Australian Government

Chief Scientist

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Energising Progress

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About 20 years ago an economist named William Nordhaus wanted to change the way we think about progress. But how do you measure progress across millennia? The Big Mac index is too new, and CPI makes no sense. The yardstick he chose was *light.*

Think of a single 75 watt, incandescent light globe operating for one hour.

Now imagine how hard the ordinary person would have to work at various points in human history to produce the equivalent of that incandescence.

If you were an ancient Babylonian, you would have a sesame oil lamp, and you'd need to work for *forty hours* to pay for that much light.

If you were a French Revolutionary, you'd have candles, or perhaps flaming torches, costing you *five hours*.

If you were a Late Victorian, you might have Edison's carbon lamp, costing you *45 minutes*.

If you turn on that light globe today – it costs you *less than half a second*.

You can have, for half a second of your work time, the light for which a Babylonian would be working all week.

Now if we were content to get by in Babylonian darkness, we would have no problems. Except for the fact that we would be living like Ancient Babylonians, subject to starvation, disease and boredom.

And that, indeed, was what life was like, for the overwhelming bulk of human history, in the millennia between sesame oil and steam.

Step back two hundred years and you might as well step back to the Stone Age. But crack clean, cheap energy – and you shoot to the Space Age.

To get there, we need energy.

Energy drives progress, progress delivers more energy.

Beyond incrementalism

Our aim is to supply people with the energy to make better lives. We *also* want to reduce the burden that this goal imposes on the planet.

It follows that we need a big goal in energy productivity, such as to double it by 2030.

And the bottom line is this: on the plotline of the story that we're starring in, *we don't get to that goal in time.*

It seems that whatever we do, it's not enough.

Markets and regulation will get us part of the way. But they work best when they help take us to the next level.

We need *science* to break through the barriers of possibility.
And we need *innovation* to deliver the solutions.

All of this has to be done at scale. Huge scale. In all sectors of the economy.

Let me make that concrete. Take cement.

We use over four billion metric tonnes globally every year, and every year that grows by another few hundred million tonnes.

Producing that cement accounts for nearly five per cent of carbon dioxide emissions.

Now imagine we can meet that same need with a geopolymer equivalent.

We can make it from the chemical activation of two industrial wastes – blast furnace slag from iron production, and fly ash from coal fired electricity generation.

This is a development in which Australia has a strong position, led by researchers from the universities of Melbourne, Monash and Curtin, along with CSIRO, and ANSTO.

And it results in up to 80 per cent fewer carbon dioxide emissions than if we were making old-school cement by the old-school method.

If we converted all cement production globally we would wipe about 1.3 billion tonnes of CO_2 off the ledger.

Here's another example: autonomous vehicles, or self-driving cars.

What are the implications of automation?

Some say – all good.

- Streets can be narrower – because smart cars don't need the same margins as stupid humans.
- Gridlock disappears – because cars just swim together like a school of fish.
- And emissions fall – because each car takes the most efficient path to its goal, and doesn't over-rev the engine on the way.

All up, McKinsey Corporation estimates that autonomous vehicles could contribute a 15 per cent reduction in emissions by 2025.

Not bad, considering that the transport sector accounts for 90 million tonnes of greenhouse gas emissions in Australia per year, and is one of the fastest-growing sources of our emissions.

But hang on – can we bank those savings just yet?

- Say you own a self-driving car. You're off to a meeting downtown, where the parking is extremely expensive. Do you park the car, or just tell it to drive round and round the block on its own until your meeting is over?
- Say you're a couple with schoolkids. Do you carpool in the mornings like you used to? Or do you now send the car out on three independent trips – one for mum, one for dad, one for the kids?

Probably the latter. And if we do this in increasing numbers as self-driving cars come onto the market, our congestion problem could get a whole lot *worse*.

I'm not suggesting we should stand in the way of this progress, because the cars will just find a way to drive around us. There are more than enough human inventors and investors to propel them.

What I *am* saying is that we can't wait for incremental change to sort the problems out. We should be thinking about a whole new transport and urban

planning model to maximise the energy productivity gains that are there to be made.

- Imagine Sydney – reconfigured with billions of roadside sensors into a single, networked and ultra-efficient grid where autonomous vehicles talk to each other and to the traffic control operating system.
- Sydney, in which the ownership model has been reimagined so that all vehicles belong to fleet operators who guarantee the rapid allocation of the next available vehicle.
- We cut the number of needless trips.
- We cut the number of cars on the road.
- In time, we cut the number of cars that we manufacture and ship.

In short: with examples such as geopolymer cement and a reimagined vehicle fleet we run up the slope of progress: fast, hard and with better energy productivity.

That's how we make an Australia that values its energy – and through availability of energy, an Australia that achieves the progress its citizens want.

Building capability

As Chief Scientist I want to make *my* best possible contribution.

In part, it's about driving people up the slopes, by pointing out how good the view will be from the top.

But I don't expect to push the country up mountains by the force of my enthusiasm alone.

I expect that Australians will make their own way along a national path that is achievable, explainable and desirable.

This is the second half of my role – to help find that optimum path and make sure we have the wherewithal to take it.

Energy is already identified as one of our nine National Science and Research Priorities.

The Australian Government invests about $190 million towards this goal each year, plus additional investment through university block grants and R&D tax incentives.

But is it enough? Can it be used to greater effect? The Priorities force the question. Our challenge is to respond effectively.

As Chief Scientist I will also be pursuing two projects of particular interest to you.

The first is my role at Innovation and Science Australia to help lead the development of a 15 year plan for investment in science, research and innovation.

What's in it? Well, we haven't started. But you would be very surprised if energy productivity doesn't end up part of the mix. Just as *I* would be very surprised if you were not active contributors.

If we get it right, the Government will adopt our recommendations and optimise the conditions for bold investment.

The second project I am leading is the mapping of Australia's long-term research infrastructure needs. The big, national scale equipment that underpins our advanced research capabilities.

National scale collaborative research is something like the scientist's Olympic Games: the field where we push ourselves to be our absolute best, in ways that markets and 'business as usual' don't allow.

And so it is one of the best places to look for the transformational science and innovation that we need.

A fortnight ago I was in Parliament House for the announcement of the first detection of gravitational waves.

It was an extraordinary feat of ingenuity that simultaneously confirmed Einstein's theory of relativity, and opened a whole new way of observing the cosmos.

The fluctuations in space itself, which scientists measured for the very first time, are tiny – about *one thousand times smaller than a proton*.

In this case, they arose from two black holes colliding 1.3 billion years ago, when the only life forms on Earth were microscopic.

Einstein himself did not believe that human beings could ever produce scientific instruments with the sensitivity to listen in on the universe in this way.

So to prove Einstein right about general relativity, we had to prove him wrong about the limits of human ability.

In the world of Big Science, the imperative for breakthrough solutions is clear – which drives incredible people to get down to the business of finding them. That benefits all of us.

The knowledge discovered through the use of the national scale research infrastructure spurs a new wave of innovation in turn.

To name just one – the Australian Synchrotron's work in light-weight materials for transport.

We have known for years that magnesium alloys can be just as strong as aluminium, but significantly lighter. The problem is their tendency to corrode.

Late last year a research team using the Synchrotron announced the development of a new magnesium-lithium alloy: the first of its kind to prove immune to corrosion.

It is half the weight of aluminium and a major step to the goal of economical *stainless magnesium* for aircraft and cars. This weight reduction will reduce transport energy consumption and reduce emissions.

The national-scale research infrastructure roadmap that I will be leading is our chance to make sure we can keep pursuing opportunities like these.

To generate big ideas – and get them to the market. At scale.

Scaling the mountain

This is the challenge that makes my job worth doing. But as I say, I'm only one mountaineer.

So my challenge to you today is to tackle the slopes head-on.

- Keep the goal for energy productivity bold and visible.
- Ensure that it drives total emissions reductions.
- And develop KPIs that hold us to account for doing so.

Energy for progress, progress for energy.

We are taking control of an incredible story of human ingenuity.

Let’s emerge from this conference with the enthusiasm to aim high – and the endurance to get up the slope.

Thank you.