Australian conditions. It will provide recommendations for a prototype facility and will identify key parameters that determine its economic viability.

ARC Linkage Project Building a CO_2 Foundry for Sustainable Carbon Capture and Sequestration (Phase 3)

In February 2023, this large-scale government grant was awarded funding to provide the scientific and technological basis for building a carbon dioxide foundry in Western Australia. The resulting technology will turn $C0_2$ from a liability into a triple opportunity for Australia by removing greenhouse gases from the atmosphere, providing renewable hydrocarbon feedstocks, and creating new revenue streams from $C0_2$-derived products.

The $C0_2$ foundry is designed around the genuine needs, restrictions, and opportunities of Woodside Energy, including the availability of high-purity $C0_2$ from gas plants and renewable energy from Woodside Energy's photovoltaics investment in Western Australia's Karratha region.

"The networks built through Oceanworks have been absolutely defining for the projects we are running in our lab."

Dr Georg Fritz
School of Molecular Sciences

Research Showcases

Solving an industry-wide problem to biofouling on subsea assets

OceanWorks Prototype - Rapid Bar Coding & DNA Sequencing Kit

In 2020, Parwinder Kaur was introduced to Woodside Energy to test out the latest DNA technologies to develop more informed strategies to combat biofouling on subsea structures. The OceanWorks prototype tested the success of DNA extraction and Nanopore sequencing on vessel as a proof-of-concept experimental approach for the on-site acquisition of genetic data. The knowledge gained from these tests will help build a solid foundation for developing fieldwork-based protocols and procedures to characterise and assess marine biofilms.

Woodside Anti-Marine Growth Structure (AMGS) (Phase 1)

This project developed protocols for the collection and transport of biological samples from vessel to the lab for Phase 1 of the AMGS retrieval.

The learnings from this phase helped direct future projects conducted on marine growth on subsea structures including optimising the collection and experiment procedures as well as logistical constraints.

Woodside AMGS (Phase 2)

Phase 2 of the AMGS project consists of lab-based analysis of biospecimens to assess how each responds to the respective equipment samples to determine differences between the vendor materials and the control population obtained from the AMGS. The genetic and physiochemical data obtained from this project will be able to inform vendors and operators of the effectiveness of the respective equipment samples. This data can be further explored to aid the development of potential anti-biofilm countermeasures that are better targeted for the biodiversity common within this operating region.

SEAR JIP - TASER Subsea Test Structure (STS) Retrieval Test Program

In 2022, Parwinder was awarded a joint industry project grant to apply these learnings to other structures in the North-West Shelf region which will greatly expand upon the understanding of marine ecology and how marine growth/biofilms develop. The extensive analyses that will be conducted in this project will be critical in combating biofouling on subsea structures used in various industries.

"I am extremely grateful to Oceanworks for providing important funding support to test and validate initial hypothesis and technology which helped with downstream funding from industry partners. We benefit hugely from the support and connections provided through the Oceanworks team."

Assoc. Professor Parwinder Kaur
School of Agriculture & Environment

Ocean swell prediction

OceanWorks Prototype - Swell Local Adjustment via Monitoring

In 2020, Jeff Hansen completed an OceanWorks prototype to improve operational wave forecasts that feed into a range of offshore operations from loading LNG to crew transfers.

Machine learning algorithms were trained using historical wave forecasts along with observations from wave buoys, to identify and correct consistent errors in the forecasts.

Results from this prototype indicated that the machine learning methodology reduced forecast errors by as much as 20%. Based on the early results, the project caught the attention of the Bureau of Meteorology (BoM) who provide custom forecast products for many offshore operators.

As a result, the Machine Learning system has been continually developed under sponsorship from the BoM and industry. The prototype project and subsequent industry sponsored research also formed the basis for several research projects included in the Australian Research Council TIDE Research Hub (Transforming energy Industry through Digital Engineering).

"OceanWorks was a great opportunity to get to know people in industry, understand their challenges and develop novel prototype ideas that can be tested with seed funding. In the case of the swell prediction prototype this has led to developing a system that now runs operationally for industry and the opportunity, through the TIDE research hub, to focus on developing the fundamental techniques further so they can be applied in the coming years."

Dr Jeff Hansen
School of Earth Sciences

OceanWorks student wins PhD Scholarship and works on TIDE

OceanWorks Prototype - Data-Driven Real-Time Prediction of Ocean Responses

Impact can be realised in many ways. One of the key benefits of student-industry-academic collaboration is the ability for students to work on Woodside Energy projects and provide an opportunity for career employment.

In 2020, Dr Wenhua Zhao and Dr Ian Milne completed an OceanWorks prototype that investigated the capacity of different machine learning models to predict ocean responses in real-time. They engaged a student Jianlun (Eric) Chen, who enjoyed the research so much that he decided to do a Phd at UWA.

Jianlun was subsequently awarded a Research Training Program scholarship and has developed machine learning models to significantly improve the forecasting capability compared to conventional theoretical analysis with the TIDE team. He has delivered 3 papers within 2 years.

OceanWorks

OceanWorks is designed to share challenges and boost innovation in ocean engineering. We bring together high-calibre engineers, researchers and students to identify new ideas and nurture promising solutions that will shape the future of ocean industries.

In 2022, Woodside and UWA signed a renewed 3 year contract that saw the continuation of our Prototype project program, the RiverLab program, Internships and Outreach activities. We also introduced an Education & Training component designed specifically to enhance the capability of current and future Woodside Energy engineers.

Prototypes

Quantifying Net Carbon Sequestration of Kelp Forests in WA

With the aim of identifying additional carbon sequestration opportunities for Woodside Energy, this project investigated natural processes which capture carbon in kelp. Firstly, this project revealed significantly slower in situ decay rate of the dominant kelp species Ecklonia radiata compared to that of Scytothalia dorycarpa, a cooler water fucoid seaweed. We also observed little change in percent carbon during decomposition. This suggests that about one quarter to half the kelp biomass which is carried offshore in dense shelf water cascades has the potential to reach deep ocean sinks and be sequestered. The results of this project can be utilised in benthic particle tracking models to pair carbon fluxes of kelp with local oceanographic data to estimate annual carbon sequestration potential of both coastal and offshore kelp forests.

SEPLA Feasibility for Floating Offshore Wind Turbines in Sand Seabeds

This proof-of-concept study investigated the potential for suction embedded plate anchors (SEPLAs) to be used in the types of seabeds where floating wind farms are likely to be sited. The geotechnical centrifuge experiments: demonstrated plate anchors can be installed in non-clay seabed using suction-assisted installation; demonstrated the caisson can be extracted using reverse pumping and that the anchor keyed during loading; and quantified plate anchor capacity under monotonic loading conditions. In March 2023, UWA will apply for an Australian Research Council (ARC) Linkage project with multiple industry partners (including Woodside Energy) to mature the SEPLA technology for a range of seabed conditions and a range of renewable energy technologies.

Low-Cost Data Collection from Remote Offshore Assets

Reliable data transfer enables remote operations and lower cost operations. This project explored the use of the Starlink network to reliably transmit data under different environmental conditions between two locations. The prototype demonstrated: the feasibility of low-cost alternative technologies to monitor remote assets (e.g. sensor, Raspberry Pi, Starlink and Cloud technologies); collect and transmit data from remote sites where there is no transmission infrastructure; and to enable increased cybersecurity when encoding and transmitting data by a second party.

RiverLab

The RiverLab program supports research that uses the Swan River as an analogue for the ocean to trial offshore systems, investigate offshore processes and validate novel sensors. 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).

To improve the RiverLab program several initiatives have been introduced to support students. In 2022 communication workshops were introduced together with a three-minute thesis competition to enable researchers to showcase their research to a wide audience.

Offshore Floating Wind

In collaboration with the Floating Structures group at Woodside Energy, the RiverLab has been supporting research on floating wind turbines since 2021. The aim of the research is to explore coupling effects between aerodynamic and hydrodynamic effects for a floating horizontal-axis wind turbine. In this project, a floating wind turbine (with floater designed by students) was deployed in the Swan River to compare its performance with an equivalent fixed wind turbine in the same location and inform the optimal design of the tower and floater. This project is currently investigating the effect platform motions have on power absorption by the turbine and interactions between aerodynamics and platform motions.

Offshore Floating Solar

Offshore floating solar has potential to power offshore facilities. The RiverLab has been supporting research on floating solar technology since 2021 to understand the efficiency of the solar panels when subjected to salt spray & wave overwash. This project identified the local pressures created under colliding bores associated with overwash. Peak pressures were measured when the bore steepness was maximised which occurred for a lower water depth. The steeper bores created observably more violent collisions with the greatest pressures registered when the water crashed back down onto the horizontal panel. These pressures are significant and must be specifically considered in offshore photo volatic (PV) design.

Coastal Flooding & Erosion

In addition to exploring offshore technologies, the RiverLab also supports research focused on improving the Swan River environment. In 2022 researchers in the Oceans Graduate School have used the RiverLab program to investigate if wave attenuation can be achieved by using a range of different artificial reef units. An application of these units could be to reduce shoreline erosion (ocean or river). The results showed that wave attenuation performance is improved as spacing between modules increases (ie there is a lower transmission coefficient), especially for lower water depths.

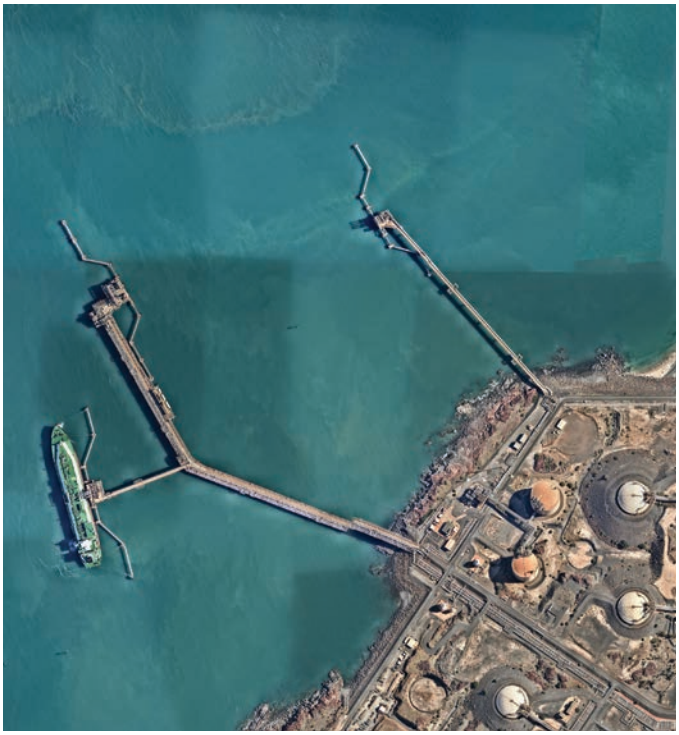
In 2022, all RiverLab students undertook Science Communication training and were invited to present their research findings in the form of a 3 Minute Thesis (3MT). Bailey Booth, the inaugural winner, is currently undertaking a Summer Internship with the Oceans Graduate School to continue researching coastal flooding and erosion.

OceanWorks

Internships

Swell Climatology in Mermaid Sound

Using Woodside Energy datasets, this summer internship project analysed the occurrence of long period swell events within Mermaid Sound. The analysis indicated significant seasonal and interannual variability in swell events. Across all years, winter and autumn had the highest number of events, while summer consistently had the lowest number of events. At interannual timescales, an 'active' period of swell events was observed from 1980-1995 (~400 events per year) and a 'low' period 1995-2005; however, since 2005, the annual number of events has steadily increased. Despite the significant interannual variability, only weak correlations were found with common global climate oscillations (e.g., ENSO, IOD, SAM), which suggests a need for further research in this particular topic to resolve drivers of long period swell events and improve our ability to predict their occurrence.



Solitary Wave Dynamics

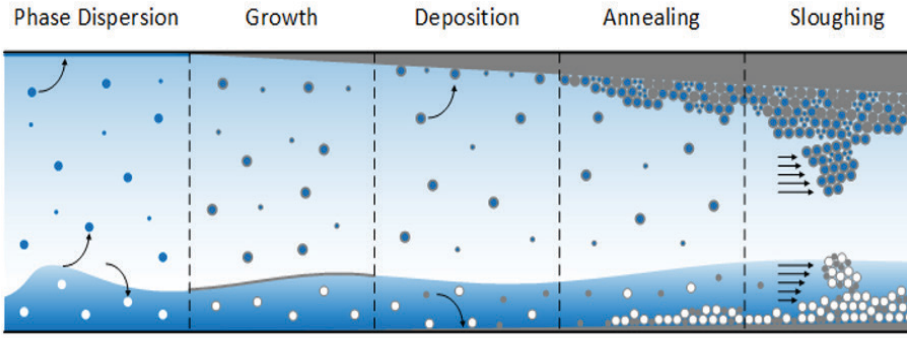
The catastrophic nature of tsunami wave events means studying long wave propagation over depth changes is always going to be important. The 'soliton up a step' problem is an interesting exploration of non-linear physics and this project involved the numerical and experimental investigation of the splitting phenomena seen as a single solitary wave propagates up into shallower water. The study found good agreement between solitary wave splitting data from numerical simulations of intermediate complexity and simple analytically solvable theory. Also, the physical data collected at the Coastal and Offshore Engineering Laboratory (COEL) wave flume was compared to the numerical model, revealing remarkable agreement. This COEL physical data will be further compared to Computational Fluid Dynamics (CFD) simulation.

Education & Training Program

Unlocking Subsea Tiebacks

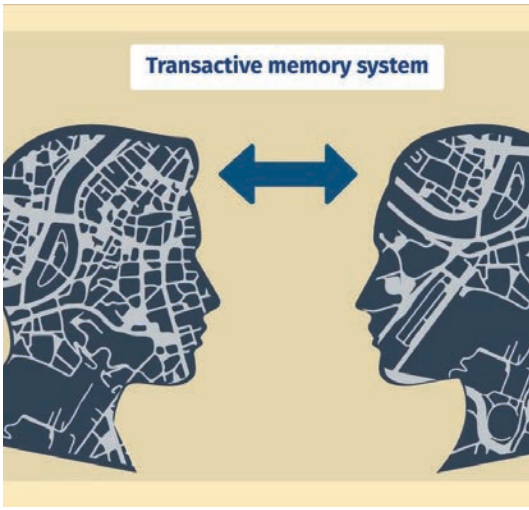
Prof. Zach Aman, Chevron-Woodside Chair in Long Subsea Tiebacks, presented to the Woodside Energy Subsea Academy in September. This presentation explored the suite of technology needs and associated projects, which were launched in 2019 through the Long Subsea Tiebacks investment from Woodside Energy, Chevron, and UWA. This included:

- The practical and technological constraints across long-distance transport systems, and how flow assurance solutions can be evolved to match these demanding conditions.
- Highlighted prospective step-change technologies, including those with which the research laboratory is collaborating, and the potential impact that these may have when applied to Long Subsea Tiebacks.
- Discussed the current state, and future needs, of those online digital twin technologies relevant to subsea tiebacks, and explored the role of these improvements in unlocking long subsea tiebacks.



Team Skill Mapping Sessions

Prof. Gillian Yeo, Woodside Energy Chair in Leadership & Management and her colleague Dr. March To, delivered a pilot of the Team Skill Mapping Workshop to the Woodside Energy Human Resources Team in October with a view of being expanded to other teams to identify skill gaps and implications for team training and development.



Research evidence suggests managing diversity in skills/expertise; divisions/backgrounds; feelings/perspectives is critical to enhance team performance and creativity. These workshops focus on building a Transactive Memory System (TMS) to enable team members to identify, store, coordinate, and retrieve each other's unique skills/expertise/knowledge for successful teamwork. "Feel different, create together."

2023 International Women's Day: Women in the Workplace

Prof. 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 include:

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

OceanWorks

Outreach

OceanWorks recognises that diversity and communication are vital ingredients for innovative engineering. Two flagship programs were created to address the need for greater gender diversity in engineering. These activities target students in primary and secondary school and are run annually in partnership with UWA Girls in Engineering and industry.

Emerging Engineers Competition

This 20-week competition is an outreach program that aims 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.

The 2022 competition invited students to design solutions that would mitigate microplastics in our urban waterways. Due to the connectivity between urban waterways and our oceans, the accumulation of microplastics in our rivers and streams directly impacts the level of pollution in the ocean. The winning team from All Saints' College demonstrated a thorough understanding of the Engineering Design Process to tackle one of the top-4 contributors to ocean plastic (plastic cutlery) and created a replacement prototype made from 100% biodegradable and digestible plastic.

"This competition gave us the chance to come up with solutions to real world problems. We were given the opportunity to meet with so many other amazing girls who shared our passion for engineering and making a positive difference to our environment. We had the chance to hear from some amazing women in engineering about their ideas, solutions and experience in the industry and had the opportunity to see what people in the industry use to make their ideas come to life. Overall it was such a great experience."

Penelope Duff, Student, All Saints College

2021 Competition Winners Create RiverLab Project

In 2021, the winning team from the Emerging Engineers Competition developed a solar-powered floating filter to collect microplastics from the ocean. This project is now being investigated further by a multi-disciplinary team at UWA as part of the OceanWorks RiverLab program.

The RiverLab program allows the University of Western Australia to use the Swan River (as an analogy to the ocean) to test prototype concepts.

Academics from the School of Engineering, School of Biology and School of Earth Sciences are working with final year engineering students to create a working prototype of this solution for their final year engineering project.

The students are designing an automated microplastics monitoring process, to monitor the top layer of the Swan River where the majority of mobile microplastics are likely to be contained. This involves filtering microplastics out of the water and then analysing them for properties such as size, shape, and concentration".

"Thanks to UWA's automation and robotics Engineering team, who built the solar powered autonomous boat, we proposed a design which would allow us to attach a manta trawl (a net) behind it, which would collect microplastics as the boat travels along a preset path at a preset speed. Once the sampling is complete, we could detach the net, dry the contents and analyse them in the lab"

Georg John
Engineering Student, UWA

Future Engineers Program

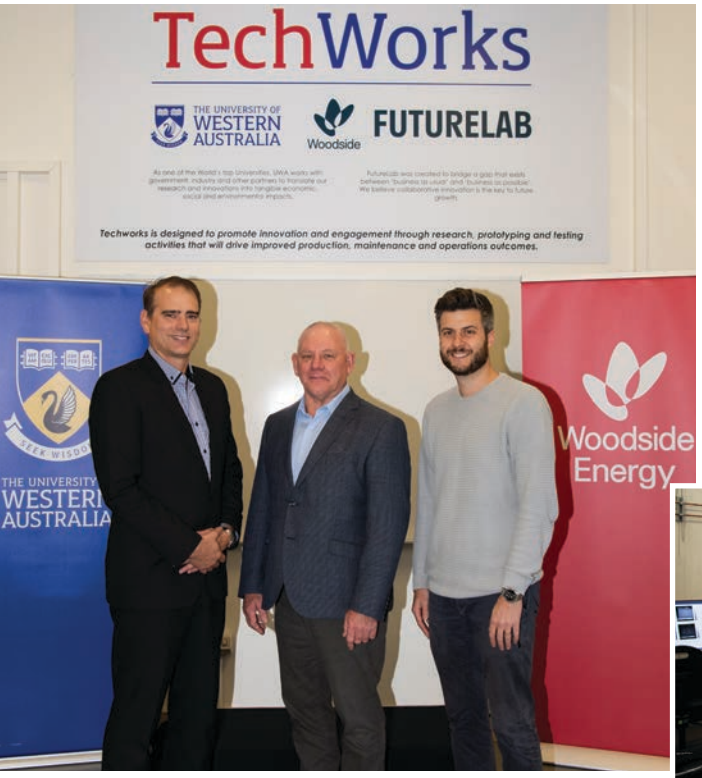
This is a week-long school holiday STEM program for High School girls in Years 8-12 designed to educate young women about where our energy comes from and explore the opportunities to pursue a STEM career in the subsea and ocean based industries.

OceanWorks were 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 Subsea Energy Australia, WISE Professional Network, Engineers Australia, Woodside Energy and Clough.

TechWorks

TechWorks is designed to promote innovation and engagement through research, prototyping and testing activities that will drive improved production, maintenance and operations outcomes. The program includes 3D Additive Manufacturing, Prototyping and in 2022 integrated closely with the Woodside Energy Robotics Lab.

3D AM Program



In May 2022, TechWorks took delivery of an EOS M290 Metal 3D Printer, which has state-of-the-art in situ monitoring capabilities. This monitoring system detects possible defects within a part as it is being built.

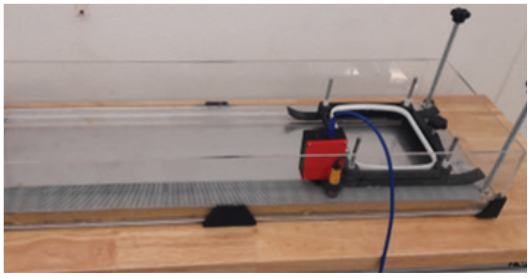
The overall aim of this program is to develop 3D Printing as a business-as-usual activity within Woodside Energy and is a collaboration between UWA, Monash, Curtin and Woodside Energy. The focus is to develop a single alloy that will satisfy all the mechanical and functional requirements across all Woodside Energy's assets.

The 3D AM Capability at UWA includes:

- Design & Prototyping – 3D scanning, design optimisation and pre-production proof of concept testing which will allow designs to be optimised and tested prior to their final production.
- Build Monitoring - understanding and incorporate the state-of-the-art in-situ monitoring system that is able to detect defects during the build process. Such a system will greatly reduce the need for post-build NDT.
- Education & Training – design and deliver professional development training courses to meet Woodside Energy's competency requirements at Awareness, Knowledge and Skilled levels.

Prototype

Pipeline Scanning & Inspection (X-ray sled)



The Mini Z scanner is being used on-site to take images of pipe insulation and to indicate possible moisture under the insulation. This allows for detection of areas where corrosion is likely to occur and can be used to develop better maintenance plans that are directly associated with at risk areas. Due to the wide variety of insulation and cladding types as well as thicknesses, there was a lack of knowledge on how these affected the resolution of the imaging. Techworks produced a prototype that facilitated simple changing of cladding types, while an optical encoder tracked and recorded the scanning speed. This allowed for a qualitative analysis of the effect of scan speed on the captured images, which aided in the optimisation of operating parameters for the scanner.

PixieDust Prototypes

Deluge Sprinker Nozzle

Given the age of some of the Woodside Energy assets, it is not uncommon for the original OEM parts to no longer be available and conventional production of replacements is often very expensive in the quantities required. This presents an excellent opportunity for additive manufacturing which may be able to provide an immediate solution. However, these OEM parts were not designed for additive manufacturing and therefore manufacturing efficiency gains are often possible through a redesign of the parts.

The images (below left) show the original deluge nozzle (left) and redesigned nozzle in plastic (middle) and metal (right). The re-designed nozzles have been optimised for additive manufacturing as well as re-designed to include a threaded coupling which will eliminate the need for post-production machining. Testing is currently underway to verify the changes have not altered part performance or function.

Eliminating the need for machining significantly reduces per part costs, and optimised design reduces post processing time and material costs.

Replacement Keys

Traditional bronze interlock keys are prone to failure. A sample key from KGP was scanned (below middle) and re-modelled in CAD and printed in Inconel 625 (IN625). Both a key blank and completed key was produced. The inherent strength of the AM-produced Inconel results in a significantly reduced risk of key failure, and the customer now has a digital copy of the blank that can be printed on demand without the need for custom tooling. Digital files can be easily adapted to include barcode and key ID number rather than relying on adhesive label.

Exploring Printed Threads

TechWorks is currently exploring the accuracy and strength of printed threads and other features that are typically post-machined into additive manufactured parts. The aim of this is to investigate whether the overall cost of the part can be reduced due to the removal of post-build machining operations.

We are also assessing the available topology optimisation software packages, the use of which will allow more material efficient parts to be designed or redesigned, while simultaneously utilising the geometric complexity that additive manufacturing offers.

Robotics Integration

The collaboration between TechWorks and the Woodside Energy Robotics labs aims to bring lean manufacturing ideologies to the lab in order to streamline workflows and help to improve lab safety. This integration will also provide an onsite presence for TechWorks which will allow easier and more efficient access to the University's resources.

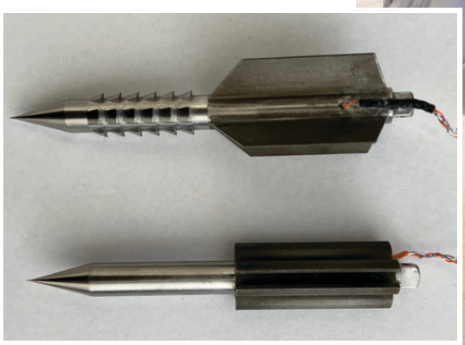
From Ideation to Collaborative Research

In July, 2021 Woodside FutureLab at UWA hosted an Ideation Session to identify opportunities to re-use and re-purpose flexible flowlines and umbilicals. The event generated 55 ideas, from which 5 research projects were pursued to test the concepts on a small scale. Results from initial prototype testing are summarised below.

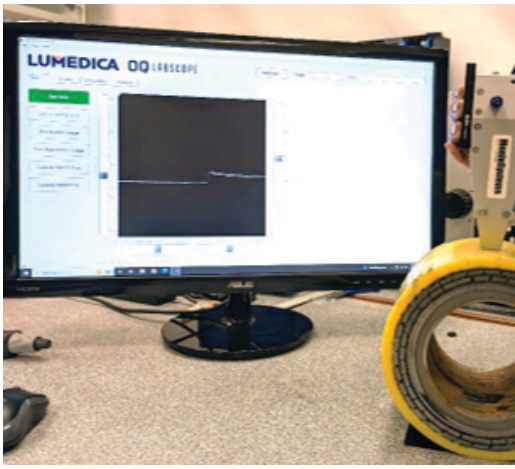
Repurposing Flexible Flowlines as Torpedo Anchors

This Co-operative Education for Enterprise Development (CEED) project investigated whether decommissioned flowlines could be re-purposed as torpedo anchors to support offshore floating wind turbines and wave energy devices. Six model anchors were tested in the UWA O-tube for hydrodynamic stability. Four model anchors were selected for further testing in the UWA centrifuge in kaolin clay.

Based on the flowline geometry, two novel designs were selected for torpedo anchors. They involved different profiles of the outer shaft. The selected two were three-semicircular-fins (i.e. utilising half-flowlines as fins) and fish-scale (i.e. creating serrations in the outer layer). These designs are currently being considered for further research and testing with Woodside with a view to commercialising this concept.



Terahertz Technology for NDT of plastics



This project sought to monitor the degradation of plastics used in subsea equipment to inform environmental considerations and decisions in regards to decommissioning subsea equipment. Using THz technology, the project characterised a number of polyethylene (PE) samples of different densities. Different accelerated aging processes were applied (water, heat and UV) to determine the effect on the PE samples.

The most important property measured is the refractive index. Because this did not change during the project, the thickness and hence any change of thickness (from initial installation) can be assessed at any point during its lifetime. If it is getting thinner, it is slowly eroding and possibly leeching into the local environment. These results should be verified with long-lived subsea samples (~20 years).

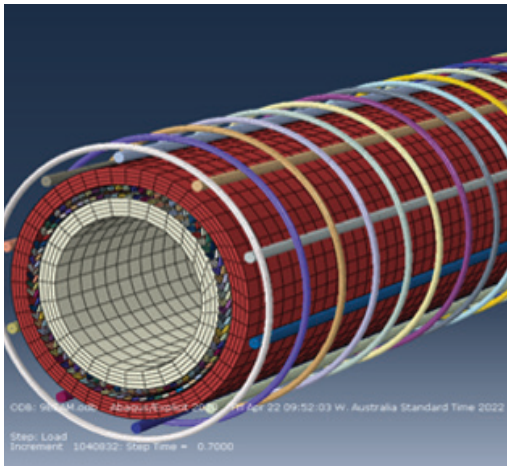
Mobile Thermal Processing Unit

Umbilicals before pyrolysis

After pyrolysis at 700 °C

This proof of concept demonstrated that a combustion technique could be used to quickly burn off the polymers in the flexible flowlines and umbilicals to liberate and recover the metals and convert the polymers into gas and liquid fuels. Fixed-bed combustion and traverse combustion experiments, and pyrolysis experiments using a thermogravimetric analyser and a horizontal fixed bed reactor were successfully completed. Results indicate that all polymers can be burnt off at temperatures as low as 600°C and the recovered metals show minimal surface oxidation. Traverse combustion of the polymers emitted large amounts of volatile matter and were hampered by softening and melting of the polymers. The polymers were turned into gas and liquid during pyrolysis experiments, with minimum solid residue.

Modular Structural Elements using Flowlines



This preliminary study investigated whether decommissioned flexible flowlines could be employed as a replacement of steel reinforcement embedded in structural elements, and if it would provide sufficient mechanical strength compared to conventional steel-reinforced structures. Results from the Finite Element Modelling (FEM) revealed that using flexible flowlines as reinforcement significantly enhances the mechanical strengths of structural elements where axial compression load is increased 3.7 times higher than a column without flexible flowline, and the flexural strength of beam is approximately 1.2 times higher than a beam without flexible flowline. Further testing of decommissioned samples is required to mature this materials re-use concept.

Engagement Unlocks the Value Chain

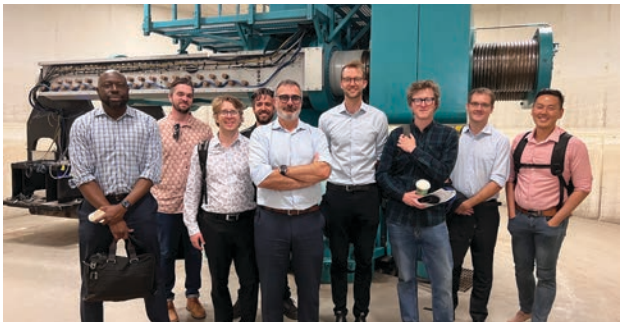
Innovation requires an environment for great people to come together to generate and explore ideas. Woodside FutureLab at UWA creates this environment within the dedicated OceanWorks and TechWorks spaces on campus, which complement the world-class facilities at UWA used to undertake the innovative research.

With the creation of the new Woodside Energy organisation in 2022, many new faces have visited Australia and have been introduced to FutureLab at UWA and the wider UWA facilities.

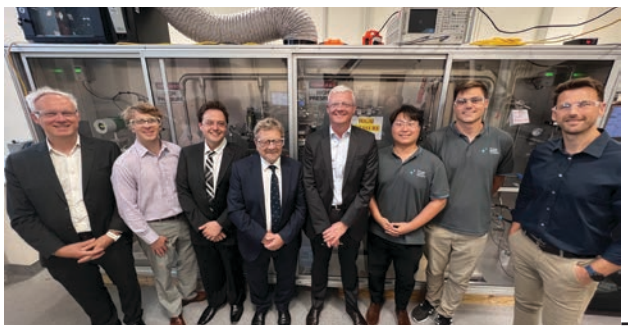
Coastal & Offshore Engineering Laboratory
Wave Flume

Coastal & Offshore Engineering Laboratory
Large O-Tube

Indian Ocean Marine Research Centre - Watermans Bay Laboratory



National Geotechnical Centrifuge Facility



Centre for Long Subsea TieBacks

Since inception

OceanWorks

38 Prototypes

Interaction of structures with the ocean environment	Novel offshore systems & sensors	Ocean monitoring, modelling & forecasting	Sustainable oceans
37%	29%	16%	18%

UWA Academics	Projects Complete	Woodside Energy Staff	Spin-off Projects
54	34	24	16

RiverLab

79 Prototypes

Interaction of structures with the ocean environment	Novel offshore systems & sensors	Ocean monitoring, modelling & forecasting	Sustainable oceans
32%	30%	18%	20%

UWA Academics	Projects Complete	Masters Students	Woodside Energy Staff	Spin-off Projects
45	70	140	13	9

Internships

40 Intership

Interaction of structures with the ocean environment	Novel offshore systems & sensors	Ocean monitoring, modelling & forecasting
38%	26%	36%

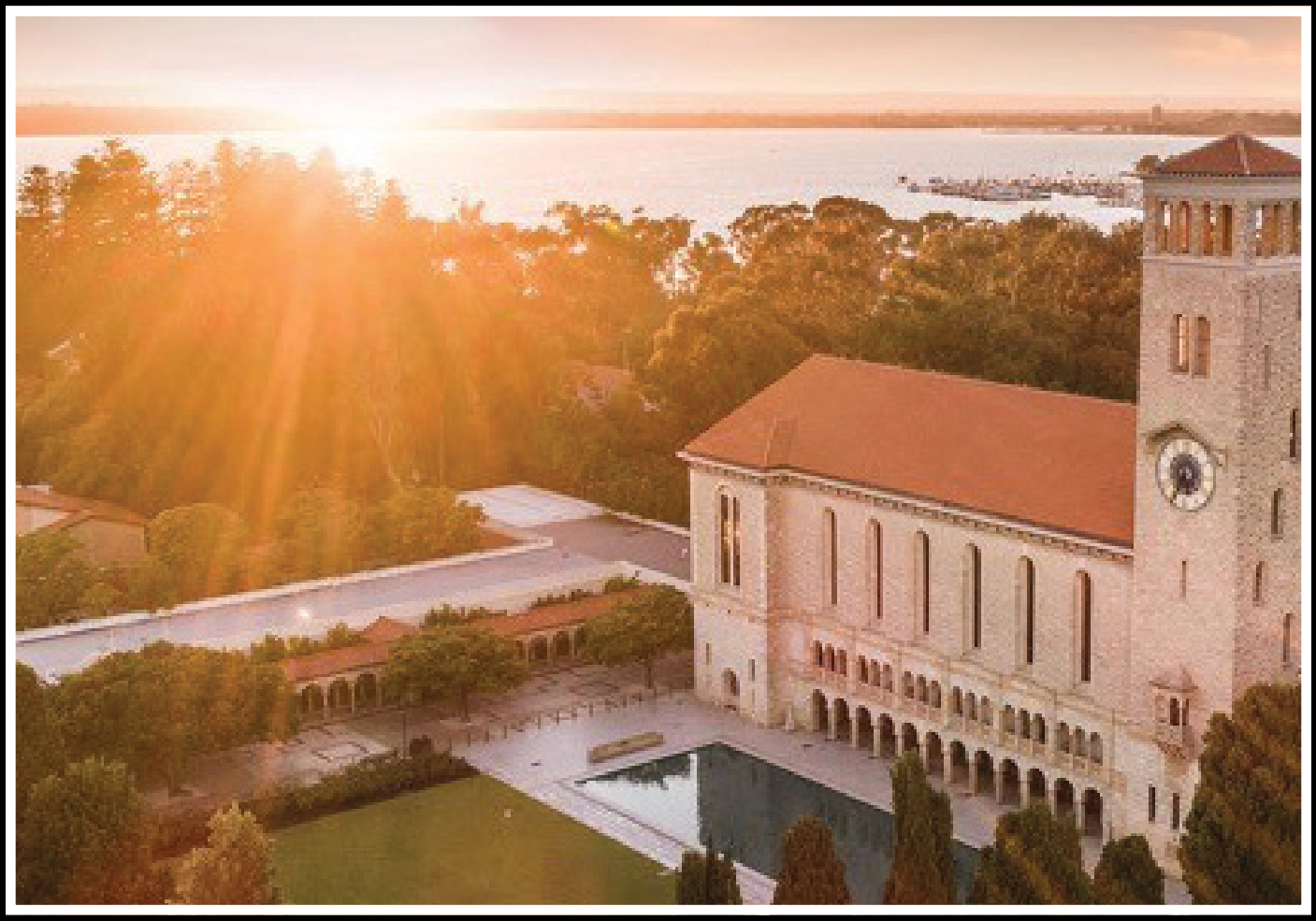
TechWorks

9 Prototypes

Metal and plastic 3D printing/materials characterisation and testing	Reliability testing	Asset evaluation and performance	Failure characterisation/ root cause analysis	Computational modelling of structures, materials and fluids
45%	22%	11%	11%	11%

UWA Academics	Projects Complete	Woodside Energy Staff
8	7	7

Nicole Austin has been pivotal in delivering the OceanWorks and TechWorks programs over the last 3 years, cultivating relationships, supporting the development of new research ideas and projects, and spearheading outreach and engagement. In 2022, we were delighted that Nicole was recognised by UWA for her outstanding contributions to the University, by receiving a Research Award for excellence in research support from the UWA Vice Chancellor Amit Chakma. Well done, Nicole!



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