Comments on Tentative Findings

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The Premier of South Australia, The Hon Jay Wetherill, is to be congratulated on his initiative to seek ways to add value to the uranium resources of his State by charging a Royal Commission to explore the whole of the nuclear fuel cycle. Admiral Kevin Scarce is to be congratulated by the most professional way in which he has organised and directed the activities of the Royal Commission.

These are some comments and criticisms which are meant to be constructive. They are presented in two parts. Part 1 deals with matters of less significance, but it refers to errors of fact, misrepresentation and irrelevance which the commission may wish to correct. Part 2 also in two parts, deals first with what is believed to be a major omission from the Commission's key finding on waste disposal. The second part of Part2, deals with a matter which may not even be in the terms of reference, but would fall within the general umbrella of the nuclear fuel cycle and could be a long term major issue and of great significance to South Australians.

Part I

Attention is drawn to paras 38 to 42. It seems that the theme here is to describe the three complicated reactor accidents in a few lines showing the deficiencies in both reactor design and in the performance of the operating staff. This is followed in para 42 by concluding that we have learnt our lessons and they probably will not happen again. Because the descriptions are so short it is not surprising that they are either in error or true, but misleading.

The Chernobyl accident was not caused by overriding of safety systems as stated in para40. This action was a necessary part of a test which had been earlier performed on this and other reactors of this type without incident. The initiating event, though not the cause, of the accident was a request from the dispatcher after the test had started to hold the reactor at half power for some hours to meet the needs of the grid. Had this request not been received there would have been no accident and the test would have been completed successfully as formerly. There are neutronic consequences from holding a reactor at reduced power after sustained operation at a higher power. The equilibrum of the neutron poison xenon 135 is disturbed and the reactor will spontaneously try to reduce power as the xenon level in the reactor core builds up. To maintain power at the lower level the operator has to withdraw control rods as the increasing xenon level takes reactivity from them. The further he withdraws them, the less effective they become. The longer the delay at the lower power the greater the reactivity is invested in xenon poison and less in the control rods. Depending on the response time designed into the control rods, there may become a time when an attempt to raise power will commence a xenon burn up at a faster pace than can be compensated by the less effective control rods and a power excursion results. That's what happened at Chernobyl.

The operator made an administrative mistake. He should have either aborted his test and met the needs of the grid or imposed a time limit on how long he was prepared to hold at half power so that he could safely handle the xenon transient by burning it up. He chose to try to do continue with his test and also to meet the needs of the grid with the result that he left corrective action too late. In doing so he violated a number of rules designed to protect the reactor. The cause of the accident was the failure of the operator recognise that while his test and the needs of the grid could individually be met safely, in combination they imposed a threat to safety which required careful and expert handling. It was not the inadequacy of the guidelines as suggested in para40, but failure to observe them which was the problem.

Phase 2 of the accident was another uncontrolled reactivity injection, but this time it was inevitable from the design of the reactor in response to a power excursion. The power excursion from the first phase caused increased boiling of the coolant and the additional bubbles, by displacing the coolant moderator, created a further reactivity injection. This was diverging in nature producing a prompt steam explosion destroying the reactor. A fire and other explosions followed probably from hydrogen generated by very hot metal water reactions.

Probably the best description of the sequence of events appears in the World Nuclear Association website under Sequence of Events Chernobyl Accident Appendix 1

Attention is drawn to <u>para 41</u>.

A similar argument to that used above applies here. The reader is treated to an unbalanced picture. The snatches presented are true, but they only tell part of the story and when seen alone are misleading. These 40 year old reactors which were designed to withstand a certain level of ground acceleration were subjected to an earthquake much larger than their design earthquake and they behaved as the designer intended. The off shore earthquake was so large that it shifted the whole of Japan 1.5m to the east and created a large under water trench extending for 500km. The operating reactors responded by sensing the ground motion and shutting down as their designers intended. The shutdown cooling systems continued to keep the reactor cores at a safe temperature. Then the grid failed and the emergency generators sensed this and started up to maintain power to the cooling pumps. This could have gone on indefinitely, but 20 minutes later an enormous wave overwhelmed the generators which were located in the basement. With hindsight they should have been located on the roof where they are now on other Japanese reactors, but this should be viewed in the context that the same wave killed 18000 Japanese, yet not a single Japanese member of the public has died or is likely to die from radiation exposure from the damaged reactors.

However, describing the causes of three accidents does not address the subject of "What are the Risks" and should have no place under this heading. This was a great opportunity to publically state the real quantified risks of nuclear power from the historical record. This is what the public wants and needs to know in relation to its concerns about the risks:

- What does the world historical record show about health to the surrounding public from continuous nuclear reactor operations?
- What does the world historical record show about health to the workers who receive larger exposures than the public from continuous nuclear reactor operations?
- What does the world historical record show about health to the surrounding public from reactor accidents ?
- What does the world historical record show about health to the workers from reactor accidents ?

After establishing the above facts, the question then arises as to what is the Australian public perception of these risks? If it is judged to be at variance with the facts, what are the implications of the public rejecting, out of ignorance, the development of a local and or export industry which could bring South Australia and the rest of us considerable wealth. If the Commission does not want to move ahead of public opinion and it judges that public opinion lags, should it just accept that the time is not ripe, or should it conclude that national interest would be served by a public education program? While the Commission's concept that "Community consent would be essential to the successful development of any nuclear fuel cycle activities" sounds very rational and reasonable, it is suggested that these words are music to the ears of the anti-nuclear groups. They have laboured long and hard to create fear in the public mind about nuclear activities. A victory to them would be any delay in implementing action in any proposals which might arise following the Commission's report.

<u>Part 2</u>

Part 1 of Part 2

Attention is drawn to paras 73 to 102. In the Overview section the following statement is made: "The Commission's task is to identify, from credible and reliable sources, relevant facts as to this potential, (for increasing South Australia's participation in the nuclear fuel cycle) and the associated risks and opportunities for the South Australian community, economy and environment. "

The claim made here is that there are facts from credible and reliable sources which impose financial risks on the long term proposals contained in the Commission's Tentative Findings in the area of waste management, which have not been identified. Therefore in their present form the proposals do not comply with the terms of the task set down. This is not to suggest that the proposals for South Australia to extend activities into waste management are contrary to South Australia's best interests, quite the opposite, but only in a different form.

The game changer is the fast breeder reactor. The fast breeder reactor is not a dream, it is a fact. It has been with us since the days of very first reactors. Its development was slow because funding priority was given to small pressurised water reactors (PWRs) for submarines and later to the larger PWRs for power stations. The Russians have been operating a 600Mw non-breeding version since 1980 and a 900Mw breeder since 2015 and plans to build 8x 1200 Mw breeders by 2030. They are now building for China 2x 900Mw breeders and China is planning a 1200Mw breeder of its own design by 2028. Both intend to build and export breeder and non breeder versions. An unconfirmed report from China suggested that it will be building predominately breeder reactors by 2050. The breeder versions have the potential to create much more wealth for South Australia than it could achieve just by long term storage of non recoverable waste.

Of particular interest is the manifestation called the Integral Fast Reactor (IFR). This was developed in the US between the years 1984 to 1994 by the Argonne National Laboratory (which was the lab that gave us the PWR) and it was revolutionary, but simple. The reason an example of this reactor is not operating today is that in 1994 funds for the 300Mw demonstration unit were cancelled by President Clinton for purely political reasons. This suited China and Russia who were given time for their own developments.

It has many advantages in this form over current reactors. At Fukushima the reactor core melted when the water coolant boiled away at 100°C. exposing the fuel, but the sodium coolant of the IFR boils at 900°C which makes the coolant a much better heat sink. Moreover unlike the PWRs which operate at very high pressure the IFR operates at atmospheric pressure which means it can be located in a large pool of sodium which greatly extends the heat sink further. The implication of this is that fuel melting would be extremely unlikely. The big advantage this reactor offers for South Australia is that it can take the so called waste that the present proposal would bury and extract from it 100 times as much energy as has been taken so far. In expended fuel most of the uranium existing in the new fuel is still there, but it is in the form of the isotope U238 which does not fission. The IFR converts this to isotopes of plutonium which do fission. Moreover it consumes as fuel those long lived isotopes in current waste that the public is so concerned about and its own waste only lasts for 300 years.

It cannot be denied that as in most nuclear matters there are people who will disparage the fast breeder reactor and there have been some development problems. Usually one doesn't have to look too far to find the critic's real motive. Nevertheless it would take some courage to deny, in a study of this nature and in the face of the documented history of the fast breeder reactor, its potential to render redundant long term burial of expended PWR fuel, in a non recoverable form. Other countries such as Sweden and Finland are continuing with non recoverable burial, but they are already committed and we are not. One question which comes to mind is who will own the title of expended PWR fuel delivered intact? If we could acquire it, it may be worth many millions later. Also the storage facilities might look very different from those proposed in the Tentative Findings. South Australia may not necessarily need its own breeder reactor as there are many options to consider.

It is suggested that the Commission's credibility is at stake here. To continue to ignore the IFR as a waste management tool implies ignorance of its existence. To acknowledge it and dismiss it, may suggest a misunderstanding of its significance. To set out a plan as to how its future existence is compatible with and may be incorporated into current planning is the preferred action, but time for this has run out. It is suggested that this section be amended to say that the fast breeder option should be considered and that the topic is so pivotal to the financial success of the long term waste proposal that further resources be devoted to it beyond this study.

Part 2 of part 2

When it comes to identifying and seizing opportunity Australia often "misses the boat." In the 1940s US car manufacturers came here and built factories for us to build cars to their designs, mainly for them to penetrate our market. By the 1980s we had acquired considerable engineering skills in design and all aspects of manufacturing. We could have seized the initiative and told the American manufacturers we wanted to buy ownership so that major decisions would no longer be made in Detroit. By now we could be marketing Australian designed cars made in Thailand to make them affordable, all based on a substantial local industry. That is what other countries have done. We lost because we held out for Australians to undertake the lower level of skills which could be bought cheaper elsewhere. There is a message here for all of us. We lost focus. If we want to be a clever country we have to lift our horizon past 2030 and develop higher level skills.

When oil was found in the North Sea in the region owned by Norway, they saw this as a national asset to retained for the benefit of all Norwegians. Norway saves its state revenue from petroleum sector activities in the world's largest sovereign wealth fund valued at over $800 billion as of mid-2015. We had an equivalent large asset in the form of iron ore, but we did not seem to take charge of it and plan its exploitation. We allowed large multinationals to exploit it paying the State Governments royalties based on tonnage not value. When the price of iron ore went up, we the owners of the iron ore received no additional benefit.

These two examples suggest, not that we planned and failed in anticipating correct future events, but that we failed to plan at all. There is another proposition emerging and that is an opportunity for South Australians to step outside Australia and be part of large nuclear energy programs centred in Asia. Although it is desirable, there does not have to be a domestic nuclear program for an enterprising state to sponsor nuclear consulting services over the whole range of nuclear activities. To do so would place South Australia in a very favourable position when nuclear power does arrive. China, India, Korea, Japan and Russia are all in the throes of setting up export industries. Are we going to yet again "sit this one out?"

We need to find a way to be a player and not just a token player. This warrants a Royal Commission in itself to examine what the energy world is going to be like in 50 years and where Australia would like to be. What should we do now to place us in a favourable position for the future? There are people now who are saying we cannot do anything because we do not know anything about reactors. They are wrong. At a personal level, I had the privilege of being a member of a team that the Australian Atomic Energy Commission recruited and trained in the 1960s. In 10 years our team which also included some experienced nuclear scientists and engineer migrants, had developed skills in every aspect of reactor technology and I always felt respected and treated as an equal when I visited overseas nuclear establishments. A new generation could do it again. One of the great secrets of the post war years was how to enrich uranium. Another team at Lucas Heights did it without overseas assistance using centrifuges. We should put behind us the suggestion, that we can't do it because we don't know how.

A final suggestion is offered. It might be described as a" long shot," but it is an indication of one possible option. At present the Government has decided to acquire 12 new submarines, but no decision yet on where they will be built or by whom. France is one of the contenders and has an interesting contract with Brazil. France is to build one of its Scorpene type diesel submarines in France for Brazil and the next four will be built with French assistance in Brazil. The last of these will have a modified hull and the diesel engine will be replaced by a nuclear reactor, presumably locally built. If we choose to go down this path preferably in collaboration with Brazil and of course France, this may give us a toe in the water. We could justify building up nuclear skills in small pressurised water reactors which could later be adapted to small modular power reactors. It would avoid the possible difficulties existing now about building nuclear power stations in Australia. It would allow our South Australian shipyards to build submarines. This course, if it were available, would be a lot more difficult than just building diesel submarines in South Australia. What would we opt for if given the chance to choose?