21 November 2023

Supplementary Submission re the proposed Oxley Solar Farm and BESS proposal that is presently before the Independent Planning Commission for Review

Preamble

I refer to the IPC document of 15 November 2023, available at:
https://www.ipcn.nsw.gov.au/resources/pac/media/files/pac/projects/2023/09/oxley-solar/additional-case-material-available-for-public-submission/statement-from-the-commission-regarding-additional-material.pdf,
and also an email sent to me from the IPC Secretariat on 15 November 2023, advising of the availability of this additional material, and inviting comment on it as a person who has "previously expressed an interest in the Oxley Solar Farm project (SSD-10342)".

I thank the Commission for the opportunity to make a submission on this additional information. I understand that any submission may address only the information provided in these additional documents, and that these documents are available as:

- the Department's Addendum to the Assessment Report, dated 26 October 2023; available at: https://www.ipcn.nsw.gov.au/resources/pac/media/files/pac/projects/2023/09/oxley-solar/case-referral-documents-from-dpe/addendum-to-the-assessment-report.pdf

- the Applicant's Response to the Commission's Request for further information, dated 3 November 2023; available at: https://www.ipcn.nsw.gov.au/resources/pac/media/files/pac/projects/2023/09/oxley-solar/additional-case-material-available-for-public-submission/response-to-request-for-further-information-from-the-applicant.pdf, and;

- Energy Co's Response to the Commission's Request for comment, received on 14 November 2023, available at: https://www.ipcn.nsw.gov.au/resources/pac/media/files/pac/projects/2023/09/oxley-solar/additional-case-material-available-for-public-submission/response-to-request-for-comment-from-energyco.pdf.

The Department's "Addendum to the Assessment Report" comprises a list of corrections to minor typographical errors in the Department's original Assessment document so, as it contains no additional substantive information, it requires no further comment on the issues raised in the original Report.

The other two documents listed above, both from the Proponent, do contain information that requires comment and critical analysis, so the addressing of aspects of these two documents comprise the content of this submission.

Executive Summary of this Submission

This supplementary submission is written to address certain matters discussed in the proponent's response to questions and issues raised by the Independent Planning Commission. I thank the Commission for providing the opportunity to provide further comment on these matters.

The particular aspects that I would like to comment on are, in general terms:

- the ability of the capacity of the proposed Oxley Battery Energy Storage System (BESS) to address any inadequacies in electricity supply that might be caused by the inherent intermittency and variability in the output of the associated Oxley Solar Farm;

- the proponent's responses to the Commission's questions regarding the potential for the recycling of components of the Oxley Solar Farm and BESS that have reached end-of-life, and its proposed waste management strategies for those components that cannot be recycled.

Oxley BESS ability to provide Long-Duration Storage for the Oxley Solar Farm

Since lodging my initial submission with the Independent Planning Commission in this matter, I have thought to examine the relevance of some items in Clause 59 in the Assessment Report on this proposal prepared by the NSW Department of Planning and Environment (the DPE). That is, the relevance of those items to the actual likely performance of the Oxley Solar Farm plus BESS project as proposed. Although the project has yet to be built, commissioned and operational, I have thought to examine the validity of these statements in Clause 59 against the actual preformance of a similar, already-operational solar farm plus BESS, in New South Wales.

While comment on that Assessment Report is not a matter for this Submission, the findings of the analysis that resulted from this investigation are, however, directly relevant to the content of the letter addressed to the IPC's Planning Director as the "Response to request for comment from EnergyCo.pdf" as the relevant uploaded file in response to the Commission's request for comment.

In that response, EnergyCo, the Proponent, very helpfully summarise the "NSW Electricity Infrastructure Roadmap" and then, how its Project, the Oxley Solar Farm and BESS, would contribute to that Roadmap.

In that response, EnergyCo state:

"*Within the next decade, three out of the remaining four coal fired generators in NSW are scheduled to retire. As a result, around 7,400 MW of dispatchable electricity generation capacity will be removed from the system. The NSW Government's Electricity Infrastructure Roadmap (Roadmap) sets out a plan to coordinate investment in new transmission, generation, storage and firming infrastructure as these coal-fired power plants come to the end of their scheduled life.*"
and,
"T*he Roadmap supports the private sector to drive the delivery of at least 12 gigawatts (GW) of new renewable electricity generation and 2 GW of long-duration storage, such as pumped hydro, in NSW by 2030.*" (Italics added for clarity.)

This objective of the NSW Government's Roadmap, then, would seem to be to obtain what is, essentially, plug-in replacement electricity generating capacity, for the remaining four coal-fired

electricity generators in NSW, by means of the building of new, so-called “renewable”, electricity generation and, where necessary, combining it with long-duration storage.

The critical requirement in the above statements is the need to replace “7400 MW of dispatchable electricity generation” (emphasis added).

My analysis (below), cited above, shows clearly that even the total BESS capacity, (some 210 MWh), that is presently available in New South Wales, is itself not enough to even begin to address the requirement for the absolutely necessary long-term duration storage that will be required to fill the void in electricity generation created each and every night by the loss in electricity output overnight that is an inherent property of the proposed Oxley solar farm, (and indeed, an inherent property of every solar farm). The minimum long-term duration storage for the Oxley Solar Farm is in excess of 1800 MWh. (See the analysis below.)

That is, the far greater amount of BESS already in operation in NSW, considerably in excess of the 50 MWh BESS proposed as part of the Oxley Project, does not even begin to address the long-duration storage required to support the requirement of just the Oxley Solar Farm generator itself, let alone the rest of the identified “12 GW of new renewable electricity generation”, so this finding begs the question: what exactly is the purpose of the project’s proposed, relatively tiny, 50 MWh BESS?

The response from EnergyCo is completely silent on this critically important deficiency of the Project – that of the provision of “long-duration storage”.

Both the proponent of the Oxley Project, and the AEMO in its recent publications, discuss the feasibility of using these BESS units to provide, what is albeit valuable, support, in addressing the need for the strengthening of synchronous inertia in provding grid stability. There is no attempt however to identify the battery storage required for these duties, nor how it is to be recharged. Such studies and comments can be regarded as very preliminary only.

These studies regarding the need for grid strengthening, however, whether by the Oxley proponent, nor the AEMO, address the absolute need to provide backup power, called “long-duration storage”, in the case of the Oxley project, by EnergyCo, at those times, that is, each and every night of the year, when the output of each and every solar farm, is zero. It is almost as if there is tacit agreement, by both the Oxley proponent, and the AEMO, that any BESS is quite incapable of providing this absolutely essential backup. With the retirement of the major coal-fired powerstations, a matter highlighted by the Oxley proponent in its response to questions from the IPC, the provision of such backup is absolutely essential. If the Oxley proponent is not prepared to provide such backup for its own solar farm, what entity does EnergyCo propose will do so on its behalf?

In summary, this lack of backup during the night-time hours is a critical, show-stopping issue, and it seems that neither the renewables’ proponents, nor the AEMO, are doing anything to address it.

One possibility is that an increase in BESS capacity might be suggested to address the long-duration storage absolute requirement. However, the sheer scale of the required long-duration storage, (see the analysis below as to its likely size), brings with it vastly increased environmental impacts and waste management issues, not forgetting the increased fire risk that is inherent in lithium-ion battery technologies. These increased waste management issues further highlight the inadequacy of the responses by EnergyCo to Issues 4 and 5 in the document entitled “Oxley Solar Farm (SSD 13046)

- Request for Information; responses". (See elaborated comment in the next section below, entitled "Proponent Responses regarding Recycling and Waste Management".)

In summary, what emerges from the proponent's responses is that it is time that a proper evaluation of this so-called "renewables" strategy be conducted and alternative forms of generation be properly considered.
Rather than recommend any such, massive, increase in BESS enabling "long-duration storage", given the now known significant fire risk, the large environmental impacts, the resulting enormously extended land-use footprint, and the waste disposal issues that are also a part of these technologies, I suggest that both the IPC, and Planning NSW, give careful thought to likely alternative strategies, such as the replacement of existing coal-fired generation by gas-fired and/or nuclear generation.

Proponent Responses regarding Recycling and Waste Management

This section of this submission is intended as a response to certain matters raised by the Applicant in the document loaded onto the Commission's website as the file:
'Response to request for further information from the Applicant.pdf', with the title: "Oxley Solar Farm (SSD 13046) - Request for Information; responses".

My comment here is on the Applicant's responses to Issues 4 and 5 that were provided in the above document.

It might be helpful that I state my relevant professional experience that relates to the matters of Recycling and Waste Management.

For some 30 years I was employed as an electrical engineer by the Organisation known originally as The Australian Atomic Energy Commission (AAEC), now the Australian Nuclear Science and Technology Organisation (ANSTO). During that time I was involved in a professional sense with Waste Management issues, and, in particular, was closely involved with what was then called the SYNROC[1] project. In more recent years, I was involved in contract work by ANSTO providing advice on the management of mine tailings and leachate to a number of mining companies worldwide. ANSTO, and this applies to the nuclear industry in general, takes its responsibilities regarding the containment and the isolation of wastes very seriously indeed. This, then, is the cultural framework in which I have worked, so I am able to critically assess proposed recycling and waste methodologies in the nuclear industry and in other industries.

Coming, then, from a background in Nuclear Engineering, I find the Applicant's response to concerns regarding the very likely deposition of Heavy Metals into the surrounding environment from both the solar PV cells and the BESS units, whether under accident or landfill waste disposal conditions, to be, at the very least, inadequate, and surprisingly so. Indeed, one might even say that the response is somewhat cavalier.

To put my comments into some sort of context: presume for the moment that a spokesperson for ANSTO were to propose that, because ANSTO might generate any quantity of a heavy metal compound such as Cadmium Telluride, that it would be perfectly ok to release this material into the environment because, to use the Oxley proponent's words:
"*While it is not present in all solar panels, some panels contain cadmium telluride (CdTe) which as*

[1] SYNROC technology, developed by AAEC/ANSTO, has become the "Gold Standard" means of isolating high-level radioactive, and other otherwise intractable, wastes from the environment.

caused public concern. Regarding this compound peer reviewed literature states:

- *The CdTe compound in commercially available thin-film solar modules is extremely stable and does not pose the same toxicological hazard as elemental cadmium. The thin CdTe film (typically they are less than 3 µm thick) means that the total amount of cadmium is less than 0.1% by weight. CdTe modules are currently collected and both cadmium and tellurium are recycled into new modules" (Mirletz, Hieslmair, Ovaitt, Curtis, & Barnes, 2023)*

In conclusion, the likelihood of breakages is very low and the consequence, given the small quantities in question, is considered low. The overall risk of contamination to ecosystems from broken panels is considered negligible and no effects on human health have been identified."
(End of quote, italics added for clarity)
(Quoted from pp. 7-8 of the document: "Response to request for further information from the Applicant.pdf".)

To not make too fine a point of it, should a spokesperson from ANSTO presume to mount such as this line of argument, for the uncontrolled release into the environment of ANY waste material generated by processes used by ANSTO, then we may be absolutely certain that politicians of virtually any persuasion would have an apoplexy, foam at the mouth, etc., in voicing their criticism in the strongest possible terms in what would be, quite properly, a very valid objection to any such proposal.

So, why should a representative of any other industry, particularly one that espouses so-called clean, green, "renewable" generation, even consider advancing such an argument?

What makes this line of argument even more reprehensible to such as myself is that the quantities of waste generated by both the solar and wind industries are ever so much larger, by orders of magnitude, than any waste disposal streams generated by the nuclear industry.

To conclude this Executive Summary, as regards other aspects of the Proponent's responses to Issues 4 and 5, the Proponent seems to think that Recycling and Waste Management matters arising from the operation of the Oxley facility are both entirely the present responsibility of other parties, and, a matter of research interest to future generations to solve. It doesn't seem to have occurred to the Proponent that it might have responsibilities regarding Waste Management that would fall under the category of Inter-generational Equity – the concept of Fairness and/or Justice between generations currently living and future generations. These matters are explored in the relevant section on Waste Management in more detail below.

Recommendation

The serious deficiencies in the Oxley Proponent's original Proposal and its Responses to Issues as identified in this submission are common to all Solar Farm with/without BESS Proposals. Rather than treat these proposals on a case-by-case basis, as seems to be the present strategy, it would seem useful that the IPC and Planning NSW issue a revised set of guidelines that require all Proponents to properly address in their original Proposals the matters of the provision of Long-Term Storage, Waste and Recycling Management, and Procedures that properly address Operational Safety issues, such as Fire Management.

Introduction

I note that the Assessment report by the Department of Planning and Environment for the Oxley Solar Farm plus BESS is available at:
https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10346%2120230920T051642.008%20GMT

In Section 5 "Assessment", under the sub-heading "5.1 Energy transition", I found the following clause (my italics):

"*59. With a generating capacity of 215 MW, the solar farm would generate enough electricity to power about 82,000 homes. This is consistent with the NSW Climate Change Policy Framework of achieving net zero emissions by 2050. The inclusion of a battery would enable the project to store solar energy for dispatch to the grid outside of daylight hours and/or during peak demand, increasing grid stability and energy security. Further the project would be located within the New England REZ. As such, the project would play an important role in:*
- *increasing renewable energy generation and capacity;*
- *firming the grid by including 50 MW / 50 MWh of energy storage; and*
- *contributing to the transition to a cleaner energy system as coal fired generators retire.*"

There are some interesting statements in the above assessment.
"*The inclusion of a battery would enable the project to store solar energy for dispatch to the grid outside of daylight hours and/or during peak demand, increasing grid stability and energy security.*", and,
"*firming the grid by including 50 MW / 50 MWh of energy storage;*"

I thought to test these statements against the findings from an analysis of actual, operational data.

Analysis: Oxley BESS ability to provide Long-Duration Storage for the Oxley Solar Farm

Although the Oxley development has yet to be built, there are any number of existing solar installations at or near the same latitude or within the same general region in New South Wales that may be considered as effective proxies for the proposed Oxley development. According to the AEMO's current list of registered participants, there are at present 31 operational solar farms in New South Wales. I thought to examine the output performance of the Solar Farm at Wellington NSW, as a useful example.

According to the AEMO's current registration and exemption list containing all registered participants in the National Electricity Market as of 31 October 2023, (available for download at: https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/registration), the Wellington Solar Farm has an installed capacity of some 216 MW, so is very similar as regards the potential power output to that of the 215 MW proposed for the Oxley development. Also similarly, the Wellington unit is a Solar PV Flat Panel Tracker unit.
It is safe to presume that the operational characteristics of the existing Wellington unit would not be all that different from those of the Oxley development.

In the Appendix, I have reproduced the AEMO's PUBLIC_DISPATCHSCADA data for the Wellington Solar Farm for the 24-hour period of 25 October 2023. The DISPATCHSCADA data

provides the output in megawatts (MW) of each registered generator and load on the Eastern Australan Grid at 5-minute time points. The data is provided as a doubly-zipped file, one file for every 24-hour day. The date is embedded in the filename. This data is made available at:
http://www.nemweb.com.au/Reports/ARCHIVE/Dispatch_SCADA/
The particular file accessed at that link was:
PUBLIC_DISPATCHSCADA_20231025.zip
As can be seen from the data, this generator produces no output during a significant period of the 24-hour day, that period being, of course, during the night. As a result of the time sequential form of the data, this period appears in two parts, being the midnight-to-dawn of one night, followed by the daylight hours, then the evening-to-midnight period of the next night.
The two periods of zero output are:
00:00 – 05:25 of 25/10/2023 and 18:30 – 24:00 of 25/10/2023.
(Note: All times are Australian Eastern Standard Time.)
This is a total period of some 10 hours 55 minutes.
I note that the maximum output on this particular day was 170.0679 MW at 11:30 hours.
The chart in the Appendix shows that this highest value is embedded in a fairly flat plateau.

I have examined separately – that is, not shown in this submission – the output of the Wellington Solar Farm for the much longer period of 1 January 2023 – 31 October 2023. I can confirm that the shape of the output curve shown in the Appendix is typical for this particular solar farm, as is the maximum value. Indeed, the highest output during the 2023 calendar year-to-date was 171.21538 MW at 29/03/2023 15:00.

Given that these long periods of zero output occur on a daily basis, that is, during the night-time hours, it is of particular interest to determine a reliable estimate of the battery storage required to maintain a useful output during that period of known, expected zero output.

According to the AEMO's current Registrations and Exemptions List, the Wellington Solar Farm is classified as "Semi-scheduled". According to the AEMO's Market Rules, generators within this classification are permitted to supply power to the grid whenever and at whatever rate is available at any given 5-minute time interval. As a result, if this generator is able to supply 171.21538 MW, for example, at any given time instant, then that amount of power will be accepted and accomodated by the grid manager immediately it is available.

The significance of this property is as follows: it is reasonable to presume that, at other times, sufficient battery storage should be available, to take a round figure, to supply up to 170 MW to compensate for any shortfall in the output of this particular solar farm. This may seem to be a somewhat stringent specification, but it has to be kept in mind that the Commonwealth Government has the very high Renewable Energy Target figure of 82% of generation, so it cannot be presumed that any shortfall in the output of any generator is to be made up by non-renewable generation, as occurs at present. At the present time, the remaining coal-fired and gas-fired fleet are required to make up for the frequent shortfalls in the outputs of both wind and solar generation. Once this fleet is retired, as is planned under the NetZero requirements, there will be no "lender of last resort", to use a banking term: wind plus solar plus hydro, plus, presumably, massive amounts of long-term battery storage, presently non-existent, will have to provide both power and ancillary services on a second-by-second basis, 24/7, 365 days of the year.

Considering then, the storage required to make up for the night-time period shortfall in the output of the Wellington Solar Farm, this is a relatively straightforward calculation.

There is some variation in the night-time period across the seasonal variation of the calendar year, but as the night-time period of 25 October is not too dissimilar to that of the Spring Equinox, (which itself ought to be a good indicator of the average night-time length), I thought to use the value of 10 hours 55 minutes determined for this particular date as the basis of the calculation of the storage requirement. For equinox and solstice data for the Australian region, see:
https://www.sunrisesunsettime.org/australia-pacific/australia/equinox-solstice.htm
This figure of 10 hours 55 minutes gives a low estimate, which may be the more useful as a conservative, underestimate, of the battery requirement.

The night-time battery requirement for this particular date, 25 October 2023 is calculated as follows:
Night-time battery storage requirement = 170 MW times 10.917 MWh
= 1856 MWh

Clearly, the associated 50 MWh BESS proposed for the Oxley Solar Farm will do little to address the night-time generation requirement posed by its complete lack of output each and every night. This finding calls into question the basis of the statements made both by the NSW Planning Assessors as quoted above, and statements made in Responses by the Proponent indicating that the Oxley Solar Farm and BESS may address the replacement of coal-fired electricity generation.

This figure of 1856 MWh night-time battery storage requirement for the Wellington Solar Farm is to be regarded as indicative only, and is a minimum storage requirement. This is easily explained as, although the Wellington Solar Farm is rated at 215 MW, it seems to be capable at present of generating a maximum of 170 MW. Should it be able to operate at full capacity, then the minimum night-time storage requirement would be significantly higher. The matter of weather impacts on the facility's generation ability also need to be taken into account in determining the battery storage requirement: there are periods of days, such as the occurrence recently of weather causing widespread cloud cover over New South Wales, that considerably reduce the daytime output of any solar farm. In these, quite frequently-occurring circumstances, the storage requirement is very significantly increased, perhaps by as much as 3-4 times, and even more under certain La Nina circumstances.

To give some indication of the physical size of the battery storage required to provide some 1800-plus MWh of Long-Duration Storage, the Geelong Big Battery has a storage rating of a mere 450 MWh. This itself is a large facility: the website of the organisation that operates this facility informs that it occupies an area comparable to an AFL stadium.

To address its "long-term storage" requirement, then, the Oxley Project would require a Grid-Scale Battery that is at least four (4) times larger, and indeed, very considerably more so, given the vagaries of the weather, than the Geelong Big Battery. That is a huge amount of storage, and would add very considerable to the land-take footprint, and the environmental impact, of the Oxley Proposal.

This storage requirement is typical of that required for each and every solar and wind farm. Given that these battery storage facilities last a maximum of some 7-10 years, the disposal of these materials poses a very significant, indeed huge, waste disposal and recycling problem. On this matter, both the Proponent's original Proposal and its Responses are silent.

Requirement for additional generation

Being a battery, the storage facility will require recharging from a source of generation that is separate from and in addition to the Oxley Solar Farm. What form this generation is to take, other than that the battery facility is to store solar energy, is not discussed in either the Proponent's proposal nor, incidentally, in the Department's Assessment.

It is of concern too the Proponent uses the term "generates power" when discussing the Oxley BESS. A battery stores energy, it does not generate energy. It is not a "generator".

For confirmation that these BESS facilities are different from other generators, it is useful to consider how the AEMO, for example, regards these systems. In order to accommodate them in its lists of registered participants, the AEMO has not one, but two, entries for each Battery Energy Storage System. For example, the 50 MW-rated BESS at Wallgrove NSW has the following entries in the "Generators and Scheduled Loads" list in the AEMO's List of Registered Participants:

Station Name	Dispatch Type	DUID
Wallgrove BESS 1	Generator	WALGRVG1
Wallgrove BESS 1	Load	WALGRVL1

This BESS, as any other such unit, is listed by the AEMO as both a generator and a load. Note that the heading "DUID" is the AEMO's term for the unique ID code that it gives to each registered generator or load. A conventional, that is, a non-battery, generator has only one entry in the AEMO's lists, as does a conventional load. The use of this pair of classifications for a BESS enables the AEMO to accommodate such a unit by treating it as a generator when it is supplying power to the grid, and as a load when it is drawing power for recharging purposes. This is the use of the same methodology that was developed originally to enable such as the listing of the Tumut 3 Hydro Pumped-Storage System as a registered generator/load.

Proponent Responses regarding Recycling and Waste Management – detailed comment

Discussion here refers to content in the Proponent's document headed:
"Oxley Solar Farm (SSD 13046) - Request for Information; responses".

I have already commented in the Executive Summary here on the Proponent's response where it downplays residents' concerns regarding the potential for the release of heavy-metal-containing compounds such as Cadmium Telluride, (Issue 4). To reiterate, the Proponent states, at the top of page 8 in that Response:
"*The CdTe compound in commercially available thin-film solar modules is extremely stable and does not pose the same toxicological hazard as elemental cadmium. The thin CdTe film (typically they are less than 3 μm thick) means that the total amount of cadmium is less than 0.1% by weight. CdTe modules are currently collected and both cadmium and tellurium are recycled into new modules" (Mirletz, Hieslmair, Ovaitt, Curtis, & Barnes, 2023)*"

The Proponent would have the reader believe that, because the "*CdTe modules are currently collected*", then this is the end of the matter. This ideal senario does not address, for example, the outcome of accidents where panels may be destroyed and contents leach away into the environment, such as may have happened during the recent fire at the Beryl Solar Farm. It does not address the

scenario where waste components are exported to jurisdictions which may have less than adequate regulations regarding the disposal of electronic waste. In such situations, where an uncontrolled release of potential contaminants may occur, potentially on a massive scale, it is a very brave individual that presumes to state categorically that such as CdTe "*does not pose the same toxicological hazard as elemental cadmium*". Perhaps the Proponent needs to be reminded that, once dispersed into the environment, that over time, it cannot be guaranteed that any such compounds will not break down, releasing elemental Cadmium, and other toxic heavy metals. It is here that knowledge gained in personal experience in waste management issues in the nuclear industry causes one to err very much on the side of caution. To put these remarks into context, the authors Ramos-Ruiz et al (2016) state in the Introduction to their peer-reviewed, scholarly paper:

"*Cadmium telluride (CdTe) and cadmium selenide (CdSe) are two semiconductors of the II–VI group. Due to their remarkable optical and electrical properties, both compounds are extensively used in the manufacture of electronic devices. CdSe is a good light absorber which possesses excellent photoelectrical characteristics (Feng et al., 2010); therefore, it is used in the production of light emitting diodes (LEDs), photo-electronics, and transistors (Chate et al., 2013). The use of CdSe in the production of high efficiency hybrid solar cells has been investigated (Feng et al., 2010;Chate et al., 2013;Huynh et al., 2002). Likewise, CdTe is used in the production of optoelectronic devices, gamma ray detectors (Bicknell et al., 1987), and laser windows (Punitha et al., 2015). Most importantly, CdTe is used in the photovoltaic industry in the production of thin film solar cells. CdTe photovoltaic devices were ranked as the third most common type of photovoltaic solar panels commercially available in 2013 (Esterly, 2013).*

"*Increasing concerns have arisen due to the implications of the potential release of hazardous substances from CdTe and CdSe containing devices. Firstly, it is expected that the manufacture of electronics based on these semiconductors will grow over time as technology moves forward which implies an increasing release of these compounds in the environment. Specifically, the production of solar panels is expected to increase since solar energy is one the fastest growing market shares of renewable energy (Century, 2015). Despite the remarkable efforts that are being made to recycle electronic waste, it is possible that an important fraction of the decommissioned solar panels in the future will end up discarded in municipal mixed landfills as a result of a lack of regulations related to the disposal of electronic waste in multiple countries. Secondly, there is evidence that toxic compounds might be leached from electronics based on leaching experiments using deionized water as the extraction fluid (Lithner et al., 2012). More importantly, recent works have demonstrated that soluble ions of Cd, Se, and Te, such as divalent cadmium (CdII), selenite (SeO32− (SeIV)), selenate (SeO42−, (SeVI)), tellurite (TeO32− (TeIV)), and tellurate (TeO42− (TeVI)) can leach out from CdSe and CdTe under conditions similar to those commonly found in landfills (Zeng et al., 2015). Thirdly, Cd and selenium (Se) are highly toxic elements which are included in the United States Environmental Protection Agency (USEPA) list of regulated drinking water contaminants, and the disposal of Se and Cd containing waste in municipal solid waste landfills is also regulated. The maximum contaminant levels (MCL) established for Cd and Se are 0.005 mg L−1 and 0.05 mg L−1, respectively, and the toxicity characteristic leaching procedure (TCLP) limit established for Se and Cd is 1 mg L−1. Furthermore, Cd, Se and Te soluble fractions are highly toxic to some microorganisms (Trevors et al., 1986; Macken et al., 2009; Yu et al., 1997; Taylor, 1999). Given these considerations, the presence of soluble ions derived from CdTe and CdSe in the environment might negatively impact several important processes, such as, the anaerobic biodegradation of organic matter and the activity of aquatic organisms.*

"T*he aim of this work was to investigate the toxicity of the soluble species potentially released from CdSe and CdTe (CdII, SeIV, SeVI, TeIV and TeVI) towards an anaerobic methanogenic consortium*

to assess microorganisms involved in anaerobic digestion processes and the Microtox® tests that measure the bioluminescence of the marine bacterium, Aliivibrio fischeri, which is commonly used to assess aquatic toxicity. (Italics added for clarity)". End of quote.

The overall conclusion of this paper, which reports the findings of an exhaustive investigation of the toxicity of various heavy metals to microorganisms naturally present in landfill and wastewater treatment works, is:

"*From the findings of this work, it can be concluded that the presence of soluble ions leaching from II-VI semiconductor materials can potentially negatively affect anaerobic treatment processes such as the methanogenic phase in a landfill. Thus caution should be taken if decommissioned II-V semiconductors materials are disposed of in municipal landfills. Likewise anaerobic treatment processes may be impacted in wastewater treatment systems handling effluents from industrial facilities processing II-V semiconductor materials.*"

Clearly, these authors do not share the Proponent's optimism regarding the long-term stability of such heavy-metal compounds as Cadmium Telluride (CdTe) once released into the natural environment, and the effects of its breakdown products in the natural environment.

Also, the Proponent fails to address the likely impacts of other types of pollutants that may arise in leachate from landfills, other forms of release into the environment, etc., from the waste arising from the use of other solar panel technologies.

There are other aspects of the Proponent's response that also deserve critical asessment.

Under the heading "Disposal" on page 9 of the relatively brief response to Issue 5, I note that the Proponent lists 11 companies in Australia that "recycle solar panels and products".
The Proponent then lists a number of organisations either committing funding to, or actually doing, research into solar panel recycling or "end of life management" of solar panels, and concludes that section with the following:
"*Panel repurposing (such as using sub optimum output panels for other projects) and panel recycling industries are expected to grow as more solar projects are approved.*", (italics added).

The Proponent makes no mention whatsoever of any strategy of its own as to how it is presently managing or committed to manage its own solar panel wastes as panels are damaged or reach end-of-life.

As an Inter-generational Equity responsibility, this is a major failure in the Proponent's Project Proposal.

The Proponent then seems to seek to deflect consideration of the matter of what its own strategies might be in regard to this important matter by seeking to direct the reader's attention by comparing the scale of PV module waste streams to the apparent scale of wastes generated by another power generation industry, namely the waste streams that allegedly arise from coal-fired generation.

These comments by the Proponent are specious at best because they fail to acknowledge that a Project that comprises a solar farm, plus a BESS that is inadequate for long-duration storage, is NOT a plug-in replacement for a coal-fired power station, so that there are to be added to the solar farm's waste streams potential environmental impacts resulting from the generation technologies that are required to backup and support the solar generator.

There is also no attempt at comparison with the waste streams from other forms of generation, for example, those from gas-fired generation or from nuclear generation.

If the Proponent had bothered to do the comparison of its waste streams with those arising from nuclear generation, for example, the Proponent would have been forced to admit that not only does nuclear generation have a much, much smaller land-take footprint, but it produces much, much less waste, by orders of magnitude, and that the nuclear industry takes an extremely responsible attitude to waste management.

In summary: the Proponent has provided a totally inadequate response, comprising for the most part wishful thinking as to what might be available in the distant future, and short on any detailed strategy for management of the likely waste streams from the Project as proposed.

Reference

Ramos-Ruiz A, Zeng C, Sierra-Alvarez R, Teixeira L H, Field J A 2016 *Microbial toxicity of ionic species leached from the II-VI semiconductor materials, cadmium telluride (CdTe) and cadmium selenide (CdSe).* Chemosphere, 2016 Nov:162:131-8.
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Appendix – AEMO-supplied output of the Wellington Solar Farm for 25 October 2023

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D,DISPATCH,UNIT_SCADA,1,"2023/10/25 18:50:00",WELLSF1,0
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D,DISPATCH,UNIT_SCADA,1,"2023/10/25 19:00:00",WELLSF1,0
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D,DISPATCH,UNIT_SCADA,1,"2023/10/25 19:45:00",WELLSF1,0
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D,DISPATCH,UNIT_SCADA,1,"2023/10/25 20:35:00",WELLSF1,0

D,DISPATCH,UNIT_SCADA,1,"2023/10/25 20:40:00",WELLSF1,0
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D,DISPATCH,UNIT_SCADA,1,"2023/10/25 21:35:00",WELLSF1,0
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D,DISPATCH,UNIT_SCADA,1,"2023/10/25 21:45:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 21:50:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 21:55:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 22:00:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 22:05:00",WELLSF1,0
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D,DISPATCH,UNIT_SCADA,1,"2023/10/25 22:25:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 22:30:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 22:35:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 22:40:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 22:45:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 22:50:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 22:55:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 23:00:00",WELLSF1,0
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D,DISPATCH,UNIT_SCADA,1,"2023/10/25 23:15:00",WELLSF1,0
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D,DISPATCH,UNIT_SCADA,1,"2023/10/25 23:30:00",WELLSF1,0
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D,DISPATCH,UNIT_SCADA,1,"2023/10/25 23:40:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 23:45:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 23:50:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/25 23:55:00",WELLSF1,0
D,DISPATCH,UNIT_SCADA,1,"2023/10/26 00:00:00",WELLSF1,0

Some explanation of the meaning of the contents of these data lines follows.
The letter in the first column indicates the type of the contents of the line
I – Information headings as to the meaning of the contents of the corresponding columns in each of the subsequent “D” lines of generator data. This tells us that the column entries mean, in order:
1. “D” – this line contains operational data.
2. “DISPATCH” – this field will be the second field on the line – it means that the data in the last column is generator dispatch data.

3. “UNIT_SCADA” will be placed in column 3 – the type of data is the SCADA-metered measurement of the generator output.
4. “SETTLEMENTDATE” – date and time information will appear in this column.
5. “DUID” – the abbreviation that appears in the subsequent “D” columns is the AEMO’s peculiar abbreviation used as the ID of each registered generator or load. Here the identifier “WELLSF1” indicates that the data on this line of data is that for the Wellington Solar Farm.
6. The data entry type. In this case the value on the subsequent data lines in this column is the SCADA value measured at the generator at the particular timestamp given in the “SETTLEMENTDATE” column. As it is a SCADA value, the figure is the output (or input in the case of a registered load) in megawatts (MW).

D – This line contains operational data of the kind defined in the last preceding “I” line.

Below is the chart of the Wellington Solar Farm output (MW) for 25 October 2023