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Introduction

The Royal Commission is to be congratulated for the disciplined and exhaustive manner in which it has carried out its work and the clarity of the Tentative Findings. We are especially pleased to note that the Tentative Finding recommends Legislative Change to allow nuclear facilities to be considered and provide a chance for Australia to make a contribution on enhancing low carbon energy on a global scale.

However, the Australian Nuclear Association (ANA) has significant concerns about some of the Tentative Findings particularly those concerning Electricity Generation.
The key points of concern relate to the findings regarding Electricity Generation.

1. We are concerned that the application of an unrealistically high interest rate to nuclear power plants with no acknowledgement of likely falling overnight construction costs results in the unsupportable finding in Para 52 that "nuclear power would not be commercially viable to supply baseload electricity to the South Australian subregion of the NEM from 2030". The analysis of future use of nuclear electricity in South Australia is based on assuming that nuclear power plant costs will remain static through to 2030 and beyond.[1] These costs are likely to decrease with future standardized plant designs (see comments on Para 50).

   In assessing the commercial viability of nuclear generation Ernst and Young apply a Weighted Cost of Capital rate of 10.47%[2] to nuclear power development when no evidence has been provided that these rates have ever been applied to such a project.

2. Although Finding 5 proposes a target of zero energy sector emissions by 2050 the findings on the economic viability of nuclear is based on a comparison with a scenario which has

32% gas in the generation mix. The mix of intermittent renewables and gas power in the Ernst and Young Report (Pages 66 to 70) does not properly account for their correct emissions intensity.[3],[4] (see comments on Para 52). The claim in the Ernst and Young Report (Page ?) that the IS3 scenario model of the NEM results in an average emissions intensity equal to 0.12 tCO_2-e/MWh in 2050[5] is not correct. See detailed commentary on Finding 52 below.

The proposed wind/PV/gas model for electricity generation will only result in an inescapable plateau of intermediate to high level emissions.

3. Beyond some modelling of electric vehicles, there is no attempt in the Tentative Findings to extend the impact of carbon pricing or electricity demand beyond the current scope of electricity generation. There is need to broaden the boundaries into other areas of our primary energy carbon emissions. Figure 1 shows that with electricity generation accounting for only one third of our emissions, it must have the lowest possible emissions if some of the more difficult sectors such as agriculture are to remain

The Commission seems to be advocating a long term mix of wind, PV and gas which will not produce zero or even low energy sector carbon emissions by 2050 unless nuclear is added to the mix.

We contend that the outcome of the Ernst and Young modelling has demonstrated that by escalating a carbon price within the current architecture of the NEM and with the elevated interest rates they use does not result in the desired low carbon outcome unless they include nuclear. Instead Ernst and Young predict an inescapable plateau of intermediate to high level emissions.

We are reminded of the words of Professor James Hansen who said on 2014:

> *People who entreat the government to solve global warming but offer support only for renewable energies will be rewarded with the certainty that the U.S. and most of the world will be fracked-over, the dirtiest fossil fuels will be mined, mountaintop removal and mechanized long-wall coal mining will continue, the Arctic, Amazon and other pristine public lands will be violated, and the deepest oceans will be ploughed for fossil fuels. Politicians are not going to let the lights go out or stop economic growth. Don't blame Obama or other politicians. If we give them no viable option, we will be fracked and mined to death, and have no one to blame but ourselves.*

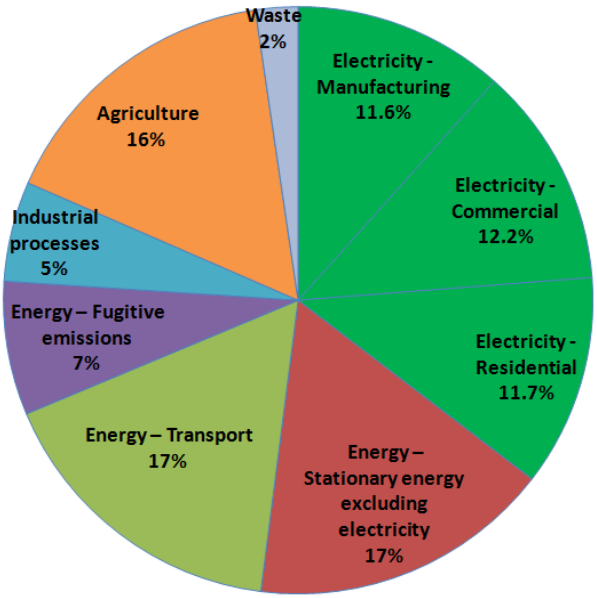

Figure 1 Australia's CO2 emissions by sector 2011-12 [6]

Despite James Hansen's warning the temperature anomaly recorded in NASA's GISS data set and graphed in Figure 2 shows that global temperature growth has reached a crisis point. This image underlines that absolute necessity identified by the Royal Commission in **Finding 8** that our emissions reductions are failing and more rapid action is required to reach net zero emissions by 2050.

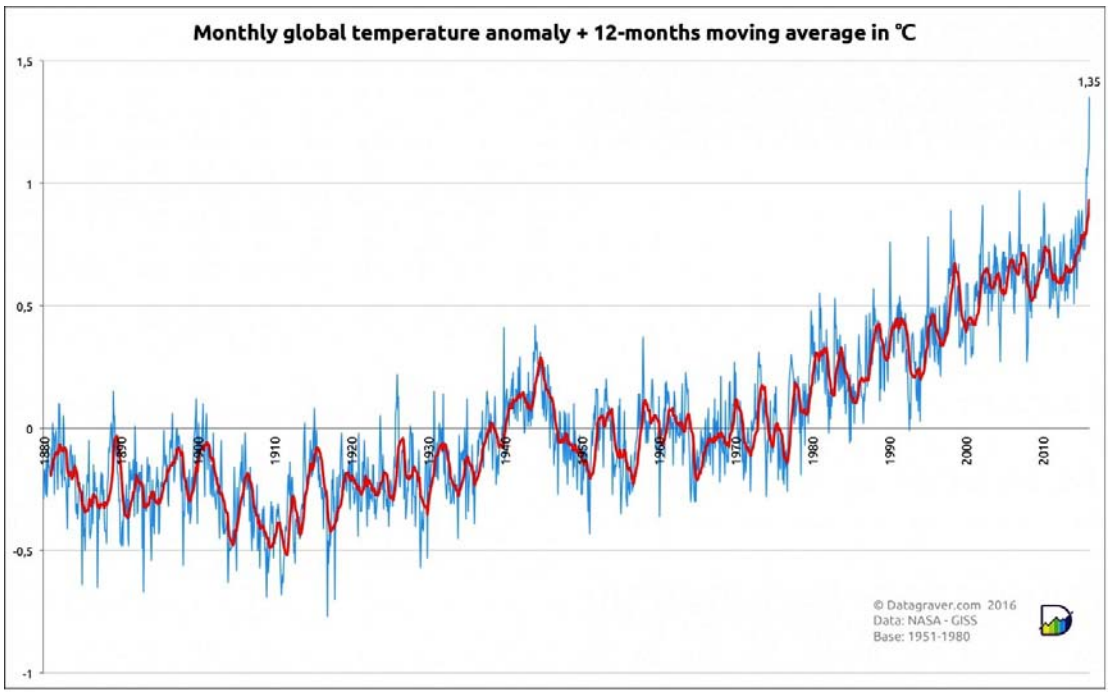

Figure 2 - February 2016 Global Temperature anomaly - from NASA GISS

Detailed Commentary on Tentative Findings dealing with the Energy Future and Electricity Generation.

Finding 1 to 9 - Energy Future

We agree with and support the need for a low carbon future to meet climate change objectives. This sets the context for Electricity Generation sections.

Finding 5. We support the target of net zero energy sector emissions by 2050, but note that this is in conflict with the inevitable result from Findings 54 and 58 that SA will depend on gas for 32% of its electricity. Refer to Figure 4 on Page 10 of this response.

If Finding 5 is our energy future, then this should be taken into account in the Findings in the Section on Electricity Generation.

Finding 7. We agree that nuclear power like wind, solar and hydro is a low carbon technology. However, wind and solar cannot exist without peaking gas or hydro backup. As such wind and solar must exist within a composite system and it is more appropriate to report on the composite system emissions rather than the discrete elements.

Finding 8 Nuclear is not necessarily affected by long lead times. In the US 113 reactors were started over 14 years from 1964. In France construction of 59 reactors started over a 20 year period were completed within 25 years. Currently in the UAE the roll out of 4 reactors started with planning in 2008 and will be complete by 2020. By contrast, Australia's total wind generating capacity of 3,669MW built over a 29 year period generates the same amount of annualized energy as one AP1000 reactor.

Long lead times for nuclear energy in some countries are not the fault of the technology so much as a failure of decision making.

The second sentence provides a strong justification for immediately starting the process to include nuclear in the South Australia's energy mix.

We recommend this Finding include the statement:

"That the use of nuclear energy is consistent with the Paris Agreement of keeping the increase in global average temperature to well below 2°C above pre-industrial levels and to aim to limit the increase to 1.5°C.

Finding 9. We strongly agree with the Commission's findings that Australia should be planning now for the use of nuclear energy. This means removing arbitrary legislative prohibitions to using nuclear

Finding 23 to 37 - Further Processing and manufacture

To Finding 34. Change last sentence and include: The current commercial viability of reprocessing has been undercut by the availability and low cost of uranium. This position may change should fast reactors enter the market in which case, there will be increased demand for plutonium and it will become significantly more valuable. The timing of the final sealing of used fuel in the geological disposal facility would need to take account of this possibility.

Finding 35 The ANA does not agree that nuclear energy will not be used in South Australia or in Australia more broadly for the reasons outlined in the Electricity Generation section. If Australia is importing quantities of used fuel as suggested in Finding 91, then whether Australia has nuclear power or not is irrelevant to whether there is used fuel to be reprocessed. However at this stage as discussed in Finding 34, it is not commercially viable.

We suggest that Finding 35 be reworded:

"The reprocessing of used nuclear fuel is a difficult process to establish., Its end purpose, commercial viability and the means by which it would be carried out is highly speculative at this stage. On that view it is not necessary at this stage to address its specific environmental and health risks"

Finding 38 to 61 - Electricity Generation

Finding 43 –We agree with the Finding 43 but suggest adding a sentence that “Newer designs of nuclear plants have an increased ability to load follow".

The ANA use the word “mature” to indicate that nuclear has a long history of successful deployment, not that it is unchanging. Nuclear energy generation is a largely untapped resource with respect to the options available as a low carbon energy source. In particular we have the technological ability to build reactors that can:

- Provide process heat to those parts of our carbon emitting processes that currently use fossil fuels such as steel making or aluminium production
- Build reactors that can load follow using passive responses to variable demand
- Roll out reactors that can generate power without the need for water cooling
- Operate to be essentially melt down proof
- Utilise fission materials nearly 90 times more efficiently
- Generate power at costs to rival fossil fuels.

The Government would need to implement policies to enable these innovations to occur and to set up the appropriate economic framework..

Finding 44 - The ANA submission to the Royal commission scoped - areas in South Australia where the geophysical properties appear to be suitable for AP1000 sized reactors. These sites had competent bedrock, access to seawater cooling, close to the existing electricity transmission grid, low seismicity and low population density within 25 km. Site selection would involve a in-depth consideration of a full range of site selection criteria.

For South Australia it is likely that suitable sites for large reactors would be on the coast and use seawater cooling. The requirement to use sea water for cooling is a commonly used process and South Australia would seem to have ideal geophysical conditions for nuclear power plants. For the longer term deployment of small modular reactors air cooling at inland locations would be a viable option.

Finding 45 –The need to maximise low carbon electricity use within all our primary energy sources is urgent. Current reactors such as the Westinghouse AP1000 meet that need now. SMR's are about to seek regulatory approval in the USA however given other longer term preconditions for their successful business case their promise should not delay the implementation of low carbon nuclear energy in the nearer term.

Finding 49 - One of the defining characteristics of the South Australian section of the NEM is its lack of full accounting for the Greenhouse gas emissions incorporated in its generation. These can be allocated as follows:

1. Behind the meter - namely domestic roof top PV - these systems are becoming cheaper as a reflection of low Chinese prices and reducing uptake in Europe. The panels themselves when manufactured in China and used where solar insolation is around 1700kWh/m2 contain lifecycle emissions of the order of 122.5gr CO2e/kWh and if the remainder of system is also Chinese derived the total could be as high as 189 gr CO2/kWh[7], [8]
2. Despatchable - The risk exists that South Australia is locking the state's greenhouse gas emissions into an ongoing interdependency between gas with its escalating prices and intermittent wind and PV. A likely outcome would be to entrench a continuing emissions intensity in the region of 400 g CO_2 /kWh where the required target is under 50 g CO_2/kWh by 2050. There is no evidence of accounting or detailed measurement of the upstream methane fugitive emissions going into the State's gas power plants. At 3% fugitive losses, the assumed emissions intensity of gas plants at around 400 gr. CO2/kWh can in fact double. Recent data from the US gas fracking industry indicates fugitive losses in the region of 10%[9]. Refer to comments on **Finding 54** following

The plan to use solar, wind and gas is not a recipe for continued emissions reduction but rather one of an **inescapable plateau** being funded largely by consumers paying out of after tax income. This outcome means that the target of net zero energy sector emissions by 2050 in **Finding 5** will not be met.

The National Electricity Market (NEM), being an energy only market, has deficiencies in securing appropriate long term investments and in ensuring adequate long term capacity and energy security. There is a clear need for a review to be undertaken of the design of the NEM to respond to the challenges of capacity security, energy security and emissions of carbon dioxide.

Finding 50 – We disagree with assumption in Reference 47 that the cost of nuclear energy will remain unchanged through to 2030. Factors that point to costs reductions from an assumed overnight cost for an AP1000 of US$5700/kWe are:

1. The entry of China into the reactor export market with the Hualong power plant with an intended cost of $2,500/kWe[10].
2. The United Emirates reactor programme. Current UAE Barakah plant costs for 4 x AP1400s are understood to be US$25billion or $US4,464/kWe - say A$5000/kWe at 60% Australian content.
3. Russia has a very aggressive export market and according to the World Nuclear Association website have some 50 or so export reactors in various stages of contract and 56 within Russia. Russian VVER 1.2GW reactors have a price in the region of US$4,200/kWh though not all aspects of the agreements are clear.
4. The IEA-NEA Nuclear Energy Roadmap 2015 estimates China's average overnight costs of approximately USD 3,500/kW are more than a third less than that in the EU of USD 5,500/kW. Costs in the US are about 10% lower than the EU, but still 30% higher than in China and India, and 25% above South Korea. In its main scenario, 2050 assumptions for overnight costs of nuclear in the United States and European Union are estimated to decline somewhat, reaching levels closer to those in the Republic of Korea, while costs in Asia are assumed to remain flat.

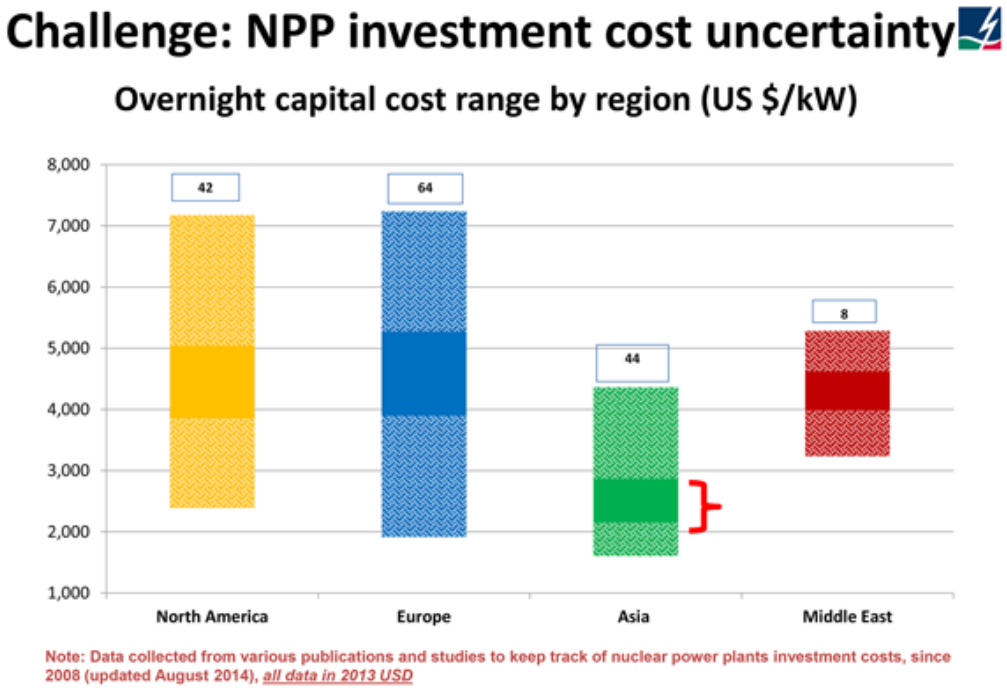

Figure 3 - From IEA Roadmap costs

In view of the competition and challenges for growth of the nuclear fuel cycle in Asia and the Middle East and Australia's close proximity to the region the ANA recommends that the review of the overnight costs assumed by Parsons Brinkerhoff be reconsidered.

The ANA recommends deleting the reference to "the cost of nuclear is assumed to remain unchanged". Finding 55 acknowledges that this is likely not to be true.

Finding 52 – The ANA disagrees with the Finding 52 that nuclear power would not be commercially viable after 2030 based on the information in Reference 49. We will not really know the costs of a plant for South Australia until there is a proper contract process. In the meantime, the Commission has based its conclusion on two consultant reports which use a range of assumptions. Finding 52 should state what nuclear power is being compared with when being considered as being not commercially viable. Findings 52 is inconsistent with Finding 55 which states the while nuclear is not currently commercially viable, this assessment may change if:…

The qualified conclusion of the Parsons Brinckerhoff report is "Analysis of the economic viability measures for the scenarios under consideration suggests that nuclear power plants in South Australia are not likely to be economically viable, unless:…". Their conclusion uses the words "suggests" and "not likely". As discussed above under Finding 50, we question the assumption in the Parson Brinckerhoff report where the cost of nuclear is assumed to be constant but that the costs other sources of electricity decrease.

Based in the two consultant reports and other background information the ANA recommends that Finding 52 be changed to:

(a) On the present estimate of costs, under current market arrangements *and compared to gas* nuclear power *is not likely* ~~would not~~ to be commercially viable to supply baseload electricity to the South Australian subregion of the NEM

(b) *gas is estimated to be cheaper than nuclear but the use of gas as backup and baseload commits South Australia to significant long term carbon emissions and will ensure the target of zero emissions will not be met.*

Finding 53 - The removal of legislation preventing all facets of the nuclear fuel cycle from taking place in Australia will resolve speculation around off grid applications. The commercial viability of remote applications of Small Modular Reactors can be tested in the market place.

Finding 54 and 57

Finding 57 in particular notes that a future national electricity system must be designed to be low carbon. None of the Ernst and Young models achieve this relying as they do on gas generation to support intermittent wind and solar generation.

The Ernst and Young models are assumed to be based upon ACIL Allen Consulting emissions factors[11], for emissions based upon fuel actually consumed. This approach does not take account of all life cycle emissions. For example it does not take account for example of the impact of emissions exported from Australia to China through the manufacture of PV components in that country but deployed in Australia.

Even more importantly it does not take any account of fugitive emissions in the provision of gas to generators. Recent "top down" satellite measurements of methane concentrations from the United States' gas wells are reflected in fugitive emissions values of 3% and 10% used in Table 1. No similar "top down" measurement for Australian gas deposits could be located. The perspective outlined by Howarth[12] in "A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas" was used as a reference in the preparation of Table 1.

We don't know what the fugitive emissions applicable to gas turbines in Australia are - the references are not exhaustive or conclusive. Nevertheless the emissions intensities of the systems modelled by Ernst and Young are considered to be too low for gas.

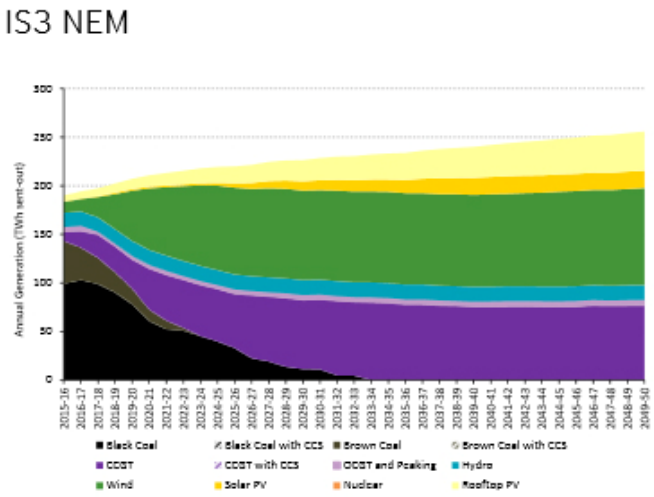

Figure 4 - IS3 NEM from page 69 Ernst and Young

	Generation	Amount tWh	Emissions intensity g CO_2-e/kWh	Calculation	CO_2-e emissions Kt
1	Rooftop PV	41	179[13] assuming 70% battery storage and all made in China	59 x 179	10,549
2	Solar PV	18			
3	Wind	100	34[14]	100 x 34	3,400
4	Hydro	18	13[15]	18 x 13	234
5	Gas generation (CCGT and OCGT)	82	443[16]	82 x 443	36,326
6	**Total nil fugitive**	**259**	**195**		**50,509**
7	If we add 3% gas losses, 20 year impact		153	16gx82x443x100x.03/(44gx259) = 153	39,628
8	**3% Fugitive (Line 6+7)**		**348**		**90,137**
9	If we add 10% gas losses[17], 20 year impact		510	16gx82x443x100x.1/(44gx259) = 510	132,094
10	**10% fugitive (Line 6+9)**		**705**		**182,603**
Values in tWh From IS3 NEM - page 69 Ernst and Young - **2050 Emissions Values in Col 3 scaled from E&Y figure for IS3 NEM**					

Table 1 - Calculation of IS3 emissions allowing for lifecycle impacts

In our analysis the capacity mix and resulting generation levels for the IS3 NEM scenario taken from Figure 45 on page 69 of the Ernst and Young report were analysed for its carbon emissions. This analysis includes:

- Life cycle carbon emissions for roof top PV with the assumption that 70% utilise battery storage in 2050 and that all units are made in China in a predominantly coal fired generating system. Refer to lines 2 and 3 in Table 1
- Wind and Hydro have allocations for carbon emissions. Refer lines 4 and 5 in Table 1
- Gas generation for Open and Closed cycle units are included in line 6
- The power generation values in 2050 were scaled from the image shown in Figure 3
- The emissions intensities of each generation type are all referenced within Table 1

The resulting values outlined in Table 1 of 195 gr. CO_2-e/kWh though to 705 g. CO_2-e/kWh are considered to be lower and upper limits with a likely value around 348 g. CO_2-e/kWh which equates to around 3% fugitive emissions.
This is a significant increase on the value of 120 g. CO_2-e/kWh (0.12 tCO_2-e/MWh) in 2050 contained in the Royal Commission supporting documents[18].

Finding 54 – In Finding 54, the Commission recognises that a substantial fraction of future demand is to be met by gas generation with its emission of carbon dioxide and fugitive methane emissions discussed above. The Commission should modify its findings to recognise that renewables backed up by gas may be cost competitive with nuclear energy but they do not deliver the emissions reductions claimed. Gas generation together with its fugitive emissions and the risk of long term price rises becomes an entrenched and highly polluting resource. In 2050 gas will be used to generate 32% of electricity in the NEM under the IS3 scenario which will result in unacceptably large greenhouse gas emissions if the Paris Agreement levels are to be met.

Finding 55f and 57 - We endorse the observations of Finding 55 generally and Finding 55f in particular.
Based upon evidence taken from Prof John Fraser, Prof Ken Baldwin, Mr. Mark Higson from the UK it is evident that to get low carbon base load viable on the grid will need more than a price on carbon. It will also require some form of sovereign loan guarantee, long term power price agreement such as a contract for difference. Other support such as reliability incentives may also be required.
The evidence given by the three witnesses demonstrates that all markets are constructs with often unintended constructs - it is evident the current design of the NEM does not provide sufficient

confidence for long term high capital cost investment. This has required interventions in the form of the Renewable Energy target and the Clean Energy Investment Corporation to get wind firmly placed on the market.

Finding 56 – The ANA strongly recommends an additional sentence in Finding 56 that "The Federal and State Government should remove legislation preventing consideration of the option of nuclear power, including amending the Environmental and ARPANS legislation.

Finding 62 to 102 - Management, Storage and Disposal of Waste

The Australian Nuclear Association strongly supports the establishment of a radioactive waste storage and disposal facilities in South Australia. As well as benefits to South Australia the five benefits outlined in the Jacobs report on page 120 of paper 2 highlight that this facility will remove the used fuel handling impediment from nations considering using nuclear energy. Nations without the natural advantages that South Australia offers will have lower perceived risks, reduced financing, greater societal acceptance and greater surety of outcome. This will result in a great benefit in the global quest for a low cost, low carbon energy source.

What are the risks?

Finding 74. Deep geological repositories are the best technical solution for the disposal of used fuel at the current time however we cite the French 2006 Planning Act: "*other areas of research complementary to deep geological disposal which called for continuing research on partitioning and transmutation in conjunction with research on future generations of nuclear reactors and accelerator-driven waste-transmutation reactors.*"

The ANA consider there is a very real possibility that the used fuel transported to South Australia has potential in the future for partitioning and transmutation in fast reactors. While it is very speculative at this stage the potential would be to create a sophisticated fuel manufacturing facility in South Australia and to reduce the amount of used fuel being stored for hundreds of thousands of years.

We request the Commission change the first line of Finding 74 to:

> *"There is international consensus that geological disposal is the best technical solution to dispose of used fuel to the degree that it cannot be otherwise recycled or partitioned and transmuted in future reactors."*

Finding 77 - Add Finding 77g drawn in part from the Jacobs Executive Summary report page 9 -

> "Spent fuel could be recovered from the Geological disposal facility after encapsulation but before final sealing into the disposal galleries there is also potential for re-sale should spent

fuel attract a value for re-use in new generations of nuclear reactors or for recycling through thermal spectrum reactors."

Finding 96 - 102 - Fuel Leasing The Findings should include reference to used fuel recovery. The ability to recover used fuel would add significantly to the business case for fuel leasing.

Findings 103 to 111 - Social and Community Consent

The ANA is in agreement with these tentative findings.

Finding 111g - The ANA notes that even if the proponent is not involved, it is unrealistic to expect the community discussions to be free from the influence of lobby groups with their own agendas. The community engagement process needs firm and insightful guidance.

Finding 126 Finally, under the section dealing with non-proliferation and security, the ANA agrees that plutonium storage requires strong security measures however the high burn up of fuel in commercial reactors does not produce plutonium suitable for weapons manufacture.

Yours sincerely

Robert Parker

President,

Australian Nuclear Association

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[1] Ernst and Young report, Figure 36:Capital Cost trajectory page 62

[2] WSP Parsons Brinkerhoff Feb 2016 Quantitative Analysis Report Appendix B

[3] Ernst and Young Figure 42: IS3 Generation mix (LTIRP) in the NEM and Figure 45 : Generation mix (2-4-c) in the NEM and SA - IS 3N EM pages 67 - 69

[4] Emissions Intensity Values, AC/t Allen Consulting (prepared/or AEMO), 11 April 2014.

[5] Ernst and Young report Para. 6.5 Nuclear Power Generation, page 97

[6] AUSTRALIAN NATIONAL GREENHOUSE ACCOUNTS *Quarterly Update of Australia's National Greenhouse Gas Inventory, June Quarter 2013*

[7] Assessing the Lifecycle greenhouse gas emissions from solar PV and Wind Energy: A critical meta-survey

[8] How Sustainable is stored sunlight, Low - tech magazine 2015-05-14 Kris De Decker http://www.lowtechmagazine.com/2015/05/sustainability-off-grid-solar-power html

[9] Remote sensing of fugitive methane emissions from oil and gas production in North American tight geological formations. Sc Oliver Schneising, John P. Burrows, Russell R. Dickerson, Michael Buchwitz, Maximilian Reuter, and Heinrich Bovensmann, 2014

[10] http://www.scmp.com/business/china-business/article/1915891/china-general-nuclear-power-and-rival-china-national-nuclear

[11] Emission factors

[12] Robert W Howarth, A Bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas. Energy and Science Engineering 2014; 2(2) 47-60.

[13] How Sustainable is stored sunlight, Low - tech magazine 2015-05-14 Kris De Decker http://www.lowtechmagazine.com/2015/05/sustainability-off-grid-solar-power html

[14] Assessing the lifecycle greenhouse gas emissions from solar PV and wind energy: A critical meta-survey, Nugent and Sovacol, 2013, Table 13

[15] Ibid

[16] Ibid

[17] Remote sensing of fugitive methane emissions from oil and gas production in North American tight geological formations. Sc Oliver Schneising, John P. Burrows, Russell R. Dickerson, Michael Buchwitz, Maximilian Reuter, and Heinrich Bovensmann, 2014

[18] Ernst and Young report Para. 6.5 Nuclear Power Generation, page 97