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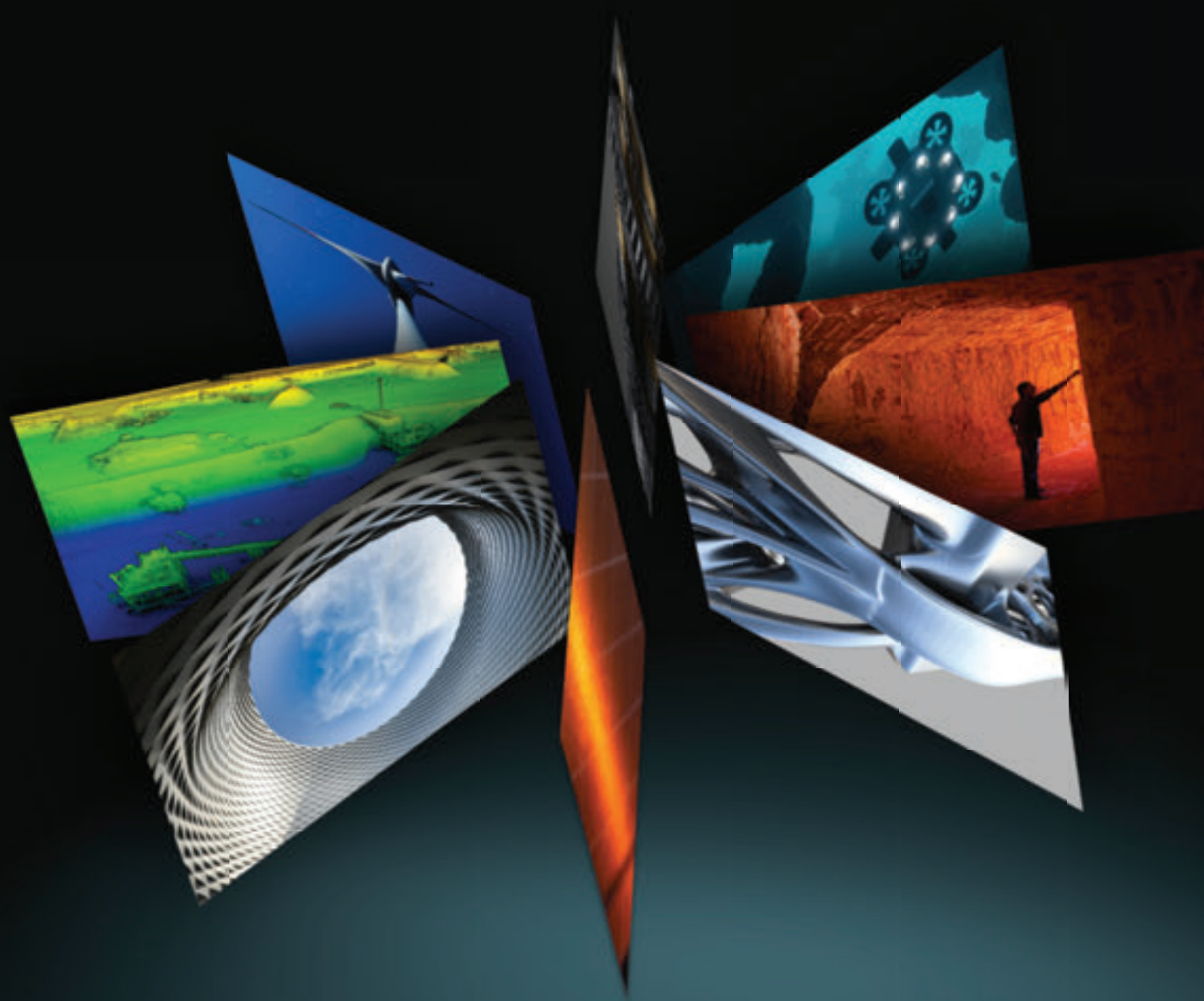

Future skills

How AI and the circular economy are changing engineering practice

create VOL 10 | NO.7 | 2024 ENGINEERS AUSTRALIA

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Avoid a corrosion disaster

As a specifier for your building project, understanding the impact of the environment on steel is crucial when considering corrosion protection.

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Don't risk a corrosion disaster – trust the expertise of the GAA.

For more information scan the QR code and look for Advisory Note 49

galvanizers
ASSOCIATION OF AUSTRALIA

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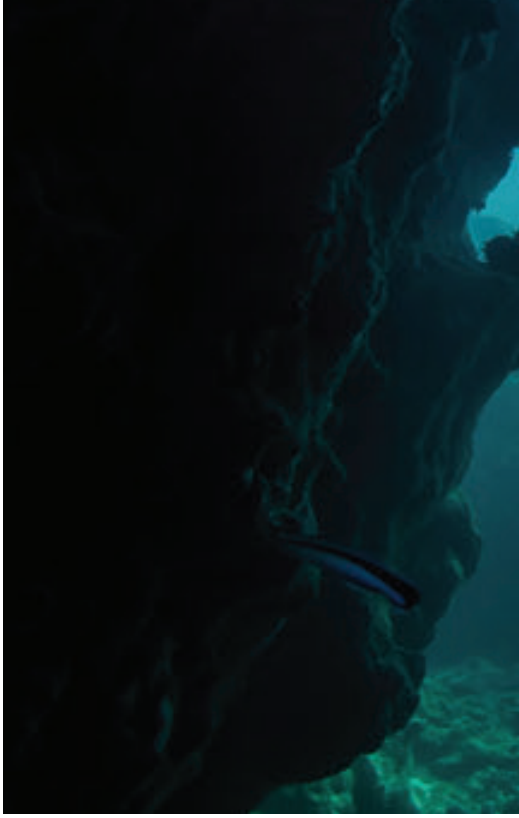

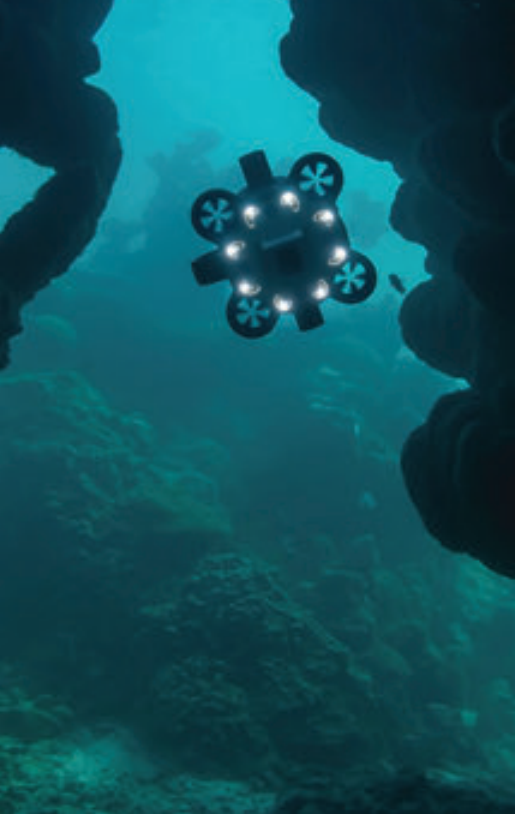

PROJECTS

EXPERIENCE

IMAGE: Advanced Navigation

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www.mahlab.co
Printed by: IVE
Mailed by: D&D Mailing
ISSN 2205-5983

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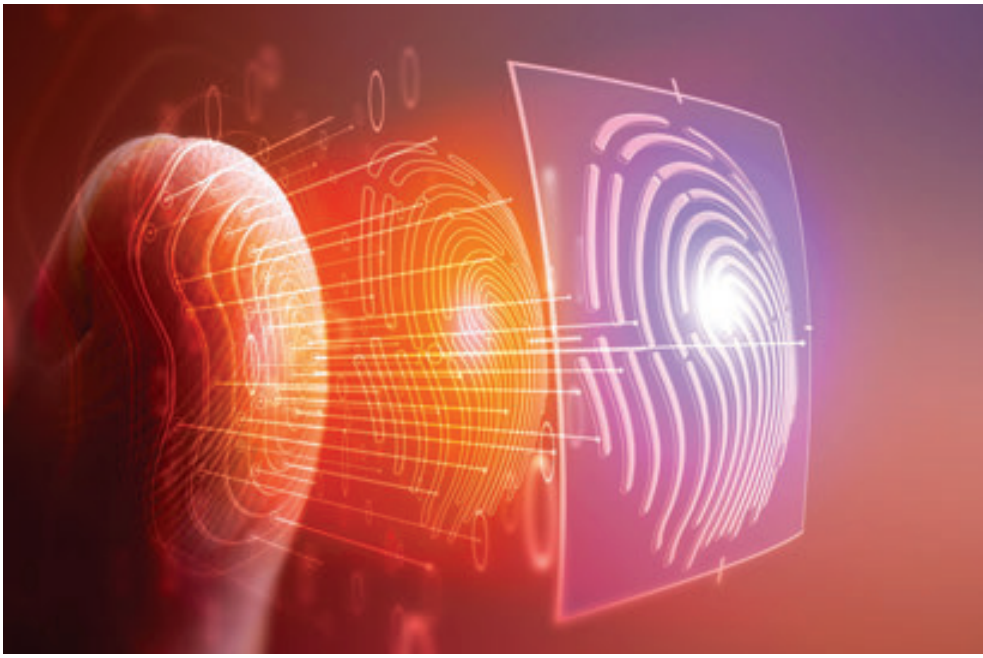

Big brother already watching

The risks associated with the growing use of biometric technologies were well highlighted in Chris Sheedy's article (Getting personal: The ethical engineering behind biometric technology, *create*, April 2024). Along with the rapid evolution of AI, the potential for misuse of these combined technologies is already with us. It's creating a sense of mistrust and unease about the world around and within us of anything we see, hear or read, which is appalling. In times past, perhaps my naivety encouraged a trustful approach first followed by scepticism later, but not anymore.

I wish now that I didn't start using my fingerprint to login to my iPad – goodness knows what Apple does with that little piece of me.

The article rightly points to logical areas where it can enhance safety and security, but opting out of less compelling applications should always remain a choice for all of us. Just stay vigilant!

PAUL SMITH CPENG (RETIRED)

Do we need high-speed rail?

The question that Engineers Australia should answer is: "Do we need a high-speed rail (HSR) train set because we don't have one?" (*create*, September 2024). Studies have shown that it is not economically beneficial to have HSR along the east coast of Australia.

I am concerned that the value of the benefit can be fudged if you want the consultant to give you a good number. However, the current record of cost overruns from various railway projects in Australia speaks volumes of the actual cost of an HSR project – and don't forget that the taxpayers will have to pay for the ongoing maintenance costs.

We better off spending money on energy security or better hospital services for the growing population.

GEORGE VOROBIEFF, VIA LINKEDIN

Yes, we do

I understand the concern regarding the costs and value proposition of HSR.

However, focusing purely on data without considering the broader impact can separate us as a community, rather than bringing us together for a shared future.

Projects such as HSR aren't just about immediate economic returns – they represent an investment in the nation's growth, much like the infrastructures of developed countries.

A growing population needs more than energy security and health care. It also needs opportunities, connectivity and a vision for the future. HSR can be a catalyst for these, connecting people, cities,and economies; fostering internal and external tourism; and enabling new businesses and jobs to flourish along "transportation veins". The future generation will thank us for laying the groundwork that allows them to thrive. They will feel proud of a country that took bold steps towards development, embracing a vision that goes beyond what's easy or immediately profitable.

ANTON RUCKMAN, VIA LINKEDIN

create
welcomes feedback from the community

Do you know of an exciting project we should write about? Is there an outstanding engineer in your midst? Are you working on an innovative technology that you'd like to share with your fellow members? Are there engineers out there doing their bit to help the community? Do you want to comment on an article you've read in *create*?

Email *letters@engineersaustralia.org.au* and we'll be pleased to consider your suggestions.

[Leadership]

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FROM THE NATIONAL PRESIDENT AND CEO

Future-fit workforce

Engineers have always evolved to meet society's needs. As the world changes, so does the engineering skill set.

This quarterly edition of *create* explores how AI, the energy transition, transferable skills and the circular economy have created an ever-changing global landscape that will shape the future of the engineering workforce.

Boosting the nation's engineering pipeline, innovation and a future-ready workforce with requisite skills are areas Engineers Australia is strongly advocating for on behalf of our members and the profession.

Concepts such as the circular economy are now ever-present in the thinking of many engineers. But even though we have discussed the importance of reusing scarce resources for decades, we still only recycle seven per cent of building products in Australia. This issue looks at how we can embed circularity into the engineering mindset.

Our *Making a clean transition* report provides advice to employers, workers, government and training providers for engineers transitioning from thermal industries to the growing renewable energy sector.

Findings highlight the importance of transferable skills, flexible training pathways, and coordinated policy support in achieving Australia's net-zero emissions goals. Engineers will be vital to driving this change.

Decoding AI's impact on engineering is unfolding in real time and changing the landscape of work. We explore the array of new technologies reshaping the notion of remote work across our vast country; and ways AI is being implemented to improve safety and productivity, and ensure distance is no barrier to getting the task done.

We know Australia will face significant demand for engineers in the coming years, with a projected shortfall over the immediate and long term. Engineers Australia is working closely with migrant engineers, industry and policymakers to tap into this underutilised and highly skilled cohort.

We have developed career resources, facilitated industry networking events that connect migrant engineers with business, and our new Overseas Qualified Engineers Career Support Hub (via our website) will be home to a wealth of information, downloadable resources, and access to networking opportunities.

We continue to work closely with schools, students and educators on attracting more young people to choose STEM subjects and consider a career in engineering. We are focused on promoting the profession as one that is at the forefront of sustainability and making a positive societal impact. To that end, we unpack a new career paths report which reveals we still have a way to go in changing many students' perceptions of what an engineering career is all about.

As we approach the end of 2024, we take this opportunity to thank you for your support, and wish you a productive, safe and happy festive season. The new year will bring more engineering innovation and impact. *create* will be there to investigate, reflect and showcase the best of the profession's changemakers and engineering projects, and their influence on society through great engineering.

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The big picture

The world of engineering is changing faster than ever before. How do engineers, and the way they work, need to change to keep pace?

Fill vacancies

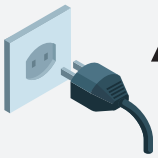
The rate of vacancies for engineers is **4.5** per cent higher than the Australian total. By far the largest share of vacancies are for civil engineering professionals, at **39.7** per cent of all jobs advertised.

Consider AI's growing influence

AI's rise has motivated engineering firms and businesses to embrace new ways of working, and this is showing no signs of slowing in the future.

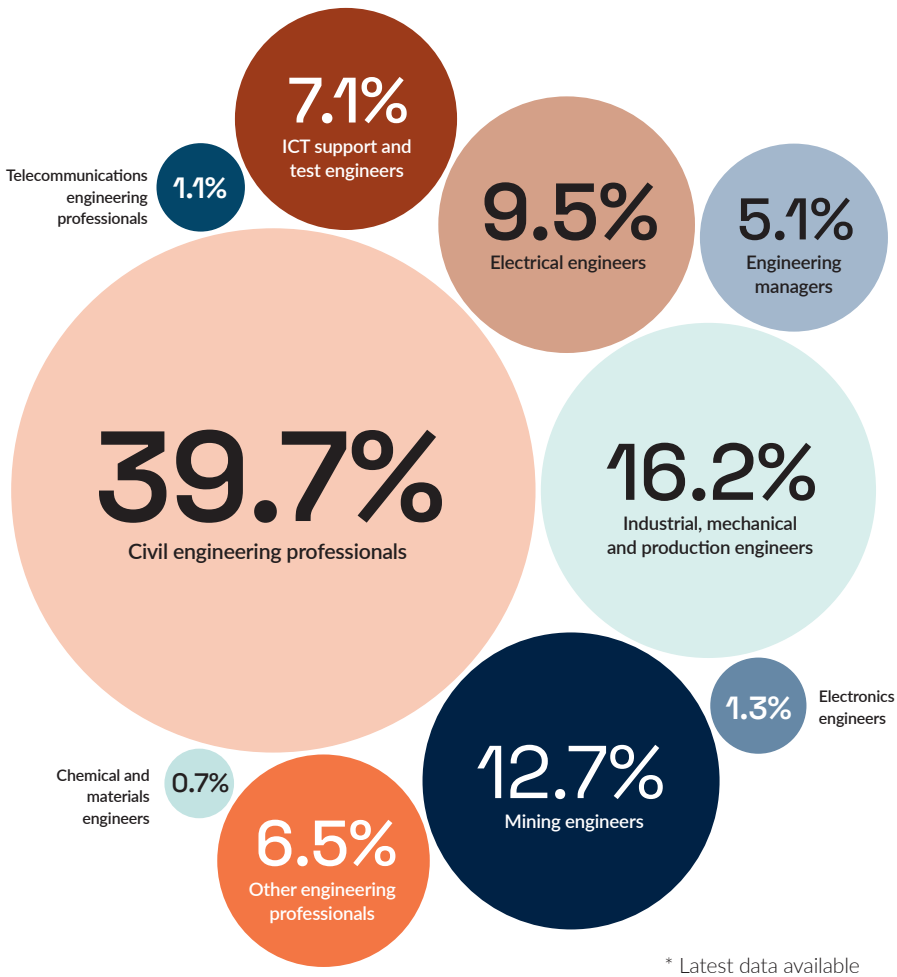
80% Australian construction companies planning to increase investment in AI in the next 12 months

Expected reduction in downtime of industrial machinery thanks to AI-enabled predictive maintenance **20%**



15% Estimated increase in energy efficiency thanks to AI optimisation

Job advertisements for engineering occupations in June 2024*



* Latest data available

Embed circular thinking

In the future, engineers must centre their work in circular ideas and processes.

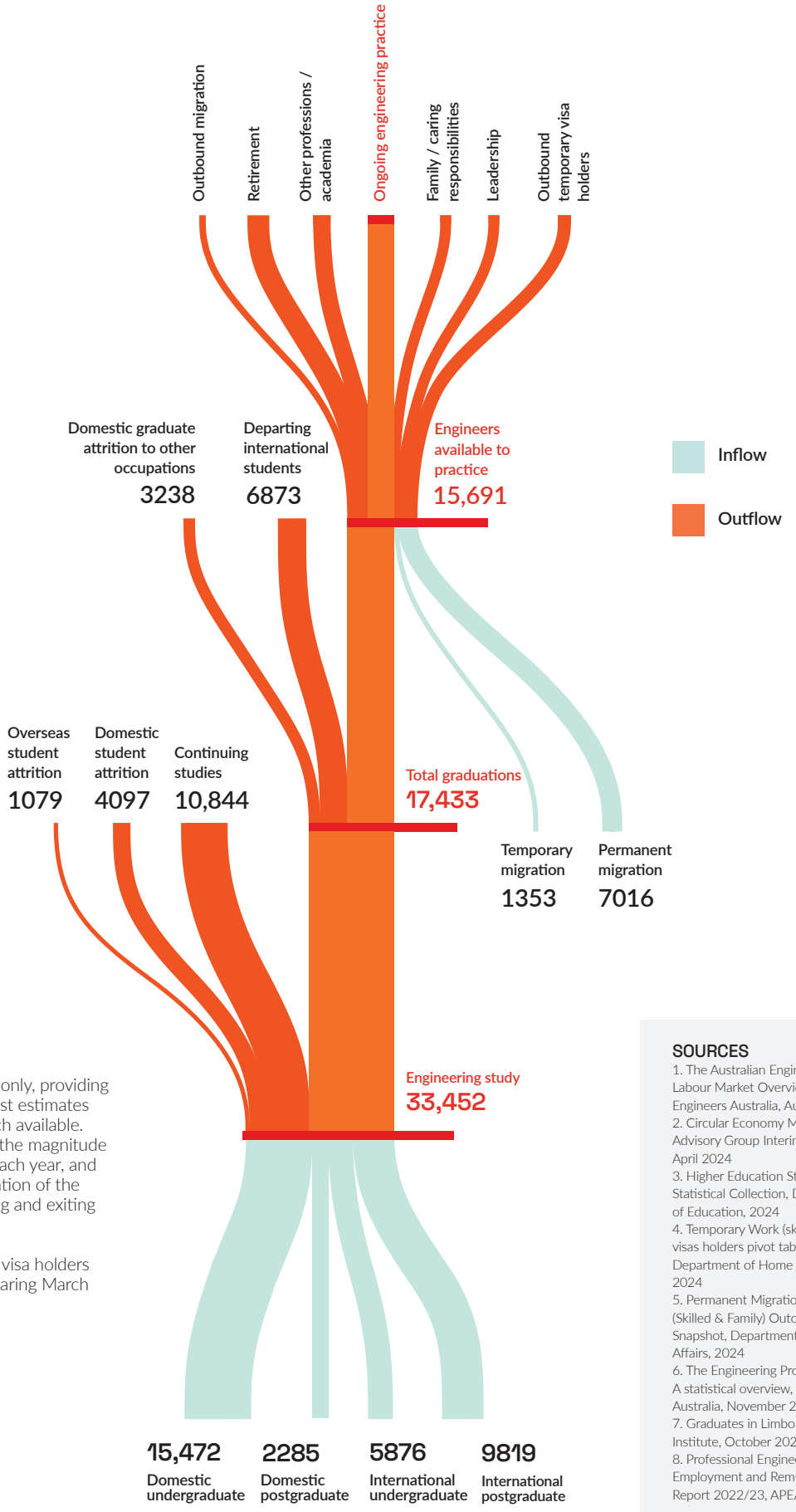
Australia has, per capita, the highest material footprint of the G20 and third highest of the OECD.

Australia has the fourth lowest rate of material productivity in the OECD. The country generates US$1.20 of economic output for every kilogram of materials consumed, under half the OECD benchmark of US$2.50.

Modelling done for the UK showed that an increase in resource productivity by three per cent annually could translate to seven per cent GDP growth by 2030 compared to current practice, improve the trade balance by one-two per cent of GDP, and generate more than 200,000 jobs to 2030.

Understand the skills pipeline

But where do Australian engineers come from? What are the routes into the profession? And what causes engineers to leave the profession?



This diagram is indicative only, providing provisional figures and best estimates from the data and research available. It is provided to illustrate the magnitude of inflows and outflows each year, and is not an exact representation of the number of people entering and exiting the profession.

Net additional temporary visa holders residing in Australia comparing March 2024 to March 2023.

SOURCES

1. The Australian Engineering Labour Market Overview, Engineers Australia, August 2024
2. Circular Economy Ministerial Advisory Group Interim Report, April 2024
3. Higher Education Student Statistical Collection, Department of Education, 2024
4. Temporary Work (skilled) visas holders pivot table report, Department of Home Affairs, 2024
5. Permanent Migration Program (Skilled & Family) Outcomes Snapshot, Department of Home Affairs, 2024
6. The Engineering Profession: A statistical overview, Engineers Australia, November 2023
7. Graduates in Limbo, Grattan Institute, October 2023
8. Professional Engineers Employment and Remuneration Report 2022/23, APEA, 2023

Words by Caroline Riches

Building engineering's reputation

Australians not wanting to be engineers is a sociocultural problem that requires a multi-pronged approach, according to a leading Australian academic.

Karen Whelan is acutely aware that engineering and mathematics have a reputation problem among Australia's young people, and she finds it incredibly frustrating.

The Associate Dean of Learning and Teaching in the Faculty of Engineering at Queensland University of Technology (QUT) said it is a sociocultural problem. "There are simply no heroes for them to look up to," she said.

"Look at the narratives in mainstream media. We have radio shows and podcasts about health, science and law. We have very little on engineering.

"Movies portray scientists as wonderful and exciting characters. Engineers, however, are rarely represented, except for characters like Howard in *The Big Bang Theory*, who's not exactly desirable."

An engineer and self-confessed "maths geek" herself, Whelan believes that a teacher's passion can instil a love for a subject in students. Unfortunately, many high school teachers in maths, which is crucial for engineering, are not even qualified in the subject.

According to a 2021 report on Australia's teaching workforce, around 40 per cent of high school maths teachers are teaching out-of-field. Another 2021 study shows that Year 8 students attending affluent schools are more likely to be taught by specialised maths teachers (54 per cent) compared to their counterparts in disadvantaged areas (31 per cent).

Mathematics and engineering are so often "associated with a masculine thinking", Whelan added.

"They don't attract a diverse group of people. Many believe you are either good at maths or you're not. That's simply not true. Anyone can excel in maths. With high-quality teachers and the right approach, it's a beautiful and wonderful thing to study."

RIGHT: Karen Whelan, Queensland University of Technology

Adding to the problem is a general confusion about what engineers actually do.

"People think engineers just build bridges. They associate engineering with hard hats and dirty work. Potential students link them with the problems of industrialisation, not realising that engineers are part of the solution to climate change.

"Engineering is all around us. Everything from your car to traffic systems to a Mars bar all needed an engineer at some stage of their development."

This lack of passion for the profession has led to a shortage of homegrown engineering talent that Whelan describes as "dire".

While university attendance grew between 2001 and 2021, the percentage of students choosing to study engineering has remained stagnant, she said.

It comes as Australia's Future Made in Australia policy, aimed at utilising Australia's natural resources for a clean energy transition, cries out for engineers.

"When you look at Australia's science and research priorities and translate them to the real world, it's engineers who make it happen. We need to support a transition to renewable energy to develop and maintain our standard of living through innovative solutions.

"We can't have 'Made in Australia' without engineers."

Education's virtuous cycle

Whelan believes that Australia's engineering degrees adequately equip students with the skills needed for tomorrow's workforce.

In fact, she argues universities are actually shaping the profession. QUT's Centre for Robotics is a prime example.

"Through world-leading research, we are changing how the industry operates. These researchers then integrate their findings back into the curriculum by teaching a Master's in robotics and AI. It's a virtuous cycle."

There's also a significant focus throughout Australia's universities on sustainability and energy transition.

QUT offers undergraduate engineering courses in chemical and sustainable >

"Potential students link [engineers] with the problems of industrialisation, not realising that engineers are part of the solution to climate change."

processes, computer and software systems, electrical and aerospace, electrical and renewable power, mechatronics and medical engineering, among others.

"These courses are informed by researchers working in biotechnology and developing sustainable aircraft fuels. So, while people might think of chemical engineering as a dirty field, green chemistry is making a huge impact," Whelan said.

Flinders University, meanwhile, offers undergraduate courses in biomedical engineering, environmental and maritime engineering. Monash, Deakin and the University of Sydney offer globally renowned Master's degrees in robotics and mechatronics.

ABOVE: Karen Whelan in QUT's Centre for Robotics

Fostering collaboration

Quality engineering education relies on collaboration between the government, industry, universities and other research institutions, said Whelan, who tries to lead by example. She's an active volunteer with Engineers Australia and will chair the National Committee for Women in Engineering from next year.

"I always try to maintain that connection between educational institutions and working professionals," she said.

Each of QUT's three engineering schools has industry advisory groups comprising recent graduates, middle managers, government officials and senior industry professionals who meet at the university four times a year. Moreover, each school has a professor of practice, an industry leader who spends one day a week driving research and education in areas like robotics, mechatronics, artificial intelligence and renewable energy.

Universities also tend to nurture close relationships with local and state governments, Whelan added. The Australian Research Council funds Linkage Projects, which are research alliances between universities and industry, while governments fund industry chairs at various universities.

"Practically speaking, we're in constant communication with industry professionals and government departments that employ engineers and support engineering organisations.

"Sometimes industry brings innovation, sometimes they bring a challenge, and university researchers find a solution. It's another example of that virtuous cycle."

Opportunities for more

However, Whelan emphasises that there are always greater opportunities for collaboration to drive innovation.

"Governments, industry and educational institutions should be drawing closer together and fostering partnerships that will shape our future," she said.

Funding, of course, remains a perennial challenge, especially for research and development.

"Universities in Australia are not well funded, and now there are talks about capping the number of international students. Some of these policies are negatively impacting what universities can achieve."

Providing world-leading research and education in Australia's regional areas presents another unique obstacle, with an engineering curriculum hardly cheap to deliver.

"You need equipment and laboratory spaces. Ensuring people from diverse communities in regional and remote areas have access to that level of educational experience is a real challenge."

Vocational training and apprenticeships are essential for ensuring a diverse mix of experiences.

"Every engineering function needs a well-rounded team. You need professional engineers who have been to university, and also engineering technologists or individuals with VET-level qualifications."

Whelan sees room for improvement in this area.

"We don't have as close a relationship as we might between vocational training and university-level education in Australia. There have been some trials, and the Australian Industry Group has been working with industry partners to set up degree apprenticeships."

Degree apprenticeships combine on-the-job training, mentoring and supervision with degree-level study, allowing students to develop skills while getting paid.

"This approach makes engineering education affordable for those who can't afford time off work and provides a diverse mix of skills."

A problem of reputation

Whelan believes diversity in engineering is crucial not only from a business perspective, but also from a social justice standpoint.

"Engineers influence every aspect of our lives, and it's troubling that only a narrow segment of society is influencing the design and construction of so many things that we interact with."

> "Engineers aren't just on building sites with hard hats, or isolated with computers. Around 50-60 per cent of an engineer's time is spent interacting with others."

But attracting diverse individuals to the field of engineering – including more women, Indigenous Australians and various types of men – requires overcoming its reputation problem.

Simply depicting women in pink hard hats isn't enough, Whelan said. Instead, a multi-pronged approach is needed to influence not only young people, but also those who have the power to shape their career choices including teachers, career advisers and parents.

First up, we need to get children excited about mathematics and empower girls by affirming their mathematical capabilities.

"We need to portray engineering as a profession that can be fulfilling for anyone. Engineers aren't just on building sites with hard hats, or isolated with computers. Around 50-60 per cent of an engineer's time is spent interacting with others.

"It's an exciting and dynamic profession where you collaborate to make a difference, and we need to share those stories."

Additionally, we must ensure that male-dominated fields like engineering are safe and inclusive environments for women, Whelan added.

"Unfortunately, harassment, bullying and misogyny still exist. However, organisations employing engineers are increasingly stamping out these issues, and so are we. We're also incorporating curriculum experiences that emphasise psychosocial safety, which we're all responsible for."

Global opportunities

Whelan believes that if we can enhance the perception of engineering, strengthen students' connection to mathematics, improve schooling, and increase the number of students pursuing engineering degrees, Australia has the know-how and expertise to compete on the global stage.

"Australia has a leading curriculum and we have that potential, absolutely," she said.

The high demand for skilled workers is also accompanied by high salaries.

"Our graduates likely earn more than some university academics. So while they have opportunities to attract fantastic salaries, they can also travel and engage in all kinds of interesting activities as they help to create a better tomorrow.

"With so many opportunities available, there's no better profession to be engaged in, as far as I'm concerned." □

INNOVATIVE **'LOW STRESS'** DESIGN

With its innovative design and patented post/fuse system, DOLRE 'Regular' barrier delivers MASH TL4-rated protection while limiting the maximum transverse force transmitted to the bridge deck to less than 44 kN/post (22 kN/metre), which equates to only 14% of the ultimate outward transverse design load as per AS 5100.2:2017.

What's more, at around 80 kg/m installed, DOLRE bridge traffic barriers are significantly lighter than many AS 5100 'Regular' / MASH TL4-rated barrier alternatives.

SEAMLESS **PROTECTION** WITH **DOLRE TL4** TRANSITIONS

DOLRE transitions have been designed and tested to provide full longitudinal load transfer between the bridge traffic barrier and connecting roadside barriers.

The DOLRE 'Regular' barrier, together with the DOLRE transitions and Thrie-Beam barriers create an engineered continuum of MASH TL4 protection – delivering maximum safety for road users onto and across the bridge structure.

WHERE **PERFORMANCE** AND **AESTHETICS** MEET

DOLRE's clean, uncluttered lines and aesthetically pleasing design make it an ideal match for a wide variety of bridge designs and locations. The design allows for rapid installation, as well as rapid repair and reinstatement of the barrier following an impact. DOLRE is also easy to dismantle and remove in times of flood, thereby helping to significantly reduce the risk of damage to valuable bridge assets caused by flood-borne debris.

DOLRE is also available with an extensive range of standard or custom fascia designs and integrated lighting options.

CHOICE OF PERFORMANCE LEVELS

Available in a range of AS 5100:2017 performance levels, including DOLRE Low (MASH TL2 | EN1317 N2), DOLRE Regular (MASH TL4 | EN1317 H2) and DOLRE Medium (MASH TL5+ | EN1317 H4b), there is a DOLRE barrier to suit virtually any bridge, culvert or road embankment application.

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INNOVATION
TOWARDS ZERO
DISCOVER MORE
SCAN ME
THE REVOLUTION IN BRIDGE SAFETY UPGRADES

Words by Joe Ennis

Engineering at the top end

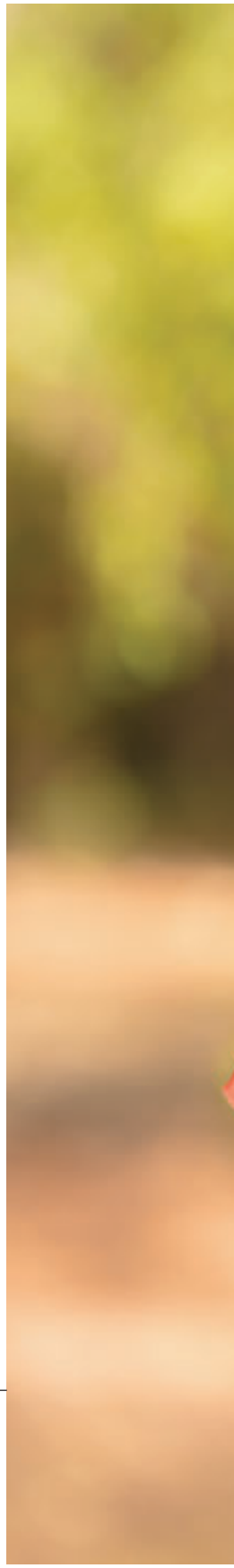
As a teenager, Jacinta Kelly FIEAust CPEng never wanted to be an engineer, pursuing law and science instead. But a series of critical choices shifted her focus back to engineering.

The oldest of 10 children raised in a STEM-focused household on a 50-acre bush property in the Northern Territory, Jacinta Kelly has always had family and community at heart. It's no surprise she has spent her entire career on projects that improve conditions for Territorians.

"I have a great sense of pride about being able to influence my community's way of life for the better," Kelly, who is currently working on the Middle Arm Sustainable Development Precinct, told *create*. "I enjoy going around town and physically showing my kids the projects I've been a part of."

But engineering was not her first career choice. The daughter of a science teacher and granddaughter of an engineer, she had all the influences to guide her into engineering, but, as is the case with many high-school students, engineering wasn't promoted as clearly and effectively as other careers.

"Engineering was never a career I considered. It didn't capture my interest. There was no medical degree available in Darwin at the time – I would've had to move south to pursue that – so I enrolled in a double degree in law and science at Charles Darwin University."



RIGHT: Jacinta Kelly FIEAust CPEng

Pivotal experience

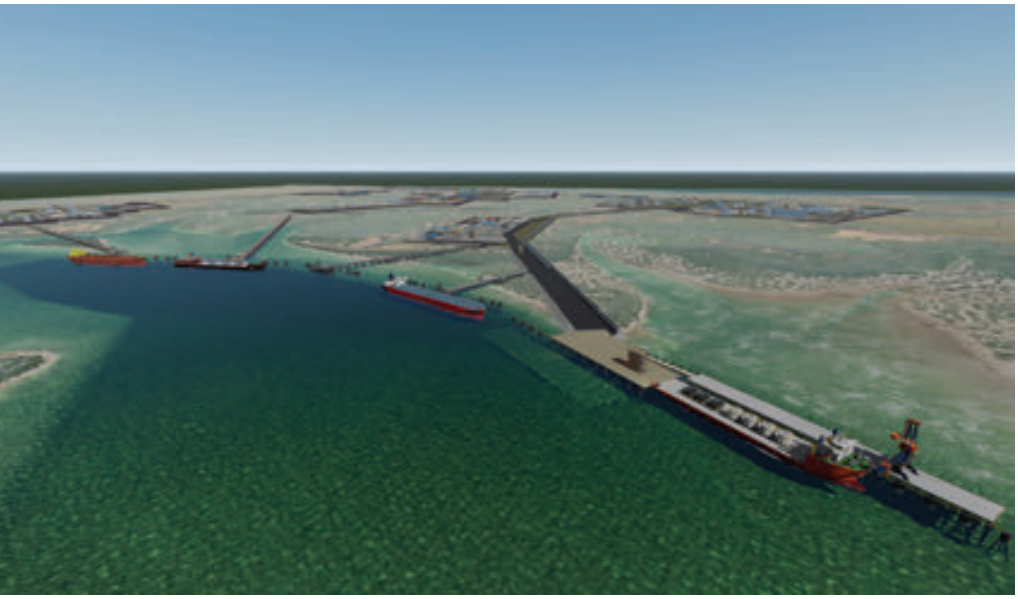
But she didn't even start her law degree, as an overseas debating trip as part of the United Nations Youth Conference transformed her perspective.

"I was surrounded by the top law students from across Australia," she said. "I felt like the odd one out, coming from the NT, and while I enjoyed the debating I didn't think I had any of the same interests. That experience changed my perspective. I came back home and immediately dropped out of law."

Still unsure of an alternative direction, she decided to study pure maths to keep her options open.

"Then, everyone in the maths units dropped out except for myself and the engineering students. I quickly worked out that I was very good at solving problems, and that sounded much more interesting. Although I still wasn't 100 per cent sure I wanted to be an engineer, engineering found me regardless." >

"All engineers should be leaders. I live by that. We have the ability to understand issues."



ABOVE:
An artist's rendering of the Middle-Arm Sustainable Development Precinct in Darwin

Early career

After graduating with a degree in civil engineering, Kelly landed her first job with GHD as a structural engineer working on a variety of projects from solar farms to water pump stations.

"It was interesting work in a surprisingly very young and female office. I never had the negative experiences that some other female engineers have in a male-dominated workplace."

Seven years later, heading off on maternity leave, she decided to pursue a mechanical engineering degree to expand her knowledge and open up more career opportunities. She even tried to answer the age-old question that plagues every engineering student: "Is civil or mechanical harder?"

Asked for a definitive answer to the question, she takes an each-way bet.

"I found both disciplines were difficult in their own ways, with mechanical engineering involving more abstract thought processes."

Her qualifications proved effective, with several exciting opportunities then coming her way, including Manager of Transport Assets for the NT Government.

"I managed a variety of transport assets – jetties, barge landings, weigh bridges, bus stops, even aerodromes," she said. "It gave me a great perspective. When you're working for a government organisation, you can see the broader strategy at play. You ask questions such as 'What is the long-term goal for this jetty or for the aerodromes across the NT?' That guides your decision-making about what capital works and maintenance programs need to happen."

Deliberate choices

Corralled by her choices into a career in engineering, Kelly had two degrees and nearly a decade of professional experience. But she still wanted to build her skills and broaden her focus.

"I went from the private sector to government to construction, because I felt that was the best way to understand how all the slices of industry work together."

It was then she really saw how vital it is for engineers to lead, pointing to how the aspects that make a great engineer are similar to those that make a great leader.

"All engineers should be leaders. I live by that. We have the ability to understand issues, but we also have to communicate to the policy-makers and our clients, and make them understand their options.

"We can't sit back and say that, because we did something one way last year or a generation ago, we should do it again. We should try to be leaders on every project."

Leadership skills were key while working on remote housing projects with issues around community acceptance. As well as project managing the contractors, Kelly became involved in the day-to-day problems.

"Many of our remote projects had issues with vandalism. School kids would head onto sites and vandalise the houses that were being built. I became interested in how to involve the community in the project and make sure they had an invested pride in this asset."

Planning for the long term

All of this experience led to Kelly's current role as the Integration Manager for the Middle Arm Sustainable Development Precinct project, currently in early concept design stage.

"An engineer influences ... how the world will live. Your decisions shape the way society develops in the future."

"Middle Arm is one of the most exciting long-term projects I've ever been involved in. It's groundbreaking because if we can do this it could become the blueprint for sustainable development across Australia."

Usually, a company such as a liquified natural gas producer would identify a developable location, and work with governments and stakeholders to gain environmental and other approvals for individual projects, putting their own infrastructure in place.

"Middle Arm aims to centralise this process," Kelly said, "encouraging businesses to set up in the precinct."

"If the precinct can take the lead and develop shared infrastructure such as roads, navigational channel and modular offloading facilities, then this gives these companies certainty that they can get in without having to go it alone.

"It's a huge incentive for all industries, especially when you're talking about emerging technologies such as green hydrogen, ammonia and critical minerals."

Shared infrastructure also reduces the overall carbon footprint.

"We're also going for a strategic environmental assessment, where, if successful, the NT Government will hold an environmental approval for the entire precinct," Kelly said.

BELOW: The plan for the Middle-Arm Sustainable Development Precinct in Darwin

"Once this is done, it would provide a set of conditions under which the tenant industries must fit."

The right representation

Kelly is also a big part of the Australian engineering community, recognised by her peers through awards and election to office.

She was named the Engineers Australia Young Professional Engineer of the Year in 2021 and became President of the Engineers Australia Northern Division nearly two years ago.

"As I reflect on my term, I believe we are facing a shift in how engineers are valued, and want to be recognised in our society and operate in our community," she said.

"In our division, we've prioritised building relationships with ministers and decision-makers, and raising the profile of engineers as leaders.

"We are focused on having a voice in the future of Australia's STEM education, workforce and strategic infrastructure decisions by engaging with both sides of politics."

Kelly also has several professional accreditations, including becoming a Chartered engineer.

"This was a great marker of my development and competency as an engineer. It's not a substitute for years of experience, but a recognition of the competency that experience has given me."

So what is an engineer?

Kelly said engineering is the ideal career for people who want to have an impact on the fundamental issues facing the community.

"The most exciting thing about engineering is the ability to be involved with big-picture problems. There are few careers that offer that type of generation-defining experience. An engineer influences on a large scale how the world will live, whether that's building a bridge, designing the next substation, or being involved in emerging technologies. Your decisions shape the way society develops into the future." □

ICT and the energy transition

What does AI have to do with climate change? And how can information systems help to manage the millions of connection points in a grid full of renewables? Here are two perspectives on the role of ICT in the energy transition.

Dr Ian Oppermann FIEAust

What is the connection between data, AI and climate change?

The United Nations (UN) General Assembly recently adopted a resolution on artificial intelligence (AI), for the promotion of 'safe, secure and trustworthy' AI systems that will also benefit sustainable development for all. The resolution includes calls for:

- 4(a) Expanding participation of all countries, in particular developing countries, in digital transformation to harness the benefits and effectively participate in the development, deployment and use of safe, secure and trustworthy AI systems
- 4(d) Aiming to increase funding for Sustainable Development Goals (SDGs) related research and innovation related to digital technologies and safe, secure and trustworthy AI systems and build capacity in all regions and countries to contribute to and benefit from this research.

ABOVE: Dr Ian Oppermann

For some, this may seem an incongruous connection. What do data and AI have to do with the UN SDGs? The UN SDGs are a set of 17 goals to which most countries (including Australia) have committed and which describe how we want the world to be by 2030. Among other things, they address poverty (Goal 1), gender equality (Goal 5),

IMAGE: Linkedin

This article is an edited extract from Engineers Australia's Accelerating the Energy Transition series. Read the full article, alongside Dr Alan Finkel's view on the critical barriers to transition and Neil Greet's take on energy security.

the availability of affordable and clean energy (Goal 7), and sustainable cities (Goal 11). They represent desired outcomes in the real world. They are both aspirational and inspirational. We know, however, that real-world outcomes are driven or influenced by many factors, including social attitudes, the convictions of politicians, policy settings, and technology.

The SDGs are deeply interconnected, so a lack of progress on one goal hinders progress on others. There is also a need to place greater emphasis and focus on the complementarities and trade-offs between the different SDGs.

For example, action to develop affordable and clean energy (Goal 7) to tackle climate change (Goal 13) – such as significant construction of hydroelectric systems, wind or solar farms may have negative effects at a local level on biodiversity (Goals 14 and 15). Similarly, development of coal-fired power stations is a means of creating work and economic growth (Goal 8); however, it may lead to poorer health and wellbeing outcomes (Goal 3), as well as poorer environmental ones.

Acknowledging these trade-offs requires careful consideration when seeking to understand the link between the application of technologies and their impact on the SDGs, as well as in policymaking.

We know we have a long way to go to deliver on the UN SDGs. In September 2023, the UN Secretary General, António Guterres, lamented that we are 'woefully off-track'. Despite this, we also know there is great willingness within many communities to meaningfully and positively impact the UN SDGs. This often leads to communities, politicians, or policymakers going it alone just to do 'something' that will make a difference.

While there are many 'no regrets' actions that communities or individuals can take to impact any one goal, we need to better understand the impact of the efforts we are all making.

We need a framework that highlights the mechanisms or pathways through which individual efforts impact the goals and what more we can do to drive them forward. Such a framework must also reflect the complex interconnection between the SDGs themselves and the complex interactions between technology, other factors and real-world outcomes. Data is what helps create these frameworks. AI can then be used to make sense of them.

Data can improve our understanding of what is actually going on in complex networks (be they energy or the environment), track longer-term trends, allow 'drill-down' analysis of points of friction, and even allow us to explore 'what if we did this' scenarios. On the operational side, data can be used to improve the effectiveness of these networks, allowing local or large-scale optimisation and even personalisation.

The ability to hit the affordable and clean energy goal (Goal 7) requires policy settings to align with technology capabilities and investment. Most importantly, however, it requires the ability to share >

and use individual household-level data at scale while simultaneously preserving individual privacy, and doing so in a secure way.

Think of an energy network with millions of individual contributors optimising generation and consumption at a household level, all rolling up to a more secure, resilient and affordable electricity grid. We are some way from that.

The mobile telecommunications world gives an example of how it can be done. Data is the valuable payload in the network, but is also used everywhere in the network to understand, analyse and optimise performance.

Mobile users can also simply change providers if they choose. Additionally, access to data from mobile networks has also driven consecutive generations of innovation. Imagine if we could do the same with energy networks?

Photons carrying information in the form of radio waves are different from the photons carrying energy in electrical networks, but the principles of 'understand', 'analyse' and 'optimise' are very similar. Electricity networks have a long way to go to approach the highly agile and consumer-centric networks of the mobile communications world, but the blueprint is there.

If we are to make meaningful progress on the UN SDGs, the complexity of these real-world outcomes needs a lot of will and a lot of alignment, but increasingly it will need a lot of data shared at scale, and a lot of AI to make use of that data. Without this effort, we continue to run the risk of not achieving any of our 2030 goals.

DR IAN OPPERMAN
is the former NSW Chief Data Scientist. He is a board member of the International Electrotechnical Commission (IEC), an industry professor at the University of Technology Sydney, a Fellow of Engineers Australia, and Chair of the Pearcey Foundation's Australia 4.0 Working Group, exploring the transition to net zero for energy networks.

Wayne Fitzsimmons OAM and Tim Ryan

Accelerating the national energy transition

The role of ICT in the transformation of our national electricity distribution grid is critical. Viewing this transformation through a digital and data lens highlights a number of critical issues that must be addressed if we are to have a distribution grid fit for purpose in the 21st century and ensure a net zero emissions level is achievable.

The diagram to the right highlights the complexity of the 'new' system, especially the number of new elements that will be required to achieve this new paradigm.

Whereas the current distribution contemplates tens to hundreds of generation points and millions of consumers, the new model contemplates millions of concurrent generators and storage devices as well as consumers. The mix of these three roles can change in milliseconds, both individually and in aggregate, similar to the internet and global communications networks.

This a traditional ICT/engineering perspective, but not one that is ordinarily discussed in the energy/climate debates. In 2023 there was a series of national discussions around this approach as a genuine attempt to engage the ICT sector in this transformation process, with the outcomes published in a communique in April 2024.

ABOVE:
Wayne Fitzsimmons

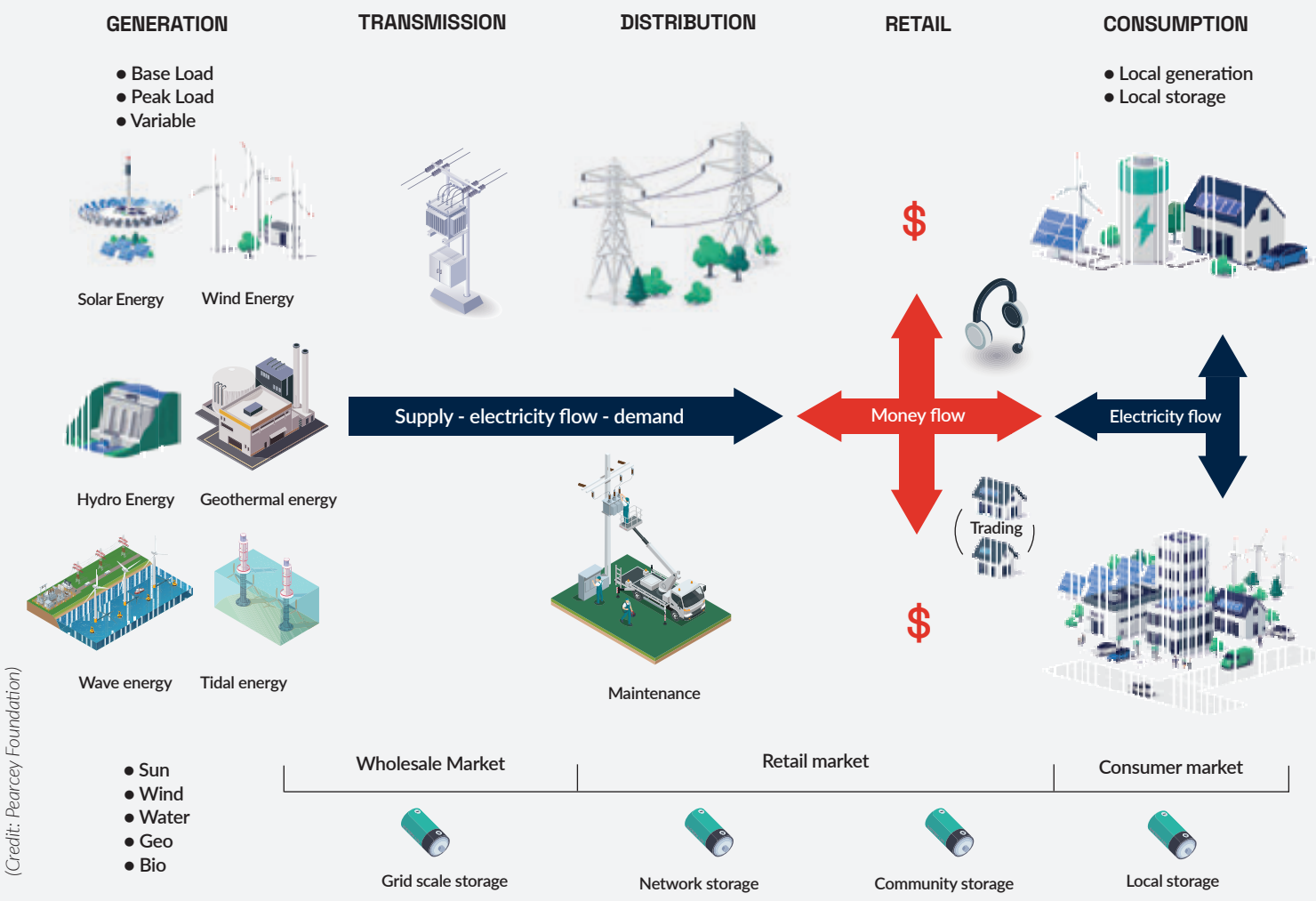
These discussions highlighted the complexity of the future electricity grid and signalled an urgent requirement for more-sophisticated grid management. The need to coordinate and regulate the future grid in a multistakeholder environment also emerged as a major challenge.

The question of how to optimally use new digital technologies that will require access to data from existing and new sources gave rise to a number of urgent issues:

- How will household data be generated, who will own that data, who will, or can, use that data individually and in aggregate, and what data standards will be applied nationally or will be left to individual vendors to decide?
- Should existing electricity generation, transmission and distribution networks remain centralised, or is there a case for a decentralised systems approach similar to the internet?
- Can we contemplate a different approach to managing despatch of power concurrent with managing the demand for that power, or should they be asynchronous systems?
- Given the energy market operator is a federal agency while the distribution systems are

IMAGE: Linkedin

Electricity supply chain at net zero



(Credit: Pearcey Foundation)

operated under individual state regulatory environments, what new legislative paradigm is needed to preserve the agency of the consumer through the transition?

In thinking about these issues, the agency of the consumer in this transformation process takes on a new meaning that cannot be ignored. Who is intending to represent and defend consumers' interests and actual rights under this 'new' schema?

To progress these challenges will require a collaborative approach between industries that, up until now, have operated within their traditional silos. It will also demand the proactive involvement of the ICT industry to ensure this complex transition is successful. □

WAYNE FITZSIMMONS
is a communications engineer (University of Queensland 1964). He started his professional career at the Aeronautical Research Labs in Fishermans Bend, joined Fairchild Semiconductor (pioneers of silicon semiconductors and the raison d'être of the term Silicon Valley) and then in 1973 set up the Australian arm of mini-computer company Data General. Data General took him to the UK in 1980 and to Boston in the USA in 1983, holding senior executive roles with two NASDAQ-listed companies, Data General and Banyan Systems. Returning to Australia in 1994 as CEO and board member of publicly listed communications company Datacraft Ltd, he had a successful exit from his own IT start-up, OpenDirectory, in 1998.

Wayne is currently chairman of the Pearcey Foundation, a national not-for-profit ICT industry group focused on promoting the ICT sector to the nation. He has been a board member of several successful early-stage Australian ICT companies – launching his latest Melbourne-based cloud software start-up, iPro, in early 2018. He was awarded an Order of Australia Medal in the 2018 Queens Birthdays Honours. His current focus is on the role of digital and data in the transformation of the national electricity distribution grid as we approach net zero emissions, including ensuring consumer agency is paramount in this transition process.

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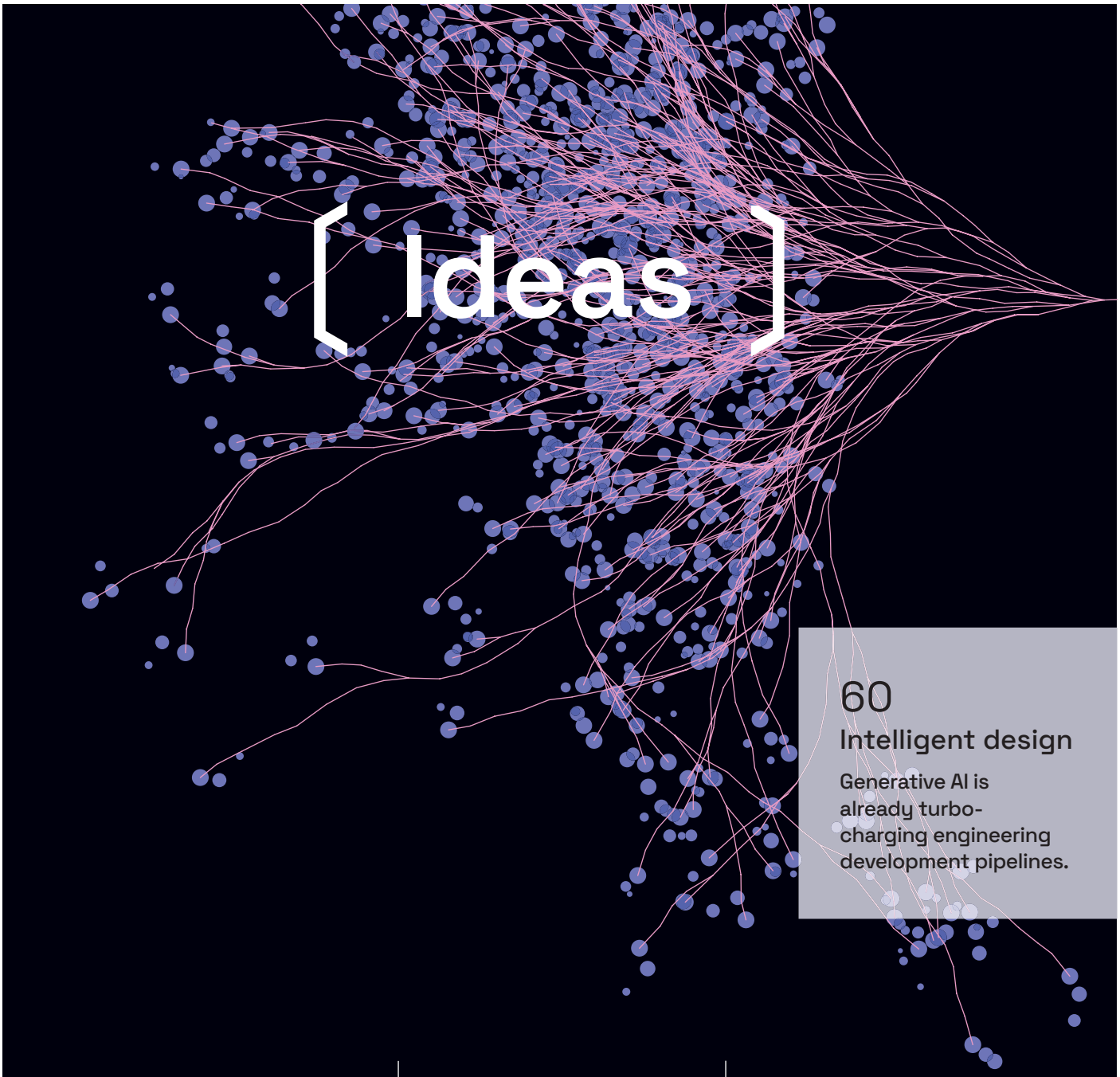


NEWS

Making a clean transition

A new Engineers Australia report reveals clear pathways for engineers pivoting to the renewable energy sector.

The *Making a clean transition* report provides clear advice to employers, workers, government and training providers for engineers transitioning from thermal industries to the growing renewable energy sector. Building on earlier insights, the Engineers Australia report highlights the crucial role that transferable skills, flexible training pathways, and coordinated policy support will play in achieving Australia's net-zero emissions goals.

With their problem-solving mindsets and deep technical expertise, engineers are the key to driving the net-zero transformation. The research, conducted in partnership with Mott MacDonald, confirms that while many engineers will transition smoothly to the growing clean energy sector, others need more support.

The final report offers concrete solutions to one of the country's most pressing workforce challenges, Engineers Australia Acting Chief Engineer Bernadette Foley FIEAust CPEng EngExec said.

"We have seen that engineers with experience in thermal industries are well-positioned to take on new roles in renewables," she said. "This report gives us confidence that, supported by the right training pathways and coordinated policies, we can ensure these professionals continue to thrive in a net-zero economy."

Foley emphasised the importance of coordinated action across government and industry. "Australia is at a pivotal moment. We have a generational opportunity to shape a workforce that can lead the world in clean energy. Investing in our engineers and providing them with the tools to succeed will be key to a sustainable and prosperous future."

ABOVE: Bernadette Foley FIEAust CPEng EngExec, Engineers Australia

Key recommendations

- Employers can support transition pathways through diverse continual professional learning and interim roles, and tailor recruitment to highlight the transferable skills engineers already possess; re-engage qualified engineers; and promote the purpose-driven opportunity to work in clean energy.
- Governments should continue to undertake skills mapping

and showcase the similarity in roles; consider location and the local workforce when investing in clean energy initiatives; and support skills recognition and familiarisation training in clean energy.

- Training providers should continue to ensure all engineering courses include sustainability alongside foundational engineering skills, and work with industry to promote training pathways and work experience opportunities.

"Our research coincides with a raft of initiatives to support the transition to renewable energy," Engineers Australia General Manager of Policy and Advocacy Jenny Mitchell said. □

SUMMARY OF REPORT KEY FINDINGS:

01 Engineers possess transferable knowledge, skills, mindsets and capabilities

The report confirms that employers are increasingly prioritising engineers' mindset and adaptability over discipline-specific expertise. Many core engineering skills, such as systems thinking and project management, are highly transferable from thermal to renewable energy roles. However, expanding capabilities in areas such as stakeholder management and community engagement is crucial. Some highly specialised roles, such as grid engineers, remain challenging to fill due to limited transferability and a shortage of experienced professionals.

02 Building the engineering labour force remains a key challenge

With global competition for engineering talent intensifying, Australia must focus on re-engaging underutilised segments of its engineering workforce, particularly women, older engineers and skilled migrants. Promoting the environmental and social impact of renewable energy roles in job ads can attract talent, while addressing salary disparities and offering flexible working conditions can improve job satisfaction and workforce stability.

Scan the QR code to read the full report.

03 Location will continue to play a role in the capacity to attract workers

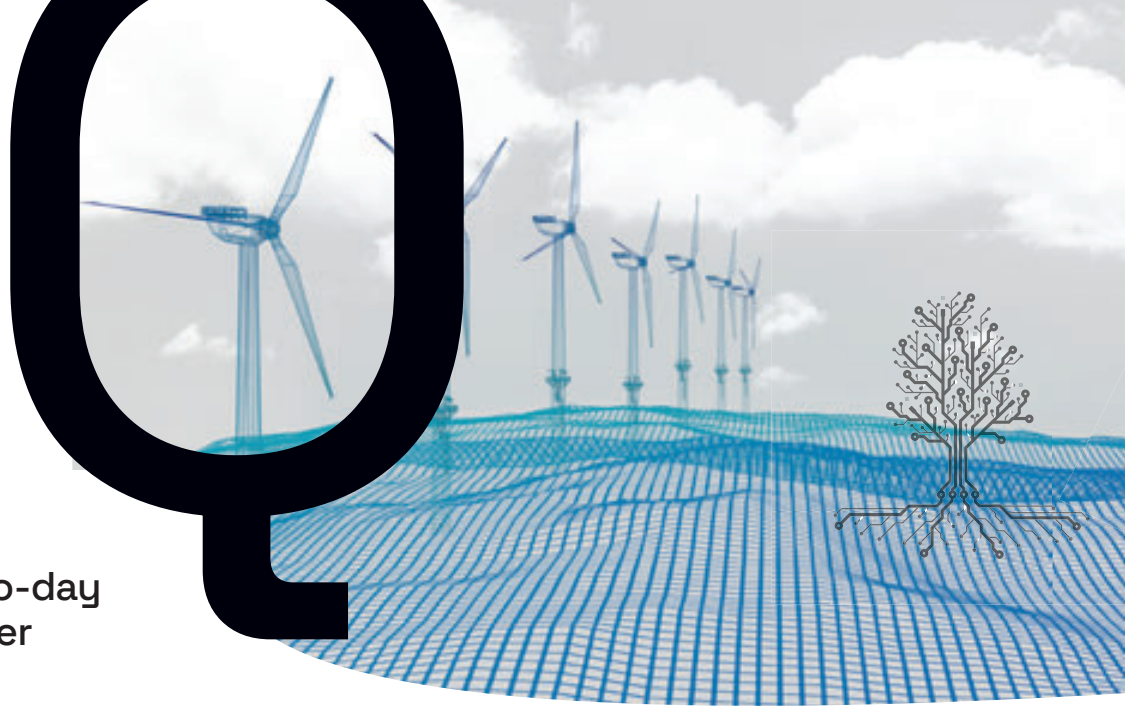
The report highlights the importance of creating clean energy jobs in existing thermal energy communities to minimise disruption for workers and their families. Engineers are more likely to remain in the profession if they can transition to renewable roles without relocating. Leveraging remote work and automation technologies can further enhance flexibility and retention in these communities.

04 Policy drivers are supporting innovation but need coordination

Governments are encouraged to better define and classify new roles in the renewable sector to support workforce transitions. Consistent and stable policy settings are needed to encourage investment and innovation in clean-energy projects and transition plans. Alignment across federal, state and local government initiatives will be critical for ensuring Australia can meet its net-zero commitments.

05 Training pathways are still needed

Embedding sustainability across all engineering courses is seen as more beneficial than bespoke clean energy engineering degrees for future engineers. Offering micro-credentials that demystify jargon, and standards will equip transitioning engineers with the skills needed for the renewable sector. These credentials can help bridge gaps between sectors by providing targeted, practical training, allowing workers to gain confidence in new industries.



BLUE-SKY THINKING

It's the year 2039. What does the day-to-day of an average engineer look like?

JODIE KILPATRICK *TMIEAust CEngT*
is Associate Consultant – Geotechnics and Mine Waste Engineering at SLR Consulting. She was the 2023 Engineers Australia Emerging Engineering Technologist of the year.

In 2039, the day-to-day of an average engineer will be unique to each individual professional. Inclusion, diversity and technological advancement within the future workplace will allow businesses to excel in embracing the needs of individual employees.

Creativity will become one of the most important skills and characteristics of the engineering field. With technology allowing the automation of most routine tasks and problem-solving exercises, engineers will need to engage in more creative thinking to solve the complexity of future challenges.

From a technical perspective, protection of our core environmental resources (water, land, air) will be at the forefront of the engineering field, increasing the demand for professionals in this area. In addition to changes in the demand for different technical fields, the average engineer will require increased skills in communication and stakeholder management to enable collaboration with multidisciplinary teams.

Although technology and the digital world is predicted to assist in most fields of engineering, it is the "human" component that will increase in demand over time. As a current young and emerging engineer, I look forward to watching how the skill set of a typical engineer will evolve over the coming years.

"Although technology and the digital world is predicted to assist in most fields of engineering, it is the "human" component that will increase in demand over time."

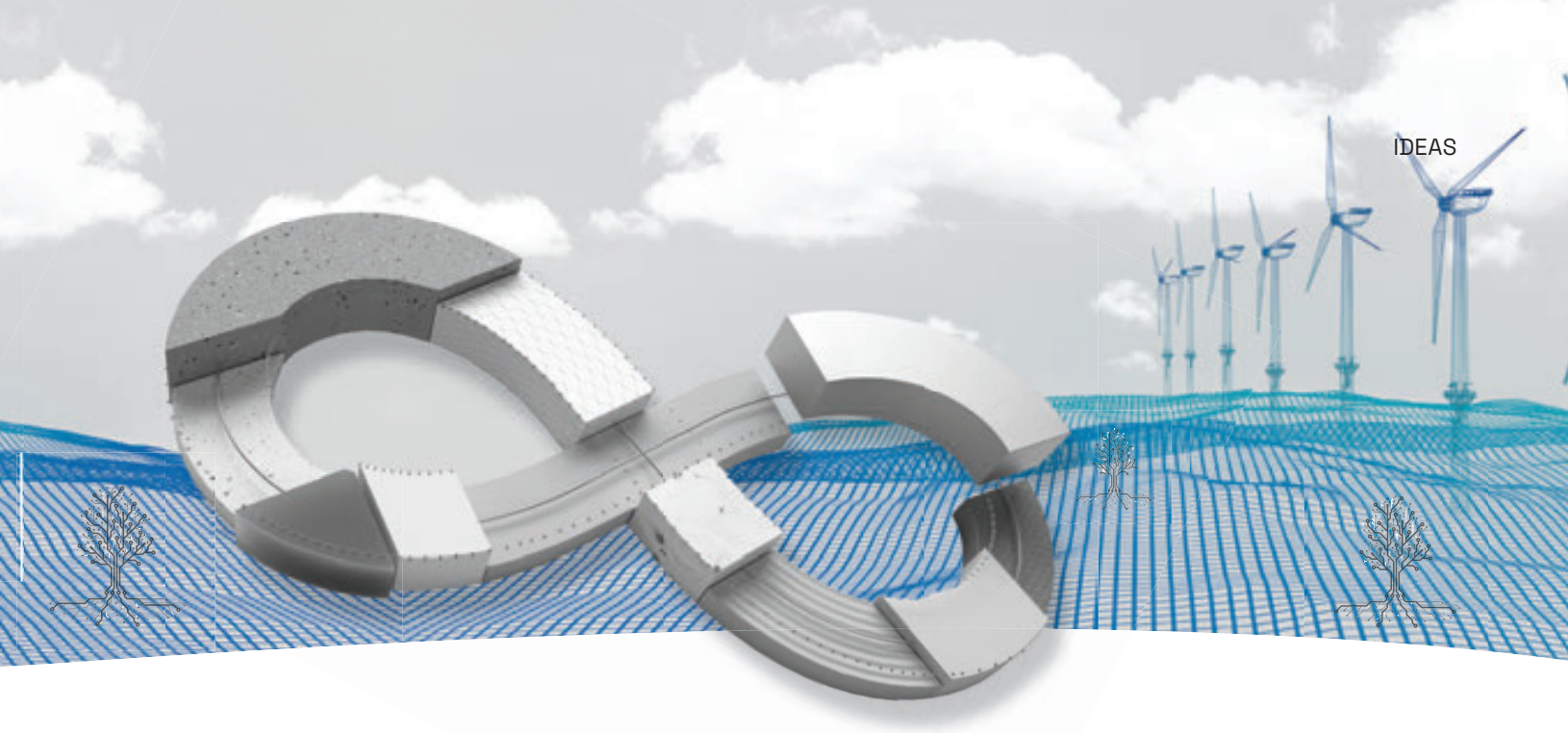
CHRIS NIELSEN *FIEAUST CPEng EngExec*
is the former President of Engineers Australia, Queensland and the current Chair of the Engineers Australia Civil College.

Engineers are just people working in our society, so as our society adjusts and changes according to emerging attitudes, technologies and ways of living, so will we.

I foresee a progression in how we live sustainably and how we balance work with other aspects of our lives. I would like to think we will be more progressive in work-life balance and be more cognisant of how contented and happy we are in our working lives.

Flexible working will further evolve, with improvements in communications, virtual reality (VR) and remote access to almost everything we need to work.

The office will become more of a place to meet, socialise and network, and less of a place where people will sit down and actually work. Perhaps remote working will become so prevalent that we will become more respectful of a person's right to sleep when working in different time zones!



“Site visits will remain an important element of an engineer’s job. We will still need to get our boots on and get dirty.”

Will AI become our bosses? High-level decision-making in organisations will either be directed, or judged, by AI. Remote sensing, data collation and engineering analysis tools will continue to grow in sophistication and capability, further pushing engineers more into high-level decision-making and interpretation roles, and less process-driven analysis and number-crunching roles.

Irrespective of these changes (and despite any step change improvements in VR), and especially for civil engineers, site visits will remain an important element of an engineer’s job. We will still need to get our boots on and get dirty. And, as always, civil engineers will continue to make responsible and ethical decisions that deliver the best outcomes for society.

PROFESSOR VEENA SAHAJWALLA is an internationally recognised materials scientist, engineer and inventor. She is the founding Director of the Centre for Sustainable Materials Research & Technology at UNSW.

In 15 years’ time, I hope there will be greater alignment between research and industrial application, much as I expect there will be greater alignment between recycling and manufacturing.

The role of engineers is becoming more important than ever as we innovate and seek decarbonisation.

Sustainability is no longer a choice – it’s a necessity. The transformation of waste into valuable feedstock for manufacturing represents a profound shift – and opportunity – in our approach to resource sustainability and de-carbonisation. Engineers can take a front-row seat.

“When considering true sustainability and the creation of a circular economy, the role of waste must be central to those efforts.”

This paradigm shift is particularly crucial for the metals and critical materials needed for future electrification, such as batteries and renewable energy infrastructure. As we transition to a more electrified world, the demand for these materials will surely skyrocket.

Using “waste as a resource” is the missing ingredient as we seek to secure national capability and capacity for future green metals and energy production. When considering true sustainability and the creation of a circular economy, the role of waste must be central to those efforts.

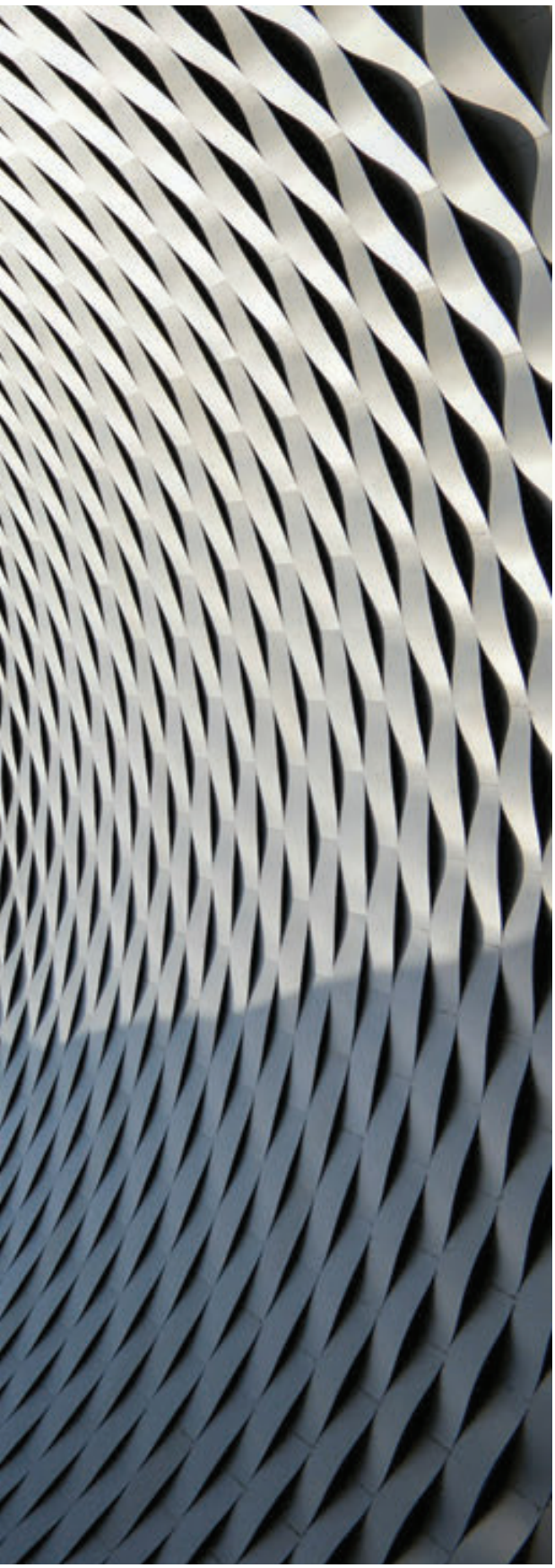
Addressing this demand sustainably requires innovation, including the integration of waste feedstock into the manufacturing process and the rise of microfactory technologies for decentralised and localised production, particularly where waste resources are located.

Advanced recycling technologies, such as our UNSW SMaRT Centre technologies, must be used to recover metals in a more environmentally friendly manner. By developing efficient methods to recover and recycle these materials from waste, engineers can reduce the need for virgin resource extraction, mitigate environmental impact, and create more secure and resilient supply chains. □

Coming full circle

WORDS BY CHRIS SHEEDY

More than seven million tonnes of construction waste goes to landfill each year – equivalent to enough bricks to build a metre-high wall around Australia's coastline. So how are engineers rethinking design for circularity?



ABOVE:
Joe Karten, Built

Joe Karten's daughters, aged six and nine, enjoy playing with LEGO. Perhaps unsurprisingly for the children of a core member of the team for developer Built, they regularly spend hours assembling all sorts of creations, which sometimes stand proudly for several days before the girls break them down and pack the pieces into a bucket, ready for their next production.

"Imagine, though, if every time they got bored with one of their LEGO creations, they threw the pieces in the bin, and I had to go out and buy new LEGO sets," said Karten, Built's Head of Sustainability and Social Impact. "If that happened, they wouldn't be playing with LEGO for very long.

"And yet, that's what we do with buildings and fit-outs. We know how to get the very best value out of materials even when we're children. But as engineering and construction businesses, we need to do a lot better."

In fact, a spokesperson for the Department of Climate Change, Energy, the Environment and Water said, circularity is already happening in the construction supply chain. Engineers have to get on board.

"There is no escaping the change towards circular construction," the spokesperson said. "It's growing in momentum internationally, and Australia is committed to making this transition.

"It is a growing area of policy focus and the construction supply chain will be expected to deliver materials-efficient, circular solutions."

What is circular construction?

Many consider the idea of circularity anywhere in the economy to have something to do with recycling, or reuse of materials. While these certainly make up a part of the concept, the idea of circular construction covers a lot more ground.

"It is about keeping things in use for longer, at their highest and best level of use," said Katherine Featherstone, Senior Manager Products and Materials at the Green Building Council >

BY THE NUMBERS

HOW MUCH OF A PRODUCT'S ENVIRONMENTAL IMPACT IS DETERMINED AT THE DESIGN STAGE

80%

Source: Circular Economy Ministerial Advisory Group Interim Report, April 2024

of Australia. "Circular construction focuses on ensuring that during the design stage, we work together to maximise the lifespan of each element, so it continues to provide value and functionality for multiple uses over time."

Some of the most important ingredients for success include design for disassembly, meaning welding is out and mechanical fastening is in, as well as fastidious, digital recording of maintenance of all parts of each building. "An engineer needs enough information to be able to safely reuse what's there," Featherstone said. "We don't do that well enough right now, and that's a real roadblock."

ABOVE: Katherine Featherstone, Green Building Council of Australia

Circular construction involves the engagement of every part of the supply chain, and entirely new processes at the design, construction, maintenance and disassembly stages.

Of course, certain types of construction have long been relatively circular. Some mining businesses are familiar with the need for modular housing for staff during the life of a mine. Military engineers regularly assemble and disassemble portable bridges for mission purposes. In Canberra during the COVID pandemic, Aspen Medical built a 51-bed surge facility in just 37 days – a building that could pack down into shipping containers for use elsewhere once no longer needed. However, in the mainstream construction arena, and particularly in Australia and New Zealand, examples of circularity are few and far between.

"Because it is still new, businesses aren't yet working together in the different parts of the supply chain," said Sophie Degagny, Director of Climate Change and Sustainability at KPMG. "We see great examples of circular construction in

temporary building projects, but on large buildings we need plans for end of life.

"We will see a lot more green, sustainable procurement in Australia – I moved to Australia four years ago and in that time I have already seen a lot of changes in relation to the circular economy."

The one absolute necessity in the move towards circular construction is leadership by engineers, Degagny said.

"Engineers must be deeply involved from the design stage," she said. "They need to lead that discussion around how the building is put together to enable it to be disassembled at the end, instead of just knocked down. From an engineering side, if it's easy to disassemble, it will be a lot easier to repurpose, record and reuse."

ABOVE: Sophie Degagny, KPMG

Driving change

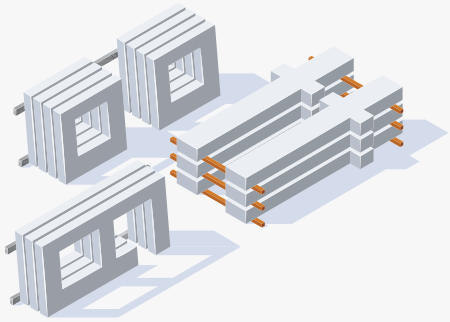
When the current government won power, ministers were very clear that the circular economy was a priority, said Romilly Madew AO, CEO of Engineers Australia and member of the Circular Economy Ministerial Advisory Group (CEMAG).

"The role of CEMAG is to provide high-level advice to the Minister," Madew said. "Tanya Plibersek, the Minister for the Environment and Water, comes to all meetings, and she usually brings another Cabinet minister as well, because it's not just an issue for her department.

"Sector plans are being developed by the government, and we help make sure they take into account the circular economy."

It's not just government taking charge of driving the circular economy. Engineers Australia is >

How to write a building disassembly plan



Specialists at Built and Coreo recently released a paper offering clear advice on the essential ingredients of a building disassembly plan.

How to write a Building Disassembly Plan is intended to enable a shift in how design for disassembly is prioritised. It says design for disassembly offers solutions to several critical challenges, including carbon emission, nature impacts and industry productivity.

Instead of regarding buildings as infrastructure that will one day need to be demolished to make way for newer versions, the paper defines buildings as material banks in which valuable building products – from outer skin and structural materials to internal fittings and services – are stored and maintained, always ready for their next use.

The paper holds that, importantly, in an environment driven by economic considerations, design for disassembly need not result in higher cost than traditional builds, and also should not increase project timelines. In fact, the modular nature of design for disassembly lends itself to faster, safer project timelines.

The order of disassembly, the paper states, should be:
1) loose furniture
2) joinery and finishes
3) services
4) roofing and facade
5) superstructure

The paper includes a link to a disassembly plan template that outlines for each part of the building (furniture, joinery, ceilings, floors, roofing, electricals, fire, façade, elevators, etc.):

- purpose
- material locations
- disassembly methods for each item
- storage instructions for each item

"We must rethink what we take, how and when we make, and what we do with materials we no longer need," Coreo CEO Ashleigh Morris told *create*.

"To achieve this vision, we must revolutionise the built environment, property and infrastructure sectors. We need to embrace a design philosophy that looks beyond the present and envisions a future where buildings stand tall today, yet hold the promise of being recreated tomorrow. This is the power of design for disassembly, a concept that not only preserves the integrity of our structures, but also fosters a sustainable and resilient built environment for generations to come."

"We must rethink what we take, how and when we make, and what we do with materials we no longer need."

launching multiple Climate Smart Engineering initiatives aimed at improving awareness and the capability of engineers.

To encourage change at a university education level, Madew has met with the Australian Council of Engineering Deans to discuss the importance of circularity, and how the topic can be worked into curricula.

"At Engineers Australia, an important task is demystifying circular construction among engineers," Madew said.

"We have become comfortable with safety and sustainability. The profession now needs to recognise that the circular economy must be part of the vernacular when we're talking about climate change and sustainability.

"Our role is to boost skills as rapidly as possible in the profession so engineers understand all the elements of circularity and bring that into their mindset when they're designing products and processes, designing out waste, rethinking project planning and innovating."

After an industry roundtable in May 2023, Engineers Australia produced the report *Circular Economy: Built Environment and Carbon Emissions*. It outlines examples of circular principles being brought to life in local projects, as well as pain points, inhibitors and, most importantly, solutions.

Fitting out

Consider when an office or shop is about to be fitted out. Typically, the walls and floors will be stripped back to bare concrete, steel and brick.

No matter what came before, it is completely cleared out for the new tenants to start afresh. And most of what previously existed is sent to landfill, said Vanessa Cullen, CEO of Forward Thinking Design and Lead Partner with FTD Circular.

"We've always undertaken a lot of pro bono work with charities," Cullen said. "When you have little money to spend, you have to be resourceful. So you design out waste and you reuse, and you procure things second-hand."

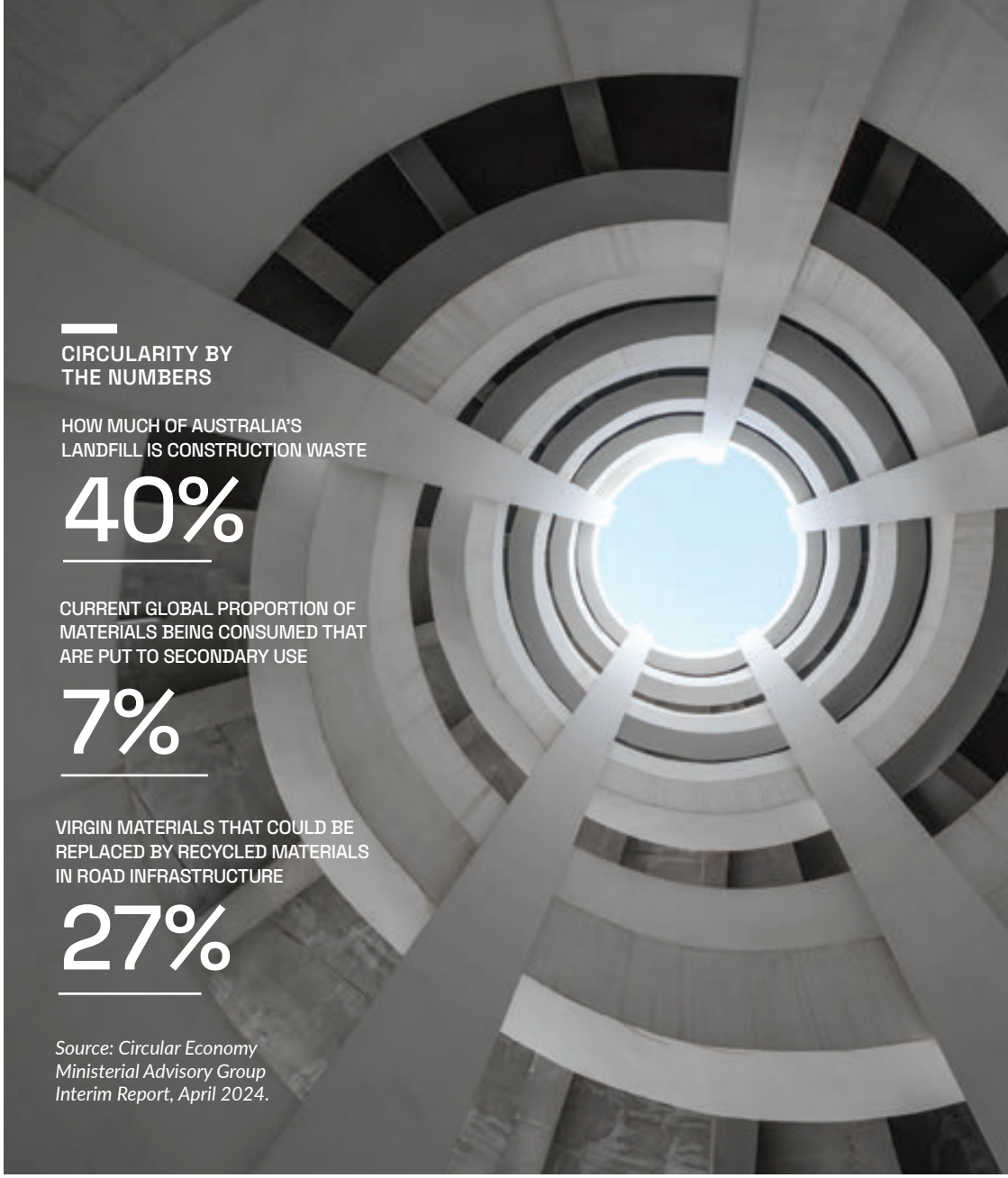
One of Cullen's areas of specialisation is fit-out. Success in circular fit-out begins with the landlord, who writes policies and guidelines for tenants.

These guidelines then flow on to affect the work of designers, engineers, contractors, certifiers and every organisation in their supply chains.

"Landlords for most shops and restaurants ask tenants to build false walls within the concrete walls," Cullen said. "You're building a frame and then putting your plasterboard onto that. But why is that being stripped out each time a tenant changes?

"Fortunately, more landlords are appreciating that there are parts of a fit-out that could be retained and used by the next tenant, and then the landlord potentially doesn't need to give as much of a financial contribution towards the fit-out. This is not just for sustainability; it's about good financial sense."

ABOVE:
Romilly Madew HonFIEAust EngExec, Engineers Australia; Vanessa Cullen FTD Circular



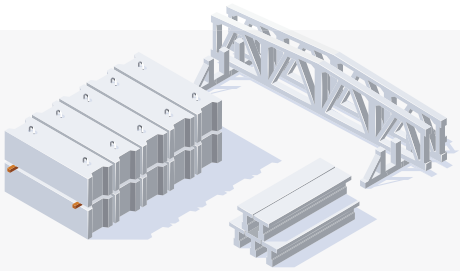
$1.4 b

COLLECTIVE AMOUNT SPENT BY AUSTRALIAN FIRMS ANNUALLY SENDING $26.5 BILLION OF MATERIAL TO LANDFILL

"We have become comfortable with safety, and sustainability. The profession now needs to recognise that the circular economy must be part of the vernacular."

FTD Circular recently worked with a commercial client on tracing and enabling the circular de-fit of a tenancy. At the same time, a charity client was in need of joinery work. The charity's needs matched what was being removed from the fit-out.

"The commercial clients saved on the landfill, transport and labour fees, and the charity saved around $40,000. There was also great social-impact value because the charity was able to create the space it needed for the people it served; and the environment did not suffer the impacts of the joinery, which was salvaged from the commercial building going to landfill." >



Focusing on solutions

An industry roundtable in May 2023, hosted by Engineers Australia, Circular Australia and the City of Melbourne, canvassed solutions for improving circularity in the built environment.

Responses included:

- Creating a market for recycled products
- Reforming the National Construction Code
- Regulating waste suppliers to collect and transport materials more efficiently
- Education and awareness campaigns
- Financial incentives for circular strategies
- Adopting internal environmental and social prices
- Collaboration and international cooperation to achieve circularity targets
- Dis-agglomeration to waste systems, repairing and reusing waste materials, reducing the need for raw materials, and efficient design
- Resource management and efficiency, reduction in embodied carbon, and the use of a shadow carbon price to influence the upstream supply chain to decarbonise
- Reviewing subsidies shift to construction and engineering companies, and recognising the true value of products and systems
- Developing a Sufficiency, Efficiency and Renewables Framework – what is enough to thrive, and how do we make it efficiently and renewably?

The top three solutions to improving the circular economy were:

01

Regulatory change that creates financial incentives through policies and regulations in the form of subsidies, tax breaks, credit programs and other mechanisms, that encourage investments in products, equipment and infrastructure for waste reduction and recycling.

02

Investment in research and development in circular economy practice to encourage innovation in the field of waste management, and to create new markets and opportunities.

03

Capacity building for skills, knowledge, innovation and behaviour change through work with marketing and branding businesses to:

- Frame the circular construction process as one that makes clear sense
- Label products, training opportunities and processes clearly
- Introduce product stewardship whereby suppliers design out waste from the goods they supply

CASE STUDY

Circle House project, Denmark

In 2020 in Aarhus, Denmark, 60 social housing units, comprising two- and three-storey terraced houses and five-storey tower blocks, were built according to circular principles, with 90 per cent of materials able to be reused without loss of value.

DESIGN: A reuseable structural system including demountable and reuseable concrete foundations, steel walls, concrete slabs and steel plate connectors, was designed before any physical work began. This system ensured relatively simple disassembly as well as easy access to all parts for maintenance.

CONSTRUCTION: With clear purpose and a focus on the specific outcome of circularity, traditional building methods were abandoned as modularity rose to the top of the priority list. All parts of the buildings were reused from elsewhere – shingles were made from upcycled plastic waste; the facades, made from clay and reclaimed wood, are easily disassembled; and reclaimed timber features are found throughout. There is also great consistency of proportion, with just two sizes of wall elements and two lengths of beams.

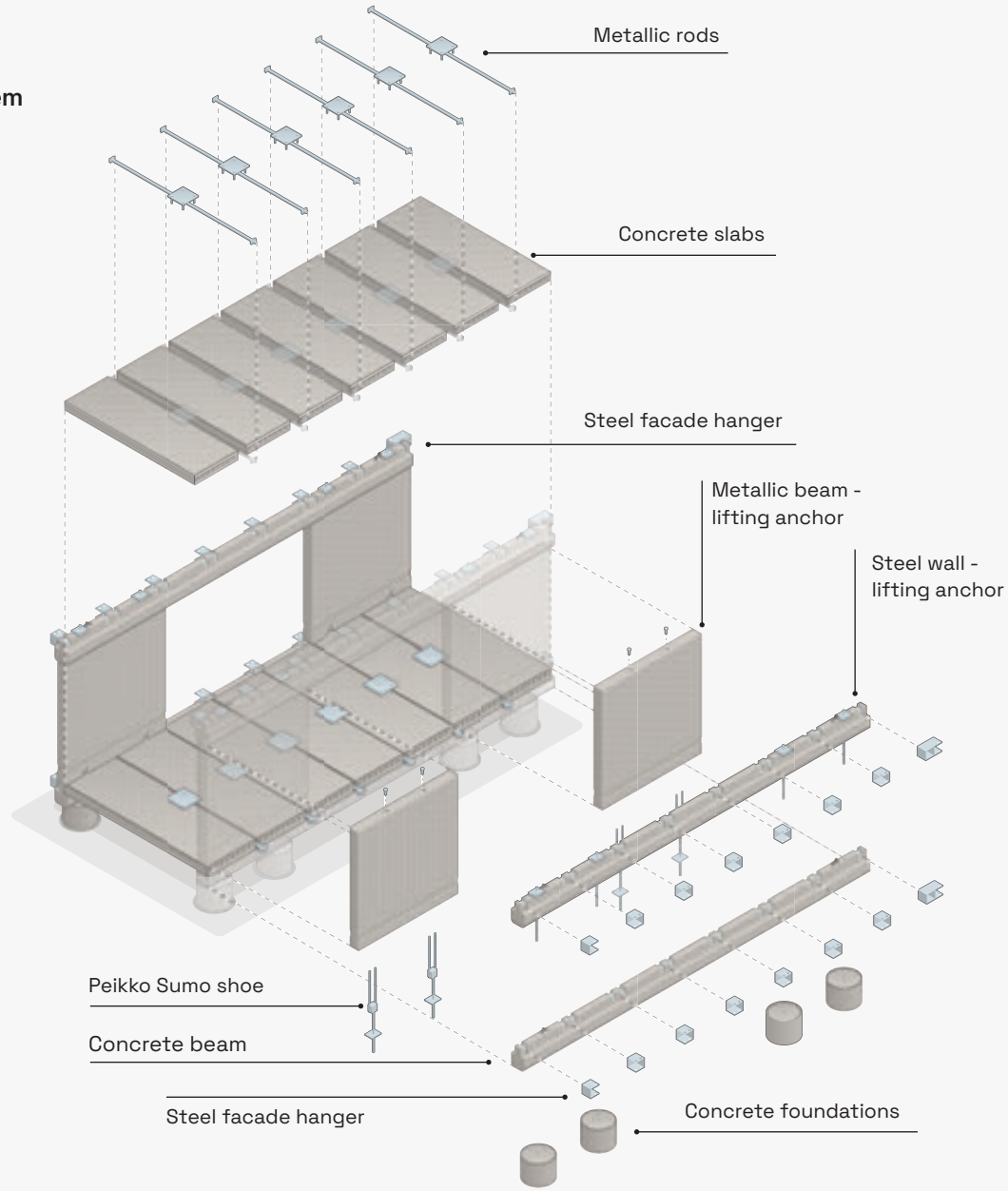
ABOVE:
Part of the Cirde House project in Aarhus, Denmark

MAINTENANCE: Every piece of the buildings contains an ID number, a barcode and an embedded RFID chip. This enables a material passport to be kept for each part during each building's life, and onwards as each piece is used in future builds. Digital maintenance chronicles are kept, ensuring engineers are always able to access records of various maintenance events during the life of the material.

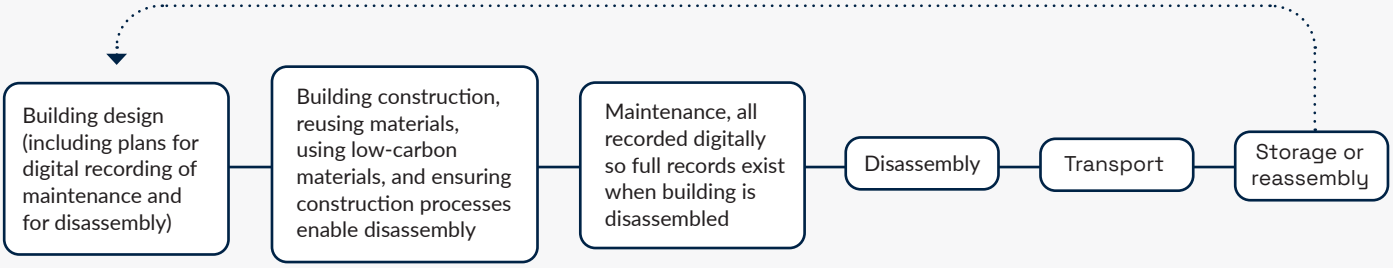
DISASSEMBLY: Clear disassembly plans and processes were drawn up during the design stage, enabling the economic and engineering value of each part of every building to remain intact.

REASSEMBLY: Thanks to the maintenance records, the consistency of dimension of parts and the ease of transport of materials, each segment can be designed into a new build.

Circle House demonstrator: structural system



Circular construction



This example illustrates an important point in sustainability reporting, said Cameron Kaufman, Circular Economy Specialist at Coreo. In circular construction, Kaufman said, diversion-from-landfill statistics mean little if they're not backed up by information about where the materials are instead being used.

"I don't care about the diversion-from-landfill target," she said. "Instead, tell me where you are directing those materials to capture and preserve their value. That is the flipping of the switch that we need to see."

Circle House is an excellent example of a circular build, Kaufman said.

"Everything is standardised and everything is designed for disassembly. All of the maintenance is recorded in a digital passport. There is a plan for every element of the buildings to be reused in 20 years. That is happening right now."

ABOVE: Cameron Kaufman, Coreo

Follow the leader

Australia's federal and state governments are also pushing the economy to go circular, beginning with the construction sector.

In terms of procurement decisions, and governed by the Environmentally Sustainable Procurement Policy, in place from 1 July 2024, the Federal Government encourages circularity through regulation, as do the Victorian, NSW and Queensland state governments.

The initial federal focus is on procurement of construction services at or above $7.5 million.

CIRCULARITY BY THE NUMBERS

3 in 4

G20 NATIONS HAVE AN OVERARCHING CIRCULAR ECONOMY POLICY – AUSTRALIA DOES NOT

Other categories being introduced on 1 July 2025, at or above a value of $1 million, are:

- Furniture, fittings and and equipment
- Information and communication technology goods
- Textiles

The policy outlines a number of principles suppliers will be asked to address, including circularity issues such as:

- Waste minimisation
- Use of less materials
- Ability to be deconstructed and reused
- Use of refurbished or reused materials
- Ability to be recycled at the end of the material's useful life

Public Service entities and their suppliers will be required to prove the various environmental claims.

"The circular economy is the big opportunity to decarbonise the built environment sector in Australia," the DCCEEW spokesperson said. "There's a bit left to do in terms of electrification, but then it's all about the materials we're using and how much carbon is in them. You'll see a big focus on that, on reusing materials, and on not knocking buildings down, but instead refurbishing and adaptively reusing them. They're the big-ticket opportunities for decarbonisation in Australia." □

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Includes an optional hands-on coding session and free lab tours the following day. Use the QR code below for more details, including registration.

Many engineers are unaware that they can deploy machine learning (ML) —based solutions in their industry to reap enormous benefits. Providing machines or processes with the capability to think for themselves can increase productivity, improve quality, reduce waste, encourage the more sustainable use of precious resources such as water, improve the quality of medical interventions, and help Australia reach near-net-zero targets faster.

The symposium will explore the various advantages we, as scientists and engineers, could generate by transforming our processes and devices to autonomously adapt to changing environments, similar to how self-driving vehicles continuously adjust to their surroundings.

- Renowned keynote speakers from across the globe will share insights on leveraging ML-based strategies to enable adaptive, autonomous decision-making in systems.
- The symposium will cover a diverse range of domains, including additive manufacturing, flow chemistry, robotics, energy, aerospace, quantum computing, digital twins, Australian standards, and more.
- Attendees can take advantage of excellent networking opportunities, including a cocktail reception at the end of the day.
- CPD hours.
- The registration fee may be tax-deductible for some, as it can qualify as a career enhancement expense.

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WORDS BY CAROLINE RICHES

The migrant experience

Overseas-trained engineers are vital for Australia, but it's not always smooth sailing. What is being done to break down barriers and make the most of their skills?

BY THE NUMBERS

AUSTRALIA GRANTED

2931

TEMPORARY VISAS AND

8574

PERMANENT AND PROVISIONAL VISAS TO ENGINEERS

When Gaudioso Jr Balot MIEAust CPEng NER took his engineering licensure exam in the Phillippines, he was among the top 20 per cent of his university cohort. But when he came to Australia in 2005, he felt like "an imposter in his own profession".

"My wife kept encouraging me to go back to engineering, but it was heartbreaking," he said.

With only $1000 in the bank and living with relatives, Balot worked as a labourer before finding a job in a factory.

Despite his extensive experience in surveying, designing, CAD drafting and construction, his job search was hindered by a lack of local experience and references, and significant language barriers.

"I'm a licensed civil engineer back home, but companies here didn't recognise my qualifications," he explained. "I handed in more than 200 applications, but only got two or three interviews. I was trying to tell people I was an engineer, but nobody was listening.

"I lost my confidence as an engineer and I lost the motivation to return to a profession that I loved. Every day in that early period I told myself not to cry because, if I started, we would go home, and I wanted to give this the best shot I could."

Anita Anchery experienced similar challenges. She completed a degree and post-graduate studies in civil engineering in India, then worked for four years as a structural engineer before having children and moving to Australia in 2018 for her husband's job.

She took some time off work to look after her kids, then eagerly looked for opportunities when they started school – but she was in for a shock.

"I realised that it's not easy to get a job in Australia, that an overseas qualification is not something that anybody considers," she said. "I needed to prove I had local experience, which was really hard."

ABOVE: Gaudioso Jr Balot MIEAust CPEng, Sydney Trains; Anita Anchery, PTG Group

Struggles and barriers

While not all overseas-qualified engineers struggle to find engineering positions, many do – despite the fact the existing workforce consists of more migrant engineers than local engineers.

Almost three in five engineers working in Australia were born overseas, according to Engineers Australia's research report *Barriers to employment for migrant engineers*.

"Australia is highly reliant on migrant engineers," Michael Bell AffilIEAust, Head of Policy at Engineers Australia, said. "We have a lot of challenges developing engineers locally. Engineering university commencements have been declining since about 2018.

"While we're working as a country to improve that, it's going to take time."

Australia produces the second-lowest percentage of engineering graduates across the G7, ahead only of the US, according to OECD data. Meanwhile, the need for engineers is only increasing due to major government investments under the Future Made in Australia agenda.

"With the transition to net-zero emissions and the broader energy transition, the rise of artificial intelligence and the drive to increase onshore manufacturing, we require specialised engineering skills," Bell said.

Fortunately, Australia attracts many migrant engineers. In the program year up to May 2024, the country granted 2931 temporary visas and 8574 permanent and provisional visas to engineers, recognising their qualifications through the Washington, Sydney and Dublin Accords.

India, China, the United Kingdom, the Philippines and Sri Lanka were the top countries of origin, according to the 2021 Census.

"We're certainly an attractive nation, with our high salaries, good weather and beaches. Engineers clearly want to come here," Bell said. "But while we seem to be able to get the skills in, in many cases, our migrant engineers aren't using them."

Despite being overseas-qualified and issued with visas for their skills, only around 40 per cent of skilled migrant engineers in Australia are employed in an engineering role.

The *Barriers to employment* report identified issues such as a lack of local >

knowledge and experience, perceived cultural differences in soft skills, visa or sponsorship issues, a lack of local references, certification queries, flight risk concerns, and a tendency to hire within networks for senior roles.

Bell describes these barriers as a "challenge that needs to be addressed".

"If we don't overcome the barriers to employment migrant engineers face, we will be a less appealing country to come to."

Matching skills to needs

The government is currently overhauling its migration program to attract and retain skilled migrants crucial for Australia's long-term prosperity, and has sought public input on how to reform the points test to better identify these individuals.

In a May submission to the Department of Home Affairs, Engineers Australia recommended prioritising necessary skills and experiences in the points test, including bonus points for skills in priority industries like renewable energy.

"There's a breadth to engineering; it's one thing to say Australia needs mechanical engineers, but where do we need them?" Bell said. "We need to ensure migrant engineers have the experience that we're lacking because that will make them in-demand, while ensuring we get the skills we really need.

"We should also consider visas and ensure migrant engineers aren't tied to a region that doesn't have a lot of engineering work."

A spokesperson for the Department of Home Affairs told Engineers Australia that its aim is to better align the skills of incoming migrants with Australia's needs.

"Skilled migration reforms announced in the Migration Strategy [released 11 December 2023] will better connect skilled migrants to Australia's skills needs, helping to reignite productivity growth, which will ensure rising living standards, business growth and better wages," they said.

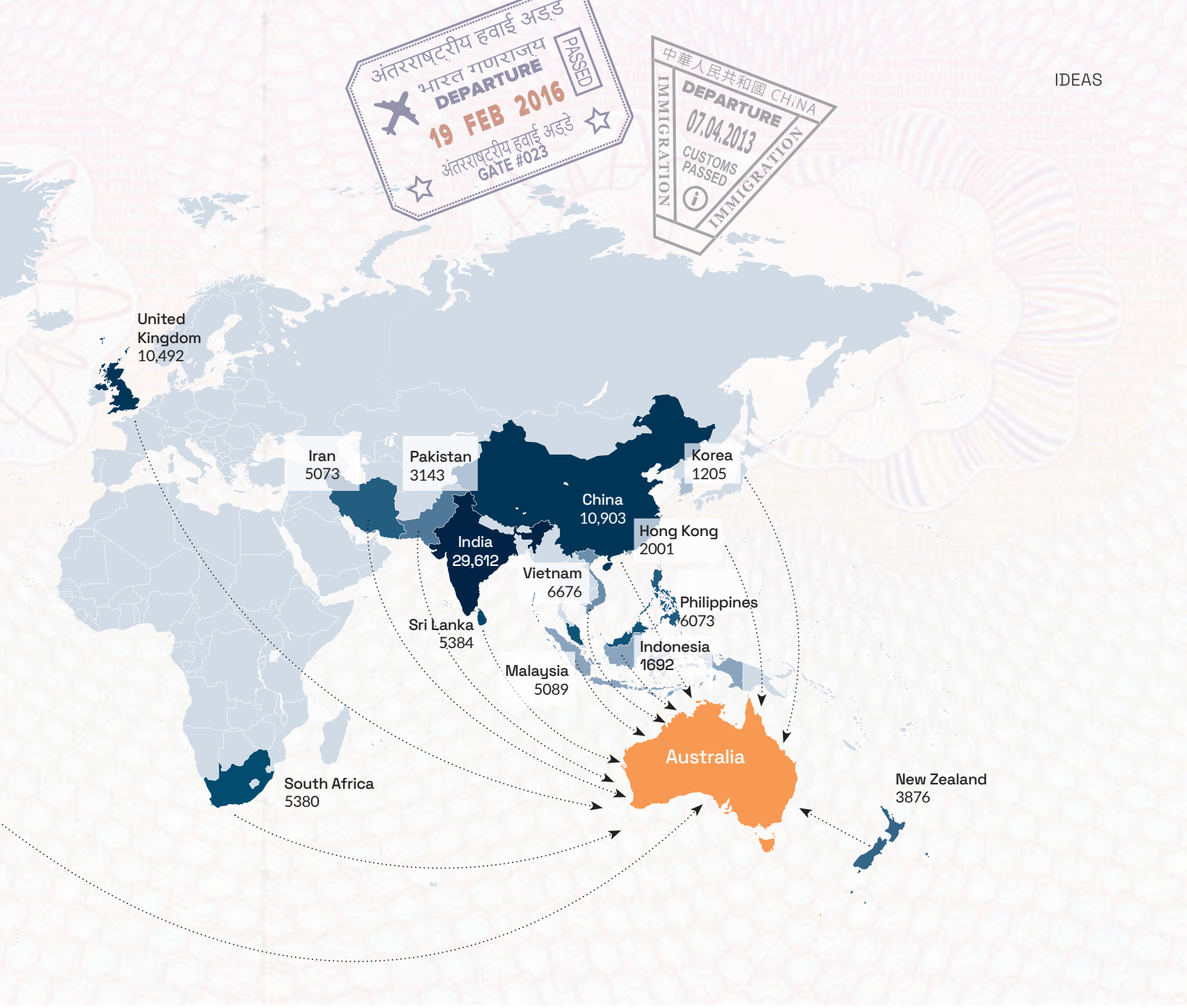
Australia also encourages international students who graduate locally to remain in the country through its Professional Year in Engineering program. This initiative, which includes experience-rich workplace internships, helps improve employment outcomes and boasts an employment rate for engineering graduates who complete the program of above 80 per cent.

ABOVE: Michael Bell AffiliEAust; Shellie McDonald, Engineers Australia

> "To build a more diverse workforce, we need migrant engineers. We need their global experience."

Getting new talent

With a lack of local experience identified as a significant hurdle in the *Barriers to employment* report, Engineers Australia created a Global Engineering Talent (GET) Program in 2023 to help migrant engineers find



rewarding employment in their field more quickly while supplying businesses with a steady stream of skilled candidates.

To be eligible, engineers must have a relevant degree and three years of overseas experience in the field, with Engineers Australia matching their skills to appropriate employers.

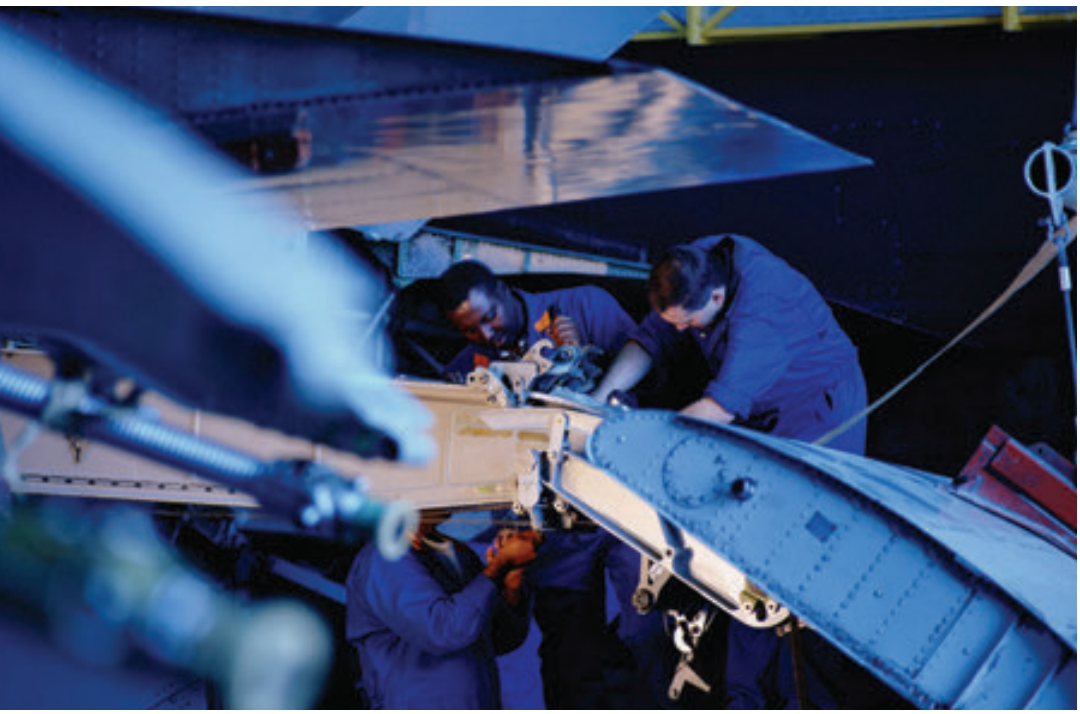
The 18-week program includes six weeks of online training on Australian standards in work, health and safety, technical terminology and engineering project operations, followed by a paid work placement. The program is employer-funded, with additional support from the Queensland and Northern Territory governments. Engineers Australia has also called for national funding for the initiative.

"The long-term objective of the GET Program is to change the narrative around migrant engineers," Shellie McDonald, Senior Manager of Engineering Talent at Engineers Australia, told *create*.

"We want Australian employers to recognise their experience and qualifications, and move away from treating skilled and experienced migrant engineers like graduates."

The feedback from employers has been positive. "They've told me that the program is enlightening and gives them a better understanding of overseas experience and engineering qualifications," McDonald said.

While there's no guarantee of employment with the host employer after the placement, 90 per cent of participants from the first pilot were offered further opportunities with host employers. >



"Even if they aren't, they will at least have 12 weeks of Australian experience on their resume, plus a year of Engineers Australia membership for further training and networking," McDonald said.

To date, more than 200 engineers have registered for the program, with 17 companies on board. Anchery, who took part in the program, found the experience transformative. After applying, she was selected by PTG Group for a placement.

"I felt so lucky. Even if I wasn't offered a permanent position, I would at least have a three-month experience working in Australia, which was a big deal," she said.

She said the online training provided a "broad view" before entering her workplace. While she was initially nervous at the start of her placement, her experience was positive.

"When you come from a different country, the work culture and processes are all so different. But I received immense support from the team and everybody was very patient. It was a really good experience."

Anchery was actively involved in various projects and appreciated the exposure to both offsite and onsite work.

"By the time the three months were up, I was sure this was what I wanted to do and this was the company I wanted to work for," she said.

Post-placement, PTG offered Anchery a permanent role on its Brisbane structures team.

ABOVE: Jamie Alonso, PTG Group

Power of diversity

PTG Group CEO Jamie Alonso is proud that his company was the first employer host of the GET Program and praises Anchery as a "fantastic" addition to his team.

"We were struggling to find talent so jumped on board right from the start," he said. "It was great to see Anita's readiness, enthusiasm and excitement about joining the team, which is a great reflection of the GET program."

He said PTG will continue to assess talent through the program.

"We're constantly evaluating who we need to recruit for our growth goals and we will keep looking into the program for candidates, given its positive impact for us. It's great to have access to a wider talent pool."

Alonso added there's "often an unconscious bias that migrant engineers may not meet the required standards", which the GET Program helps to dispel.

"The beauty of the program is that Engineers Australia vets the candidates and validates their qualifications, ensuring they are technically proficient. Having the tick from Engineers Australia makes the decision easier.

"The nine-week trial not only lets us assess the individual but also allows them to decide whether they like our company and culture. It works really well."

As a migrant himself from Spain, Alonso loves how the GET Program promotes diversity.

"When you look at our most successful offices, they often have significant cultural diversity within the workforce. Our varied experiences enable us to approach projects from different perspectives, which gives us a wider overview of solutions so we're able to offer clients more comprehensive options."

Hydro Tasmania, meanwhile, was the first employer in Tasmania to join the GET Program, selecting Surendran Rajindram, a mechanical engineer from Malaysia. Rajindram completed an internship with the major projects team, which is working to expand the island state's hydropower capacity.

Laura Jacques, People and Culture Manager, said Rajindram "absolutely smashed it".

"He's been a fantastic addition to the team and a valued contributor. We've now extended him an offer of full-time employment."

Jacques said skilled migrants have a lot to offer Australia, but are often overlooked because they don't have local experience.

"Australian employers are less familiar with overseas employers, so migrants don't get a fair go compared to those educated

and employed locally. This is an injustice we wanted to address. Skilled migrants bring diverse perspectives that enhance our culture and the quality of work.

"We're very excited about our ongoing partnership with Engineers Australia and we look forward to continuing to support this important initiative."

She added that once recruited, it's crucial for Australian employers to support overseas-qualified employees through diversity and inclusion initiatives.

"At Hydro Tasmania, we offer public holiday swaps, allowing employees to exchange traditional Australian holidays for those aligned with their culture or beliefs. We also provide training on respectful workplace behaviour and creating an inclusive environment."

Jacques said employers should recognise the skills and value of overseas-qualified individuals and tap into the deep talent pool of skilled engineers. "If employers hire an engineer with overseas qualifications, they will be gaining a valuable employee and helping to break down barriers to employment for skilled migrants."

McDonald said the GET Program gives Australia an opportunity to raise the profile of engineering and build a more diverse workforce that includes more women and migrants.

"We know that diversity enhances innovation and boosts business outcomes, and we know that it improves staff engagement, so it helps to both attract and retain employees. To build a more diverse workforce, we need migrant engineers. We need their global experience."

However, McDonald noted that companies must ensure their HR processes are inclusive.

"You hear the good stories when a company has employed a migrant engineer and says how great they are, but often there's still an unconscious bias through the recruitment process."

Scoring a break

Anchery hopes more companies will sign up for the GET Program to help integrate more migrants into the engineering workforce.

"To find a job, migrants just need that first opportunity. There are many migrant engineers who are capable of making a difference in Australia but like me, they simply have no idea how to."

After seven years of struggle and hard work in Australia, Balot also had success in scoring an engineering role. He decided to return to university to study English as well as structural engineering. After graduating, he joined EA as a graduate engineer and progressed through the organisation's competency standards to become Chartered.

He then landed a job in the private sector as a draftsperson, before moving to Sydney Trains where he's worked for six years, first as a Design Officer then as a Design Engineer.

"It took me a very long while to get back on the right track, but I was determined, and what I've achieved makes me happy," he said.

Balot is now leader of the Sydney Migrant Engineers support group, and is passionate about helping engineers with overseas qualifications transition into engineering careers in Australia through training workshops and networking opportunities.

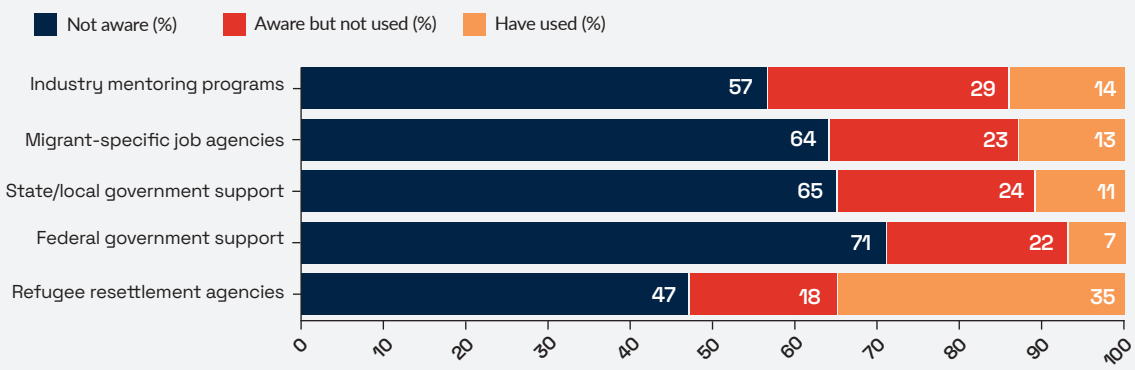
"When I arrived in 2005, I didn't know where to go for help. Now I want to guide other migrant engineers to stay in the profession, to do their best to make it work," he said.

"I hope that one day we can break down these barriers to employment so we have a good balance of migrant and homegrown engineers. There are so many opportunities in Australia for engineers to learn and do what they love." □

ABOVE: Surendran Rajindram; Laura Jaques, Hydro Tasmania

"I handed in more than 200 applications, but only got two or three interviews. I was trying to tell people I was an engineer, but nobody was listening."

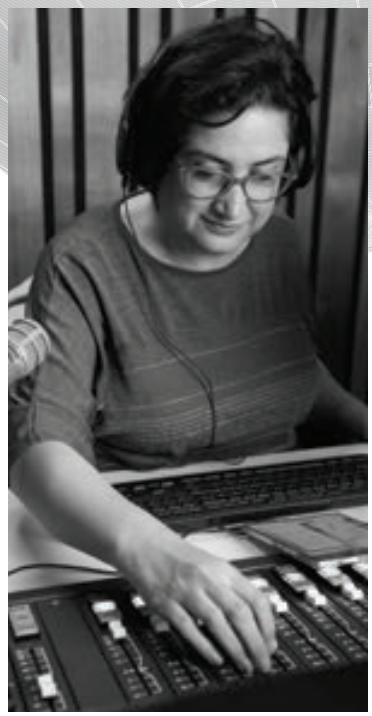
Awareness and use of support services



Three very different experiences

ELENA SHULYAK FIEAust

When Russian-born Elena Shulyak arrived in Australia, she expected a very different environment. "The culture is much more relaxing here," Shulyak told *create* on board one of Sydney's ferries; she works as a Fleet Performance Manager for Transdev. "It's friendlier. People are more supportive, and helped me settle in when I arrived." She said that similar programs and methods are used by engineers in both countries, which eased the transition.



SHAZA RAVAJI

Despite training in biomedical and medical engineering in Tehran, Shaza Ravaji no longer practices directly, although she is still closely involved. "I work for a biomedical engineering company that designs medical implants, and I manage distribution," she said. "My husband is a biomedical engineer as well, so I help him in his work." Ravaji also maintains connections with the profession via a role at the Royal Adelaide Hospital. She is a podcaster and a PhD candidate at the University of South Australia.

TEDDY ZVIDZA GradIEAust

"I'd like to get into politics," Teddy Zvidza told *create* with enthusiasm. "I believe my engineering background would bring something different to policy and international relations. If you ask my friends, they'd say I'd like to become the prime minister. If I can't do that, I'd definitely like to be the country's first Black Secretary of the Department of Defence." Zvidza, who works as a safety engineer in the Defence industry, was named the 2024 Canberra Emerging Professional Engineer of the Year.

Watch interviews with Shulyak, Ravaji and Zvidza on the create website.

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At arm's length

WORDS BY MEGAN BREEN

In a country the size of a continent, "remote" is a familiar word. These days, remote also describes the array of new technologies that promise to improve safety and productivity – and make the tyranny of distance no impediment to getting the job done.

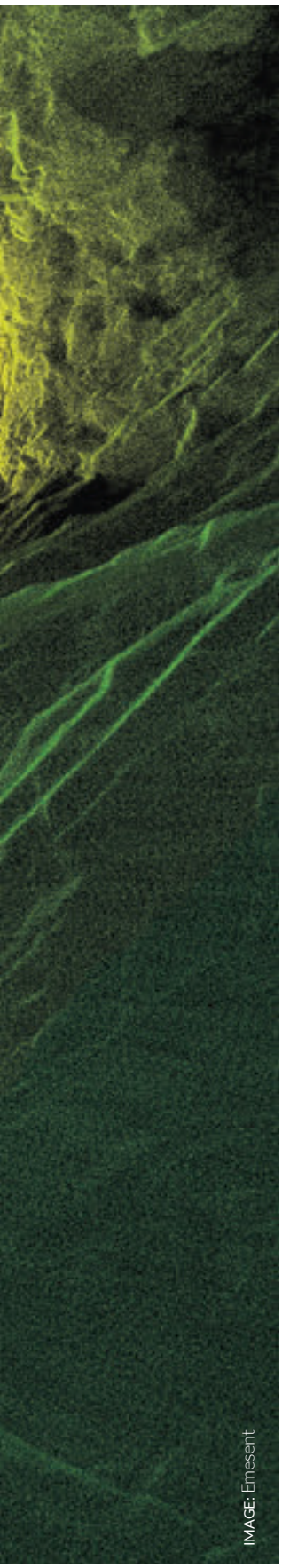


IMAGE: Emesent

From mining to aerospace, remote technologies are enhancing efficiency, improving safety and minimising the time engineers need to spend in harsh and challenging conditions.

The oil and gas industry uses remote operated vehicles (ROVs) for deep-sea tasks and automated well monitoring systems for real-time performance tracking. Construction benefits from building information modelling (BIM) and remote management tools such as drones. In the energy sector, smart grids and wind turbine sensors enable remote monitoring and optimisation.

Engineers Australia Acting Chief Engineer Bernadette Foley FIEAust CPEng EngExec told *create* there have been significant improvements in both safety and productivity in all industries that have embraced remote technology for operation and monitoring from a distance.

The use of technology has changed how engineers and associates approach their work, shifting from hands-on tasks in hazardous environments to remote oversight. This transition not only enhances operational efficiency, but also significantly reduces exposure to risks such as heavy machinery accidents and extreme conditions.

"Automation has been a game-changer in improving safety for engineers," Foley said. "Tasks that once involved significant risk, such as handling hazardous materials or performing high-risk maintenance, are now safer thanks to the use of remote systems.

"This has led to a cultural shift within the industry, where safety is increasingly built into the design and operation of engineering systems."

ABOVE: Bernadette Foley FIEAust CPEng EngExec

Remote technology in action

In the demanding environment of the Pilbara, Rio Tinto's mining operations are heavily reliant on advanced technology to maintain efficiency and safety. The company's Remote Operations Centre (ROC) in Perth, located 1500 km from the mining site, plays a crucial role in this setup.

Mining industry director and consultant Greg Lilleyman said the current ROC used by Rio Tinto is a far cry from its first iteration, which was basically a desk and a computer in a room in London House, Perth. The technology has come a long way and is now embedded in mining operations around the globe, he said.

"We pioneered the first remote operations centre to see how easily we could control and run the processing plant at the West Angelas mine in the Pilbara from a desk in Perth," he said.

"When that was successful, we then introduced the modular mining dispatch system and ran the pit control as well from the scaled-up location at Wesfarmers House."

Today, the ROC leverages artificial intelligence and real-time data analytics to manage operations, predict equipment failures and optimise performance. It oversees rail systems, infrastructure and port operations, making it a central element of Rio Tinto's operational strategy.

The company's early adoption of remote operations began with the introduction of fully autonomous haul trucks in 2008. This approach has since become standard in the industry, with companies such as BHP implementing similar systems in 2013 to manage their Pilbara operations remotely. The success of these ROCs has driven a wider adoption of remote management technologies across the global mining industry.

While there are some personnel onsite for tasks that require human intervention, such as maintenance, inspections and emergency response, the remote management system has greatly minimised the need for a large onsite workforce. This has not only improved safety and productivity, but also attracts candidates who value not having to relocate from Perth.

"While it's possible to handle diagnostics onsite, it's often challenging to attract skilled professionals to remote mine sites," Lilleyman said. "Remote operations centres in major cities like Perth allow these experts to contribute to value-added work without needing to relocate.

"For example, a haul truck is equipped with hundreds of sensors around its engine and components. When a sensor triggers a warning, the truck's system only provides basic alerts: an orange light for a minor fault and a red light for a severe issue >

– essentially a 'check engine' or 'stop engine' signal," he said.

"At a remote operations centre, a specialist engineer can analyse detailed data from these sensors. If a sensor indicates that cylinder number five is running cooler than the others, the engineer might diagnose a potential problem, such as a glow plug failure or an injector fault.

"They can then offer precise advice to the onsite tradespeople, helping them address the issue more effectively."

For the mining and offshore energy industries, the biggest benefit in terms of productivity for engineers is the reduction in travel time, Foley said.

"You no longer need to travel to a remote area to manage a mining or energy asset. Similarly, remote sensing technologies and UAV [unmanned aerial vehicle] inspection can provide huge productivity boosts, while increasing safety through reduced need to work in hazardous environments or at heights."

Putting safety first

Professor Robin Burgess-Limerick from the Minerals Industry Safety and Health Centre (MISHC), University of Queensland, said there is clear evidence that removing people from hazardous mining environments through remote operations technology has major safety benefits.

"Autonomous haulage systems, which track the position of every vehicle and incorporate extensive safety measures, aim to prevent collisions – and notably to date there have been no significant incidents involving autonomous haul trucks and other non-autonomous vehicles," he said.

Research undertaken by MISHC shows the total number of autonomous haul trucks in operation globally in 2022 was 1070 (an annual increase of 39 per cent), of which 706 were operated in Australia; and the number of autonomous trucks in operation globally is forecast to exceed 1800 by the end of 2025.

"In some metal mines, semi-autonomous loaders are used, which significantly improves safety by reducing exposure to dust, vibration, noise and musculoskeletal disorders. Previously, workers operating these loaders faced severe risks – such as being thrown forward if the bucket struck a rib – so removing people from those loaders is definitely beneficial. Those are horrible jobs from a health and safety point of view."

In underground mining, different hazards are being addressed, such as automating longwall shearers, which use rotating drums equipped with sharp, heavy-duty bits to shear the coal from the face of the wall.

"In underground coal mining, there is also progress in automating longwall shearers, which reduces the number of workers needed on the longwall faces," Burgess-Limerick said. "Although complete removal of personnel

ABOVE: Professor Robin Burgess-Limerick, University of Queensland

IMPROVEMENTS DRIVEN BY AUTOMATION

MINING

81%

REDUCTION IN FATALITIES (12.4 DEATHS PER 100,000 IN 2003 REDUCED TO 2.4 IN 2022)

TRANSPORT

15%

INCREASE IN FREIGHT PRODUCTIVITY BY USING AUTONOMOUS LOGISTICS VEHICLES

ENERGY

60%

REDUCTION IN ELECTRICAL GRID SYSTEM DOWNTIME BY USING REMOTE SYSTEM DIAGNOSTICS

Sources: Engineers Australia, Safe Work Australia, Transport Australia Society

IMAGE: Emesent

from these operations is still a way off, automation is making substantial strides in enhancing safety."

Rio Tinto has also reported the technology used in the ROCs has significantly contributed to improved safety outcomes across its operations. The company's 2023 annual report highlighted a reduction in the all-injury frequency rate from 0.40 in 2022 to 0.37 in 2023, partly attributed to innovations such as ROCs.

The adoption of ROVs in subsea operations has also improved safety conditions and decreased the need for divers to work in hazardous conditions such as high-pressure environments and low-visibility areas.

As a result, the incidence of accidents and fatalities involving human divers has declined. Reports from the International Marine Contractors Association have documented trends showing fewer fatalities and serious injuries, attributing this decrease in part to the broader adoption of ROV technology.

For example, the lost time injury frequency rate dropped between 2006-20 from one per 100 million hours worked to 0.38, and the fatal accident rate dropped from 2.72 to 0.31 in the same period.

According to a spokesperson from Italian cable maker and installation services provider Prysmian, which recently signed a $647 million contract to supply and install a new interconnector between Victoria and Tasmania, the use of ROVs in their operations has increased safety primarily because it means divers are used less often.

"One of the aspects we always consider when planning our installation activities is to minimise the use of divers, and by doing so we have drastically reduced one of the most risky factors of a subsea cable installation," they said.

"Today, the vast majority of activities are executed through ROVs, still operated by technicians but from safe locations inside the installation >

ABOVE: Lori Brown, University of Michigan

Using technology to train maintenance engineers

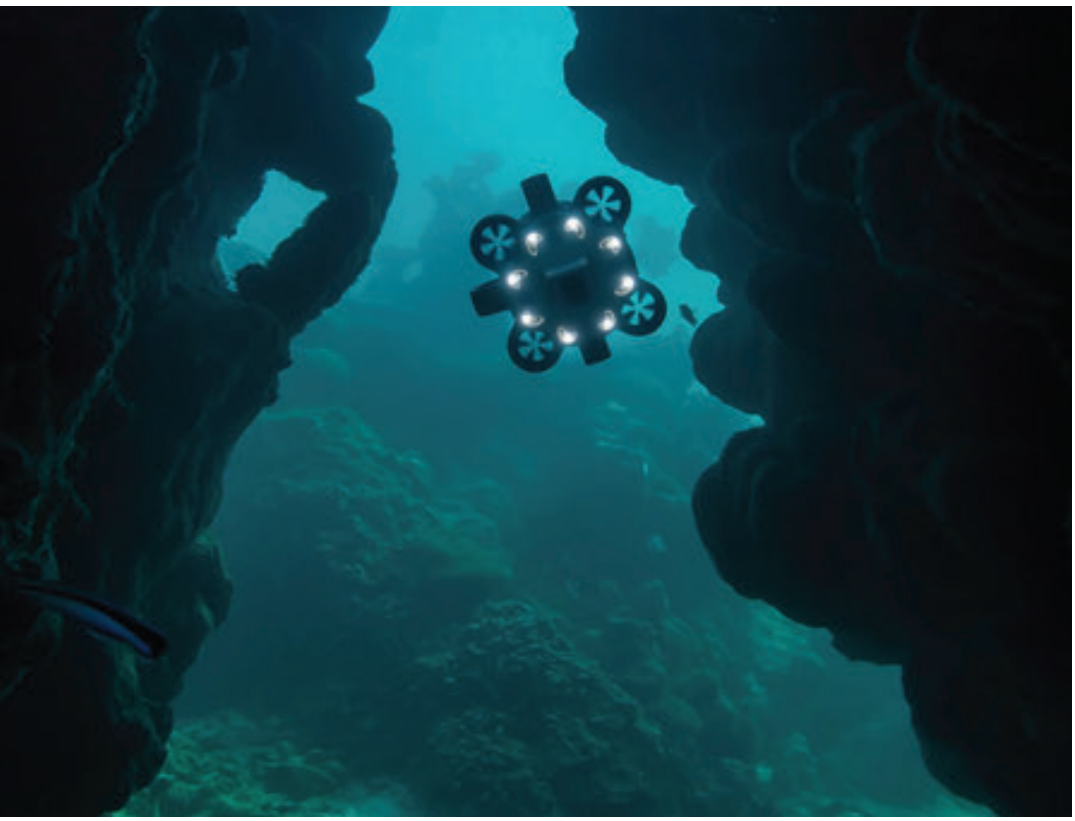
Mixed reality (MR) applications, which blend augmented reality and virtual reality, are transforming interactive learning and training. By creating immersive environments where digital and physical objects coexist and interact in real time, MR is reshaping education.

At Western Michigan University's College of Aviation, Professor Lori Brown has integrated MR into the core of aircraft technician training. "We can build a full digital twin of an aircraft, replicating all the features of its physical counterpart," she said. "This allows technicians to familiarise themselves with aircraft systems, components, checklists, flows and procedures in an immersive way."

This technology is especially valuable in maintenance training, where digital overlays reveal the inner workings of components, enhancing understanding and safety. "MR lowers the risks associated with traditional training methods, reduces the need for large physical training labs, and supports retention and immersion, all while offering mobile, cost-effective solutions."

The aviation industry faces a growing need for skilled technicians, with computer-aided engineering predicting a demand for 402,000 personnel over the next decade. This underscores the importance of innovative training methods that resonate with the younger generation of aircraft maintenance technicians.

Looking ahead, Brown sees the convergence of AI and AR as a transformative force in aviation training.



vessel. Cable pulling, trenching and landings are all done by machines, and that has increased the safety level of human operators."

Increasing productivity

Alongside the improvements to safety, advanced remote operations technology has a huge impact on productivity, said Professor Farid Boussaid of the University of Western Australia.

"We can now automatically identify issues in a mine or a plant and make decisions without being there. You can change your maintenance schedule, improve operational efficiency and, with drones, monitor offshore platforms and get first-hand data," he said.

"The amount of data is enormous – but you also need a more diverse, skilled workforce to be able to use that data. We need engineers who can operate algorithms to process and interpret data effectively so they can focus on more complex and interesting work that artificial intelligence cannot manage."

> "I always stress that while automation offers significant benefits, it is essential to consider human capabilities and limitations in its design and implementation."

Engineers Australia is proactively addressing this by offering targeted professional development and ensuring that educational outcomes prepare the next generation of engineers for these challenges, Foley said.

"As automation and remote operation technologies continue to evolve, engineers must adapt by acquiring new skills. Knowledge in data analytics, cybersecurity and programming is becoming essential," she said.

Another key technology enabling remote work is the digital twin, which involves creating a replica of a plant or mine to allow companies to simulate and predict system behaviour under various conditions, Boussaid said.

"It provides powerful insights for managing and improving operations, and it is something that companies have been developing because if they can put the real-time data in a model of a mine, then they can predict what's going to happen before it happens."

ABOVE: Advanced Navigation's micro AUV Hydrus; Professor Farid Boussiad, University of Western Australia; Greg Lilleyman

Addressing challenges

Burgess-Limerick argues that advancements in technology bring several new challenges, including the removal of people from direct observation of operations. This shift creates difficulties in maintaining situational awareness in control rooms.

"We should be cautious of overtrust in automation," he said. "For example, while autonomous vehicles have safety features, they cannot always overcome the laws of physics, such as stopping quickly on a wet ramp.

"Additionally, systems must account for human cognitive workload to avoid overloading control room operators."

It's a concept that resonates with Lilleyman, who argues it is important to integrate technology in a way that genuinely enhances productivity and safety, rather than adopting it for its own sake.

"As an engineer, I might not fully grasp all the underlying technology, but I do understand its potential and how it should be integrated with its impact on people. When we began automating our haul fleet at Rio Tinto, it was a daunting transition for all the truck drivers involved.

"I had extensive discussions with the technology teams, emphasising that this was a people-focused project, not just a technology initiative."

It's vital humans and machines work together. "Automation offers significant benefits, but it is essential to consider human capabilities and limitations in its design and implementation." □

IMAGE: Advanced Navigation

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- Direct Online Support
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Compliance Checking

- ☑ **clause 2.5.5.3 arcing fault clearing capacity of protective devices for feeds of 800amps and above**
- ☑ **clause 2.5.7.2.3 supply circuit discrimination with option for checking protective devices less than 250amps**
- ☑ **clause 5.3.3.1.1 protective earth conductor thermal stress check**
- ☑ **clause 5.7.4 earth system impedance check at 0.4 s and 5 s disconnect times**

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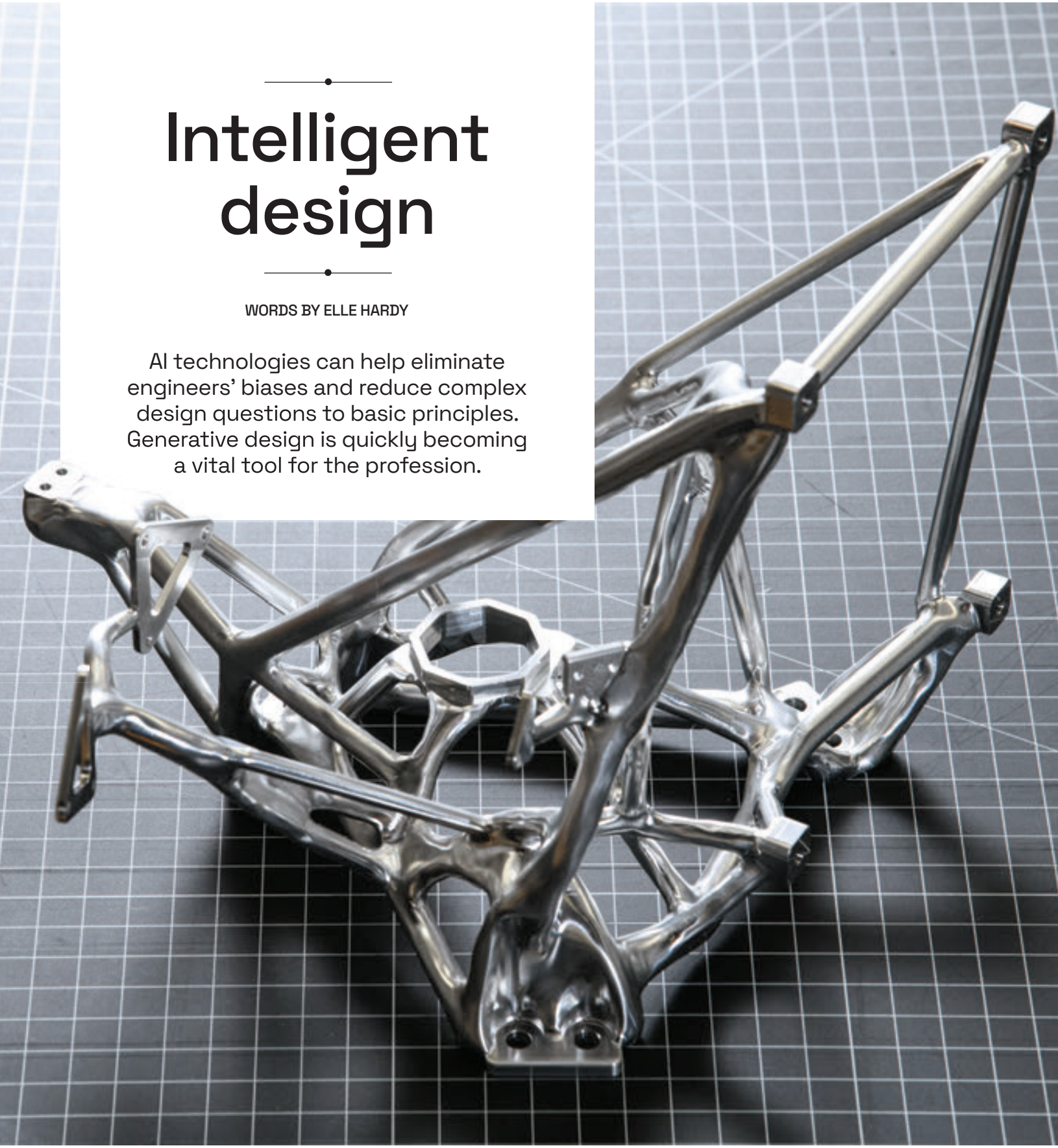
Intelligent design

WORDS BY ELLE HARDY

AI technologies can help eliminate engineers' biases and reduce complex design questions to basic principles. Generative design is quickly becoming a vital tool for the profession.



Hype around artificial intelligence (AI) remains sky-high, with some predicting it could add $200 billion per year to the Australian economy. But we still don't fully understand how it will affect engineering. But as engineers have thrown themselves at the task, solutions have started to appear. Some are now being implemented, others are in testing and more are in design.

Forget large language models (LLMs) such as ChatGPT. AI-powered generative design is showing strong potential as the leading technology to help engineers design faster and more sustainably, and achieve better outcomes.

It's an iterative process that allows engineers to collaborate with AI algorithms to create designs within a certain set of predefined constraints, it is changing the way engineers look at design. And while it's best known for making significant advances in additives manufacturing – where weight, strength and minimising waste are the name of the game – experts believe that's only the tip of the iceberg.

Long time coming

Andy Harris, Senior Research Manager and Head of Manufacturing Industry Futures at software firm Autodesk, said generative design is drastically accelerating and enriching traditional ways of design and manufacturing.

"It boosts innovation, speeds up the development cycle and promotes sustainable material use," he said. >

ABOVE: Andy Harris, Autodesk

"[AI in structural design] generates multiple solutions that consider functionality, manufacturability and cost, fuelling a more versatile approach to design challenges."

BY THE NUMBERS

THE PROPORTION OF CIVIL ENGINEERING FIRMS IN AUSTRALIA ACTIVELY USING AI TO ENHANCE INFRASTRUCTURE PLANNING

40%

AUSTRALIAN CONSTRUCTION COMPANIES PLANNING TO INCREASE INVESTMENT IN AI IN THE NEXT 12 MONTHS

80%

EXPECTED REDUCTION IN DOWNTIME OF INDUSTRIAL MACHINERY THANKS TO AI-ENABLED PREDICTIVE MAINTENANCE

20%

ESTIMATED INCREASE IN ENERGY EFFICIENCY THANKS TO AI OPTIMISATION

15%

NUMBER OF PATENT FILINGS BY AUSTRALIAN COMPANIES FOR NEW AI TECHNOLOGIES IN 2022 (LATEST DATA)

13,699

Sources: Australian Manufacturing Forum, Center for Security and Emerging Technology via Our World in Data.

"If we look at it through a manufacturing lens, it facilitates the design of complex and resource-efficient parts, often suggesting dozens or hundreds of ways to get to better outcomes, and it does so in less time than a designer could have explored a single concept."

By automating options for generation of design, engineers have an increased capacity to focus on optimisation and customisation, as well as improving product performance – without added complexity or cost.

"While topology optimisation focuses on material distribution within a space for structural efficiency, [AI in] structural design takes a leap to explore a wider array of possibilities," Harris said. "It generates multiple solutions that consider functionality, manufacturability and cost, fuelling a more versatile approach to design challenges."

To infinity...

Ryan McClelland, a research engineer at NASA's Goddard Space Flight Center, is pushing the possibilities for generative design to the limit.

"The 'text-to-spaceship' vision is a bold way of thinking about the maximum we can do with generative AI," he said. "At Goddard, we start with the science need, such as imaging exoplanets, and then that gets broken down into requirements, such as a certain size of mirror or kind of orbit. That is broken down into the requirements of the systems, such as what is needed from a detector."

NASA uses generative AI to help "radically speed up" this process of requirements decomposition. "Once you have those requirements – if you have computational design systems like text-to-structure – then you can almost fully automate making the structures," McClelland said.

He uses generative design to find areas where material isn't stressed, and remove them, before creating a surface that encompasses the higher strength zones. "It uses things like gradient descent to figure out what the next step is, but it isn't generative AI in the same sense that LLMs are generative."

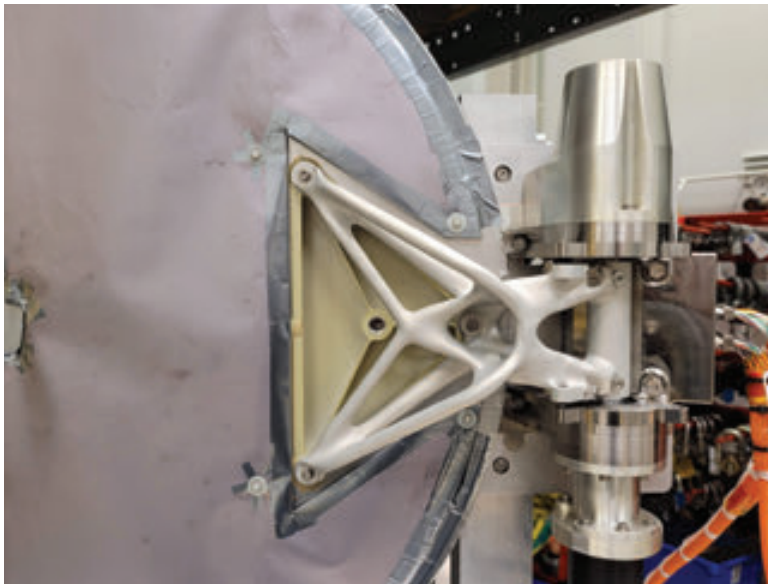
In fact, the inspiration for what NASA calls "evolved structures" came from the engineers noticing the parts "looked like alien bones".

> "The technology can rule out the bias of the engineer and reduce design questions to basic principles."

ABOVE: Ryan McClelland, NASA

While engineers tend to associate generative design with additive manufacturing, for NASA, this usually isn't the case.

"For most of our applications, additive is not the way to go. When we're CNC machining, it is made within plus or minus 75 µm in metric units," McClelland



ABOVE: Jacqueline Rohrmann, TBG Consult

LEFT: The Mars Sample Return Capture, Containment and Return System. Images: Netwon Engineering; NASA Goddard Space Flight Center

said. "One of the most surprising things we found is that, because of software advances, CNC milling of parts has a lower cost, lower schedule, better tolerances and higher strength."

Sky's the limit

Alongside traditional manufacturing methods, generative design can suggest larger and more complex objects than were previously thought possible. With it still in its relative infancy, engineers are continuing to explore new applications for generative design technology across a wide range of disciplines.

In additive manufacturing, for example, engineers can prototype products by quickly using test materials and perfecting designs before moving them into a live production environment. For injection moulding or casting, engineers can find a balance of mass and strength – a crucial step for selecting the metals and alloys for final production parts and structures.

Autodesk's Andy Harris points to Toyota Japan, which used generative design to make a seat frame thinner to create more space in its vehicle cabins. "The outcome was so positive it proved to be a roadmap for the company to consider other components to be optimised."

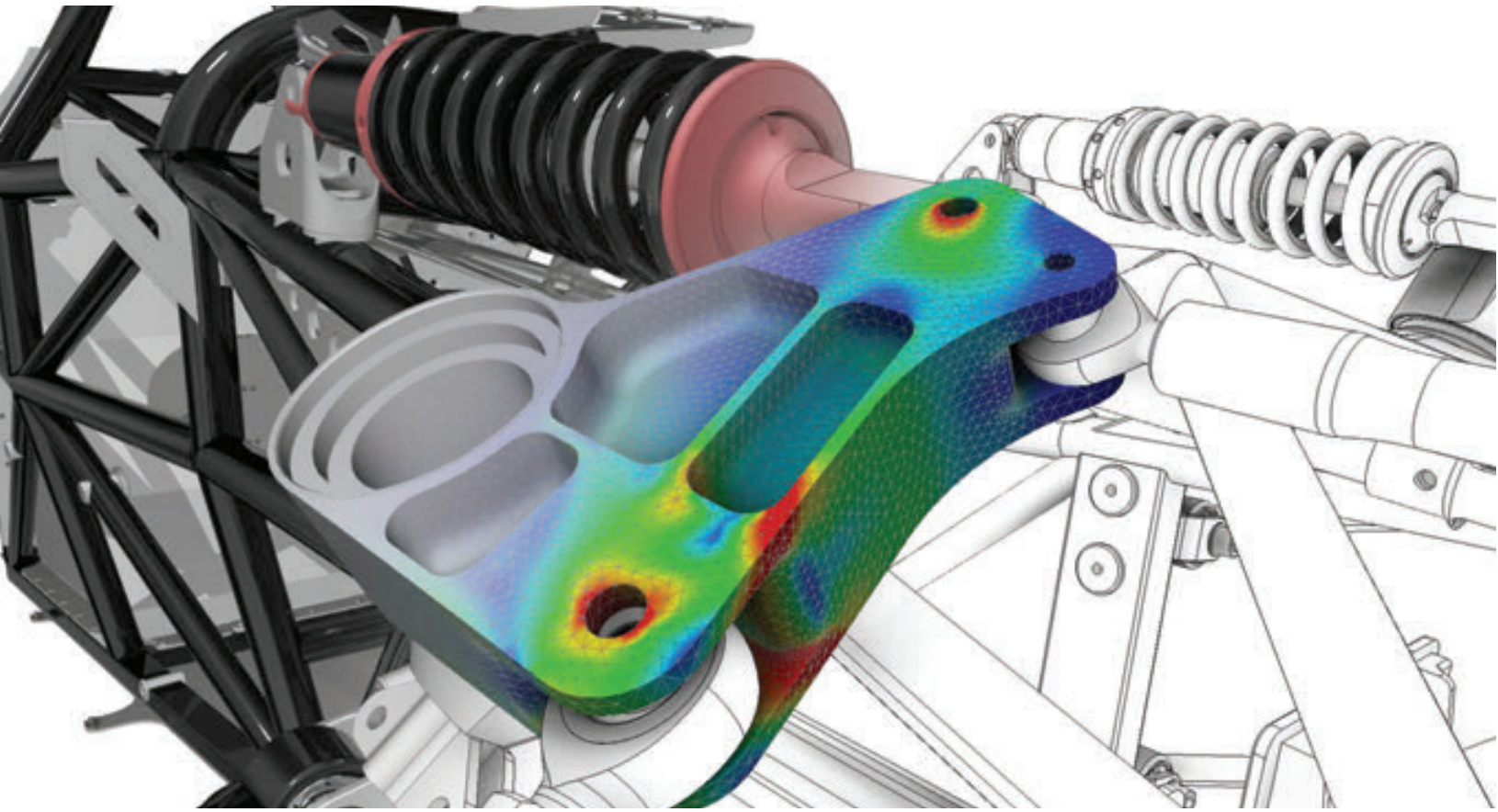
Advancing on the back of machine learning research and training methods, "early adopters are testing the results in real-world applications, and that's producing invaluable data from systems such as the industrial internet of things (IoT)," Harris said. "It's an example of how automation prompts new disciplines and skills to create a new set of jobs rather than replacing manufacturing staff."

Generative design is also helping industry manufacture more sustainable products. A study by McKinsey, which looked at the technology's impact on automotive, aerospace and sporting goods, found that generative design reduced material mass by up to half. Sporting retailer Decathlon has already employed generative design to halve the amount of plastic used to produce its performance swim fins.

Human vs machine

Engineering consultant Jacqueline Rohrmann said that a less heralded aspect of generative design is that it asks engineers to drill down into what they are trying to achieve, the limits they can operate within and which constraints need to be satisfied. Design parameters are often not linear in their effect on each other, so engineers work by trial and error. That's exactly what generative design algorithms automate, and they navigate design options at a faster speed than humans.

"The technology can rule out the bias of the engineer and reduce design questions to basic principles," she said. "Simple optimisation problems – say, finding the biggest square to fit inside a circle – can easily be solved mathematically by an >



engineer. However, in real-life applications, our engineering challenges are usually defined by many, often conflicting properties. Reducing one undesirable factor might increase another and eliminate a third."

More questions

Of course, no technology is without its pitfalls, and Rohrmann believes that the biggest obstacle in the implementation of generative design isn't related to regulation, compliance or manufacturing constraints. Instead, it lies in the fact that humans think and work differently to generative design processes.

"To use generative design, we need to describe our problem as a set of goals that we want the algorithm to optimise towards," she said. "In order for the software to do so, each goal needs to be matched with a quantifiable indicator.

"Factors such as revenue, material usage or energy efficiency can easily be measured. But what about the more elusive factors that turn an engineering project into a masterpiece? How can we quantify appeal, comfort or usability in a way that is possible for an algorithm to score? With too much focus on design automation, could we rationalise away what makes human design special, amazing, jaw-dropping, thought-provoking, challenging, newsworthy – and human?"

"With too much focus on design automation, could we rationalise away what makes human design special, amazing, jaw-dropping, thought-provoking, challenging, newsworthy – and human?"

Harris adds that technological advancement cannot come at the expense of precision, accuracy and trust, and generative design technology will be in a constant battle to maintain them. Nowhere is this conflict more prevalent than in eliminating hallucinations in LLMs that power so much AI technology, alongside ethical considerations.

"The industry needs to keep a close eye on ensuring the protection and privacy of information sitting within corporate firewalls, while still aggregating adequate databases to inform generative design and generative AI," he said.

Engineers also need to solve for technological challenges when the complexity of design increases beyond the inputs to the model. Harris said that this means that the engineer and software must work together to solve problems.

IMAGE: Autodesk

There's still plenty of scope for generative AI using purpose-built LLMs in engineering. The Large Language Models for Design and Manufacturing report from MIT looked at the opportunities and challenges for LLMs in manufacturing and design.

"One of the reasons generative design is so impactful in the conceptual design stage," he said, "is that you have maximum flexibility in your approach to the problem, and you are looking to find a set of solutions that will allow you to move more towards a detailed design."

Diving in

For engineers wanting to dip their toes into the world of generative design, NASA's Ryan McClelland said, that curiosity and "requirements thinking" are paramount.

"You have to start from a place of understanding what the requirements are, especially for something that's more complex. This often looks like ensuring material doesn't 'grow' in an undesired location, or if there are thermal requirements."

Rohrmann said that, beyond knowing how to handle the software, engineers need to be willing to learn about genetic algorithms and multi-objective optimisation, and be able to think both abstractly and structurally.

"Generative design systems can only create a design within the space that we define," she said. "No computer has had an original thought yet – and if you ever worry about AI taking your job, go ask a large language model like ChatGPT to create and describe a floor plan of a simple one-family house to you. The response you get might sound professional at first glance, but if you were to draw the proposal, you'll soon realise it's a bunch of gibberish."

As with any technology, Rohrmann said engineers should use AI in a way that serves them, their workplaces and communities – and just maybe makes the world a better place. □

OPPORTUNITIES

Generating designs from natural language specifications:
They are particularly beneficial for creating complex structures, and impractical suggestions can usually be corrected within a few user interactions.

Reasoning challenges:
Crucial to design and manufacturing, analytical reasoning and complex computations lead to challenges such as limited ability for spatial reasoning.

Computational design:
LLMs are able to identify semantically meaningful design variations within a given design space.

Design for manufacturing:
Trained models can serve as a repository of manufacturing expertise, with programming and pattern analysis enabling them to generate and modify designs and streamline workflows.

Design to performance:
LLMs can conduct detailed evaluations of designs and suggest sophisticated considerations, even without all information to hand.

Inverse design:
LLMs can select designs that offers the best performance within certain constraint criteria.

CHALLENGES

Correctness and verification:
Inaccurate results or inadequate justifications remain a hazard. However, application processing interfaces can be added to perform checks and verifications.

Scalability:
More numerous or complex tasks often deteriorate performance, but can be overcome by breaking tasks into smaller pieces.

Iterative editing:
Specifying modifications to a design often generates an entirely new design and discards details from prior attempts.

Context information:
Performance of LLMs dramatically improves with the addition of more comprehensive descriptions and context, and without such information designs can be limited.

Unprompted response:
Excessive proactivity can stifle creativity.

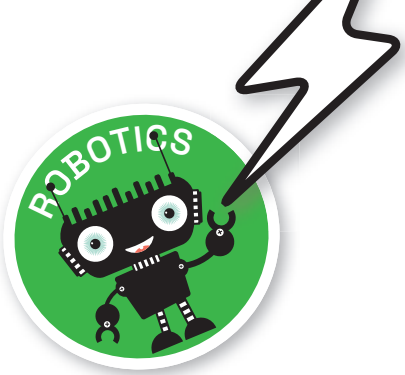
Ethical considerations:
Job displacement and infringement on intellectual property remain concerns, while humans should retain responsibility for verifying designs.

Source: Large Language Models for Design and Manufacturing, MIT, 2024.

engineering

Students currently in high school are regarded as the most environmentally conscious modern generation. So why aren't more of them embracing the opportunities engineering presents to help build a more sustainable world?

WORDS BY LARISSA FOSTER



There are few, if any, professions more central to decarbonising our society and building its resilience to climate change than engineering. At the same time, movements like the global school strikes for climate change show the deep environmental consciousness of Generation Z, who comprise the current crop of high school and university students and recent graduates.

And yet, any observer confident that these two facts would lead to soaring interest from school-leavers in engineering would find themselves disappointed.

In fact, the uptake of STEM subjects is decreasing in the later secondary years, while enrolments in engineering at tertiary level have plateaued.

"Over the last 10 years, the numbers of domestic engineering graduates have not grown, and the pipeline is weakening," said Alexandra Sparvell, General Manager Engineering Talent at Engineers Australia.

Research conducted by Student Edge for Engineers Australia surveyed high-school students and their parents about career plans and attitudes, and revealed engineering's image problem, particularly among girls.

Engineering was ranked as the fourth most popular field of study, with male students (31 per cent) much more likely than female students (11 per cent) to want to pursue it at university. Female students (27 per cent) were more inclined towards medical and health sciences degrees.

The study noted that boys were driven by an interest in STEM and building and construction, whereas the career aspirations of females were driven by creativity and the provision of public services.

The most common reason cited for not choosing engineering was lack of awareness of what engineering is and what engineers do. Engineers Australia's Career Drivers research found engineering is generally perceived positively for its societal impact, but fields such as healthcare and education have a more established association with community benefits.

The paradox that many students haven't connected their desire to change the world for the better with engineering – particularly among females and other underrepresented groups – requires a cut-through message that engineering is a profession that's creative and social as well as technical.

The heart of the matter

"It's a career for problem solvers," Sparvell said. "If you look ahead to things like the energy transition, the impacts of climate change, advanced manufacturing and the global economy, these all give rise to complex problems to be solved.

"Research shows a clear link between diversity, innovation and problem solving, so opening the profession to a more diverse range of students who may not have considered engineering will help solve the challenging problems ahead."

The task of effectively engaging young people involves communicating the industry's competitive salaries and healthy work-life balance, as well as the positive societal impacts of engineering.

Emphasising its inter-connectedness with other industries – for instance, how hospitals function effectively due to advanced engineering, or how health sciences benefit from cutting-edge technology – speaks to problem-solving, collaboration and creativity.

"Showcasing engineering through stories and role models challenging bias will help students make an engineering career decision," Sparvell said.

ABOVE: Alexandra Sparvell, Engineers Australia

LEFT: L-R: Sally Williamson; Penrith Selective High School students Haripriya Mehta, Hazel Malhotra, Taran Margapuram, William Kulcsar, Mahiejith Aravind, Oliver Milne and Amiya Joshi

Poor numbers

But even with enhanced engagement, Australia's declining rates of maths education are cause for concern. Fewer students are studying maths in years 11 and 12 and Australia's overall maths standards are declining, as revealed by metrics including NAPLAN and the 2023 Programme for International Student Assessment.

Engineers Australia CEO Romilly Madew AO FTSE HonFIEAust EngExec has described the maths crisis as "a ticking time bomb for Australia, hindering our capacity to innovate and compete globally".

A deficit in maths educators equates to a deficit in engineering talent, she said. "[It is] a mathematical equation with profound implications for Australia's future prosperity."

Currently, 45 per cent of high school maths teachers do not have specialist maths training. Engineers Australia's goal is for teachers to be subject-matter qualified and have a strong awareness of real-world applications of maths. >

"A lot of girls are now saying they'd like to be involved in the cybersecurity industry. It's a matter of just exposing young people to opportunities that aren't necessarily available in the traditional syllabus."

"We want teachers who instil confidence in mathematical concepts in students," Madew said. "If primary school students exit with adequate maths literacy, the transition to secondary maths subjects becomes less daunting."

Building student capability through education outreach, particularly in maths, is a critical activity. Additionally, its engineering-based education outreach provides inspiring curriculum-based learning experiences while demonstrating the local impact of engineering.

Tutes on the ground

The crowded STEM advocacy space sees hundreds of programs of varying quality compete for the attention of schools across Australia, but the impressive results of the NSW iSTEM program have positioned it as the gold standard for encouraging students into STEM.

Collaboratively developed in 2017 by Professor Scott Sleap, who still coordinates various aspects of the program, iSTEM saw an almost 20 per cent increase in STEM subject enrolment in the Hunter Valley trial by its participants across a period of five years. To date, more than 14,000 students have completed the course, and it has been taught in approximately 320 NSW schools.

The program engages students in real-world problem solving and was originally devised as a specific program for the Hunter Valley with a focus on the region's aeronautical engineering and advanced manufacturing industries.

"Then we added new units so it was more applicable to the whole of the state. It can be modified and adapted to whatever industries existed in the regions the students were coming from," Sleap said.

Developed with the help of industry (including Engineers Australia), universities and experts in various STEM disciplines in the school system, iSTEM was designed to tap directly into students' interests and engagement (cybersecurity has proven popular, along with projects concerning space and robotics). A NSW Education Department-approved elective for Years 9 and 10, it sees students working in teams to solve a problem via an engineering design process.

The iSTEM course and materials are used in other subjects and age groups as well, including primary school.

ABOVE:
Top to bottom: Hazel Malhotra; Mahiejith Aravind; Haripriya Mehta; Taran Margapuram

ABOVE:
Sally-Ann Williams, Cicada Innovations; Professor Scott Sleap

A version of iSTEM has now been rolled out in Queensland, ACT and WA.

An important focus of iSTEM is targeting underrepresented communities: girls and children from low socio-economic, rural, regional and remote areas and First Nations students.

"We've been tapping a lot of girls on the shoulder, saying, we know you're good at STEM; we believe you will excel in our enrichment programs," Sleap said.

"Cyber is one of them. A lot of girls are now saying they'd like to be involved in the cybersecurity industry. It's a matter of just exposing young people to opportunities that aren't necessarily available in the traditional syllabus."

iSTEM is delivered by science,

technology and maths teachers. "It is a challenging subject to deliver, but teachers can pick the modules they're comfortable with," Sleap said.

"Science teachers can pick the space module, for example. But our issue is the same as engineers have; we simply don't have enough STEM teachers."

Engineering influence

Increasing the number and diversity of STEM-trained teachers is a key recommendation of the Pathway to Diversity in STEM Review. "They're the original influencers for children," said panel chair and Cicada Innovations Chief Executive Sally-Ann Williams.

Released in February, the review details 11 recommendations for increasing the diversity of STEM professionals through implementing structural and cultural change in Australia's STEM system. They include creating accessible pathways for diverse people to engage in STEM learning (at all stages and ages) and improving the Australian curriculum through future reviews. It also highlights the need for a government-developed and led communication and outreach strategy emphasising the opportunities and potential for careers in STEM.

The rationale, the report says, is to drive home an important message: "STEM jobs can be creative and caring. They have the potential to change people's lives – such as finding ways to increase food security, or creative ways to help wildlife conservation and address climate change."

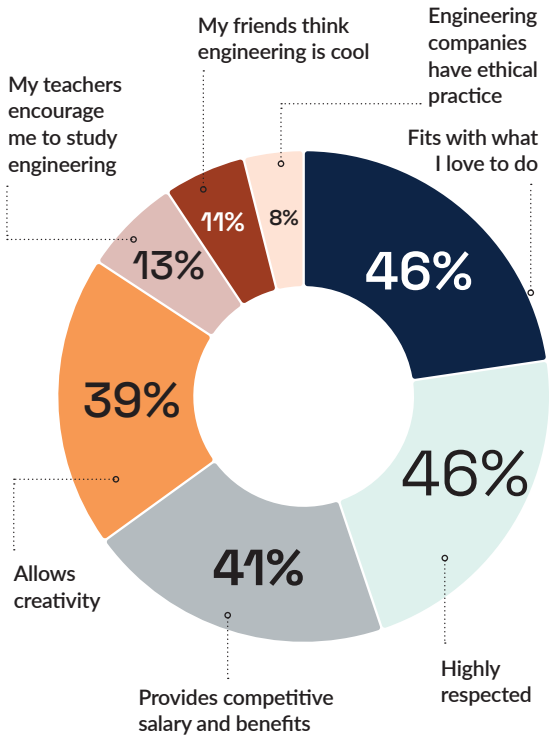
Linking the conversation and narratives in high school about reflecting those career preferences for their children.

"We know from research that engineering is narrowly defined by society in the traditional view of engineering related to infrastructure and construction and as such does not attract a diverse range of students," says Alexandra Sparvell, Engineers Australia's General Manager Engineering Talent.

"It's a foundational piece for us to present a clear narrative showing it as a creative technosocial profession which solves complex problems that have impact on the community and the economy, and as a future-focused profession that offers a career with engaging work, varied options and paths, and financial security.

The study also found that preferences varied within engineering.

Reasons for studying engineering



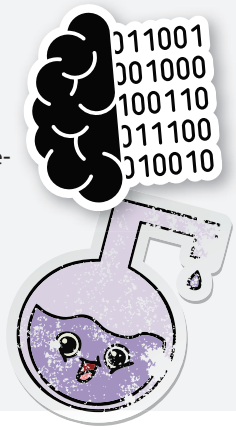
Source: *Engineers Australia Career Paths report, 2024*

Engineering a fulfilling career

Research conducted by Student Edge for Engineers Australia surveyed the career goals of thousands of young Australians aged 13-18, along with their parents, for a snapshot of the next potential generation of engineers.

The 2024 report confirmed STEM-related industries are predominantly favoured by male students, whereas female students show a stronger interest in the areas of healthcare and medicine.

While engineering ranked as the fourth most popular field of study overall, there were stark gender differences at play. The top choices for boys revolved around STEM, including building and construction, while girls focused on creativity and the provision of public services. Parents help reinforce the gender bias by



Males favoured traditional engineering disciplines and electrical engineering, while females showed more interest in chemical and biomedical engineering. Computer engineering proved popular across genders thanks to its technology focus and positive beliefs about its relevance to the future.

"The core challenge lies in identifying and dismantling the barriers that prevent large segments of the population from viewing engineering as an accessible, rewarding and impactful career path," Sparvell said.

"Unlocking the untapped potential of these groups, increasing the overall capacity of the engineering workforce, and fostering a more diverse and inclusive profession better equipped to drive positive change in society."

STEM to career outcomes is important, Williams said.

"We still miss that step, but it's easily done – you can link the curriculum in a physics, engineering or maths class with a real-world example of how that learning might be applied."

Although the narrative about pathways is changing thanks to the emergence of new engineering disciplines, the fundamentals of the core curriculum remain unchanged, Williams said.

"Mathematics, scientific and engineering principles are foundational and critical skills. The narrative around pathways is the piece that brings them to life. There are a lot of great organisations that do this work – Careers with STEM, for example, which publishes profiles of all sorts of diverse STEM careers, and diverse STEM professionals," she said.

"So it's about tapping into those resources and connecting the dots. That's where, if we get the foundations right, a role model can be an inspiration. But it requires multiple touchpoints over the course of a student's education for these things to align."

Well-intentioned but short-term interventions were unlikely to create lasting change, Williams said. "If you're looking for long-term transformation you need to embed it in the curriculum, work with teachers to support them with appropriate materials, and provide very clear links and pathways to career opportunities.

"All the literature globally says if you want to encourage young people onto a STEM pathway, you start in primary school. People start making gender-based assumptions in kindergarten, so exposure at a very early age is crucial."

Williams said there was plenty of noise in the sector around encouraging a diversity of young people into STEM and increasing the visibility of engineering careers, but industry needed to accept its own responsibility for the pipeline problem.

"Everybody wants to fund a program working with kids in schools, but you don't move the needle unless you fix the system's drivers. It's time to hold businesses to account on it and say it's fabulous you've been funding all these not-for-profit initiatives to bring people into the pipeline, but what have you been doing in your workplace to ensure they thrive and stay?" □

WHY STUDY ENGINEERING?

Here's what students at Penrith Selective High School had to say about the role of engineering in their future.

"It's about developing the world, and it affects everyone. I really aligned with that. I want to help people as a career."

Oliver Milne, *Year 11*

"I chose to do engineering because ... it can help me understand how everything around me works."

Taran Margapuram, *Year 11*

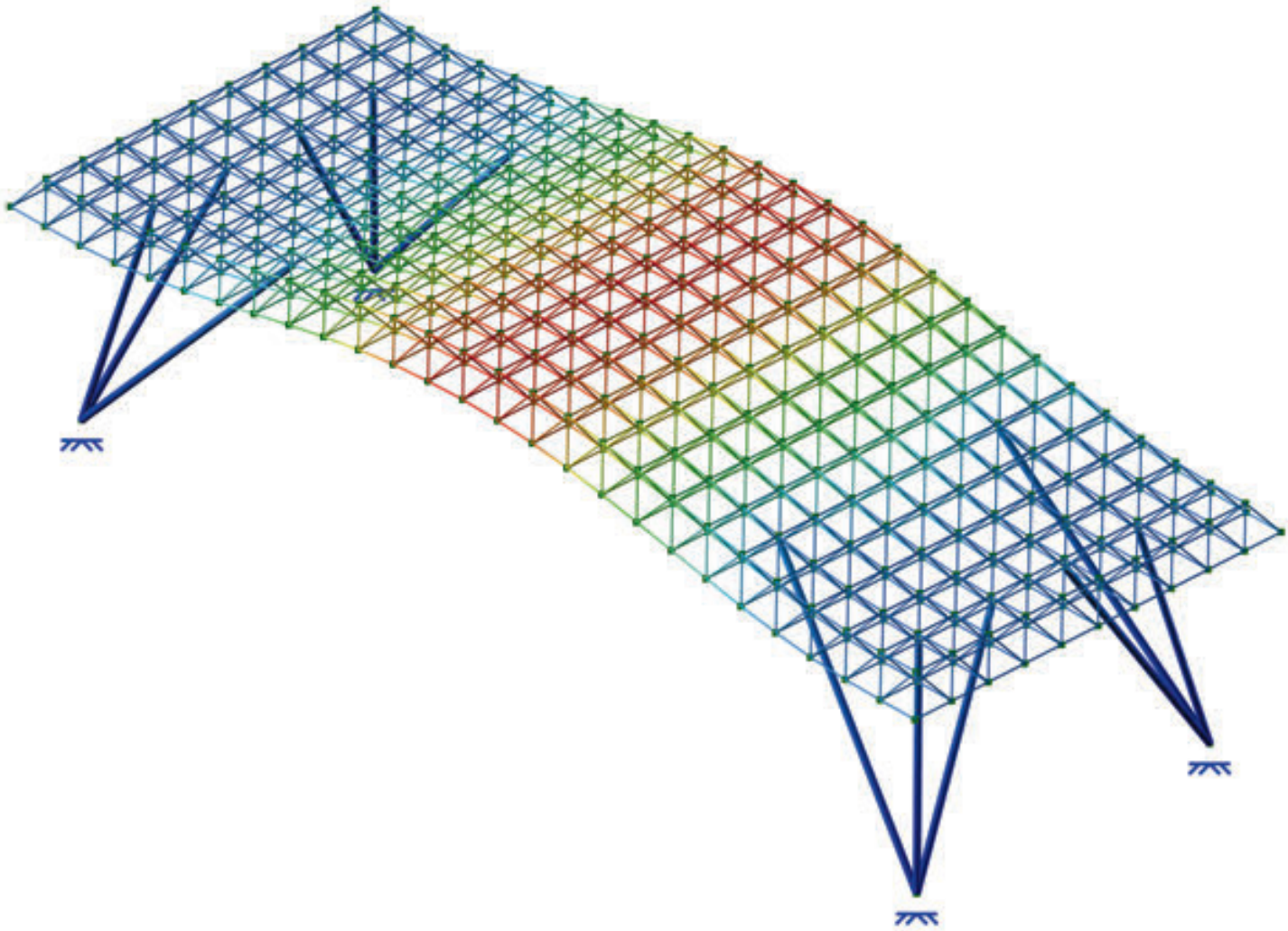
"Even still today, I'm learning that there are so many different [engineering] fields that I just didn't know were out there."

Hazel Malhotra, *Year 12*

"People start making gender-based assumptions in kindergarten, so exposure at a very early age is crucial."

ABOVE LEFT: Hazel Malhotra; Engineer name; TaranMargapuram; Haripriya Mehta: William Kulcsar

Water engineer Sally Williamson chats with high students studying the subject.



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Projects

Going with the flow

WORDS BY PAUL MERRILL

The biggest weir built in Australia since World War II is a masterclass in engineering innovation and sustainability, and services a catchment area larger than England.

The Fitzroy River in central Queensland supports six species of freshwater turtle, two of them threatened species.

To forage for food and conduct breeding migrations, the reptiles must sometimes swim tens of kilometres up and downstream, leaving the safety of the water only to nest or, during dry conditions, move between isolated pools in different sections of the river.

So a $568.9 million weir stretching more than 350 m across the river that's made from 131,000 m³ of concrete could present a challenge for a white-throated snapping turtle heading upstream in search of juicy tadpoles or water striders.

Luckily, the engineers and scientists behind Rookwood Weir (Managibei Gamu) – the biggest weir to be built in Australia since World War II – found an innovative solution that means the hungry turtles needn't fret about their next meal.

The team deployed a series of ingenious solutions that have made the structure one of the most technically accomplished recent engineering projects and won it the Australian Construction Association's prestigious Australian Construction Achievement Award for 2024.

Engineers Australia CEO Romilly Madew AO FTSE HonFIEAust EngExec described it as an example of the power of creativity. "By integrating sustainable practices and cutting-edge engineering, they've shown the construction industry can lead the way in environmental responsibility and innovation," she said.

Completed in November 2023, Rookwood Weir is 55 km west of Rockhampton and a short drive from the small rural town of Gogango. Its sweeping spillway rises 16.2 m from the riverbed and, at full supply volume, holds 74,325 ML of water,

"Rookwood Weir is a great example of the power of pioneering design, cutting-edge engineering and environmental responsibility."

40 per cent of which will go to local farms and create 500 jobs. It is projected to also inject $3.5 billion into the area's agricultural sector over the next 20 years.

One recipient of the new supply has already planted 800,000 macadamia trees, while another has announced plans to grow 4000 lychee trees. Water has also been allocated to the traditional custodians of the land, the Darumbal people, to support their economic development.

ABOVE:
A white-throated snapping turtle

The weir was jointly funded by the Queensland and Australian governments, with design and construction carried out by Sunwater in alliance with GHD, Acciona and McCosker Contracting.

"It will enhance long-term water security in central Queensland," Sunwater Project Director Inaki Goni said, "creating sustainable employment and economic development opportunities for local businesses."

The project was conceived and approved after a feasibility study by Sunwater and the Gladstone Area Water Board evaluated the opportunities and potential impacts of building a water storage asset on a river with a daily discharge of 16 GL into the Coral Sea and a catchment of 142,665 km^2 – an area larger than England.

By regulating the water flow, the weir ensures businesses and residents receive a consistent >

and reliable supply. And that the local turtles aren't left high and dry.

Ecologically friendly design

Rookwood is home to the world's first bespoke turtle passage, which consists of a 172 m textured ramp with resting pools every 15 m. It was built following the biggest-ever freshwater turtle telemetric tracking project to understand their behaviour, and allows the animals to climb up and past the weir.

"It's a unique design feature, and we used the results of the tracking research to develop the design criteria for the ramp," Rookwood Weir Alliance Lead Ecologist Dr Natalie Clark said. "It will be monitored to assess its success in maintaining turtle movements, and avoiding injury and mortality."

Equally groundbreaking is the fish lock that allows barramundi, sooty grunters and other species to swim freely through the weir with flows of between 0 and 1.3 million L/s. It contains two lock chambers with multiple entrances and exits, which doubles the operating range of a more typical single-chamber design.

To reduce turbulence adjacent to the fish lock that might deter fish from entering, five castellated crest blocks were placed on the downstream face of the spillway crest. Flow guide slots concentrate the fast-moving water, thereby increasing the depth and reducing any churning.

Bank defences

Another implication of high water flows on the left bank is slope stability and seepage which could lead to the gradual erosion of the riverbanks.

"A high river flow is extremely powerful and was one of the main project risks, with potential failure of the alluvium riverbank, so we had to make sure we had robust defence mechanisms in place," Alliance Construction Manager James Heenan told *create*.

The original concrete mix design had to be adjusted after it was discovered to cause cracking, while the mix of conventionally vibrated, unreinforced concrete used elsewhere on the build was also innovative. It contains an unusually high 61 per cent of fly ash, sourced from nearby Gladstone, and an aggregate size of 75 mm (three times the norm) to prevent cracking.

An inspection committee was established to ensure the structure's foundations met design requirements. The variable geological conditions meant the foundations in some locations were up to 12m deep. This was much deeper than anticipated.

"Our geological foundation was extremely complex, resulting in having to go down deeper than expected," Heenan said. "We adjusted our approach accordingly to be completely confident the foundation is on competent rock."

The importance of equipping the weir for severe weather events was brought home to the construction team when work had to be halted six times due to flooding. The first stoppage lasted 154 days, with the others totalling 117 days. For the 250 workers billeted in specially built cabins nearby, they were frustrating times.

To minimise the impact, contingency tasks such as preparing precast concrete, in-situ casting and work on the right abutment above inundation level were carried out.

"Rookwood Weir is a great example of the power of pioneering design, cutting-edge engineering and environmental responsibility," Heenan said. "It will continue to benefit the local communities for decades to come."

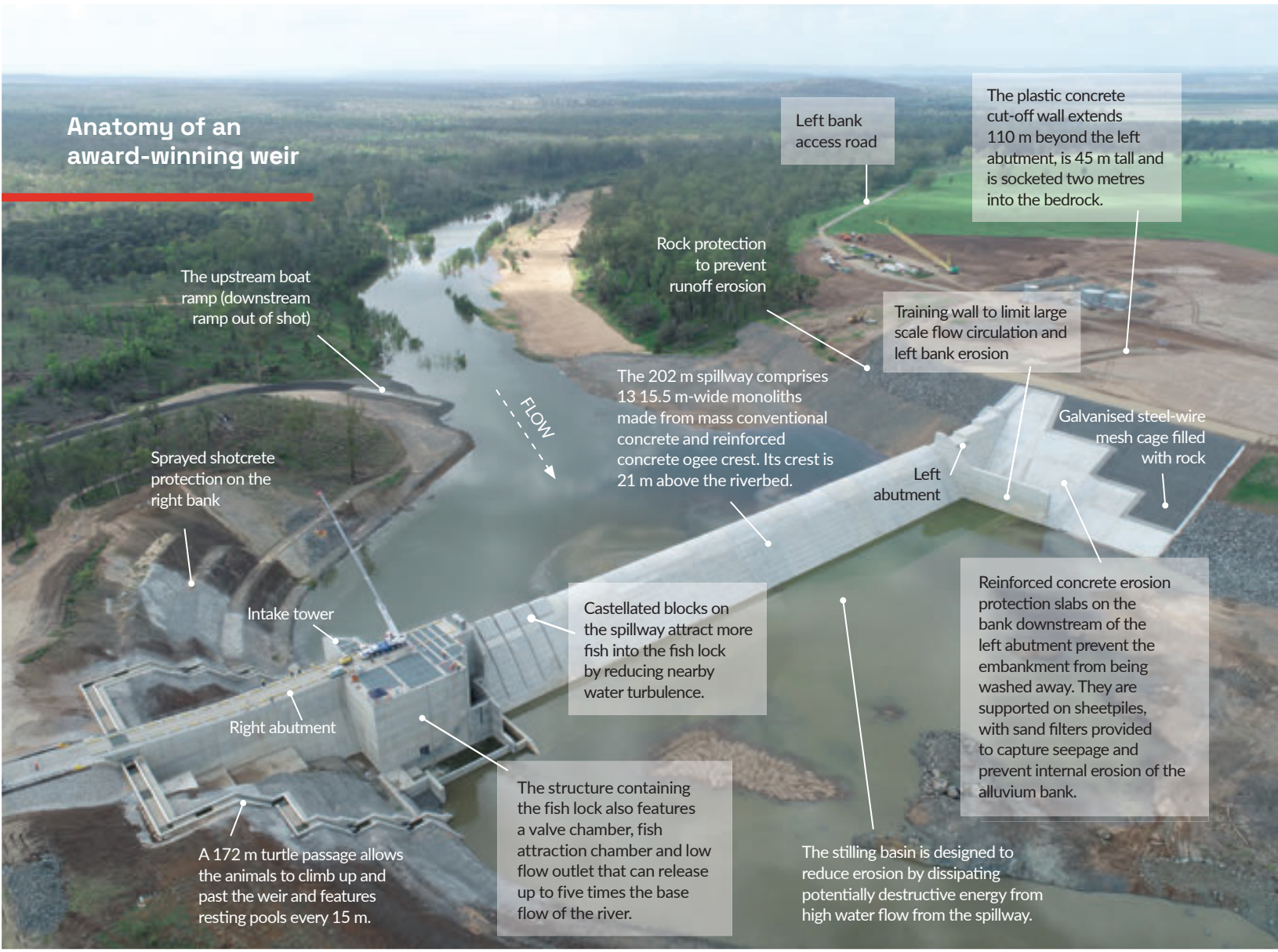
Less than a month after the building work wrapped up, the water level reached the top of

BELOW LEFT: This 1:50 model was used with 3D computational fluid dynamics to test the weir's hydraulics and validate computer modelling.

Community engagement

A Darumbal Elder performs a Smoking Ceremony at Rookwood Weir, which is known as Managibei Gamu (keeping water) by the land's Traditional Owners. The project team held regular meetings with Aboriginal leaders and coordinated events each year to celebrate NAIDOC Week.

"[The weir is] our lifeblood, our life source, and it's really important we look after our water," said Malcolm Mann, Director of the Darumbal People Aboriginal Corporation, a non-profit organisation advocating for traditional land management.



the spillway. After three years of intensive earthworks, concreting and mechanical installation, the site fell strangely silent other than the roar of water cascading down the concrete slope. And the almost imperceptible pitter-patter of tiny, webbed feet navigating their way up and down their new ramp.

Sustainability focus

Minimising the carbon footprint of Rookwood Weir was central to its design and construction, and has resulted in it becoming the first weir in the country to be awarded an "excellent" rating by the Infrastructure Sustainability Council, for its focus on sustainability, habitat connectivity and local employment.

"It will enhance long-term water security in central Queensland, creating sustainable employment and economic development opportunities for local businesses."

Alliance's Environment and Sustainability Manager Jason Cork oversaw a swathe of initiatives that drastically reduced emissions.

"We replaced 98 per cent of potable water with non-potable water and reduced supplementary cementitious materials by 50-60 per cent," he said. "Our design reduced the spillway length, which means we've used less concrete, steel and water, and caused less disturbance to the site." □

New trams are all class

WORDS BY JOE ENNIS

The next generation of rolling stock to hit Melbourne's tram network promises to deliver the holy trinity of improvements in energy efficiency, passenger safety and reliability.

When Melburnians first boarded a horse-drawn tram 140 years ago, it opened up the suburbs and encouraged people to move to areas now considered inner-city, such as Preston and Northcote. Today, Melbourne boasts the world's largest tram network, with more than 500 trams running up and down 250 km of double track.

This demands a constant cycle of innovation and upgrade, a cycle that's clearly visible across the six generations of trams to have thus far operated across the city.

Onboard energy storage

Designed to meet the requirements of the Victorian Government through a competitive tender process, the new G Class fleet, the seventh generation of trams to run on the network, will be built by Alstom in Dandenong. The first 100 of these accessible, low-floor trams, based on Alstom's proven Flexity 2 platform, are set to replace some of the longest-serving high-floor trams (the Z, A, and B Class) still in service, with testing of the new fleet commencing in 2025.

While the G Class boasts many new features, the headline upgrade is the onboard energy storage system (OESS). Alongside more modern traction motor equipment, LED lighting, and other energy-efficient equipment this will lead to a 30-40 per cent reduction in energy consumption per passenger.

ABOVE RIGHT: A mock up of the new G Class tram

"The OESS is a roof-mounted lithium-ion nickel manganese cobalt battery cell pack consisting of two batteries with a 48.9 kWh capacity," said Dr Himani Mazumder, Principal Mechanical Engineer at the Victorian Department of Transport and Planning, in the Rolling Stock Development team overseeing the development of the G Class trams.

"The main purpose of the battery is similar to that of a hybrid car. It assists in providing power when the vehicle is accelerating and captures energy from regenerative braking.

"But as an added feature, it will also be able to trickle recharge from the overhead wiring, effectively time-shifting part of the tram's current draw away from times when it would be accelerating to moments when it is stationary or coasting."

This technology not only benefits the vehicles, but also the entire network, Mazumder explained.

EFFICIENT MODE

THE G CLASS TRAM USES

30-40%

LESS POWER PER PASSENGER

CAN CARRY UP TO

150

PASSENGERS (DOUBLE THAT OF THE A AND Z CLASS TRAMS)

Estimated power usage across Melbourne's transport modes

	Energy use *MJ per passenger-km*	Energy use *kWh equivalent*
G Class trams	0.105	0.029
Current fleet	0.150	0.042
Electric train	0.040	0.011
Diesel train	0.180	0.050
Electric car	0.700	0.194
Bus (diesel, E10 or natural gas)	0.280	0.078
250cc motorcycle (petrol)	1.600	0.444
Petrol car (inc. LPG and E10)	3.400	0.944

Source: *Public Transport Users Association Victoria. G Class trams usage estimate based on a 30 per cent reduction in energy consumption. Figures rounded.*

"It will assist acceleration once the power being drawn by the tram from the overhead line exceeds a current of 600A. This is referred to as 'peak shaving' and supports operations across the network by helping to manage power demands in each substation's section, while allowing the tram to accelerate and keep its timetable."

The reduced power draw will help limit the need for capacity upgrades across the tram power-supply system in the initial rollout saving significant capital expenditure.

Melbourne's tram network is already extremely efficient, servicing more than 200 million passengers each year using approximately 82 GWh of electricity. The OESS promises to improve this even further with the introduction of the first 100 new trams expected to reduce this demand by 6.8 GWh.

It's another environmental tick for Melbourne tram travel following the Victorian Government's Solar Trams initiative, announced in 2019, where 100 per cent of the energy used by the network is offset by new solar generation capacity. This made network operation effectively carbon neutral.

Significant evolution

Though built on a similar base product as the recently delivered E Class trams, the G Class is a significant evolution, Penny Vorvolakou, Project Engineering Manager from Alstom, said.

"A tram is no longer a box on wheels being propelled up and down a city street," he said, pointing to the innovative >

SAFETY FIRST

THE G CLASS SAFETY FEATURES ADDRESS PEDESTRIAN SAFETY AND COLLISION AVOIDANCE IN AN ENVIRONMENT WHERE:

75%

OF THE NETWORK IS SHARED WITH OTHER VEHICLES

THERE WERE

960

VEHICLE COLLISIONS (2022)*

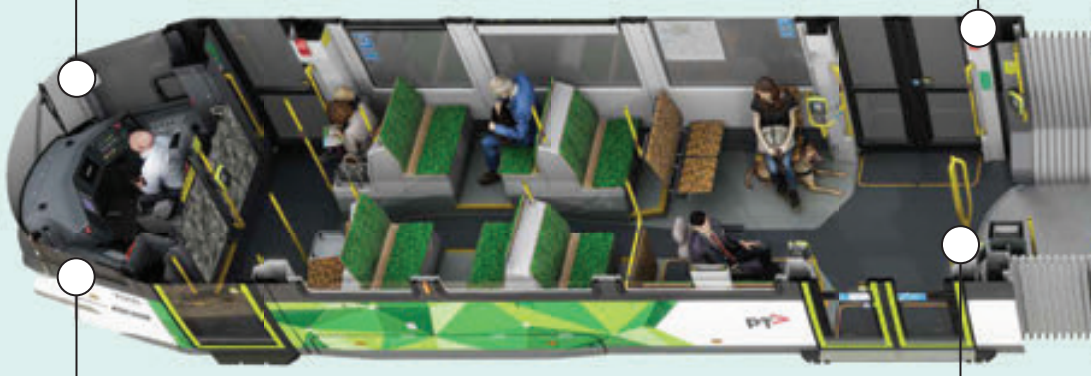
THERE WERE

47

PEDESTRIAN COLLISIONS (2023)*

**latest available data*

Key features

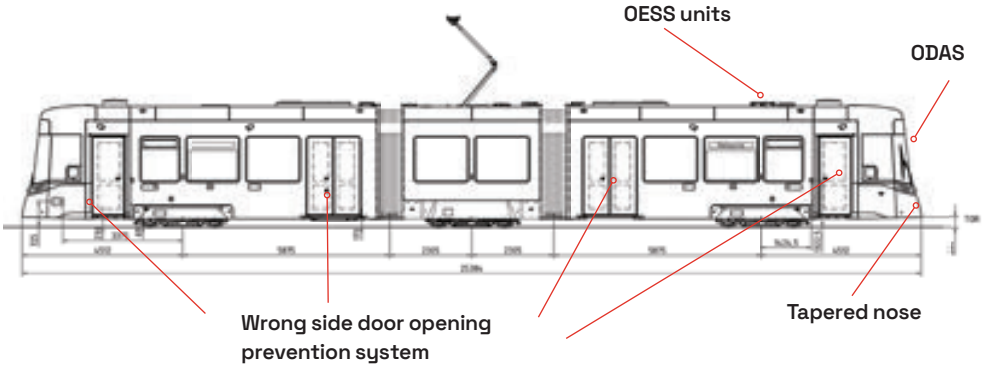


Dedicated rear-view LED screens
Providing improved driver visibility along the tram.

Better passenger information
More screens with detailed real-time information.

New technologies
CCTV, collision avoidance and other intelligent systems will be fitted.

Convenient hand-holds
Handrails and hand-holds have been placed at key locations throughout the tram, supporting better passenger access, movement and amenity.



technology Alstom is deploying in the G Class."

Innovative elements include smart vehicle safety systems such as forward obstacle detection assistance and correct-side door opening technology.

Simultaneously, the network is rolling out an enhanced automatic points system, which automatically switches points to reduce the potential for human error and wrong route selection, providing greater capability to share onboard vehicle diagnostics and performance telemetry in real time from the tram to the operational centre.

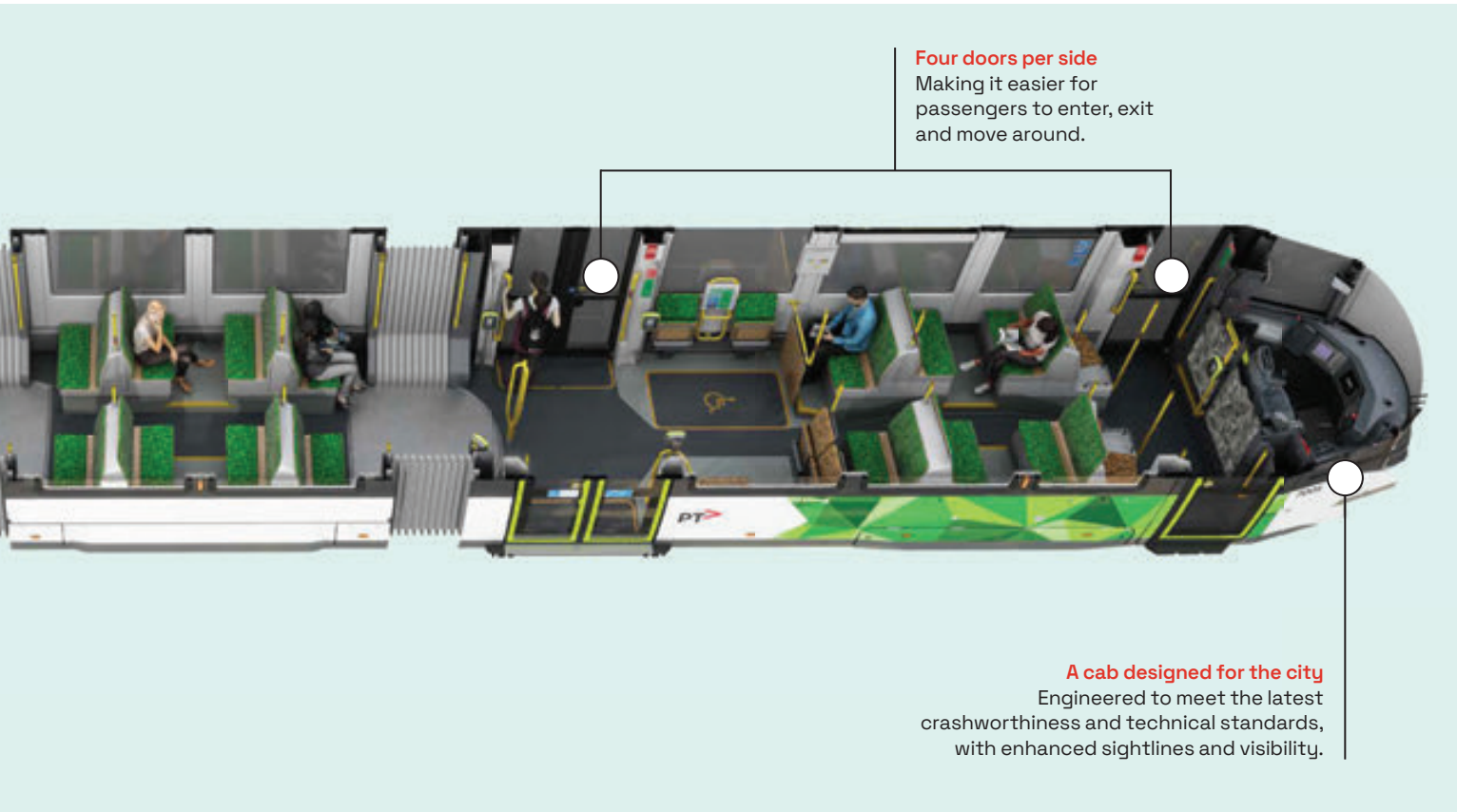
"We are customising a mature design for Melbourne's needs, ensuring [the] specific challenges and needs of the local network and passengers are met."

This includes elements based on feedback from human factors testing prior to construction and experience from the E Class tram, which was also delivered from Alstom's factory in Dandenong.

Safety a priority

With 75 per cent of Melbourne's tram network shared with other vehicles, safety is a top priority in the design of the G Class trams. The final design has several

"Designing a tram to be compatible with all locations and conditions of the world's largest network required careful consideration to meet all operational scenarios and passenger needs."



advanced systems integrated to protect both passengers and pedestrians.

This includes the Obstacle Detection Assistance System (ODAS), a game-changer in terms of tram safety according to Mazumder. "It's designed to recognise any obstacle in the tram's path that exceeds a specific size, allowing the driver to react swiftly and effectively," she said. "It can be adapted to any track environment."

Pedestrian safety is also a major concern, with 47 incidents involving pedestrians in 2023.

"The tram's exterior cab design has been optimised to meet modern pedestrian protection standards, reducing the risk of injury in the event of a collision."

This includes a safety bar under the front bumper that deploys when the emergency brake is applied. In the event of a collision, it prevents the pedestrian from being dragged beneath the tram.

The proposed side door opening technology would mean the doors will only open on the correct side at each stop, Brooks said. "This system would use wayside-mounted tags and the tram's vehicle management system to help maintain passenger safety.

"New accessibility technologies include hearing aid loops and clearer passenger information systems.

"The low-floor trams are also accessible for passengers using wheelchairs or mobility aids, with an increased proportion of accessible seating."

Locally manufactured

From a local manufacturing perspective, the G Class is a big win. The first weld to the final coat of paint will be completed at Alstom Dandenong, with a 65 per cent local content requirement across the entire project, including local materials from Australian suppliers.

The project is helping to support 1900 jobs across the state, including the manufacturing, maintenance and operation of the new trams.

Unique challenges

Designing a tram to fit in with such an established network was not without its challenges, according to Steve Brooks, Alstom's NGT Interface Engineer.

"Designing a tram to be compatible with all locations and conditions of the world's largest network required careful consideration to meet all operational scenarios and passenger needs."

The result is a modern, safe, energy-efficient tram with a higher passenger capacity than the models it is replacing. □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Closing the organic waste loop

WORDS BY CHRIS SHEEDY

At Veolia's Bulla Organics Facility in Melbourne's north-west, food and garden organics are saved from methane generation at landfills and transformed into high-grade compost.

There is a common belief that organic waste is fine to send to landfill. After all, it would simply break down over time. However, sending nutrients back into the soil and resulting in a healthier natural environment is the preferred option.

Not only does placing organic waste in landfill miss a powerful opportunity for resource recovery and circularity in waste management; it also poses serious environmental risk.

When organic waste decomposes anaerobically, or in an environment of low oxygen – as is the case when the waste is buried – methane is released as a result of the breakdown process. Methane, compared to carbon dioxide, can be 26 times more potent in terms of greenhouse gas emission.

In an engineered composting facility such as Veolia's Bulla Organics Facility in Melbourne, the composting occurs in an aerobic environment.

Engineering a compost facility

The facility, constructed in 2011-12 after Veolia tendered for the processing of organic waste from 11 local councils in the north-west of Melbourne, is centred around 14 enclosed vessels into which the organic materials are placed. The vessels are purpose-built with a forced aeration system. "The floors have a series of pipework underneath that forces air through the organic mass," Mark Globan, Veolia's General Manager, Resource Recovery, told *create*.

"One of the key desired outcomes with the engineering of the facility was to have a system that sampled the oxygen inside the vessel. Once you're below 10 per cent oxygen, you're heading towards unfavourable anaerobic conditions."

"There's a tarpaulin that goes over the top that encloses the system, and a door at the front."

Within the vessels – each measuring 24 m long, 4.2 m wide and 3.6 m high – sensors measure temperature, moisture and oxygen saturation.

"We need to get up to greater than 55°C for more than 72 hours to meet the Australian standard," Globan said. "We hold it for a little bit longer and at a slightly higher temperature, just for comfort.

ABOVE: Mark Globan, Veolia

If the sensors say it's getting too hot, we'll force air through to bring it back down."

A vital ally

That airflow is vital in preventing the engineered aerobic system from becoming anaerobic and releasing harmful methane into the atmosphere.

"One of the key desired outcomes with the engineering of the facility was to have a system that sampled the oxygen inside the vessel," said Tony Strobbe, Veolia's South-East Organics Manager. "Once you're below 10 per cent oxygen, you're heading towards anaerobic.

"There's a fail-safe system that ensures the oxygen is always above ten per cent. That's calibrated every hour, on the hour. If required, oxygen is pulled from the surrounding air, and once the oxygen in the mass is at an acceptable level, the system goes back into recirculation mode." >

Research for and development of the facility dates back to the late 1990s and early 2000s, when Veolia ran a similar but smaller plant in Dandenong.

"We originally ran two vessels and eventually built up to five," Strobbe said. "We had to engineer these facilities to suit the Australian market. The design in later plants has been very similar. We've just improved on the original and fixed some problems."

Aeration holes in the floor are roughly 600 mm apart over the full, 24 m length, with each hole measuring 18 mm in diameter. A false concrete floor made from 200 mm double mesh combines with concrete walls of 150 mm single mesh to allow liquid to escape onto a floor that slopes at one end.

"Without this, the liquid would sit in the base of the pile and convert the process into an anaerobic state," Globan said. "Removing the liquid allows the process to remain in an aerobic state."

The plant runs 14 small vessels instead of fewer, larger ones, Strobbe said.

"If you have a very long vessel and something fails – if you're unable to keep the mass above 55°C for 72 hours, for example – that's a major failure. With a batch system, you engineer out that risk."

Sorting and grinding

When trucks loaded with food scraps and green organic waste arrive at the facility, they pass over a weighbridge before dumping their valuable cargo onto a pad.

Fine materials are separated out from larger materials, which are taken to a sorting station where a team of six to eight staff members sort the acceptable materials from the non-acceptable ones.

"Sometimes people will throw out their garden clippings, and sometimes they will throw out their entire garden pots," Globan said. "Every so often, we'll find a sledgehammer or another garden tool – all sorts of stuff."

Large items such as tree branches are sent through a grinder before being remixed with the fine products and sent into the vessels for processing.

Leave it to the microbes

The temperature of the mass must be kept slightly above 55°C to enable micro-organisms to decompose the various organic materials without causing the release of methane.

"If the mass is too hot or cold, the process stops," Globan said. "If you don't have the optimal conditions in terms of oxygen, the microbes decide the

What can and cannot be composted?

Outside of the obvious – including food waste, branches, twigs, leaves and lawn clippings – certain items are good for the composting process. Others are a definite no-no.

Accepted for composting

- **Shells from seafood:** Crumble easily and add valuable calcium
- **Coffee husks and grounds:** High in potassium and nitrogen
- **Paper towels and newspaper:** Only in small amounts; when used to wrap food waste, for example
- **Animal hair:** Only if it is not dyed or synthetic
- **Soil:** Only in small amounts, such as around the roots of plants and weeds
- **Pet food:** Unusual, but acceptable

Not accepted for composting

- **Plastic or compostable bags:** "Compostable" bags can take a very long time to break down, particularly ifknot-ted, and may hide other non-com-postable products
- **Sawdust and wood shavings:** Often treated with chemicals
- **Animal faeces and kitty litter:** Potentially carries pathogens
- **Teabags:** The small tags are often coated, so don't break down in the vessel
- **Shredded paper:** Paper of varying grades break down at varying speeds, and may be coated
- **Paper bags:** Better suited to the commingled recycling system
- **Vacuum dust:** Potential for contamination

A rule of thumb for what can safely be placed into a food and garden organics bin for composting is that it should be anything that can grow in your garden, or anything you can eat.

environment is not working for them, and once again the process slows or stops."

If that occurs, the material must be removed and the process restarted, or the mass must be allowed to remain in the vessel for twice as long as it previously would have.

"Finding the optimal temperature in the cooler months might take a day or two longer than it would in spring or summer," Globan said. "No matter the time of year, we don't use heated air. The heat itself is generated by the microbial activity. Our job is then to create the environment in which it can remain above 55 degrees, and to help it cool down if it goes too much higher."

Waste to wealth

From more than 90,000 t of feedstock, approximately 40,000 t of high-grade, nutrient-rich compost and 20,000 t of mulch is produced.

The products are sold back into the market, including to garden centres, landscaping companies, civil construction firms, horticulture and viticulture businesses, and broadacre farms.

In doing so, the facility not only prevents organics going to landfill. It also improves soil health and increases stored carbon in the soil where its products are used.

While the Bulla Organics Facility is not carbon neutral, it utilises solar panels to offset some of its energy requirements. Its carbon emissions are expected to further reduce as renewable energy options come online.

Sustainability and community outcomes are front-of-mind for the facility, whose staff pride themselves in the role they play in creating a circular waste management environment.

"Having the composting in an enclosed environment also significantly reduces any risk of odour impact, which is important for the local communities," Globan said. "But most importantly, we're removing organics from landfill.

"On the waste hierarchy, at the very bottom of the inverted triangle, is disposal of waste via landfill. If there's one thing we really want to avoid, that's it. Bulla Organics Facility makes that possible." □

ABOVE: Sorting, grinding and mulching at the Bulla Organics Facility

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[Experience]

DISASTER

Trouble in paradise

Words by Lachlan Haycock

The Paradise Dam rebuild has led to several key recommendations for bolstering dam safety management.

LEFT: Essential works were conducted in 2021 to ensure dam safety.

IMAGE: Sunwater

In stark contrast to its name, Paradise Dam has had a fraught development.

The 300 GL-capacity roller compacted concrete (RCC) gravity dam, the largest by volume in Australia, experienced severe structural damage from flooding that threatened its integrity. It was subsequently announced that the dam couldn't be fixed and a new wall would be built immediately downstream.

So why did this happen – and how has it influenced the management of dam safety in Australia?

Structural questions

After the Burnett Dam Alliance completed construction in 2005, Paradise Dam experienced a series of flooding events, including in December 2010-January 2011 – the most serious Queensland flooding event since 1974 – and in January 2013.

The 2010-11 flooding caused spillway flows for the first time in the dam's history. The 315 m-long primary spillway has an ogee crest shape, while the 485 m-long secondary spillway is a trapezoidal crest section. In the months following, it was identified that considerable damage had been caused to the primary spillway, training walls on the left and right, the fishway and other areas of the dam. Erosion was also evident along the banks.

Flooding in 2013, when the primary spillway crest overtopped by 8.65 m, caused the riverbed further down the Burnett River to experience severe scouring, which developed along a fault zone in the rock. Despite the flooding being "well within" the dam's limits, according to the Paradise Dam Commission of Inquiry, there was damage to roughly half of the top layer of RCC in the apron slab. Sections of the apron's sill had been dislodged and washed downstream.

The two flooding events left the dam's stability and integrity in question. The Queensland Government-owned operator Sunwater lowered the dam height to 5.8 m in 2020 to undertake safety improvement works.

This alleviated but didn't solve the problem; Sunwater is planning to build an entirely new wall to meet modern safety standards and restore the dam's full water supply, and expects the existing dam wall will act as something of a cofferdam, shielding the new dam wall from the body of water during construction. >

Civil engineer Dr John Macintosh HonFIEAust CPEng, who is a former Queensland Professional Engineer of the Year, told *ABC News* in January that rebuilding was essential.

"If nothing was done [there was] a good chance there would be a failure of the dam some time in the future," he said.

Findings and recommendations

The Paradise Dam Commission of Inquiry Report, released in 2020, investigated sliding stability of the RCC layers and scour protection downstream of the primary spillway. It came to the conclusion that sufficient uncertainty exists about the structural stability of the dam given the risk of more future serious flooding events.

"Despite the relatively high cohesion values, the RCC was not tested in a laboratory or in situ during design or construction to determine if the design values could be achieved," the report said. "Without confirmation testing, assessing whether the design parameters had been met relied on the construction quality assurance program.

"In 2015, testing of core samples retrieved from the [dam] called into question whether the design values had been attained. Despite further testing since 2015, doubts remain about whether the assumed design values of friction angle and cohesion have been achieved in the [dam] as-constructed."

The report found that, at 20 m, the primary spillway apron was not long enough to combat scouring and erosion downstream. Its recommendations included:

Sufficient testing: "The materials used to construct a dam and the dam as-built should be subjected to inspection and physical testing to confirm the values adopted for critical design parameters."

Consideration of force: "The designer of a dam should give proper consideration to the erosive force of water and the capacity of the riverbed to withstand such force. This may include testing and simulation using computational and hydraulic modelling."

RIGHT: Damage from the 2013 flood included scouring and erosion downstream.

BELOW: The dam during the 2011 flood.

"With differing sets of guideline documents ... and a different department providing oversight to these two sets of processes, there is the opportunity for inconsistencies."

> "The designer of a dam should give proper consideration to the erosive force of water and the capacity of the riverbed to withstand such force."

Operator input: "The entity that is ultimately to own or operate the dam after its commissioning should have an opportunity to influence its design and construction."

In a submission made in response to a consultation paper by the Department of Natural Resources, Mines and Energy, Engineers Australia recommended an overhaul of dam regulations and guidelines to reflect the findings from the inquiry.

"Dam safety in Queensland is managed under two key processes, the referrable dam process for clean water dams, and the 'regulated' dam process for other dams, such as dams containing hazardous substances on mine sites," the submission said.

"Engineers Australia recommend[s] a combined review of the dam safety requirements in these two processes. With differing sets of guideline documents applying for each, and a different department providing oversight to these two sets of processes, there is the opportunity for inconsistencies." □

ABOVE: Paradise Dam Improvement Project concept design as of August 2024; Warragamba Dam. Images: Sunwater, Getty

DAMMING FINDINGS

Paradise Dam is not the only dam whose safety has been called into question.

Although the Warragamba Dam west of Sydney is not considered to have any structural weaknesses, the large population situated downstream does present a possible cause for concern due to the risk of flooding.

Whether any changes to the dam structure are required to ensure compliance with safety regulations is currently being investigated.

Scan the QR code to access references and read the story online.

IMAGES: Sunwater

THE LOOK BACK

Sailing cargo

International trade was powered by wind for millennia, before falling from favour with the rise of fossil fuels. Now the decarbonisation imperative is putting wind back in the sails of shipping.

Words by James Chalmers

Maritime shipping is incredibly efficient. For every tonne of cargo a modern container ship transports, it will emit as little as 10 g of carbon dioxide per kilometre. Truck transport emits at least six times more emissions, while air freight is about 50 times more carbon-intensive.

Nonetheless, the vast scale of maritime freight transport means the industry currently accounts for almost three per cent of global greenhouse gas emissions. Without strong action, this proportion will swell rapidly as shipping volumes grow and other sectors decarbonise.

Achieving the industry's target of halving emissions between 2008 and 2050 demands a wide variety of innovations, with green hydrogen, ammonia and methanol all being touted as replacements for bunker fuel. While future fuels will undoubtedly be crucial to decarbonising shipping, some engineers are revisiting wind power, with encouraging results.

ABOVE: The engineless brigantine Tres Hombres, at full sail off the coast of France

Cutting the engines

When it comes to sustainable shipping, the most radical approach of all might in fact be the most traditional – relying only on sail power.

A small handful of shipping companies are doing this already. For instance, Fairtransport has been shipping cargo across the Atlantic since 2007 on the Tres Hombres, a 1943 brigantine, and now operates a small fleet of sailing ships.

However, their largest ship has a capacity of just 100 t, a tiny fraction of even the smallest modern container ships.

Recognising that traditional designs cannot offer close to the volume demanded by modern shipping, others are working on designing and building sail-powered container ships.

France's Windcoop is developing an 85 m sailing ship with a 100-container capacity, 14-fold greater than the Tres Hombres – though still much smaller than the vast majority of the maritime freight fleet. Its two masts will be self-supported rather than guyed, to facilitate container handling. Its projected average speed, however, is just eight knots, about half to a third of a traditional container ship.

Meanwhile, fledgling Canadian outfit Veer Voyage has plans for a sail- and hydrogen-powered container ship capable of carrying 150 shipping containers at 18 kn.

There have also been a number of attempts, some ongoing, to improve ships' efficiency with high-flying kites.

The current leading proponent of this approach is the French outfit Airseas, founded by Airbus engineers. Their automated kite system deploys and operates a 1000 m^2 kite mounted to the bow. By flying continuous figure-of-eight loops, the system aims to produce up to 100 t of traction, delivering fuel savings of up to 16 per cent.

CLOCKWISE: Berge Olympus; Maersk Pelican; Zephyr et Boree; Shofu Maru.

It is in use on a 154 m cargo ship, while one of Japan's largest shipping companies is also invested in the technology.

Different spin on wind

Innovators have long been exploring alternatives to sails.

One of the oldest technologies harnesses the Magnus effect, in which a spinning body in an airstream creates an air pressure difference on one side.

Known as rotor ships (or Flettner ships, after an early proponent), these ships use tall cylinders mounted vertically, driven by an onboard power source. By spinning the cylinders in the right direction, these ships can harness crosswinds to create forward propulsion.

They were first developed a century ago, but interest revived in recent decades as a way of boosting the fuel efficiency of more traditional ships.

In 2018, Maersk installed two 30 m rotor sails on the Pelican, a 244 m crude oil tanker with a carrying capacity of more than 60,000 t. When operating, the rotors cut fuel use by 8.2 per cent. And last year, Airbus commissioned six large "ro-ro" (roll-on, roll-off) ships for transporting aircraft sections.

Solid state

The International Windship Association estimates that at least 20 commercial cargo ships are using a form of retrofitted wind-assist technology.

The current leading technology for modern sail power is rigid sails, for making traditionally designed and fuelled ships more efficient.

Numerous technologies are being developed and deployed, many featuring retractable or foldable self-supporting structures to capture the wind, with automated control to maximise performance.

In 2022, the 235 m Shofu Maru began shipping coal from Australia with the assistance of a Wind Challenger, a telescoping sail up to 53 m high and 15 m wide, mounted on the bow. Depending on conditions and routes, the sail can deliver average fuel savings of between five and eight per cent per voyage.

The Shofu Maru's operator, Japan's Mitsui OSK Lines, plans to launch another 25 vessels with the technology by 2030, and 55 more by 2035.

Since August last year, the 37 m bulk carrier Pyxis Ocean has been operating with two foldable wingsails, deployed on the starboard side so as to not interfere with loading and unloading operations.

Consisting of three adjustable elements (lead, main and trailing), each WindWing is more than 37 m tall. With a combined surface area equal to the two wings of three Boeing 747s, the technology has delivered an average fuel saving of 14 per cent, or three tonnes per day.

This September, four WindWings were retrofitted to the 300 m Berge Olympus bulk carrier, for a projected carbon dioxide reduction of almost 80 t per day, sailing between Brazil and China.

Meanwhile, French shipbuilder Zephyr et Boree has built what is likely the largest modern purpose-built sailing cargo ship, the 121 m ro-ro Canopée.

It sports four articulated wingsails that can provide up to 40 per cent of the total propulsion, and is shipping rocket parts from Europe to French Guiana. □

Events

DECEMBER 2024 to OCTOBER 2025

DECEMBER

04-06 DEC 2024
Combined Australian Materials Societies (CAMS) conference

Location: *Adelaide*
Website: *www.cams2024.com.au*
Symposia themes include exciting presentations on advanced manufacturing and advances in materials characterisation. There will also be talks on corrosion and degradation, a selection of durable materials for demanding environments, and much more.
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FEBRUARY

17-28 FEB 2024
National member event

Location: *Various*
Website: *engineersaustralia.org.au*
Get ready for a series of after-work networking events hosted across major capital cities, offering members the chance to connect, celebrate and engage with peers.
Save the date

MARCH

04 MAR 2025
World Engineering Day webinar

Location: *Online*
Website: *engineersaustralia.org.au*
World Engineering Day celebrates engineers and their role in sustainable development. Visit our website to learn how you can get involved.
Save the date

04-07 MAR 2025
International Women's Day (IWD)

Location: *Perth, Melbourne, Brisbane and Sydney*
Website: *engineersaustralia.org.au/iwd*
Our keynote speaker will be Captain Mona Shindy, a trailblazer in male-dominated environments who delivers outstanding organisational outcomes.
Register now

MAY

21-23 MAY 2025
11th International Risk Engineering Conference 2025

Location: *Melbourne*
Website: *engineersaustralia.org.au/risk2025*
The RISK 2025 conference theme Turning risks into opportunities: engineering strategies for infrastructure and projects, promises an engaging forum.
Abstracts and early bird registration open.

SEPTEMBER

29-04 SEP-OCT 2025
IUPESM World Congress on Medical Physics and Biomedical Engineering 2025

Location: *Adelaide*
Website: *wc2025.org*
Join the IUPESM World Congress 2025 to share your work in medical technology and science. Connect with global leaders in advancing equitable, sustainable health care innovations.
Abstracts close 2 March 2025.
Early bird registration open.

24-26 MAR 2025

21st Australian International Aerospace Congress (AIAC21)

Location: *Melbourne and Avalon*
Website: *engineersaustralia.org.au/aiac21*
The congress will explore advances in aerospace and aviation through technical, industry, government, sustainability and diversity lenses.
Register now

27-28 AUG 2025

Climate Smart Engineering (CSE) Conference 2025

Location: *Adelaide*
Website: *engineersaustralia.org.au/cse*
Returning in 2025 with a two-day technical conference, CSE is your opportunity to contribute to critical climate change conversations by submitting an abstract.
Abstracts close 11 February 2025.

RESOURCE RECOMMENDATIONS

A haven for structural engineers

The Construction Physics Substack publishes deep-dive essays about construction and industrial technology, covering everything from data centres to supersonic airliners.
construction-physics.com

Build your brand

Enhance your engineering career and professional profile with Engineers Australia's Build Your Brand toolkit. Explore tailored resources designed to help you unlock skills, advance your career and gain greater recognition.
https://bit.ly/4cV4QIf

Epic engineering failures

Mistakes often educate more than successes. AppleTV's Epic Engineering Failures and the Lessons They Teach explores the flawed design and construction decisions that led to some of history's greatest engineering mishaps.
tv.apple.com/au

Global Engineering Talent program

The Global Engineering Talent (GET) program bridges the gap between overseas qualified engineers and the Australian businesses who need them using a combination of online learning and paid placements.
https://eea.org.au/global-engineering-talent-program

THE LESSON LEARNED

Dr Anne Hellstedt FIEAust CPEng EngExec

While overseeing modelling for a large data-centre project, Hellstedt, the first woman to obtain a PhD in fluid mechanics from the University of Melbourne, was reminded of the importance of clarity.

As told to Joe Ennis

I was working for a company with a focus on building sustainable projects. Sustainability was and still is a great passion. I led a team with specialist sustainability and modelling skills. We were working on the computational fluid dynamics (CFD) modelling of the cooling system's heat loads and failure modes within a significant new data centre, to inform the mechanical design of the air-conditioning system.

On this particular project, I was the "checker" of the output generated by the CFD modelling. When the modelling came to me, I could see that the results were far removed from what I would have expected to see.

We couldn't provide these results to the client, as I knew how difficult it is to build a reputation for quality, and how easy it is to lose that reputation. So I went to the team member who had completed the work and discussed the results. I saw too much faith in the model and not enough appreciation of the underlying physics.

Although difficult, I agreed with the project director on an extension to the modelling deadline, and I worked with the team member to redo the modelling. Accuracy outweighed timeliness in this case. With the pressure placed on the team member to produce accurate results within a tight new deadline, along with my role as a senior leader in the business overseeing the work, I faced a challenge in balancing support and guidance, accountability and cultural sensitivity to hierarchy for us to successfully deliver the results together.

For the failure-mode modelling, I realised the scenario we were trying to investigate was not clear. Rather than make assumptions, we set up a meeting with the client to better understand what they needed. The lack of clarity was highlighted when the two senior members of the client team had wildly different expectations. We left that meeting with clarity across all parties.

I saw that we had fallen into the stereotype of engineers running off to solutions mode, and not taking enough time to clarify and confirm the problem before launching into the work.

Ultimately, the work delivered by the team was excellent and high-quality, and the client was happy.

This project taught me many things and reaffirmed others. Firstly, in CFD, the physics must lead the model, not the other way around. As engineers, we need to deeply understand the outputs of any model. This has never been truer than today with the advent of AI.

It's also important that everyone has enough time to fulfil their role. As the quality assurance person on this project, I should have been involved earlier.

As a leader, I aim to foster a culture where people are supported in how they go about their work; where they are able to accept feedback, absorb it and build on it. They should know the importance of this thought process, and it should be championed, so I know we will get the best-quality outcomes.

I've kept these things in mind in every project I've worked on since. □

KEY LESSONS

01
Don't put complete faith in a model. An engineer's professional scrutiny is vital.

02
Ensure you have a very clear problem statement before you start designing a solution.

03
If things don't look right, ask questions. Don't just keep working on the problem, hoping the solution will become clear.

As engineers, we need to deeply understand the outputs of any model. This has never been truer than today with the advent of AI.

Dr Anne Hellstedt is the Chair of the Engineers Australia College of Leadership and Management.


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