Australian Government
Chief Scientist

DR ALAN FINKEL AO

Australia's Chief Scientist

Australian Engineering Conference

Human Ingenuity in High Concentration

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Before I begin my speech I want to clear up a small matter that a number of you have raised with me in the course of the year.

Why am I the Chief Scientist – and not the Chief Scientist slash Chief Engineer slash Chief Entrepreneur?

It's very simple. As an engineer I deeply believe that our core mission is the pursuit of elegance. What's a title with a slash or a comma? Inelegant, writ large! A title should be a signature, not a job description.

So if I took the initiative to stretch out my title to include "Chief Engineer" and "Chief Entrepreneur" I would *ipso facto* be unworthy of the name. As a scientist, I take great pride in my current signature. And as an incurable engineer, I'm satisfied that it works.

I am certainly not the first scientist-slash-engineer-slash-entrepreneur to hold this post, or to venture into the public policy realm.

In preparation for this conference, I wrote an article about the first of our kind known to history: the Ancient Egyptian engineer Imhotep, who lived and worked in the third millennium BC.

We know his name because he was worshipped as a god for more than three thousand years after his death. And rightly so – after all, this was the man who decided that the base of a pyramid ought to be square. His great achievement, the Step Pyramid at Saqqara, still stands today: the oldest stone monument on the face of the Earth.

Yes, ladies and gentlemen, it was that rare thing: a pyramid scheme that actually paid. He was also a celebrated physician, poet, astronomer, architect and statesman:

First after the King of Egypt, Administrator of the Great Palace, and Vase Maker in Chief.

Short-hand title: God. Profession: Engineer.

The engineer in the ascendant

Now I'm not here to tell you that we need to be up there on quite that pedestal today.

I do want to put it to you that engineers are very much in the ascendant, in public as well as corporate life, far beyond their bread and butter roles.

The Secretary General-elect of the United Nations is António Guterres: an engineer. China is run by an engineer. The CEOs of Amazon, Google, Apple and Microsoft are engineers.

In fact, of the ten largest American companies on the US stock exchange as of last week, five are run by engineers, three are run by Bachelors of Science and one is run by a Bachelor of Applied Mathematics.

Some might suggest that the incoming American President runs counter to this theme. But the man himself would disagree! It just so happens that Donald Trump's uncle was a professor of engineering at MIT, celebrated for his contribution to the design of X-ray machines and radar research in the lead-up to the Second World War.

And Donald Trump is very proud of this connection. As he put it, "My uncle used to tell me about nuclear before nuclear was nuclear… I mean, it's a great gene pool I've got right there."

Whatever we might say about his grasp of the science of genetics, at least the respect for engineering is clear.

And we could say the same of many leaders in all walks of life, across the political spectrum. These days, if they're not trained as engineers, they try to sound like engineers. They want to think like engineers. And they openly compete for engineers.

So I ask myself: why? What explains this surge of interest in engineering? And what is its appeal – not just to investors and politicians, but to shareholders and voters as well?

Yes, it must be the role model provided by prominent engineers, thriving in leadership roles, and delivering enormous value by their talent for doing things differently.

But more importantly, I think the answer lies in the ethos that those role models embody: that we are always capable of better things.

We hear constantly that politics has failed, democracy is dead, the Age of Enlightenment is gone. In other words: humans are hopeless. I've seen countless variations on that theme in recent times.

But I've also flown on aeroplanes. I've charged my phone. I've checked my email – along with millions of people all doing the same, every minute, every day. Aviation, electricity, ICT – what do these and countless other systems have in common?

They are staggering feats of technical and organisational complexity. But more to the point, they prove that human beings are constantly making things that actually work!

And they work not because people are perfect – but because we can engineer around our own flaws.

Yes, we can be unpredictable, selfish and short-sighted. I won't deny it. But at core, we are also ingenious. And engineering – from the Latin '*ingeniare*' – is human ingenuity in high concentration.

Of course, the better our achievements the more that is expected of us. When I started using computers in 1975 I expected every piece of software to have bugs! Now, customers expect their apps to work perfectly.

My first car overheated often and needed oil every week. Today, most young drivers have never seen the temperature warning light, would not know where to add water and probably don't even know that engines need oil.

Aeroplanes rarely crash, skyscrapers twist and turn in improbable shapes, resources don't run out, the efficiency of our appliances improves every year and the air quality of our cities is better than it's ever been.

And all of this is possible because engineering has given us the space to imagine; but just as importantly, the means to actually *achieve* – and to do so safely, efficiently and reliably.

Of course that combination of a big vision and a pragmatic path speaks to our anxious age – and often far more eloquently than other disciplines can.

Take lawyers, for example. They are capable, and necessary. But in my experience many lawyers are fearful of risk. Instead of managing it, they make it their mission to see it and squash it at every turn. And their hypervigilance can be stultifying.

In principle, perhaps you could eliminate all risk from a system – at infinite cost. But this would not be conquering risk, so much as succumbing to the fear of it.

Sometimes, there is more security in a confident leap than a tentative step. And often, it takes an engineer to see it.

The engineering ethos in public policy

Of course, seeing it is one thing – selling it to a group of lawyers, much less your accountant, is another.

This is a lesson I learned in business: you have to bring your team and your clients along. And the most effective way to deal with customer complaints is to anticipate them, and fix them in advance.

The same is true in public policy: as technologists, we have to imagine not only the solution but the web of consequences attached. We must travel the path to the future not only with our goal in mind, but with a commitment to think about the unintended consequences.

We have a responsibility not only to our customers, but to those other members of society who might be adversely affected by our solution. We have powerful modelling tools at our disposal that can help us see the unintended consequences. If we look.

With these tools in hand we bear greater responsibility for the calibre of our advice – not less. Paradoxically, with these tools in hand there is more need for human intelligence – not less.

The best algorithms in the world today are still no match for the messiness of human affairs. Prediction needs human insight as well as technical literacy – as the US election made abundantly clear. And if it's true of prediction, it's even *more* true of persuasion: it demands a bilingual approach, speaking human and speaking machine.

In policy formation, as in business, or in marriage, or in life, you can imagine a better way, but you can never expect to impose it. You can only build confidence that your vision is worthy, and the path is sound.

That is why I have made it my mission this year to talk not just about what the future might be, but how we can have confidence in our ability to bring it about.

And I can report that there's nothing as reassuring to any audience as solid engineering logic.

- First: Define the problem
- Second: Do the analysis
- Third: Build a trial solution
- Fourth: Iterate the solution
- And fifth: Deliver an outcome that society actually wants.

But I don't just explain that logic – I find I constantly apply it, because it works. Ten months ago when I commenced as Australia's Chief Scientist I set out with big ambitions.

Today, I can report that:

- The Commonwealth Science Council has met, with the Prime Minister as Chair, and charged the Australian Council of Learned Academies with a new series of horizon-scanning reports.
- Innovation and Science Australia has been established and armed, as the nation's pre-eminent future-thinking authority.
- The Fraser-Finkel-Ferris review of R&D tax incentives has gone to the Government, and now to the public.
- The ten-year National Research Infrastructure Roadmap is well in hand.
- And we have made substantial progress on a project that I hope will join ATSE's STELR as a cornerstone of science education.

I think of education as a three-legged stool: teachers are one leg, curriculum another, extracurricular activities the third. And you know what happens to a three legged stool if one leg breaks. So let's look at the state of the three.

Teaching gets a lot of attention. The national curriculum is basically sound. The third leg of the stool, extracurricular activities, needs attention. It's not the lack of programmes, they exist in abundance. Engineers Australia runs many. It's the lack of information and hence access.

Our project, the Star Portal, is going to change that. It is a web platform that will connect the parents, school students and teachers to the growing range of providers, such as dedicated individuals, research agencies, companies and universities.

The Star Portal is backed by Microsoft, CBA, BHP, Telstra and the Australian Mathematics and Sciences Institute. And who is managing the project? Who else, but Engineers Australia.

In late September, I might have said that the "To Do" list was more than enough.

Then the lights went out in South Australia. And I woke up a few days later as the Chair of the National Electricity Market Review. Fair to say I haven't slept a great deal since.

Saluting the profession

But if I had to distil all of it down to just two words, I would say my priorities are simply the same two words printed in bold type on almost every page of 2016 *State of the Engineering Profession* report published by Engineers Australia.

It's all about energy, and infrastructure.

One is the great imperative – the other is the great enabler. And engineers are critical to both.

So it's no coincidence that I've spent a lot of quality time in your company, sometimes in power stations, sometimes in research facilities, sometimes in boardrooms.

I can say with all sincerity that I have emerged from all my travels with greater appreciation for the breadth and calibre of Australian engineering.

The National Electricity Market, in particular, is a stupendous feat of engineering blended with sophisticated market economics. The more you know about it, the greater your respect for the scale of the achievement – as well as the magnitude of the challenge ahead.

Right across the world, the physical electricity system is undergoing one of its greatest transformations since Nicholas Tesla and Thomas Edison clashed in the War of the Currents in the early 1890s. Tesla's alternating current generation and distribution system prevailed over Edison's DC system, leading to more than a century of central generators supplying the grid.

Irrespective of whether the primary power was plunging water, or flaming oil, gas or coal, the spinning generators operated in a synchronous mode that provided not just the electrical energy but also the frequency stability that the grid needs in order to operate securely.

Now, in Australia, we have millions of rooftop micro-generators that operate without movement or flame, distributed throughout the system.

We have zero-emission wind farms that are large, central sources like the traditional generators but with new characteristics that we are still learning to optimise.

And we have customers who expect to store their own electricity and participate in the market by selling it back to the network operators or their peers.

Our challenge in the face of these rapid and ongoing changes is to design the blueprint for the future electricity system so that it is secure and reliable, but also low cost and a participant in a carbon constrained world.

It must continue to satisfy the stability principles of control engineering, while being consistent with the underpinning logic of market forces as the primary drivers of sound decisions.

Fortunately, in my discussions with governments, systems operators and consumers I have found a genuine enthusiasm for change and a desire to help.

On that topic, you'll hear a great deal more in the months ahead.

An agenda for the engineering profession

The upshot for today is that the National Electricity Market will remain a work in progress for engineers, working alongside regulators and economists.

It will rely, as long as it lasts, on a healthy pipeline of capable leaders, and well-trained graduates.

But we could say the same of every industry, every utility, every hospital, every home: the good life needs great engineers!

Many of them will be needed in classic engineering roles – but more and more will be needed in public agencies and corporate boards.

Our challenge today, as the custodians of the profession, is to decide who we recruit, how we train them, and what sort of jobs we encourage them to do. So let me conclude with a few thought-starters on that theme – in the spirit of the incurable engineer.

It seems to me that, for all its strengths, engineering like all disciplines has to be constantly on guard against the growing appeal of two great myths.

The first great myth is that engineering students have to become engineers – or in other words, that engineering is a tunnel to a pre-determined job and not a door to any number of opportunities.

This has never been the case: in Ancient Egypt or the modern era.
It is certainly not true today.

We have entered an era where more than half of school leavers enter universities. The inevitable consequence is that enrolment in professional degrees is growing faster than job opportunities in the associated professional roles.

We produce 15,000 law graduates every year for a legal profession with only 66,000 jobs. Only one in twenty economics graduates becomes a professional economist. Medicine is on the verge of oversupply; and there is plenty of talk of gluts in teaching and accounting.

Engineering is in better balance.

Of the existing 400,000 or so workers in the engineering population today, some 40 per cent are employed outside the profession.

The fact remains, many engineering graduates will need *and want* to do what graduates have always done: which is pivot from the conventional path, by using their skills in different ways.

Is that a problem? Not necessarily – it may well be the master plan! My son, Victor, chose aerospace engineering because he wanted to go into management. He never intended to practice as an engineer, but from his discussions with his father he was convinced that the engineering way of thinking would serve him well in business and management.

For my part, I chose engineering because I enjoyed it! No other reason. Actually, of all the reasons to choose an undergraduate degree, doing something you enjoy is probably the best. From electrical engineering I pivoted to neuroscience, manufacturing, publishing, education, and public policy.

Engineers, of all people, ought to thrive on change. We ought to be capable of inventing the sort of jobs we want to do!

If graduates doubt that capability in themselves, then we have failed.

But that brings me to the second great myth, which may well be more dangerous in the long run than the first: that broadening the opportunities for graduates means hollowing out the degree.

By that, I mean replacing discipline content with generic workplace competencies. Or worse still – lowering the bar, at entry or exit.
It would be disastrous for the reputation of the profession, and it would do no favours to the graduates themselves.

As a CEO, I want to hire a candidate who has demonstrated the capacity to learn. Mastering one discipline gives you the mental toolkit to tackle the next.

I know that graduates from an Australian accredited course have both the intellectual capacity and the inner fortitude to accomplish challenging things.

Now, I would be happier if universities would set students up for success by bringing back advanced mathematics as a prerequisite for any

engineering degree. In my idle moments, I wonder if we could introduce an interview process alongside the ATAR. Could we identify those students who come to engineering with raw ambition, as well as a raw score?

Perhaps. But irrespective of the way they enter, the graduates who exit should be masters of content, maestros of ideas. Let's teach them that way.

Conclusion

And let's hold ourselves to the same standard. If you're afraid of change, you're in the wrong room. If you thrive on it – welcome to this conference. Friends, it's time to engineer Australia.

THANK YOU