TERRESTRIAL
ENERGY

17 March 2016

To: The South Australian Nuclear Fuel Cycle Royal Commission

RE: Response to the Tentative Findings of the South Australian Nuclear Fuel Cycle Royal Commission

We welcome the release of the Tentative Findings of the South Australian Nuclear Fuel Cycle Royal Commission (the Tentative Findings).

The Tentative Findings appear to be a robust and highly conservative appraisal of the opportunities in the nuclear fuel cycle for South Australia.

We firstly offer remarks pertaining to the whole document and then specific responses to several findings.

We look forward to acknowledgment of our response and trust the additional evidence presented will be reflected in the final report of the Royal Commission.

Yours sincerely,

Canon Bryan,

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Whole of document:

Across the whole document there is virtually no acknowledgement of the scientifically well-established potential for the recycling of used nuclear fuel for beneficial purposes and the prospects of advanced nuclear reactor designs to re-invent the nuclear fuel cycle. In only one paragraph (45) is there acknowledgement of "fast reactors or other innovative designs" and here it is in the context of this technology being unavailable in the foreseeable future (a finding we and our Northern American investors and industrial partners strongly disagree with). Given the broad scope, terms of references and resources of the Royal Commission, and the timeframes of up to 120 years that are considered in relation to managing used nuclear fuel, this presents both a disjunction of timeframes and an important oversight.

Terrestrial Energy noted the following remarks from South Australian Government MP Tom Kenyon :

> *The wealth that can be generated by the storage of spent fuel is not a silver bullet in and of itself. It provides us with an amazing opportunity, similar to the transformative power of the Victorian gold rush, but if in 30 years time all we have to show for it is outstanding infrastructure and a bunch of companies sitting around waiting for the next government contract, we will have failed.*

There is little in the Tentative Findings to reflect the exciting commercial and manufacturing opportunities available in advanced nuclear technologies. South Australia might be well-positioned to proactively engage with this sector yet it appears to have been overlooked.

For example, the Integral Molten Salt Reactor (IMSR), when combined with advanced recycling technologies that exist today, offers a beneficial pathway for disposal of problematic nuclear material from existing used nuclear fuel as discussed in the previous submission from Terrestrial Energy. The availability of such pathways offers a powerful additional argument to the establishment of facilities for the storage of used nuclear fuel, such as those outlined in the Tentative Findings. Some involvement in bringing such technologies to commercial fruition may provide exciting commercial opportunities for South Australia.

Terrestrial Energy recommends substantially greater recognition of this potential and the benefits it may offer to South Australia, in the context of a greater overall recognition and identification of opportunities in the advanced nuclear sector.

[1] As published to InDaily February 16 2016 http://indaily.com.au/business/analysis/2016/02/16/kenyon-nuclear-storage-can-be-the-bedrock-of-a-spectacular-state/

TERRESTRIAL ENERGY

HEADING	THE ENERGY FUTURE
SUB-HEADING	**N/A**
PARAGRAPH	**9**
PAGE NUMBER	**4**
COMMENT	**Agree, revision recommended**

Finding 9, page 4 states: "While it is not clear whether nuclear power would be the best choice for Australia beyond 2030, it is important that it not be precluded as an option".

We agree with the sentiment expressed however we are struck by the relatively passive language brought to bear on this crucial issue. Terrestrial Energy has (in our submission) expressed a keen interest in the Australian market, Australian manufacturing capabilities and Australian scientific capabilities. Given the independent and exhaustive nature of this investigation, we consider clear direction on the matter of the legal status of nuclear technology to be of utmost importance.

Policy decisions remain the responsibility of the South Australian and Australian governments as representatives of the South Australian and Australian people. As an external commercial entity, Terrestrial Energy emphasises that the seemingly arbitrary prohibitions on the class of technology it is developing provides a real and material barrier to further engagement with Australia. If the exhaustive investigations of the Royal Commission have found no compelling reason to maintain arbitrary prohibitions on nuclear technologies, this should be clearly and unequivocally reflected in the findings for the benefit of policy-makers.

HEADING	ELECTRICITY GENERATION
SUB-HEADING	**Is the activity feasible**
PARAGRAPH	**45**
PAGE NUMBER	**11**
COMMENT	**Strongly disagree, revision recommended**

In this section, we find the distinction between light-water SMR designs and so-called "innovative" designs to be arbitrary. We regard the finding as not reflective, in a consistent way, of the evidence in reactor design and readiness. This has important flow-on implications for the balance of the findings.

This finding states (our emphases added):

45. If nuclear power were to be developed in South Australia, a proven design should be used that has been constructed elsewhere, preferably on multiple occasions, and should incorporate the most advanced active and passive safety features. This is likely to include consideration of small modular reactor (SMR) designs, but ***exclude for the foreseeable future fast reactors and other innovative designs because****:*

a. *The generating capacities of SMRs would be would be attractive to integration in smaller markets, such as South Australia, and off-grid applications.* ***The commercial deployment of one-or-more light water SMR designs is likely overseas within the next decade. If successful this would provide credible evidence as to capability and cost.***
b. *Fast reactors or reactors with other innovative designs are unlikely to be feasible or viable in South Australia* ***in the foreseeable future****. No licensed and commercially proven design is currently operating.* ***Development to that point would require substantial capital investment****. Moreover the electricity generated has not been demonstrated to be cost-competitive with current light water reactor designs.*

Terrestrial Energy strongly disagrees with the statement that innovative, non-LWR designs will not be available for the foreseeable future. Regarding timelines, Terrestrial Energy notes a benchmark of 2030 appears to have been applied throughout the Tentative Findings as relevant for the timeframes under consideration for reactor technologies (14 years from publication of the relevant findings).

Terrestrial Energy's IMSR reactor design is on a strong pathway for first commercial deployment in the 2020s, and has in fact recently commenced regulatory engagement with the Canadian Nuclear Safety

Commission. In this regard it is ahead of many light-water SMR designs, such as the Generation mPower reactor. Hence it is highly likely to be available for South Australia by 2030. As described in our previous submission, the IMSR is both an SMR and what the Tentative Findings have termed an "innovative design", being based on the use of molten salt fuel.

Since the closure of the submissions to Royal Commission (i.e., new evidence that was not available to the Commission at that time), Terrestrial Energy has achieved the following milestones:

- Completed Series A funding, raising CAD$10 million to support pre-construction and pre-licensing engineering (January 8 2016)[2]
- Commenced formal Canadian Nuclear Safety Commission (CNSC) regulatory engagement; Phase I pre-licensing Vendor Design Review for the IMSR[3]
- Secured a CAD$5.7 million government grant from Sustainable Technology Development Canada, which will support pre-commercial activities (March 4 2016)[4]

Furthermore, since the closure of submissions, Terrestrial Energy has secured further industrial, academic and environmental expertise to its advisory boards including:

- Caterpillar Inc., a major industrial engineering firm with 2014 sales and revenues exceeding CAD$55 billion[5]
- Christine Todd Whitman: former Administrator of the U.S. Environmental Protection Agency and two-term Governor of New Jersey[6]
- Ray O. Johnson: former CTO of Lockheed Martin[7]
- James Cameron, Chairman of the Overseas Development Institute UK[8]
- Ben Heard: Principal of Think Climate Consulting and Decarbonise SA[9]
- Professor Travis Bradford, Professor of Professional Practice at Columbia University

[2] See http://terrestr a energy com/terrestr a_ energy announces comp et on of cad10 m_ on ser es a fund ng/
[3] See http://nuc earsafety gc ca/eng/reactors/power p ants/pre_ cens ng vendor des gn rev ew/ ndex cfm
[4] See http://terrestr a energy com/terrestr a_ energy awarded 5 7 m_ on grant from canad an federa_ government/
[5] See http://terrestr a energy com/terrestr a_ energy announces add t on of caterp_ ar_ nc to_ ts_ nternat ona_ adv so y board/
[6] See http://terrestr a energy com/terrestr a_ energy announces appo ntment of_ nternat ona_ y recogn zed author ty on susta nab_ ty to_ nternat ona_ adv sory board/
[7] See http://terrestr a energy com/terrestr a_ energy announces appo ntment of_ ockheed mart n former ch ef techno ogy off cer to_ nternat ona_ adv sory board/
[8] See http://terrestr a energy com/terrestr a_ energy announces appo ntment of_ nternat ona_ y recogn zed susta nab_ ty expert to_ nternat ona_ adv sory board/
[9] See http://terrestr a energy com/terrestr a_ energy announces appo ntment of_ nternat ona_ y recogn zed author ty on susta nab_ ty to_ nternat ona_ adv sory board/

Terrestrial Energy has also recruited Mr. Robin Rickman as Vice President of Corporate Development. Mr. Rickman joins Terrestrial Energy from Westinghouse Electric Company, where he was recently the Director of New Reactors [0].

Terrestrial Energy notes the benchmark SMR designs that have been considered available to South Australia in the "foreseeable future" include the Nu-Scale and BWX Technologies/Bechtel mPower designs . The licensing and commercial status of the IMSR compares well to these benchmarks, arguably on track to reach the market in a similar timeframe as Nu-Scale and ahead of mPower, which is currently not in a state of active development. The design will be first licensed in Canada and, with the remarkable inherent safety profile, there should be no unique barriers to uptake in Australia in future.

There appears no evidence-basis for the consideration of light-water SMR designs as available in the foreseeable future while making blanket exclusion of so-called "innovative designs". Consistent, objective review supports the inclusion of the IMSR as a small modular reactor that is likely to be commercially available to South Australia by 2030.

On the basis of the updated evidence provided we recommend the Royal Commission revises the status of reactor availability away from a divide between light water and other SMR deigns to better reflect the solid progress and clear path to market of the IMSR. In doing so, the advantages of this reactor design should be duly acknowledged as available to South Australia should it wish to embrace it.

[10] See http://terrestr a energy com/terrestr a_ energy announces appo ntment of former head of advanced nuc ear of west nghouse/

[11] Nuc ear Power P ant V ab ty Reports, page 1/6

HEADING	ELECTRICITY GENERATION
SUB-HEADING	**Is the activity viable?**
PARAGRAPH	**46-53**
PAGE NUMBER	**12-13**
COMMENT	**Disagree, further work recommended for revision of findings**

Regarding the evidence of cost, there appears an internal inconsistency in finding 42 between paragraphs (a) and (b). A lack of evidence for cost-competitiveness is held up as a limitation regarding "innovative" designs. Yet at the same time it is acknowledged that no such "credible evidence" yet exists for light water SMR either. This exact point is made in the supporting analysis [2].

It is a fact that in neither case (light water SMR nor "innovative" designs) is there yet "credible evidence" for cost-effective construction and operation. In both cases, we are reliant on estimates that can be robustly inferred on the basis of what is known and understood of the proposed designs. We note the Nu-Scale and mPower SMR designs are priced slightly higher than assumed for large-scale light-water reactor technology; this is appropriate as the core technology is the same [3].

This is not the case for the IMSR. It is readily and robustly surmised that the IMSR brings characteristics that lend to it substantially reduced capital costs compared to that likely to be offered by light-water SMR. These characteristics are discussed at length in the submission from Terrestrial Energy and are based on proven and well-established scientific knowledge and supply chain and manufacturing understanding. The IMSR also brings a different profile relating to fuel costs, decommissioning costs and spent-fuel liability transfer costs.

The Royal Commission's supporting work has suggested levelised cost of electricity of AU2015 $164-$328 per megawatt hour, depending on underlying assumptions [4]. Terrestrial Energy's IMSR currently has projected costs of USD$40-$50 MWh. It is evident that even with the addition of a considerable margin, this cost outcome raises the potential for entirely different findings regarding the economic viability of

[12] Sect on 6 2 4 *Small Modular Reactors*, page 35 of *Quantitative analysis and initial business case establishing a nuclear power plant and systems in South Australia*, WSP Parsons Br nkerhoff, 2016

[13] Sect on 6 2 4 *Small Modular Reactors*, page 36 of *Quantitative analysis and initial business case establishing a nuclear power plant and systems in South Australia*, WSP Parsons Br nkerhoff, 2016

[14] Tab es 7 4 and 7 5, page 88 of Quant tat ve ana ys s and n t a bus ness case estab sh ng a nuc ear power p ant and systems n South Austra a, WSP Parsons Br nkerhoff, 2016

nuclear power technology in South Australia by 2030. As such, we do not agree with paragraphs 46-61 of the Tentative Findings; these paragraphs are based on the relatively high-cost findings for large light water nuclear and light water SMR, which the IMSR intends to beat.

Terrestrial Energy strongly encourages the Royal Commission to revise the economic viability findings (46-53) for nuclear energy to reflect an impartial, evidence based appraisal of the prospects of *all* SMR designs, both light-water and other. In particular, Terrestrial Energy recommends careful consideration of the offering of the IMSR based on the submission to the Royal Commission and the updated evidence and data points provided in this response. Terrestrial Energy invites the Royal Commission to seek further evidence and information so that the IMSR might be fairly included in the economic modelling undertaken to investigate the viability of nuclear power reactors for the state of South Australia.