

**Submission to :                Royal Commission into the nuclear fuel cycle**

**Submission by :              Gary Rowbottom,**

**Issues Paper Three :       Electricity Generation from Nuclear Fuels**

**Q 3.1**        Any nuclear facility in Australia or South Australia would need to be built on the coast for adequate supply of sea water for cooling (current technology reactors at least). Adequate forethought to cater for expected sea level rises over the expected lifetime would need to be made. Proximity to grid connection points is of course another consideration. There are likely to be a number of suitable locations in South Australia. However, I do not support Australia's involvement in nuclear power generation for reasons elaborated later, including it is more expensive and not as safe as a suite of existing available renewable technologies, including some with storage capability.

**Q 3.2 / 3.3** Generation 1 and 2 nuclear reactors I believe represent too great a safety risk, and produce waste that is too hazardous to be considered seriously I think, not to mention it is outdated technology. Generation 3 reactors do not seem to be deployed very successfully as yet – Reneweconomy, in an article reproduced from Greentech media reported no single Generation 3 reactor has come into service in the past 20 years - most are delayed three to nine years and are far over budget (<http://reneweconomy.com.au/2015/around-the-world-nuclear-cant-compete-with-growing-renewables-86149>). All of these reactor types normally exist in the large capacity range, not appropriate for conceivable off grid settings in Australia or South Australia, but could be NEM connected. However in the South Australian region which already has a high % of less expensive renewable (wind and PV) there could not be a worse partner than large scale nuclear – far too inflexible – the existing Pelican Point and Torrens Island complement the existing renewables much more effectively. Furthermore as domestic and utility scale PV and battery storage and utility scale solar thermal with molten salt storage is deployed as is sure to occur, the nuclear option makes even less economic sense. Gen 3 SMR types (small modular reactors) have very limited deployment and have been very expensive in the few cases where they have been built (refer above article) – so again it is very hard to see these making sense economically for Australia compared to a suite of existing renewable technologies including those with storage – particularly for off grid locations.

Generation 4 reactors, particularly if of the smaller capacity (SMR) configuration, may possibly make some sense to Australia in the future in an on or even off grid setting, and maybe within the two decade timeframe, just – providing they do not produce long lived radioactive waste. However, it again is very likely an uneconomic path for Australia compared to available renewable options as above. I will not support any technology that leaves a long lived radioactive waste legacy for my children and theirs – or anyone else's. In any case, with effectively no existing nuclear industry, development of Gen 4 and SMR's is best left to nations that have a long grounding in the nuclear industry, like the USA. It would be ludicrous for Australia to do independent work in that area – no doubt we may have individual people with the knowledge and a passion to contribute to research and development in those areas, if so I believe they should join the existing research efforts in those overseas locations if that area of research is what they wish to make their life's work.

**Q3.4** In general, Australia can reach a very high proportion of its electricity generation from existing renewable resources, and South Australia certainly can (ref “100% Renewables for SA Report” – Mark Diesendorf – Conservation Council – June 2015 and even “100% Renewables Study – Modelling Outcomes “ AEMO - June 2013), and “Zero Carbon Australia” - Beyond Zero Emissions - 2010. Due to the inevitable and desirable penetration of intermittent renewables such as wind and PV, likely augmented by despatchable renewables (CST with molten salt storage, PV with batteries on domestic, commercial and utility scale, and pumped hydro perhaps) within a decade, large scale nuclear is the worst possible partner in the energy mix. Highly flexible baseload is much better, likely gas (whilst gas generation does of course have a CO<sub>2</sub> emissions issue, the capacity and frequency of requirement for gas generation should not be very significant. I envisage the most challenging period will be the winter peak, as solar based technology will not provide as much energy per day, and wind is lower too over winter months in many parts of Australia. Biomass may also play a part in the energy mix in the future too, at lower cost than nuclear. CST with molten salt storage is a highly viable option for a significant portion (potentially over 20% of capacity) for South Australia. Queensland and New South Wales could also utilise significant CST with storage generation.

As I have already mentioned, Generation 4 reactors, particularly if of the smaller capacity (SMR) configuration, may possibly make some sense to Australia in the future in an on grid setting, and maybe within a two decade timeframe, just – providing they do not produce long lived radioactive waste. However, it again is very likely an uneconomic path for Australia compared to available renewable options as above. I will not support any technology that leaves a long lived radioactive waste legacy for my children and theirs – or anyone else’s.

**Q3.5** Naturally any need for transmission lines is dependent on the locations being considered. I’ve already mentioned the reasons I do not think existing reactor types are a path we should follow, leaving only the distant possibility of Gen 4 reactors – it is hard to predict how those may develop and frankly it is not the right time for Australia to be considering those now – let those involved in the development continue that work and Australia can have another look in 7 to 10 years or so – in the meantime it should install more existing renewable energy and in particular those with despatchability and storage, to replace fossil fuel generation facilities. Nuclear generators tend not to be very flexible (low turn down ratios and slow ramp up/down rates), which is the reason why it is such a poor partner for an energy system with high intermittent renewables penetration. The SMR type concept, by virtue of its smaller unit size would provide a measure of flexibility, but still quite poor compared to gas generation for example.

**Q3.6** I am a bit surprised the Royal Commission found the need to ask such a question, if it can’t find reputable national/international associations and industry models to explore I am a bit concerned over the reliability of any conclusions that the commission may draw. There is of course the World Nuclear Association, and the American Nuclear Society, European Nuclear Society to name 3 principal ones, and I would be looking at the nuclear industries in America, Germany, Russia, Japan, the UK, India and China. I would be having a good hard look at the UK’s Hinkley Point C reactor. Of course the incidents at the Russian Chernobyl and the Daiichi nuclear plant in Japan should also be looked at – whilst the technological differences in today’s reactors may make duplication of those errors unlikely, but there may well be lessons to be learnt nonetheless.

Additionally, as well as examining the nuclear industry and peak bodies, the same

should be done for the renewable world associations and industries, such as the Renewable Energy Association in the UK, the US Renewable Energy Association, , the NREL in the USA, American Council of Renewable Energy, European Renewable Energy Council, International Renewable Energy Agency, and so on.

**Q3.7** Refer to answer to Q3.4 above.

**Q3.8** The principle issue to be considered is the comparison of pros and cons of nuclear energy as compared to the existing and near deployment ready range of non-nuclear renewable energy forms. In some senses the various forms of these non-nuclear renewable energy sources can be considered different parts of the same renewable energy machine – each with their strengths and weaknesses, but combined, providing a cost effective and robust energy supply system.

Issues that should be considered in the comparison are :

- Safety of Process
- Safety of waste issues
- Cost (both Capex and LCOE)
- Additional costs (externalities)
- Implementation / deployment time
- Potential to create Australian jobs
- Emissions
- Public acceptance
- Security
- Sites suitable for generation facility construction
- Impacts on other industries
- Implementation difficulties

**Q3.9** There are a number of lessons to be learnt from the 3 significant nuclear accidents, Fukushima, Chernobyl, Three Mile Island.

Firstly the process safety needs to be pretty well absolute, intrinsically safe, with no option for human error or more importantly combinations of human and system errors to create a hazardous situation.

Secondly, the occurrence of natural disasters, earthquakes, tsunamis and sea level rise in general needs to be considered, including the possibility that such events could occur at a scale not yet experienced, ie “the biggest ever”.

Personally I am not that confident we can be sure of either of the above situations being totally guaranteed (as indeed they are not for other forms of electricity generation or industry in general), the difference is in the potential long term effects, genetic damage, damages to food supplies and ecosystems that are possibilities in such accidents, noting the proximity of such facilities to the sea. Risk Management 101 – do not do the risky activity if you do not need to. We have not seen the last of the effects of the damage caused by Chernobyl and Fukushima, thyroid cancers and genetic defects for example. Lastly, whilst not specifically related to known previous incidents, security is another issue – wilful malicious harm. Sadly these considerations seem to be increasingly important and as the pressures on the world grow with expanding populations, increasingly degraded resources, climate change pressures, etc, I can’t muster the optimism to think those risks will not increase. Our geographic remoteness cannot be seen as a major defence against such threats.



From National Geographic, Long Shadow of Chernobyl - © Gerd Ludwig

- Q 3.10** As already outlined, I do not support any nuclear electricity in Australia with the possible future exception of the Generation 4 reactors, and only then if absolute safety of process and safety of waste issues (ie no high level radioactive waste), and naturally it also needs to be less expensive than other available renewable energy options. However, in the event Australia does go down the nuclear path either in the Gen 4 reactor future I would suggest essentially copying most of the regularly regimes and standards from the USA and Germany would be the backbone of a prudent strategy. Whilst I have enormous respect for the engineering ability of the Japanese, I do not advocate following their regulatory regimes – there are clearly holes in it somewhere.
- Q3.11** I would seek help on this, should it be needed noting my comments in 3.10 above, from the NREL in the USA.
- Q3.12** It seems Gen 2 and 3 nuclear reactors produce high level classified radioactive waste (mostly spent fuel rods). As in my submission for Issue Paper 4, I do not support activity in Australia that produces, handles, or stores radioactive waste in the high level classification. I do not know the waste cycle of Generation 4 reactors, these seem to be at least 15-20 years away from being deployed, Australia should allow those with existing nuclear industries to continue that research and development work on these Gen 4 reactors, and it will become relatively obvious in say 10 years time if that actually shows any potential, and offer a better view of how economically viable it is against other forms of renewable energy – refer Reneweconomy, in an article reproduced from Greentech Media:

<http://reneweconomy.com.au/2015/around-the-world-nuclear-cant-compete-with-growing-renewables-86149>).

As I understand it, a range of other wastes of varying levels of radioactivity are produced by the process of nuclear electricity generation (currently deployed ones at least), various coolants, and process liquids, down to disposable overalls worn by maintenance staff during steam turbine overhauls and replaced parts. These too need consideration.

As previously mentioned, Australia can reach a very high proportion of its electricity generation from existing renewable resources, and South Australia certainly can (ref “100% Renewables for SA Report” – Mark Diesendorf – Conservation Council – June 2015 and even “100% Renewables Study – Modelling Outcomes “ AEMO - June 2013), and “Zero Carbon Australia” - Beyond Zero Emissions - 2010. Due to the inevitable and desirable penetration of intermittent renewables such as wind and PV, likely augmented by despatchable renewables (CST with molten salt storage, PV with batteries on domestic, commercial and utility scale, and pumped hydro perhaps) within a decade, large scale nuclear is the worst possible partner in the energy mix. Highly flexible baseload is much better, likely gas (whilst gas generation does of course have a CO<sub>2</sub> emissions issue, the capacity and frequency of requirement for gas generation should not be very significant. I envisage the most challenging period will be the winter peak, as solar based technology will not provide as much energy per day, and wind is lower too over winter months in many parts of Australia. Biomass may also play a part in the energy mix in the future too, at lower cost than nuclear. CST with molten salt storage is a highly viable option for a significant portion (potentially over 20% of capacity) for South Australia. Queensland and New South Wales could also utilise significant CST with storage generation. Electric Vehicles and Smart grids may also form part of a much more distributed energy supply network in the future.

Furthermore, the costs of nuclear generation, particularly for South Australia, are not likely to compare favourably with the costs from an appropriate mix of other existing renewable energy technologies including those with storage capacity.

Protection of water resources also deserves a mention against this question, use of massive amounts of cooling water in a nuclear facility may have far reaching consequences in an already changing ecosystem, so this area must absolutely not be neglected, noting how Generation 4 reactors may impact on water resources is not currently known.

**Q3.13** Again I would recommend the USA and Germany as perhaps the best places to explore such issues but as I do not support any nuclear electricity in Australia with the possible future exception of the Generation 4 reactors, and only then if absolute safety of process and safety of waste issues (ie no high level radioactive waste) can be guaranteed, and naturally it also needs to be less expensive than other available renewable energy options, it is to me an issue for the future.

**Q3.14** Again repeating earlier comments, security is another issue – both from direct wilful malicious harm from terrorism or an individual’s unbalance, and potentially from illegally obtaining radioactive materials for non-peaceful purposes. The world does not seem to be stabilising. Standards of living are not anywhere near similar in different parts of the world – the difference is that this imbalance is now becoming more apparent to all, including those at the disadvantaged end of that scale. Sadly these considerations seem to be increasingly important and as the pressures on the world grow with expanding populations, increasingly degraded resources, climate change pressures, etc., I can’t muster the optimism to think those risks will not increase. Our geographic remoteness cannot be seen as a major defence against such threats, now or into the future.

**Q3.15** As indicated, electricity generated from nuclear is expensive – refer Reneweconomy, in an article reproduced from Greentech Media:

<http://reneweconomy.com.au/2015/around-the-world-nuclear-cant-compete-with-growing-renewables-86149>).

I refer also to the International Energy Agency recent Report “Energy and Climate Change – World Energy Outlook Special Report” – June 2015. That report clearly shows non-nuclear renewables growth is much greater than nuclear, albeit under the Bridge scenario proposed by the IEA for instance, the world nuclear generation share rises from 11% in 2013 (392 GW capacity) to 13% in 2030 (540 GW capacity), - in the INDC scenario the 2030 share for nuclear is 12%.

I believe all it would do for the Australian market is increase prices to consumers, and perhaps act as a constraint to other cheaper forms of renewable energy. Most importantly this Royal Commission must not be taken as an excuse to delay expansion and development of existing forms of renewable energy, and most importantly those incorporating storage and despatchability such as Concentrating Solar Thermal with molten salt storage.

Establishing a high cost nuclear electricity generating industry in Australia, and South Australia in particular makes little sense in a country with no existing nuclear electricity generation industry – it is akin to building an extensive poles and wires telephone system across Africa or China – they have leapfrogged across to mobile technology. For countries with existing nuclear industries, incrementally increasing nuclear share is not so costly. Another major factor is the countries physical renewable resources – many do not have the wind and solar resources that Australia has, others may be strong in hydroelectricity options – to each country according to his means – and whilst we have the raw material to establish a nuclear electricity generation industry, the cost and risks do not support doing so at this time. Maybe, just maybe, the Generation 4 type reactors may change that scenario, but only time will tell based upon the work of other nations already involved in that research and development work.

**Q3.16** I would suggest requesting assistance from the IEA, the NREL and the International Renewable Energy Agency. Do not rely on data from sources whose members are skewed pro or anti-nuclear – there is too much of that biased panel membership in reviews carried out by Australian Governments.

**Q3.17** Development of a nuclear industry would likely negatively affect the growth of the non-nuclear renewables sector, and also the other remaining base load generators, whether it be coal or gas. But repeating again, I do not support any nuclear electricity in Australia with the possible future exception of the Generation 4 reactors, and only then if absolute safety of process and safety of waste issues (ie no high level radioactive waste) can be guaranteed, and naturally it also needs to be less expensive than other available renewable energy options.

There may be some impacts on the tourism industry, likely more negative than positive. A nuclear industry would require a considerable training and educational support framework to be set up in advance of any construction, but considering the stance on maybe Gen 4 only, now is not the time to think further about that.

## **Appendix to Submission for Issue Paper No. 3 – Gary Rowbottom**

1. Essentially, I do not support Australia's involvement in nuclear electricity generation in Australia with the possible future exception of the Generation 4 reactors, and only then if absolute safety of process and safety of waste issues (ie no high level radioactive waste) can be guaranteed, and naturally it also needs to be less expensive than other available renewable energy options, which appears unlikely.

Generation 4 reactors seem to be at least 15-20 years away from being commercially deployed, Australia should allow those with existing nuclear industries to continue that research and development work on these Gen 4 reactors, and it will become relatively obvious in say 10 years time if that actually shows any potential, and offer a better view of how economically viable they are against other forms of renewable energy. Until then I advocate it remain illegal to construct such a facility in Australia.

2. Given the above position, I would advocate that public funds could be better spent in investigating what does constitute a reliable and flexible mix of existing and near deployment status options such as PV and batteries will work best for Australia and South Australia, particularly those options that feature storage and despatchability, such as concentrating solar thermal (CST) with molten salt storage. More importantly, Australia should start construction of these despatchable/storage types of facilities (CST in particular) to gain operational experience of its own with these types of plants.

South Australia has the opportunity to take the lead in Australia in the Concentrating Solar Thermal with molten salt storage technology deployment, and there would be scarcely a better place to site that than near Port Augusta as has been advocated from many sources for over 3 years.

3. We seriously question if nuclear will be a cheaper option than an appropriate mix of other non-nuclear renewable energy forms, including CST. It is the cost that is always thrown up as the barrier to CST (despite the fact it has/is being built in many countries considered less wealthy than Australia). However, if CST is considered just one element of an overall renewable energy portfolio, the costs appear differently, so where is the gain from nuclear?
4. As for jobs, yes there would be significant jobs in nuclear, but a lot of those would be jobs for overseas companies, and as indicated above, would be 10 years or more before those jobs appear in numbers. CST on the other hand has a decent number of jobs, a good proportion being local, and still with a reasonable range of complexity. That is one of the things I like about CST in preference to wind and PV, apart from the all important thermal storage capability. CST still has many different components, large rotating machines, pressure vessels, kilometres of welded piping and the like. The state does desperately needs employment but things like CST can deliver those now and in the near future, not nuclear.

**Yours Faithfully**

**Gary Rowbottom**