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create

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ENGINEERS AUSTRALIA

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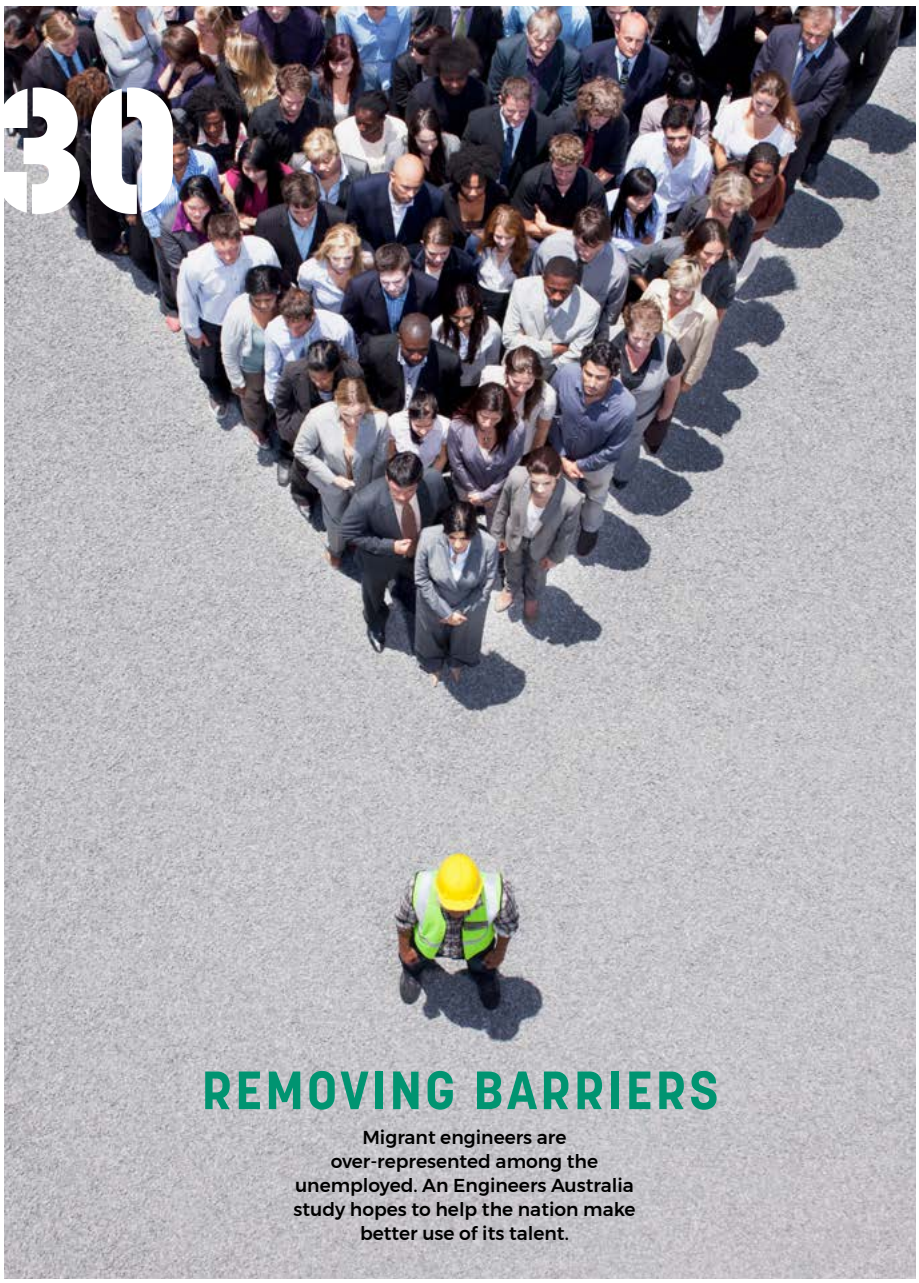

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Engineering a world of potential

AS AN INTERNATIONAL PROFESSION FACING GLOBAL CHALLENGES AND OPPORTUNITIES, ENGINEERING MUST DRAW ON SKILLS AND SOLUTIONS FROM AROUND THE WORLD.

"Why would a qualified engineer choose to drive a taxi?"

This was among the questions Engineers Australia's representatives were asked during a Commonwealth parliamentary inquiry into skilled migration earlier this year.

Australia demonstrably relies on, and benefits from, migrant engineers. More than half of the people working in Australia as engineers were born overseas — and migrants constitute an even greater proportion of those with engineering qualifications.

At the same time, it's also true that migrant engineers face significant barriers to professional employment, and are more likely to be underemployed in roles like taxi driving — even in periods of relatively high skills demand.

In response to the Joint Standing Committee on Migration's "taxi" question, Engineers Australia Senior Manager Assessments Robin Liu provided a firsthand example. His visa conditions had tied him to Canberra, where many jobs require citizenship or security clearance: "On one hand, I need to stay in a city for two years, but on the other hand I cannot find any Federal Government jobs. In that sense I'm going to drive an Uber if I can't find work."

Engineers Australia helps Australian engineers work overseas, and vice versa, through international accords and agreements that recognise equivalent benchmarked qualifications. Our Chartered credentials are also globally recognised.

As highlighted at the inquiry, we believe the Federal Government needs to overhaul its skilled migration system to better match talent supply with employment demand.

Engineers Australia is also working to more effectively support the migrants who collectively contribute so much of our nation's engineering capability, and to help organisations access talent. Our first step — research involving migrants, recruiters and employers — will underpin new initiatives.

Migration is only one part of the equation when it comes to the future of the pipeline for the engineering team, which must expand to meet growing demand while evolving to address changes in the way engineering is practised and delivers — itself a subject deserving further conversation and consideration.

While COVID-19 has temporarily slowed migration, engineering is increasingly international.

Just as engineers can move, so can engineering work, for example through offshore design centres which — despite variable track records — will remain. Supply chains, commodity pricing, cloud computing and space-enabled technology are also international. Expertise is transferred globally through research, international standards and industry practice.

In November, we will (virtually) gather experts from Australia and around the world at our Climate Smart Engineering conference. Headlined by keynote speaker, former US Vice President and Nobel Laureate Al Gore, speakers will share unique perspectives, insights and practical experiences on the challenges posed by climate change, and the opportunities for adaptation and mitigation.

We look forward to this flagship event, and hope you can join us — from wherever you are in the world (even your lounge room).

"Engineers Australia is working to more effectively support migrants who collectively contribute so much of our nation's engineering capability."

Dr Nick Fleming
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DEBATE AND DISCUSSION BY *CREATE*'S READERS

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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.

Flying high again

International airlines have been largely grounded in Australia since March 2020 and flights, except for a small number of repatriation flights, indefinitely suspended.

Nineteen months on from the COVID-19 pandemic outbreak, approximately 38,000 Australians are stranded overseas, many of whom are engineers. They have lost jobs, accommodation, and the ability to see friends and family due to the pandemic and have faced serious hardship. More than half of all Australians attempting to leave Australia are rejected every month.

Yet it doesn't have to be this way! As professional engineers who are very good at problem-solving can attest, once track-and-trace virus testing, vaccines and quarantine facilities are available, along with a system to keep track of this information in real time, flights and a relatively normal life should be able to resume.

"We devised an electronic health passport – including virus test results, virus recovery results and vaccine inoculation – to help get airlines flying again."

With a grant from the UK Government via the South East Local Enterprise Partnership and the European Union Regional Development Fund (which has now ceased), we at Raptohna devised an electronic health passport — including virus test results, virus recovery results and vaccine inoculation — in October 2020 for one of our clients.

Israel and the European Union have either already implemented or are currently rolling out schemes like this among their citizens.

However, this solution has sparked a debate around ID cards and the reluctance of democratic governments to be seen as effectively mandating that their populations get vaccinated. It could also be seen as discriminating against those who cannot or will not get vaccinated.

However, individuals keeping a record of their vaccine and test status with them when they fly or want to access services — such as music venues, pubs and restaurants — could get our economies moving again and help to reduce the mounting debt burden.

Surveys have shown that the majority of people in free democratic societies currently suffering from the restrictions imposed by lockdowns all over the world are willing to sacrifice some of their freedoms and carry an electronic health or vaccination passport with them when they need to fly or to access social venues on a short-term basis.

However, some politicians and human rights organisations are still reluctant to follow the will of the majority; they believe once these measures are introduced, it will be very difficult to withdraw them when the pandemic is under control, as there will always be a future virus threat.

If we continue as we have been doing, with lockdown following lockdown, the cost in terms of jobs lost, social isolation and debts incurred by governments will fall most heavily on the younger generation.

They will experience high levels of unemployment and underemployment in an increasingly insecure and competitive job market. More socially isolated people will chase fewer and fewer jobs with very limited and more expensive options for vacations, inflicting incalculable effects on mental and physical health.

Dr MARCO CIANNI FIEAust
CTO, Raptohna Ltd

Striking oil

BY APPLYING LESSONS FROM THEIR PROFESSIONAL CAREERS TO FOOD PRODUCTION, A MARRIED COUPLE OF ENGINEERS BUILT A UNIQUE OLIVE OIL BUSINESS FROM SCRATCH.

WHEN TANUJA Sanders and her husband Keith relocated to rural Western Australia in the late 1990s, making olive oil was not part of the plan.

The pair had been sub-contracted by Transfield to work on the expansion of the Worsley Alumina bauxite mine and decided to put down roots in the area.

They purchased a picturesque 40 ha property near Bunbury and set about building a house.

At the house-warming party, a neighbour suggested to Sanders that she plant some olive trees on a 12 ha parcel of empty land at the front of the property.

"I ended up buying 2500 trees," she says, laughing. "I thought it could be a fun hobby."

That hobby would eventually become the Sathya Olive Company, a thriving enterprise that now cultivates about 30 t of olives per year.

Overseen by Tanuja Sanders, whose background is in project-managing power plants, the company produces extra virgin olive oil that has won awards from Perth to the US.

Some of the couple's success can be attributed to the location of their property, atop sandy soil in a sun-drenched corner of WA.

"We're blessed with beautiful weather and land that is very conducive to growing olives," says Sanders.

Because sandy soil drains more freely than clay-based earth, the couple's trees are less susceptible to common diseases caused by water logging.

But sandy soil poses challenges, too.

"Because the soil drains so easily, the trees require frequent watering," says Sanders. "And all that water leaches essential minerals from the soil."

She realised that the long-term success of her olive grove would depend on how effectively it was irrigated and fertilised.

First, she installed bore pumps that could pump large volumes of water at speed. Then she turned her mind to fertilisation.

Sanders knew that small-scale fertigation – injecting fertilisers into an irrigation system – was established agricultural practice.

But she needed to replicate that technique on a larger scale.

"It was difficult to dose precisely because bore pumps are very powerful and the flow rate varies," she says. "We couldn't just pump X amount of fertiliser into the water."

"BORE PUMPS ARE VERY POWERFUL AND THE FLOW RATE VARIES. WE COULDN'T JUST PUMP X AMOUNT OF FERTILISER INTO THE WATER."

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Worth bottling

Sathya Olive Company founders Tanuja and Keith Sanders now have their sights set on export markets.

To compete with the big players, Sathya will need to transition from manual bottling to automation.

"The challenge now is to come up with a bottling methodology that prevents cross contamination," Tanuja Sanders says.

"Automated bottling is nothing new, but there is no bottling system that is designed to be used for multiple varieties of infused oils without wasting too much oil in flushing lines."

One option is simply to purchase a bottling machine for each variety of oil the company produces.

"But we can't justify that cost right now," says Sanders.

Instead, she hopes engineering ingenuity will once again help the Sathya Olive Company gain a competitive advantage.

"If anyone out there in the engineering community can design a method that works, we would love to hear from them," she says.

"TO CREATE A SUSTAINABLE OPERATIONAL MODEL, YOU HAVE TO GIVE BEFORE YOU GET. SO WE GIVE A LOT OF LOVE AND ATTENTION TO THE TREES."

However, Sanders was familiar with the chemical-dosing pumps used in modern power plants.

"Those pumps are designed to measure the flow rate of the water in real time and to pump the exact amount of chemicals required to achieve consistent concentrations," she says.

She purchased several dosing pumps, and with help from her husband Keith Sanders – a commissioning engineer – configured them to interact with the bore pumps.

The fertigation problem was solved.

Sathya Olive Company grew steadily, and by 2019 it was producing 5000 L of oil per year. Although Sanders continued to project-manage for energy and resources companies in WA, she spent much of her time developing the business.

Encouraged by their early success, the couple decided to ramp up production by adding 6000 new trees in a super high-density configuration with a plan of replacing the existing plantation progressively over five years.

But another problem loomed.

"Because we were on a farm that only had single-phase power supply, we were restricted to using pumps that can run on single-phase power," Sanders says. "To grow, we needed even bigger pumps."

They approached Western Power to see if the property's power supply could be upgraded to three phase and were shocked when they received a $500,000 quote.

So they began to brainstorm alternatives with their electrical engineering colleagues.

"We came up with a method by which we applied variable speed drives to convert the single-phase power supply to three phase," says Sanders. "That enabled us to run a three-phase motor from a single-phase input."

As a result, Sanders has been able to scale up production without compromising her precise fertigation process.

TOP: The trees are planted in a high-density configuration. ABOVE: Sathya Olive Company founders Tanuja and Keith Sanders.

"I've learned as a project manager that to create a sustainable operational model, you have to give before you get," she says. "So we give a lot of love and attention to the trees."

The production of the oil is undertaken just as carefully: the olives are stored in shallow bins to prevent bruising, then cold pressed within six hours of being picked.

Among the awards won by Sathya's olive oil are a gold medal in the 2019 Los Angeles International Extra Virgin Olive Oil competition and a trophy at the 2019 Australian International Olive Awards. ●

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WORDS BY **CHRIS SHEEDY** AND **JONATHAN BRADLEY**

WELCOME TO CLIMATE SMART ENGINEERING 2021.

OUR WORLD is at a turning point. More aware than ever of the effects of climate change, more receptive than ever to guidance from subject-matter experts, and more concerned than ever about the future of our planet, people are looking for leadership.

Engineers have to be a major part of the solution, being involved in processes from planning and design to construction and maintenance.

At this year's Climate Smart Engineering conference, global experts and specialists, including former US Vice President Al Gore, will outline the fascinating challenges and enormous opportunities for engineers as businesses, investors and policymakers pivot to face the future.

In these pages, we meet four speakers from Climate Smart Engineering 2021 and get a taste of the breadth of the event's information, value and content.

Brett Mitsch

Managing Director, Steam Plains Capital

THE PLENARY session I'm chairing at the Climate Smart Engineering conference is all about bringing together the money side of the business with engineering.

Through the lens of the United Nations Sustainable Development Goals (SDGs), there is clearly a role to play for the engineering community in understanding what the investor universe is looking for and how it thinks about monitoring and measuring sustainable investment.

There are two major parts of the investment arena: equity and debt. In the session, we'll have representatives from major Australian superannuation funds, as well as ANZ's Head of Sustainable Financing and an engineer from GHD.

The idea is to give an understanding of the importance of the SDGs to the investor

"INVESTORS THEMSELVES ARE NOW BEGINNING TO SAY, 'I'M A RESPONSIBLE INVESTOR, SO I'M USING THE SDGs TO FRAME HOW I THINK ABOUT WHERE TO PUT CAPITAL.'"

community, and to then relate why it's important to understand that those SDGs must have clear targets and indicators supporting them.

A lot of those targets that are built around the SDGs are deeply connected to engineering. The engineering community has a vital role to play in finding solutions and in measuring, reporting and monitoring against clearly defined SDG targets.

In many cases, this is about breaking down the silos that exist between the investment community and the technical professions. It's about being able to understand the language of the investor from the engineering perspective. This assists in understanding the whys, the hows, and the tools required to ensure that the SDGs are a well-understood standard.

Investors are increasingly moving away from what has become relatively ambiguous environmental, social and governance (ESG) language. Because of the ambiguity in ESG language, they are moving towards SDGs because these more clearly indicate how and whether targets are being met.

Investors are now beginning to say, "I'm a responsible investor, so I'm using the SDGs to frame how I think about where to put capital."

It's a framework that allows all stakeholders to measure success.

A classic example is SDG 6, which concerns access to clean water and sanitation. That's a classic engineering challenge.

What is the baseline of who has access to clean water today? What is the capital required to improve that, to meet a new goal? What is the best technology to put to work to reach the target? Who is going to fund it?

If you understand these conversations you can begin to have a powerful discussion around investments – and a discussion that is tied to a clear target and the precise language of engineering.

Elise Brown

Sustainability Design Consultant, WSP

ENGINEERS HAVE such an influential role in shaping and ensuring our sustainable future.

In *A Sustainable City: How Engineers Will Ensure Long-term Sustainable Prosperity*, a paper I co-authored with James Gleeson from Marvel Engineers, we examined how innovative infrastructure has begun to influence our ability to meet the United Nations Sustainable Development Goals. These goals are aimed at creating enduring value for an ever-evolving society.

We explored advances in digital technology and green infrastructure, solutions that cater for our shifting society and that potentially offer infinite capability and potential, thanks to the scalability of technology.

Our stance is that smart innovations and smart technology provide good alternatives to our current behaviours.

For example, there's an opportunity, which we're seeing in action in some places, to integrate things like artificial intelligence and big data to create a more sustainable agricultural system. Smart technology allows farmers and policymakers to create strategies based on real-time feedback about climate conditions, weather patterns, soil quality, moisture, fertilisers and more.

Smart tech can optimise the use of fertilisers and pesticides and identify accurate irrigation levels for crops in a specific field and a specific geography. This ›

"ENGINEERS ARE INNOVATORS AND THEY EDUCATE POLICYMAKERS ON OPPORTUNITIES. THEY ARE INFLUENTIAL IN PLANNING, DESIGN AND CONSTRUCTION – IN EVERY FACET OF THE BUILDING OF OUR CITIES."

replaces the current, typically unsustainable methods of irrigation and fertilisation.

By integrating data, processes are optimised and new opportunities are presented. Vertical farming is a good example. It brings agriculture into the areas that consume most of its produce.

Engineers implement these designs. They're innovators and they educate policymakers and others on opportunities. They are influential in planning, design and construction – in every facet of the building of our cities.

And we'll require engineers to come up with new solutions in every facet of our cities.

This is what we'll be discussing at the Climate Smart Engineering conference.

Perhaps the best way to illustrate the breadth of opportunity is to quote from the abstract of our paper, which I think sums it up quite nicely.

"Picture a sustainable city: net-zero carbon emissions, interconnectivity, digital networks, and existing infrastructure proactively maintained for optimal performance. Energy is centred around clean and renewable sources such as wind and solar, and waste is valuable capital for circular and regenerative systems. As a service, transport prioritises inclusivity and accessibility, with well-connected high-capacity mass transit corridors. As society grows, new infrastructure is adaptable, flexible and regenerative.

"For our current society, changing climates and outdated infrastructure, unable to keep up with demand, have forced a rethink of how our cities operate. With the risks of climate change intertwined with our societal desire for continual growth, is our infrastructure capable of meeting the challenges that lie ahead?"

Only engineers can provide the answer.

Theresa Tian Qin

Mechanical Engineer, Aurecon

INLAND REGIONAL communities tend to miss out on a lot of major renewables initiatives, such as big wind, hydro and solar plants. These plants are typically on-grid, coastal and built to benefit cities.

What can the smaller towns that miss out on these major initiatives do?

I looked into this during my recent honours thesis research. My thesis, which I'll be presenting at the Climate Smart Engineering conference, is about integrating a solar thermal generator with a geothermal generator, and at the same time desalinating water.

"I SUGGEST NOT WASTING THAT GEOTHERMAL ENERGY AND USING IT INSTEAD TO MAKE A SOLAR THERMAL SYSTEM MORE EFFICIENT."

There hasn't been a lot of research conducted on the idea of combining multiple different small-scale, renewable systems into a single system to improve efficiency. I framed my research as a case study on Winton in Central West Queensland.

The local area has quite a few low-grade geothermal sources. On their own, these are not good enough to run a geothermal power plant. There are a few bores in Winton supplying geothermal fluid to the town at about 80°C. It is allowed to cool and then used to supply the town mains.

I suggest not wasting that geothermal energy and using it instead to make a solar thermal system more efficient. This is a new concept and a lot more work needs to be done before we see a market-ready design.

This is niche in the sense that it's only suitable for regional towns that are not connected to the grid, which usually have their own diesel generator. But that is the case for a lot of regional towns – not just in Queensland but throughout Australia. It's niche, but there is potentially a very large market for it in Australia.

I ran simulations to figure out an optimised arrangement. Solar thermal is the main generation technology, with a boiler being powered by solar thermal energy. When we combine a geothermal source to the mix, the efficiency is dramatically improved.

Adding thermal-powered water desalination means the system wastes as little heat as possible while providing enough water for the entire town to drink.

That's just one option of combining technologies; I'll go through more at the conference. Energy storage, for times when the sun is not shining, also needs discussing.

Making the systems fit together is a fascinating challenge and the solution will be all about brilliant engineering. ▸

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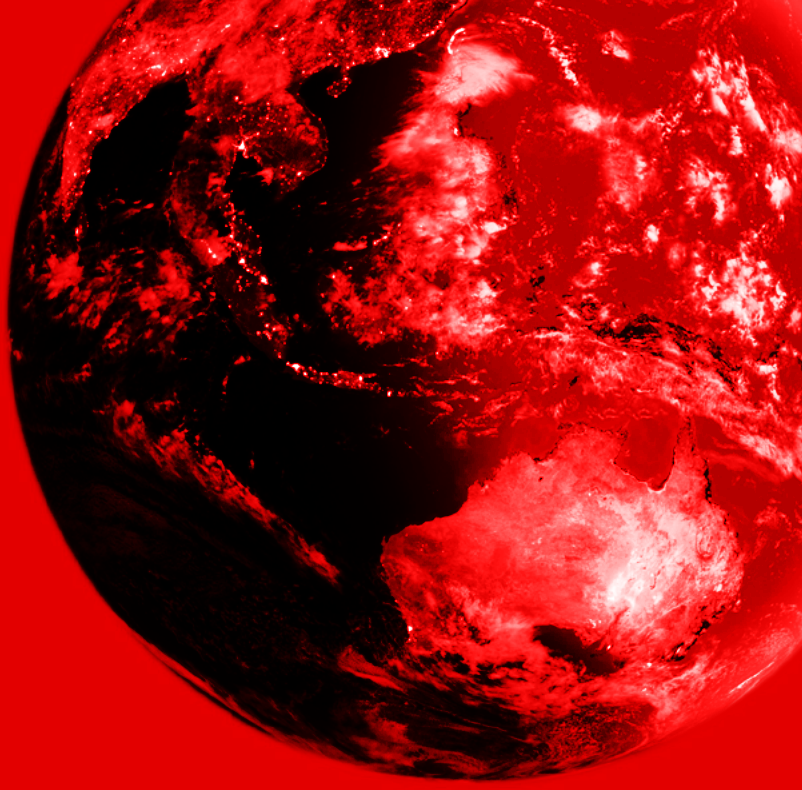
AN ENGINEERS AUSTRALIA EVENT



CLIMATE SMART ENGINEERING CONFERENCE 2021

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Tom Quinn
Head of Policy and Research, Beyond Zero Emissions

AT BEYOND Zero Emissions we've focused a lot of energy on creating a model for the reindustrialisation of Australia through doubling down on green industry and green export.

Much of this effort will centre on renewable energy industrial precincts (REIP).

We have identified 14 ideal REIP locations, almost every one in current industrial heartlands. And we've taken a much deeper dive into two of these: Gladstone in Queensland and the Hunter Valley in New South Wales, both known for their intensive fossil fuel economies.

These areas could become powerhouses of the future green export space, particularly in green steel, green aluminium and green hydrogen.

From a jobs perspective, we've shown that, in those two locations alone, REIPs could create 45,000 jobs by 2032. These precincts would bring billions of dollars of revenue into regional areas and significant capital investment.

All of this will rely on engineering skill sets.

These REIPs are a good news story from every angle. Our proposals have garnered support from industry, from local communities and from both sides of politics.

In the past, people have been stuck on the argument that we need to choose between fossil fuels and green energy, or between the economy and the environment.

We're arguing that it's simply a smart economic approach to diversify local and regional economies.

Global demand is clearly and rapidly shifting towards net-zero emissions. Australia's top five trading partners, who take 80 per cent of our fossil fuel exports, have all committed to net-zero emissions. Right now they are implementing policies that will result in net-zero emissions earlier. There is no long-term future in fossil fuels.

Why should engineers be interested in this? Because engineers will be critical to its success. They are the designers and the builders.

Engineers will be required to design and build new industries and to re-tool existing facilities. Engineers will be needed to convert steel smelters and other plants from running on metallurgical coal and gas to green hydrogen. It's a fascinating challenge, and one that only engineers can solve.

Finally, we'll need more smelters across the country to bring us up the value chain. Rather than simply exporting very large quantities of iron ore, we can create value and jobs onshore as we tap into our abundant and competitive renewable energy resources.

All of this will require a lot of very smart engineers to make it a reality. ➤

"THESE AREAS CAN BECOME POWERHOUSES OF THE FUTURE GREEN EXPORT SPACE, PARTICULARLY IN GREEN STEEL, GREEN ALUMINIUM AND GREEN HYDROGEN."

BELOW: Port of Gladstone, Queensland.

Dr Massoud Sofi
Research Fellow, The University of Melbourne

AS AUSTRALIA'S uptake of photovoltaic (PV) solar panel technology has grown over the past few decades, a new problem has come along with it: what to do with the panels when they reach the end of their life.

Australia will have to deal with 1.5 million tonnes of decommissioned photovoltaic waste by 2050. Globally, that figure is roughly 80 million tonnes. But the current approach to PV panels as they reach their end of life is to dispose of them as general waste. There are no other alternatives.

Those disposal costs are around $2000 per tonne, and although there's technology to recycle the materials in panels to a very high purity that could possibly be used to remake solar panels or similar electronics, these new materials cost approximately the same. So electronics manufacturers would prefer to use virgin materials rather than recycled ones.

But rather than recycle the materials, my research is looking at upcycling them. The problem is complex; a lot of hazardous materials are involved in the make-up of a solar panel, including lead, copper, zinc and other heavy metals. And because the panels are made to be very compact so they can function the way they do, it becomes quite challenging to process them.

We are trying to look at how we can create value out of these materials – in our case, we are looking at processing the materials to turn them into construction materials. And because the panels are made up of a composite where the front is glass and the backing is a polymer material, we're trying to use that to produce oil and fuels that could be also used for other applications.

"AUSTRALIA WILL HAVE TO DEAL WITH 1.5 MILLION TONNES OF DECOMMISSIONED PHOTOVOLTAIC WASTE BY 2050. THE CURRENT APPROACH TO PV PANELS IS TO DISPOSE OF THEM AS GENERAL WASTE."

LEFT: Photovoltaic waste.

This involves some challenges. We are setting up an innovative high-capacity separation process that ensures the volume of upcycled materials is high. Conducting experiments in laboratories is one thing, but when it comes to scaling the process, it must be transferred so that it is suitable for industry.

Lastly, the output materials produced by the process must meet Environmental Protection Authority requirements, to make sure there are pathways for those materials to actually be used.

It's not just a matter of putting solar panels into a machine and producing phones or polymer materials at the other end. How do we separate materials that are classified as non-hazardous from those that are classified as hazardous? Are the extracted materials efficient in terms of meeting industry partners' investment requirements? Are those products useful enough for them to have a market down the track? Otherwise, it would be quite easy to process these materials and use them as a filler material in concrete or construction.

Once the technique is established, we could look at ways to upcycle similar types of waste. For example, TV screens have similar features to PV cells – they are made up of glass and polymers and metals. Future research could consider what other outputs the process could create with properties that fit the market.

One example is grinding glass to a level fine enough that it could be automatically taken up by cement production industries and combined with fly ash. You could actually combine different types of materials to give them value. ●

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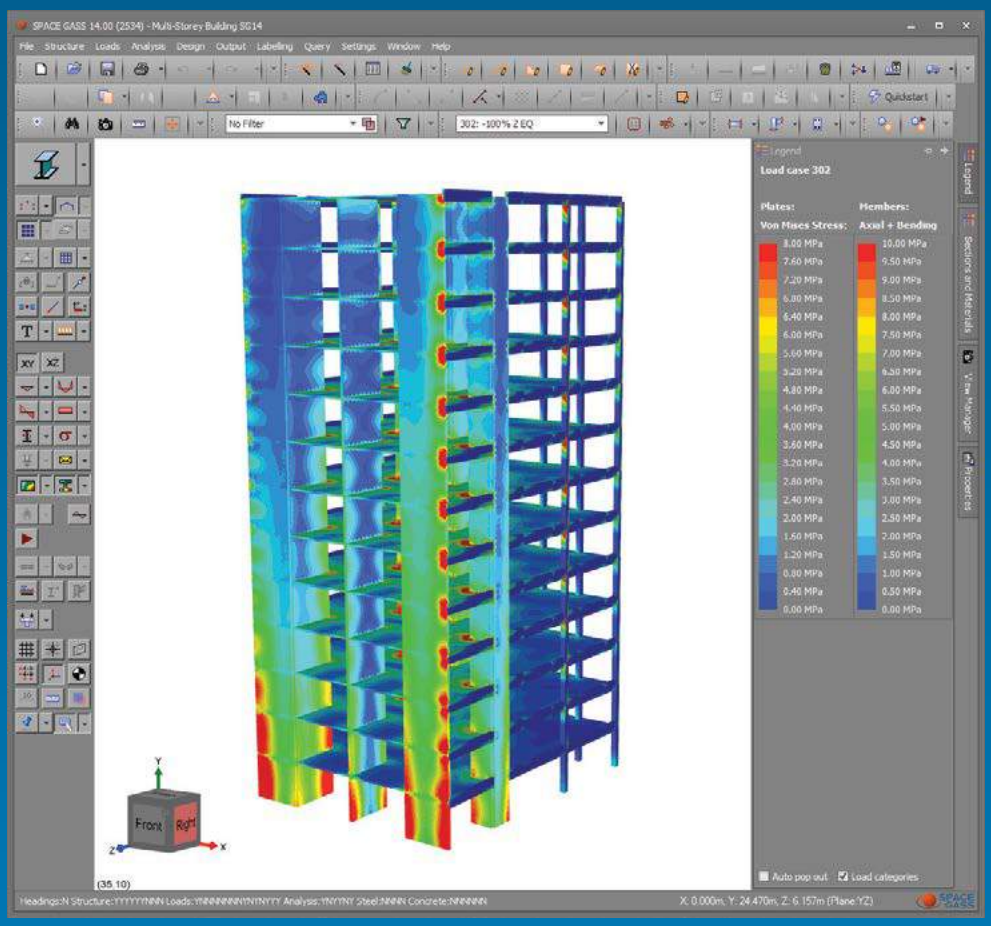

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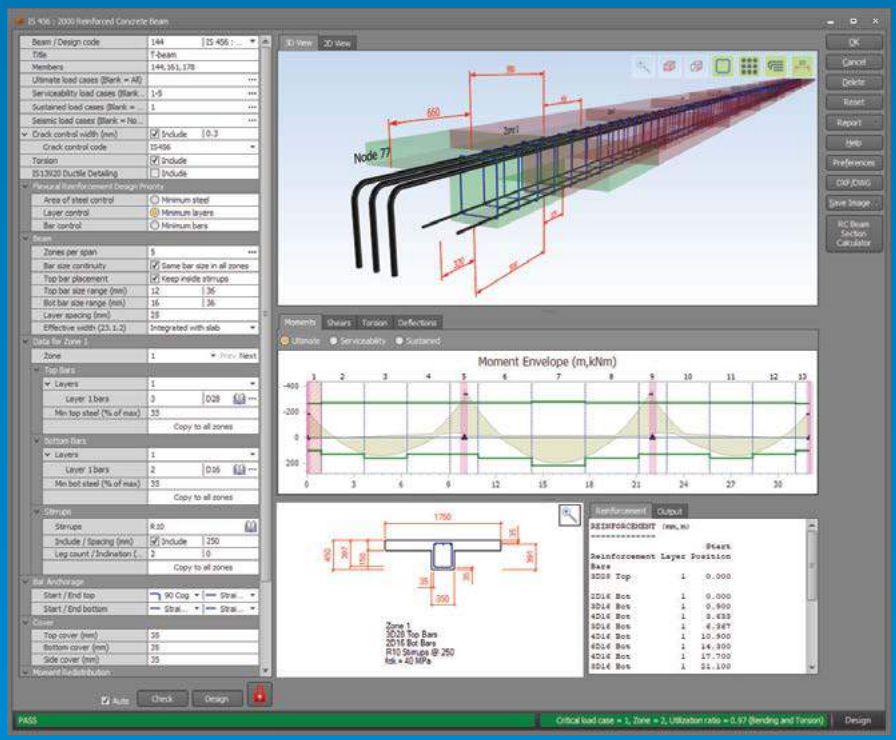

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NEW SENSATION

WORDS BY **JONATHAN BRADLEY**

A CAR ACCIDENT DURING MEDICAL SCHOOL LEFT DINESH PALIPANA PARALYSED FROM THE CHEST DOWN. NOW HE'S WORKING WITH A TEAM OF ENGINEERS TO HELP PEOPLE LIKE HIM ONE DAY WALK AGAIN.

IT BEGAN in an elevator.

That's where Claudio Pizzolato ran into his neighbour, Dinesh Palipana, a fellow student who was living a couple of doors down. The two found they had a lot in common: Pizzolato was an engineer and Palipana was in medical school, but each was studying at Griffith University, and both had an interest in spinal cord research.

But for Palipana, the interest was also personal. When he met Pizzolato in 2016, he had been paralysed from the chest down for five years. A car accident in 2010 had put him in hospital for nearly a year, disrupted his studies and left him with quadriplegia.

"I came back to medical school, but through this whole period, I was looking at what the new developments were with spinal cord injury research and paralysis, and looking at what was happening around the world to treat and restore function in people that had been paralysed from it," he tells *create*.

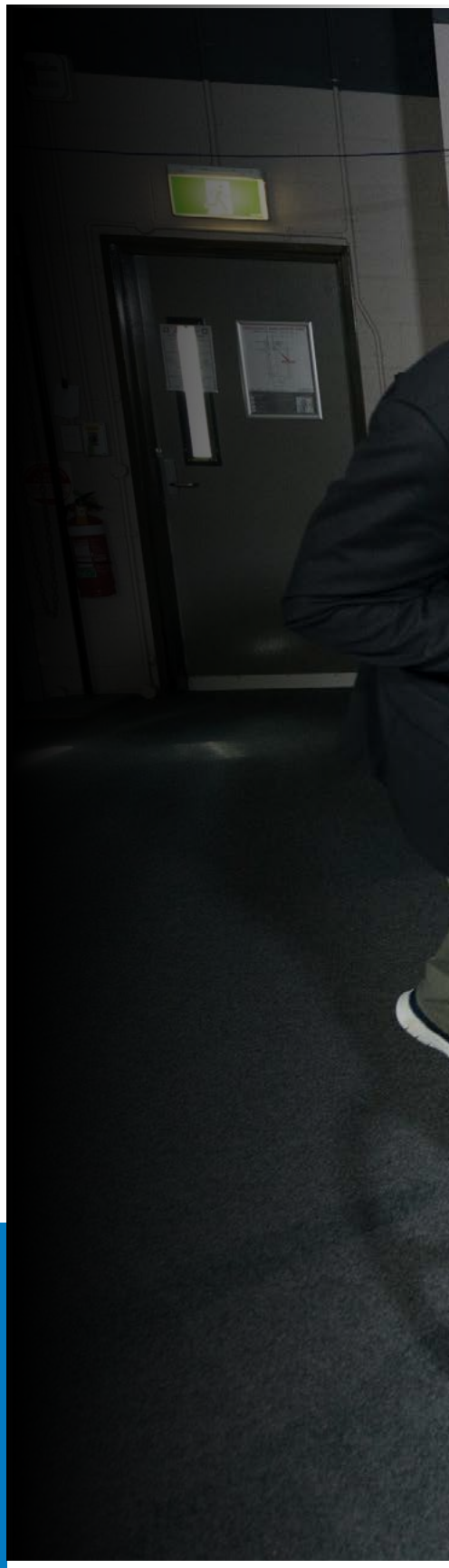
"I saw some really interesting research coming out with robotics and robot-assisted rehabilitation [and] thought-control rehabilitation, which was really interesting. It was actually giving people return of function after being paralysed for many years, and it's really the first time we've seen that in human history."

At the same time, Pizzolato was researching musculoskeletal models – computational models that help explore the interaction between muscles and the nervous system during movement and rehabilitation.

"We started talking about spinal cord injury research, and his work and my work," Palipana recalls. "And we started fiddling around with the idea of putting some of these studies together, building on it, and building a research project and building therapies here in Queensland."

"We found this great synergy where we could apply our excellent research and years of research – not in spinal cord injury, but in computational ▸

"IT WAS ACTUALLY GIVING PEOPLE RETURN OF FUNCTION AFTER BEING PARALYSED FOR MANY YEARS, AND IT'S REALLY THE FIRST TIME WE'VE SEEN THAT IN HUMAN HISTORY."



OPPOSITE: Dinesh Palipana (seated) with BioSpine team members Professor David Lloyd (left), Dr Laura Diamond (second from right); and Dr Claudio Pizzolato (far right).

modelling – to the problem of spinal cord injury," says Pizzolato.

The two graduated on the same day in 2016. Today, they're running the BioSpine Research Group, based at Griffith's Centre of Biomedical and Rehabilitation Engineering.

The goal: for Palipana – and for other people with spinal cord injuries – is to walk again.

BELOW (from top): Dr Laura Diamond; Palipana uses the BioSpine ergometer.

themselves, as would happen organically in the case of someone with an undamaged spinal cord.

"That is basically three components: the brain, the computer model to transform the thought into controlled signals for the devices, and then the devices themselves," Pizzolato says.

But to make this work requires the technology to mimic a lot of bodily functions we do not usually notice. A cyclist does not think about every contraction of their muscles required to move; they think of the cycling action and allow the specific signals required to make it happen to fire from the spinal cord, and then adjust their movement according to the sensations they feel in their legs.

"Part of the technology involves stimulating the muscles so that there's a thought-provoking process, of course, as well as actual [functional electrical stimulation] of the muscles," says Dr Laura Diamond, a biomedical engineer on the team. "We want to understand that feedback loop: how much stimulation is required, how much is safe."

"THAT IS BASICALLY THREE COMPONENTS: THE BRAIN, THE COMPUTER MODEL TO TRANSFORM THE THOUGHT INTO CONTROLLED SIGNALS FOR THE DEVICES AND THEN THE DEVICES THEMSELVES."

MIND AND BODY

BioSpine is billed as a "novel neural restoration technology". It combines technological solutions designed to help people with spinal cord injury to regain control of their limbs, such as a brain-computer interface and machine learning, with a therapeutic approach designed to one day restore damaged nerve connections.

The technology involves a motorised ergometer – an exercise bike, essentially – on which the patient sits. A brain-computer interface in the form of a head-fitting picks up the patient's thought patterns using electroencephalography, and a machine-learning algorithm classifies the intention of those thoughts.

"You put the headset on and then you think about cycling or walking or just relaxing and the AI basically distinguishes what the person is trying to think and that generates an appropriate signal," says Pizzolato.

That signal is then transmitted to the ergometer to enable the desired movement – in this case, cycling – to be performed. The system also stimulates the muscles

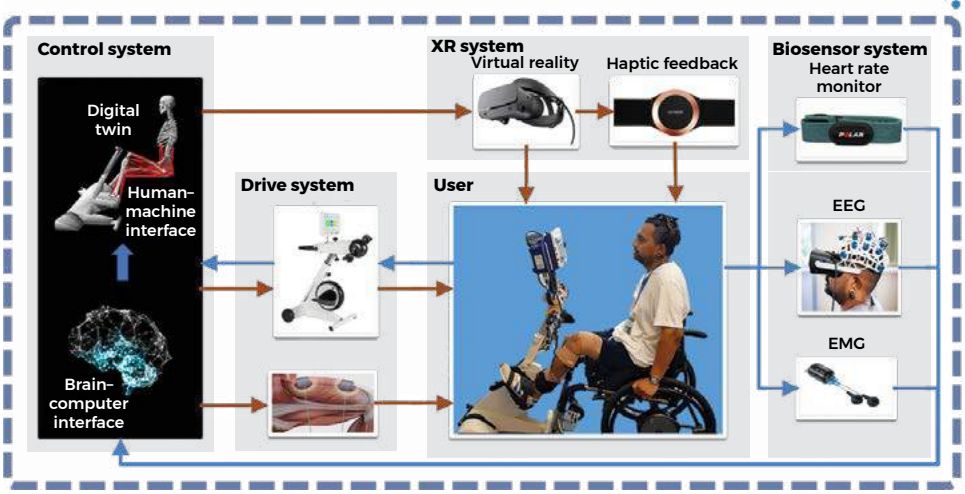
A CUSTOMISED TWIN

This is a complex system, and to make it all work, a digital twin is integrated into the technology.

"It's a computational model of the nervous system, the muscular system and the skeletal system of the person," explains Pizzolato. "That allows us to translate these signals into something appropriate for the rehabilitation devices that is consistent with how the person would actually move."

"It's actually a clinical problem as much as it is an engineering problem," says Diamond. "People with spinal cord injury, because ▸

CONNECTING MIND AND MUSCLE WITH THE BIOSPINE SYSTEM



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TOWARDS ZERO

they don't have that sensory feedback loop, that can often result in injuries, over-training."

That's because they cannot rely on feedback from their nervous system to tell them if something has gone wrong.

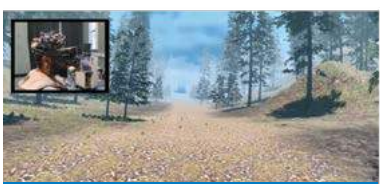
"Without that feedback, we need to rely heavily on the computation, and the digital twin is what we're actually able to do that with," Diamond says.

The ultimate goal of this is rehabilitation: the hope is that the patient will be able to regain at least some control over the paralysed portion of their body.

"By combining the downward signals from the brain down and upward from muscles and tendons back up, there is evidence that it promotes neuroplasticity," Pizzolato says. "That enables reconnection of neurons within the spinal cord, as well as neuroplasticity, meaning that these signals can be redirected through still intact pathways back to the brain."

That's based on pre-existing research showing that such connections are possible to form, and the digital twin is designed to adapt once the patient has regained some control.

"At the moment, Dinesh doesn't have any voluntary control of muscles in his lower limb; he's relying fully on stimulation," Diamond says. "But the assumption is that when that changes, we would then want the stimulation to adapt depending on how much he was actually contributing to the cycling."



"EVERY INJURY IS VERY UNIQUE AND HOW THAT PRESENTS ACROSS PEOPLE IS VERY UNIQUE. WE WILL HAVE THE CHALLENGE OF NEEDING TO PERSONALISE THESE TREATMENTS."

EXPERT INSIGHT

BioSpine is now undergoing its first round of clinical trials and, as well as leading the team, Palipana is currently its sole test subject. Using his experiences and expertise, they plan to report their results and make refinements to their processes, and then proceed to phase two, which will be a year-long trial with six subjects.

Having Palipana as a test subject gives the team unique insight.

"Dinesh gives us an opinion and brings in lots of expertise from a medical perspective and also from the perspective of an individual with spinal cord injury so we also understand what are some of the additional constraints we need to undertake," Pizzolato says.

That enables his feedback to be more precise, says Dr Ana de Sousa, an expert in using robotics for rehabilitation.

"It's funny to see our conversations, like we're trying to find out when he's the patient, when he's the boss of the thing," she tells *create*. "He doesn't know the engineering aspect of it, but he knows the overall purpose, and overall goal … his feedback is a little more on point. He knows more where he wants to get."

TOP: A virtual reality set-up (inset) helps the patient direct the right signals to the brain-computer interface. ABOVE: Dr Ana de Sousa.

Palipana's unique place in the research means the team can ensure the patient's experience is centred in what they do – which matters, because rehabilitation is most successful when the patient is engaged, comfortable and has their needs addressed.

"With spinal cord injury, obviously every injury is very unique and how that presents across people is very unique," ›

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explains Diamond. "We will have the challenge of needing to personalise these treatments."

The team engaged industrial design students to customise the equipment so it would be more comfortable. Pizzolato describes the brain-computer interface, for instance as a "rigid hat".

"We went through a couple of very expensive research-grade systems which were uncomfortable to wear after a while – after 10, 15 minutes," he says.

"And if it's not comfortable to wear, you can't use it to do rehabilitation. So, through our students, we redesigned some of these headsets, and what we have done is basically redesigned them based on the head shape of the participants.

"So we used structural scanning to do a 3D-reconstruction of each person's head and virtually we've selected the optimal location for the electrodes where they need to be placed."

The technology is also constructed so that it can be easily changed or repaired.

"One of our ideas is having a system that's modular, in a way that you can add new features, you can remove features, and you can just replace features quite easily," says De Sousa. "So I use what's called a robot operation system, ROS. With the system, I can create this environment where we add everything, and we can remove parts of the system, and it still works."

"WE DON'T WANT IT TO REMAIN A NICE EXERCISE THAT WE DO AT THE UNIVERSITY AND NEVER GOES OUT TO THE PUBLIC."

BELOW: Palipana is the sole test subject in the first round of trials.

TAKING STEPS

The BioSpine project uses existing technologies but combines them in unprecedented ways in hopes of making a breakthrough that is not yet possible. That, Pizzolato says, is what distinguishes it from similar work being conducted overseas.

"Our foundation is solid," he says. "What we're doing is putting everything together, plus adding a computational model of the person to really coordinate the rehabilitation devices."

The BioSpine team comprises engineers, doctors, physiologists, pharmacologists and more in pursuit of a genuinely multidisciplinary goal.

"The thing with medicine is that it's so slow to adapt to change," Palipana says. "Engineers are so solution-focused and they're practical as well, which I have found to be really good because we are able to identify all these different problems and the guys in our team drive solutions."

And though the team is yet to report results, everyone *create* spoke to was optimistic about the technology's future prospects. If the round two trials go well, Pizzolato expects the therapy to be used outside a university setting by the end of 2023.

"We don't want it to remain a nice exercise that we do at the university and never goes out to the public," he says. "Eventually, if the technology goes in clinics, you need to get the clinicians on board."

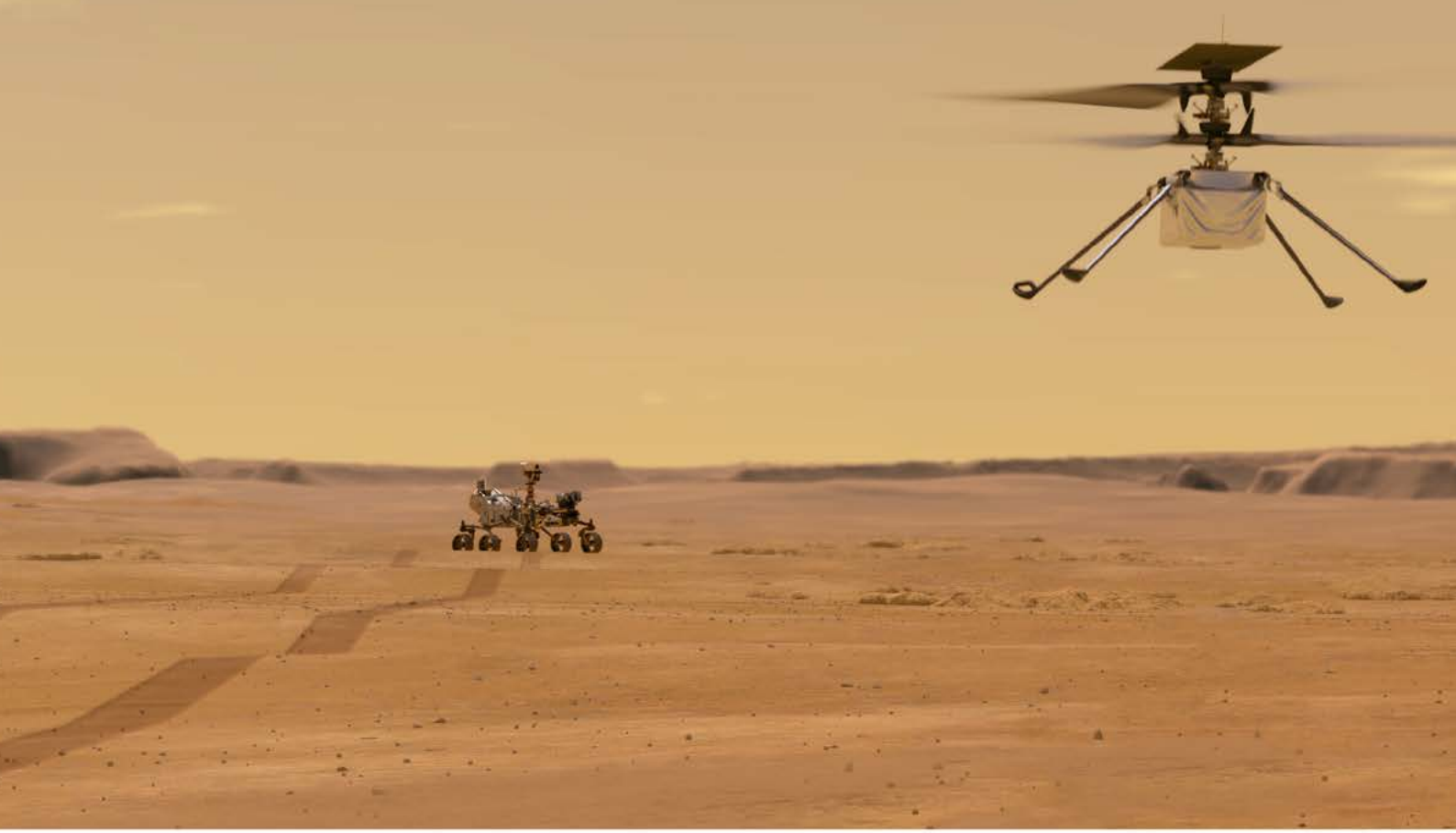
Diamond concurs.

"We can't service large numbers of people in the community within the university long-term. It's not sustainable," she says. "The idea is that you want accessibility; you want effective therapy to be accessible to all."

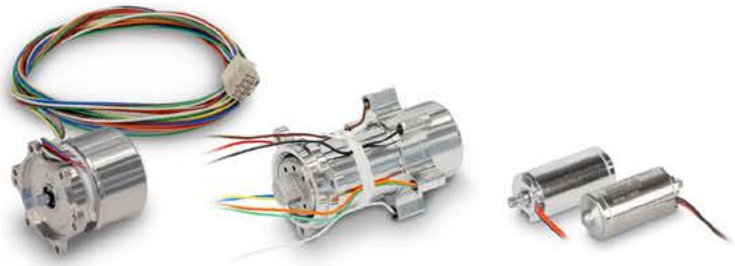
When asked about his next steps, Palipana's response is direct – and literal.

"To take steps," he says.

"That would be the dream actually. It's an audacious dream, but that's what we're working towards. To give people that opportunity." ●



maxon motors on Mars



DC motors from maxon have been used in virtually all successful robot missions on Mars. More than 100 of these drives from maxon are already on the Red Planet including the Perseverance rover and the helicopter drone Ingenuity.

Perseverance rover's mission is to collect soil samples that will be analysed on Earth later. maxon's precision DC motors and gearheads are used in numerous mission-critical tasks. They will power the small robotic arm in the rover which moves the valuable samples from station to station. The motors are based on our standard industrial products: a flat, brushless DC motor and a planetary gearhead with a diameter of 22mm. maxon's brushless DC motors are also used for sealing and depositing the sample containers.

Ingenuity helicopter will perform the first flights on the Red Planet. There are six 10mm brushed DCX micromotors used to control the tilt of the rotor blades, which determines the direction of Ingenuity's flight. The drone weighs 1.8kgs, is solar powered, and is designed to take aerial photographs. This experiment will primarily test the concept for further drones of this kind.

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Main Image Credit NASA/JPL-Caltech

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WORDS BY **CHRIS SHEEDY**

HELP WANTED

DESPITE CLOSED BORDERS, A TALENT SQUEEZE AND RECORD INFRASTRUCTURE SPENDING, MIGRANT ENGINEERS REMAIN OVER-REPRESENTED AMONG THE UNDEREMPLOYED. A MAJOR ENGINEERS AUSTRALIA STUDY SEEKS TO UNDERSTAND BARRIERS AND HELP EMPLOYERS, MIGRANTS AND THE NATIONAL INTEREST.

RIGHT: Sam Matti, GHD.

AS A YOUNG graduate, engineer Sam Matti had a seemingly promising role at a Baghdad power station – until a personally targeted death threat from the Islamic State terror group (ISIS) tucked under the windscreen wiper of his car forced him to flee.

Today, Matti is a Senior Project Manager at GHD and Site Access Lead on Melbourne's North East Link Project.

However, like many migrant engineers, he has had to overcome significant barriers along the way to employment in his chosen profession.

In October 2012, Matti was a site engineer at Baghdad's Al-Dora Power Plant. The role drew on his freshly minted degree from Russia's Don State Technical University, his cross-cultural skills and his fluency in five languages. He was the perfect middleman between Russian power plant managers and his fellow Iraqi engineers.

But the job only lasted 13 months.

"I received a personally targeted death threat. My car was vandalised. An envelope on the windscreen contained a letter that said I could pay US$40,000 and leave my job, and live, or I would be killed," Matti recalls.

"I'm an Assyrian Christian and I worked with people ISIS referred to as 'infidel Russians', so it was a double strike."

With his parents, he fled to Turkey the next morning, taking only a few possessions and leaving behind his job, his home, his friends and his country, most likely forever.

He spent four long years working outside the profession – in construction in Turkey and, in Australia, as a catering assistant, an interpreter and community volunteer.

Matti had lost all faith he would ever find appropriate professional work again before landing a 12-week internship with GHD in 2017 via a CareerSeekers program that supports refugees and asylum seekers.

The internship led to a contract role and then ongoing work, all with GHD, where he still works today.

"Being displaced is a terrible thing," Matti says. "If we give people opportunities to prove themselves then they absolutely will. That's very good for them, and very good for the business that had faith in them."

51% of engineers working in the profession in Australia are born overseas.

59% of qualified engineers in Australia are migrants.

VITAL AND UNDERUSED

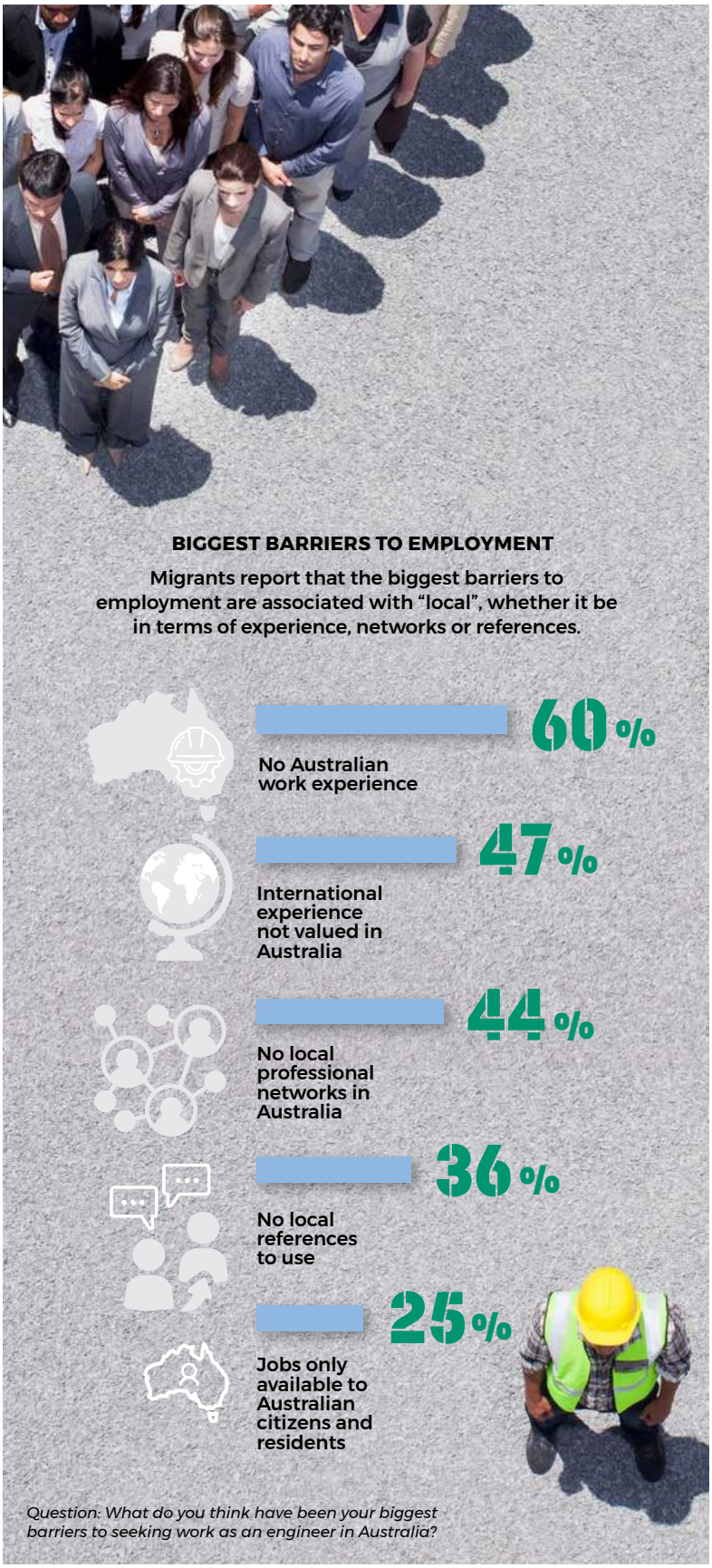
With an emerging engineering skills shortage exacerbated by COVID-19, an engineering job vacancy rate that has gone up 97 per cent in just 12 months, and an economic recovery hinging on major infrastructure projects, the effective use of all available engineers could be considered a national strategic imperative.

"Most of the engineers working in the profession in Australia today were born overseas – 51.1 per cent. And 58.5 per cent of qualified engineers in Australia are migrants, going on Census data," says Justine Romanis, Engineers Australia's National Manager, Professional Diversity and STEM.

"Overseas-born engineers have a higher unemployment and significantly higher underemployment rate compared to locally born engineers. And overseas-born female engineers have almost three times the unemployment rate of Australian-born female engineers."

Engineers Australia has publicly called for an overhaul of the skilled migration system, ›

"OVERSEAS-BORN ENGINEERS HAVE A HIGHER UNEMPLOYMENT AND SIGNIFICANTLY HIGHER UNDER-EMPLOYMENT RATE COMPARED TO LOCALLY BORN ENGINEERS."



and given voice to these issues in a March 2021 submission to the Federal Joint Standing Committee on Migration inquiry, as well as in its evidence to the committee.

The peak body's submission referred to an "inefficient utilisation of migrant engineers", which sees qualified professionals more likely to work in "non-engineering roles".

In other words, there are smart, skilled engineering professionals driving taxis and delivering takeaway while they struggle to crack the Australian jobs market – at a time when employers are reporting skills shortages.

RESEARCHING THE BARRIERS

To better understand the barriers to employment of migrant engineers, and to help develop vital solutions and help employers access this talent pool, Engineers Australia recently commissioned research.

The first phase of the project involved surveying more than 800 migrant engineers and conducting in-depth interviews with employers and recruiters, as

BELOW: Justine Romanis, Engineers Australia.

"MOST OF THE ENGINEERS WORKING IN THE PROFESSION IN AUSTRALIA TODAY WERE BORN OVERSEAS. AND 59 PER CENT OF QUALIFIED ENGINEERS IN AUSTRALIA ARE MIGRANTS."

well as migrants. It found that the biggest barriers to employment for migrant engineers are associated with "local". Whether it's experience, networks, standards, references or qualifications, the top five obstacles identified by migrant engineers are all to do with not being a local.

Other issues include visa conditions that preclude migrants from moving to areas with more opportunities and jobs requiring an Australian security clearance or citizenship.

According to the research, Matti's experience of taking a long time to find engineering work, and of falling away from the profession as a result, is common. In addition, one in three respondents (34%) with engineering jobs feel, based on their experience, that they should be in a more senior role.

"PRODUCTIVE EMPLOYMENT OF MIGRANT ENGINEERS IS VITAL TO OUR NATIONAL ENGINEERING CAPABILITY."

LEFT: Bronwyn Evans, Engineers Australia.

Respondents report their international experience is simply not valued in Australia.

This speaks to subconscious and conscious biases amongst hiring managers.

One recruiter told the research team: "I'll get clients that tell me, 'no Indians'. They put it on the recruiter as they can't write it themselves." Another advises migrant engineers to anglicise their name on their CV to get interviews.

Employers saw migrant engineers without local experience as more of a risk. Hiring managers could not "ask around" to get someone to vouch for the applicants. Many expected migrants to go initially into more junior roles, which have greater supervision, to gain local experience before being promoted.

Other employer concerns included the amount of time it would take to bring an applicant up to speed, English skills, visa complexities and cost, quality of certifications, and the risk the person might need to return overseas for family reasons.

At senior levels, an applicant's inability to bring a network of suppliers to roles was raised with researchers.

"All employers want someone who's worked for the competition and, unfortunately, that's not these guys," is the way one employer summed it up.

Migrant engineers, on the other hand, view their unique knowledge as an asset that allows them to provide a valuable skillset and fresh perspective on a project or within a business – including experience where overseas practice is ahead of Australia or projects are larger in scale.

34%

of respondents with engineering jobs felt they should be in a more senior role based on their experience.

OVERCOMING THE EMPLOYMENT CHALLENGE

Engineers Australia recognises the importance of improving pathways into the profession for migrant engineers.

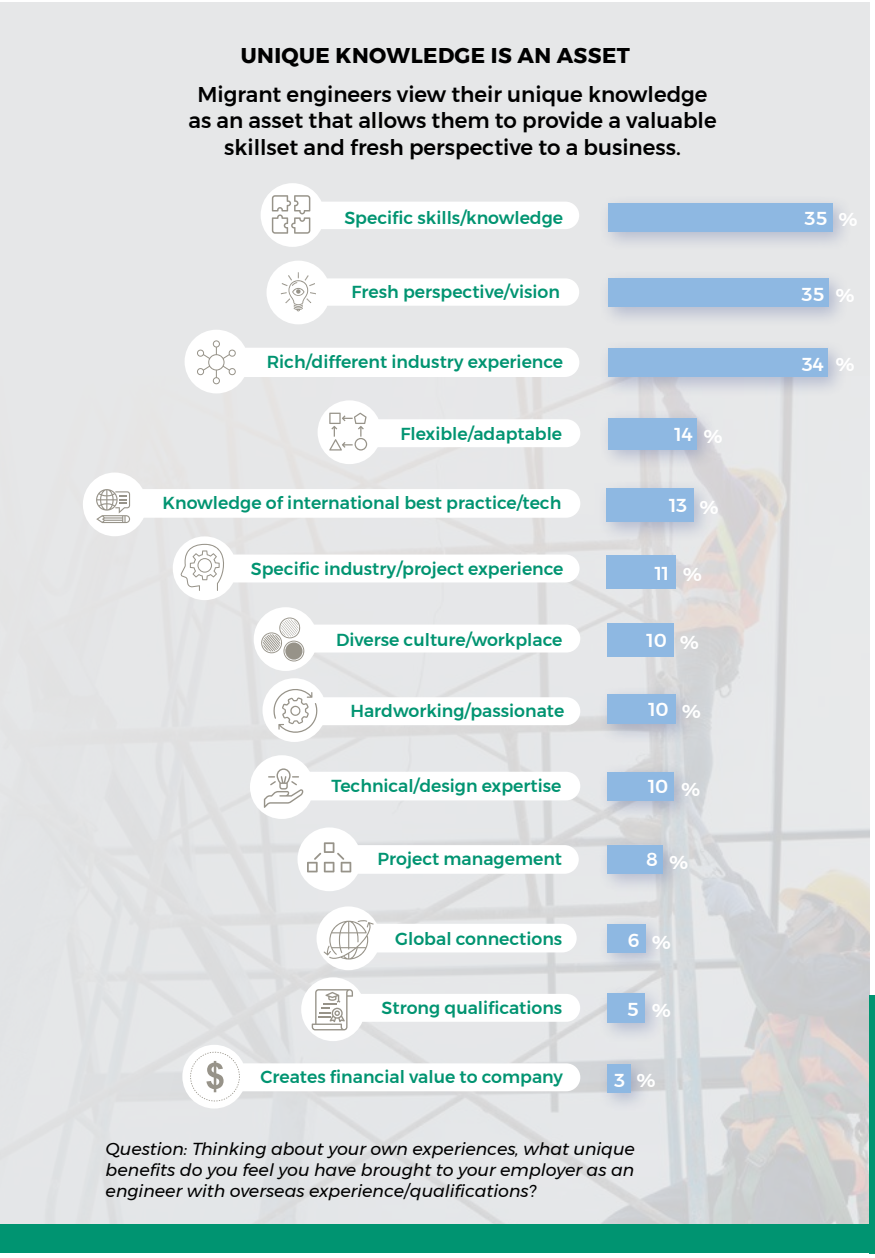
"We absolutely value the importance of getting this right from a personal, professional and national perspective," says Engineers Australia CEO Dr Bronwyn Evans AM HonFIEAust CPEng. "Productive employment of migrant engineers is vital to our national engineering capability.

"There is a serious mismatch between the objectives of the skilled migration program and what is being achieved in the community. Unless research is done and changes are made, we will continue to fail both migrants and employers, and put Australia's engineering capability and future economic growth at risk."

Engineers Australia has long been active in this arena, and its events, groups, webinars and other training opportunities offer opportunities to build local knowledge and networks, as well as contributing towards local credentials such as listing on the National Engineering Register and becoming Chartered.

One valuable resource is the Starting in the Australian Engineering Workplace online course, provided by Engineers Australia subsidiary Engineering Education Australia (EEA).

"We did some initial work with employers to identify where the issues are in terms of migrant engineers, and how we can help,"



says Alexandra Sparvell, EEA's General Manager. "The course is based on a virtual internship for international engineers we have been running for the past year as part of our Professional Year program. Over 180 engineers have been through it.

"The online course covers the Australian workplace in terms of ethical, legal, regulatory guidance; how to document your engineering workflow; what's expected in the Australian workplace; how people work; and much more. It is very valuable for migrant engineers."

Engineers Australia also runs local networking events and LinkedIn groups to help connect migrant engineers with employers, as well as webinars and information sessions to guide new migrants to useful resources.

In some regions, Engineers Australia has worked with organisations to promote and create employment opportunities.

For example, in Newcastle, NSW, it has worked with a local group called Northern Settlement Services on its multicultural employment program. One of its Division Committee members ran a workshop with its clients to help them with resumes, cover letters, LinkedIn profiles and more.

In Western Australia, Engineers Australia supports the Kaleidoscope Initiative – which helps migrants find secure employment in their field of expertise – by finding mentors for migrant engineers.

But there is a recognition that many of these offerings are localised and require an individual to be part of a network before they hear about them. Solutions must be broader, more inclusive and supported by all stakeholders, including employers.

"WE DID SOME INITIAL WORK WITH EMPLOYERS TO IDENTIFY WHERE THE ISSUES ARE IN TERMS OF MIGRANT ENGINEERS, AND HOW WE CAN HELP."

AN INTERNATIONAL PATHWAY

Obafemi Adio, Acciona's Quality and Completions Manager, has been directly involved in Engineers Australia presentations to help overseas-qualified engineers.

Having experienced the process of migration firsthand, after moving to Australia from Nigeria on a skilled migration visa, he is well placed to do so.

"I had to apply through Engineers Australia, and do an assessment," says Adio, who had six years of engineering experience at the time he applied for a visa.

"It involved submitting all of my degree qualifications and writing about my experience, what I'd done, and what my roles were."

That was 14 years ago. When he arrived, Adio still faced the ▸

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challenge of finding work. While Engineers Australia is empowered by the Federal Government to assess the skills of engineering professionals for skilled migration visas, it has no control over engineer migration numbers, visa eligibility criteria, visa restrictions or employer demand.

Jobs are far from guaranteed.

For Adio it meant more than simple financial security.

"I was also engaged to be married," he says. "To bring my fiancée over, I had to prove I could look after her. This meant a job and a place for us to live. So not only was I looking for a job, but I was trying to get my family started, as well."

Adio had a support network, of sorts. His sister lived in Australia with her husband.

"When I considered taking work outside of my training, they encouraged me against a rash decision," he says.

"They were both professionals and they knew the value of sticking with your training."

RIGHT: Obafemi Adio, Acciona.

For Adio, the wait was a relatively short one.

"An agency found work for me on Melbourne's EastLink project a month after I arrived," he says.

It is a story with a happy ending: Adio is now happily married, employed, and an Australian citizen. But for many migrant engineers, the result is not so positive.

Everyone involved in the engineering sector has a role to play in ensuring the skills of migrant engineers are more fully harnessed. This includes Engineers Australia, universities, employers and recruiters. It's essential for the nation's engineering capability.

"My question is this," Evans says.

"How can Engineers Australia work with industry to help address the skills shortage by enabling them to draw on this existing talent pool? With this research project, we're a lot closer to developing a clear answer. We want to work with employers to co-design solutions, because they will only be successful if employers embrace them. That's the next step." •

"WE WANT TO WORK WITH EMPLOYERS TO CO-DESIGN SOLUTIONS, BECAUSE THEY WILL ONLY BE SUCCESSFUL IF EMPLOYERS EMBRACE THEM."

ISHMEET KAUR'S CAREER CHALLENGE

ISHMEET KAUR, A WESTERN AUSTRALIA-BASED TELECOMMUNICATIONS ENGINEER FOR WESTERN POWER, ARRIVED FROM INDIA IN 2015. THIS IS HER STORY.

—

What brought you to Australia?
I did my bachelor's degree in India, then came to Australia to study my master's.

What challenges did you face?
I began looking for work six months before graduating and discovered universities in Australia lag other countries on this. In India, companies come to the colleges. But here, you need to apply for jobs. A graduate program will have a deadline eight months before the recruitment process, and often migrant students simply aren't told.

ABOVE: Ishmeet Kaur, Western Power.

Could universities do better?
It felt as if universities in Australia don't take the initiative to help students find work. That should be a university's responsibility. They should conduct mandatory workshops, equip students with tools they need and make all opportunities clear. The college has a responsibility to invite companies into their recruitment process.

Where did you go for information?
All of my friends were from India — I didn't have an Aussie network. None of us had any information we needed. I started applying for jobs and going to careers events. I researched graduate programs, but they were for the next year. I frantically looked for work for over a year while I worked at Nando's.

How did you eventually find a job?
I went for an interview with APD Engineering in Perth and, at the time, I was even willing to work for free to gain work experience. But they instead offered me a one-year contract. I stayed with them for three years.

What can the profession do?
When people see fellow migrants working in odd jobs, it is very demotivating. Migrant engineers, and in fact all engineers, already established in their careers should take responsibility for mentoring, to make themselves more visible, to motivate younger engineers and to give back to the community.

TUNNEL VISION

WORDS BY **SUSAN MULDOWNEY**

DRIVERS SLOWING DOWN TO PASS THROUGH A MELBOURNE TUNNEL HAVE PLAGUED THE THOROUGHFARE WITH BOTTLENECKS. VR EXPERIMENTATION PROVIDED A SOLUTION.

WHAT DO traffic engineers think about when they're stuck in traffic? For David Blair CPEng and his colleagues at engineering firm SMEC, innovative ideas often spring to mind.

During a recent taxi ride through the heart of Melbourne, they came up with a high-tech solution to notorious bottlenecks in the city's Burnley Tunnel that may change driver behaviour and save tunnel owner Transurban significant costs.

The 3.4 km Burnley Tunnel carries traffic eastbound via three lanes from the West Gate Freeway to the Monash Freeway and is known for congestion than spans beyond peak hour.

Studies from Transurban show that while drivers enter at the speed limit of 80 km/h, they slow down during the uphill climb out of the tunnel and exit at about 60 km/h, causing traffic to bank up.

There are a number of reasons for the driver behaviour. A tragic accident in the Burnley Tunnel on 3 March 2007 left three people dead and a coroner's inquest noted the accident had left "a fear in the minds of many using the tunnel as to its safety".

The Burnley Tunnel is also quite dark and has been known to leak.

"The environment of the tunnel makes it difficult for drivers to perceive the uphill change and how they should respond," explains Blair, Manager, Transport Planning, Logistics and Analytics at SMEC.

"If Transurban could increase the speed or the vehicle throughput by one per cent, it would be classed as a project success."

SETTING A VIRTUAL PACE

SMEC's proposal to Transurban included the delivery of a virtual reality (VR) model of the Burnley Tunnel to examine how potential changes to its physical attributes would impact on driver behaviour.

In the absence of VR, road operators like Transurban would typically look to overseas case studies for best-practice design upgrades.

"Transurban would have potentially looked at tunnels in places like Japan and Scandinavia, where some of the best tunnel design ideas come from, and then implemented

"THE ENVIRONMENT OF THE TUNNEL MAKES IT DIFFICULT FOR DRIVERS TO PERCEIVE THE UPHILL CHANGE AND HOW THEY SHOULD RESPOND."

ABOVE: David Blair, Manager, Transport Planning, Logistics and Analytics at SMEC. LEFT: A virtual reality representation of Burnley Tunnel. BELOW: Lidar scans allowed Snobal to create a photorealistic representation of the tunnel.

those ideas in the Burnley Tunnel," says Blair. "The solution would have probably been lighter walls and brighter lights, but the only way to know if it worked would be after completion, when they'd already spent all the money investing in the asset."

SMEC proposed an innovative methodology to support the redesign of the tunnel, which was accepted by Transurban as part of its overall program of works.

SMEC worked with virtual and augmented reality technology company Snobal to test the proposed designs. Snobal used lidar scans of the Burnley Tunnel to create a digital model in its proprietary platform, Snobal Cloud.

Transurban then recruited 120 drivers, representing a cross-section of road users, who would travel virtually through the tunnel twice – once through a model of the existing tunnel and once through an enhanced version.

Murray James CPEng, Snobal Co-founder, CEO and CTO, says the idea was to help identify the behavioural changes required to solve the bottleneck.

"We can measure how people respond to design changes or changes to any environment in virtual reality," he says. "We had a commercial driving simulator hooked up to our software and monitored things like driver eye tracking and heart rate response to stress. We used that information to test various design iterations, such as changes to lighting finishes, traffic lane changes and other elements to induce people to drive in a more proactive manner through the tunnel.

"We basically created a dynamic model of the tunnel where you could tweak the dials and measure how people respond from a vehicle telemetry point of view."

The tests were conducted in a VR driving rig that looked a little like an arcade machine – a steel frame supporting a driver seat and a steering wheel.

"It looked like an arcade game from the outside, but when you put on the VR headset, you may as well have been in a Mazda 3," says Blair.

Along with gathering biometric information, testing included a driver survey to gauge what drivers remembered about the experience of driving through both iterations of the VR tunnel.

"The VR driving test numbers gave us the confidence and the ▸

"WE BASICALLY CREATED A DYNAMIC MODEL OF THE TUNNEL WHERE YOU COULD TWEAK THE DIALS AND MEASURE HOW PEOPLE RESPOND FROM A VEHICLE TELEMETRY POINT OF VIEW."

certainty that there is a benefit in changing the design, and the qualitative data from the surveys gave us more insight as to what kind of things were going to work and what was preferred," says Blair.

PEDESTRIAN APPLICATIONS

This is not the first time SMEC has drawn on VR for road projects. Its work on Melbourne's recent Streamlining Hoddle Street project, for instance, included one of the world's first road safety audits in virtual reality.

VR has also been used for some time by companies such as Norwegian engineering consultancy Norconsult.

In 2015, for instance, while working on a tunnel project beneath Mount Ulriken, Norway, the company used integrated building information modelling to create a VR game experience for train operators to "drive" through the tunnel before it was built. This helped engineers to optimise signal placement before construction.

James says recent tech developments are making it much easier to digitise environments.

"You can now create a complete digital asset from the existing environment by using drones or aircraft and get really high-definition lidar scans," he says.

TOP and INSET: VR has been used to model rail projects in Europe. ABOVE: Murray James, Snobal.

VR can provide validated design testing for complex environments, as well as seemingly simple ones, such as zebra crossings.

Professor Mark Hickman, Chair and Professor of Transport Engineering in the School of Civil Engineering at the University of Queensland, says VR is increasingly being used in pedestrian safety studies.

"I have a PhD student now looking at how people will behave ›

IMAGE: BANE NOR/ NORCONSULT

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"THE VR DRIVING TEST NUMBERS GAVE US THE CONFIDENCE AND THE CERTAINTY THAT THERE IS A BENEFIT IN CHANGING THE DESIGN."

in pedestrian environments like zebra crossings," he says.

"If you were to introduce autonomous vehicles into that environment, how will people react, especially if they haven't seen an autonomous vehicle before, or they don't know whether the vehicle is actually going to stop or slow down, because there's no driver to interact with."

Hickman says VR can help engineers understand how pedestrians feel in such situations and test the impact of different design devices.

"If you put in a raised crossing or different colours or striping, does that make the pedestrian feel more confident when an autonomous vehicle approaches? What sort of indication could the vehicle give to let the pedestrian know that it recognises them and it's safe to cross? VR allows you to test a range of different scenarios."

ENHANCED THOROUGHFARE

The next phase of the Burnley Tunnel project will include a detailed design of the enhanced tunnel, which Blair says may be implemented next year.

"For people to be driving on their roads or their assets, Transurban needs to make a profit," says Blair. "They cannot indefinitely increase tolls, so they must look to reduce costs. The VR methodology is innovative, but I think the main thrust is that it is a potential major cost-saving initiative that can be applied to any other asset."

Blair explains that a number of new design elements were considered for the tunnel.

"We looked at paint colours, reflectivity, LED lights, spotlights – all the stuff you're doing when you're decorating the house, but this was a tunnel," he says. "Transurban would ask us to test designs and we'd then go back to them with advice as to what would work."

Blair adds that the new design may include pace-maker lights inside the tunnel to help improve traffic flow.

"As for the new colour in the tunnel, I can't tell you what it is, but you can probably guess that it will be clean and simple." ●

TOP: Snobal's driving rig. ABOVE: Mark Hickman, University of Queensland.

Setting the pace

Pace-maker lighting technology is used in a number of tunnels in countries such as Japan to reduce congestion and regulate traffic flow.

SMEC's David Blair explains that green pace-maker lights were tested in VR models of Melbourne's Burnley Tunnel. The lights flow at the tunnel speed limit, and drivers subconsciously try to match it.

"It's a strip of lighting that covers the walls and ceiling and it moves along the tunnel at 80 km/h, or the speed that's set by the road authority, he says. "The lights act as a guide and, without thinking about it, you automatically try to keep up with it and therefore increase your speed to somewhere closer to 80 km/h."

Blair says studying driver behaviour was an interesting element of the project.

"The human behaviour side of it was something new for us," he says. "We always believed that if you have a baseline and then you do something different, if you test enough people, the data will tell a story. When we got to the end of the project, we could say 'this is what we changed, and this is how people responded and this is what happened'.

"I'm certainly not an expert in human behaviour, but it was a very interesting thing to study."

RIGHT: Green pace-maker lines encourage drivers subconsciously to maintain road speed.

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WORDS BY **KIM THOMSON**

LOFTY AMBITIONS

AEROSPACE ENGINEER AND PILOT RENEE WOOTTON HAS ACHIEVED A LOT IN HER TIME IN THE INDUSTRY, BUT SHE'S ALSO DETERMINED TO HELP OTHERS SUCCEED.

FROM STINTS at Qantas and CAE Australia to gaining her commercial pilot licence, Renee Wootton has made big strides in her decade in aerospace and aviation.

The proud Tharawal woman is a 2020-21 Superstar of STEM, and recently joined Western Sydney Airport as Strategy and Planning Manager.

But it all started with an ad in the local newspaper.

As a teenager, Wootton had moved to a small town in regional New South Wales and, looking for a way to meet people, joined the Australian Air Force Cadets.

"My auntie actually found [the ad] in a newspaper and suggested that I go along for an intro session," she tells *create*.

"I did and I really liked it – I think I was drawn to wearing the uniform, learning about the military and polishing my boots for the marching."

For the next two years, she took up opportunities to travel around the country with the cadets, becoming ever more curious about aviation.

"I participated in marching competitions that took me to RAAF bases around NSW, where we got to meet fighter pilots and engineers – all of these people with incredible careers," she says.

"It really opened my eyes to new experiences, new adventures and new people."

While still in high school, she enrolled in a Certificate II in Aeroskills (Mechanical), travelling to Sydney in the school holidays to complete the program.

"During that time, I got to learn all about aircraft; how to pull them apart, put them back together, how to use maintenance manuals and power tools," she says.

"You'd walk out on to a tarmac at an airport or get to sit up in the [air traffic control] tower and watch aircraft come in and out. And it was just this really cool, exciting, loud experience. That's when I realised that this was really interesting to me."

OPPOSITE: Western Sydney Airport Strategy and Planning Manager Renee Wootton.

"WE GOT TO MEET FIGHTER PILOTS AND ENGINEERS – ALL OF THESE PEOPLE WITH INCREDIBLE CAREERS. IT REALLY OPENED MY EYES TO NEW EXPERIENCES, NEW ADVENTURES AND NEW PEOPLE."

FUEL ALGORITHMS TO FLIGHT SIMULATORS

While completing adegree in aerospace engineering at the University of New South Wales, Wootton began interning at Qantas Engineering across Maintenance Operations, Fleet Performance and Development and Powerplants (Engines).

She worked on one of her most gratifying projects yet: an algorithm that predicts fuel tank temperatures of the Airbus A380 plane.

"On a 14-hour flight, say from Sydney to Johannesburg, the fuel temperature drops extensively," she explains.

As the fuel level and volume drops over the course of the flight, heat transfer speeds up. Fuel freezes at approximately -67°C, so predicting and reacting to temperature changes is crucial.

"There are two alternatives [for pilots]: you can either fly faster, which creates aerodynamic heating on the surface of the ▸

"THE ALGORITHM THAT I WAS BUILDING WAS PREDICTING AND FORECASTING WHAT THAT FUEL TEMPERATURE WOULD BE – TO ENABLE THE PILOT TO MAKE THAT DECISION TO EITHER FLY FASTER OR LOWER."

wing and, in turn, heats the fuel inside the wing. Or you can reduce your altitude to warmer temperatures," Wootton says. "The algorithm that I was building was predicting and forecasting what that fuel temperature would be – to essentially enable the pilot to make that decision to either fly faster or lower."

With a lack of available data, she had to work backwards to establish key details like fuel tank surface, which was no easy feat.

"It was incredibly challenging and very rewarding," she says of the 18-month project.

"I learnt so much more about the aircraft; I built skills in coding and used some really key mathematical concepts and theories to build that algorithm."

After finishing her degree, she spent two years in the Qantas Graduate Program before becoming a senior analyst for the airline's loyalty program.

Taking a six-month break to work at tech start-up Kintell, she then returned to Qantas in 2019 and joined the QantasLink Flight Operations team where she worked on performance engineering problems and supporting the Dash 8 fleet operation.

In April 2020, Wootton moved to aerospace company CAE. As a project engineer, she worked on flight simulator upgrades for the C-130J Super Hercules and KC-30A Multi-Role Tanker, aircraft used by the RAAF.

She also found time to study for her pilot licence, which she accomplished in October 2020.

In July, she stepped into her new role with Western Sydney Airport, supporting the development, monitoring and refinement of its business and corporate strategy.

ABOVE: Wootton earned her pilot licence in October 2020.

SPACE IS THE LIMIT

As her career takes off, Wootton's fascination with aviation continues to deepen.

"When you learn the basics of flight, and experience it for yourself, you start learning more, and your curiosity leads to so many other options. That's always been my experience in aviation," she says.

"Hundreds of years of development and testing and fatalities and accidents have led us to where we are today. But there's just so much further we can reach and many more boundaries that we can push."

"THERE'S JUST SO MUCH FURTHER WE CAN REACH AND MANY MORE BOUNDARIES THAT WE CAN PUSH."

There's one big boundary she's interested in pushing: becoming an astronaut. But that's a long-term goal and, for now, she's staying grounded.

"If the astronaut thing doesn't work out, I think the opportunity to work in the space sector and continue to work on such exciting technology and be a part of the plan to make it to Mars one day – that would be pretty amazing."

Paying it forward

Alongside her own engineering achievements, Renee Wootton has long dedicated her spare time to helping others break into the industry.

She's determined to help more people access information about engineering, particularly young women and Indigenous youth, as well as those in remote and regional towns.

"Growing up in a regional town, I was never told about engineering and it was only because of Air Force Cadets that I was exposed to it — it wasn't something that I came across through my schooling," she says.

She has volunteered with not-for-profit Indigenous internship program CareerTrackers, which facilitated her own internship with Qantas, and Power of Engineering, running workshops in schools and mentoring young engineers.

"[It's about] giving them the confidence that they can do it on their own and leave their hometowns and communities to make that change and achieve those outcomes in themselves," Wootton says.

She says strong support networks are critical for young engineers.

"I've had so much support to get to where I am today, and I think anyone, honestly, can get to where I am," she says.

"I try and make sure people are aware of that. I try to relate to people that typically experience more disadvantage and demonstrate that I was once in your position; I have experienced geographical, family and financial hardship. However, I did X, Y and Z, and you can do it too."

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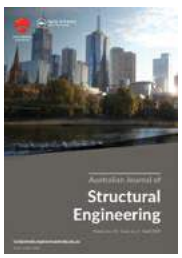
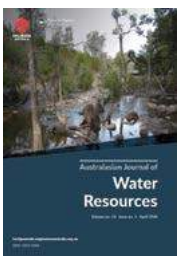


TROPICAL CYCLONE IMPACTS ON THE WESTERN AUSTRALIAN COAST AND EXTREME WIND SPEEDS IN REGION D

Journal: *Australian Journal of Structural Engineering*
Author: J. Holmes

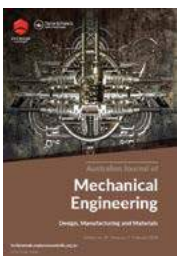
This paper reviews the numbers of tropical cyclones in the southern Indian Ocean and the land-falling cyclones that have impacted the Pilbara and Gascoyne coastlines of Western Australia since 1970, with particular emphasis on those of Category 4 strength and above. It shows reductions in impacts of severe cyclones on that coastline in the most recent two decades, suggesting the limits of Region D may need reviewing.



DRINKING WATER SECURITY: THE NEGLECTED DIMENSION OF AUSTRALIAN WATER REFORM

Journal: *Australasian Journal of Water Resources*
Authors: K. Howey & L. Grealy

This article considers Australia's chief water policy of the past two decades, the National Water Initiative (NWI), and its aim of providing healthy, safe, and reliable water supplies. Taking the Northern Territory as a case study, it describes how, despite significant policy and research attention, the NWI failed to ensure drinking water security in Indigenous communities in the NT, where water supply remains largely unregulated.



DEVELOPMENT OF ENERGY SAVING TECHNIQUE FOR SETBACK TIME USING ARTIFICIAL NEURAL NETWORK

Journal: *Australian Journal of Mechanical Engineering*
Author: K. B. Mehboob

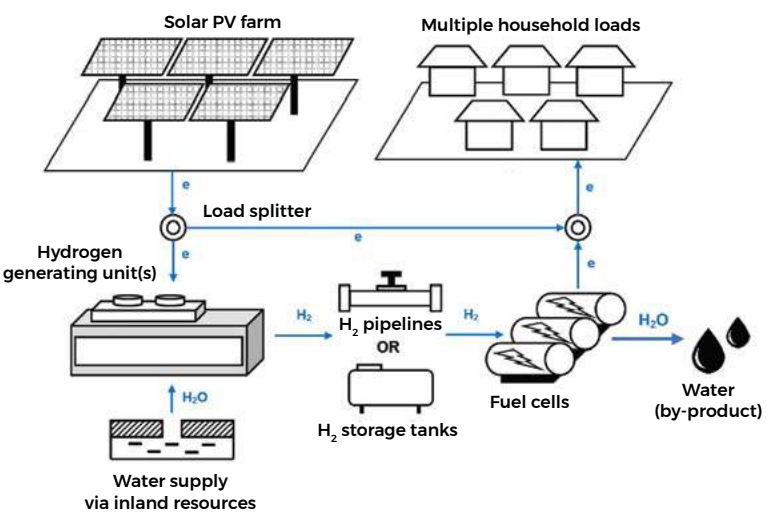
This paper describes an adaptive artificial neural network-based model for optimal setback period application, thus predicting the suitable time for setback temperature deployment. A single building model was simulated under five climatic conditions: Taxila (Pakistan), Mogadishu (Somalia), Darwin (Australia), Phoenix (US) and Havana (Cuba). It was found that inside air condition is the most influencing parameter for the setback time period.

Hydrogen energy supply to remote communities in Australia's Northern Territory: a feasibility study

Journal: *Australian Journal of Multi-Disciplinary Engineering*
Authors: T. Thai, A. Rajabipour, C. Fairfield & S. Thennadil

This paper discusses current practice around and challenges facing energy provision in Australia's Northern Territory remote communities. It introduces hydrogen energy as a solution to alleviate the challenges there. Options for hydrogen supply in NT remote areas are also economically evaluated and their feasibility is discussed. While current capital expenditure limits pose the main barrier to hydrogen supply in remote areas of the NT, the solution was found promising in terms of environmental effects, long-term economic return, reliability of energy supply and community empowerment.

RIGHT: A schematic representation of a community-scale solar-hydrogen system.



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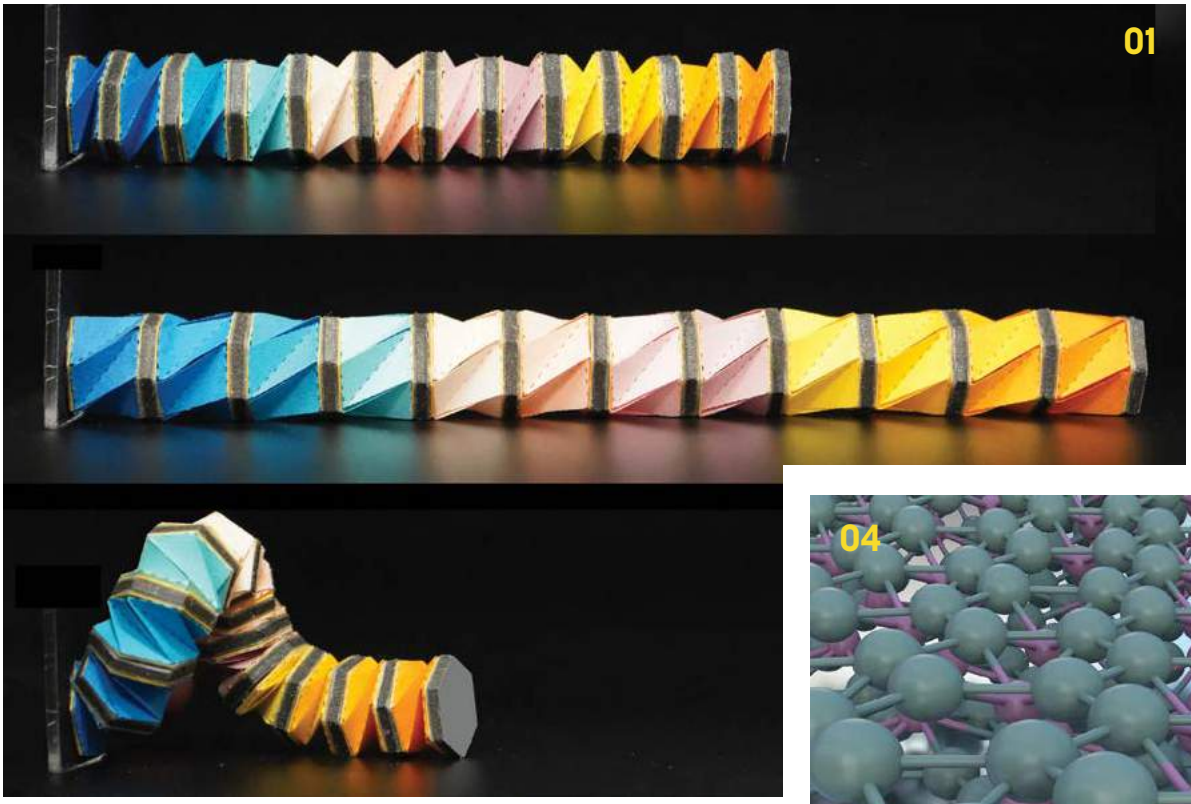
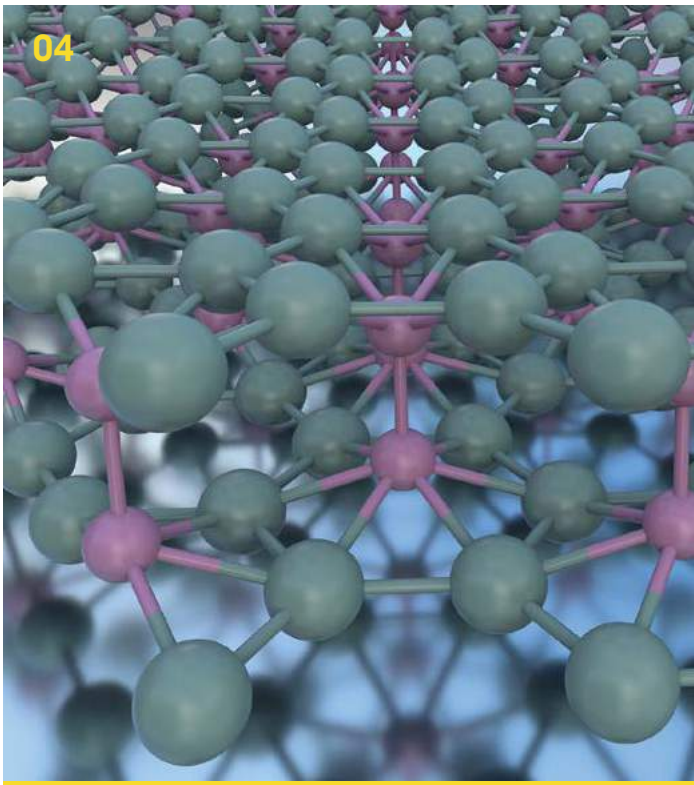
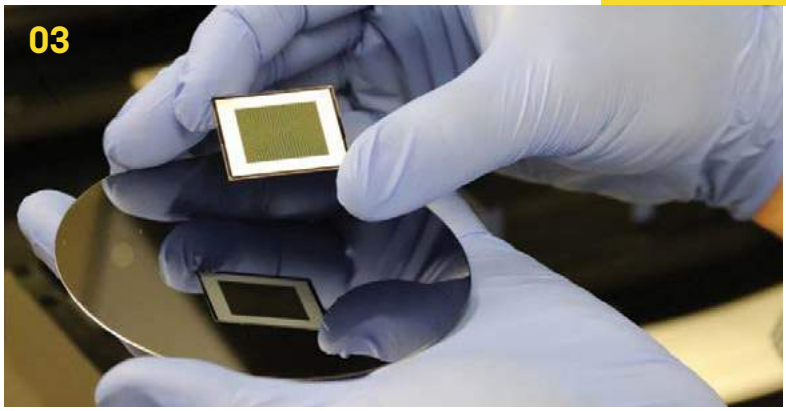


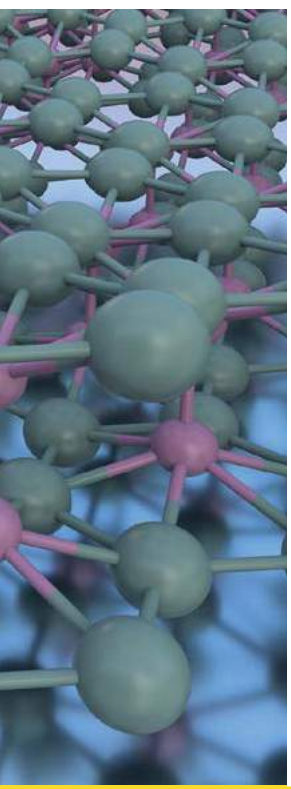




01 Octopus-inspired robot

Embedded magnetic particles allow the robot arm to move without relying on an engine. Image: Shuai Wu

A robotic "octopus arm" created by researchers from Ohio State University and Georgia Institute of Technology is able to move without using a motor. Constructed from origami-inspired hexagonal segments made of silicon, the arm is embedded with magnetic particles, and motion is achieved when the properties of a magnetic field surrounding the arm are changed. Each segment has its own magnetic particles, allowing for fine control of the arm, which can move 360 degrees, as well as fold and stretch like a concertina. According to the researchers, the technology could be used in places with limited access, where navigation, sensing and interaction are important, such as during medical procedures. The arm is not strong but compensates with increased dexterity and accuracy. It also has the advantage of being able to be produced at a small and lightweight scale.



02 Touch-sensitive glove

Electrodes embedded in the glove's lining are able to sense changes in pressure. Image: Courtesy of the researchers

Engineers at the Massachusetts Institute of Technology have created a glove embedded with electrodes that can measure and map subtle changes in pressure. Sensitive enough to detect a person's pulse as it vibrates their skin, the glove could be used to help people who have suffered a stroke to regain fine motor coordination. "The simplicity and reliability of our sensing structure holds great promise for a diversity of health care applications, such as pulse detection and recovering the sensory capability in patients with tactile dysfunction," says Professor of Mechanical Engineering Nicholas Fang. The technology was produced by adapting sensors that measure humidity by using a layered structure that sandwiches a rubbery "dielectric" material between two electrodes. In the glove's sensors, however, human sweat takes the place of the centre layer: moisture from the skin causes ions to accumulate on the underside of the electrode when pressure is applied.

03 Bifacial solar cell

A new ANU solar cell outstrips its traditional competitors in terms of efficiency. Image: Eric Byler/The Australian National University

A bifacial solar cell produced at the Australian National University promises a more efficient form of power generation than traditional cells. The cell can collect energy from both of its sides, allowing it to achieve an effective power output of 29 per cent. The cells are made with a technology called "laser-doping", which increases electrical conductivity. "It is a low-cost, industry-compatible process for boosting solar cell efficiency," says Chief Investigator Dr Marco Ernst. Over the next five years, bifacial solar cells are expected to have a market share of more than 50 per cent. "We have developed what I would call a true bifacial solar cell, as it has nearly symmetrical power generation capacity on both surfaces of the device," says Dr Kean Chern Fong. "When deployed on a conventional solar farm, a bifacial cell absorbs direct incoming light, while also taking advantage of ground reflection."

04 Double-layered borophene

An atomically flat network of boron, with the atoms in pink being used to bond the layers. Image: Northwestern University

Borophene is an atomically thin substance that has promising electronic properties but is difficult to produce. Now, engineers at Northwestern University in the US have created a double layer of the substance that resists the material's tendency to form clusters. "When you try to grow a thicker layer, the boron wants to adopt its bulk structure," says Professor Mark C. Hersam. "Rather than remaining atomically flat, thicker boron films form particles and clusters. The key was to find growth conditions that prevented the clusters from forming." The engineers produced the material by developing it on a flat, silver substrate that was exposed to high temperatures. "When we grew borophene on these large, flat terraces, we saw a second layer forming," Hersam says. "Following that serendipitous observation, we intentionally focused our effort in that direction. We weren't looking for the second layer when we found it."

Venkatesan Narayanaswamy

CPEng, Project Manager, Public Transport Authority

THE LESSONS VENKATESAN NARAYANASWAMY LEARNED AS A CHEMICAL ENGINEER HAVE SERVED HIM WELL THROUGHOUT HIS DIVERSE CAREER.

VENKATESAN NARAYANASWAMY trained as a chemical engineer, but his career has taken him through a rich variety of industries, from mining to risk consulting to project management.

Today he is working with Western Australia's Public Transport Authority delivering projects including Perth's Morley–Ellenbrook Line and the Bayswater Station and Turnback.

He believes that it is his mindset that has permitted him to adapt to a broad range of engineering work.

"I've worked all over the place, but the important aspect of process engineering is how you work through processes," he says.

"How you gain efficiencies in terms of improving the process — that concept applies everywhere."

And no matter the industry, Narayanaswamy says, it is important to identify and anticipate what knowledge is at hand about a project .

"How we anticipate the unanticipatable things," he says. "That's the first question that you would ask as an engineer: what are the known unknowns that we are managing here? What are the unknown unknowns and [how do] we engineer solutions in such a manner that we narrow that space as much as possible?"

Narayanaswamy's response is to provide better information to all the stakeholders involved. It was in chemical engineering that he first learned this approach.

04 TIPS FOR SUCCESS

1 Involve more stakeholders in your work and engage in a collaborative manner.

2 Participate in and contribute to industry and professional body meetings, seminars, conferences, and webinars. Make the most of them.

3 Pursue Chartership to improve your self-discipline and self-organisation for a goal-oriented career progression.

4 Networking is a valuable path to continuous professional development.

"They're all concepts that we have borrowed from the chemical and petrochemical industries," he says. "That gave me an edge in a holistic understanding of those tools, those processes — how we can facilitate those processes and how we can create solutions together by working collaboratively with other disciplines."

As a Chartered engineer, Narayanaswamy values the self-discipline and self-organisation involved in maintaining his status.

"Chartered status offers opportunity for continuous professional development," he says. "That gives me an opportunity to get out and meet people in the conferences and seminars, and to be able to listen and engage in contemporary debates in my profession."

Narayanaswamy says it also allows him to track the latest knowledge.

"There are some real cutting-edge things happening — how we can embrace that best-practice in our discipline," he says.

And it ensures that he never gets complacent.

"That keeps me on my toes all the time," he says. "Every day I get up and say, how can I do things differently? What are the things that I could learn; how can I contribute differently?"

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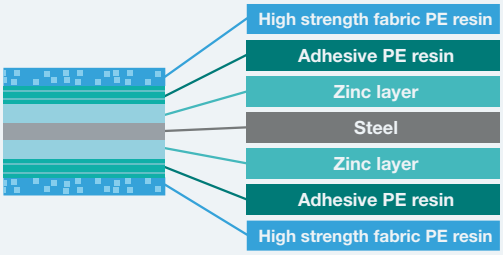

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