Submission

A Submission in relation to the

Environment and Other Legislation Amendment (Removing Nuclear Energy Prohibitions) Bill 2022

On 27 October 2022 the Senate referred the *Environment and Other Legislation Amendment (Removing Nuclear Energy Prohibitions) Bill 2022* to the Environment and Communications Legislation Committee for inquiry and report by **31 March 2023**.

About this inquiry:
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.

This submission is made by Dr Adrian Paterson, Principal and Founder, Siyeva Consulting. I refer to the work of others and honour them for their contribution the policy domain we are addressing and to the policy challenges we face.

The interpretation of their work is my own. I have sought to faithfully reflect the sources used in the work. We I have not done this, and it is brought to my I will amend future versions of the work.

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Preface

This submission it is intended to give context to, and support the objectives of, this Bill. The benefits and options which would result for Australia, economically and socially include meeting national carbon mitigation obligations already entered into respect of climate change, and the practical and proactive reduction of greenhouse gasses in the atmosphere.

It will allow Australia to align its nuclear interests and priorities, by directly addressing electricity supply. This is consistent with our positioning in the Asia- Pacific region as good neighbour, and an economic powerhouse, currently.

Dilute renewables, storage, and reliance on intermittent sources is, and will continue to, cause the exit of electricity intensive industries. This is eroding our future economic options – for example knowledge-based smart manufacturing will escape us. However, strategic use of nuclear power will move us from over-dependence on geographical advantage and minerals endowments. We will be able to leverage, for example, smart agriculture, our distinctive landscapes and smart

manufacturing for the benefit of future generations – beyond our current reliance of resource endowments.

The Electricity Market and its Current Expansion

Australia's current plans and arrangements (as most clearly exemplified by the Australian Energy Market Operator (AEMO) – ***the Operator***) are codified in a potentially bewildering range of planning and "scenario" documents.

These are, almost without exception, produced or procured by ***the Operator. AEMO*** is a direct participant in the market. AEMO governance, structures and processes drive its planning in a rigid and non-strategic manner. Its work is not subject to independent contestation.

For the purposes of this submission AEMO's assumption that the ban on nuclear power will continue is a key factor. Therefore, ***the Operator*** is not able to be independently strategic (or useful to the nation) on electricity policy. Specifically, they do not explore all viable options for the future of the nation. For example, the June 2022 AEMO Integrated System Plan: For the National Electricity Market [1] plan does not contain the word "nuclear".

By contrast the International Energy Agency report on Net Zero Emissions (NZE) [2] states:

"Failing to take timely decisions on nuclear power and CCUS would ***raise the costs of a net-zero emissions pathway*** *and add to the risk of not meeting the goal by placing an additional burden on wind and solar to scale up even more quickly……"(*pg119).

The IEA report also reflects on the costs of **not achieving nuclear build** objectives in the NZE plan (pg119) :

"Our analysis indicates that the burden of replacing those [nuclear] sources of low-carbon generation would fall mainly on solar PV and wind power calling for 2 400 GW more capacity than in the NZE, an amount far exceeding their combined global capacity in operation in 2020.

*There would also be a need for about 480 GW of battery capacity "above and beyond" the 3 100 GW deployed in the NZE, plus more than 300 GW of other dispatchable capacity to meet demand in all seasons and ensure system adequacy. Globally, this would call for an additional USD 2 trillion investment in power plants and related grid assets (****net of the lower investment in nuclear and CCUS****).*

Taking account of avoided fuel costs, the estimated total additional cost of electricity to consumers between 2021 and 2050 is USD 260 billion."

What does this mean? Simply put, the absence of nuclear in our system – assuming we meet our obligations in closing fossil plants under AEMO plan - means that we will have an "additional cost of electricity" and still use gas! The clear message from the IEA is: a world without nuclear has expensive electricity.

Currently that is what AEMO offers us.

Therefore, AEMO planning is based on a deeply flawed overestimation of the utility of intermittent renewables (and storage). How will this supply cost-effective electricity for Australians, now and into the future?

Because this planning is "enmeshed" in the structures of Government AEMO can only create long-term options with artificial constraints (most notably the ban on nuclear). Like other jurisdictions

(Germany for example) we are on a path to policy failure. The evidence: expensive grid extensions, renewable energy zones and, most recently, offshore wind. Supply instability is increasing.

The IEA plan, referenced above, shows clearly that nuclear (though more costly than wind and solar) reduces the PRICE to the consumer. This benefit has been modelled for the Australian setting by different groups – but not by CSIRO.

The IEA report quoted above supports the analysis by Australian electricity experts. Key finding: *Dispatchable nuclear power reduces the price of electricity to consumers – and in a careful grid design, greatly reduces the cost and proportion of intermittent renewables required.*

The consequence: lower price, lowest carbon, predicable electricity, in a simpler grid.

For example, Robert Barr and Robert Parker have presented the scenario modelling in Parliament House (November 2022) and to other stakeholders (Figure 1) below [3].

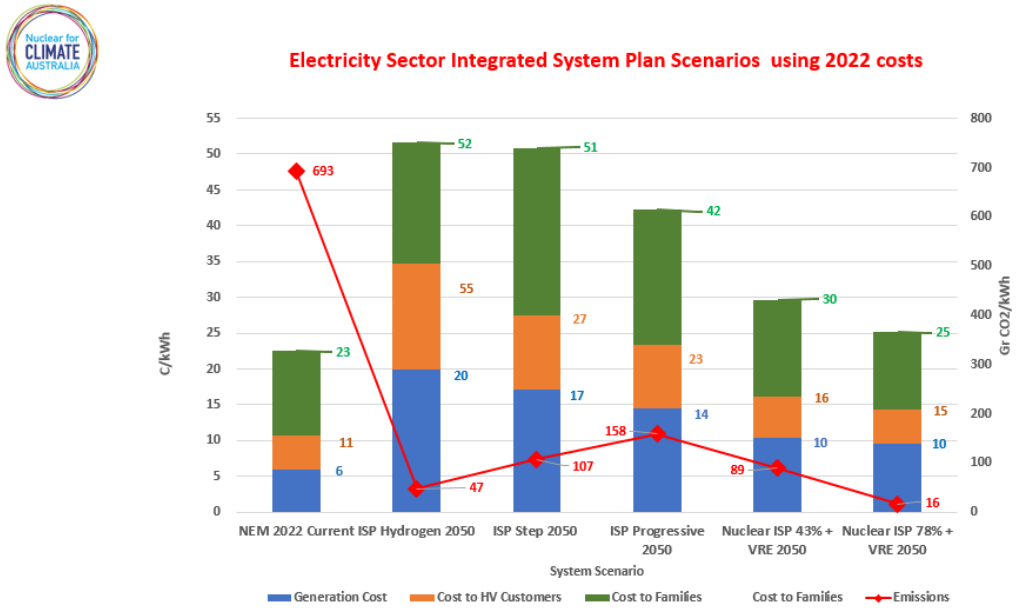

Figure 1: Electricity price and carbon: AEMO ISP vs nuclear inclusion in Australia's Grid (Barr 2022)

The lowest cost scenario (the bar on the right of the graph) is 78% nuclear at a domestic cost of 25 c/kWh with the lowest carbon footprint of 16gCO_2 per kWh (redline).

This graphic helpfully shows how AEMO Integrated System Plans (ISP) fail to achieve the cost benefits or carbon mitigation of nuclear power.

The unmitigated risks to the Australian Economy of **maintaining** the peaceful nuclear energy ban:

1. We will still burn gas, thereby not reaching the lowest carbon option for Australia.
2. We will build significantly more intermittent renewables than are required in the lowest cost scenario (plus a larger grid with more storage and a less attractive energy profile for future investment)

3. Our Defence posture is likely to include nuclear, but with no local benefit of a civilian nuclear power skills pool, to reduce defence costs over the 80-year lifecycle of the AUKUS submarines.
4. Our region is very likely to adopt nuclear power extensively and our close allies and economic partners will be nuclear nations: USA, UK, France, India, South Korea, Indonesia, the Philippines (among others). NZ has Hydro and Geo-thermal electric power.

The Government can act to change this:

1) Undertake planning with independent and credible groups as we transition to a technology neutral approach.
2) Explore a genuine **technology agnostic planning framework for future electricity supply** in Australian electricity grids.

This basis of this work has already been framed by local experts and academics. This provides an alternative platform, as presented in Parliament on the 24th and 25th November 2022. This non-partisan meeting was undertaken in good faith to address the strategic vacuum, and associated overconfidence of the Parliament, Departmental, and Agency structures in Canberra at present.

We must move beyond the inflexible renewables mindset: it constitutes an unmitigated risk to our national future. It hobbles our capacity to be an effective and credible middle power in the Asia Pacific.

This situation is undergirded by the ongoing ban on nuclear power – a relic of a very different era.

Reliable Methods and Local Knowledge

Policy Failure 1: Inappropriate use of Levelised Cost of Electricity (LCOE) as a proxy for price of electricity to consumers.

The role of nuclear is as a low carbon, dispatchable and load-following technology underpinning predictable low-cost electricity supply. The value of this resource is amply demonstrated in peer-reviewed literature and global datasets.

Strangely, Australian academics associated with the annual GENCOST report are publishing in the LCOE field without referencing nuclear at all:

"…..the calculation of VRE [Variable Renewable Energy] LCOE introduces new challenges compared to traditional LCOE methods. These include: 1. VRE LCOE is location specific and this together with the nature of the renewable resources, ***will influence the capacity factor*** *and the capital and O&M costs. 2. VRE LCOE input variables may be interdependent. 3. Plant-level LCOE calculation is not enough to determine the cost as* ***the intermittency of VRE can increase grid related costs.*** *4. There is more uncertainty and risk in estimating VRE LCOE* **due to its intermittency***. 5. VRE LCOE is susceptible to renewable policies and harmonisation issues.* [4]

From the above extract it is clear that CSIRO and University academic LCOE experts are very well aware of the lower price consumers will pay for electricity if nuclear power is adopted in Australia. Given the inherent safety of modern nuclear plant designs, the opportunity to reform regulation to achieve effective and timely adoption of nuclear power, is now available to Government.

Policy Failure 2: Electricity economics and GENCOST

A second anchor of policy failure which frames this narrow perspective is the CSIRO ***Gencost*** Report.

Policy failure risk for Australia has been exemplified by GENCOST over the years. This year the report has been made more substantive. Pleasingly there is a more open approach to nuclear (for example). This is to be welcomed. However, the report, notwithstanding the academic research cited above, still retains it is simplistic "early Lazard" LCOE approach, which Lazard is has largely moved beyond.

1. However, the CSIRO Gencost Report is still based on a deeply flawed misunderstanding of the Levelised Cost of Electricity methodology. Firm resources and dispatchability are not properly addressed – although it is clear they are understood.
2. The resulting model contains assumptions involving very high penetrations of intermittent renewables which cannot be achieved in a properly engineered grid and in our planned energy market. (They are disconnected from engineering reality.)
3. Page i of Gencost 2022-23 produced in December 2022 states: " CSIRO advises that the information contained in this publication comprises general statements based on scientific research. The reader is advised and needs to be aware that such information may be incomplete or **unable to be used in any specific situation.** *No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice."* **This disclaimer is very important and preceptive.**

   Gencost 2022-23 notes that ANSTO is participating in an International Atomic Energy Agency project to appraise the costs of nuclear SMR (sic) to be competed in December 2024.

   Gencost 2022-23 referenced nuclear SMRs in section 4.3.6 stating **"this result demonstrates that nuclear SMR can play a greater role."** It is notable that the treatment of nuclear, for the first time departs from the tendentious "too expensive" claim in the previous year's report of close to $18000. However, the "learning curve" still does NOT incorporate a "fleet effect". This is an error that needs to be corrected.

   In addition, since the reports is developed around the LCOE (with no reflection of grid and ancillary services) it does not address the following key elements as shown on the work of Barr (figure 1 above):
   1. Reduced need for grid extension with SMRs – they directly reduce the need to "overbuild" unpredictable intermittent renewables.

   In addition, there are other factors that contribute to a distorted view:

   1. Benefits of high availability and load following – nuclear plants are given capacity factor of *up to 80%* when in some markets they have higher availability (as high as 96%).
   2. Credit for frequency services and power quality , and
   3. Lowest overall PRICE of electricity as a result.

Furether, we note that offshore wind is as expensive and nuclear: Nuclear LCOE overlaps with offshore wind in the 2040s! This is a crucial finding. It is already known from North Sea experience that nuclear has a considerably better environmental footprint than offshore wind! If these benefits

and the capacity factor were properly included, nuclear would be at a demonstrably a lower cost and a more reliable source of electricity than offshore wind!

This is further confirmed in figures 5.5-5.6, even though nuclear is not afforded a significant "learning option".

Gencost needs to be shifted to a more integrated price-centric model, as a matter of urgency.

Recommendation 1: Set GENCOST and AEMO "Scenarios" Free. It is recommended that all AEMO data and planning frameworks and GENCOST data, models and assumptions are placed in the public domain so that the academic community and other stakeholders can undertake alternative modeling and develop a richer set of scenarios than are available from AEMO – which is after all a market actor that cannot be viewed as an independent authority.

Independent authoritative work and academic rigour, as well as scenario tools, are essential to our energy future.

Rather than relying on a small group of CSIRO experts, whose own publications in the literature do not reference nuclear, this annual planning activity could be professionalised in a structured set of annual discussions, facilitated by an independent panel of experts, for example.

Justification:

1) The broadened approach to the AEMO scenario work and GENCOST reports has shown, in its first year, a much wider range of options and scenarios (modelling for grids and with different sources) than previous narrow reliance on AEMO models. GENCOST has begun to show, despite the continued conservatism on nuclear costs and delayed adoption, the inherent attractiveness of the nuclear option. AEMO should follow suit. [

2) Less politically constrained scenarios, inclusive of nuclear would show great benefits and produce better options for reduced carbon footprints for our Eastern and Western grids – this has already been shown in robust scoping work by Robert Barr and Robert Parker (Nuclear for Climate).

3) As indicated above open modelling options would undoubtedly put the current perspective to the test. Scope: AEMO plan for deep penetration (and overbuild) of Variable Renewable Energy and Storage would not survive proper scrutiny.

4) It is already evident that the quality of electricity supply has declined in South Australia, and costs have increased. Indeed, it is notable that the problems with quality of electricity supply and associated frequency and voltage challenges as experienced in South Australia recently are not referenced in the GENCOST work. It strongly suggests "overbuild risks" are unknown to the authors.

Global Experience

It is crucial that we are aware of the high resolution studies of what is happening with carbon footprints from electricity in the global setting.

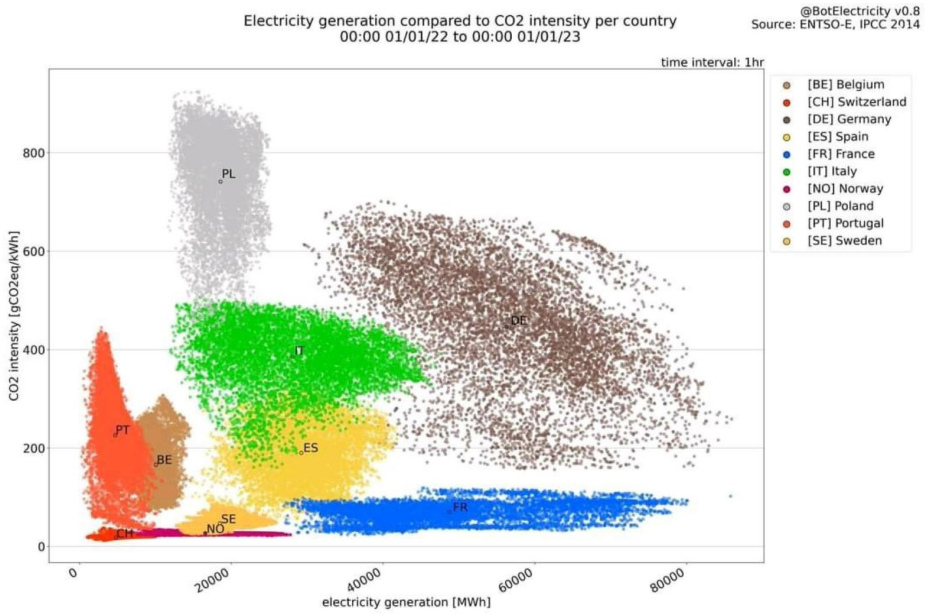

Figure 2: Hourly CO_2 intensity for European countries 2022 of electricity generation for the listed countries.

The figure above shows, starkly, the failure of the German Model. The German and UK experience appears to underpin much of the work of AEMO and CSIRO.

With respect to Fig. 2 Poland (PL) is 100% coal essentially (think Queensland). Norway (NO) has hydro and also flirted with wind as has Portugal (PT) (think Tasmania). Belgium (BE) is closing nuclear plants and putting in a gas pipeline to Germany (GE). Italy (IT) dropped nuclear in the 1980s, but Spain (ES) held onto theirs. By contrast Germany (GE) has closed 17 safe nuclear plants and has resorted to increasing lignite mining and offshore wind (which completely underperformed in the North Sea in the last 2 years).

France (FR) has held onto its nuclear fleet (notwithstanding massive pressure from Germany!)

Notably, there was not a single day in 2022 when France had a carbon intensity higher than Germany. Germany has built lots of panels, on shore and offshore wind – but, not unexpectedly, the weather in Northern Europe is highly correlated – the wind is NOT always blowing somewhere!

Implication: This is also true of the Eastern Coast of Australia – our wind resources are highly correlated. For energy planners this is (usually) a strong signal to diversify low carbon resources (such as adding Hydro and Nuclear) and NOT to "disperse" resources in the hope that correlation not true!

From Costs to Returns

We must move from an input approach (GENCOST and AEMO planning) to a robust model that reflects the returns on our electricity investments. This is what underpins the type of modelling presented above.

This approach fully backed up in the academic literature in science and engineering. Most recently this was presented in a comprehensive way in 2018 in a key paper - Energy Ratio analysis and accounting for renewable and non-renewable electricity generation: A review [5]

This work looks at electricity options from an **output perspective "Energy Return on Investment"** - not limited by the input-centric GENCOST approach. A high EROI ratio is a good thing - showing a good return on the input investment. Below is an extract from the Abstract of the paper.

*Based on the Energy Return on Investment (external), the generation methods fall into three tiers: (1) nuclear, natural gas combined cycle, and geothermal (in New Zealand) **with ratios > 30**, (2) hydro, wind, and geothermal (in Iceland) with **ratios between 5–30**, and (3) solar PV with **ratios less than 5**.*

High Energy Return on Investment ratios correspond to short Energy Payback Times and vice versa. Energy Ratio performance levels for renewable energy generation sources – hydro, wind, geothermal and solar – heavily rely on the quality of the primary natural resource available. This review recommends Energy Return on Investment (external) and Resource Utilisation Factor as the most useful metrics for inclusion in full sustainability assessment.

Recommendation 2: Adopt an Energy Return on Energy Invested (EROI) investment and Resource Utilisation Factor approach to energy planning in Australia.

What Happens in Real Grids

Recent Australian research has made strong findings on **saturation** – strict limits on the level of renewables sources available to the grid before costs increase very significantly. In planning and practical terms: aim for much lower levels of penetration of intermittent resources in the grid than currently planned and announced in government and AEMO forecasts.

1. This crucial finding is backed up by robust scenario work published in the science and engineering literature.
2. It is also evident in established grids, such as Germany, Texas and California. A key element of this is the persistence of high carbon sources and/or rapidly increasing electricity costs as saturation increases.

Firm resources ("dispatchable") are critical to the operation of large, interconnected grids. This conclusion, which has been modelled and published in the literature, also accords with the findings from experience in countries like Germany, and also, though less obviously, from California and South Australia. Therefore, the intuition of the South Australian Government that they need to consider nuclear is absolutely correct!

The learnings from work undertaken in the United States at the Massachusetts Institute of Technology (MIT) and the University of Queensland (for the Australian setting) are instructive.

This work stands in stark contrast to the "human intuition" planning approach that the "wind is always blowing somewhere." This false intuition, unfortunately, is the mental model underpinning the establishment of Renewable Energy Zones, grid extension and, more recently, the proposals for Offshore Wind in Australia (now that it has failed in the UK and Europe!).

A key paper: *The Role of Firm Electricity Sources in Deep Decarbonisation of Power Generation Electricity Grids [6]* gives a scenario-based analysis that clearly demonstrates the benefits of firm resources.

> *Full decarbonization of the electricity sector is critical to global climate mitigation. Across a wide range of sensitivities,* ***firm low-carbon resources****—including nuclear power, bioenergy, and natural gas plants that capture CO2—****consistently lower the cost of decarbonizing electricity generation. Without these resources, costs rise rapidly as CO2 limits approach zero.*** *Batteries and demand flexibility* ***do not obviate the value of firm resources****. Improving the capabilities and spurring adoption of firm low-carbon technologies are key research and policy goals.*

The work undertaken to produce these findings introduces a helpful *new* framework to defining energy resources:

1) *"Fuel saving" variable renewable resources (VRE) resources.* This follows closely the nomenclature we use in Australia and include wind, PV, concentrating solar power and run of river hydropower. The typically have zero fuel costs.
2) *"Fast-burst" balancing resources.* These include short duration energy storage (batteries, low volume hydro) that can meet flexible demand and demand response. They face constraints – energy capacity in the case of storage, or can have very high variable costs. *They lack the capacity to be continuous over long periods of time and when demand is high.*
3) *"Firm" low carbon resources.* These can be counted on to meet demand at all times of day, in all seasons and over long durations. They include flexible nuclear power plants, high-capacity hydro reservoirs, coal and gas with CCS, and geothermal and biogas.

The MIT research deals with: (i) interconnected grids, (ii) the intuitive problem of high-cost resources like nuclear power, and (iii) real demand profiles. It scans 912 distinct scenarios looking at costs, renewables intensity and technology mixes. It also deals with curtailment (think South Australia) and increasing transmission requirements for dilute resources. To test robustness, seven separate CO2 limits are examined form a maximum 200gCO2/kWh to zero emissions.

A summary of the findings:

"Even with very-low-cost projections for wind, solar, and energy storage and conservative assumptions for firm low-carbon resources (i.e., the costs of nuclear, natural gas with CCS, biomass, and biogas resources remain unchanged relative to their current levels), the cost of achieving zero carbon emissions in each region is lower when firm resources are available than when they are not".

More generally, the results indicate that *including firm resources in the portfolio of available low-carbon technologies is a more robust strategy* for achieving affordable deep decarbonization of power generation. It is found in this work that: VRE and batteries are *weak capacity substitutes* for firm low-carbon resources. Put another way: the VRE and battery requirements, when wind and solar are low, is up to 5-8 times peak system demand!

This paper is worthy of detailed study by AEMO and CSIRO planners as it covers the full range of **flawed assumptions that they have put forward to senior stakeholders and politicians**. It also shows the risk of the "toy scenarios", of limited scope, that currently characterise AEMO planning.

In Australia the recent robust scenario work of Robert Parker and Robert Barr is very compelling. They come to similar conclusions to those in the MIT paper. They show clearly that the same dynamics appear in our grid, with high and medium resolution modelling, based on our own weather data.

Separately and independently, the work of Gabriel Rioseco and Prof. Stephen Wilson at the University of Queensland has shown that nuclear in combination with renewables has lower costs. Their ground-breaking research uses a very elegant "solution-seeking" approach that optimises the system without forcing the result. It shows clearly how storage, transmission costs and curtailment are minimised, and, at the same time, the lowest PRICE of electricity is achieved.

Recommendation 3 (a) Since the (i) MIT work, the (ii) Barr-Parker work and the (iii) Rioseco-Wilson work, separately and independently, come to the same conclusion, and they are systems level approaches, that they are adopted as the basis of a new planning framework for Electricity resources in Australia.

Recommendation 3 (b) That the government accept that: *The lowest carbon grid with the lowest cost to the consumer requires nuclear power.*

Recommendation 3(c) Consequentially, that the Government expedites the removal of the ban on nuclear power at the Federal level as a matter of urgency.

The challenge is simple: does this Parliament have the courage to move beyond the flawed assumptions and "hopeful" investments that have been presented by internal stakeholders in the **Market Operator**?

Will it continue to make uneconomic "me too" investments that will not deliver?

Are we going to continue to use trivial scenario work and spreadsheet economics to take us away from the best destination?

The science and engineering **are** clear. Does this Parliament have the courage to act?

It is possible that we do not need a single offshore wind turbine. We need to reframe our VRE strategy to adopt a lowest cost lowest carbon strategy. It will, with proper engineering, provide a richer texture of achievable scenarios and investments to minimise cost growth.

Recommendation 4: Capacity building for our lowest carbon future

Proposal: Create the Australian Low Carbon Electricity Grid Resources Agency (ALEGRA) through the restructure the Australian Renewable Energy Agency (ARENA).

ARENA has done a good and positive job of promoting renewable energy. However, it is now clear that the challenge of our future will not be met without a lowest carbon strategy. By broadening the mandate of this agency we will have capacity in the Federal Government to address the broader set of issues that will maximise public benefit, and permit us to meet our international obligations in a timely fashion

It **is recommended that** legislation is brought forward to create the: the Australian Low Carbon Electricity Grid Resources Agency (ALEGRA) to maintain the scope of ARENA and broaden it to a richer and more effective lowest carbon approach for Australia (based on sound engineering and science), including among other underrepresented sources of power: nuclear fission and fusion.

This could also provide a home for national programs and obligations, including the Generation-IV International Forum, and providing predictable funding in this regard.

References

1. AEMO Integrated System plan (2022) 2022-integrated-system-plan-isp.pdf (aemo.com.au)

2.International Energy Agency: Net Zero by 2050 Net Zero by 2050 Scenario - Data product - IEA

3. I am indebted to Robert Barr who provided me with this information for some meetings and also presented it in Parliament House on at the Parliamentary Friends of Nuclear meeting 25 November, 2022. More information can be found here: Nuclear Energy in Australia is vital for a low carbon future (nuclearforclimate.com.au)

4. Wei Shen et al: Renewable and Sustainable Energy Reviews (sciencedirect.com), November 2020 pg. 110301AEMO: 2022 Integrated System Plan © 2022 Australian Energy Market Operator Limited

5. Timothy G. Walmsleya,∗ , Michael R.W. Walmsleyb , Petar S. Varbanova , Jiri J. Klemeša

Energy Ratio analysis and accounting for renewable and non-renewable electricity generation: A review [https://doi.org/10.1016/j.rser.2018.09.034]

6. *Sepulveda et al., Joule 2, 2403–2420 November 21, 2018 [https://doi.org/10.1016/j.joule.2018.08.006] [*