ENGINEERS AUSTRALIA

create VOL 12 | NO.2 | MAY 2026

create

Engineering. Making Life Happen.

Race to the bottom

What Australia is getting wrong when it comes to infrastructure procurement

ENGINEERS AUSTRALIA

The big thing that really shines through is **Agilitus understands us**

AGILITUS


Sometimes clients can’t articulate what they want. We said we needed a tug harbour.
Agilitus said, ‘we’ve got a solution for you, and we’ve also got a solution to reduce your surge issue.’ That wasn’t in our initial brief, but it’s now the most crucial part of the project.
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CEO Mid West Ports Authority
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New tug harbour & berths
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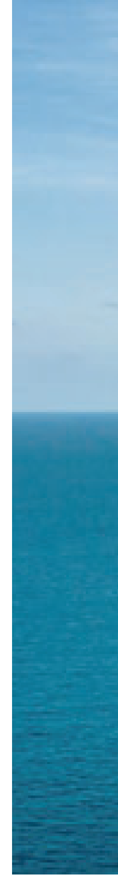

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Engineers Australia
Phone: 1300 653 113
Website: *engineersaustralia.org.au*

For subscription enquiries, please contact the Engineers Australia Member Services team:
contact@engineersaustralia.org.au

For advertising enquiries, please contact Sudip S Gupta, Advertising Sales and Partnerships Manager:
ssgupta@engineersaustralia.org.au

LOCATIONS:

Adelaide
Level 11,
108 King William Street
Adelaide SA 5000

Brisbane
Level 9,
340 Adelaide Street
Brisbane QLD 4000

Canberra
Level 1,
11 National Circuit
Barton ACT 2600

Darwin
9 Cavenagh Street
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Hobart
Level 5,
188 Collins Street
Hobart Tasmania 7000

Melbourne
Level 26,
181 William Street
Melbourne Victoria 3000

Newcastle
Suite 3, Tonella Commercial Centre
125 Bull Street
Newcastle West NSW 2302

Perth
Level 10, Allendale Square
77 St Georges Terrace
Perth WA 6000

Sydney
Mezzanine Level
44 Market Street
Sydney NSW 2000

.Mahlab

Editorial Director: James Chalmers
Commissioning Editor: Joe Ennis joe@mahlab.co
Production Editor: Lachlan Haycock
Creative Director: Gareth Allsopp
Art Director: Caryn Isemann

CONTRIBUTORS:
Julia Abbondanza, Brent Balinski, Jonathan Bradley,
Larissa Foster, Peter Gow, Elle Hardy, Fran Molloy, Chris Sheedy

Level 3, 727 George St, Haymarket, NSW 2000
www.mahlab.co

Printed by: IVE **Mailed by:** D&D Mailing **ISSN 2205-5983**


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Words by Joe Ennis

Ambitious Australia

A recent federal report on R&D has outlined potential major structural reforms, with engineers to play a key role in strengthening the links between research, industry and economic outcomes.

Australia's engineers are being positioned as central players in a sweeping overhaul of the nation's research and development (R&D) system, following the release of the Federal Government's *Ambitious Australia* report.

The 112-page Strategic Examination of Research and Development, released in March, calls for bold, nation-changing reforms to reverse declining productivity and better translate research into economic outcomes.

At its core is a plan to refocus Australia's fragmented R&D ecosystem into six National Innovation Pillars: health and medical; agriculture and food; defence; energy and environment; resources and technology. The report argues that concentrating effort in these areas will drive scale, attract investment and improve global competitiveness.

For Engineers Australia Chief Engineer Katherine Richards AM HonFIEAust CPEng EngExec, the implications are clear. Engineers must be embedded across the entire innovation life cycle.

"Engineers work across the entire R&D pipeline, from research through to commercialisation and scale," Richards said following a government roundtable on the report.

"That system-wide view matters as the government considers how research programs are designed and connected to industry."

Read the final report by scanning the QR code.

Workforce at the centre

A key theme of the report is workforce reform, including more industry-aligned PhD programs, higher stipends and a national strategy to address skills gaps. The panel warned that without action, Australia risks losing talent and falling behind global competitors.

Richards said engineers should play a central role in shaping that response, particularly in strengthening pathways between universities and industry.

"Better pathways between universities and industry will be critical, especially for PhD students and early-career researchers," she said.

Engineers Australia CEO Romilly Madew AO FTSE HonFIEAust EngExec reinforced the profession's importance, noting engineers already underpin a significant share of the nation's innovation activity.

"Almost half of the nation's $24 billion in business R&D involves engineers," Madew said. "Engineers are the bridge between research and practical solutions. By strengthening our engineering pipeline, Australia can turn scientific discoveries into market-ready technologies that boost productivity and global competitiveness."

The report also proposes structural reforms, including a new National Innovation Council to coordinate funding and priorities, alongside changes to tax incentives and investment settings to drive private sector participation.

Madew welcomed the emphasis on commercialisation but said success will depend on a capable workforce.

"To fully realise the panel's recommendations, Australia must invest in the people who turn ideas into impact." □

"To fully realise the panel's recommendations, Australia must invest in the people who turn ideas into impact."

Leadership

FROM THE NATIONAL PRESIDENT AND CEO

Backed by passion

For the country to achieve its goals, Engineers Australia urges policymakers to strengthen the nation's engineering workforce and sovereign capability.

In a period of global instability, Australia faces extraordinary challenges that demand unique and innovative solutions. Building a diverse engineering workforce of thinkers and problem-solvers will support our national security, prosperity, infrastructure, and the health and wellbeing of all Australians.

While Australia is a powerhouse of ideas, we lag behind comparable countries in capitalising on homegrown innovation. In the Harvard Growth Lab's Atlas of Economic Complexity, Australia ranks 25 places behind New Zealand, 39 behind Canada and 52 behind the UK. Closing this gap will require not just reform, but a strong belief in what Australian engineers can deliver.

This quarter's theme explores the barriers to engineering innovation and progress.

We look at the sluggish construction sector, where $1.4 trillion worth of projects are underway nationwide, and ask whether alternative approaches, such as rethinking the procurement process, could reduce cost and schedule blowouts on major developments.

On a smaller scale, *create* speaks with Australian businesses successfully scaling their ideas locally. From carbon-nanotube X-ray technology to energy-efficient air-conditioning systems, the engineers behind these innovations share their insights on overcoming the commercialisation gap. For them, barriers to scaling are not obstacles, but engineering challenges to solve.

This mindset has a name: intrapreneurship. While entrepreneurs build startups, intrapreneurs drive innovation within existing organisations. Engineers make exceptional intrapreneurs, combining creativity with the problem-solving skills needed to navigate complex systems.

This blend of productivity and passion is helping to push Australian projects forward across every sector.

In Townsville, at the National Sea Simulator, engineers and researchers are collaborating to operate one of the world's most advanced marine research facilities. The simulator enables experiments on how coral reefs respond to environmental pressures, improving our understanding of climate change impacts.

With fuel shocks reverberating around the world, *create* also speaks with Blossom Fernandez, an automotive engineer in rural NSW who works with Standards Australia alongside her day job to help define how EVs communicate with charging infrastructure. She has turned a lifelong passion for vehicles into a career contributing to the transformation of our infrastructure network.

This edition is filled with examples of engineers solving complex problems through myriad lenses – and in doing so, helping position the nation and Australians for a more prosperous and secure future. □

Tom Goerke
FIEAust CPEng EngExec
National President and Board Chair
nationalpresident@engineersaustralia.org.au

Romilly Madew AO
FTSE HonFIEAust EngExec
Chief Executive Officer
ceo@engineersaustralia.org.au

The big picture

With a risk-averse business environment that can stifle innovation, and significant productivity gaps and cost overruns on major infrastructure projects, Australian engineering has significant barriers to overcome.

Economic complexity comparison

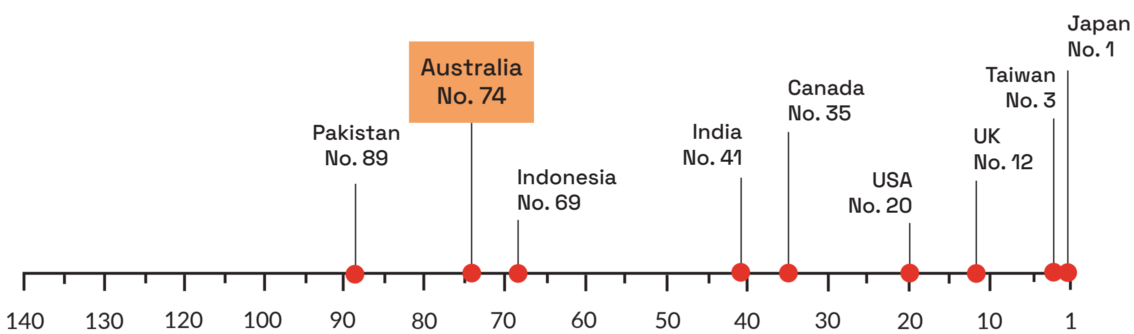
Harvard Growth Lab's Atlas of Economic Complexity is an assessment of a country's ability to export advanced and diverse products.

Australia has jumped more than 30 places and now sits in 74th place. But that's not due to any significant change in Australia's economic capability. It's primarily attributed to the way the index is calculated.

Australia now sits 25 places behind New Zealand, 39 places behind Canada – with its comparable economy to Australia's – and 52 places behind the UK.

Japan has consistently taken the top spot for more than a decade, while countries such as South Korea, Taiwan and Germany consistently rank in the top half-dozen countries.

Country economic complexity rankings 2026



Poor returns

With just 0.3 per cent of the world's population, Australia has contributed to more than 4 per cent of the world's published research. Despite this strength in research capability, the country struggles with commercialisation.

IN 2024, THE NUMBER OF PATENT APPLICATIONS WAS

3.3%

LOWER THAN IN 2023 ↓

THIS WAS COMPRISED OF A

0.9% ↑

INCREASE IN THE NUMBER OF APPLICATIONS BY AUSTRALIAN RESIDENTS, TO

2578

3.7% ↓

DECREASE IN THE NUMBER OF APPLICATIONS BY NON-RESIDENTS, TO

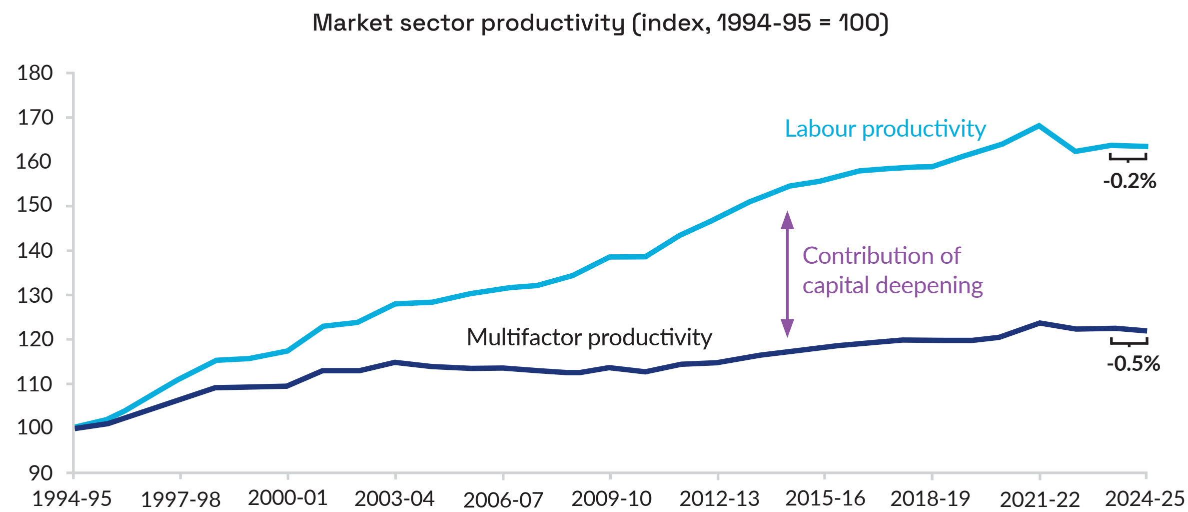
227,900

Productivity plateau

Let's look specifically at productivity in the Australian construction sector. Multifactor productivity (MFP) is a measure provided by the Productivity Commission that judges how well labour and capital inputs are combined to produce outputs.

MFP in the Australian construction sector declined by 0.5 per cent over 2024-25, below the 20-year average of a 0.4 per cent increase per year, and far below the 1.6 per cent annual growth seen from the mid-1990s to the mid-2000s.

"There are many possible reasons for Australia's recent poor track record of MFP growth," said the Commission's Deputy Chair Alex Robson. "One possible reason is slowing accumulation of human capital – while our labour force continues to grow, we also need a skilled workforce that can adapt to changes and meet employer demands."



Lowest price wins

So what's stopping the country from rising up in the complexity rankings – stopping us from improving our productivity?

Australian infrastructure procurement is dominated by a single, persistent logic: the lowest upfront price wins. While this approach is often justified as fiscally responsible, it arguably has created a false economy – one that drives avoidable maintenance costs, premature asset failure, safety risks and systemic underperformance.

This model – characterised by an aversion to recognising the total cost of a project; only part – reflects a broader preference for cutting costs in all areas, to the detriment of the domestic supply chain and manufacturing.

"Domestic steel fabrication capability presents a potential sovereign supply chain risk to a key infrastructure input," said Infrastructure Australia in its *Infrastructure Market Capacity 2025 Report*. "The industry reports being under severe pressure from cheaper imports (offered at up to 50 per cent cheaper than what local producers can viably offer) and with import volumes growing by 50 per cent."

THE NORTH EAST LINK ROAD PROJECT IN VICTORIA IS PROJECTED TO COST TAXPAYERS

$26.2 billion

COMPARED TO ITS 2017-18 COSTING, MEANING THE TOTAL COST IS UP

67.6%

SOURCES

The Atlas of Economic Complexity, Harvard Growth Lab.
Annual productivity bulletin 2026, Productivity Commission, February 2026.
Infrastructure Market Capacity Report, Infrastructure Australia, November 2025.

Words by Jonathan Bradley

The power behind the pipeline

Australia has grand ambitions for its infrastructure as the nation readies itself for growing housing and transportation demands while overseeing an economy-wide shift to a net-zero energy mix.

The predicted value of major public infrastructure projects in the pipeline for the half decade beginning in the 2024–25 financial year was $242 billion. Approximately $1.14 trillion worth of construction activity is being undertaken across the country right now.

As Chief Executive of Infrastructure Australia, Adam Copp oversees the independent statutory body tasked with advising governments at all levels how to best finance, deliver and operate the vast economic engine that is Australia's infrastructure network.

The potential from all activity is immense, but delivering on it is not without its challenges. Infrastructure Australia's *2025 Infrastructure Market Capacity Report* identifies critical risks that include labour shortages (particularly in regional areas), low productivity, and structural workforce issues including a lack of diversity and a heavy reliance on subcontracting.

"The simple fact of the matter is we need to do more with less," Copp told *create*. "Infrastructure Australia predicts that the industry currently has 204,000 workers to deliver this pipeline of work, but is short by 141,000. By 2027, this shortage could balloon out to 300,000.

"This will include shortages of engineers, architects and scientists as well as project management professionals."

That shortage of workers means project budgets and timelines will be strained, Copp said, all while public investment in some regional areas in NSW, Tasmania and Queensland in particular is forecast to at least double.

"Without the workers, we simply cannot deliver everything that is needed without the risk of delivery costing more or taking more time," he said.

"In their absence, we need to deliver on the demand in the pipeline. The spotlight falls very directly on the construction sector's productivity as the means to achieve this higher level of demand. Unfortunately, though, construction sector productivity is a hurdle in and of itself.

"For the past 30 years, productivity growth has been incredibly sluggish. It has barely moved since the days of dial-up internet and fax machines, while other industries like transport and manufacturing have advanced dramatically."

RIGHT: Adam Copp, Infrastructure Australia.

Shared challenges

Australia is not alone in facing these challenges, however. That's why Infrastructure Australia is looking to initiatives other countries are undertaking >

> "Entrenched delivery models, fragmented procurement practices and low appetite for risk sharing continue to hold back initiatives such as modern methods of construction."

IMAGE: Ross Coffey.

IMAGE: Ross Coffey.

to help the construction sector embrace data and digital technology, along with offsite and modular construction.

"One of our key recommendations in our 2025 Infrastructure Market Capacity Report is for governments to incentivise the market to trial productivity-enhancing innovations such as modern methods of construction, which can then be scaled – just like the UK, the US and Singapore have done," Copp said.

"We're also recommending the development of consistent nationwide training programs to upskill workers in these innovations. This can only be made possible if we start investing more into projects.

"What this will take is governments willing to put more money in the front end of a project, to give the market the shot in the arm it needs to find the solutions that can work best for project delivery. Of course, this will mean governments need to deviate from trying to deliver infrastructure at the lowest possible cost."

Copp also points to a slow innovation uptake across the infrastructure sector as a key barrier to productivity enhancement. According to the 2025 report, although multifactor productivity rose by 2 per cent in the 2023-24 financial year, that follows a decline for the previous year and a flat long-term trend far below mid-1990s levels.

"While engineering and design firms are increasing their investment in digitalisation, adoption across the broader construction ecosystem remains limited.

"Entrenched delivery models, fragmented procurement practices and low appetite for risk sharing continue to hold back initiatives such as modern methods of construction and other productivity-enhancing technologies. High upfront costs and uncertainty in project pipelines only compound the challenge."

Stabilising the future

These challenges are real and significant, but the outlook isn't all grim. Copp is positive about a number of initiatives that are seeing increases in innovation and productivity, and a smoother passage for projects through the infrastructure pipeline.

He points to the Federation Funding Agreement Schedule (FFAS) as a development already having a stabilising effect on the industry.

The most recent FFAS, implemented in 2024, is an agreement between the Federal Government and the states and territories that consolidates current funding arrangements for specified initiatives in the infrastructure sector, along with providing a framework for facilitating future funding initiatives.

"From our perspective, the FFAS is helping turn the pipeline from a wish list into a more deliverable, long-term program – and that's exactly what the sector needs, to manage capacity and keep costs under control.

"For the first time, governments are required to bring forward 10-year infrastructure plans, follow a two-pass investment process and report transparently on performance. What that's done is lift the quality of project planning and force more rigorous due diligence before projects enter the pipeline."

The result: projects are being sequenced more realistically, and investments align better with national priorities like housing and the energy transition.

"That means fewer speculative projects, better-timed ones and far greater confidence for industry about what's coming."

Copp also praised models such as the nation's cooperative research centres, which he said show that collaborative

> "For the first time, governments are required to bring forward 10-year infrastructure plans, follow a two-pass investment process and report transparently on performance. What that's done is lift the quality of project planning."

hubs can overcome the "valley of death" separating research and commercialisation.

"Governments and industry are increasingly recognising that innovation won't scale unless solutions are developed, proven and deployed in a coordinated way.

"But critically, the next step is embedding proven innovations into everyday practice – and Australia's public infrastructure program offers a powerful platform for doing exactly that."

Cultural transformation

While such structural reforms are paying off, Copp also points to cultural shifts that can help deliver projects more effectively and productively. The construction industry's Culture Standard is a framework that seeks to address the traditional long hours, low flexibility and limited diversity that has historically characterised the sector and continues to drive high turnover and skill shortages.

According to Copp, where the standard has been piloted, it has demonstrated that cultural improvement and project performance go hand in hand. He cited the Brunt Road Level Crossing Removal Project in Victoria, which adopted a five-day work week as part of the Culture Standard pilot (without additional weekend or shift work).

In doing so, Copp said, the project reduced total workdays by 21 days a year, met all time and budget milestones, and improved mental health, retention and gender diversity onsite.

"Leaders on the project have said the shift transformed engagement and wellbeing without compromising delivery. This demonstrates what's possible when innovation, capability and culture are improved."

Procurement is an effective way for governments to encourage companies to adopt the standard and lift productivity.

"Procurement is one of the most powerful tools governments have to drive cultural, environmental and productivity improvements at scale – because it directly shapes the behaviours, materials and methods used across the sector.

"One of our key recommendations through our 2025 Infrastructure Market Capacity Report is for governments to use their purchasing power to stimulate demand for innovation. By incentivising trials and early adoption on major projects, governments can help the market cover the initial upfront costs, build capability and accelerate the shift to more productive delivery models."

Ideally, the outcome is for innovation, capability and culture to be improved in tandem.

"A rested, supported workforce is a happier and more productive workforce – key attributes for a sustainable workplace culture that people want to be a part of and stay in for the long-term.

"If governments incentivise innovation, scale training in emerging skills and embrace the Culture Standard through procurement, Australia can lift productivity while creating a more modern infrastructure sector." □

LEFT: Copp said slow innovation uptake is a key barrier to productivity enhancement.

BELOW: The completed level crossing removal at Brunt Road in Beaconsfield, Victoria.

A scientific approach to flood damage

A government enquiry into flooding insurance delivered stern warnings to the industry. Now, an engineering firm is collaborating with industry to help deliver better outcomes for all claim assessments.

ABOVE: A tour of the University of Sydney's engineering facilities.

WHEN THE Parliament of Australia delivered a report detailing the findings of its inquiry into insurers' responses to claims from the 2022 floods in Queensland, NSW, Victoria and Tasmania, it came with a clear message for the industry.

"Policyholders need to be treated better," wrote Dr Daniel Mulino, the Chair of the House of Representatives Standing Committee on Economics.

The floods triggered the greatest number of claims lodged for any natural disaster in Australian history – more than 300,000.

Mulino titled the report *Flood failure to future fairness*, a name that he said reflected the "collective failure by insurers to meet their obligations to policyholders after the 2022 floods".

When Deniz Bekir FIEAust CPEng NER EngExec, CEO of the forensic engineering and building consultancy Silver Wolf Projects, saw the committee's findings, he knew the insurance industry had a problem. He also knew that he wanted to help it provide a better response to future claims.

"When someone makes a claim on an insurance policy, the insurer is obligated to investigate causation to enable their policy response," he said. "The *Flood failure to future fairness* report identified that the current General Insurance Code of Practice and use of experts in providing reporting on causation for property damage hasn't been up to standard.

"It was identified that many insurers were drawing on opinions of experts who had formed conclusions without factual engineering basis on the cause of building movement, and damage that consequentially led to incorrect or poor decision outcomes."

Responding to the recognition across the industry that standards needed to improve, Silver Wolf Projects was instrumental in establishing the Association of Insurance Building and Engineering Consultants (AIBEC) in 2024, a national industry-based association for people who work with the insurance sector, including engineers.

Working empirically

Bekir said AIBEC aims to assist all stakeholders by improving the training and delivery of expert reporting services towards higher-quality outcomes.

"One of the major issues of contention with insurance claims regards the movement of buildings that have been subject to escape of liquid or flooding events," he said.

"In a flood or after a pipe has leaked, the ground may or not move due to its exposure to moisture or saturation. At the moment there is no empirical guideline that all stakeholders can use to determine what is damaged, whether it was damaged and therefore to enable the insurer to make a qualified decision on policy response."

At the moment, an engineer assessing damage would draw on their training and experience, including the use of measuring tools such as a floor level survey (FLS) – which varies greatly depending on the engineer – to form a subjective assessment of what damage took place and how it was caused.

Bekir said the limitation of this method is that, as a floor survey is limited to measuring the current geometry at the time of the inspection, without reference to a pre-event FLS, a datum of movement cannot be established. This prevents a true and evidential establishment of cause, timing or extent of soil-related movement.

As such, current investigation is not an accurate forensic representation of resulting ground or building movement from a ground saturation. This leads to assumptions rather than analysis based on factual engineering principles and data.

"A home might have a bathroom leak that has caused some damage, but the owner might make an insurance claim for damage 30 m away in another room outside of the leak's zone of influence.

"But we have no engineering basis for adjudicating whether the leak caused that damage. Buildings move after a water leak, but also naturally as well. The damage might be a result of the leakage or it might not be, or it may be preexisting damage that has been exacerbated."

To help consulting engineers deliver more reliable and consistent results, AIBEC wants to help engineers take a rigorous and empirical approach to assessing damage which will improve expert reporting and the claims handling outcome for all stakeholders.

"That would be subject to understanding three things," Bekir said. "One would be the length and extent of the leak. Second would be the ground condition itself – understanding what the geotechnical conditions are and what the reactivity of the ground would be subject to it getting wet and drying. Thirdly, understanding the structure itself: what it is and how it would move subject to ground and foundation movement.

Currently we have a FLS that is one equation with multiple unknowns, he said.

"It's going to benefit all stakeholders involved in the claims handling process of property insurance claims."

BELOW:
Nik Housh, Deniz Bekir, Professor David Airey and Associate Professor Yixiang Gan.

"If we look at property damage as 'one equation, one known and many unknowns', at present we consider assessing property damage resulting from flood or escape of liquid utilising FLS alone cannot establish pre-loss conditions, determine when movement occurred, define zone of soil influence, quantify soil expansion or shrinkage or distinguish leak-related movement from seasonal or historic effects."

Doing the research

To ensure engineers can approach flood damage and other similar claims with rigorous thinking based on scientific principles, the organisation is partnering with the University of Sydney in a research study to produce a set of guidelines for the industry.

Working with Associate Professor Yixiang Gan of the School of Civil Engineering, Silver Wolf Projects and AIBEC aim to develop a formalised and empirically rooted approach engineers can take when assessing insurance claims.

"It's going to be a 12-month research project headed up by the university itself.

"When you want a credible independent guideline or basis for all stakeholders, bringing academia into the process – a body that has no stakeholder in the outcomes – allows the guidelines to draw purely on the science and engineering.

And the outcome of the research will be truly innovative.

"The innovation is to solve an issue that affects a lot of claims. It's going to benefit all stakeholders involved in the claims-handling process of property insurance claims. It will be used by not only engineers and experts; it'll be used by the insurers themselves. It'll be used by loss-adjustment assessors, brokers and the insured.

"All properties are insured and the assessment of claims on that insurance is critical. People need the comfort to know that there are engineers who use scientific principles and technology in their reports on any damage." ○


GB
AUTO

“They knew things I didn’t, which was confronting early on. What surprised me was how little any of that mattered to them. They wanted to know if you were competent, and that was it.”

IMAGE: Dave Smyth The Studio Door.

Choose growth

From struggling to keep a motorcycle upright to shaping how EVs need to operate, Blossom Fernandez MIEAust has built a career around a single question: Why does this work?

As told to Julia Abbondanza

LEFT: Blossom Fernandez, GB Auto Group.

It started with a motorcycle. A Royal Enfield Thunderbird 500, to be exact. And at 52 kg, I could barely keep it upright at full fuel capacity.

But I wanted to understand how it worked, and that question – why does it work that way – turned out to be the thread that pulled me all the way to where I am now: an EV systems engineer contributing to international EV standards, and the 2026 Changemaker Ambassador for Women in Automotive.

Growing up in India, curiosity like mine came with friction. My father worked in military training and fitness, and when I told him I wanted to join the Air Force as a jet pilot, he was blunt about the risks – and pushed me towards engineering instead.

I had strong maths and science scores, so I followed that path even if I wasn’t sure what I was heading towards.

What I did know was that I needed more space than the options available to me at home, so when RMIT in Melbourne offered me a place in its Master of International Automotive Engineering, I packed my bags within a week. I had never been to another country, I didn’t overthink it, and I just left.

Melbourne was a cultural shift I hadn’t >

prepared for. I was the only woman in most of my classrooms.

But I still leapt at opportunities. During a campus tour, I spotted the Formula SAE cars the university students built, one team running on petrol and one on electric. I walked up and asked if I could join, and they told me to show up and do the work.

Some of these students were undergraduates and I was a postgraduate, but they knew things I didn't, which was confronting early on. What surprised me was how little any of that mattered to them. They wanted to know if you were competent, and that was it. No-one dismissed me because I was a woman or because I had come from a different engineering background, and it took me a while to trust that.

LEFT: Blossom Fernandez has a drive to keep showing up.

Unlocking the network

My undergraduate degree had been in electronics and telecommunications, and now I was learning automotive systems, so to bridge the gap I took electives in EVs and hydrogen technology, building what I can only describe as an unusual cocktail of knowledge that, as it turned out, was exactly what the industry needed.

Through RMIT's industry mentorship program, I met an engineer who asked if I would consider working in EVs, and even though I didn't fully know what that meant at the time, I said yes. GB Auto created a role for me working on the retrofitting of diesel mining vehicles with electric drivelines. It was technically complex, entirely new to me, and exactly the kind of problem I wanted to solve.

When we started testing those converted vehicles at facilities such as Lang Lang in Victoria, one thing became clear fast: Australia's EV standards were developing more gradually than the more established frameworks in Europe and the US. Where international models were adopted, their application was uneven, and this occurred when a clearly defined, nationally coordinated technical perspective was still emerging. From my perspective, the standards development process was shaped largely by established industry participants, with the rest of industry aligning around outcomes as they matured.

I found out that Engineers Australia could endorse engineers to sit on Standards Australia committees, and I applied without knowing if I had any real chance.

They returned with an offer and paired me with a colleague who had 25 years of experience. Rather than a one-way exchange, the partnership was collaborative, and my background in mining safety, risk assessment and EV conversion brought a perspective that complemented his experience. I quickly learnt the value I brought lay in having a different viewpoint.

Australia is working towards a more comprehensive framework for battery safety, focusing on establishing baseline guidance for handling, maintenance and repair activities, particularly where technician safety and electrical risk are concerned. However, when applying this framework, I found there was limited clarity around how to objectively assess vehicle operation.

There was no clearly defined testing criteria against which vehicle behaviour could be measured. Interpretation relied on benchmarking against internal combustion vehicle testing criteria. >

"No-one dismissed me because I was a woman or because I had come from a different engineering background, and it took me a while to trust that."

RIGHT: Blossom Fernandez, GB Auto Group.

Australia's challenge is specific. Without major domestic vehicle manufacturers, our role in shaping international standards is more limited, and much of our regulatory approach is built around the adoption of overseas frameworks.

Mostly, this means aligning with European standards, which are adapted to reflect Australian regulatory structures. I have been working with the Society of Automotive Engineers Australasia to push for faster adoption of international standards where they are already fit for purpose, and for targeted, practical adjustment where Australian conditions genuinely differ. Mining environments, long-haul regional travel and remote grid infrastructure all introduce real operating variables that warrant consideration.

One of the recurring challenges in this work is pace. In rapidly evolving technical domains, standards that take many years to develop can struggle to remain current by the time they're published. A more flexible model, one that supports interim updates, would allow frameworks to remain relevant without requiring the process to restart each time the technology advances.

Keep showing up

I've sometimes been afraid of talking to people who were more experienced than me, not because I doubted my thinking, but because their time felt precious and I wasn't sure I had earned it yet.

I dealt with that by treating it like exposure therapy, volunteering for everything, showing up to events where I knew no-one, and asking the questions other people weren't asking because the technical ones were the ones I actually needed answered. I started training in martial arts around the same time, and for much the same reason. Learning to take a punch taught me something about being in an uncomfortable room.

> "I was afraid of talking to people who were more experienced than me, not because I doubted my thinking, but because their time felt precious and I wasn't sure I had earned it yet."

You can either be comfortable, or you can grow, and I kept choosing growth even when it felt exposing.

That is how I ended up in the 2026 Women in Automotive Changemaker Ambassador program.

I met Kate Peck, the director, at a launch event where I was one of the few people asking technical questions, and when she asked what I wanted to represent. I told her that confining me to EVs alone would be too narrow. I wanted to represent STEM broadly, because that is where the gap is widest. I mentor university students, speak to schoolgirls about engineering careers, and pay particular attention to immigrant students – because I know what it takes to navigate a technical career in a new country with no roadmap.

The projects I'm assigned often begin with limited information, where the expected outcomes need to be defined and there is little prior example of how to deliver the work. This can be challenging due to the number of unknown variables. Supported by my manager, I've come to recognise that my ability to research independently, develop solutions with incomplete inputs, and progressively build a realistic picture is central to how I add value.

Australia is at a pivotal point with EVs and smart transport, and the infrastructure decisions being made now will shape what this country's mobility network looks like for decades. We need engineers at the table who understand what happens on the ground, not just in policy documents, and we need more pathways for people who arrive in this field from unexpected directions, because the problems we are solving are complex enough to need every kind of mind.

I didn't plan any of this. I kept asking why, and I kept showing up. □

IMAGE: Dave Smyth The Studio Door.

Register once, practise anywhere

Words by Peter Gow FIEAust CPEng(Ret) EngExec

Australia's engineering workforce underpins the nation's infrastructure. A nationally consistent registration scheme would support standards, reduce regulatory barriers, improve workforce mobility and unlock productivity.

Australia is facing a productivity challenge that is both urgent and structural. Across infrastructure delivery, energy transition, advanced manufacturing and housing construction, productivity growth has slowed, while project costs and complexity continue to rise.

Engineers sit at the centre of these national priorities. The profession underpins sectors responsible for a significant share of Australia's economic output, technological advancement and resilience against global shocks. Good engineering saves lives, increases living standards and improves productivity. Poor engineering can have the opposite effect.

Yet despite the scale and importance of engineering work, Australia does not regulate the profession consistently across jurisdictions. In many cases, engineering work can be done by anyone. Government regulation of engineering work has increased in recent years, but engineers operate within a patchwork of state and territory registration schemes, each with different legislative frameworks, competency assessments and areas of practice.

The fragmented regulatory landscape is not only an administrative inconvenience, but a productivity barrier.

Identifying appropriately trained engineers and ensuring that only they can do engineering work is necessary to drive innovation and economic growth, while protecting the safety and wellbeing of those impacted by our work. A nationally consistent engineering registration framework that enables engineers to register once and practise anywhere supports this, and would remove unnecessary friction from the labour market, strengthen safety and professional standards, and support more efficient delivery of national infrastructure and innovation.

For a country seeking to boost competitiveness, this reform is both practical and overdue.

The productivity challenge

Engineers are central to Australia's economic and technological capacity. More than 450,000 engineers work across the Australian economy, making engineering the largest component of the STEM workforce.[1]

Engineering expertise underpins industries such as mining, construction, manufacturing, energy and telecommunications. Sectors that together generate more than half of Australia's value-added economic output.[2]

At the same time, Australia is confronting mounting productivity pressures. Infrastructure projects are experiencing cost escalation and delays, and key sectors such as construction have seen productivity decline significantly over the past decade.[1]

Improving productivity in this environment requires two things:

- Better utilisation of engineering expertise
- Reducing unnecessary regulatory barriers that constrain workforce mobility and project delivery

Nationally consistent engineering registration addresses both.

A patchwork of regulation

Unlike many other professions, including medicine, law and architecture, engineering registration in Australia is not nationally harmonised. Instead, engineers must navigate a complex system of state and territory schemes.

Some jurisdictions operate comprehensive professional engineering registration frameworks. Others regulate only engineering work related to buildings or specialist facilities.

> "A nationally consistent engineering registration framework that enables engineers to register once and practise anywhere would remove unnecessary friction from the labour market."

The inconsistencies span multiple dimensions:

- Areas of engineering that require registration
- Legislative frameworks
- Competency assessment models
- Continuing professional development (CPD) requirements
- Sector scope (some schemes apply only to building work)

For engineers working across jurisdictions, navigating these differences is costly and inefficient.

The financial cost of fragmentation

Engineering firms frequently operate across state borders, particularly on national infrastructure, energy and defence projects. In these environments, inconsistent registration systems translate directly into higher costs and reduced efficiency. >

Comparison of state engineering registration schemes

Jurisdiction	Established	Areas of engineering covered	Sector focus	Regulatory body
Queensland	1929	19	Broad coverage	Board of Professional Engineers Queensland
Victoria	2021	5	Broad coverage	Business Licensing Authority
NSW	2021	6	Building sector only	Building Commission NSW
ACT	2024	5	Broad coverage	ACT Planning
WA	2024	4	Limited sectors, primarily building	DLGIRS
Tasmania	2016	3	Limited sectors, primarily building	Consumer, Building and Occupational Services
Northern Territory	1993	3	Limited sectors, primarily building	NT Building Practitioners Board
South Australia	Pending	–	–	–

Source: Engineers Australia submissions to Treasury and the Productivity Commission.

Current vs nationally consistent registration

Dimension	Current fragmented system	Nationally consistent system
Registration process	Separate schemes in some states, no schemes in others	Single aligned framework in all jurisdictions
Workforce mobility	Limited by regulatory differences	Engineers can work nationally
Administrative burden	Multiple registrations and CPD tracking	Single set of requirements
Industry costs	Duplicate fees and compliance overhead	Reduced compliance costs
Project delivery	Delays due to regulatory requirements	Faster mobilisation of skilled engineers
Business competitiveness	Companies bidding for interstate projects	Competitive market for at-a-disadvantage engineering services

Credentialling data from industry partnerships tells a compelling story:

- Engineering firms often pay multiple registration fees for staff working across jurisdictions
- Large engineering firms report credentialling costs between $100,000 and $500,000 annually[3]
- Industry-wide, fragmented registration, estimated to cost around $144 million per year in duplicate registrations and administrative overheads[3]

These costs are only part of the problem. Regulatory fragmentation also leads to:

- Delays in project mobilisation when engineers must secure additional registration
- Duplication of competency assessments and CPD record-keeping
- Reduced ability for firms to deploy the best talent where it is needed most
- Work drifting to the least regulated states and the least qualified engineers

In an era of national infrastructure pipelines and increasingly mobile engineering services, these barriers are counterproductive.

Workforce mobility

The engineering workforce is inherently mobile. Engineers frequently work on projects located in different states, often simultaneously. They may also contribute remotely to design and engineering analysis across jurisdictions.

However, fragmented registration requirements limit this mobility.

Consider a common scenario. An electrical engineer based in Victoria may design renewable energy infrastructure in the ACT through Automatic Mutual Recognition, and in any other state except Queensland because it doesn't register that area of engineering. The same engineer will need to undertake a separate registration process in Queensland to do the work there. The result is uncertainty, duplication and inefficiency.

A nationally consistent system would enable engineers to move seamlessly between jurisdictions, and to work on projects in any jurisdiction, ensuring that expertise can be deployed quickly where national priorities demand it.

Safety, standards and public trust

Registration reform is not solely about productivity. It is also about protecting public safety and strengthening professional accountability.

Engineering failures, whether in buildings, infrastructure or energy systems, can have significant consequences for communities. Registration schemes provide mechanisms for regulators to investigate misconduct, enforce standards and remove unsafe practitioners from the profession.

However, the current system creates regulatory gaps. In some jurisdictions, registration applies only to specific engineering work, meaning an engineer deregistered in one context may still operate in others.

Nationally consistent registration would ensure:

- Uniform competency standards
- Consistent CPD requirements
- Stronger oversight and accountability across all engineering practice

This approach aligns with international practice. Many comparable economies, including the United States, Canada, Japan and several European countries, require professional engineers to be registered before undertaking work that affects public safety.

Leveraging international standards

Engineering is uniquely positioned to support national regulatory harmonisation because the profession already operates within well-established international competency frameworks.

Australia is a founding signatory to the Washington, Dublin and Sydney Accords, which recognise equivalent engineering qualifications across multiple countries.

Through the International Engineering Alliance, competency standards for professional engineers are globally aligned, supporting both international mobility and consistent professional practice.

This international alignment means that developing a nationally consistent registration scheme does not require reinventing professional standards. Instead, it involves aligning existing state frameworks with globally recognised benchmarks.

It's clear that engineering is one of the most feasible professions for achieving national licensing harmonisation.

A pathway to reform

Fortunately, governments are listening. Late last year, treasurers identified harmonising engineer registration as a prime opportunity to boost national productivity. States and territories will be incentivised to align through the $900 million National Productivity Fund.

There are a few models that treasurers could consider for implementation. While a new federal regulator is one approach, states and territories could each retain their regulatory responsibilities while enacting "model legislation" or by using applied law from another jurisdiction. The National Competition Council has also been tasked with reviewing how mutual recognition arrangements are working (or not) in practice.

As governments weigh up their options, Engineers Australia continues to advocate for a straight-forward register once, practise anywhere approach, similar to a driver's licence. This reflects feedback from practising engineers that existing mutual recognition arrangements are simply not working because state registration schemes are too dissimilar.

"Engineering is one of the most feasible professions for achieving national licensing harmonisation."

ABOVE:
Peter Gow FIEAust CPEng(Ret) EngExec, Engineers Australia.

Scan the QR code to learn about Engineers Australia's role to publicly advocate on issues that affect the profession.

No-brainer next step

Engineering is one of Australia's largest and most strategically important professional workforces. Any regulatory barrier affecting engineers ultimately affects national productivity.

A nationally consistent engineering registration scheme would deliver measurable benefits including improved workforce mobility, reduced compliance costs, stronger professional standards, improved safety and public confidence, and greater global competitiveness, aligning Australia with international best practice.

In short, it would allow the engineering workforce to operate as a truly national profession.

Australia has already recognised the productivity gains of harmonising licensing for other professions. Extending the same principle to engineering is a logical next step.

Because when engineers can bring their expertise to projects without artificial barriers, the entire economy benefits. □

Peter Gow is former Western Australian Building Commissioner and Chair of Engineers Australia's Professional Standards Committee.

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Ideas

Buy now, pay later

Pursuing value for money seems logical in a cost-conscious world, but infrastructure built on a budget too often delivers substandard results. The challenge is not just cost, but how procurement can evolve to drive better long-term value and innovation in infrastructure delivery.

WORDS BY JONATHAN BRADLEY

Too often, getting a project to the procurement stage means adhering to a single, persistent logic: the lowest upfront price wins. But while this approach is often framed as fiscal responsibility, engineers across disciplines argue it has created a false economy – one that drives avoidable maintenance costs, premature asset failure, safety risks and systemic underperformance.

In effect, procurement is optimising for the wrong thing: lowest cost at contract award, rather than highest value over the asset life cycle. But beyond frustration, a consistent and familiar theme emerges: procurement is designed to manage risk and cost, not to enable innovation.

"What that translates into is time: huge periods of time for procurement processes that, from our perspective, cost a lot of money," said Aurecon Chief Executive Todd Battley FIEAust CPEng EngExec.

Battley finds himself wondering whether these laborious, months-long processes deliver anything of value that a client couldn't have got from a rapid decision, even one requiring a lot of complex considerations.

"Faster, even if it's still onerous, is better than slow and onerous." >

ABOVE: Todd Battley FIEAust CPEng EngExec, Aurecon.

RIGHT: The Bowen Hills interchange in Brisbane plays a critical role in the city's traffic network.

A decades-old problem

"We've been acutely aware of these issues for more than 20 years," said Susan Kreemer Pickford FIEAust CPEng EngExec, Principal Engineer at Engineers Australia. "Industry understands the problem very well, but it persists."

So how do we shift how procurement is evaluated?

"We could reframe the procurement structure and process to enable balanced input from the outset," she said. "If we leverage the insights from all stakeholders collectively, we will better understand the long-term project needs and align on the desired outcomes at the beginning."

Crowding out innovation

"On the tendering side, one of the biggest problems is knowing too much," said Dr Nick Fleming FIEAust CPEng, founder of consultancy Innergise and former National President and Chair of Engineers Australia.

"If you've been working for a client, or you've worked on a particular project in an earlier stage, you develop a really rich body of understanding.

"Often that translates into anticipating issues that, if you had a fixed price, you would price in. Arguably, that's going to be a more realistic price.

"Somebody who doesn't know anything about the job, who comes to it cleanly, doesn't have that knowledge. That actually gives them a competitive advantage."

Kreemer Pickford said the persistence of these issues points to a deeper structural inertia.

"There's a risk-and-cost cascade. Let's say you choose a tender that's 15 per cent cheaper, but at the end of the job, it might have cost you 25 per cent more because of all those unknowns."

ABOVE: The main tunnel entrance on the Snowy Hydro project.

ABOVE: Susan Kreemer Pickford FIEAust CPEng EngExec, Engineers Australia.

"We've seen cycles of reform, but they tend to circle back to the same fundamentals: cost, compliance and risk transfer; rather than genuinely rethinking how value is defined."

Skewed incentives

A major part of this problem is how the incentives in Australia's infrastructure sector focus almost solely on upfront cost.

Politicians find themselves thinking in terms of election cycles rather than the decades or

IMAGE: Snowy 2.0.

centuries-long lifespan of a critical piece of public infrastructure.

According to University of Melbourne Professor Colin Duffield, Australian governments can sometimes find themselves "paralysed by probity" when it comes to procurement.

"They won't do a very sensible thing because they say, 'we haven't gone to the market' or 'maybe there's a magic bidder somewhere that we don't know about that might do something,'" he said. "If you force the market to price things that they may or may not win – or if it's not even a fair playing field – you're just wasting people's money."

That doesn't mean contracts should be given without due process, however.

"You get nepotism, people gilding the lily and, over time, inflated prices, so it gets out of control. There has to be a balance."

The beginnings of change

According to Fleming, the companies delivering projects face skewed incentives too.

"If you're the consultant or the contractor involved in tendering, it's a natural reaction to think we're giving ourselves a better chance of winning if we have the lowest cost. It would be a riskier proposition to bid at a higher price.

"I think that is also a function of the way tendering might be constructed. If a client is looking for a single tender price, that's all you can give."

In this case, even small tweaks to the tendering process can deliver better outcomes.

If a client asks for a range of prices – three options – that creates an environment in which the tenderer can give their best and lowest price, one that gives different options and functionality.

"That shift to asking for options relieves some of the pressure to be lowest cost," Fleming said.

But a laser focus on cost can affect more than a single project.

"There's a risk-and-cost cascade. Let's say you choose a tender that's 15 per cent cheaper, but at the end of the job, it might have cost you 25 per cent more because of all those unknowns.

"And that extra 25 per cent might have incurred additional delays, which has flow-on effects to people and their availability to do other work," Fleming said.

It may also impact whether a company is seen as a reliable client capable of managing public funds effectively.

"So there are all of these flow-on costs – the tangible and intangible costs mount up as well – and it can go into the next job. It can go into your cost of capital."

Fleming highlighted that the risks involved affect more than individual companies and projects.

"It has a cascading effect across sectors," he said. "The construction sector has been the worst performer in terms of productivity uplift over decades. That's not an isolated phenomenon; that's not one or two organisations. That's a sectoral issue."

Risk of minimising risk

While cost is always a factor, Battley believes procurement processes are too focused on eliminating risk. He believes procurement processes more often try to minimise any risk to the customer.

"What that sometimes translates to is a very complicated process to select someone to start the process," he said. "Often, where the procurement process is such a process, I wonder sometimes whether the client's lost sight of what it is they're trying to achieve in the first place. The process is often very detailed in terms of the things they need from the provider."

This can result in expensive work finding solutions to problems that are better solved over the course of the project itself.

"Procurement is only ever a decision-making tool to >

ABOVE: Professor Colin Duffield, University of Melbourne; Dr Nick Fleming FIEAust CPEng, Innergise.

Lessons from Australia's biggest infrastructure cost overruns

Major projects rarely fail for a single reason. But reviews of several high-profile Australian builds over the past decade highlight a recurring theme: procurement decisions made early can shape costs for decades.

$10 billion

Snowy 2.0 (NSW) cost escalation from early estimates of about $2 billion highlights the risk of locking in budgets before technical uncertainty – such as geology – is properly understood.

$1.5 billion

Extra costs on Sydney's CBD and South East Light Rail (NSW) followed contractual disputes that showed how risk allocation in public-private partnerships agreements can reverberate through delivery.

$3 billion

The West Gate Tunnel (VIC) blowout illustrates how an incomplete scope – in this case, contaminated soil disposal – can surface after contracts are signed.

$9-10 billion

Reviews of Inland Rail (QLD–NSW–VIC) found construction progressed before planning, approvals and scope were fully resolved.

$2-3 billion

Rising costs on the Melbourne Metro Tunnel (VIC) underscore the complexity of packaging and integrating mega-project contracts.

commence the work you wish to commence," Battley said. "It doesn't, in and of itself, deliver anything in particular. But it does set the project up for success."

Theory versus practice

An industry insider speaking to *create* said consulting engineers in particular want to avoid risk, thereby introducing a bent towards conservatism in the infrastructure environment: an attempt to design for cost rather than purpose.

"The conservatism doesn't show up in the budgeting exercise at the front; it shows up in the over-specification when you get to the point of taking it to market," he said. "They produce a reference design. That reference design generally takes a few years, but it's really general.

"And because that engineering group hasn't been given enough cash to actually develop it properly – and doesn't have the constructability skills to develop it properly either – it's designed as a theoretical exercise.

"The design might be so theoretical it doesn't work. All the effort has gone to fitting a client's brief rather than producing a project that can be realistically constructed.

"The advice that should have been given is: 'Actually, we need more time to develop this because this is really ambiguous.'

"The construction engineers get there and say, 'That design doesn't work; we don't have approvals; the program doesn't fit its political timeline.' It's death by a thousand cuts."

Divorced from reality

The problem, as the industry insider sees it, is an infrastructure landscape where decisions are divorced from engineering reality. He uses the Snowy 2.0 pumped hydro expansion as an example.

"It was sold as a $3 billion project, and everybody in the industry looked at that and said, there is absolutely no way that's going to cost $3 billion," he said.

"But it was determined to be a $3 billion job so they could get it signed off and move forward. I think it's a good project and something the country needs, but to blame politicians for prices orders of magnitude out – well, they're being advised by the wrong people."

Infrastructure projects should be driven by need, the insider said, rather than finance-driven cost-benefit analyses.

"Look at the big works of infrastructure that have been built around Australia and the world. Their real value doesn't come into play until 10, 15, 20 years later. I think we start with the wrong questions," he said.

RIGHT: A new rail trench has replaced the level crossing at Bedford Road in Ringwood, northeast of the Melbourne CBD.

IMAGE: Supplied by the Level Crossing Removal Project.

> "The conservatism doesn't show up in the budgeting exercise at the front; it shows up in the over-specification when you get to the point of taking it to market."

Delayed value

Brisbane's Bowen Hills "spaghetti junction" offers a useful case study in how procurement settings can shape outcomes long after construction ends.

Delivered in stages between 2002 and 2012, the interchange itself functions as intended, but its core tunnel components –

BY THE NUMBERS

$3 BILLION

THE INITIAL ESTIMATED COST OF THE SNOWY 2.0 PROJECT

$12 BILLION

THE UPDATED ESTIMATED COST AS OF LATE 2025

Clem7 and Airport Link – became high-profile financial failures, collapsing within years of opening due to overestimated demand and optimistic revenue modelling.

The issue here was not engineering capability, but an environment that prioritised getting projects financed over interrogating long-term viability >

The right model for the right time

Given the challenges that procurement presents to all parties involved in a project, there would ideally be a single contracting model that could be followed in all cases to deliver the best outcome. Unfortunately, University of Melbourne Professor Colin Duffield told *create*, that's not the case.

"The different contracting models can all work very well for the right situation," he said.

"If you want flexibility in your contracting arrangement, it would be a poor thing to lock in a price, and think you're going to get that price if you've got every intention of changing the goalposts as you go forward.

"Whereas if you have a project that's been fully documented by a client and you just want to enact it, a firm price is probably not unreasonable."

This is what the experts say about some of the more common contracting models.

Alliance contracts

Alliance contracting brings separate parties together to deliver a project cooperatively while sharing both risk and reward. Duffield pointed to Victoria's ongoing Level Crossing Removal Project, which is dismantling 110 level crossings throughout the Melbourne area, as an example of how using multiple alliances with multiple contracts can work well.

"The government has become a very informed client; they have a good understanding of the costs and the prices," he said. "If a contractor comes to them with a price, they can sit down and say, 'Have you understood the risk? We think you've underbaked or overbaked the price'."

Public-private partnerships

Public-private partnerships (PPP) see governments drawing upon the private sector to wholly or partly fund a project. According to research prepared by Duffield, the PPP approach can deliver real benefits.

"They won't win one of these very large projects unless they've got excellent teams," Duffield said. "The other real advantage is the fact that it's got financing, which brings costs, and also high-end management skills that will control costs."

He points to Victoria's County Court, which was delivered as a PPP project.

"That's been in operation for about 30 years and it's as good as the day it was new. All of the other courts that are run and even refurbished by government become obsolete or run down."

Traditional procurement

According to Duffield, traditional approaches to procurement are still appropriate in the right circumstances.

"Some people who have been burnt by design-and-constructs or alliances or PPPs go back to traditional contracts.

"If the client knows exactly what they want, they've got expertise and they can document it, the traditional contract is fine. You can get a good price, and you get what you want if you know what you want."

and real-world usage. Though considered a failure against the original procurement objectives, it now plays a critical role in Brisbane's traffic network.

Process paralysis

Battley acknowledged that procurement can make it harder to provide innovative solutions, with providers attempting to avoid any ideas that seem complicated or risky. Considering alternative scope often involves a lot more work.

"Unless the client is actually engaged in the detail – if they just leave it to the procurement officers – it's very hard to be able to share something that's novel, different, new or unexpected.

"Where we see it work best is wherever there's a sense that the customer, through the process of procurement, has an

"The bigger and more complex these projects become, the more capable the client must be."

engagement. There's a deliberate part of the process where you're sitting down in a confidential manner and exploring these things in an open way, and for the most part that works pretty well."

Early contractor involvement, which centres the project around this sort of partnership from the beginning, Battley said, allows all the parties involved to make assessments on cost and innovation based on trust and team dynamics.

"Can we work with these people, and are they bringing the right sort of balance to our team? Are they going to integrate well? What are their behaviours and leadership like?

"Those things all matter because they're all great enablers to great problem-solving down the track when you're in the project."

Fleming echoed this sentiment, saying that much of engineers' frustration on a project derives from poor management of foreseeable problems, creating extra work and friction from decisions that don't get made.

"The bigger and more complex these projects become, the more capable the client must be," he said. "If the client is not an informed client, if they're not set up to make decisions in a timely way, if they're not helping manage the risk that they alone can manage – they are not a good client, and that's going to carry >

ABOVE: The West Gate Tunnel in Melbourne.

IMAGE: VIDA Roads.

risk and cost, and impose that on the project in a variety of different ways."

For Fleming, the best results come from projects where stakeholders can work productively and collaboratively. And project life cycle concerns mean that it's important to introduce this dynamic early.

"The greatest scope you have for making decisions is right at the beginning, and as you work through the first stage of engineering and procurement and design and delivery, the latitude you have reduces.

"As you work through that process, the cost increases and it increases early because you start to make big decisions. Then you're locking in millions or billions of dollars because of those decisions. So the big opportunity for very significant improvement is always upstream."

Prevailing engineering and design processes often miss this fundamental step. Stakeholders should always be reminding themselves of the outcome they're trying to achieve and to whom they're actually delivering benefits.

> "The greatest scope you have for making decisions is right at the beginning, and as you work through the first stage of engineering and procurement and design and delivery, the latitude you have reduces."

ABOVE: Sydney Metro cavern formwork at Hunter Street.

"Invariably, when I've seen and been involved in leading design processes with that mindset, not only do you get a vastly superior design, but very often it's cheaper," Fleming said.

"You've had an opportunity to think beyond time, cost and quality, and to think about the smart and clever ways we might get these multiple outcomes."

Getting in early

This approach of early contractor involvement, according to our industry insider, has shown particular success in the US.

"We're going to sole-source you after selecting based on qualitative criteria – financial capacity, ability to mobilise and technical skills – then work to develop the project" is how he described the process.

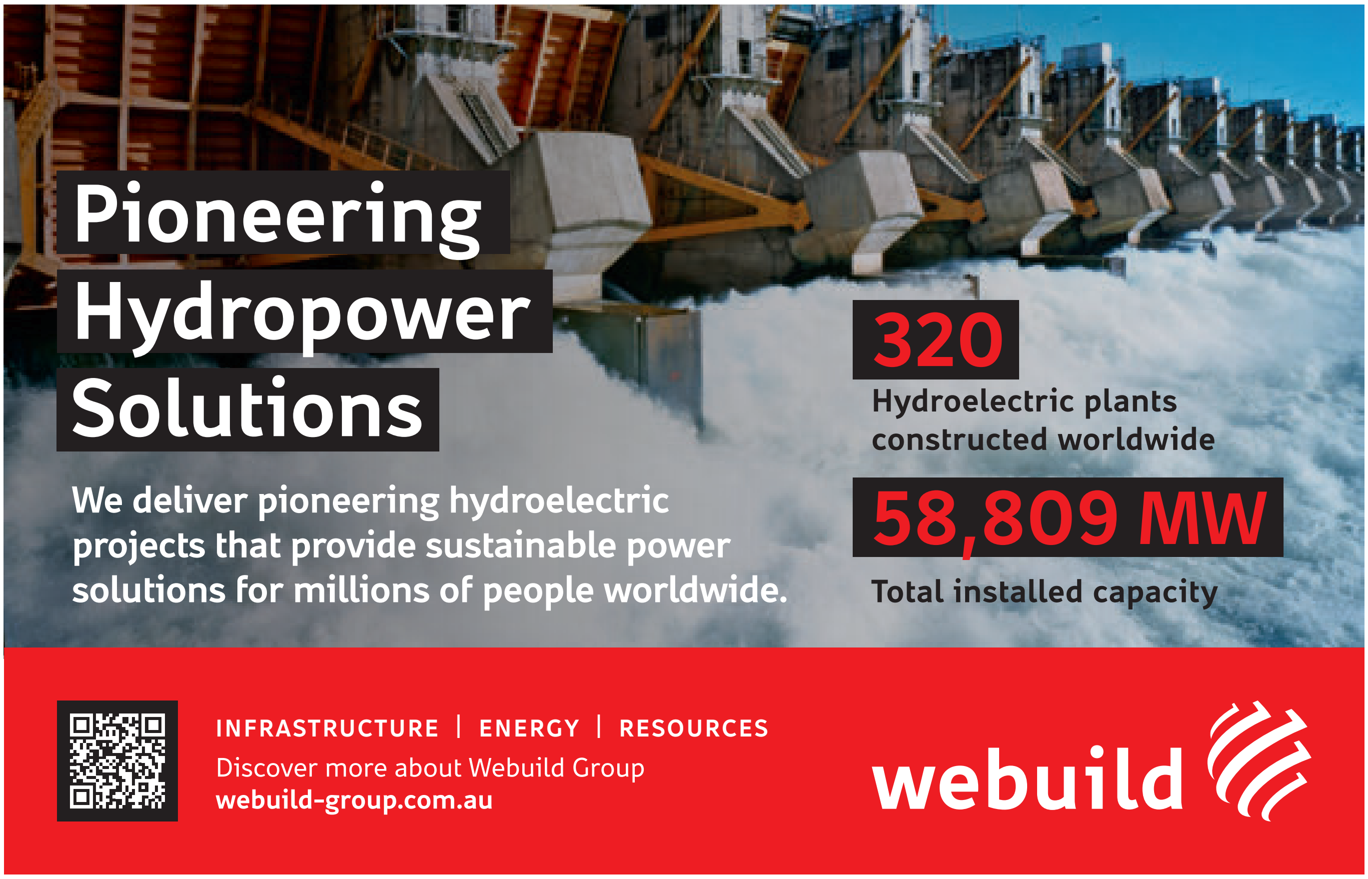
"So that individual company then prices the job over a period of time collaboratively with the client, then they get to the end and the client's either happy with the price or not happy with the price. The contracts allow for that.

"If they're not happy with the price, they can go to the market because they own all the things that have been developed to that point. But usually what happens is the client's happy with the price that's been delivered."

The result is that the contract team is able to then transform into the delivery team, allowing them to focus on delivering the job rather than creating tendering documents that promise to deliver.

"Remember, procurement only gets you to the starting line," Battley said. "The actual delivery of the project or the program – often over many years, for the work that we do – that partnership is where we see value best shared by all parties." □

IMAGE: Sydney Metro.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Made in Australia

Australia has no shortage of engineering ingenuity, but our innovations tend to struggle to scale domestically. Here's how some homegrown firms are cracking the code to overcome these challenges.

WORDS BY ELLE HARDY

From universities to startups, research hubs to established firms, Australia produces a steady stream of world-class ideas and the people needed to bring them to life. Yet we have a long-recognised structural problem: engineering innovation struggles to scale domestically.

Too often, intellectual property (IP) is commercialised offshore, manufacturing is outsourced, or promising technologies stall between pilot project and full deployment.

A frequently-cited illustration of Australia's commercialisation gap is Wi-Fi. The underlying technology was developed by CSIRO scientists in Australia, yet much of its commercialisation occurred offshore, along with the jobs, companies and long-term economic value generated by one of the world's most significant digital breakthroughs. The pattern repeated a decade later with the software underpinning Google Maps, which was developed locally before being sold overseas, once again exporting much of the downstream benefit.

Understanding why innovation stalls – and, more importantly, how to unlock it – is a complex challenge with no single solution. Recurring cultural, financial and structural barriers continue to limit the ability of new technologies to scale.

Equally, there are identifiable strategies for building the conditions in which engineering ideas thrive. A growing number of Australian firms are now pushing through these constraints, demonstrating that local innovations can be manufactured onshore, scaled successfully and deliver substantial benefits across the economy.

"If you've got something clever and don't manufacture it yourself, your IP walks out the back door," said Conry Tech co-founder Sam Ringwaldt.

For him, the risks and benefits of scaling innovation in Australia are immediate and tangible.

Beyond structural challenges, technical chokepoints also hinder innovations on the road to commercial success. Engineers consistently report falling into the gaps between university research and industry uptake, between demonstration projects and full commercial rollout, or at the point of procurement rather than technical feasibility.

Even when performance is proven, components can be difficult or costly to manufacture at scale, while certification and compliance regimes introduce additional design challenges that must be resolved before technologies can progress. None of these obstacles are insurmountable, but together they create a narrow passage between research success and commercial viability.

ABOVE: Flavia Tata Nardini, Fleet Space.

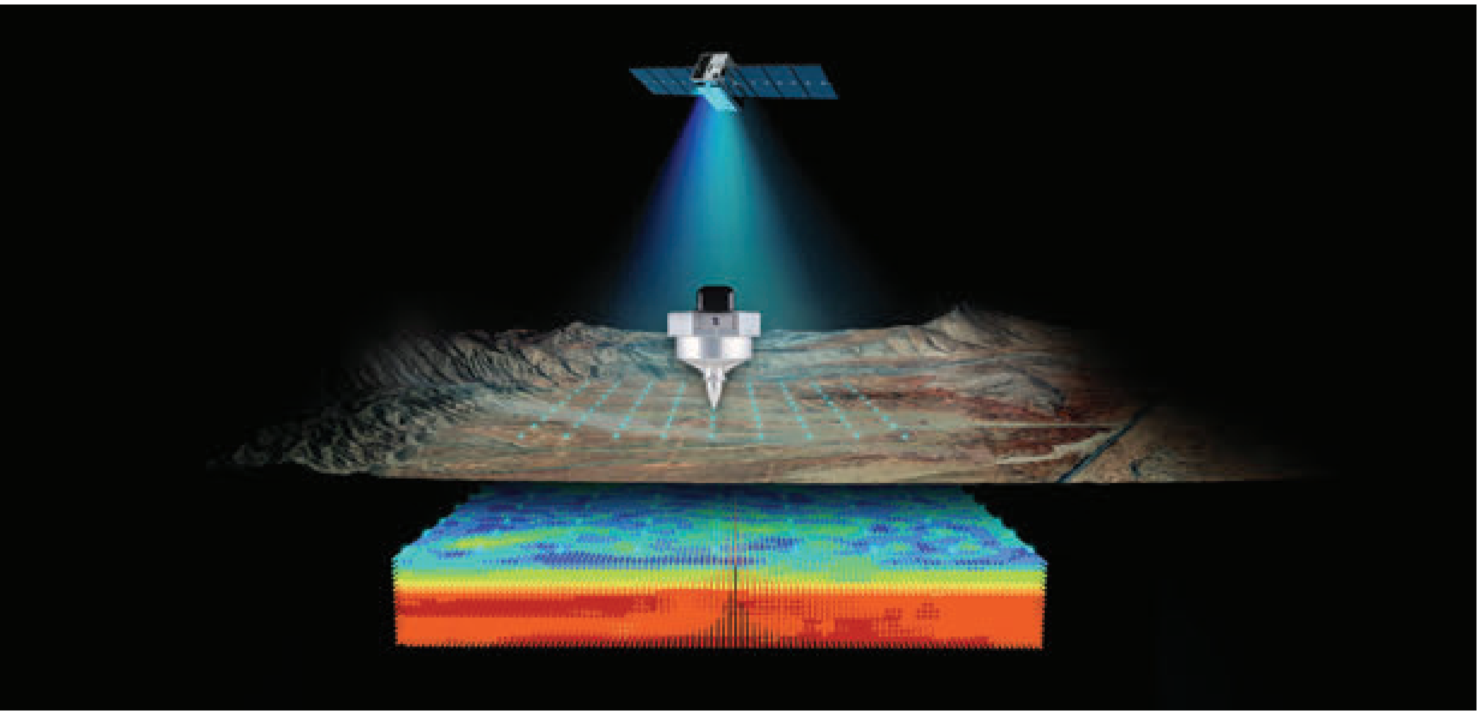
Advanced HQ

One Australian company charting this course is Adelaide-based Fleet Space Technologies, which has built a proprietary sophisticated satellite-enabled platform of low-orbit nano-satellites while keeping core engineering and manufacturing capabilities onshore.

With capacity to produce hundreds of satellites and thousands of next-gen sensors annually, its new 5300 m^2 advanced manufacturing headquarters will accelerate its development of scalable solutions for defence, space and mineral exploration.

Fleet Space's founder and CEO, Flavia Tata Nardini, said the company's growth has been driven by decisions about how its technology will operate. >

IMAGE: Micro-X.



"We focused early on designing systems that were modular, manufacturable and compatible with software used in the field today, so each prototype could evolve directly into a scalable product."

That principle has ensured that prototypes were not stuck in commercial cul-de-sacs, but on a path towards repeatable production. Equally critical was the company's approach to overcoming the dreaded first-mover problem.

"Trust came from putting real hardware in the field and proving reliability under operational conditions, not lab assumptions," Tata Nardini said.

These arrangements accelerated Fleet Space's transition from promising technology to commercialisation.

"Early customer application with customers such as Rio Tinto was critical. It validated the technology and accelerated our ability to invest in larger-scale deployments on Earth and in space."

The lesson Fleet Space draws from that experience is one many only recognise in hindsight.

"Design for scale earlier than feels comfortable. The transition from demo to deployment happens when engineering decisions are grounded in manufacturing, reliability, and customer outcomes – not just technical success."

ABOVE: Fleet Space's new advanced manufacturing facility. **TOP:** Schematic overview of Fleet Space's ExoSphere ANT system.

"The transition from demo to deployment happens when engineering decisions are grounded in manufacturing, reliability and customer outcomes – not just technical success."

Scale of ambition

Not all innovations begin from a position where scale can be assumed. Micro-X, which designs and manufactures carbon-nanotube X-ray technology, operates under the unique constraint of manufacturing products where the science itself is still developing.

Conventional X-ray systems rely on heated filaments to generate electrons, which generate significant heat.

"For decades, the research was stuck, because you simply couldn't draw out enough current without the nanotubes breaking down," Micro-X COO Anthony Skeats said.

Solving this problem required not only new materials, but a new understanding of how millions of nanoscale emitters behave collectively under stress.

Micro-X replaces them with cold-cathode carbon nanotube field emitters, which generate electrons using electric fields rather than heat. This means smaller, lighter, faster and more controllable X-ray tubes. Typical

IMAGES: Fleet Space.

"We're foolishly patriotic. But if you've got something clever and don't manufacture it yourself, your IP walks out the back door."

BY THE NUMBERS

CONVENTIONAL CT TUBES
15-20 kg

MICRO-X CARBON NANO TUBES
200 g

TYPICAL MOBILE UNITS
25 kg

MICRO-X MOBILE UNIT
2.5 kg

ABOVE: Anthony Skeats, Micro-X. **BELOW:** Micro-X manufactures carbon-nanotube X-ray technology.

mobile units are around 25 kg and Micro-X's are 2.5 kg. Conventional CT tubes are usually 15-20 kg but Micro-X's weigh 200 g.

"The carbon nanotubes are the invention," Skeats said. "The innovation is how we use them – and that's what eventually has to bring in revenue."

Unlike more mature technologies, where product development follows proven principles, Micro-X had to take what Skeats described as an "extraordinary risk" to develop its core technology and its commercial products in parallel. That meant leaps such as committing to manufacturing pathways, certification processes and market entry while the technology is still being engineered.

Working with such highly specialised technologies presents another problem: finding early adopters in Australia can be difficult. "When you go overseas, the first question is always: who's using this in your own country?"

The experience illustrates a recurring pattern: when technologies are hardest, the gap between technical success and commercial scale is amplified. And there are still fundamental problems in committing to making advanced products onshore.

"The quality of manufacturing in Australia is extremely good, but suffers from the demise of things like the automotive industry ... the biggest challenge we face in Australia is that tyranny of distance."

IMAGE: Micro-X.

Automating success

If Micro-X highlights the difficulty of scaling scientific breakthroughs, Conry Tech highlights different pressure points in turning domestic innovation into mass production.

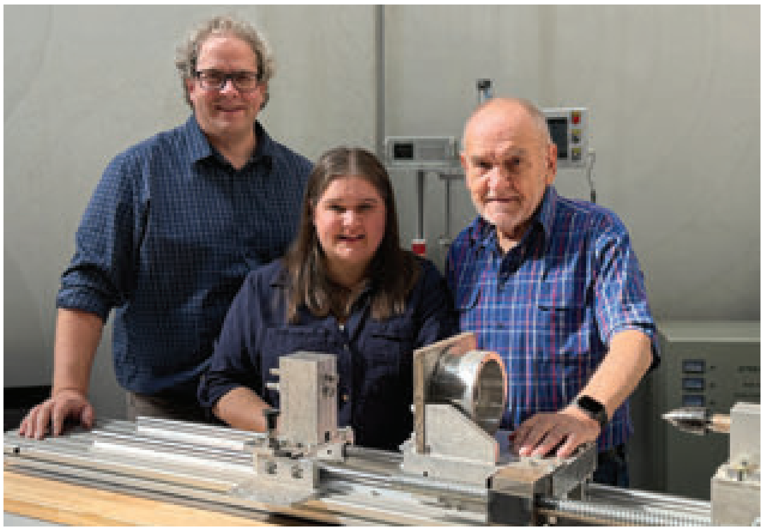
The Melbourne-based company is developing the BullAnt, an air-conditioning system designed to radically reduce energy use in commercial buildings by decentralising and transferring heat rather than relying on traditional energy-intensive cooling units. Conry believes it could halve energy bills and eliminate billions of tonnes of carbon emissions.

The technical ambition is significant, but the decision that has most shaped Conry's trajectory is where, and how, that technology is built.

"We're foolishly patriotic," co-founder Sam Ringwaldt said of the firm's commitment to manufacture in Australia, despite strong incentives to offshore.

But Ringwaldt wouldn't do anything differently, as he sees controlling the manufacturing process as the first step in retaining control of their IP.

Company co-founder Ron Conry, who has had 40 factories in 10 different countries, added: "Australia still has a competitive >



BELOW: Sam Ringwaldt, Brenda Ringwaldt and Ron Conry.

advantage in terms of our education system, where we produce people who can think and question and problem-solve on the shop floor."

Despite the need to protect IP, Ringwaldt said the obstacles to manufacturing in Australia are well understood. Capital is harder to secure, labour costs are higher and the domestic market is small. Investors expect "global aspirations", yet value companies as if their ceiling were the Australian market alone.

"If you want to stay in Australia, you need to build a high-quality team and start manufacturing locally. Otherwise, be prepared to give up a lot more of your equity locally, or capital will pull your business offshore."

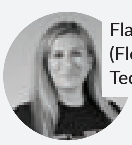
The resulting funding gap means businesses need to give away more equity than similar firms overseas. Government assistance is similarly constrained, tending to operate on risk matrixes that are oriented towards commercial success.

Conry Tech's response has been engineering-led. Rather than attempting to compete with low-cost and subsidised manufacturing jurisdictions on labour, it has designed the BullAnt system with advanced

> "If you want to stay in Australia, you need to build a high-quality team and start manufacturing locally. Otherwise, be prepared to give up a lot more of your equity locally, or capital will pull your business offshore."

Engineering scale

Australia's commercialisation gap is often cited as an inevitable hurdle, but for these three leaders, scaling is an engineering problem to be solved, not an external barrier to be endured. By integrating manufacturing, certification, and automation into the earliest phases of R&D, they are keeping high-value IP and jobs on home soil.

The innovator	Core scaling strategy	The insight	The turning point
 Flavia Tata Nardini (Fleet Space Technologies)	Design for modularity: Transitioning from bespoke science to repeatable hardware that integrates with existing field software.	"Trust isn't built on lab assumptions; it's built by putting real hardware in the dirt (or space) and proving it works under fire."	Moving from prototypes to a $5300m^2$ advanced facility to support defense and mineral exploration.
 Anthony Skeats (Micro-X)	Parallel development: Engineering the core technology (CNT) while simultaneously navigating global certification and market entry.	"The carbon nanotubes are the invention, but the innovation is how we use them to generate revenue."	Shrinking conventional 25 kg X-ray units to 2.5 kg, solving the heat problem that stalled research for decades.
 Sam Ringwaldt (Conry Tech)	Design for automation (DfA): Using 3D printing and additive manufacturing to offset high domestic labor costs and protect IP.	"If you've got something clever and don't manufacture it yourself, your IP walks out the back door."	Decoupling from traditional central plant units to create the BullAnt, designed to halve energy bills in commercial buildings.

manufacturing practices, such as 3D printing and additive manufacturing, and ensuring processes minimise labour.

"For manufacturing to work in Australia, you have to design for automation from the very start."

Stall patterns

Taken together, the experiences of Fleet Space, Micro-X and Conry Tech point to patterns that distinguish Australian innovations that scale from those that stall. In each case, engineers realised early that their technologies would need to confront Australia's structural barriers through bold engineering choices.

Australia's challenge, then, is not a lack of ideas, talent or technical ambition. It is a lack of sustained support for the most demanding phase of engineering work: the transition from something that functions to something that can be built, certified, sold and supported at scale.

For engineers, the implications are clear: scaling innovation is a key component of the engineering discipline itself. When manufacturability, reliability and deployment are treated as solvable design problems rather than external barriers, Australian innovations are far more likely to thrive. □

IMAGES: RØDE.

Case study:

Automation over offshoring

Sydney's RØDE Microphones is an example of a global company that has moved production onshore to Australia as a deliberate engineering and operational strategy.

Synonymous with high-quality audio, powering everything from podcasts to major films, RØDE designs, tests and manufactures microphones and audio products that compete with – and often outperform – counterparts made overseas.

Needing to significantly improve product quality to compete against Chinese firms with cheaper labour with closer proximity to parts, RØDE invested millions in automated machinery that makes high-precision parts, quickly and at high volume – and with a greater degree of accuracy than those hand-made overseas.

The strategy has also enabled RØDE to respond to market pressures with unusual speed. When threatened by a rival's wireless microphone product, the company redesigned and brought an advanced replacement to market in just 100 business days. Such a business decision was only possible thanks to the integration of engineering, tooling and assembly under one roof.

Where it once sourced many of its components in China, since bringing capsule production in-house, RØDE has dramatically tightened quality control, with rejection rates falling from around 50 per cent to less than 3 per cent today. The early success of bringing some of its key production in-house is leading the company to consider what else can be brought back to Sydney, as it aims to move more production under its own control, with its own machines.

Early investments in production technology – including machines for printed circuit board assembly and precision lapping equipment for capsule manufacture – have allowed engineers to iterate rapidly between design and manufacture. Previously, when the company depended on overseas contractors, it faced months between ordering and sampling, and experienced price and quality risks once parts were in the hands of third parties.

Operating their own manufacturing means engineers can flesh out ideas and be producing concepts within days.

It's already reaping the rewards. According to RØDE founder Peter Freedman, onshore, automated manufacturing now means "we're cheaper and better than China".

Strong headwinds

Australia has some of the world's best offshore wind conditions, but other territories such as China and Europe are decades ahead in sustainable offshore wind energy generation. If the technology is mature, why is it so difficult to deliver locally?

WORDS BY CHRIS SHEEDY

There are several levels to answering the question of why Australia currently has zero offshore wind capacity. It's not a single blocker, but instead a layered set of challenges that include engineering, regulations, and commercial, environmental and social constraints and, since the pandemic, increasing costs and uncertain supply.

At the same time, said Alexander Newcombe, GHD's Technical Director for Wind, nothing is getting in the way. Not any longer. After all, while it takes time and drive to build a new industry from scratch in a new market, with 13,000 turbines already installed in the ocean worldwide, there are existing solutions we can draw from.

"There are challenges, of course, but offshore wind is happening right now," Newcombe told *create*. "It's a completely new industry in Australia. It's not just a new project; it's a new sector, and potentially new ports and new transmission networks. So it does take time to do it the right way.

"That means setting up the regulatory framework to make sure the projects are built in an environmentally and socially sustainable way. Outside of the actual wind farm, there is a lot that needs to go into offshore wind to make it a success."

Offshore wind delivery is inherently multidisciplinary and logistics-heavy, Newcombe said. Projects include foundation design and geotechnical investigations; wind, meteorological and oceanographic measurements; and electrical design, array cables, export cables, offshore and onshore substations, and more.

In China and Europe, these systems evolved over decades. In Australia over the last 10 years, they have been developed in parallel.

As James Perry MIEAust CPEng, EPC Director at Star of the South, an offshore wind project targeting 2.2 GW of capacity in Gippsland, said: "We're starting from scratch." >

ABOVE: Alexander Newcombe, GHD.

RIGHT: An operational offshore substation and turbines in Germany.

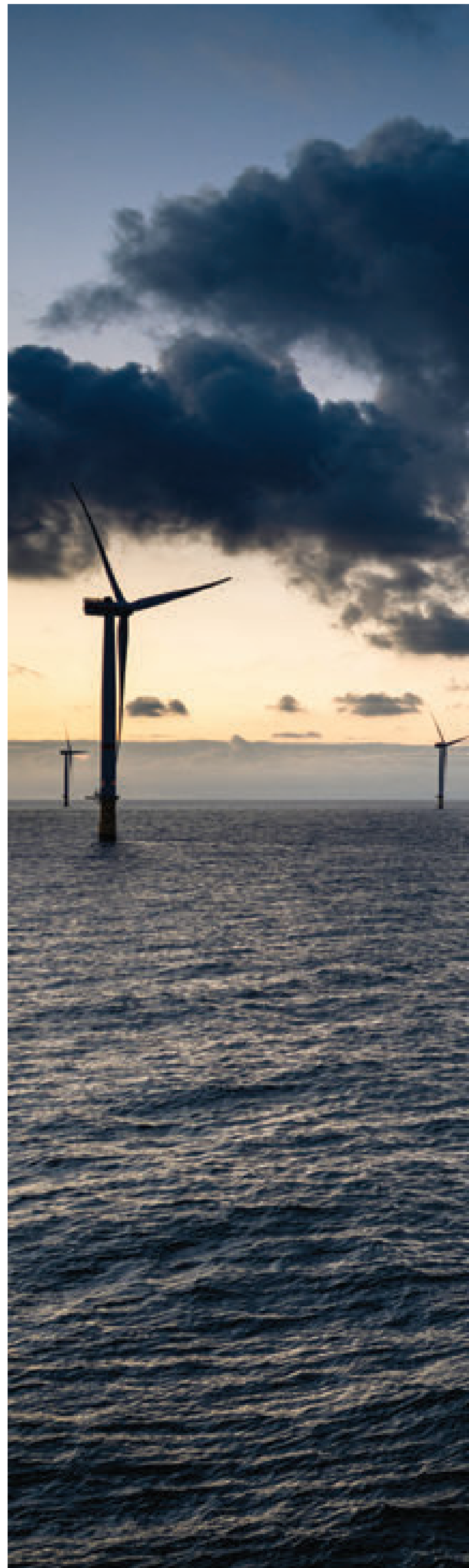


IMAGE: Star of the South.


VMOSS

Enabling a new industry

The offshore wind challenges in Australia began with the fact that an enabling regulatory framework had to be developed. It didn't exist until recently.

"When Star of the South was originated, it had to follow a development pathway under a lot of oil and gas regulations," Perry said. "We completed our first offshore geotechnical engineering assessment and geophysical assessment using an exploration license under the oil and gas regime."

Star of the South is now credited with stimulating the need for a unique offshore wind regulatory environment.

"That has now come. We now have the Offshore Electricity Infrastructure Act and the regulations that go alongside that. We have a regulator. We have a registrar. We have licensing of seabed. We have regulation on the state-side for Victoria, and we have legislative targets from Victoria. So there has been a whole lot of progress and work already."

Still, that regulatory regime remains largely unproven until a project is up and running, said Jenny Mitchell, General Manager of Policy and Advocacy at Engineers Australia.

For engineers accustomed to delivery pathways, standards and other guidelines that are tested and proven, this matters. New regimes suggest uncertainty, less-than-efficient processes and potentially longer timeframes, particularly when responsibilities are split between Commonwealth and state.

Mitchell said this is not an unfamiliar challenge in innovative major infrastructure delivery.

"With any new regime, the legislation does need to be tested and it does need the kinks ironed out," Mitchell said. "Of course, the best way to do that is to progress a project to construction and operation."

ABOVE: Jenny Mitchell, Engineers Australia.

BELOW: Jacket foundation installation in Taiwan.

Beyond the turbines

Because Australia's best offshore wind sites are so well-suited, the technical engineering of the country's first offshore wind farm is not particularly difficult, at least by global standards.

"A lot of the engineering challenges we have here in Gippsland are not significant compared to what has been achieved around the world, and compared to the challenges more mature markets are currently facing," Perry said.

What makes a suitable offshore wind site? The main ingredient is obviously high and reliable wind speeds. Shallow water is another important inclusion, as is suitable seabed conditions that make monopile

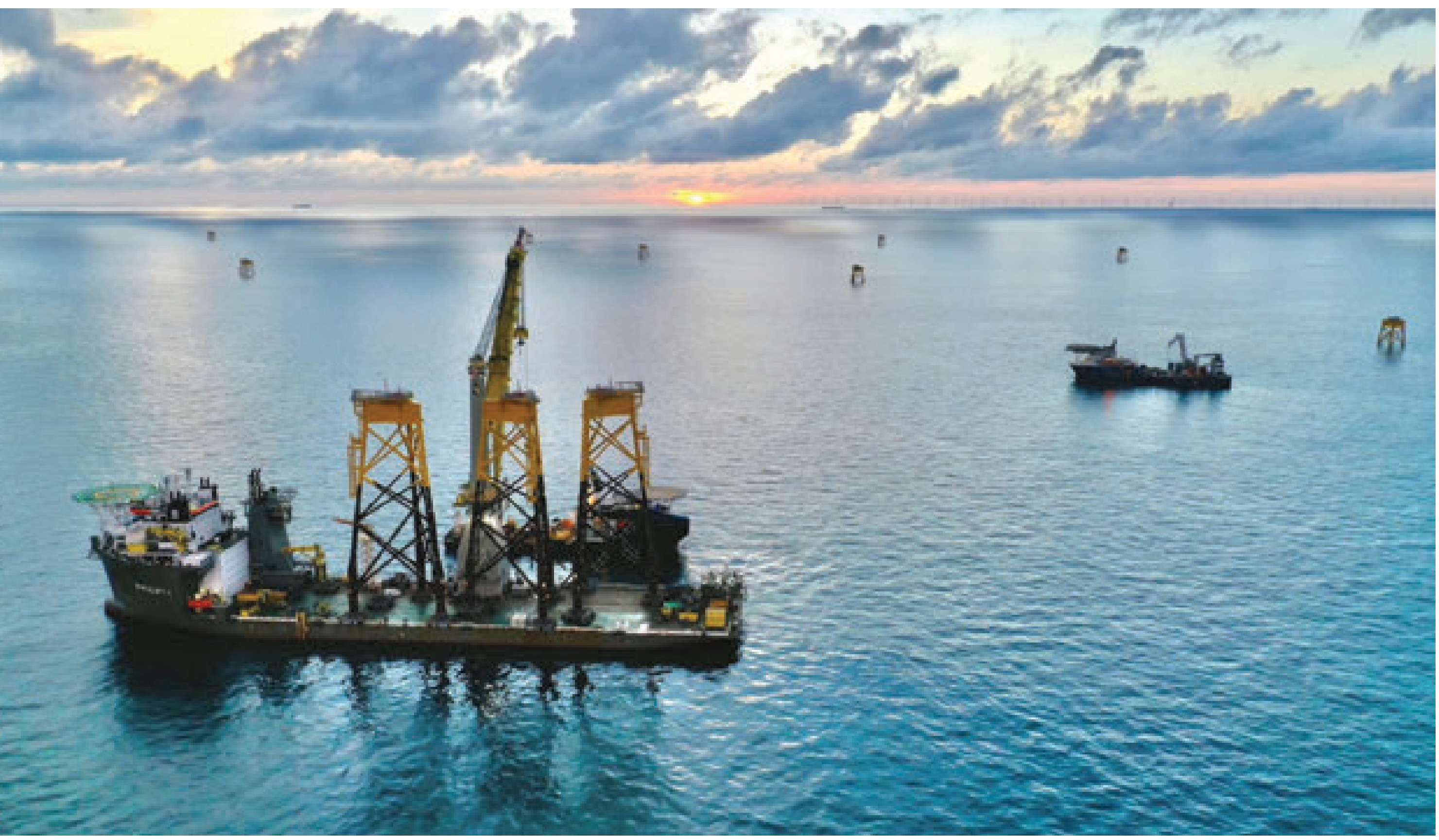


IMAGE: Star of the South.

> “A lot of the engineering challenges we have here in Gippsland are not significant compared to what has been achieved in the past around the world.”

foundations, the cheapest and most mature foundation solution, feasible. After that, the nearer the proximity to market and to existing transmission infrastructure, the less challenging the project becomes.

According to the Australian Energy Market Operator’s Integrated System Plan, as 90 per cent of coal-fired generators in the National Electricity Market are projected to retire by 2035, transmission infrastructure must adapt. The Gippsland region’s transmission capacity is already strong due to the legacy of coal-fired power generation.

“Gippsland is a great location because of the legacy that coal has left, and the connection hubs with the power plants at Yallourn and Loy Yang,” Perry said.

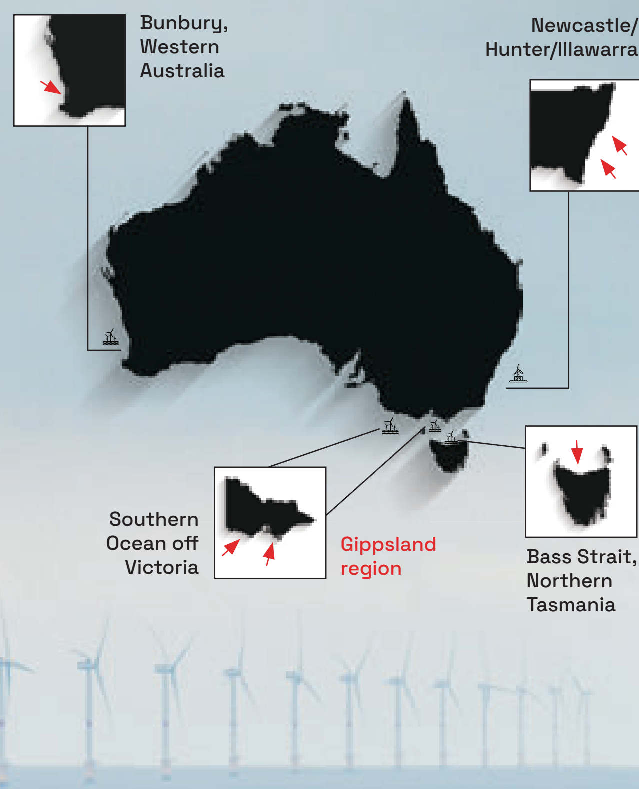
Offshore wind also delivers high volumes of energy per kilometre of new transmission investment. “If you look at building transmission to move electrons around, building offshore wind zones in Gippsland gives you far more electrons per kilometre of transmission investment than any other option.”

But it’s not all plug-and-play. More connections hubs must be delivered. That work is already happening for the Gippsland project. VicGrid is developing the transmission line to connect two GW of offshore wind energy to the grid.

“The line will use 500 kV double circuit overhead transmission technology, starting near Giffard and connecting >

ABOVE: James Perry MIEAust CPEng, Star of the South.

Australia’s best potential offshore wind zones



Gippsland region, Victoria
Identified as Australia’s prime offshore wind site, to supply Melbourne with energy.

Bunbury, Western Australia
Preliminary feasibility licences have been offered to three offshore wind projects off the coast near Bunbury.

Newcastle/Hunter/Illawarra
Identified as suitable for floating offshore wind farms, a technology operational in various regions including Norway, UK, Portugal and China, but with a significant cost premium.

Southern Ocean off Victoria
Declared in March 2024 an offshore wind zone by the Federal Government, 15-20 km off the coast between Port Fairy and Peterborough.

Bass Strait, Northern Tasmania
While Bass Strait has been declared an offshore wind area, applications for feasibility licences were open from December 2024 to April 2025. In January 2026, the preliminary decision not to award a licence was announced.

to the Loy Yang Power Station switchyard," VicGrid said.

Gippsland, with all of its unique characteristics both offshore and onshore, and with its pre-existing infrastructure, is considered Australia's most suitable offshore wind location. But it still tosses up unique challenges.

For example, construction of offshore wind systems isn't just about what's in the water, but also what's on the coast. The sector relies on large, specialised ports and a fleet of installation and maintenance vessels. Australia has neither.

Infrastructure Australia, in its *2025 Infrastructure Market Capacity Report*, said that "the import and local transport of large components such as wind turbines can be constrained by existing port or road infrastructure".

What's unique about ports that can handle the demands of offshore wind facilities? The assembly of turbines, with hub heights over 150 m and rotors measuring more than 230 m in diameter, requires deep-water ports, heavy-lift capacity and large laydown areas, all of which are limited domestically.

Various constraints, including logistics and supply chain availability, feed back into engineering decisions, Perry said.

"We may be limited by the water depth we can use to a port. And if you're limited by the water depth, you become limited in terms of the vessels you can select. So you start to reduce the supply chain down, and there's already a very small supply chain for these large vessels. And then maybe you start to limit the type of foundation you can use.

"So, if you look at just the site without the context, it might be a great, constructible site. But once you start to add in the need to transport monopiles out to the site – or maybe we need to select a jack-up vessel that is capable of sailing to a specific port, and it needs to be able to carry monopiles that distance – you may start limiting the logistics options that are available."

Have costs increased?

Offshore wind has always carried a premium over onshore renewables for obvious reasons. However, it also offers significant added value.

"If you only look at the levelised cost of electricity on a spreadsheet, there are benefits that aren't easy to understand," Newcombe said.

Offshore wind typically generates more consistently at night and in winter, when solar and onshore wind are less productive or unproductive, complementing Australia's high levels of solar penetration.

Cost is an enormous factor in decision-making, and while greater cost efficiencies are expected as the sector matures, the first movers, along with government and regulators, will need to bear the costs that come with setting up a new industry.

"It's not just about being the first project," he said. "Setting aside the regulatory environment

The cost of wind power over time

It's no surprise that offshore wind has always carried a cost premium compared to onshore wind and solar, but it fills a valuable gap and its trajectory has followed a familiar pattern in terms of infrastructure cost.

According to CSIRO, renewables remain the lowest cost range of new build electricity technology, despite future onshore and offshore wind costs being revised upwards.

"This competitive position reflects the decade of cost reductions experienced by wind, solar photovoltaics and batteries prior to the pandemic, while costs of their more mature competitors have remained flat," CSIRO's GenCost 2023-24 report said.

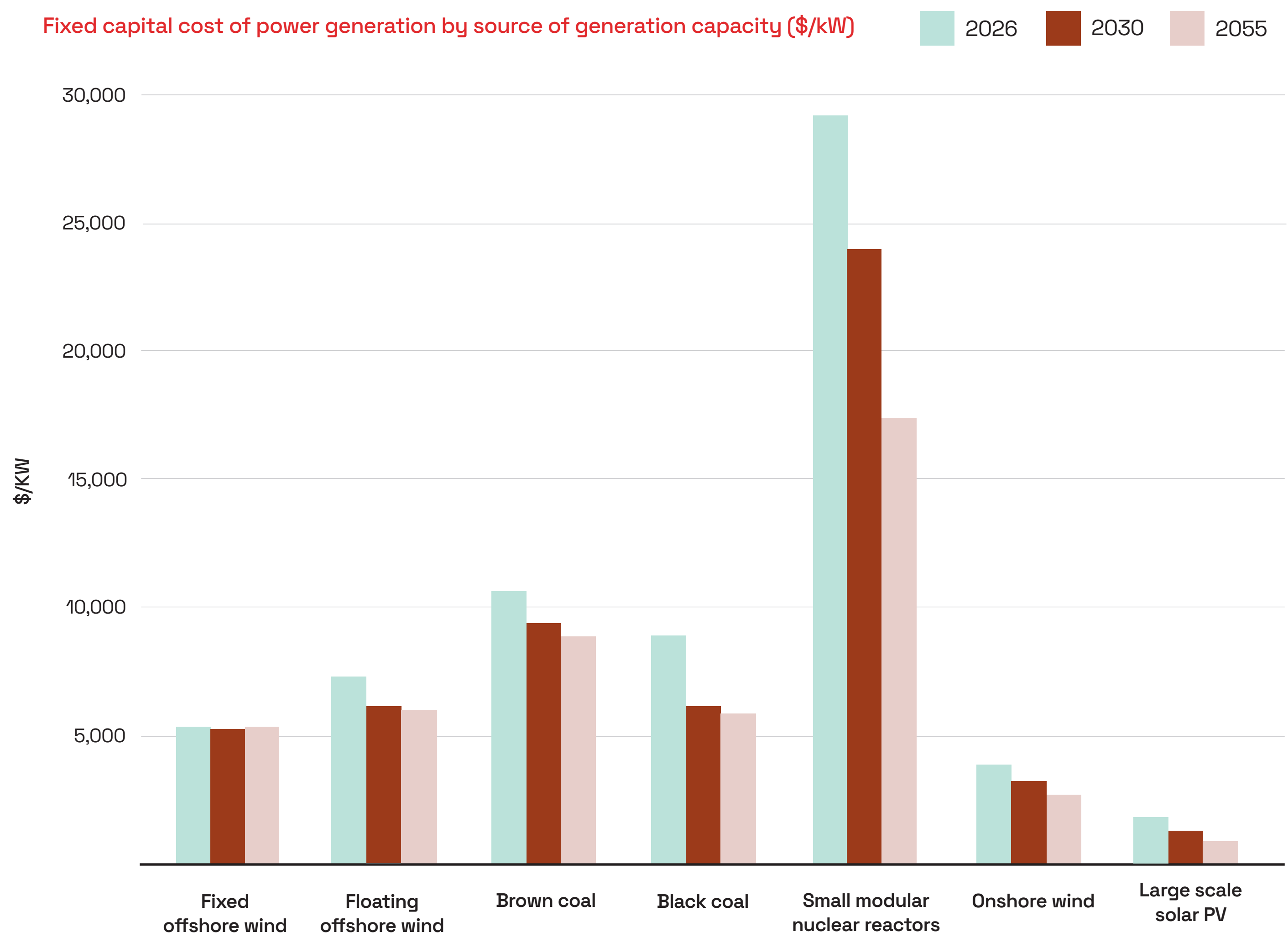
According to that report, offshore wind remains more expensive than onshore wind and large-scale solar due to higher capital costs, as well as the need for specialised vessels and the greater construction risk.

However, that cost will flatline as the technology matures in Australia.

A simple breakdown of cost per kW for fixed and offshore floating wind

Cost component	Fixed offshore wind ($/kW)	Floating offshore wind ($/kW)
Foundation	597	2393
Remainder of cost	4065	4065
Total cost	4662	6458

SOURCE: GenCost 2025-26 report. Apx Table A.1 Cost breakdown of offshore wind



SOURCE: GenCost 2025-26 consultation report. Apx Table B.1 Current and projected generation technology capital costs under the Current policies scenario

and the technical feasibility of these ambitious projects, there is also the social licence to consider. Unlike onshore wind, you're not putting turbines into people's backyards, so to speak.

"But there are still social licence issues to address, whether it's because of the visual amenity – they could be seen from shore – or because of environmental impacts on birds and marine ecosystems, and even the potential impact on other industries such as fishing and tourism. These costs need to be viewed in comparison to the advantages of offshore wind."

Interestingly, as the cost of everything has been increasing, some prices in the offshore wind supply chain are going down. This is because the offshore wind sector has experienced turbulence globally. Delayed auctions, withdrawn bids and cost and supply chain issues in the small and specialised offshore wind space has meant some suppliers are cutting prices.

"Vessel suppliers are looking at reducing their charter rates because they want to keep their assets working. One of the key things needed is a clear pipeline, so turbine suppliers and vessel suppliers can see it's not just a one-off."

Birds, fish and people

One of the most complex elements of offshore wind delivery in Australia is the environmental one. Each project must assess potential impacts on marine ecology, migratory birds, whales and more.

For Star of the South, a multi-year, comprehensive marine ecology survey program working with leading scientists and research agencies has provided strong baseline data to work from. >

"Some questions are difficult for us to answer because of the scientific evidence that's currently available," Perry said.

Bird collision risk modelling is a key example.

"One of the inputs you need is species-specific avoidance behaviour. That data exists in Europe for local species, but there's limited data here."

And so, Australian projects must reach for conservative worst-case assumptions that increase uncertainty and potentially constrain design.

Underwater noise needs to be carefully managed during construction. Piling turbine foundations in the seabed requires significant energy, generating noise which travels underwater, potentially impacting noise-sensitive marine species such as whales. Engineers have developed innovative mitigation technologies to address this, including double-bubble curtains which release a wall of bubbles around piling activity to dampen sound.

Then there's the question of skills. Does Australia even have the people it needs to manage such projects?

"One of the inputs you need is species-specific avoidance behaviour. That data exists in Europe for local species, but there's limited data [in Australia]."

"Engineers Australia has been able to demonstrate through research how transferable engineering skills are into renewables and greener industries," Mitchell said. "Unsurprisingly, the research found that the technical engineering skills are overwhelmingly transferable."

In some cases, there is a training gap, but it's often around specific jargon or the use of particular standards.

"What can be more challenging is the breadth of capabilities like stakeholder management, community engagement and negotiation skills that can be expected of engineers for clean energy projects. Government, industry and education providers need to work together to make pathways clearer for engineers to move into offshore wind."

ABOVE: The Veja Mate wind farm port in Germany.

Upskilling Australians

Newcombe, who trained and worked in Denmark, including roles with Ørsted and the Danish Energy Agency, cautioned against assuming European delivery models can be simply transplanted. "The technology is proven," he said. "The first-mover anxiety isn't about technology. It's about the Australian-specific market conditions."

Perry agreed, saying that while plenty of talent can be brought in from other territories, no project wants to make the importing of skilled specialists a significant part of its business model.

There will be benefit for everyone in upskilling Australians in constructing, maintaining, operating and decommissioning offshore wind farms.

"Star of the South skills mapping with both the coal and the oil and gas industries shows 70 per cent of those workforce skills overlap with offshore wind. With a level of training, it will bring great opportunities." □

IMAGE: Star of the South.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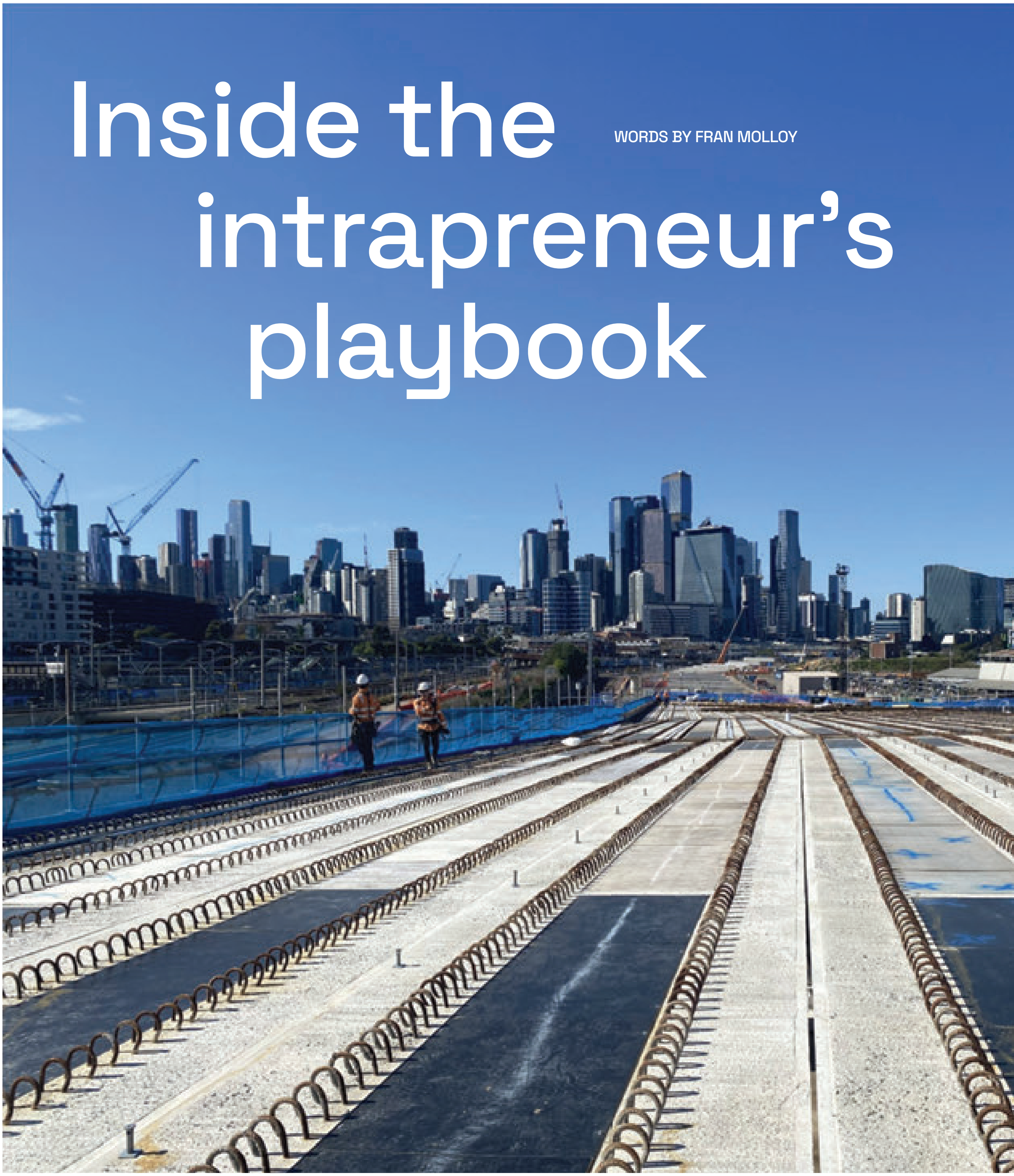
Inside the intrapreneur's playbook

WORDS BY FRAN MOLLOY



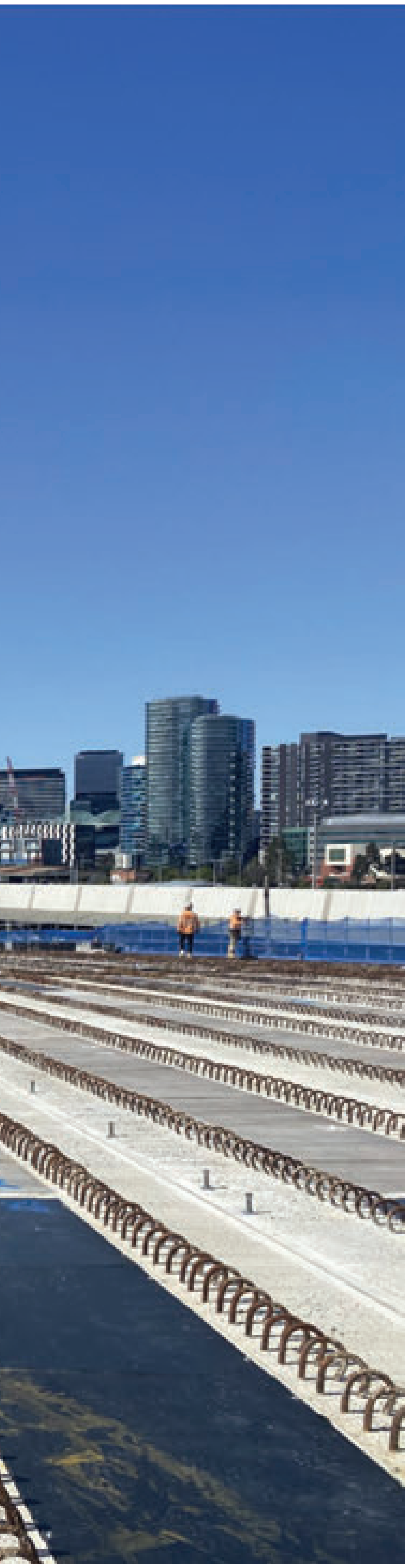
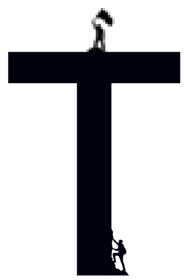


IMAGE: CIG.

Innovation inside Australia's biggest engineering firms rarely looks like a startup. It's driven by engineers who spot problems on live projects and push ideas through layers of risk, approval and culture – reshaping how infrastructure is designed and delivered from the inside out.



The League of Intrapreneurs sounds like something from a Marvel comic, but this global membership group is all about supporting people with an entrepreneurial spirit – who drive change within large organisations, rather than turning innovation into a new business. And engineering firms are full of them.

Take Civil Infrastructure Group (CIG) Director Andrew Rovers MIEAust. As more Victorian rail viaduct projects began shifting to precast concrete construction a few years back, he realised the company's bread-and-butter work building reinforced and post-tensioned concrete structures on site could start to disappear.

"Up until the last few years, all the bridges we worked on would have three spans, and now they all seem to have more than a dozen," said Rovers, a civil engineer with two decades of construction behind him.

Precast solutions can cut the build time for supporting beams from three weeks to around eight days, reducing disruption and speeding project delivery times.

And while installing precast beams and crossheads was more logistically challenging than in-situ builds, requiring huge 400 t cranes and complex route arrangements, customers were won over by the significant time savings.

"We realised that we were going to keep losing jobs to precast unless we worked out how to deliver our in-situ work much faster."

His team developed a patented heat-curing system that slashes concrete curing times from days to hours, allowing entire pier columns and crossheads to be poured in a single operation.

The CIGcure technology, which Rovers and his colleagues developed with over 15 months of testing, has since helped the company win nearly every rail viaduct contract in Victoria.

By completely rethinking the fundamentals of their approach, Rovers and the team at CIG cut a three-week process back to days.

This is intrapreneurship in action. While entrepreneurs launch startups to commercialise their ideas, intrapreneurs drive innovation from within existing organisations, navigating complex approval processes, risk-averse cultures and commercial pressures to transform the way infrastructure gets delivered. >

ABOVE: Andrew Rovers MIEAust, CIG.
LEFT: Construction on the West Gate Tunnel, a CIG project.

Sustaining agility

As engineering firms scale, they face the innovator's dilemma: failing, not through incompetence, but by doing what shareholders demand – prioritising revenue streams over uncertain ventures.

Although most large engineering firms were founded on innovation, as organisations scale, entrepreneurial agility becomes harder to sustain.

Sue Brown, Executive Group Director for Sustainability at Worley, points out that large engineering firms are full of people with brilliant ideas and solutions; the challenge is to channel them. "Bringing discipline and rigour and prioritisation to those ideas is actually difficult," she said.

ABOVE: Sue Brown, Worley; John Hilton, Aurecon.

BELOW: Camms Road Level Crossing removal.

The problem extends beyond shareholder pressure to an industry-wide culture. Engineers build their reputations on delivering reliability, and can struggle with the inherent uncertainty of innovation.

"One thing I find that can challenge engineers is that expectation to provide a definite outcome," said Emma Jones, Executive Advisor for Innovation and Transformation at GHD. "With innovation, we start with a problem and the solution is unknown at the beginning of the process."

Large engineering organisations face particular barriers to innovation. Complex approval processes, risk management requirements, procurement conservatism and delivery pressures create resistance even when everyone agrees innovation is needed.

Rovers encountered this when he first proposed testing his rapid-curing system on a live project. The technical innovation itself posed challenges. Unlike precast curing, which uses steam applied to thin concrete elements, Rovers' approach required heating massive pier structures while simultaneously cooling their cores to prevent thermal damage.

"You can't just heat concrete up non-stop so it goes hard quickly, because you'll actually damage the internal structure

IMAGES: CIG.

ABOVE: West Gate Tunnel Project.

long term," he said. "You have to be able to heat it and then cool it down so no part of the concrete is more than 20 degrees different from any other part."

Proving compliance before live deployment required extensive testing. The team invested 15 months in development, conducting trials that replicated real-world conditions as closely as possible. Even then, to convince stakeholders – clients, the Department of Transport and VicRoads – the team had to show compliance with tests they hadn't anticipated.

"We did as many tests as we could come up with – then they had a couple that we hadn't thought of. We actually met all the requirements of all, every test we did."

> "One thing I find that can challenge engineers is that expectation to provide a definite outcome. With innovation, we start with a problem and the solution is unknown at the beginning of the process."

Real problems

Successful engineering innovation often emerges not from corporate innovation labs, but from practitioners solving real problems on live projects.

John Hilton, Design Director at Aurecon, spent almost 50 years in bridge design before bringing his A-Bridge concept to life. The idea first took root 30 years ago when his father pointed out deteriorating timber bridges during a country drive and said, "You ought to do something about it".

Existing replacement options for timber bridges can be expensive and time-consuming, requiring cast-in-situ concrete decks with long curing demands, closing roads for extended periods.

Hilton assembled a deliberately diverse team at Aurecon to develop the A-Bridge, drawing on geotechnical engineers, road designers, flood modellers, environmental specialists, surveyors and digital modellers alongside senior bridge experts to develop an alternative using fully precast, modular components.

"When you're innovating, you need a diversity of views," he said. "You don't want people who will think like you. Some of the best ideas come from new graduates, because they haven't gone down the same path I've gone down."

The team explored a range of ideas before coming up with their solution. The A-Bridge eliminates bridge bearings and deck joints, requires minimal on-site concrete work and reduces construction time from weeks to days. With an estimated 1500 timber bridges in place across NSW alone, the solution could save many millions of taxpayer dollars.

Hilton said the strong innovation culture at Aurecon was instrumental in getting the A-bridge over the line.

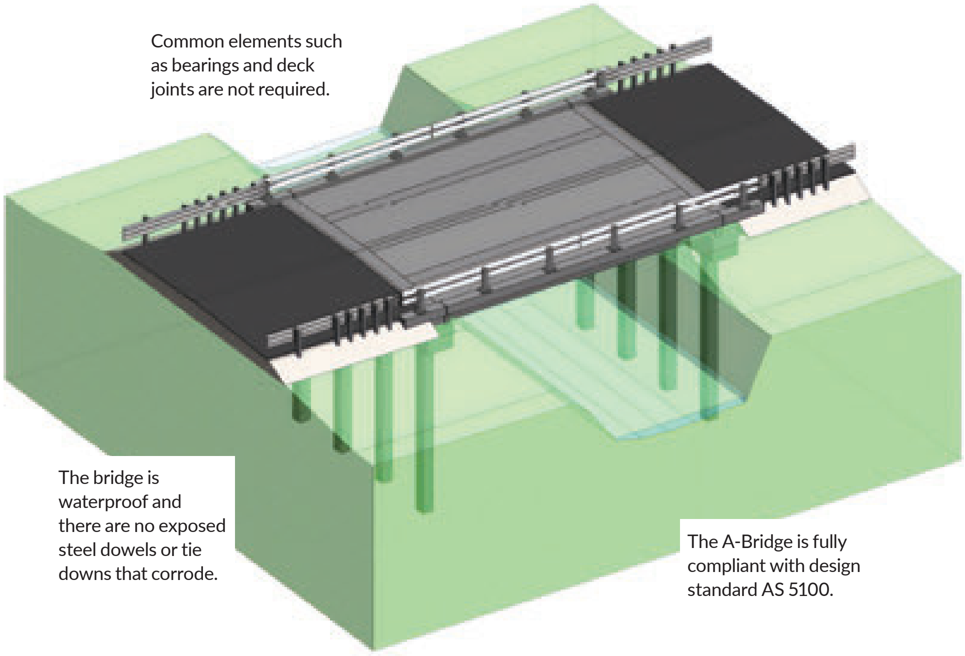
"We are not encouraging innovation for the sake of it. >

If you can show real benefit, the company will step in and be right behind you."

At GHD, innovation teams operate as what Jones describes as a "pit crew for innovators", helping staff develop and test ideas while maintaining connection to live project delivery.

The company has seed funding for pilots, while a global technical conference brings together about 100 different technical leaders several times a year for cross-pollination across more than 45 disciplines.

The innovative A-Bridge design



"When you're innovating, you need a diversity of views. You don't want people who will think like you. Some of the best ideas come from new graduates."

LEFT: Aurecon's A-Bridge design was put to use in Kyogle, northern NSW.

Success factors

Across different organisations and innovation types, common success factors emerge.

Executive sponsorship is essential – but insufficient on its own. Every firm we spoke to said innovation must connect to genuine delivery problems, rather than abstract opportunities.

At Worley, a grassroots process shaped the company's strategic direction. Following a major acquisition, CEO Chris Ashton ran 80-100 workshops globally with about 20 participants each to define the new organisation's purpose.

Brown said the process meant priorities emerged from across the body of the organisation.

IMAGES: Aurecon.

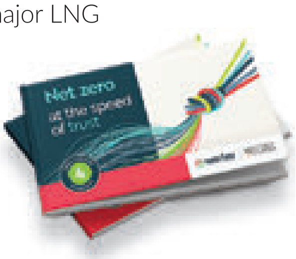
"There was really deep engagement and consultation."

This organic mandate gave Brown a "strong North Star" for developing sustainability as a core capability and prompted the establishment of a thought leadership partnership with Princeton University focusing on scalable solutions for the energy transition.

The importance of customer co-creation recurs across organisations. Worley developed carbon accounting platform EmissionsView with a major LNG player willing to share operational data and experiment together.

Brown noted that executive buy-in typically hinges on whether there's "a customer willing to go shoulder to shoulder with you and support the development of something".

BELOW: Sustainability and collaboration are key values at Worley.



Worley's venture board brings further discipline to innovation, tracking ideas from seed funding through to market. The company prefers rapid conversion from idea to value, Brown said. "We'd rather go hard and fail fast."

At Aurecon, Hilton says the company helped address client risk concerns through a licensing model for A-Bridge. All relevant design documentation was handed to Transport for NSW, ensuring continuity even if Aurecon no longer existed.

"The state government always needs to manage that element of risk," Hilton said. "The licensing model makes sure that a product which is ultimately beneficial to the state is fully available to them."

Perhaps the most under-estimated success factor is persistence. GHD uses a "double diamond" framework, showing how innovators repeatedly hit walls of resistance, with each collision being an opportunity to refine their approach.

"You don't really know how many goes that will take," Jones said. "People really underestimate how challenging that is, from developing a minimum viable solution versus when it actually will scale."

Rovers and his business partner faced scepticism from colleagues and external consultants who thought their heat-curing idea would never work. "We didn't have support at >

all, at first. But we persevered."

The breakthrough came when test results demonstrated the system worked. "Once we had the information that it was actually working, heating and cooling, everyone started getting on board."

The path forward

Intrapreneurs in engineering organisations operate at the intersection of technical expertise and organisational navigation. Their innovations often emerge from intimate knowledge of project challenges that external disruptors lack.

For engineers wanting to drive change, Brown suggests leveraging existing processes within their organisation. "For people who are intrapreneurially minded, find those sponsors and champions within your organisations and work through the processes to get your ideas out there."

Hilton encourages engineers not to be restricted by conventional thinking. "Don't just be confined by what's in the textbook," he tells his university students. "Think about how we can do things better, more efficiently, safer, more sustainably. If you keep doing the same thing, you get the same result."

Jones says that collaborative frameworks can help facilitate intrapreneurs in organisations. "Intrapreneurs do need that support group, people who can do that translation. Having that team around them helps them to feel comfortable, and helps bring in those diverse perspectives."

The construction and engineering sectors face intensifying pressure to deliver more infrastructure faster while reducing environmental impact.

Intrapreneurs who can navigate organisational complexity to bring innovations from concept to deployment will be essential to meeting that challenge. □

ABOVE: GHD's Smart Seeds program offers funding for innovative pilot initiatives.

BELOW: Emma Jones, GHD.

Why most innovation units fail – and some don't

Corporate innovation programs often struggle to deliver results. Protected spaces that were meant to nurture new ideas become isolated from commercial reality, generating concepts that never translate to client value.

Emma Jones has spent more than a decade working to avoid that fate. As Executive Advisor for Innovation and Transformation at GHD, she describes her team as a "pit crew for innovators" rather than innovators themselves.

"A lot of what we do is helping others to spark ideas, develop those ideas, test them and validate them, and bring them to some form of maturity," she said.

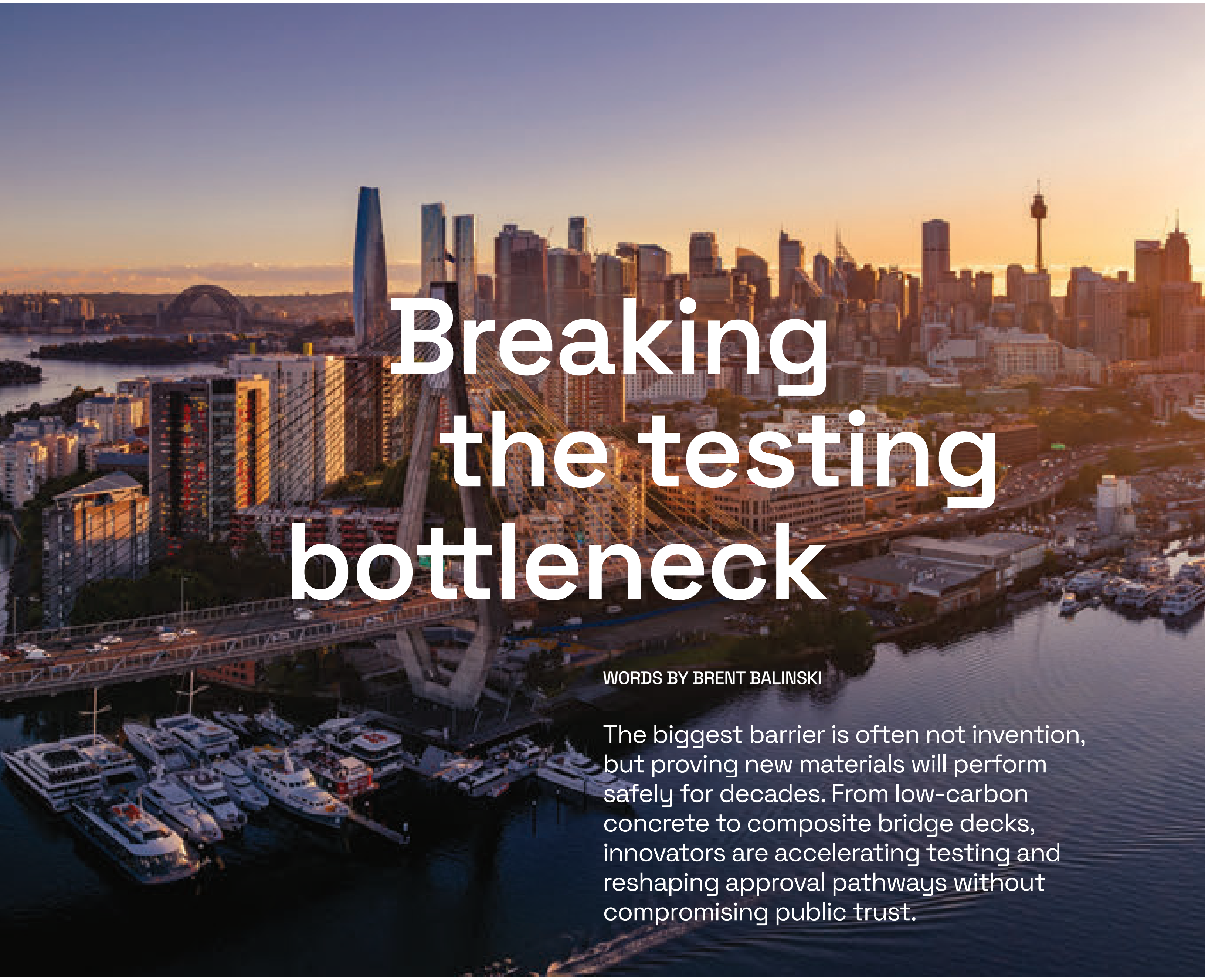
The difference between programs that succeed and those that merely generate ideas lies in connection to real delivery challenges – and practical risk management.

GHD bases its approach on the ISO 56002 standard for innovation management, bringing systematic rigour that brings a level of ease to an organisation dominated by scientists and engineers.

"It's measured. There's evidence, there's financial and investment rigour around the steps. There's also some appropriate flexibility, along with room for experimentation and, importantly, failure too; but it's calculated to be safe to fail."

Innovation at GHD isn't treated as a value-add that can be cut during downturns, Jones said. Instead, it focuses on doing more with less, finding ways to deliver greater value using fewer resources.

"A lot of people associate the word innovation with, 'Oh, let's do more. Let's do some crazy stuff.' It's when there are constraints that we need innovation the most, and it forces you to be so much more creative."



Breaking the testing bottleneck

WORDS BY BRENT BALINSKI

The biggest barrier is often not invention, but proving new materials will perform safely for decades. From low-carbon concrete to composite bridge decks, innovators are accelerating testing and reshaping approval pathways without compromising public trust.

IMAGE: Infrastructure NSW.

Concrete is sometimes referred to as the second most consumed substance on earth, after water. In Australia alone, an estimated 29 million m^3 of concrete premix is made annually.

Globally, manufacture of its key ingredient, cement, contributes between 7 and 8 per cent of all carbon dioxide emissions, chiefly through converting limestone into clinker (the key ingredient in cement) and the heat required to do this.

Some experts express frustration at the pace of concrete greening in relation to our national decarbonisation targets: 62–70 per cent below 2005 levels by 2035, and net zero by 2050.

"As new concretes get developed, how do we get them out of the laboratory and into practise more readily, more quickly?" Professor Stephen Foster told *create*.

ABOVE: Professor Steven Foster, UNSW.

The Professor of Structural Engineering at UNSW has a biography listing more than 400 publications in the field of structural concrete and concrete materials, awards for his contributions, and numerous standards development roles.

"It can take 15 years for something that's been developed in the laboratory to find its way to a standard, if we're generous,

and we don't have 15 years."

Clare Tubolets, CEO of the SmartCrete Cooperative Research Centre (CRC), said Australia has led the world in research on geopolymers, which don't use cement as a binder and contain much less embodied carbon.

"We have 40 years under our belt of understanding how that material functions, and you can't get a commercial geopolymer in Australia," she said. "We could keep putting money into testing these new whiz-bang concrete mixes. But until we actually have a market that's ready to adopt them, it's just flushing money down the toilet.

"Or it's giving that research to other countries, because geopolymers are being very happily adopted in, say, the UK, the US or other major markets. If you look at the quantity of research that's been done, Australia has done about 80 per cent of all the research in geopolymers. It's our research money that's now supporting development in the rest of the world. Are we happy with those spillovers?"

ABOVE: The new Sydney Fish Market; Clare Tubolets, SmartCrete CRC.

Concrete isn't the only corner of the built environment where progress is slow, and standards development often gets cited as an impediment. Dr Ali Mohammed CPEng, Technical >

Lead at Wagners Composite Fibre Technologies, agreed that standards development was cautious and deliberate.

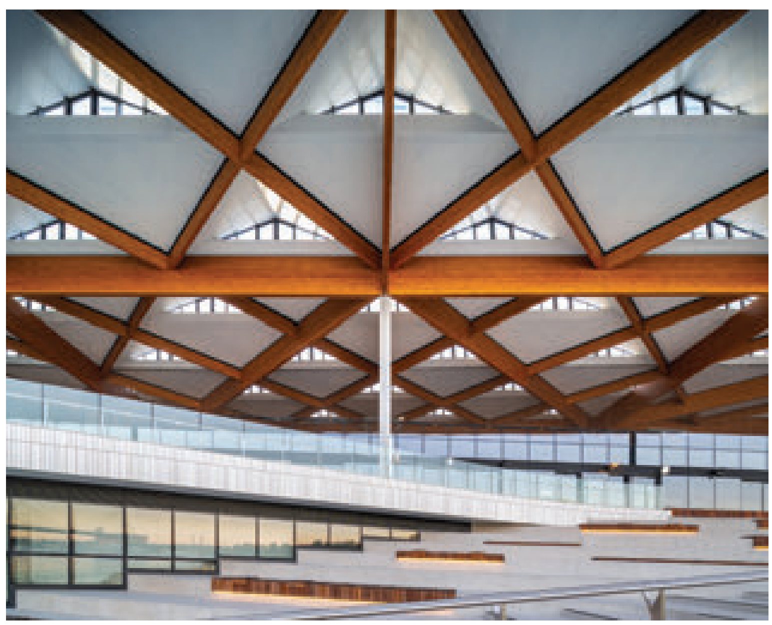
"It's very careful work," he said. "We understand it's a slow process, but we need to see [it through]."

Timber dream

The new $836 million Sydney Fish Market opened to the public in January. Media coverage noted the expectation of six million visitors a year, with superlatives such as the most significant Sydney landmark since the Sydney Opera House, and the building with the biggest timber roof by mass in the Southern

ABOVE, RIGHT: The timber roof is the largest by mass in the Southern Hemisphere.

ABOVE: Dr Ali Mohammed CPEng, Wagners Composite Fibre Technologies.



IMAGES: Infrastructure NSW.

Hemisphere. The 200 m floating roof came about due to a commitment to turning a timber dream into reality, said Graham Babcock, Buildings Market Lead – Australia at Mott MacDonald.

"During that initial reference design, we looked at many options in terms of what the roof structure could be," he told *create*. "In terms of materials, we looked at concrete, steel and timber in various primary and secondary structural arrangements, but timber was the one we were most passionate about, given the form, function and environmental conditions."

Mass timber is arguably gaining interest in Australia, helped by projects such as the 183 m hybrid timber Atlassian Central building under construction near Sydney's Central Station, as well as the claimed carbon sequestration benefits. The new Sydney Fish Market captured more than 100 t of carbon in its timber canopy.

According to vendor Rubner Timber Engineering, the timber structure includes 1800 m^3 of spruce glulam and 594 parts, sourced from the Dolomites in Northern Italy, with the largest of these 32.7 m.

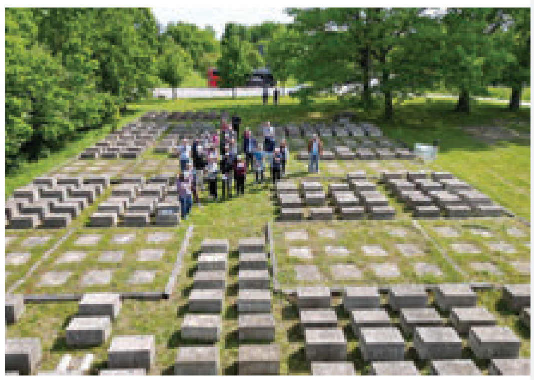
Babcock said some of the key aspects of turning the vision of a timber roof into a reality was early market engagement, and the development of key details to de-risk construction.

And while it might look complex, it's actually "a very simple structure" and its beauty is in this simplicity.

"Originally, the organic roof form was geometrically independent from the supporting structure. By collaborating with the architectural design team to pull and push the points of contraflexure to align with the columns, we could achieve the same effect, but with simple straight elements that could be easily fabricated and constructed.

"Splicing timber beams to accommodate changes in direction can be done. It's just costly and adds risk."

ABOVE: Vute Sirivivatnanon, SmartCrete CRC.



BELOW: Testing at the UTS Tech Lab; an exposure site in Ottawa, Canada.

"Steel would've likely required repainting every 10-15 years due to corrosion in the marine environment. Timber, on the other hand, requires very little maintenance in these environments."

Babcock said his mantra is "the right material, in the right place, for the right use".

"Steel would've likely required repainting every 10-15 years due to corrosion in the marine environment. Timber, on the other hand, requires very little maintenance." >

ABOVE: Graham Babcock, Mott MacDonald.

Accelerated ageing tests

Concrete needs to perform appropriately in its workability (how easily it can be moulded), strength and durability, said Professor Vute Sirivivatnanon, Research Director at SmartCrete CRC.

He added that the first two are the easiest to test for. The third involves understanding how well a type of concrete will last in a certain environment, which is "possibly the most difficult and most challenging test". This is what accelerated ageing involves.

Sirivivatnanon showed a slide from a recent presentation citing Thomas and Innis's three methods for judging the usefulness of accelerated ageing tests. These are based on ease and time taken, repeatability and reproducibility (precision), and predictive ability.

So how do you predict the durability of a bridge that might have to last 100 years, when a deterioration issue like cracking from the reaction of alkali in cement and reactive silica in the rock (ASR) might only show up 20 years in?

There are three broad ways to accelerate ASR, said Sirivivatnanon, whose career includes nearly two decades as a CSIRO Senior Principal Research Scientist, leading a research team and conducting work on concrete durability in particular.

One is to increase the temperature. One is to increase the alkalinity in the specimens. And then aggregate in the concrete can be made into smaller particle sizes to increase the exposure surface.

Short-term tests are compared against long-term exposure sites, such as the CANMET site, to gauge their predictive accuracy.

The project was delivered by Infrastructure NSW on behalf of the NSW Government, with architecture by BVN/3XN.

SCMs catch on

Low-carbon concrete is poorly defined. However, the two most common types are: concrete with supplementary cementitious materials (SCMs, with one or a combination of fly ash, blast furnace slag or silica fume) partially replacing ordinary Portland cement as a binder; and geopolymer, which uses an alumina silicate material and an acid or alkaline activator.

One perspective is that adoption of concrete incorporating SCMs is progressing well. This comes from Ed Bond, Principal at Robert Bird Group (RBG).

Asked about RBG's work on 555 Collins, a commercial building with a concrete frame using 30 per cent fly ash in its binder mix, he said things have been "evolving pretty quickly" since design work started on the project in 2019 and completion in 2023.

"I've been having discussions with the major suppliers within industry, and they have started to default to low-carbon concrete mixes, in some cases without a premium," he said. "Also without selling it as something very different to traditional mixes."

The construction sector "appears to be moving towards a 30 per cent SCM mix as industry standard on larger projects", and low-carbon concrete mix libraries are now readily available online to help guide engineers.

When it comes to engineers reducing their concrete's greenhouse gas emissions, Bond made suggestions including not over-specifying strength, with each higher strength class nominated representing up to an extra 20 per cent of embodied carbon. This allowed for strength gain based on a 56-day cycle rather than 28 days, depending on construction program and time when full strength is required, and specifying Portland cement replacement within a mix.

ABOVE: 555 Collins Street (Artist's render), Melbourne; Ed Bond, RBG.

Further complications

One of the real challenges to novel concrete mixes is understanding durability. Long-term performance of long-term structures is no small issue.

"The way our standards are written is that they can, if we're not careful, be a barrier to implementing these new materials – and we don't want

When modelling isn't enough

RIGHT:
1. Pre-installation
2. Early installation
3. Mid-installation
4. Pre-seal
5. Post-seal
6. The finished product


1


2


3


4


5


6

Providing a novel deck replacement for the South Australian heritage-listed Birkenhead Bridge, opened in 1940, required Wagners Composite Fibre Technologies to overcome a shortage of established standards for their specialty material.

The composites manufacturer was approached by Wallbridge Gilbert Aztec, which was tasked by the Department for Infrastructure and Transport for an alternative deck system for the structure's ageing bascule span. It provided 24 pultruded glass fibre-reinforced polymer sections laid across the length and width of the existing deck.

It devised inhouse tests for a full-scale testing of a prototype deck based on bridge design codes in AS5100 and Austroads '92.

Among performance validation work was a proof test (over 15 minutes up to 145.7 kN, or 4 per cent higher than the factored ultimate load), cyclic tests (2 million cycles of between 10 and 100 kN, with a spike load of 150 kN) and testing to failure, which occurred at 378.2 kN, or 53 per cent higher than the ultimate test loading case.

The failure mode was established as "flexural buckling of the distributor beam beneath the applied load where the two panels joined", a Wagners paper explains.

The results corresponded with and helped build on Strand7 finite element modelling software for future projects.

"We have developed a finite element model, basically being calibrated with the test results we got from the experimental studies we have done," Dr Ali Mohammed, the company's Technical Lead, said. "And that [finite element analysis] FEA model helps and enables us to predict mainly the deflection of the deck, and also at the same time the stress concentration around the bridge deck panels."

The bridge was reopened in late 2020.

them to be," said Foster, who has been on the Australian Standards BD2 committee for the AS 3600 Concrete Structures Code for more than two decades. He also chaired the committee that developed Standards Australia Technical Specification 199:2023, Design of geo-polymer and alkali-activated binder concrete structures.

"We want to work on how we rewrite some of our standards so we're better aligned with a performance-based specification rather than an empirical-based specification. Removing things such as minimum cement contents out of standards and relying on the performance, whether durability or serviceability. Strength is usually not the key issue. Durability is.

"There's no point using materials that all of a sudden in 10-20 years we're going to have to replace because they haven't performed, because there's nothing sustainable in that."

Tubolets gave a somewhat tongue-in-cheek hypothetical example, naming the wonder- >

material Clarecerete. This new combination of climate-positive concrete and thought experiment is able to capture atmospheric carbon, and has been demonstrated to meet important performance requirements, she said.

It has passed the Accelerated Mortar Bar test and the Concrete Prism test, two accelerated tests for alkali silica reactivity. But given that it was synthesised six months ago, exposure testing results only go back that far.

"We certify our bridges for 100 years, our roads for 40 years and our buildings for 50 years," Tubolets said.

"Do we feel comfortable that the known tests are actually giving us that accelerated result when we don't necessarily have data to support that over, say, a 30-50 year timeline?"

Another thorny issue for new materials is that it's a collection of stakeholders needing to trust something unknown.

"There must be designers actually selecting for that material, the engineers saying, 'Yes, we can actually put that into that build', and he architects, again, making decisions about which materials are going to be used. Then you've got the asset owner who has to sign that off."

Though mass timber is not a new material, its adoption faces some hurdles on the way to widespread adoption in the Australian market.

Put simply, Babcock said, the supply chain in Australia is not as mature as it is in Europe, where his company ultimately had to look.

Without a strong supply chain and subcontracting market experienced in the delivery of timber buildings and structures, it becomes challenging for clients to achieve cost-effective solutions.

"We look at a number of schemes each year where the client wants to adopt timber," he said. "It's about understanding and communicating the implications.

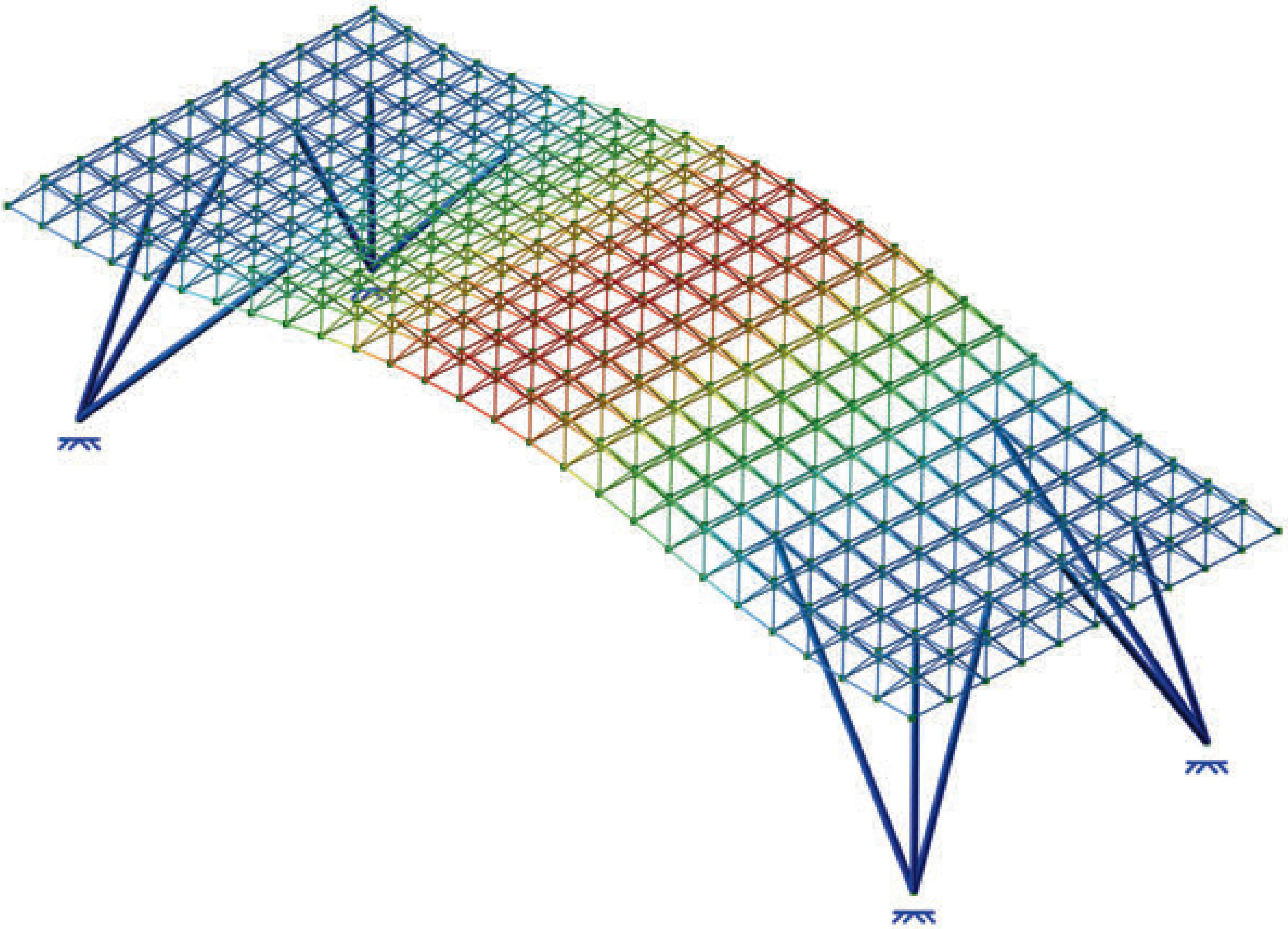
"Basic considerations such as floor-to-floor heights on certain building typologies increasing, making buildings taller and facades more expensive; or design coordination needing to happen earlier to meet supply chain lead-times to prevent impacts on construction programs.

"While the raw cost of timber as a material often matches or betters that of steel and concrete, it's the industry's lack of familiarity with timber, the supply chain maturity and the perceived risks compared to traditional construction that can really drive up overall project costs." □

"Do we feel comfortable that the known tests are actually giving us that accelerated result when we don't necessarily have data to support that over, say, a 30-50 year timeline?"

BELOW: Atlassian Central, currently under construction in Sydney's CBD, will be the world's tallest hybrid timber building.

IMAGE: Dexus / Atlassian / BOJV.

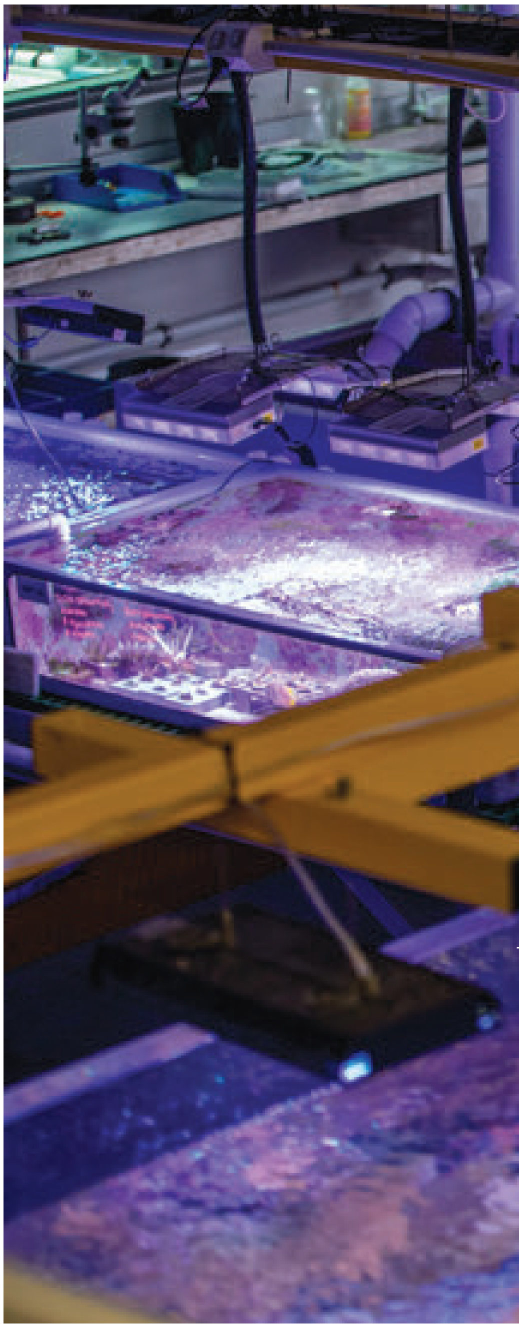


[Projects]

How to save a reef

At the National Sea Simulator, engineers are working with researchers, using advanced automation, environmental modelling and industrial control systems to help safeguard the Great Barrier Reef.

WORDS BY CHRIS SHEEDY



As soon as global environmental challenges become technically defined problems, engineers are able to step forward and solve them.

A timely example of that intersection between science and engineering is Australia's National Sea Simulator, aka SeaSim. One of the most advanced experimental marine research facilities in the world, SeaSim opened in 2013 and is operated by the Australian Institute of Marine Science (AIMS), using Siemens technology for industrial process automation.

"The impact of climate change on the reef is actually a science and an engineering challenge," said Dr Eva Riesenhuber, Global Head of Sustainability at Siemens. "Once it's defined, the first people who speak up and fix it are engineers."

SeaSim, located in Townsville, has been designed to recreate specific ocean conditions with precision. This enables researchers to experiment around coral reef responses to changing environmental pressures.

"One of the reasons we went down the industrial process automation pathway is that we get better levels of control," said Craig Humphrey, National Sea Simulator Director. "We get more reliability out of the process and instrumentation than we would from traditional systems."

But this also tosses up challenges for engineers.

"Standard industrial process automation is, to a certain extent, set up then left to sit. If you're manufacturing a product, you want that consistency. We have around 30 different experimental spaces, and those spaces are reconfigured continuously to meet the needs of our experiments. So, our industrial process automation system is dynamic."

ABOVE: Craig Humphrey, SeaSim.

Engineers originally set up SeaSim with a centralised data system to control everything. Then, because different areas of the facility required continual changes, a more distributed system with individual programmable logic controllers (PLCs) was added, enabling ongoing reconfiguration.

The combination of these control systems, sensors and

"With the control we have now, we can get much better resolution. We can recreate daily variations we see on the reef."

IMAGE: © Budd Photography.

modelling tools to replicate natural environments with unprecedented levels of accuracy represents a new level of opportunity for environmental researchers and engineers.

Constant change

At SeaSim, scientists simulate present and future ocean conditions under tightly controlled laboratory environments in seawater systems. Most importantly, the seawater systems are able to introduce constant change, just as the ocean does.

The recreation of these natural environmental cycles, Humphrey said, is one of SeaSim's most powerful capabilities. "With the control we have now, we can get much better resolution. We can recreate daily variations we see on the reef."

The technological limitations of earlier coral experiments meant many environmental conditions were kept constant. Now, new technologies driven by data collected in the field of ocean science can ensure the water systems within SeaSim experience the same natural fluctuations that ocean environments do throughout each day.

SeaSim is essentially a large- >

scale seawater processing and distribution system.

The coastal seawater brought into the facility – up to 800,000 L per day – is processed to ensure variability is reduced, then delivered as needed into various experimental rooms where the final experimental water quality parameters are established.

"We filter out the sediments and, as required, we will correct the salinity," Humphrey said. "Then we'll create different temperature streams, and that water is reticulated around the facility to a variety of experimental spaces.

"Within those experimental spaces there's control of water quality parameters. In terms of process automation, there's a central SCADA system that does the seawater processing, and then distributed PLCs do the experimental, finer-scale manipulation."

Dynamic loads

Consistency of water quality at the start is vital to ensure outcomes at the end aren't distorted.

"Variability is the worst thing we can have in research."

The system can control parameters such as:

- Temperature, the primary driver of coral bleaching events
- Salinity, or the concentration of salts in seawater
- Nutrients, which influence algae growth and coral health
- Light intensity, which affects photosynthesis in coral symbiotic algae
- Water flow, replicating ecosystem water movement
- Total suspended solids, or particles in water

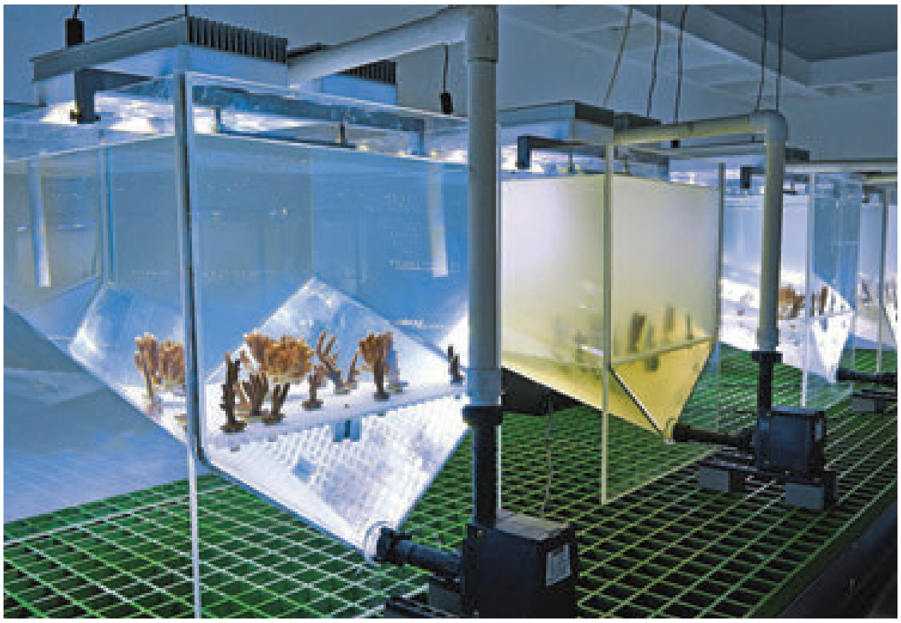
In doing so, engineers have enabled SeaSim and researchers to simulate real ocean conditions to help develop an understanding of system behaviour on a coral reef under dynamic loads. The resulting data contributes significantly to improving the accuracy of ecosystem models used to predict how coral reefs will respond to climate change.

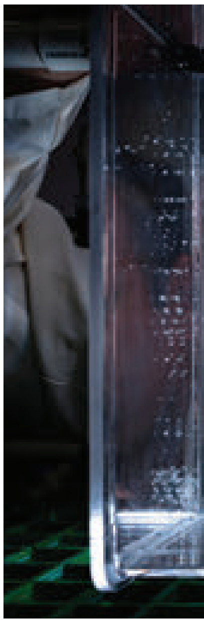
"In SeaSim, it's about data generation for decision-making," Humphrey said. "Good-quality data in, good-quality decisions. Poor-quality data, poor decisions."

As an example of where this data will be useful, Humphrey explained the science behind coral bleaching.

"Corals are a partnership between a small algal cell and a host that live together, and they make a calcareous skeleton, which is their home. It's what forms those complex reef structures where fish, snails and other organisms live to come up with this incredibly rich ecosystem."

That partnership between algae and coral is vital. Through photosynthesis, the algae provides much of the energy requirements of the coral. In return, the coral provides sugars, carbohydrates and protection for the algae. The algae are colourful, so give the coral its hues.





ABOVE: Water quality testing at SeaSim and coral symbionts inoculation.

BY THE NUMBERS

UP TO

800,000 L

PER DAY OF SEAWATER BROUGHT INTO THE FACILITY FOR PROCESSING

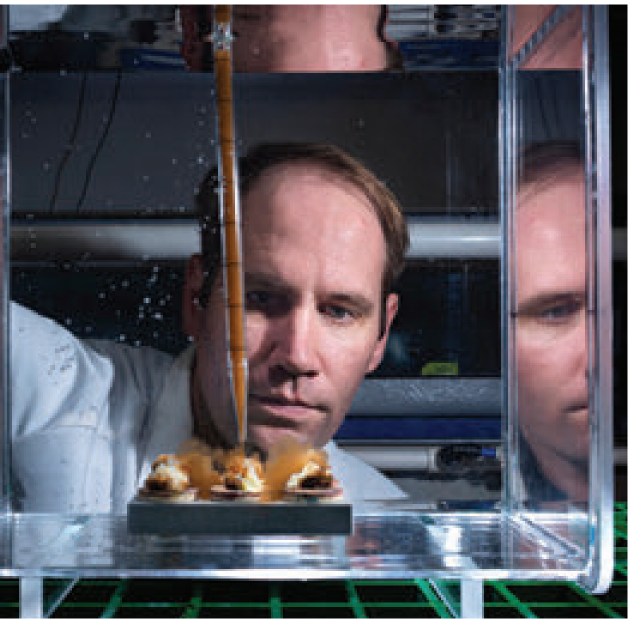
> **"Two of the researchers from the Maldives came to SeaSim and learned about the technology behind how we do things."**

Bleaching frequency

But this is a delicate balance, and when the sea-surface temperature increases above a certain threshold for a prolonged period of time, the partnership starts to break down.

The coral, sensing something is wrong, expels the algae out of its tissue and becomes transparent, revealing its white skeleton and looking bleached. Of course, this creates a serious problem for the coral, as it is weak and stressed on its own, and can die if the ocean doesn't cool down and the algae isn't welcomed back.

If bleaching events occur too frequently, reefs can struggle to



ABOVE: Coral seeding device assembly.

RIGHT: The coral spawning system automatically harvests egg/sperm bundles and manages the fertilisation process using auto valves and feedback from turbidity sensors.

recover. That's bad news as reefs are home to around 25 per cent of ocean species.

"If the bleaching events are widely spaced, coral reefs can recover," Humphrey said. "But they're becoming more regular."

Engineers have helped SeaSim to containerise versions of systems to share the research with other regions.

Professor Selina Stead, CEO of AIMS, said engineers have designed and developed portable, modular research systems that can be transported internationally in a shipping container.

"We have just recently done that and sent a mini SeaSim to the Maldives."

The unit is designed to operate in remote areas, and breed a large number of young corals for reef restoration.

"Two of the researchers from the Maldives came to SeaSim and learned about the technology behind how we do things."

Virtual models

Riesenhuber said technological innovations currently emerging from facilities such as SeaSim, and from infrastructure builds around the globe, demonstrate the way engineering will play a central role in enabling global sustainability.

One such example, she said, is digital twin technology that involves virtual models of physical systems designed to simulate performance before construction or deployment.

"First you design and simulate it, then you build it much more efficiently, and then you optimise," she said.

By combining modelling with real operational data, engineers can identify inefficiencies, clashes and design improvements before those systems are built, reducing waste, resources required and energy consumption.

For Riesenhuber, this type of thinking is essential for tackling climate change which, like the rejuvenation of the Great Barrier Reef, is a challenge specifically for scientists and engineers. What it will take is greater attention paid to the maintenance of natural systems and environments.

"Nature has value. It's an infrastructure," she said. □

ABOVE: Dr Eva Riesenhuber, Siemens; Professor Selina Stead, AIMS.

IMAGES (L-R): © AIMS / Steve Clarke; Giacomo d'Orlando; Australian Institute of Marine Science.

Peak energy

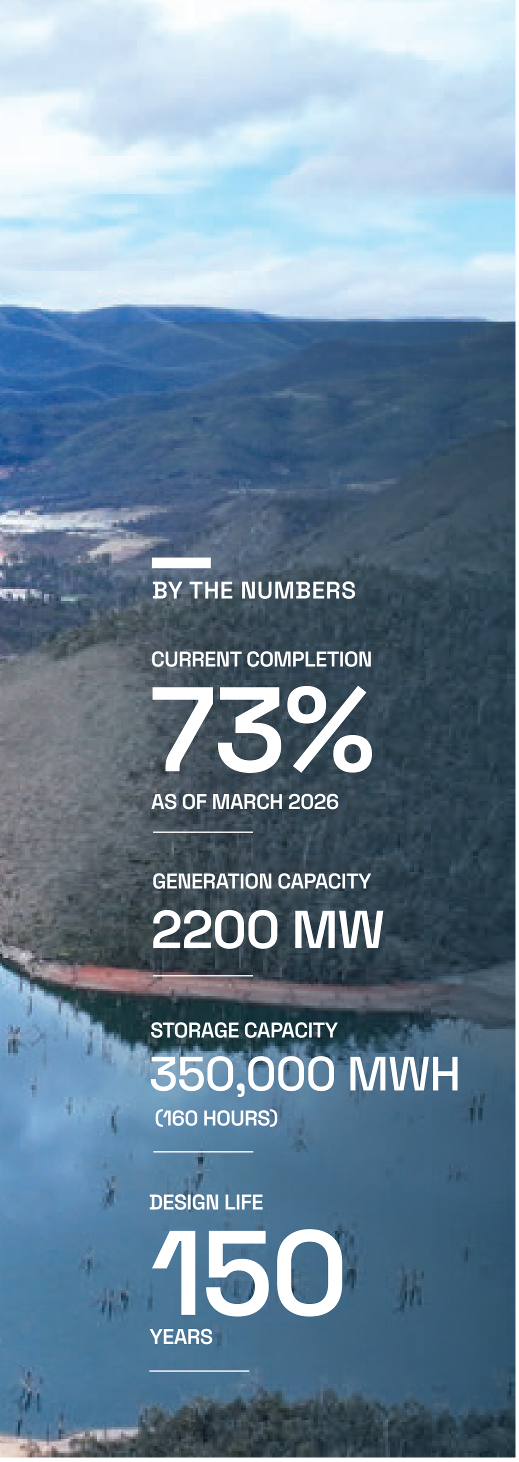
By connecting existing reservoirs through a massive network of underground tunnels, Snowy 2.0 is designed to stabilise the Australian national grid and accelerate the transition to renewables.

WORDS BY LARISSA FOSTER

It would be difficult to think of an engineering project more important or complex than Snowy 2.0. Burrowing its way below the Snowy Mountains, it's one of the most ambitious energy projects ever attempted in Australia. A vast pumped hydro expansion of the original Snowy Mountains Hydro-Electric Scheme, it is designed to store renewable energy at unprecedented scale, stabilising the electricity grid while helping accelerate the transition away from fossil fuels.

Once completed, it will increase the original's generation capacity by 2200 MW of power and 350,000 MWh of large-scale storage, connecting the existing Tantangara and Talbingo reservoirs via 27 km of underground tunnels and a new underground power station.

"I would think that this is the most complex infrastructure project we have in this country, but also one of the most complex across the globe," Snowy 2.0 Chief Delivery Officer Dave Evans told *create*.



"There's a certain reason for that, the remoteness of the site being one of them, but also the scale of the components."

Extreme challenges

The remoteness alone would challenge any project. Construction, which began in 2019, occurs deep within a national park, in terrain that can be inaccessible for months each year. But the logistics of supporting a fly-in, fly-out workforce are only the beginning.

IMAGES: Snowy 2.0.

ABOVE: Dave Evans, Snowy 2.0.

TOP: Construction is occuring deep within a national park.

ABOVE LEFT: An aerial view of the cavern entrance.

"We've got the deepest, biggest cavern anywhere in the world that's been excavated, by a long shot. Our machine hall in particular," Evans said. In fact, the machine hall – the space to house the turbines and generators – is large enough to fit the Sydney Opera House inside. "The downstream surge shaft cavern has been constructed underground to support the excavation and lining of the 166 m deep vertical shaft. This cavern is one of the widest in the world at this depth, measuring 32 m."

Most of this work is accessed through a handful of tunnels, through which enormous volumes of equipment, materials and people must move.

"It's a huge amount of work, a long way underground, in a remote part of the national park where we get snow for about four months of the year," Evans said.

"There were actions that could have been taken to better support and prepare the ground. We need to learn from that going forward."

Rethinking hydro

One of the most significant technical innovations lies in how water will travel between the reservoirs. Traditionally, pumped-hydro schemes rely on vertical shafts lined with steel. This project pioneered a different approach: a 47 per cent inclined pressure tunnel excavated by tunnel boring machine (TBM) Kirsten and innovatively lined with force-activated concrete segments.

"The vertical shaft steel lines would have added more than a kilometre to each of our access tunnels, and it would have extended the construction period significantly," Evans said. "By locking segments together under extreme pressures, it means you can use the same machine that excavates your access to the cavern and do a pressure tunnel with that same machine."

Developing the technique required years of collaboration with universities and contractors.

"Multiple new innovations have been developed on Snowy 2.0 that will roll through hydropower projects across the globe." >

Grid of the future

At its heart, Snowy 2.0 is about energy storage and grid stability. Its turbines are six massive units delivering up to 2200 MW, engineered for rapid response.

"We can get 1000 MW on the network within 90 seconds. We can get all of it in about four minutes, which helps us, because Australia has moved to a five-minute market."

This speed is critical in an electricity system increasingly powered by wind and solar, where supply can fluctuate quickly. The plant is designed not just to generate electricity, but to stabilise frequency and absorb excess power.

"We can actually have a generator and a pump running at the same time, which can help stabilise the network if the network has some big issues."

Unlike traditional hydro stations that run intermittently, Snowy 2.0 is expected to operate most of the time in either pumping or generating mode.

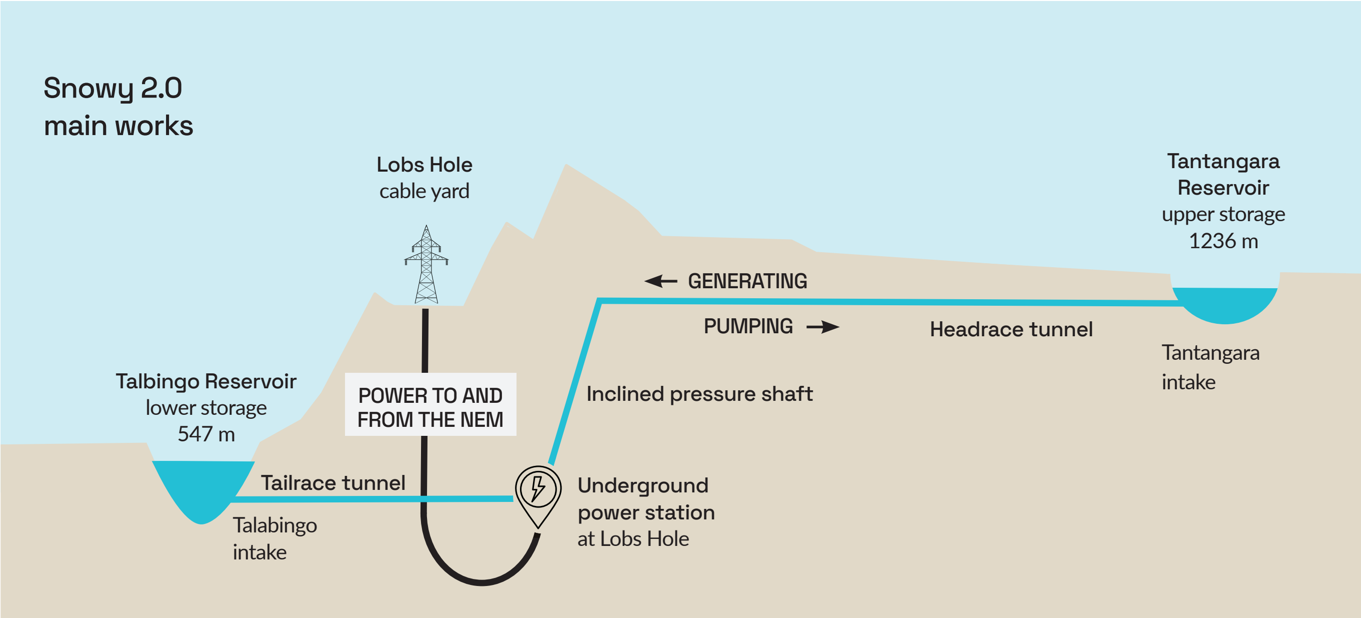
"It has been designed to facilitate the transition and support renewable energy. There are a lot of components in the power station whose usefulness you'll never realise, because they sit in the background, stabilising everything. Units which run our other power stations might run around 10 per cent of the time, whereas Snowy 2.0 will run more than 50 per cent of the time, either in pump or generation."

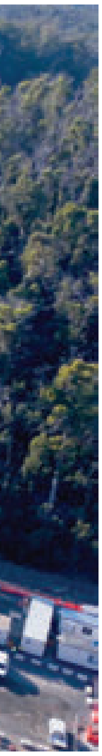
ABOVE: TBM Monica prepares to enter the tunnel.

Geological patchwork

Snowy Hydro's own feasibility study notes "the geological, geotechnical and hydroecological conditions vary significantly along the alignment". Tunnelling has required navigating 30 different types of rock and three major fault zones. Repeated problems with

IMAGE: Snowy 2.0.





The Snowy TBM fleet

Four specialised TBMs have been employed to navigate more than 30 different types of rock and three major fault zones.

TBM	Primary role	Key status and specifications
Kirsten	Inclined pressure tunnel	Pioneered a 47 per cent inclined excavation using force-activated concrete segments
Florence	Main tunnelling works	Faced challenging geological conditions; achieves excavation through refined methods
Monica	Long Plain fault zone	Designed to operate under high pressure and drill while advancing to manage water and unpredictable ground
Eileen	Main access tunnelling	Excavated the project's 2.8 km main access tunnel to the power station at Lobs Hole and was relaunched to excavate the 6 km tailrace tunnel

TBM Florence, which became bogged in hard rock, combined with “initial design immaturity” to deal with geologically complex terrain, prompted the recalculation of what it would take to complete the tunnelling works.

The delays prompted Snowy Hydro to acquire an additional TBM to reach the 2028 deadline.

“Florence is an interesting one,” Evans said. “There were actions that could have been taken to better support and prepare the ground. We need to learn from that going forward.”

What followed was a deliberate focus on continuous improvement. A dedicated team began analysing processes, refining methods and implementing changes.

“If you look at Florence as a case study … every month or every kilometre, we've gotten better and better.”

The results have been measurable, with record excavation rates achieved in recent months despite increasingly difficult conditions.

Snowy Hydro CEO Dennis Barnes recently said a lot of the challenges were now behind the project, which is now more than 73 per cent complete. "You know an awful lot more when you're 70 per cent of the way through, than 40 per cent or 10 per cent.”

Underground innovation

On a project of this scale, innovation often emerges from necessity. “Something will come up, and it'll be a hurdle, and you'll have to design around it and find a different way,” Evans said.

One example is the installation of a suspended monorail system inside the inclined tunnel to improve safety and logistics during the construction phase.

Another innovation is the specially designed TBM, dubbed Monica, built to cross the Long Plain fault zone. Roughly 200 m long and four storeys high, Monica can operate under high pressure and even drill while advancing, ensuring progress through unpredictable ground conditions.

“It was best to get a new machine designed specifically for these conditions. It can run under a fairly significant pressure to hold back any water. If there's water in the rock, it has drill rigs so you can keep excavating while you drill through segments. It's purposely designed, but all of those technologies will be used for other projects around the world.”

Invisible giant

As excavation nears completion, construction is shifting to the power station itself. A cavern comparable in height to a 22-storey building represents immense structural challenges. Ice plants, precision temperature control and heavy engineering all converge in the hidden space. Massive concrete pours must be cooled so the material contracts, then allowed to expand and lock into surrounding rock, ensuring the structure can withstand the forces generated by turbines spinning at high speed.

That’s where AI comes in. One of the most unexpected tools on the project, it has been used to model different scenarios and identify where small investments such as an extra crane beam or a passing bay in a tunnel could save months of construction time. It also helps streamline around 3000 critical handover points between civil and mechanical teams.

For Evans, the technology represents a turning point in managing megaproject complexity.

“Using AI to really make a complicated issue simple and give you the levers to make some decisions can be so useful.”

When Snowy 2.0 eventually begins generating power, its vast workings will never be seen by most Australians. But even experienced tunnel engineers are often overwhelmed when encountering first-hand the sheer scale of the project.

“It blows people away when they see it.” □

Desalination solution

Perth's population is growing, but drinkable water is becoming harder to find. To keep the city quenched, engineers are laying pipelines underground and under the sea.

WORDS BY JONATHAN BRADLEY

Off the coast of the northern suburbs of Perth, buried 15-60 m beneath the ocean floor, two pipelines are being laid to help secure the city's water supply for decades to come.

The shorter of the two, which extends 1.6 km from the shore, will pull seawater from deep below the ocean's surface and transfer it to the Alkimos Water Precinct, where a new desalination plant will filter and treat it by removing salt, bacteria, viruses and other impurities via reverse osmosis.

The resulting drinkable water will then be delivered to Perth's water network through a 33.5 km, mostly 1.6 m diameter underground pipeline – the largest ever built by Western Australian water utility Water Corporation – that runs to Wanneroo Reservoir.

The leftover water from the process – a brine that is just under twice as salty as seawater – is returned to the ocean through the longer of the offshore pipes, which extends three kilometres from the coast.

The project is vital for keeping the residents of the growing – and increasingly parched – Perth region supplied with a clean and reliable water supply. The city's population is expected to reach 3.5 million by 2050, yet rainfall in the region has reduced by a fifth since 1970.

ABOVE: The shoreline west of the Alkimos Water Precinct.

RIGHT: Artist's impression of the Alkimos Seawater Desalination Plant.

Today, 40 per cent of Perth's water supply comes from groundwater, but that allocation is set to drop by 27 per cent in 2028 when the Alkimos Seawater Desalination Plant is scheduled to come online.

"We're ready for full production by mid-2028 when some of those groundwater allocation reductions come our way," said Daniel Rossi, Water Corporation's Manager of Major Source Projects.

"We're well into our civil and structural works on the plant itself, and we're building our pipelines out to the ocean. Right now, we've got a large jack-up barge installing our marine work."

These pipes have to extend kilometres out to sea so they can collect the best-quality water to use in the desalination process – and then to dispose of the resulting brine in the safest environment.

"There are a lot of investigations >

IMAGE: Alkimos.

BY THE NUMBERS

AVERAGE ANNUAL RAINFALL RUNOFF IN PERTH DAMS IN 1975

420 BILLION L

AVERAGE ANNUAL RAINFALL RUNOFF IN 2026

<70 BILLION L

PROJECTED PERTH POPULATION IN 2050

3.5 MILLION

ALKIMOS DESALINATION PLANT ANNUAL CAPACITY

50 BILLION L

ENERGY SOURCED FROM RENEWABLES (ANNUALLY)

400 MW

PIPELINE FROM PLANT TO RESERVOIR

33.5 KM

LONG

INTAKE STRUCTURE

5.9 M

BELOW SEA LEVEL

OUTFALL STRUCTURE

20 M

BELOW SEA LEVEL

ESTIMATED DELIVERY DATE

2028

and environmental studies so we're able to best locate where that water goes," Rossi said. "Ultimately, what we're trying to do is bring the best-quality water in and then disperse the saltier water out in the high-energy environment along the coast, where it can mix well with the existing environment and within a regulated area."

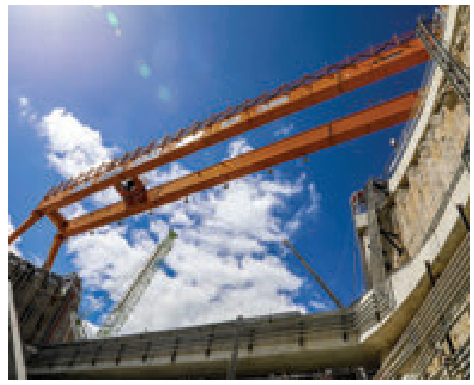
Installed beneath the seabed, these pipelines funnel water in, bring it back to shore and deliver it to the Alkimos plant through a series of vertical risers. Selecting the best depth and locations requires significant engineering expertise.

"That's all about the soil conditions that we need to construct in and trying to find the best conditions for tunnel boring.

"There's a lot of technical work that's done to get optimum outcomes in terms of how deep these tunnels go, where they're finally located, and then the type of equipment that you select for their installation."

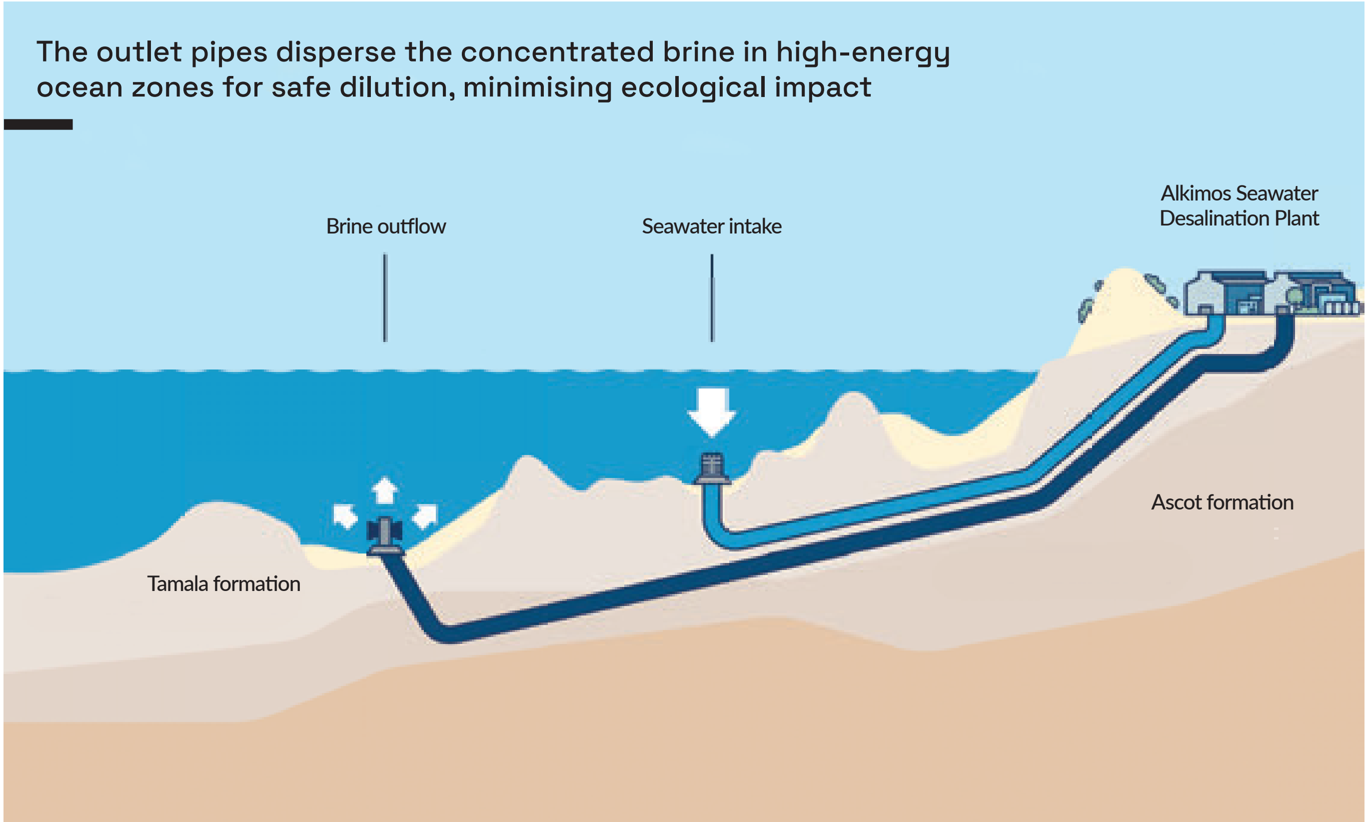
As well as drawing on the global expertise of partners such as Acciona, which brings substantial tunnelling experience to the project, Water Corporation also builds on the knowledge it has accumulated in constructing two previous desalination plants for the Perth area.

"We have two existing facilities, and we learn from how those plants perform," Rossi said. "We learn from other



RIGHT: The largest registered jack-up barge in Australia, installing the intake structures; the view from within the Alkimos facility.

BELOW: The plant in 2026.



"These are long-term assets that will be operating for 100-plus years. Having a solution that gives us as low as possible operating cost over time is really critical."

facilities around Australia and the desalination network is quite a tight-knit network. Then globally, we're looking at the latest practice and best technology around energy efficiency and around the performance of the key equipment that goes into these desal plants."

Eye on energy

One advantage the Alkimos plant will have over its predecessors is the size of the pipe delivering the treated water to the Wanneroo Reservoir – 1.6 m in diameter.

"Having a larger pipe means that we get quite substantial energy savings that offset the cost of buying and installing that larger pipe," Rossi said.

A larger diameter of pipe uses less energy to pump the same amount of water, and those savings will add up. And to ensure Water Corporation could access a pipeline big enough for this project, it worked with long-term supplier Steel Mains to upgrade its equipment so it would be able to produce the parts needed in Western Australia.

"They've upgraded their facility so we can make these larger pipes locally, and so we then save further on transportation from the eastern states, and factors we're interested in around sustainability and carbon footprint.

"These are long-term assets that will be operating for 100-plus years. Having a solution that gives us as low as possible operating cost over time is really critical."

While Rossi acknowledges that desalination can be energy intensive, he said the plant incorporates processes to reduce energy use, including such behind-the-meter solutions as solar cells.

"Energy recovery devices convert the high pressure that's used in the desalination process into energy and put it back into the system to get benefit.

"We've been able to reduce that power consumption by up to 40 per cent, and that brings down our overall operating cost, which is really important."

Water Corporation is also working closely with state utilities to connect to the power grid's sustainable energy production solutions, as well as pursuing other carbon offsets to ensure the project achieves net-zero carbon emissions during construction and operation. □

IMAGES: Alkimos.

[Experience]

DISASTER

Cold compromise

Forty years ago, the Space Shuttle *Challenger* disintegrated shortly after launch. As the Artemis mission puts space travel back in the spotlight, *create* reflects on what happens when management overrules engineering.

Words by Joe Ennis

On the morning of 28 January, 1986, the temperature at Kennedy Space Center hovered at -1°C. While the public watched in anticipation, a group of engineers in Utah watched with a sense of impending doom. They knew something the flight directors didn't want to acknowledge: the rubber seals designed to keep the rocket's flames contained would not operate effectively at sub-zero temperatures.

Seventy-three seconds later, the world watched as a plume of white smoke signaled the deaths of seven astronauts and the grounding of the US space program.

Now, 40 years on, the *Challenger* disaster stands as a definitive ethical case study and the prime example of what American sociologist Diane Vaughan called the normalisation of deviance.

Known vulnerability

The space shuttle's solid rocket boosters (SRBs) were too large to be shipped in one piece. Instead, they were manufactured in segments and assembled at the launch site using field joints. These joints were sealed by two fluorocarbon elastomer O-rings.

The engineering intent was simple: upon ignition, internal pressure would seat the primary O-ring into a gap, creating a gas-tight seal. However, the design suffered from a critical flaw known as joint rotation.

Under the massive pressure of ignition, the metal tang-and-clevis joints would bow outward, momentarily pulling the sealing surfaces apart. For the seal to hold, the O-ring had to expand rapidly to fill that widening gap. This was a property known as resiliency and had occurred successfully in all 24 previous missions.

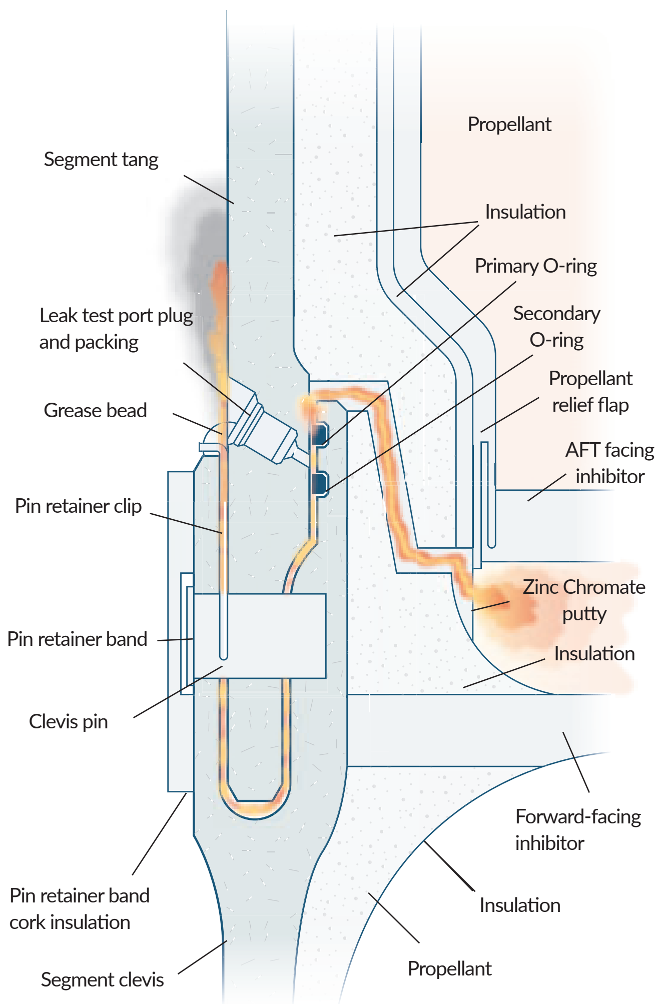
But as temperatures drop, elastomers lose resiliency, becoming brittle and slow to respond. On that freezing January morning, the primary O-ring was too cold to move. It failed to seal, allowing a jet of super-hot combustion gas to blow past it and begin eroding the secondary backup in a process called hot gas scour.

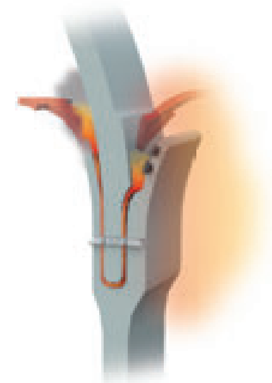
This failure was, tragically, predictable. Roger Boisjoly, a lead engineer at Morton Thiokol, the manufacturers of the SRBs, had been tracking O-ring erosion for years. He had seen damage on previous flights launched in warmer weather and knew that cold would exacerbate the issue.

Six months before the disaster, he wrote a memo to his managers: "It is my honest and very real fear that if we do not take immediate action ... we stand in jeopardy of losing a flight along with all the launch pad facilities."

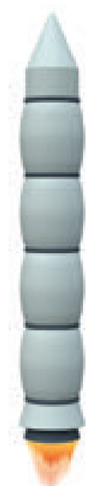
LEFT: The main engine exhaust, solid rocket booster plume and expanding ball of gas from the external tank of the *Challenger*.

Solid rocket booster field joint assembly





An exaggerated diagram of the joint rotation that enabled combustion gas to pass through the field joint.



A depiction of the rocket booster, home to primary and secondary O-rings.

IMAGE: NASA.
DIAGRAM: Adapted from Rogers Commission into the loss of the Space Shuttle *Challenger*.

The night before the launch, engineers including Boisjoly filed a desperate protest. During a tense three-hour teleconference, he and his colleagues presented data showing a direct correlation between low temperatures and seal failure.

The engineers recommended not to not launch below 11°C. However, NASA was under immense pressure. The mission had already been delayed multiple times, and a State of the Union address was scheduled for the following evening. When NASA officials challenged the Morton Thiokol data, claiming it was inconclusive, a pivotal shift occurred.

In a move that has since become a staple of engineering ethics courses, Thiokol's Vice President of Engineering, Robert Lund, was told by his manager, Jerry Mason, to "take off his engineering hat and put on his management hat".

The recommendation to delay was rescinded. The launch was a go.

Boisjoly couldn't believe it. "I was so mad I couldn't even stay in the room. I left ... I was just totally helpless to do anything about it."

Engineer Bob Ebeling told his wife that night: "The *Challenger* is going to blow up."

The failure could be seen at launch. A puff of black smoke emerged from the right SRB, indicating that the O-rings had

BELOW: *Challenger* is carried to the launch pad prior to launch.

"Prioritise data over schedules, document every warning, and recognise that your primary loyalty belongs to public safety, not the corporate bottom line."

already failed to seal. For a few seconds, the leak was temporarily plugged by aluminum oxide slag generated by the solid fuel.

However, 58 seconds later, the shuttle encountered severe wind shear. The buffeting dislodged the slag plug, allowing a plume of flame to escape the joint, acting like a blowtorch against the massive external fuel tank.

At 72 seconds, the lower strut holding the SRB to the tank failed. The booster swivelled, piercing the tank's skin. The resulting structural failure released a cloud of liquid hydrogen and oxygen, which ignited and tore the shuttle apart.

Acceptable risk

Nobel Prize-winning physicist Richard Feynman famously demonstrated the O-ring's vulnerability by simply dropping a piece of the rubber into a cup of ice water during a televised hearing of the Rogers Commission, which investigated the accident highlighting the tragedy even further.

The disaster gave rise to the term "normalisation of deviance", the dangerous tendency for organisations to accept a technical anomaly as normal because it hasn't resulted in a catastrophe – yet.

For years, NASA had seen minor O-ring erosion and concluded that, because the shuttle had always returned safely, the erosion was an acceptable risk.

Feynman summed it up in Appendix F of the Rogers Commission report: "For a successful technology, reality must take precedence over public relations, for nature cannot be fooled."

Following the *Challenger* disaster, the Rogers Commission overhauled NASA's safety culture and hardware. The primary technical fix was the redesigned solid rocket motor. Engineers added a capture feature, a metal lip that physically prevented the joint from bowing outward during ignition, and included a third O-ring to ensure a redundant seal even if the primary failed.

Organisationally, the commission established the Office of Safety, Reliability, and Quality Assurance (OSRQA), giving it a direct line to the NASA Administrator to bypass management pressure.

ABOVE: A piece of the left solid rocket booster.

It also implemented a telescopic pole escape system, allowing the crew to parachute out during a controlled glide.

Crucially, the critical items list was overhauled; any criticality 1 component, where failure meant loss of life, required a complete redesign or rigorous re-testing. These changes prioritised technical integrity over the launch schedule, leading to a successful "return to flight" with Discovery in 1988.

Today, OSRQA is known as the Office of Safety and Mission Assurance, and is the primary authority for ensuring the safety of the Artemis campaign. □

IMAGES: NASA.

DUTY TO DISSENT

Following the *Challenger* incident, engineer Roger Boisjoly became a forensic engineer and spoke widely on leadership and ethics. He frequently called for engineers to have courage in their convictions and never "take off their engineering hats" to accommodate management pressure.

"Prioritise data over schedules, document every warning, and recognise that your primary loyalty belongs to public safety, not the corporate bottom line," he said.

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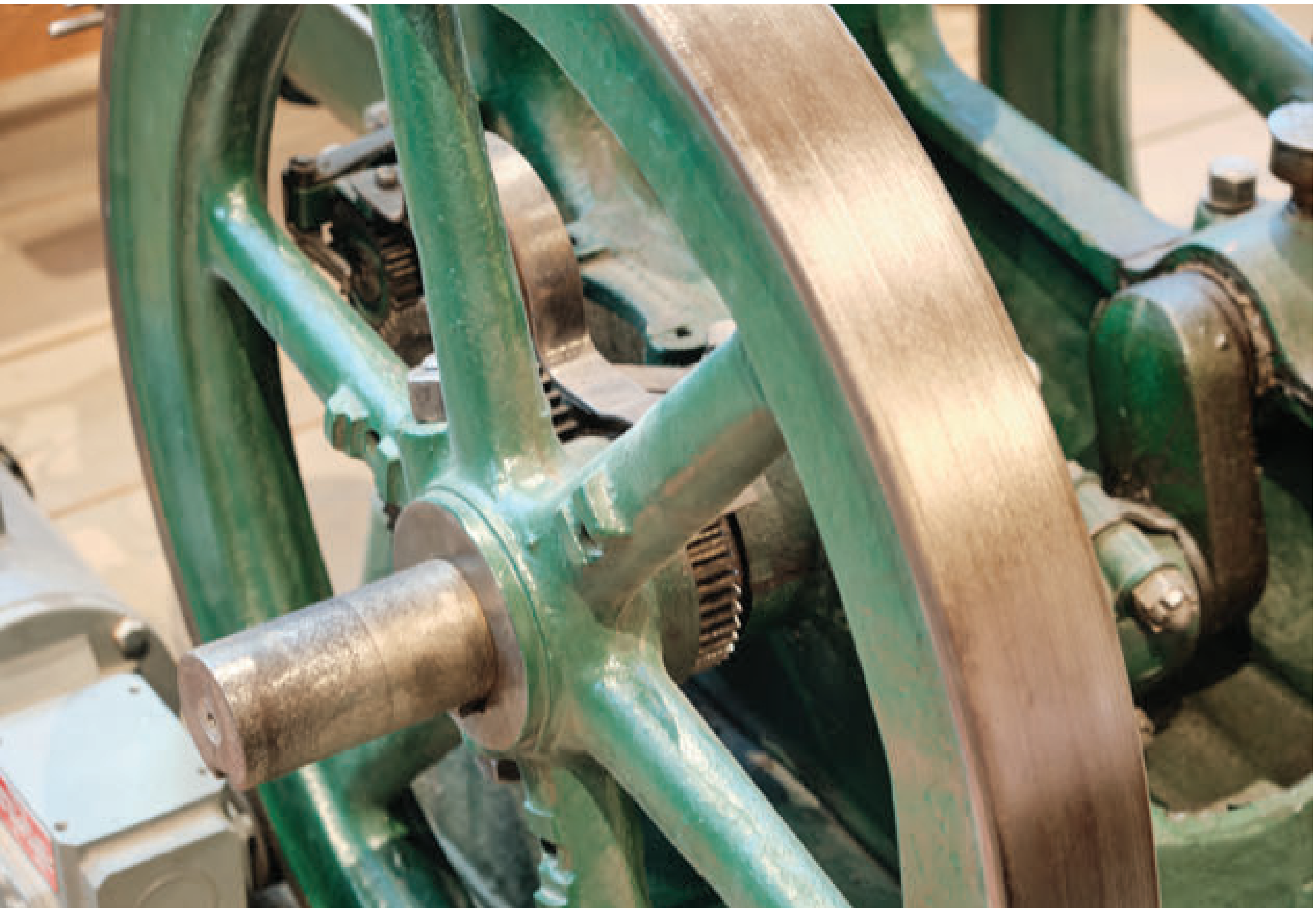


THE LOOK BACK

Spin cycle

With its ability to store a massive amount of kinetic energy, the humble flywheel is a marvel of mechanical engineering in the midst of a technological resurgence.

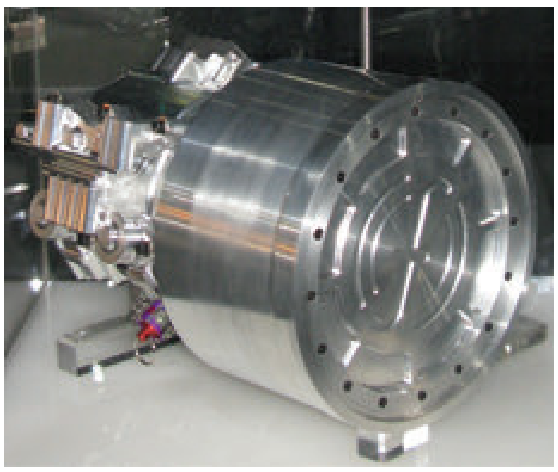
Words by Lachlan Haycock

The potter's wheel offers an early example of the flywheel in use, while engineers of the Islamic Golden Age were responsible for bringing it to the realm of agriculture. The 11th-century scholar and botanist Ibn Bassal, who wrote extensively on agronomy, applied the principle of the flywheel to the noria (a water wheel used to scoop up into an aqueduct) and the saqiyah (when a noria is powered by an animal).

During the Industrial Revolution, flywheels were heavily deployed in steam engines, with Scottish pioneer James Watt and English inventor James Pickard in particular being responsible for this integration. The latter's decision to install a simple crank that worked in conjunction with the flywheel greatly increased the efficiency of its function.

Going to war

The flywheel soon had military applications. John Adams Howell, an American Civil War veteran who made many innovations in ordnance, invented a self-propelled torpedo in the 1880s that was powered by a 60 kg flywheel. The flywheel was spun to 10,000 rpm by a ship's steam turbine, with its gyroscopic effect helping the torpedo maintain a straight course with minimal wake. The Howell torpedo was soon replaced by a superior model developed by English engineer Robert Whitehead.



CLOCKWISE FROM FAR LEFT: The flywheel of an industrial steam engine; a boat launching a Howell torpedo; Flybrid's kinetic energy recovery system; a gyrobus in Ostend, Belgium, in 1985.

The 20th century saw various attempts to harness the flywheel's inherent energy boon, to varying degrees of success.

One of these attempts was made by the Swiss engineering firm Maschinenfabrik Oerlikon, which in the 1940s and 50s attempted to commercialise flywheel propulsion in public transit. The gyrobus used flywheel energy storage as an alternative to the overhead wires used in trolleybuses. A single large flywheel approximately 1.6 m in diameter was installed in fleets and deployed in locations including Switzerland and modern-day Kinshasa, Democratic Republic of the Congo. The system could reach a top speed of up to 60 kph.

Despite the inherent advantages in cutting down on pollution by not using fossil fuels, and in forgoing the use of overhead wires, the gyrobus proved unsustainable due to the weight of the flywheel itself (1500 kg) and the danger to users from its high rotation (3000 rpm). The gyrobus in Kinshasa was also a victim of its surrounding environment, with the wheel exposed to rust caused by the humid climate, and the limited number of routes with sufficient tarmacked road constraining the vehicle's movements.

Only with the material science breakthroughs of later decades would the flywheel become viable for wider implementation in transport.

Fast forward to the 21st century, and flywheel technology has seen a renaissance driven by innovations in motorsport and energy storage.

Formula 1 vehicles were first allowed to use a kinetic energy recovery system (KERS) in the 2009 season, marking a turning point along the road of flywheel innovation as several Formula 1 teams and automakers began testing KERS integration. A KERS stores the kinetic energy generated during braking, stores it in a flywheel and deploys it during acceleration to avoid reliance on the engine. The KERS is also called a regenerative braking system owing to the way it recovers part of a vehicle's kinetic energy which would otherwise be lost to friction during braking.

Energy assets

Meanwhile, the US-headquartered Amber Kinetics has integrated the flywheel into an energy storage unit. Its flywheel spins at a lower speed, approximately 50,000 rpm slower than a flywheel in Formula 1, and can maintain its rotation for longer owing to highly efficient magnetic bearings and vacuum systems. Critically, the system has been designed to discharge across a much longer period than that found in motorsports – hours rather than seconds – moving the consideration of flywheels from short-term power assets to long-term energy assets.

A hybrid system from Amber Kinetics that combined four 32 kWh flywheels was installed at a farmstead in Armidale, NSW. The system powers the workshop shed with three-phase power, operates completely off the grid, and was designed to integrate with the facility's existing solar and battery setup. □

Events JUNE to NOVEMBER 2026

JUNE

09-10 JUN 2026
Transport Conference

Location: *Cairns*
Website: *engineersaustralia.org.au/transport*
The Transport Conference 2026 is your gateway to the latest insights shaping Australia's transport future. Seats are almost gone, so secure yours now.
Last chance to register

16-18 JUN 2026
Australasian Congress on Applied Mechanics (ACAM)

Location: *Melbourne*
Website: *engineersaustralia.org.au/acam*
Shape sustainable engineering at ACAM 2026. Explore multifunctionality and digital twins with leading researchers and innovators driving the future of applied mechanics.
Last chance to register

AUGUST

17-19 AUG 2026
Conference on Railway Excellence (CORE)

Location: *Adelaide*
Website: *rtsa.com.au*
This is where the future of railway policy, operations and engineering takes shape. Join dynamic discussions, technical tours and networking opportunities.
Early-bird registration closes 16 June

SEPTEMBER

13-18 SEP 2026
35th Congress of the International Council of the Aeronautical Sciences (ICAS)

Location: *Sydney*
Website: *icas2026.com*
This forum highlights the latest research and practices in next-generation aviation. Share your insights and help shape the future of aerospace by submitting an abstract.
Early-bird registration closes 8 June

OCTOBER

28-29 OCT 2026
Australasian Structural Engineering Conference (ASEC)

Location: *Melbourne*
Website: *engineersaustralia.org.au/asec*
This year's theme, 'Smart sustainable structures', explores the innovations redefining the profession. Enjoy two days of presentations and networking opportunities.
Early-bird registration closes 26 July

NOVEMBER

19-20 NOV 2026
Information Telecommunications and Electronics Engineering (ITEE) Symposium

Location: *Melbourne*
Website: *engineersaustralia.org.au/itee*
Submit an abstract on AI, cybersecurity, software or communications engineering, and help shape tomorrow's digital engineering landscape.
Abstracts close 25 May

23 Jun 2026

International Women in Engineering Day (INWED)

Location: *Various locations*
Website: *engineersaustralia.org.au/inwed*
Join us this June as we celebrate INWED and recognise the achievements of women in engineering. Explore this year's theme, 'Engineering intelligence', at events held nationwide.
Register for an event near you

ENGINEERS AUSTRALIA EXCELLENCE AWARDS NOMINATIONS OPEN

Location: *Various*
Website: *engaus.org/awards*
This is your chance to celebrate the people and projects that make us proud to be engineers – those who inspire and spark our imagination. Nominate yourself, someone else or a project.
Nominations close 1 July

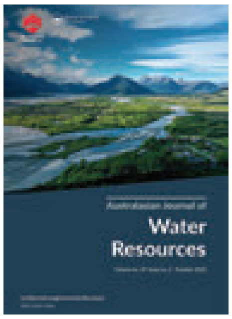
11-12 Nov 2026

Australasian Engineering Heritage Conference 2026

Location: *Melbourne*
Website: *engineersaustralia.org.au/heritage*
Explore engineering heritage as we connect past, present and future through conservation, digital innovation and collaboration with engineers, historians and industry leaders.
Early-bird registration closes 10 August

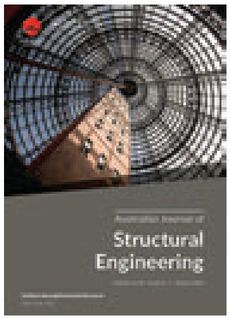
Resources

JOURNALS



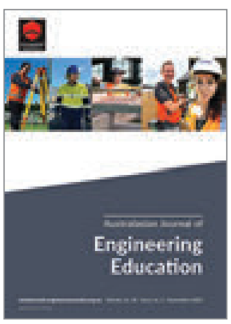
WATER
Recommended daily rainfall-runoff model for Australian hydrology consulting

This study compares performance of AWBM against three other conceptual rainfall-runoff models – SIMHYD, IHACRES and GR4J – that are used in Australia and around the world.
bit.ly/3ZQyGJ2



STRUCTURAL
Fracture energy of ambient-cured fly ash-based geopolymer concrete

The purpose of this study was to measure fracture energy for this specific type of concrete using the wedge-splitting test method.
bit.ly/46ieD9Z



EDUCATION
Influences on engineering students' choices of higher-level mathematics

This study used semi-structured interviews to explore the choices of year 11 and 12 mathematics subjects that had been made by students commencing an engineering degree.
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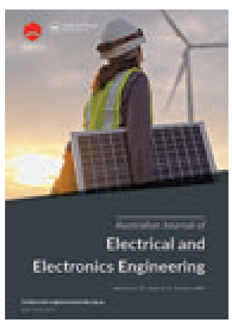

ELECTRICAL
Hybrid energy system for rural electrification: integrating energy management and electric vehicles to enhance reliability

This paper presents a novel hybrid renewable energy system that incorporates photovoltaic and biogas generation with an advanced energy management strategy to enhance rural electrification.
bit.ly/3MTMFe6

RESOURCE RECOMMENDATIONS

Revealing the unseen
The *99% Invisible* podcast is about all the thought that goes into the things we don't think about. With more than 650 episodes covering everything from who invented ringtones to why metal fire escapes are mostly found on older buildings, this show is 100 per cent fascinating.
99percentinvisible.org

Energy excellence
Energy Source & Distribution is an Australian site dedicated to the latest energy news alongside deep dives into the biggest topics affecting the energy generation and transmission sector.
esdnews.com.au

Support hub
The Overseas Qualified Engineers Career Support Hub is your go-to for credible, industry-specific guidance, supporting you to take the next step in your Australian engineering career.
bit.ly/3LBtfJU

Engineers Australia members have access to a plethora of technical journals free of charge.

THE LESSON LEARNED

Adrian Vesnaver FIEAust CPEng EngExec

As a child, Adrian Vesnaver built a road around his backyard for his Tonka trucks. Two decades later, when carving a real one through the Ramu Valley in PNG, he discovered that technical knowledge alone doesn't make a leader.

As told to Joe Ennis

Growing up, my family really encouraged curiosity. And I really leant into it; I was always building LEGO or pulling things apart to see how they worked. I built a mud road in our backyard in Adelaide when I was five or six. Looking back, civil engineering was an inevitable career path.

What wasn't inevitable was finding myself at 22 running a $90 million road project in Papua New Guinea, responsible for 400 local staff and nearly 20 expatriate staff.

I wasn't long out of university, trained for consultancy. University also pumps you up a bit, positioning the engineer as the font of all knowledge. But working onsite for a contractor in PNG, I realised very quickly that I had technical knowledge, not practical knowledge. And there's a big difference.

I was managing supervisors 20 to 30 years older than me. Some were patient mentors. Others expected you to get up to speed quickly or get out of the way. Either way, I had to confront the fact that I "didn't know what I didn't know".

KEY LESSONS

01
You don't know what you don't know. Humility is as important as technical competence.

02
Context is critical. Engineering decisions don't exist in isolation. They affect real people with real consequences.

03
Active listening is not optional If you fail to genuinely engage with stakeholders, you'll pay for it later.

One moment that crystallised this for me was on a Bailey bridge repair. A local supervisor named Gerry – who had little formal education and spoke only Tok Pisin – was configuring the counterweight for a bridge launch. His approach appeared random and I was worried it wouldn't meet the required safety factors. So I went away and did the calculations. Turns out he'd got it spot on, and did so for every subsequent bridge launch.

It reinforced a simple lesson: never judge expertise by appearance, language or education. Knowledge and experience appears in many guises. Some of the most resourceful, inventive people I've worked with were PNG locals who had very little formal schooling but immense practical intelligence.

I also learned quickly what happens when you don't actively listen to the local community. In one case, a culvert was installed where locals had warned it would flood their vegetable gardens. The culvert was installed anyway, so they simply took matters into their own hands and dug up sections of newly built road as a form of protest. It wasn't vandalism – it was about survival and agency. When you're a subsistence farmer and a drainage decision threatens your food supply, that's not an inconvenience; it's existential.

It reinforced for me that technical compliance means nothing if you haven't genuinely engaged with the people who live with the consequences.

Those experiences fundamentally changed how I engage with stakeholders today. I learnt to stay three paces away from someone with a machete and keep an eye on the person with the throwing axe. Whether it's in community consultation or solving a problem with a junior colleague, I try to understand the context before landing on a solution.

PNG taught me that if you don't engage and actively listen early, you'll pay for it later – in trust, in time or in rework. Listening isn't a courtesy; it's a critical part of good engineering leadership. □

Adrian Vesnaver FIEAust CPEng EngExec is the National Branches Liaison Lead on the Engineers Australia College of Leadership and Management board.