

## **Tallawang Solar Electricity Generating + BESS – Independent Planning Commission NSW**

**Development of a 500 megawatt (MW) solar farm including a battery storage facility and associated infrastructure. Reference Number (SSD-23700028)**

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**Submission by Ivan Kennedy to IPCN at Gulgong, August 28, 2025**

### **Two Issues Lack Due Diligence in Risk Research**

- I. The Environmental Toxicity of the Solar Panels Employed**
- II. The Futility of Renewable Electrical Energy as an Effective Solution to Climate Warming**

From professional expertise developed in research on environmental and climate science at the University of Sydney, managing agricultural risk for farmers, my research group opposes this development; it is likely to damage farmland irreversibly and fails to diminish climate risks. These two issues call for a halt in introduction of renewable energy until relevant, longer-term, risk research is performed. Two specific risks we have identified previously from our research are (i) turbulent drying downwind of wind farms (Kennedy et al. 2023; Kennedy, 2025 Valley of Winds Submission 10-461) and (ii) heavy metal toxicity from solar panels (Kennedy, 2025, Submission 240002 Muswellbrook Solar Farm).

We estimate at least 100 grams of toxic heavy metals such as silver (Rout et al. 2025), or others classed as carcinogens like lead and cadmium (Nain and Kumar, 2022) in each of more than 4 million rooftop solar installations in Australia, some 400-600 tonnes in total of metal toxins with unknown future effects on human health, but certainly not zero when distributed so widely. Today, we deal with the level of threat to the Gulgong agricultural environment from the 500 MW Tallawang installation, equipped with 1000 MW-hours of battery storage.

**There is a Need for Due Diligence in Dealing with Climate Change. The current failure to conduct risk research under Australian environmental conditions for solar farms may lead in future to legal class action claims for damages to farmlands and the environment. Overall, the science of climate change is characterised by uncertainty, both in causes (Kennedy et al., 2025a, 2025b) and in outcomes from mitigation. Without both prior and continuing research, this uncertainty looms larger.**

#### **I: Major Risks from Toxic Heavy Metals Content in 500 MW of Solar Panels**

Crystalline silicon photovoltaic modules contain approximately 75% of the total weight from the surface of the module (glass), 10% polymer (polyvinylidene difluoride (organofluorine PVDF) & ethylene vinyl acetate (EVA)), 8% aluminum as framing, 5% silicon (solar cell), 1% copper (interconnectors) and 0.1% silver contact lines, with other metals like tin and lead. The cells are electrically interconnected by copper, creating a string of cells in series.

About 20-30 tonnes of metallic silver may be embedded in the monocrystalline silicon solar panels at Tallawang (Balji et al. 2024), just under 0.1% of the weight of the installation (about 35,000 tonnes). Possibly, less toxic copper wiring could be substituted for silver as conducting wires, although this possibility still needs development.

New solar panels will have no immediate toxic effect, with heavy metals contained in glass, unless cells are broken. Only 1% of this chemical silver becomes leachate in the Tallawang solar panel lifetime at 30 years, because of extreme environmental conditions, like variations in temperature, ultraviolet radiation or in impulsive pressure in meteorological hailstorms. Then at least 1300 ha of prime land needed for agriculture could be lost forever. Remediation of the top layer of soil from bound silver or other heavy metals is economically impossible. Faulty solar panels are usually prohibited by government from disposal in landfill because of their heavy metal content, although the risk of contamination of groundwater is real, particularly if soil texture is low in organic-clay content with poor metal binding capacity. Otherwise, binding of heavy metal ions is so tight to organic soil complexes that only strong acid extraction will remove them, also a harmful process.

A recent pamphlet (August, 2025) from the Clean Energy Council entitled *Debunking Myths about Solar Panel Toxicity* unwisely discounts longer term toxic risks from panels, claiming all metal contents can be successfully recycled, ignoring the previous life cycle. The Clean Energy Council has no evidence to guarantee such a costly requirement, given responsibility is not clearly allocated. Reliable evidence to the contrary is presented below of recycling's ineffectiveness, because it assumes all panels will survive for processing. **The CEC has ignored the fact that only traces of heavy metal content, such as silver, cadmium, selenium, lithium, copper and even silica itself are needed to express lethal toxicity to living organisms. Silver ions are the second most toxic heavy metal after mercury. The long life cycle of solar farms up to 30 years invalidates short term leaching tests on panels, unstressed by physical and chemical corrosion, including pressure pulses in turbulent storms, hailstorms and temperature extremes.** The recycling concerns have very recently been taken up by researchers at Macquarie University in a patented Jet Electrochemical Silver Extraction (JESE) process, a "pressure washer" method using strong nitric acid to selectively dissolve and extract silver from discarded solar panels while leaving other components intact, including silicon wafers and glass. Their publicity confirms that standard solar panels contain 20 g of silver making the process possibly worthwhile since 630 g per tonne of solar panels, this is similar in content to average silver ores (Balaji et al. 2024). However, such recycling is only possible "after the event" with respect to possible soil and groundwater contamination.

## **II: The Futility of Renewable Energy is Shown by Our Recent Research: Our TAC hypothesis predicts net CO<sub>2</sub> is emerging from a warming ocean from acidifying calcification, reversing cause and effect**

Climate science lacks certainty. Even serious warming by CO<sub>2</sub> requires twice as much warming by extra water. The vibrational spectrum of CO<sub>2</sub> is saturated at low altitudes, requesting rotational shoulders to provide radiative forcing.

Our recent peer reviewed research published since 2019 (e.g. Kennedy et al. 2025a, 2025b, 2022) indicates that, as a net process, CO<sub>2</sub> is emerging from the ocean as a response to surface seawater warming. Obviously, this reverses cause and effect, requiring different climate change management. Our thermodynamic evidence (Kennedy et al. 2022) showed that the warming of seawater favours absorption of CO<sub>2</sub> in spring and summer, acidifying the surface water slightly while making calcite or calcium carbonate and then a net excess of emission of CO<sub>2</sub> in autumn and winter as seawater cools. We refer to this as the thermal acidifying calcification hypothesis (TAC), based on our literature review modelling calculations as well as previously unexplained oceanographic data, showing falling pH in seawater. This evidence has recently been submitted to the US Department of Energy for assessment by a Review Team. Our TAC hypothesis proposes that fossil fuel emissions are largely being absorbed by two processes, firstly calcification as seawater warms and secondly, photosynthetic greening as observed from satellites.

If this TAC hypothesis, well supported by peer-reviewed research by other oceanographers (Kennedy et al., 2025a) is soon accepted, new strategies to manage climate change will be needed. The impacts of toxicity from solar panels will also have been in vain.

Each of these two issues will now be dealt with in more detail.

## **I: Monitoring risks of soil and groundwater contamination from toxic heavy metals**

For crystalline photovoltaic cells, silver paste is applied to silicon solar cells of panels to speed up electron transport from sunlight in a voltage gradient, for better electrical output efficiency. Silver can be reactive, particularly with hydrogen sulphide (Mukherjee et al., 2025) formed by plant metabolism from photosynthesis and slowly in soils under anaerobic conditions of respiration. The ubiquitous blackening of silver-plated vessels is evidence of this process, allowing surface leaching as ionic silver sulphide. Thin-film panels containing cadmium telluride rather than silver contain about 7 tonnes of heavy metal per 100 MW of power (Zapf-Gottwick, 2021). Field research by Yousuf et al. (2024) showed rice field solar panels experienced an increase in Cd levels from 0.47 mg/kg in 2022 to 1.55 mg/kg in 2023, although other metal concentrations decreased, probably a result of field surface variations and sampling challenges. In obtaining field data under solar panels, questions arise as to soil type and depth of infiltration of leachate from panels and the age of solar installations affecting the extent of corrosion.

Each solar panel rated for 400 W could contain about 10-20 g of dispersed silver wire (Ag) (Rout et al., 2025), as well as copper and other minor metals. A 500 MW facility could contain up to 20-30 tonnes of silver, dispersed in the glass panels, to improve flow of electricity. Even a small lifetime leaching rate of less than 1-5% could lead to serious 'forever' contamination of soil, preventing plant growth.

The specific heavy metal composition of the bifacial solar panel modules used at the Tallawang Solar Farm is not publicly detailed, so these literature values are assumed as approximate. The International Energy Agency Report for the Technology Collaboration Programme gives Figure 4 as one example of bifacial PERT solar cell scheme invented at

UNSW, showing front and rear metal grid material of aluminium and silver (Ag). See [https://iea-pvps.org/wp-content/uploads/2021/04/IEA-PVPS-T13-14\\_2021-Bifacial-Photovoltaic-Modules-and-Systems-report](https://iea-pvps.org/wp-content/uploads/2021/04/IEA-PVPS-T13-14_2021-Bifacial-Photovoltaic-Modules-and-Systems-report). And

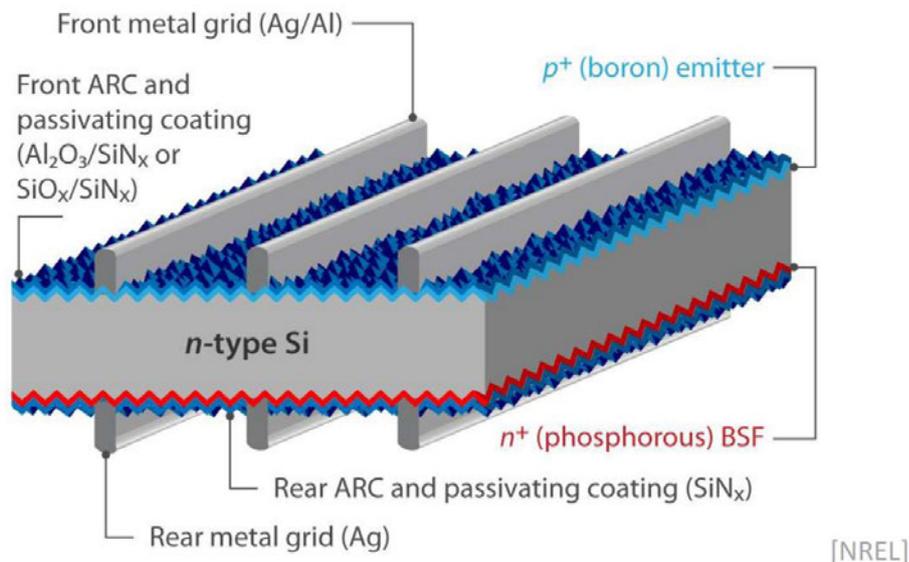


Figure 4: Typical bifacial n-PERT cell scheme.

More recently, shown as Figure 5 in the above reference, more efficient hetero-junction solar cells (HJT) that specify silver (Ag) only for front and rear metal grids have been developed and may be employed in the Tallawang depending on cost.

- i) **Recommendation for immediate soil testing and future monitoring of current solar farms and urban panels sites.** Have risks of toxic contamination of soil been scientifically assessed by accurate monitoring under Australian conditions? Such a programme would require prolonged collection of runoff from panels and precision analysis after concentration of liquid samples. Short-term laboratory testing overseas has confirmed leaching of broken cells (Nover et al. 2021), but not for testing in solar panels after environmental stressing for years. In Australia, no peer-reviewed long-term statistically valid quality-controlled analyses of soil under solar panels have been conducted after 20 years maturing, despite some current retirement of solar farm sites, possibly for fear of positive results and lack of funding.
- ii) **Likelihood of thunderstorms panel-shattering hail greater than 25 mm.** Misadventure such as thunderstorms with large hail destroyed much of a functioning Houston solar farm in Texas, USA, in March, 2024, just two years after its commission. This is not an isolated incident. Raupach et al. (2023) reviewed evidence for hailstorm damage in Australia. This July, Raupach and Aldridge (2025) published their modelled prediction that risk from hailstorms is increasing with warming, expected to increase hail size in the 21<sup>st</sup> century, potentially exceeding 100 mm in diameter. For example, Kalgoorlie showed increases in both giant hail (from ~12% to ~21%) and 100 mm hail (from ~1% to ~2%). Even more common 25 mm hail stones can shatter glass-enclosed solar cells. Fragments from

shattered panels will certainly be leachable to soil, with mildly acid rain. At least one such major hailstorm event is probable during the operation cycle of each solar farms of 20-30 years, a period claimed by manufacturers for operation retaining at least 80% efficiency. Slightly thinner glass used in bifacial panels as proposed for Tallawang solar farm are reported to fragment more easily into smaller sizes (Solar Choice data) than monofacial cells. Once shattered on soil corrosion would be rapid by oxidation, leaching into runoff water as an ionic form ( $\text{Ag}^+$ ), binding firmly with organic matter complexes with clays in soil. Silver ions are at the highest scale of heavy metal toxicity just below mercury (Tsepina et al. 2022); they bind in ionic form to essential components of living systems like enzymes and rank next after chromium on the list of mutagenic substances, potential carcinogens.

- iii) **Estimating toxic concentrations in soil underneath panels.** According to available information, a concentration of silver in soil considered toxic generally falls within the range of 1-10 mg/kg (1-10 ppm by weight) depending on the soil type and the form of silver present in soil (Tsipina et al., 2024); however, even concentrations as low as 0.1 mg/kg may show detrimental effects on soil microbial communities in certain situations. Such a low concentration might be reached with as little as 0.1% lifetime leaching of silver from panels to soil. Sterilisation of drinking water at risk from *Legionella* is achieved by electrolytic formation of silver ions ( $\text{Ag}^+$ ). For soil density of 1.3 or around 1,300 kg per cubic metre, and for a mid-range toxicity 5 mg/kg (5 ppm by weight), then a total release of only 1.3% or 650 mg of silver per metre square out of 50 g silver would contaminate 130 kg of soil to a depth of 10 cm, enough to prevent all surface plant life. Alternatively, considering there is 50 g of heavy metal toxin in every kW of solar panels, 0.5 g or 1% would contaminate 130 kg of soil to 10 cm depth to 3.8 ppm by weight of soil. Once released as leachate from panels, heavy metal ions may bind firmly to surface soil and the contaminated area lost to agriculture as a hazardous site, possibly forever.
- iv) **Need for risk research for the probability of toxic impacts.** A legitimate question regards chaotic meteorology (Raupach and Aldridge, 2025) that may be further induced over solar farms with low albedo. A warmer surface on solar farms will cause more evaporation, providing the huge latent heat energy of water vapour that at 5% of air powers major storms. What is the likelihood of major hailstorms in the 20-30 year life cycle of solar panels? The 350 MW "Fighting Jays" solar farm's lifetime for many of the panels was reduced to zero less than 2 years from July 2022. Research is needed to determine the risk of leaching under such circumstances, as conducted by Sharma et al. (2021) for solar panel waste, indicating USEPA toxicity characteristic leaching procedure (TCLP) leachate levels in ppm in water. This research study indicates that solar panels should not be disposed of at end-of-life in land fill, because of toxicity in ground water, particularly if at acidic pH values.
- v) **Benefits of risk research and management of solar panels.** There may be ways of reducing damage, such as protection from storm or hail damage, such as orientation of panels, use of monofacial panels or avoidance of leachable sandy

soils. Professor Penelope Crossley of the University of Sydney advised NSW Parliament on this matter of inadequate faulty or end-of-life solar panel disposal, provided as expert legal opinion; she stated that no legal methods of disposal for used solar panels are currently available in Australia. This practice confirms their hazardous toxic nature, at variance with the Safe Energy Council. Dismantling and transport costs for the major components would be uneconomic and the quantities of silver involved from 30 million tonnes of super structure such as aluminium at Tallawang make recycling practically impossible.

**This brief analysis concludes with the following recommendations:**

- (i) A life cycle risk analysis for the Tallawang site should first be performed, including clear responsibility for funding safe methods of panel disposal, given chemical recycling in Australia is not economic nor likely to be. We cannot accept a high probability of losing such an area of our productive soils, either from future agriculture or the natural environment.
- (ii) Nover et al. (2021) have confirmed ease of leaching from photovoltaic modules focussing on cadmium for 1.5 year leaching experiments, less than one-twentieth the expected module lifetime. Short- term experiments with crushed PV modules are irrelevant, given the naturally more disruptive environmental variables of oscillating temperature, leaching by acid rainwater with pH value less than 7 and significant ultraviolet radiation, stressing the glass modules, causing their structural deterioration by separating their layers and increasingly exposing metals to leaching. Poddar et al. (2024) point to the greater rate of solar panel deterioration with warming. Meteorologists have even proposed recently that very large, blackened panels could be used to increase precipitation from convective rainfall (Branch et al. 2024); this could apply to a 11,300-ha low albedo site. Hail damage might be minimised by orientation of panels, and protective shielding in storm prone areas of higher humidity. Such measures should be investigated as risk mitigation by proprietors for insurance, as recommended by Raupach and Aldridge (2025).
- (iii) Who is responsible for monitoring? Properly conducted periodic analyses of runoff and soil under solar installations should be performed at least annually to help ensure environmental safety is guaranteed. No long-term leaching experiments have been performed, suggesting too much confidence by the SEC and IPCN regarding safety because of the noble purpose of combating climate change. By contrast, trials including simulated hail damaged panels are needed. Such soil and water analysis is readily available commercially, or in government departments. If serious leaching is detected, who will enforce the process of replacement with non-leaching panels?

**In the Muswellbrook Solar SSD 46543209 (27<sup>th</sup> May 2025),** risks from solar panels (Kennedy, Submission 240002) were disregarded casually without counter evidence in the following statement:



Is there an insecure scientific basis for current climate science? Here we identify strong chemical reasons why there might be. Global warming is attributed to increasing pCO<sub>2</sub> in the atmosphere, assuming a larger climate sensitivity factor caused by increased water vapour in air from radiative forcing by CO<sub>2</sub>. Furthermore, the theoretical radiative forcing evidence for warming is based on spectral shifts by the rotation spectrum of CO<sub>2</sub>, because its vibrational spectrum at 15 µm is saturated. World-wide policies by governments to reduce combustion of fossil fuels to zero are now regarded as essential by the United Nations. However, as explained here, there is a distinct risk that such policies will not have their desired effect. This risk stems from confusing the causes of warming with its effects. At issue is the direction of causation. Is warming occurring because of increasing pCO<sub>2</sub> or is pCO<sub>2</sub> increasing because of warming? Our analysis of published data (Kennedy et al. 2025a, 2025b, 2025c, 2024; 2022; Kennedy and Hodzic 2019; shows that the rising trend in pCO<sub>2</sub> in the atmosphere seen in the Keeling Curve on Mauna Loa could result from seawater warming and pH-lowering calcification. On a seasonal basis this can be seen as a fall in the pH value of seawater in spring and summer with calcification, forcing a net emission of CO<sub>2</sub> to the atmosphere in autumn and winter with decalcification while pH rises. These effects are supported by published ALOHA oceanographic data showing large seasonal variations in pH values, with a decreasing pH value of seawater with time. If our hypothesis is confirmed with more field evidence, all efforts to achieve zero carbon by solar and wind renewable energy, or to artificially absorb CO<sub>2</sub> from the atmosphere, will fail thermodynamically. Any diminution of atmospheric CO<sub>2</sub> from such efforts will inevitably force emissions of CO<sub>2</sub> from the ocean surface to restore equilibrium, which is controlled by the pH value of the ocean surface seawater, or on land where bicarbonate is present. [See Appendix Kennedy et al. (2025b) attached for description of the TAC hypothesis for net CO<sub>2</sub> emission from surface seawater.]

## Conclusion & Recommendation

All references supporting my 5-minute verbal presentation are given below. In view of uncertainty in causes of climate change we recommend a halt in renewable energy development until its benefits for managing climate change are made clear. Risk management and quality controlled research should be employed to give clear scientific guidance for responsible action, minimising the likelihood of the serious unintended consequences that we predict. Unfortunately, this is not true in August 2025.

Yours sincerely,



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