Brisbane, QLD

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Senate Senate Standing Committees on Environment and Communications
Environment and Other Legislation Amendment (Removing Nuclear Energy Prohibitions) Bill 2022

SUBMISSION

This submission is made in response to the call for submissions by the Senate Environment and Communications Legislation Committee on the *Environment and Other Legislation Amendment (Removing Nuclear Energy Prohibitions) Bill 2022*, to which the bill was referred on 27 October 2022, for inquiry and report by 31 March 2023.

As the Committee's website states:

> The bill would amend the Australian Radiation Protection and Nuclear Safety Act 1998 to remove the prohibition on the construction or operation of certain nuclear installations; and Environment Protection and Biodiversity Conservation Act 1999 to remove the prohibition on the Minister for Environment and Water declaring, approving or considering actions relating to the construction or operation of certain nuclear installations.

I submit that it is clearly in the national interest to removed prohibitions on the civilian use of nuclear energy in Australia. That includes the prohibitions in Commonwealth law contained in the two acts under consideration by the Committee.

The content of this submission draws on my experience in electricity and other energy systems, from professional work as a consultant, an industry executive, and university professor in over 30 countries across three decades. I have been involved in all forms of energy, along the entire value chain from customers to natural resources. My experience covers the technical engineering, economic, markets and financing; strategy and policy and regulatory domains of energy and emissions. My profile is available at: http://au.linkedin.com/in/energyeconomist

I make this submission in a personal capacity.

I currently have roles in advisory work, technology commercialisation, and academic research. I have been involved previously in early-stage energy project development work, while based in London.

This submission is consistent with my prior work. My public statements on Australia's impending energy crisis date from at least 2016. A brief summary of my prior work on energy, electricity and nuclear energy, that may be of interest to the Committee is appended to this submission.

The bans in federal law never had broad public support, nor even broad party political support.

The minor party that insisted on the bans did not publicise their enactment, and the majority of the Australian electorate was unaware of their existence until recently.

Today, far less than half of the Australian electorate supports the bans.

Public support for nuclear energy is growing. Far from being banned, the mainstream, centrist, cross-party, non-partisan Australian view is that nuclear energy should be on the table and appropriately considered.

It is hard to find anyone willing publicly to defend the bans on principle.

What has emerged as the 'standard defence' of the bans is ill-informed, illogical, or based on circular reasoning: that nuclear energy is 'uneconomic' or that 'the business case doesn't stack up.'

Concerns based on the 'big four' historical reasons for opposition to nuclear energy—identified by the mnemonic W.A.R.N.—can be laid to rest.

W: '**waste**' is a misleading term. High Level Waste (HLW) refers to nuclear fuel that has been used in a reactor. Some call it 'spent fuel'. A more accurate term would be 'used fuel' or 'irradiated fuel' because it can be reprocessed and used again. It can be stored indefinitely, reprocessed later, and used again. Or it can be locked away safely in geological repositories. Used nuclear fuel is very safe precisely because it is so dangerous: it is initially physically very hot and requiring several years of cooling, and subsequently highly radioactive. Engineering processes for handling and managing spent

fuel are simple, well-understood, and well-implemented. (Dr Chris Keefer in Canada notes that no-one has ever been killed or injured by used nuclear fuel.)

A: accidents in nuclear reactors can be very serious. Major accidents have been extremely rare. There have been three serious accidents: at Three Mile Island in Pennsylvania, in the United States in 1979; at Chernobyl in the Soviet Union in 1986; and at Fukushima in Japan in 2011. Only the Chernobyl accident involved fatalities and harm to people from radiation. The adverse effects of all three accidents have tended to be exaggerated.

R: radiation can induce fear. This is partly a legacy of the Cold War and popular culture (especially television cartoons and Hollywood movies) in the 20th century. It is also the result of the excessively cautious and unscientific adoption of the Linear Non-Threshold (LNT) dose-response model of radiation. The LNT has been conclusively shown to be wrong, by the most highly qualified and authoritative people, supported by extensive empirical data.

N: nuclear weapons proliferation is often conflated with the peaceful use of nuclear energy. This is a major error. There are many countries using nuclear energy that do it have nuclear weapons. There are countries with nuclear weapons that do not use nuclear energy. There is an important role for straight-forward explanation and public education about the basic differences between nuclear reactors and nuclear weapons, of IAEA governance processes, and of Australia's role as a founding member of the IAEA in 1957.

Australia's bans have damaging long-term ramifications.

The introduction of such major policy without proper public or parliamentary debate represents an abuse of the democratic process. It is to the credit of the Senate and its Committees in the 47th Parliament that it is having the debate, more than 20 years later. Better late than never.

The bans contradict and unnecessarily constrain other government policy.

There is bi-partisan agreement, not only in Australia, but in every country in the world—rich and poor, large and small, democratic and autocratic—aspiring to energy that is reliable, affordable, and that has minimal impact on the environment. It is equally well-recognised that those three goals tend to be in tension, and to require trade-offs.

It is established fact that any binding constraint imposed on the choice of energy sources will reduce reliability, or drive costs up, or increase emissions, or some combination of the three.

The bans are antithetical to the policy goals of the Australian Government, and also work directly against the interests of ordinary Australians and future generations.

Without nuclear energy, Australia has little hope of an energy system without CO2 emissions.

Rigorous engineering and economic analysis show that attempting to decarbonise of Australia's electricity and wider energy systems while retaining the bans on nuclear energy will compromise reliability, will be extremely expensive, and may simply not be technically achievable.

Australia needs urgently to begin preparing REAL OPTIONS to be in a position to deploy nuclear energy if we decide we need it from the 2030s.

This was a key part of my testimony to the Victorian Parliamentary Inquiry. This was the major recommendation of the report published by UQ on our study What would be required for nuclear energy plants to be operating in Australia from the 2030s.

A major crisis is looming for Australia's electricity systems and for its gas system.

Nuclear energy is one of the keys to the resolution of the deepening crisis, which is undermining Australia's energy security, reliability, affordability, and competitiveness, and constraining the nation's ability to fulfil long-term emissions reduction commitments. Removing the bans on nuclear energy is a necessary condition for the deployment of nuclear energy in Australia (although by itself it is not a sufficient condition: many other things are required).

Previous statements of relevance to the submission

1. **Presentations and keynote address** to the bi-annual conferences of Engineers Australia, the Australian Nuclear Association,[1] and the Four Societies (The Royal Society of NSW, the Australian Institute of Energy, the Australian Nuclear Association, and Engineers Australia Sydney Branch).
2. **Testimony at three parliamentary inquiries** (Commonwealth, NSW, Victoria).[2]
3. **The study published by the University of Queensland** on *What would be required for nuclear energy plants to be operating in Australia from the 2030s*. I presented the draft findings and recommendations of that study at the invitation of the cross-party Parliamentary Friends of Nuclear Industries group on Monday 21st June 2021. The report has been provided by the study sponsor to senior federal and state politicians throughout Australia.[3]
4. **A delegate** at the event *Modern Nuclear Power Generation in Australia's Clean Energy Future*, hosted by the Parliamentary Friends of Nuclear Industries in Parliament House on 24th and 25th November, 2022.[4]
5. **Media interviews** on ABC Radio, Channel 7, 4BC, Sky News, and elsewhere.

   Details on request.

References

[1] The slides and video of my keynote address to the ANA conference in April 2022 are available here: https://www.nuclearaustralia.org.au/ana2022-conference/
The address to the annual meeting of the Four Societies in Sydney in February 2022 are available here: https://www.royalsoc.org.au/blog/annual-meeting-of-the-four-societies-2022

[2] Testimony is available in HANSARD and transcripts as below.

Commonwealth:
https://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;db=COMMITTEES;id=committees%2Fcommrep%2Fddfef922-b8a8-4990-a181-b96cb466fed8%2F0002;query=Id%3A%22committees%2Fcommrep%2Fddfef922-b8a8-4990-a181-b96cb466fed8%2F0000%22

NSW:
https://www.parliament.nsw.gov.au/lcdocs/transcripts/2191/Transcript%20-%2018%20November%202019%20-%20CORRECTED.pdf

Victoria: Friday 11 September 2020:
https://www.parliament.vic.gov.au/epc-lc/inquiries/article/4349
https://new.parliament.vic.gov.au/get-involved/inquiries/inquiry-into-nuclear-prohibition/

[3] The report is available under 'Nuclear Energy' at http://energy.uq.edu.au/WhatWouldBeRequired
Printed copies are available upon request.

[4] The transcript of the session in the Main Committee Room of Parliament House on Thursday 24th is appended to this submission. The videos of the session and the presentations on the 25th are available at: www.youtube.com/@friendsofnuclearindustries/videos

Canberra Small Modular Reactor Forum

25th November 2022

On the 25th of November 2022, Dr Adi Paterson led a team of electrical and nuclear engineers, economists, and lawyers to Parliament House, Canberra, to participate in a Q&A session with to educate and inform Australia's 227 Federal politicians on the need to ensure Small Modular Reactors are incorporated into the nation's electricity grid to replace the retiring coal generators and compliment wind and solar generators.

The following is a transcript from the 110-minute Q&A session, please refer to the attached biographies for more information on the attending speakers.

Dr A. Paterson: *Intro* It's great to be here today to talk about what nuclear energy could do in Australia at this time.

We have approached putting this panel together and reflecting on this, based on deep concerns that we have, that there is a very inaccurate representation of what it will take to have a reliable and effective grid.

We're going to concentrate on the Eastern grid, but I believe our colleagues from Western Australia can also show equally that we already entered the area of unreliability and unpredictability that is starting to drive the costs up, and the plan is to increase that unreliability and that unpredictability by following the same menu that we've been following for the preceding years.

Decarbonization of the grid needs firm dispatchable resources as the anchor tenant of what we do, and so today we have gathered a group of people together who I will introduce as we work through the plan that we have to share a wide range of information but just before we do that I'd like to say something, that I didn't think I'd ever have to say in the next 10 years, but which came true over the last two weeks.

Over the last two weeks California, who had shut a number of nuclear plants and had one left, the House of Representatives in California voted 157:3 to keep their one remaining nuclear plant open.

Why did they do that? It is because the intermittent and unreliable sources of electricity on which they are relying has proven insubstantial in the current conditions that they have in their market economy, remember that California still gets 35 percent of its power from other states around it, so it's protected by a blanket if you will.

Our Eastern grid is not protected by any blankets, and therefore we are starting to see what I would call the California effect.

More profound perhaps is Germany, Germany has integrated and connected into the European grid one of the most integrated Goods in the world they have built

Dr A. Paterson: *Intro cont.* over the last 15 to 20 years many, many wind turbines and many, many solar panels.

The Fraunhofer Institute in Germany, which is the equivalent of our CSIRO, in particular their solar energy group three years ago produced a report after they had some problems in their grid, and there's one graph in that report which is really interesting.

It's got a big red circle on the solar power piece and it said “50 percent too little”, what they meant was a hundred percent but being scientists they sort of fudged it, what they meant was we have to build this all again if we're going to have enough solar and they've been doing this for nearly 20 years.

We cannot rely in Australia on this sort of planning, and yet this is the planning that we're a bit we are being told is being done.

The UK also on a journey towards large amounts of intermittent renewables, particularly in Scotland which doesn't really have any other backup at the moment, has also decided to continue reinvestment in nuclear power plants.

Their particular choices that they are making are based on their history of deep investment in nuclear and in fact Tony, who said a few words a little bit earlier in the other session, Tony how many of the plants did you start in the UK system?

Assoc. Prof. T. Irwin: Eight

Dr A. Paterson: *Intro cont.* So Tony Irwin switched on and operated eight nuclear power plants in the UK system, he then came to Australia to help us set up the early operations of the opal reactor, a non-power reactor that does not make electrons, in Australia and it's been a privilege to work with Tony over the years.

The UK ran down its fleet I think with the similar argument that went on in in Germany that somehow we were going to escape the need to have this firm dispatchable safe power that comes from nuclear power plants, but in fact the UK is now switching back quite strongly into a rational policy of having firm nuclear power available in order to provide that resilience to the grid.

So whatever you hear today, you will not find people objecting to intermittent renewables.

I personally was responsible for the group that developed the wind map in the eastern part of South Africa, I was involved in the commercialization of battery technologies; my battery Technology Group developed intellectual property that we sold, to Toshiba, and licensed that lithium battery technology in the 1990s before lithium batteries were famous.

And so, in a sense one sense, we're a technology agnostic but one thing we're sure about: it has to be low carbon, it has to be completely predictable, and it has to be low cost.

We believe that small modular reactors fit that bill for our Eastern grid and likely will fit that bill for all the electricity Supply in Australia in the future, and we believe that the modern greens movement, the one that follows the anti-nuclear greens movement, is in support of that.

Dr A. Paterson: *Intro cont.* We have a short video from Finland, where the greens have become pro-nuclear because they live in the straightened circumstances of being nestled between Russia and the rest of Europe, being in a very cold place, and adding the benefit of nuclear power so if we could roll that video.

Mr A. Harjanne: *Finnish MP* At the moment we're globally facing two crises: climate crisis and the loss of biodiversity and tackling these challenges was a lot down to energy policy, and in energy policy one highly debated issue is the role of nuclear in the future.

The problem we're facing, the parameters we're facing, is the amount of energy we need to decarbonize to get rid of fossil fuels and ensure human development. What are the actual tools that can be used? What is the portfolio that we should have of different vintage sources? Are renewables alone enough?

And I encourage everyone to do this math and kind of look at as robust strategies as possible for tackling this global crisis, this is what the Greens of Finland have been doing, and as a result we've actually adopted a more technology neutral, pragmatic, and to some extent pro-nuclear stance on energy policy, so that's the position in Finland.

Dr A. Paterson: *Intro cont.* And I think it is the logical end of a process of thoughtful reflection about all of the issues that will face society as we decarbonize for the future.

Now we've got a group of people today and I'm going to introduce them as they come up in the program.

First up is James Flay and he is going to outline for us the problem with the Australian Energy Market operators integrated system plan now some people might start saying ISP, when they say ISP they mean the integrated system plan, and that is the published plan for the eastern grid which is currently being imposed on us.

Mr J. Fleay: *ISP & AEMO plan* So before I talk about the AEMO plan, I just want to be careful to point out that this is not a critique of AEMO as an organization, they fully understand the challenges that we have ahead of us.

They are between a rock and a hard place, they feel the need understandably to implement government policy both at federal and state levels.

I think left to their own devices their ISP would look different from the one that we examined today but, nevertheless.

Firstly, the ISP hasn't seriously considered any alternatives to nearly 100 percent wind and solar, in any large engineering project generating and comparing alternative concepts is a prerequisite to a good plan.

The only concept that's being proposed seems to want to shoehorn a fun political daydream into an essential physical system, this failure to consider alternative concepts means this plan shouldn't get past any project review board.

It also inadvertently proposes that we reverse a 300-year-old trend towards ever higher quality fuels, and instead revert to being wholly dependent on weak intermittent flows of energy seems to conclude that there's no downsides or

Mr J. Fleay: *ISP & AEMO plan*

risks to this approach, but of course if it were that simple it'd be difficult to explain why 19th century merchants quickly replaced their sailing ships powered by free wind with steamships powered by coal.

A lack of awareness, or perhaps disinterest, in recent overseas events it's another feature of the plan which honestly seems stuck in the recent past, no other G20 nation is still working towards an electricity grid nearly exclusively powered by intermittent flows of energy.

The Japanese, the South Koreans, and other serious nations, all understand that we will always need a large amount of base load and flexible power to work alongside a sensible amount solar and wind.

The ISP also ignores the accrued technical knowledge of generations of electrical engineers by accepting that a wholly speculative grid transformation is both inevitable and good, and this seems strange because I don't really recall hearing many complaints about the cost and reliability of the old grid, the one that we're being asked to abandon, sure it was heavy on CO_2 but it did the job.

The old grid, and the current grid I suppose, was centrally planned, it was centrally operated, and it was optimized around large base load power stations and actual customer demand.

This philosophy worked for a hundred years on six continents, the distributed alternative philosophy of a grid forced to accommodate sort of take-it-as-it-comes renewable electrons hasn't yet worked anywhere at scale and certainly not on an isolated grid like Australia's, and that's despite the best efforts of places like California and Germany who have far more economic resources than we do.

The plan doesn't consider that each technology has a unique set of attributes and shortcomings, which may make it uniquely suited to fill a particular role within the overall grid system, instead by focusing on a single outdated and misunderstood cost metric it essentially treats these different generating Technologies as competitors in a in a winner takes all popularity contest. Unfortunately, this is why the energy minister can continue to insist that adding more solar and more wind to our nation's grid will bring down energy prices, that's in the face of all real-world observations to the contrary; so using a systems approach to intelligently combine technologies in a way that's complementary is much more sensible than trying to pick winners.

Finally, the plan is not purposeful, it doesn't really set out to build the grid of the future, it merely tries to anticipate a future that it apparently cannot influence.

It's submissive, and it meekly concedes control, or at least won't push back against self-interested investors and well-intentioned but ultimately ill-conceived government policy, both state and federal, and yet it admits of no role for intelligent engineering design and optimization.

Instead of building a grid that is simple to operate and minimizes costs to the end user, we are getting ready to build a grid design for investors, to connect far-flung renewable projects and to maximize the transmission access they have.

Mr J. Fleay: *ISP & AEMO plan*

The operators of this future grid be forced to accommodate or absorb every last renewable electron, regardless of the mismatch between their production and actual customer demand throughout the day.

In short, it's unlikely this plan will work, and while it's probably hard to believe, our energy situation stands to get worse.

Structurally expensive electricity, loss of energy intensive industries, and more frequent blackouts by 2030, all seem very plausible.

Coal to small modular nuclear reactors is this sensible transition that we need to start working towards, it makes the best use of the existing grid to provide always-on, zero emissions, affordable power.

So, this I contend: this nation needs an alternative ISP, independently produced, that's balanced on technologies and that considers a sensible role for Small Modular Reactors, and I'll leave it at that.

Dr A. Paterson: Thank you, James. Stephen Wilson is one of the top people on the complex integration between the origin of electrons on one side of the grid and how much comes out of your pocket at the other.

He is one of the most rounded and globally respected people in terms of understanding the grid, but often because we see him talk about nuclear power plants we don't realize that he's got a background in the economics of how electricity works as well as the politics, I think he's got a pretty good idea about that as well.

It's been an honour to sit at his feet and have many discussions about where our grid is going, and I'm going to ask Stephen to answer the question today what happens when there are too many and too few electrons going into the grid at any time.

Prof. S. Wilson: *Grid stability*

Okay, thank you very much Adi, what happens when there's too many electrons or too few electrons on the grid?

The short answer to that question is you'll have over frequency or under frequency. But this is a very good point, and the question is actually reinforcing some of the points that James had just addressed.

We're talking about a system, this is really important, and that system has to be balanced almost exactly in real time to the sub-second level which means that you can't really put too many electrons or too few electrons on the grid.

As Adi phrased the question, you need to keep the generation in balance with the load, you need to keep the supply in balance with the demand. It's not like bottles of milk in the supermarket - its real time balancing and that's why we call it an AC synchronous grid.

On that synchronous grid, where the frequency is the same in Port Douglas, through Brisbane, and Sydney, and Canberra, and Melbourne to Adelaide, and up to Olympic Dam 5000 kilometres long, the frequency has to be matched and balanced all the time.

Prof. S. Wilson: *Grid stability*

If you walk into the control room at AEMO and you look up on the screen it'll show 50.0 if it's perfectly balanced, it'll show 49.9 if there's a bit much load or a little bit too little generation, or 50.1 if there's too much generation and not quite enough load.

So this is not some nerdy technical issue, this is crucial to the balancing to the operation of the system and if you can't maintain that frequency and stability you're at risk of collapsing the whole system and blacking out the whole system, with something that is called an under frequency load shedding event, but you can also have over frequency events.

So that's the that's the technical answer to Adi's question, but there's another answer to Adi's question which I was pleasantly surprised to see in the newspaper yesterday: The Reserve Bank of Australia Governor Philip Lowe has issued a blunt warning saying that the renewable energy transition would probably spark higher and more volatile energy prices in the years ahead, it was actually the first paragraph in the article in the financial review from a speech I think he made at the CEDA conference.

Now the only thing I would disagree with: I would probably not use the word "probably" - I think that there's a much higher level of certainty that this is exactly what we're facing, the reason I was pleasantly surprised is I've been trying to give this message for three/four/five/six years privately and publicly at conferences and so to hear that the message is now getting through to people like Philip Lowe is quite encouraging.

Now there were some other things in that article I think we need to pay attention to, and this is to Adi's point, the problem in my view is not just the transition, people will say "oh yeah it's a transition problem" - transitions are hard, of course they're hard.

I think the problem is the destination: we're being told, we're being sold, that you can have a system configuration when there's no evidence whatsoever that it's actually going to work, and if we can make it work the evidence is it's going to be extremely expensive, or reliability and power quality/frequency all over the place/voltage all over the place, it is going to be compromised or a combination of both.

So this is what we're looking at, and this is not something that might happen in 10 years, this is something we can see the symptoms of already so we're violating a long-established principles of systems architecture and planning, engineering design, and principles that are very technical and specific to power systems and we're being told that we should be striving for this 100% renewable energy with storage – 100%... this is totalitarian.

Now a lot of people are afraid to say this, you know, you've got a mortgage and school fees to pay, people are afraid to spend, there's a lot of people who know this but are afraid to say so; and you know as an Australian, from my perspective it doesn't matter: any Australian person from any political party, whether they work for the market operator, or AEMO, or Arena, or the ALP, or down at the local Aldi, they should have no fear of losing their job or being side-lined for

Prof. S. Wilson: *Grid stability*

saying I believe in well-balanced diversity of power generation - I am open to the inclusion of nuclear power in the future, and all Aussies have an equity stake in a strong reliable affordable grid.

At the moment it's very hard to say those things, so this is unbalanced literally and metaphorically, you know balancing I've said it's the essential thing and we've got to recognize that saturation is a real problem and we and we need to understand this, to stop take a deep breath and look at what's a sensible way forward now.

For more technical explanations of this, come along to the seminar tomorrow morning in the theatre.

Dr A. Paterson:

Thank you very much.

Robert Barr has made a deep and ongoing and intensive study on the predictability of electrons on our grid, and he has looked very deeply in that context at the AEMO plan.

So, I think the question is building on what Stephen has just said, based on that high resolution modelling and based on his experience and his deep reflection on these things, the model for the actual grid and the one that you've been modelling: how do they join up?

And what would be your reflections on the nature of that grid, related to the very careful and thoughtful modelling that you've done?

Dr R. Barr: *Grid modelling, does it line up?*

I'm going to be very brief, I'm going to talk about the integrated system plan, the ISP, that comes from AEMO and within it there are four scenarios: there's a step change scenario, slow change, progressive change, and hydrogen superpower.

Now with my modelling I've been able to model all those and there's a common thread, and what I what I look for particularly, and I teach this to my students at the University of Wollongong, is that when you do these plans you look at the end game, and the end game for this plan is 2050.

Do I want to end up where this plan leads me in 2050?

Now if I go through my modelling, what it shows is that I'm going to have blackouts in 2050, it's not going to work with the resources that I see inside the plan, in fact I need 40% more resources, 40% more generation, 40% more storage, and more transmissions required to make that that system work.

With sun and wind the power systems have got to work under worst case conditions, and the worst case conditions are in the middle of winter where the solar resources are at their lowest, and then we have wind droughts: we have very significant wind droughts in eastern Australia and I just find that the resources are not in the ISP to get through those.

Then I go and look at the costing, the way AEMO do the costing is they look at the transmission, they look at the generation on the transmission side, they list all the resources they want on the low voltage, they want to put solar on my roof and they want to put batteries in my garage, but in the process they don't cost it.

Dr R. Barr: *Grid modelling, does it line up?*

The costing is really poorly done, because it doesn't come up with a cents per kilowatt hour, the actual cost that customers have to pay, so we've got this plan but I think it's really a poor plan, it needs a lot more work done on it and what has it led to?

It leads to the Australian energy regulator regulating and putting forward and approving projects that I don't think are properly economically viable, it leads to organizations like Reputex, who do economic studies and they take the technical input from these plans and feed it straight in as if it's gospel.

So if you put flawed information into your economic model, like Reputex have done, you end up with flawed outputs and I think we're seeing that, and we're seeing the results of that now.

We see poor inputs into other models from Access Economics, who accept the plan, the ISP, as gospel and then it leads through, I think, very poor conclusions.

I also see it with the Gratton Institute, the Gratton Institute take these plans thinking they're all gospel, that it's the way forward, and that's why we're in this very delicate situation at the moment.

We're 15 years into a transition and it's just getting worse every year, all the easy fixes are gone, and we are heading for a very difficult time ahead, there's no easy fix to the problem that we're in, no matter what we do it's going to take 10 or 15 years to get out of the situation that we're in at the moment.

Dr A. Paterson: Thank you, it's going to take 10 or 15 years to dig ourselves out of this.

I think it's important, therefore, to ask what other challenges and concerns there might be in relation to this plan, and to think through that I'm going to ask Dr James Taylor to say something.

Dr J. Taylor: *Concerns with AEMO plan*

From an engineering point of view most people would agree it's all about the numbers, and regrettably after studying the AEMO Plan for the Future, the numbers just don't cut it.

Now the reason boils down to a major factor and that is there's an attempt to put so many renewables into the market which are highly variable intermittent, as everyone knows, and there is insufficient base load power generation and there's completely insufficient storage as well, so the grid is unstable and it's insufficient power to cover the maximum loads.

AEMO talks about having a dispatchable reserve margin in the grid, that means that the total of all generation must exceed the maximum load by a certain percent, it's always been 20%, but in the new Plan for the Future that 20% goes down to minus 50% by 2030 to 2050.

That's not going to produce a reliable output for anybody, and what is shocking to me as a systems engineer, is there's very little systems engineering evident in the AEMO plan.

Dr J. Taylor: *Concerns with AEMO plan*

There are many other reasons why renewable energy is incompatible with grid scale electricity production: the cost of backup and the cost of energy storage is extremely high, and the cost of renewable energy generation is high.

I mean, you need five times more capacity with renewable energy than with a base load power plant, because a base load power plant will run quite comfortably at 65% to 80% and go to 100% outputs on demand, whereas renewable energy typically has an average of around 25% to 30% and it's completely at the whim of the weather and the day night cycle.

So, it is very difficult to imagine the economics working out and yet during the daytime, when solar which is two-thirds of all renewable is plentiful, there's too much as Stephen was saying there's too much too many electrons going into the system and you have to spill the energy, this is what AEMO calls it, when you spill the energy that means the generator isn't producing any income and just as it's happening right now with renewable energy, forcing the base load power plants to run at a very low utilization, the whole grid will run at a very low utilization when you have so much capacity in the daytime and not enough to get through a single night.

So, I think there needs to be a major rethink, this is where nuclear energy has a major role to play.

Thank you [Applause]

Dr A. Paterson:

Thank you very much, I think at this point I just need to note that there are more facts on the table in this room about the future of electricity than anywhere else in Australia.

I think it's important to realize that the experts that have been assembled here have qualifications in engineering, and the application of engineering to the systems we're talking about, and that therefore it's important to recognize that as we build on their knowledge for the future, we will be seeking more reliability and a better grid.

Now Dr David Hayden Collins is with us and he's going to pick up a couple of issues and I'm going to let him run through those at the pace that he chooses.

The first one is to do the cost of the new grid, but not just the cost in dollars, because they will also reflect on the environmental cost of construction, production, and end of life disposal in relation to that grid.

Then finally to wrap it up, we'll pull together the cost to the economy and industry, so Dave, we'll let you pick up all three in a row and just keep going.

Dr D. H. Collins: *Cost of renewables: environmental, construction, production*

Thank you Adi, which first may I say it's wonderful to see a critical mass here today, you guys are waiting for that one weren't you, I'm going to start with what Eddie and I call the integrity triangle, so this is environment economics and security.

I'll start with environment year after year we see an ever-increasing emission of greenhouse gases and associated climate change destruction, despite decades of negotiations and agreements that frustrated all of us, the world's best efforts for

Dr D. H. Collins:
Cost of renewables: environmental, construction, production

more than three decades, I can remember Jimmy Carter put PV cells on the White House in the 1970s.

I only, you know, that's a long time ago guys and we've been working on this problem for that long, and still, if you have a look at a graph of the rate of global greenhouse gas emissions: it's still rising, it's not plateauing, it's not dropping - we see these wonderful graphs coming out of all these computer models from CSIRO and others who do great work, but we're nowhere near even starting to get in the right direction, it's extremely disturbing, what's the problem?

Well realistically it's a global problem, Australia's contribution is tiny, right now all we see here at the moment in our country is discussion around what we're doing ,and how we're going to put in renewable energies, and how everyone's behaviour is going to change, we're going to have to change to meet those commitments, and even if we're successful, in the words of Bill Clinton "it's the world stupid, it's the world stupid".

We will have failed, the reality is that global emissions are dominated by China and India's growing emissions, which increase year on year, the elephant in the corner is China, the rest of the world committed to NZ: NetZero of 2050 - not China.

To ensure that Australia and the world are not held hostage we must persuade China to meet in Net Zero 2050, and lock step year on year in their progression, otherwise we will be held hostage internationally.

The only proven viable alternative to renewable energy is nuclear, land area and the associated environmental impacts of PV, solar/wind farms are over a thousand times greater than a nuclear power station's footprint, turbine blades and batteries will need to be replaced about every 20 years, we can't even recycle them, there is no viable method at the moment for recycling these things they get just thrown into the tip, into landfill.

The approvals process is for the thousands of kilometres of new transmission lines have to be approved, we have trouble even getting one approved, there's one at Daylesford at the moment that's been contentious for some years now and clearly nobody wants a transmission line on their property, neither would your voters in your electorate.

Every line is bitterly contested, can you imagine those of you who have a property, someone says from government "here I'm here to help, we're going to put a transmission line on your property and you're going to have to suffer for the rest of Australia" - it's not a very good argument, it doesn't win their vote that's for sure.

The article, and yesterday's Guardian, that's worth looking at, it talks about the Daylesford problem, that alternative underground power is wickedly expensive and there's no way that Australia can afford that, no one can.

The only response from some government officials is "hey, let's compromise our environmental standards" – really? So, we have to destroy the environment to save the planet? How ironic.

Dr D. H. Collins: *Cost of renewables: environmental, construction, production*

I'll move on to economic, AEMO ISP has been talked about quite a bit, let me put some numbers against this.

The explicit nominal costs of the ISP according to Amo are only $383 billion up until 2050, community capital cost, i.e. the solar cells that that, you know, we each put on our rooftops, that's not accounted for, but AEMO are using those those generation in their calculations, so effectively we have to include those if we're looking at an Australian cost.

How much are they? Well unfortunately AEMO don't tell us, but we've calculated there are about $250/$240 billion, hence the total Capital cost is not $383 billion, it's more like $623 billion.

Then of course the lifespan of PV panels, wind turbines, and so on, means that you're going to have to replace them about every 20 years.

So what does that mean? Well, that means that if you said say 50% of them have to be replaced your all-up cost is $1.3 trillion, this is five times greater than the AEMO's statement of $383 billion.

They have to be held to account for that, explain how you can justify this difference, and no doubt that will increase next year.

The other problem is that the costs have not allowed for the high cost of fifo laborers, because you're going to have to put these PV cells remotely, fly-in/ fly-out is much more expensive than you know if you put a facility near Melbourne or another large centre.

Well, energy generation electricity generation is only us about a quarter of the total greenhouse gas emissions, this is something that unfortunately the ISP hasn't really addressed adequately, transferred fuel and industrial emissions, can be addressed with abundant low-cost energy such as nuclear, agriculture is much tougher, and I think there's a profound change in innovation and structural change that will I think last well beyond 2050.

I think there's a there's an argument for agriculture to be studied separately and more intensively, fortunately a Consortium of University of Melbourne, University of Queensland, and Princeton engineers and academics are part way through a privately funded project called NetZero Australia 2050 -I 'm sure you've heard of that.

There was an industrial and technical update last night, they showed maps with solar panel farms larger than the size of Tasmania… Yeah right.

Hydro dams, wind farms Etc, massive basically an entire restructuring of the Australian society, the estimated capital cost to achieve and maintain this scale of change are between $100 billion, these are not my numbers these are theirs, and $150 billion every year, year in year out, for this foreseeable future.

Those costs, just for the 60-year period that I used before, that's a total of $7.5 trillion, so the real costs of the AEMO ISP or an equivalent program that would actually address Australia's greenhouse gas emissions by 2050 is more like $7.5 trillion.

Dr D. H. Collins: *Cost of renewables: environmental, construction, production*

That'll be interesting, to find out whether or not people at home are prepared to pay a lot more for their power, and the other problem of course how will the industry deal with this? They won't come, the ones that are here will go away.

Other Western countries at a more advanced stage of implementation are finding renewable plans to be much more expensive and much more difficult than expected, just look to Germany and the tribulations and trials they're going through at the moment: increased electricity prices about double out of France, where they use nuclear, massive uncertainty of supply, obviously that's multiplied at the moment because of the situation in Russia, which I'll talk about in a moment when I come to security.

The uncertainty of supply of renewables is basically untenable, as a viable country we cannot afford to take a chance given the existential consequences of climate change.

What's the alternative? Well, let's examine that.

High volume manufacturing is not Australia's strength, we can never compete with low-cost labour, and global economies of scale that we see other countries close by, it is a fool's errand to suggest that we could set up and manufacture PV and solar and wind here in Australia competitively.

However, Australia, it's not all gloom, Australia's terrific at efficient mining, mineral processing, and building large complex engineering structures that leverage our highly skilled and well-paid workforce.

Look around, the largest mining and mineral processing companies in the world are led by Australian engineers, the major buildings and infrastructure projects across Australia right now are led by highly experienced Australian-owned engineering and construction companies, these are precisely the skills that we need to deploy nuclear energy.

Costs are often used as an excuse, "this is why we're not considering nuclear, because it's not cost effective" - they say, how is it that over 30 countries around the world rely on nuclear energy?

The only places that have a systemic problem with cost blowouts and delays is in certain western countries, where the regulations are so complex that it takes 10 to 20 years to navigate, introducing delays, unproductive hurdles, and costs that make nuclear uneconomic; maybe that was their intent.

Security: firstly defense, China is the dominant and lowest cost supplier of both PV solar and wind turbines, eight of the ten top PV solar manufacturers are based in China, 10 the top 15 wind turbine companies are based in China, by committing to ourselves to a renewable energy-based Net Zero plan we are impoverishing Australia and empowering an autocratic and aggressive China.

Look no further than Russia and Ukraine, to see the influence that autocrats derive from dependent states, as we sit today several of Australia's largest companies have already been bullied into long-term costly contracts and energy technology sharing agreements with China, this is the elephant in the corner.

Dr D. H. Collins: *Cost of renewables: environmental, construction, production*

The taxi driver on the way here today had the answer, he's from Vietnam, he says the only way to withstand this threat is to be strong and gain respect, even with a hundred million people, he said, Vietnam is too weak.

The underlying Foundation of an effective defense is a wealthy and robust economy that is immune to autocratic aggression, if I could please implore you read Jim Mullen's, book to understand the risk that we face if we fail to do so, this is urgent.

There's another aspect of security that's very timely at the moment: the security of global resources.

It is impossible, and this has been known for some time by environmental engineers, to meet the world's needs for Net Zero using renewables, the world cannot do it, it's a fool's errand.

We've known this for a long time; however, this has been reinforced by an excellent study by an Australian engineer working in Finland's CSIRO, he found that on many different minerals, it's impossible for the world to meet or Net Zero objective using Renewables it's impossible there just isn't enough known minerals even allowing for the rate of new discoveries.

We might be able to achieve that here in Australia if we hoard all of our minerals, because we have quite a few here, but it would be a kind of pointless achievement a quixotic victory given that it's a world problem, I don't think our friends overseas would thank us.

So conclusion: the scientific engineering and experiential evidence is building that nuclear energy is an essential technology to address climate change.

Proven simple nuclear energy technology that can be plugged in with 100% chance of working, without the need to rewire Australia, can be deployed now.

Neither AEMO or Australian governments have seriously considered nuclear energy, despite nuclear's greater social, strategic, geopolitical, cost, ecological, and human health benefits.

We have a critical obligation to Australia, and the people in this room and this in this building have a critical leadership obligation to fulfil, we must quickly build our own Net Zero system so that we can assist developing countries and meet their global net zero objectives.

Our efforts have to be intensive, we have to act now, this decade, not waiting for the next election cycle.

If we spend this decade fulfilling our needs using nuclear, we can then focus on strengthening the world's economy and helping them achieve their objectives.

The first priority must be to remove the federal and state nuclear prohibitions, so that nuclear energy can be given urgent consideration on its merits, by AEMO defense, Foreign Affairs, industry, mining, states, and other arms of government, and most importantly we must accurately inform the Australian people.

Dr D. H. Collins: *Cont.*

Renewables or nuclear? Is the question, and in the words of Winston Churchill: when the facts change, I change my mind. What do you do?

Thank you very much.

Dr A. Paterson:

Thank you very much Dave.

One of Australia's most important exports is knowledge, and we are incredibly privileged today to have Helen cook with us.

You would not understand how the nuclear world, that is building plants around different geographies, in different areas, have to navigate a kind of a forest of regulations, and laws, and international treaties.

There is one book in the world that has been written about nuclear law, that is read by everybody, and it has just had its Third Edition, I think, approved.

The person who wrote that book, and is the sole author of that book, and who has fixed all three editions, is Helen cook.

She is a National Treasure, and I think we must give her applause for having achieved that. [Applause]

Now that she is cross with me, I think we would love to hear.

Helen, what are the legal constraints? And what it would take for us to move Australia forward and build nuclear in this country?

H. Cook: *Legal constraints, how do we move forward?*

Thank you very much Adi, as ever you are far too kind, but thank you.

So, you know it's an interesting question that you've asked me, what are the legal constraints, well of course in Australia we have a couple of pretty significant constraints being the federal prohibitions that we have on nuclear energy, and then also the prohibitions that we have in some Australian states.

So as Dave just said, of course at some point we need to address those prohibitions.

Now, the nuclear energy sector is one of the most heavily regulated around the world, and there is good reason for this efficient and effective nuclear regulation ensures the high levels of nuclear safety, the high levels of nuclear security, and ensures nuclear non-proliferation, which of course are absolute fundamentals to any nuclear energy program.

So it would not be sufficient for Australia to simply overturn the prohibitions that we have today, we would actually need to put in place, and this would be in accordance with international obligations that we have already signed up to, we would need to put in place a legal and regulatory regime that would oversee the nuclear activities involved in the construction and operation of nuclear power plants in this country.

Maybe even more importantly it's not just a matter of putting those laws and regulations in place, it's ensuring that they do two things: that they strike an appropriate balance between responsible nuclear regulation, ensuring safety, security, and non-proliferation, but also enabling and facilitating nuclear power projects, nuclear construction projects, importantly as well on time and on budget.

H. Cook: *Legal constraints, how do we move forward?*

And this is where there's a lot of work that is currently being done internationally, there's a lot of work being done by countries around the world that are looking at deploying new nuclear power plants, and in particular small modular nuclear reactors, and there's a lot of work being done by the IAEA, the International Atomic Energy Agency, in this space trying to think about how we can put in place more efficient and more effective nuclear regulatory frameworks that actually facilitate nuclear power projects, as well as maintaining that high level of nuclear regulation that promotes safety, security, and safeguards.

Now, this is where I think Australia is particularly well-placed, together with other similarly situated countries that also have existing sophisticated legal and regulatory regimes, not for nuclear energy, but in other areas that also have international obligations that of course they plan to maintain and implement, and they also have a relatively blank regulatory canvas when it comes to nuclear energy.

This is an opportunity for these countries to think about how to overcome some of the challenges, and the complexities that have developed over decades of regulation of large nuclear power plants.

Dave, you mentioned that there are some regulatory regimes in the world that are arguably overly complex, overly difficult, overly time-consuming, overly costly, so it's really an opportunity for countries like Australia and certainly other countries that are currently engaged in this process, to think about how to develop efficient and effective legal and regulatory regimes, to facilitate small modular reactor projects, on time and on budget and in the volume that we need to see Small Modular Reactors actually make the contribution to decarbonized energy systems that we know they can.

Thanks Adi.

Dr A. Paterson: Next up we want to continue to look at financial constraints, and we have with us Dr David Carland, you're up now on financial constraints and how they might hinder delivery.

Dr D. Carland: *Financial constraints*

Baseline power stations of any sort of technology, not renewables, are going to be difficult to finance in the current market, because of the way our energy only market works.

There is a hidden subsidy for renewables, and apart from a small amount of spinning reserve in each region, the renewables get preferential treatment, this is exacerbated by the solar panels on roofs, which is a sort of a negative load, it's behind the meter and you don't see it.

This issue was investigated by the ACCC about two or three years ago, identified this gap in the financial market, and recommended the government look at underwriting PPA’s, particularly in the middle to latter part of contracts, for the types of power stations you might want to build.

An obvious example would be for Small Modular Reactors.

Dr A. Paterson: Thank you very much, next up we have Robert Parker.

Robert has worked intensively on understanding how the world is changing in relation to nuclear, and Robert I'd like to kind of give you two questions in a row here.

The first one is: what does all of this thinking mean for a deeply renewable grid in terms of retail electricity prices and the expansion of the grid?

And how does that then translate into our food and consumer goods prices?

R. Parker: *Consumer prices & impacts*

First off I'd like to mention that price is not the same as cost, and we sometimes forget this particular issue because people tend to focus upon the costs of renewables versus nuclear, but I'll touch on the cost issue first because it's important and I mentioned earlier today that we've got this energy model that we use, that Dr Barr devised, and using that model we've gone to AEMO's integrated system plans, now they've got one particular plan which you might say is the favoured one, that's called the step change, this is where we basically swallow the snake oil, take the whole bottle down, and get right into it.

So having done that, we go to this step change where we're very robust and we get stuck in and when we look at the model, and so what we do is we say "okay let's look at a nuclear scenario, an optimum nuclear scenario" - and let's take the step change scenario, and what the step change has is a lot of renewables, wind and solar, and it's got a lot of batteries, and it's got a lot of pumped hydro, it's also got a bit of gas.

We see that out around 2050 it's still got 10% gas, we've still got emissions up around 100 grams per of carbon dioxide per kilowatt hour and if we go to our nuclear scenario we find well, hey presto, it's got emissions down around 20 grams, but the important thing when we compare these two scenarios, is that the cost the renewable scenario is about 2.2 times that of the nuclear scenario, it is much more expensive.

So that covers off the cost issue, and as Dave Collins has mentioned, it's not hard to imagine why we should be getting such a large rise when we look at the tremendous investment that we've got to make in all these renewables, so we've got a real cost problem here, but the next thing we suffer with in a predominantly renewable system is price fluctuations.

As we saw in July of this year, when the NEM was suspended, we had energy prices in our pool system going up to $300 per megawatt hour, that was over the month and that's when the thing was suspended, now sure it settled back a bit but price is determined by this real problem we've got with a predominantly renewable system.

If you think like a juggler trying to hold a bunch of balls in the air, and he's got a bit of solar here, and a bit of wind here, and he's got pumped hydro, and he's got a bit of gas and he's got all of these balls - and when you look at the complexity of trying to juggle this there are times when the wind and solar don't cooperate, and that's when we've got not enough reserve margin in the system, and that's when the costs go right up through the roof.

R. Parker: *Consumer prices & impacts*

That happened in July, cold weather = high demand, we could well see another sort of event occur in this coming summertime, and so volatility is a part and parcel of renewables and volatility is what drives price, cost is another factor but volatility is the main one.

If that then, we flow over into the cost implications for what it means to mums and dads, for commodities, but also the standard living, this high cost in underperforming assets driven by the huge numbers that Dave Collins mentioned, drives a massive amount of inflation into the economy, and it means that we will not have enough left in the pie for families to have a decent standard of living.

This is the net outcome and so food prices will rise, food producers, and people value-adding to the food chain, their prices will go up and our standard of living will go down, as we try to populate our economy with these high levels of renewables.

I'll leave it there, thank you.

Dr A. Paterson: Thank you very much Robert. [Applause]

Next up is Professor Peter Tyree, Peter and I have worked together quite a lot he's been a great mentor to me, thank you Peter.

When I came to Australia, you helped me think about it what it was like to be an Aussie, and I'm still practicing.

Prof. P. Tyree: He did the rugby.

Dr A. Paterson: The rugby hasn't changed, but Peter represents the industry that actually helps keep our grid together and he has got a deep knowledge of what happens when the grid is not reliable to manufacturers, and industry suppliers, and to mining and minerals.

Peter, your question today is: what effect is the intimate and renewable world that we are facing have on these two sectors?

Prof. P. Tyree: *Effects of renewables on industry*

Thank you Adi, first of all just let me say in addition to what Adi just said, I speak as an engineer who studied power systems, I worked in Sydney County Council which is today Ausgrid, Australia's largest utility, and also in the manufacturing sector after setting up my own company in making a high voltage components for the ESI, and I just chiefly say that the reason you've got air conditioning and lighting in this building today is due to Tyree Transformers.

I'm qualified to say Australia is almost at, if not already at, crisis point.

We've heard previous speakers say, our time is running out to make sure we get stable reliable low-cost electricity, industry will not exist anywhere in the world if in any substantial way the cost of that energy or the electricity is high, the reliability is poor, and the availability and quality is also poor.

Prof. P. Tyree: *Effects of renewables on industry*

So what the opposite of that is to say, that if you want to build industry and or come to the mining and mineral sector later on, if you want to do that you've got to have a reliable electricity supply that's not just low cost, reliable and robust, it's also a perfect supply 24/7, 365 days a year.

That's what you call a reliable grid, and Australia has got one of the largest grids in the world.

It's also got to be globally competitive, that if we're going to continue to create more wealth in Australia, you've got to have our electricity supply at competitive global prices, we used to be number three lowest cost in the OECD, we are now at the last, or top, most expensive three.

Consider today, maybe we ought to really consider what's been going on in in the giants of Europe, and the problems that they are now facing because they did not continue to build, as Australia did, good robust secure electricity supply.

And what Germany has done under Angela Merkel, who I used to love because she was a chemical engineer, Germany's now in a lot of trouble with its industry and if it's not careful it's going to lose that position, think about not driving a Mercedes, but more Toyotas.

We have to build our industry and it's got to have low-cost energy, we can only do this if we have the electricity I described, there is no reliable electricity: there's no industry.

We can only do this if we have a change in attitude, this is an urgent problem we've got to get on with, it is important to note mining and mineral sectors are big users of electricity and energy.

Australia's economy is and has been perhaps the best, or biggest contributor, to wealth generation for quite a few years now, not just in its taxes but its employment of people and the export of knowledge, the export of goods, and so on.

If we don't fix our power problem, and we want to see these industries thrive and survive and contribute as they have done, don't have crook power.

Lastly I'm just going to say that Small Modular Reactors are the solution that perhaps we should start preparing for, and whether the regulations or the laws that currently prohibit them are still in in place.

I think the CSIRO has been a proponent of this, we can't study what is really happening with Small Modular Reactors or nuclear of any guise because it's not legal, we can't do that.

Well in actual fact the law, as I understand it right now, will allow us to study the implementation of nuclear power or, I'm not advocating anything other than Small Modular Reactors, I might say.

Have a think about the airline industry, when the 747 jumbo was only on the drawing board at Boeing, globally the governments and air industry people started building new runways that were thicker and longer, new terminals that could handle more people, and the same thing happened with the Airbus A380.

Prof. P. Tyree: *Effects of renewables on industry*

Billions and billions of dollars were committed when these things were on the drawing board and untried, I therefore suggest that the CSIRO's approach, unless changed, is a folly.

I think Stephen Wilson said something earlier about preparing; I fully endorse what Stephen said thank you very much. [Applause]

Dr A. Paterson: So following on from that I'm going to now go again to Robert Barr, and Robert if you can talk to us about what happens in the AEMO plan if the electrons disappear out of the grid.

Dr R. Barr: *The AEMO plan & disappearing electrons*

Well we've had we've already had some cases of this sort of thing happening, when the power system is working well, the market's working well, we get good prices, and we had this five/six/seven years ago, ten years ago, then we've had some interesting things happen when things run out.

When the renewables in South Australia become very dominant, we saw the business model of the northern power station disappear and all of a sudden the northern power station had to shut down, and what happened through South Australia was fed through into Victoria: prices go up.

So when things become unstable, prices go up.

What happened when Hazelwood closed in Victoria? It didn't just affect prices in Victoria, it spread through to New South Wales and South Australia, and to a lesser extent Tasmania, so what happens when Liddell and Orion close?

They're on the chopping block next, their business model is being destroyed by the renewables, they can destroy the business model but then when the coal-fired plants go they can't replace them.

So what we end up happening is prices will go, high the market will become unstable, AEMO then intervene like they did earlier in the year and have to set like a $300 dollars per megawatt price and they just have to control the market, and it'll even get to the point of our domestic solar and PV, where they have control, they will need to control the whole system just to keep it going.

Cost becomes irrelevant and stability can be lost, I think we're in for a very difficult future unless things change and change quickly.

Dr A. Paterson: Thank you very much Robert. [Applause]

What I'm going to do now is take a segue, we have online Warren Mundine, who is up in the Northern Territory and he you know has a deep and long experience of the impact of decisions that we take quickly on indigenous relations and communities, both on and off the grid.

So Warren, we welcome you, we can see you on the screen, and thank you for talking to us about the impact on indigenous communities and also perhaps reflect at the same time on how that impact happens beyond the grid as well at the moment, where people are not connected.

Nyunggai W. Mundine: *Impact on indigenous communitues*

Thanks for that introduction, I do have to say up-front I wasn't going to be talking about this, I was talking about something else, but it's Jacinta Price's and she had to pull out, so I just grabbed this in the last five minutes.

There's going to be some really massive impacts of indigenous relationships and communities because of some of the books and policies, and what's going to be happening AEMO.

First of all it's been mentioned earlier that you're if you're going to have solar energy and wind farms, that you're going to have massive parts of northern Australia that are going to be taken up by these wind farms and buy these solar energy farms.

Then you're talking about the sun, the sunrise project in the Northern Nerritory at the moment, and that's a massive project.

That's taking up a full large cattle station up there, and there is a lot of arguments and discussion about that project, in fact I'm just up in the Northern Territory now as you can tell from my relaxing outfit, that it's uh it is causing problems.

The indigenous Community out there didn't realize how much of land was going to be covered by these solar panels, and how much that was going to be affecting their environment that they're in, and also their cultural heritage as well that would be which will be covered by this, because it completely covers this whole cattle station you know something you know 15,000 hectares of land, and people are not very happy this situation.

So where does that where does that lead in the future and other projects that are going to be going on, and we heard the conversation in regard to you know power farms the size of Tasmania up here, and but that's go that's going to cause a lot of problems.

We are struggling with a number of projects up here in Northern Australia, and I can't see it really being acceptable up here.

Where does that take us? That's the biggest issue that we've got to start talking about, where does that take us in regard to this renewable energy that the government's pushing and that everyone's pushing at this stage?

I'll be talking about the Small Modular Reactors and nuclear power etc later on in my own presentation.

But people up here are in really angry situations, in fact I'm meeting with the northern land council and some of the traditional owners tomorrow about this very issue, about what these policies are going to do to their country.

Dr A. Paterson: Thank you very much, Warren.

So we've talked about what happens if we run out of electrons, one of the surprising things when I did my deep dive into the new AEMO plan was to find that are we going to have 15% gas putting carbon dioxide into the atmosphere in 2050. And I would like to ask James Fleay to talk about that.

Mr J. Fleay: *Gas & the AEMO plan*

As you know I've spent most of my career in the upstream oil and gas industry building LNG plants and subsea gas gathering facilities, and so I think gas is a wonderful fuel, terrifically versatile, provided you can get it for the right price.

As Germany and the UK have recently discovered, you can't have solar and wind without gas, and we've seen that in all over the world where large amounts of solar and wind have been deployed, they rely on the unique flexibility of gases of fuel and in the machinery that that burns gas, we've seen it in California as well.

So why gas? Why not just use storage? And then eliminate gas altogether?

A few reasons: firstly, the amount of storage that you need is actually unknowable, we did a deep dive trying to find the best studies from reputable sorts of international bodies, MIT, Princeton, IEA and others, to find out what's a good way of determining the amount of batteries you need to get to 100% solar and wind, and no one has a method.

Okay, so I will contend that the amount of batteries you need is actually unknowable so that's the first problem, that's why you need gas to back up.

The second is batteries are cripplingly expensive, wonderfully versatile that's true, but they're very expensive.

For example at least 60%of the cost of a battery comes from the cost of the underlying raw materials that go into it, those raw material prices are not going down in case anyone's been looking, they are going up, so it's difficult to imagine battery price is reducing by 60% by 2030.

One other thing I'll mention is I said earlier that no other G20 nation is seriously still pursuing a grid powered nearly exclusively by intermittent flows, now one reason for this is not just the business in the Ukraine and how that's woken people up to energy security, but they're starting to wake up that pursuing a nearly 100% grid requires an enormous amount of batteries and everyone is going to be trying to buy the same batteries from the same Factories at the same time.

They don't want to get into an international bidding war for scarce batteries, and so they've decided that they need a balanced mix, which includes some batteries, also includes some solar and wind, increasingly we're seeing it means a lot of nuclear.

But what a waste of a precious resource, I'll just add you know as a gas person, it's the least valuable way to use those precious molecules, okay, make turning them into electricity is its least valuable use, there's lots of things we can do with gas: we can give it to manufacturers who use it as an ingredient to make every type of valuable industrial chemical that you can think, of it's in cosmetics it's in the base ingredients for nearly all our antibiotics, obviously fertilizer is a big one.

Look at what Qatar has done with their huge gas reserves, they don't actually have that much crude oil, but they have managed to become energy self-sufficient by building a gas to liquid plant with shell and so they make their own liquid fuels from gas.

Mr J. Fleay: *Gas & the AEMO plan*

So, 50%? I don't think so, I think it's going to be far higher than that, and our emissions of course won't get where we want them to be if we're burning that much gas.

I'll leave it at that.

Dr A. Paterson: Thank you very much, the Australian Energy Market Operator, I think is as we're reflecting on it is somewhat challenged, just to bring that part of our discussion together I'm going to ask Stephen Wilson the question: what will go wrong with the AEMO plan?

Prof. S. Wilson: *What will go wrong with AEMO plan?*

That's a great question, and actually it actually leads on quite well from what James was just saying, I just want to reinforce James's comment that the amount of storage is unknowable.

We are constantly presented with this notion that storage is a magic wand. People wave it around like a magic wand; it's not.

I gave a seminar to a room full of economists a few months ago and I said “okay, raise your hand if you've ever built a storage model” - and I was the only person holding up my hand, I built the bankable model for the Hungarian underground gas storage after the first Russia Ukraine gas interruption.

When you build a storage model, an economic model, a technical and economic model, like James is alluding to, you very quickly realize how complicated it is so a lot of things can go wrong, Adi, with a plan that's heavily relying on storage.

The AEMO integrated system plan it's actually a presentation of a set of what they call scenarios, I'm going to say they're not actually scenarios, there's various reasons they don't qualify for the scenario label, they're just all different versions and tweaks of basically the same thing, there's no structural difference between them, they're not truly examining genuine alternatives.

So Scenario A, as I call it is A for all: all eggs in one basket.

You know, both renewables and storage, and if that doesn't work as I expect it won't, what happens?

Well, what happens is we end up with a crisis and we do emergency refurbishments of old coal plants.

Welcome to Germany.

In Germany, they are literally this is not just a cartoon in a newspaper, they are literally tearing down wind turbines to get to the coal seam underneath, I mean this is comical stuff.

If that's not enough, if we've already dynamited the old coal plants, which not even the Germans do, then we get to a sort of dash for diesel backups, a desperate dash for diesel.

Early in my career I was an Energy Efficiency Consultant and one of the things I did was train people in the Philippines in rural electricity co-ops on how to complete their energy efficiency and demand side management plan, to submit to the regulator.

Prof. S. Wilson: *What will go wrong with AEMO plan?*

One of the things that was on everyone's mind in the Philippines is in the 1990s the power system was so unreliable that two things happened. If you're out in the countryside you had very poor power quality, we're talking before about frequency voltage all over the place, constantly destroying your equipment, you now have to go buy another fridge - not good for low-income people obviously.

Then in the city around Manila the main Meralco grid was so unreliable that the big companies basically went to Caterpillar diesel and bought diesel generators, so this this is the world you end up in is the companies will either go overseas and take their business elsewhere or they'll go to diesel generators, and the middle class will go to their own generators.

So you get a very adverse outcome, and so I call those scenario C and scenario D, and that's why we need Plan B: a balanced mix that includes nuclear power.

Dr A. Paterson: Thank you very much. [Applause]

Tony uh Irwin you've spent a lot of time looking at the grid and you've thought a lot about uranium, what was happening last week in South Australia?

Then you can immediately follow that up with your love of uranium.

Assoc. Prof. T. Irwin: *SA grid challenges & benefits of uranium*

Right, thank you Adi.

So earlier this month, 12th of November, you remember there was a big storm in in South Australia, a transmission tower failed, and the interconnected trip to Victoria.

This is not a completely unexpected event, AEMO plan for this sort of event, but what happened then was Victoria was okay.

So Victoria is supported by coal, so the Victorian side was quite stable, but when you look at the South Australian side it's a completely different story because at the time they'd got a lot of wind, but because of the storm the wind was really variable and when the wind gets too high the wind turbines cut out, so you've got this effect where the wind amount of wind is going up and down really rapidly.

Also because of the storm, the solar was up and down, because as it passes across you know you get a big change in the solar so you're getting a very variable supply in South Australia.

The only way it survived was gas, so South Australia normally have to have an amount of gas on the system just to keep it stable, they've got the big battery Etc, but really they need a lot more than that, and they’re very dependent on gas.

Stephen said you've got to keep the frequency within limits, so Victoria frequency was normal, but if you look at the South Australian frequency it was outside normal limits for over two hours.

Now this is damage into equipment, you can't operate a system like this, and this could cause real problems for them.

Assoc. Prof. T. Irwin: *SA grid challenges & benefits of uranium*

So this is the sort of event that we get now, and if we go even more variables, if we hadn't have had the gas in South Australia, we'd have had another blackout in South Australia as we did a few years ago.

Adi mentioned my love of uranium, so there are 437 power reactors operating worldwide, all it takes in uranium supplies is 62,000 tons of uranium ore, that's for all the reactors worldwide, because it's a very dense energy source.

If that was coal it was supply Bayswater for two days, so you can see the difference.

This is a fuel pellet, it's about the size of a small fingernail, and that's a ton of coal, so this is a really dense and useful energy source.

Two of these is your whole supply for a year, for your house.

Energy density is really important because of sustainability, because it's such a dense energy source you need far less materials, so we we've talked about the huge amounts of materials you need for renewables, nuclear requires far less and is more sustainable.

Then you look at the land requirements, you know a small nuclear power plant is 18 hectares while Liddell (coal plant) is 100 hectares, so it would fit on any coal-fired power station site without a problem.

Look at a big solar plant, Darlington Point, a thousand hectares and that's only 250 megawatts, peak, so there's a huge difference in materials, huge difference in land.

So, I recommend uranium as a good energy source, thank you Adi.

Dr A. Paterson: Thank you very much Tony. [Applause]

We're now going to begin to talk about an alternative plan, the plan that AEMO has presented does not pass the science test, it doesn't pass the engineering test, and as we're finding out it doesn't pass the consumer test.

Therefore, this plan needs to be challenged, and I think we need to understand just how dangerous it is to take a plan that is already failing and amplify its sources of failure in order to try to make it work.

We want to move now into the alternative plan.

Stephen Wilson has said some words about the expense of nuclear, and when you talk about building the plants it does sound expensive, could you explain why the cost of building a nuclear plant and those published figures that seem to be so high, is a wrong idea when you're thinking about nuclear in a grid in a country like Australia.

Prof. S. Wilson: *Expense of nuclear*

Yeah thanks Adi, I want everyone to imagine that they're the responsible minister and that the young advisor comes in and says “we need to decarbonize our power system, our choices are wind, and solar and nuclear power, because they have no emissions” and the minister says “okay, and how much does the wind and solar cost?” The advisor says “well, we've got these estimates from the engineers that the levelized cost the average cost of wind and solar is about $50 a megawatt hour, 5 cents a kilowatt hour” The minister asks “what about the nuclear?”

Prof. S. Wilson: *Expense of nuclear*

Well, you know, we've got this report from the University of Queensland that says the first plant will probably cost $100 a megawatt hour, 10 cents a kilowatt hour.

How do we make the system as cheap as possible?

The natural instinct of most people is: we just build lots and lots and lots of that 50-megawatt hour stuff that costs five cents a kilowatt hour, wind and solar, we just make the whole system wind and solar and it'll be as cheap as possible.

Unfortunately, that's actually not the reality, and that's why I call this the power cost paradox and the fundamental reason that's wrong is because those resources can't match to the demand.

As we said earlier, you've got to match the demand exactly, every second of every day, and it turns out that if you increase the wind and solar towards as you get closer and closer to 100% all the other things you've got to do to keep supply and demand in balance, become more and more expensive and you just end up with an astronomically expensive system.

Whereas if you put in the right amount of nuclear, and by the way in the optimal as we've seen in separate research work from this, the optimal grid does have some wind and solar, in it maybe something like 25% which is about what we've got now.

But the overall optimum has a good sensible amount of nuclear in the foundation, and that's how you get the lowest cost no emissions or very low emissions power grid.

Dr A. Paterson:

Thank you very much. [Applause]

Right, so it seems that we we're navigating towards an alternative plan, so Robert Parker is going to talk about a genuine alternative plan.

This is a plan for Australia to adopt small modular reactors for our future.

R. Parker: *SMRs in Australia's future*

Thank you Adi.

So we've got an energy future in which we're going to be decarbonizing our economy, it tends to be our commitment, but what does that mean?

Well we've heard today, that about only currently about a third of our emissions actually come from the electricity grid.

We've got sectors such as manufacturing, transport, agriculture, a whole other bunch of sectors that are contributing to carbon emissions, and so in this brave new world of emission reductions the idea is to be able to drive electricity into those other sectors and it's for that reason that the AEMO integrated system plan has come up with these different step change, and progressive change, and a whole bunch of numbers, but basically as one moves further out towards 2050 we see incremental increases in the amount of electricity that needs to be generated.

R. Parker: *SMRs in Australia's future*

I will, unfortunately, hit you with a few numbers just to give you some sense currently in Australia we're generating in the region of 200 terawatt hours per year, okay, but we're told that in 2050 with the advent of things like electric vehicles, and industrial, and electrifying a lot of these processes, for example in the cement plant that I live near in Berrima, when we drive electricity into these things we're going to have to increase the amount of electricity.

We're going to get up to about 516 terawatt hours, get that, that's a 235% increase, this is a massive increase, if plausible and the best we can try to do is to model these sorts of increases.

We put that into our energy model and we looked at what sort of energy mix we would have out in 2050 to try to meet that, and what we find that when we do, and I endorse Stephen's comments, we came up in our energy model with around about uh 23%/24% renewables.

Of course of that about 5% was hydro, and the rest in our case was solar, we didn't have any wind because wind is a problem, it's a home for gas so if you want to get your emissions right down, you don't give gas a home in this future scenario.

We have, in all our modelling, ended up with around about 75%/76% nuclear, what does that mean in terms of the grid, how big would this be? Well 24 gigawatts currently, about 2030 would need about 24 gigabytes, out around 2050 under the AEMO step change demand we'd need 47 gigawatts, that's a big number.

Let's think about the Liddell, or these big coal plants, we're talking about two in each case of those, so we're talking about a significant increase in the amount of nuclear power that one would require in in this scenario.

Notwithstanding that, when we look at the cost that mums and dads would pay out of the wall, we see that in the renewable scenario they're going to pay 51 cents a kilowatt hour, how does that relate to a similar country like Ontario province of Canada? Well, they're paying 18 (cents a kilowatt hour), okay, so we're more than double/triple what they'll be paying, and they've got 60% nuclear and a whole bunch of hydro.

So the writing is on the wall, if we look at the nuclear scenario in this new world, well we'll be down around 25 cents or just under half of what a renewable scenario would be.

So I've given you some sense of the kinds of numbers that would apply to nuclear, now they are big numbers of capacity, this is not some little gentle scheme, there is a problem, if you try to put one or two gigawatts into the NEM, you just try and put that in there, what's that going to do?

Well unfortunately the renewables will get priority access and so the capacity factor, or the ability of that nuclear power to supply into the market, will be diminished and its cost will be high, so you have to drive these things up to the optimum energy mix which is about three-quarters of our grid.

We've also got to think in terms of the future, what types of nuclear plants we could look at? Now we've been over to Canada, we've looked at a wonderful plant there that's been built by Ontario power generation on Lake Ontario, it's a 300 megawatts small modular reactor, lovely bit of kit.

R. Parker: *SMRs in Australia's future*

Just over the border, in Wyoming, we've got Bill Gates and Warren Buffett funding with the U.S department of energy a really Innovative fantastic plant called Natrium, that's another sort of small nuclear plant, though that one has also got the ability to expand from 345 megawatts out to 600 or a thousand.

So, we've got to really think in the future about the types of plants we need to use, but what we've more importantly got to do is we've got to get on and do the planning right now, because there are plants out there in the marketplace sitting there now that we could integrate into our systems.

We've got to be really mindful of if we really need figures like 24 to 40/45 gigawatts, what sort of plan what size of plant, what mix of plants, would we need for this future.

At present we're not doing that, and the time to start this planning was around about 10 years ago, but this is where we've got to harness some smarts and I would think one of the best places to start would be to go over and talk to Ontario: how is it you've got electricity at half our prices? What is it you're doing right and that we're doing wrong?

The other good thing about the Canadians is that, like Australia, they've got a remote mining industry and they're looking right now at putting small or micro modular reactors stand alone on mining areas, so we're talking about plants that could power a crusher and a refining plant on a mining site, so we're talking about plants here of 5/15 megawatts, quite small truck-mounted ones.

The Canadians are looking at building one of those at their Chalk River facility and that'll either be a small, what they call pebble bed type plant, or the other one would be a small high temperature gas plant, that's a bit of techo stuff but they're really going down that route.

Thank you, Adi.

Dr A. Paterson: Excellent, thank you very much. [Applause]

So the discussions are a little bit behind time, so highly refined statements please.

I'd like to go back to David Carland and ask him to describe the economic benefits of small modular reactors in the grid.

Dr D. Carland: *Economic benefits of SMRs*

Yeah thanks Adi.

Clearly, I've got an aluminum background, the two things you need to use energy intensive Industries: you need reliability, and you need cost.

Nn the landscape ahead of us, the only option I can see is small modular reactors, it will deal best with the cost, whether that's competitive it's up to Australia and other areas perhaps, but certainly will deal with reliability.

You can't run very expensive and complex systems relying on energy, while having blackouts at four o'clock in the afternoon, so again the simple answer is that sort of energy David's mentioned, and we've lost so much industry.

What's here will go, unless we can find a source of reliable, low-cost power for it.

Dr A. Paterson: Thank you very much.
Peter Tyree, talk to us about the educational imperative, and how we might address the need for that type of background and skills in Australia.

Prof. P. Tyree: You didn't say it, so I'll be quick.

Education imperative

The mainstay of a good society is to have acceptable quality of life and health, quality of living, and you can't get that without having education, electricity water, and sewer.

They're the facts, so if we're going to embark on a course of having small modular reactors, we must have education, the University of New South Wales first started a masters of nuclear engineering course about eight years ago and that has developed further and further.

It's also embraced an agreement with The Australian Nuclear Science and Technology Organisation (ANSTO), and it collaborates with ANSTO, it also collaborates in with the University of New South Wales Canberra facilities, which shall I say the Defence Forces rely on heavily as well, and they also go hand in hand.

The University of Wollongong has got fabulous nuclear capability, particularly with safety, and Sydney university has also got capability in there, as well as the ANU, which dare I say would play a wonderful part because they understand what they're talking about in doing policy leadership, if Australia was to do is we we've been told we can, by Helen, go down a path quite easily.

So the only other comment I might say in there is that these days whether through ATSI, the Academy of Technical Sciences, and Engineers Australia schools, and others, there is such a focus on STEM subjects, and I think all of you should have a lot of expectations that regardless of gender, the stem subjects will grow and grow and grow.

Therefore, we're not short of having the capability of people that are educated, so next point is what else can we do with this education? Australia led the world in developing coal-fired power stations, we integrated that with our coal industry, and it's no surprise that the Australian mining industry is probably number one in the world.

I could be cheeky and say the University of New South Wales School of Mining is number one in the world.

The power stations that were developed, particularly by the electricity commission of New South Wales, to mention one because it was black coal unlike what was in Victoria where it was brown, they developed technologies that are still today leading in the field.

But coal is a no-no, so why don't we replicate exactly what we did in the coal industry by using our educated people from the best mining schools and the best mining country in the world, to deploy that knowledge and capability, transfer it over into nuclear engineering, which also has got an extra benefit of course as we go ahead because under AUKUS we must have that know-how, that technology, that capability, in the deployment of nuclear subs.

Prof. P. Tyree: *Education imperative*

For the record I could easily envisage because of that nuclear sub capability, if ever South Australia has another major blackout like it did many years ago, you could park these subs in a port somewhere and plug them in.

Just a little thing, it's not far-fetched, you can do it, so I think that it remains to be said that the grids are too dependent.

I back up exactly what was being said before by Stephen again, and we didn't even collaborate on this, but the grids are too dependent on renewable and it cannot be controlled safely is another aspect, the latency in a system I.E., the time to control it, the electrons are moving the same speed as light, if you're going to have the fastest optical fibre controls, guess what? It's a dead heat.

You can't control a grid using optical fibre or light to run, you can't run signals up to the satellites because that's much slower, so if you're trying to run a grid based on all renewable, despite what Stephen was also saying which is prohibitive, it's out of control you cannot deploy maybe two/three/four/five million generators, solar or wind, all over the country or eastern seaboard, you cannot do that, and control it, because that controlled by something that is too slow therefore you've got chaos instability, massive blackouts.

So, I said I would be quick, I think that the last comment is to you parliamentarians in the room.

I love seeing, during covid, experts who are scientists and medical people, being listened to maybe for the first time.

Listen to the experts, I state the obvious of what's before us now to you people.

Dr A. Paterson:

Thank you very much, I'm going to go back to Warren Mundine, who has taught me so much and Warren thank you for being available to us from the Northern Territory.

How do you envisaged the indigenous communities could participate in this transition that we have been describing for small modular reactor in the Australian setting?

Nyunggai W. Mundine: *Indigenous participation in SMRs*

We have great opportunities in Australia to do some amazing and incredible stuff and I see working with small modular reactors is a big step forward, if you look at the small footprint I spoke of earlier, about the amount of land and amount of the environment we're going to have to take up with renewable energies, this is only a small footprint and it has a long life with it.

It also brings one of the most important things if you're ever going to have economic development, it brings power, and so if we look at the northern Australia, and even western New South Wales and other places, having this power source there and driving those economies forward you would be able to build Australia in the north, which we've been talking about for about 200 years.

This is a huge economic outcome for not only for indigenous people up here but also for the Northern Territory, you could actually get some really good things going.

Nyunggai W. Mundine: *Indigenous participation in SMRs*

You also get the power that they need to start developing a large industry up here, also bringing jobs and business opportunities, and growth, for the groups of people up here.

There's an enormous amount of opportunities and we've seen that in the mining industry, despite what people may say about the mining industry, that aboriginals don't like it, well there's actually thousands of aboriginals working in the mining industry, something like six to seven thousand aboriginals, and then there's several thousand indigenous businesses working out of those mining areas which are worth several hundred million dollars or more.

Adding this on with getting the power source across Northern Australia now will be a massive opportunity for indigenous workforce participation, as well as looking at how we can build a whole number of very prosperous townships.

So look, to me it's all good outcomes, and the enormous economic opportunities will make a very powerful thing on the ground, because we know if you've got economic prosperity you've got a power and that's driving that, you can also have better health, better education, you have a whole wide range of different outcomes and I've been writing about this for years.

One of the great things that we did to start that step, when I was on the director of the Australian Uranium Association and was co-chair of the Indigenous Committee, was to reach out to the native title rep bodies, the native title service bodies, and land councils, and we took them onto tours.

There's nothing better than to actually show people the industry and how it operates, and of course you've got a lot of these anti-nuclear lawyers who have worked in this organization, but by taking them out taking the mine sites to show them how things operate and the benefits that come out of it, we're able to change views within those communities and within those rep bodies.

That’s about making things happen, it's not rocket science, you know we can do these things, we can win people over and talk about it this way, I'm glad this that this event has gone ahead.

I gave a talk when I was in the director of the AUA and we had our annual conference in Perth and I said “put up your hands if you think the industry is bad, put up your hands if you think it's not safe etc” - and no one put up the hand, so I said outside this room no one knows about it, we have to go out into the into the into the community we have to talk about these things in the community, we have to run campaigns on it.

One of the jobs I'm doing up here is working with the traditional owner groups, especially in the Beetaloo, and don’t believe that they don't support it up here, the traditional owners want the gas fields to go ahead because they see the future, they see that within the next 20 years that their children and grandchildren are going to have a better life than they are, and they're able to look after their cultural heritage and look after their environment and make sure things are happening for them.

So, this is this is how I see the way forward, small modular reactors are going to be a fantastic addition to that and will have amazing outcomes for people.

Dr A. Paterson: Thank you very much Warren. [Applause]

Now as we are coming towards the wrap up, we do need to have the law, Helen if you could help us get a sense of what the steps would be to move Australia from nuclear bans to nuclear capability in the future.

H. Cook: *What's next? Steps for Australia to move to nuclear capability*

Thanks Adi, so my day job is really divided into two parts: I advise clients on the procurement, construction, and financing of new nuclear power plants, and I advise governments around the world on developing the legal and regulatory infrastructure that is necessary for a nuclear energy program.

And I am reminded every day that nuclear energy is not an overnight proposition, it does take time and there is a lot of work that needs to be done across a lot of different areas, it's not just laws and regulations, it's institutions, it's human resource capabilities and development, it's electricity market structures, as we've heard about today it's citing, and it's funding and financing, there's a lot of different areas that need to be considered when a country is considering whether to move ahead with nuclear energy and then looking at how to successfully implement a nuclear energy program.

Now I often get asked, well how long does it take? That's a difficult question to answer, would it take a country like Australia maybe five years? It takes other countries a lot longer, maybe it would take us five years, maybe it would take us a few more years, maybe it would take us one less, regardless, it takes a number of years to put a country, including a country like Australia, in the position to have the option to procure nuclear energy technology.

Now the other important data point I think is Robert was just talking about small modular reactors that are today being commercialized, and the demonstration unit should be online and running later this decade, and small modular reactors should be commercialized and available for purchase by customers.

So that to me that's our window, that's the window of time in which we need to get ready, we need to get in the game, we need to get on the vendor's order books if we want to have nuclear energy in our country.

Now you might say, as Adi said, "well how do we go about it?" Well, the International Atomic Energy Agency has developed a standard approach it's called the IAEA Milestones approach in the in the development of a national infrastructure for nuclear energy, and countries including 52 countries which are currently considering nuclear energy or actively implementing nuclear energy programs, these 52 countries use this methodology.

It's a methodology, or a toolkit, it starts from when a country considers nuclear as an option and goes all the way through to elections on the grid, it's a very valuable toolkit.

It was utilized by the UAE from start to electrons on their grid very successfully, so I believe that if we are to want to have the option to have nuclear energy in Australia later this decade or in the early 2030s, we must start the work now and we should use the IAEA milestones approach to do this.

[Applause]

Dr A. Paterson: Thank you very much everybody, it's been my privilege to guide my colleagues through the process, I think that we've had the brains trust of Australian nuclear capability.

You can see that we've certainly got the brain power, we just need a legal environment in which the brains can be applied to our future.