Submission to:

Australian Government Productivity Commission:
Opportunities in the circular economy - Call for submissions

from: Robert A. Gell AM

Over the last three years I have become very interested in the management of end-of-life solar photovoltaic panels and the potential for the recovery of valuable materials from them for remanufacturing. During that time I have been employed part-time by Solar Recovery Corporation, a Melbourne-based startup that has partnership agreements with international technology suppliers for the purpose of materials recovery from EoL solar PV panels.

I am making this submission as an individual as my comments go beyond the ambit of SRC.

Solar panels and the circular economy.

Solar PV panels provide an ideal circular economy model as panels have only five(5) main components: an aluminium frame, high quality, low iron content glass, copper, plastics and silicon which are all recoverable and valuable for remanufacturing to support the *Future Made in Australia* programme, Australia's clean energy transition and increased manufacturing capacity in general.

NB: silicon is now on Australia's critical minerals list, aluminium and copper are designated strategic minerals. None should be exported as 'waste'.

Notwithstanding that solar PV panels are currently not designed to be deconstructed for easy materials recovery, there are new technology systems available that are specifically designed to do so. The best available technology is provided by La Mia Energia[1] (LME), Cassino, Italy. LME has developed an entirely mechanical technology that recovers 100 per cent of end-of-life (EoL) PV panel materials, at high quality and in large volumes (~200,000 panels/yr/machine).

There are other useful processing technology system produced in China and Taiwan and some in development in Japan and Germany. These often include chemical processing or systems requiring high temperature techniques. Manual processing is offered by some organisations. There are also efforts to test EoL panels to make them available for second use both in Australia and for export to e.g. South Pacific nations. It is highly unlikely that those propositions will be economic without significant government support.

More importantly Basel Convention E-waste Amendments and Hazardous Waste (Regulation of Exports and Imports) Act 1989 will be important when considering second use as an option. It is also unlikely manufactures will provide warranties or process guarantees for second-use panels. 'Reuse' as a primary option is not viable because of rapidly increasing size and efficiency of modules. Most importantly it would be considerably more valuable for Australia to develop new solar panel manufacturing capacity and to provide large, high value, Australian-made solar panels to e.g. South Pacific nations, though our overseas aid budget.

If governments seriously wish to promote circular economy thinking that will support a *Future Made in Australia,* they should be identifying the technologies that will recover the most materials (i.e. 99+%/panel), at the highest quality and at the highest efficiency rates to facilitate new manufacturing capacity.

Notwithstanding the opportunity end-of-life solar panels represent as a a circular economy model it's currently a complex playing field with many overlapping (coincident?) interests.

See attached: SRC_Siemens_circular_July 2024.pdf - slide 3

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[1] La Mia Energia

Terminology

Solar Recovery Corporation is not a involved in recycling of solar panels. SRC passes recovered materials on to recyclers for reprocessing. The company describes itself as:

... a materials recovery company trading commodities in a circular economy.

The word 'recycling' is poorly used in Australia. Most so-called 'recyclers' are collecting aluminium frames for export, perhaps some copper from junction boxes, perhaps some silicon. They are not actually recycling any of those materials - they're collecting them. Few are using sophisticated technology and/or processing large volumes of panels.

The opportunity.

End-of-life solar panels are a growing problem worldwide. Some contaminate landfills; there is not constant legislation across Australian states to keep them out of landfill and certainly no legislation to ensure the valuable materials in them are kept in the country.

In Europe the WEEE Directive (2012)[2] responds to two important drivers:

1. Ethically, wireless, electric and electronic 'waste' should not be exported to developing nations as they have less capacity to manage it than European nations.
2. The materials in wireless, electric and electronic products are finite in nature, valuable to clever economies and should be retained in Europe for reprocessing.

The incipient Federal Government solar panel produce stewardship program *Wired for change*[3] will be a valuable step forward, however, the question that should be asked by government is "*what are the best technologies and processes available for materials recovery*" not whether or not a programme proposal will keep solar panels from entering the landfill stream.

Two million solar PV panels is the equivalent volume of Uluru. By the end of 2025 it is estimated that there may be 5 million EoL panels in Australia. From this volume of panels LME technology is technically capable of recovering approximately:

- 75,900 tonnes of glass
- 13,200 tonnes aluminium
- 12,100 tonnes HDPE/EVA
- 5,500 tonnes silicon (suitable for upgrading - could produce 400 tonnes of nano-Si)
- 5,500 tonnes copper
- 110 tonnes silver (+ small amounts of other metals)

While the *Australian Silicon Action Plan*[4] has identified the need to find more silicon in Australia to support a potential PV panels and battery manufacturing industry, the solution proposed is essentially new quartz mines in southern Western Australian and northern Queensland for the production of silica for the extraction of silicon. More mines with undoubted planning and indigenous land issues to consider together with large infrastructure capital costs.

Economic considerations

The economics of the solar PV panel supply chain is not well understood. The value and future value of recovered materials is underestimated.

Typically Australian companies export scrap metals such as aluminium from solar panel frames. It's the easy part of solar panel 'recycling'. Unfortunately there are few facilities for value-adding aluminium PV panel frames in the country and exporters can earn in the order of AUD 1.65/kg.

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[2] Waste from Electrical and Electronic Equipment (WEEE), European Commission

[3] Wired for change: Regulation for small electrical products and solar photovoltaic systems

[4] Australian Silicon Action Plan, CSIRO and PwC, November 2022

However, there is at least one aluminium remelting facility in Australia although this is not understood by DCCEEW (*pers.comm*. Smart Energy Council *Solar Module Product Stewardship: Reuse Desktop Study Draft Report launch*, Brisbane 26 August 2024). That company offers AUD 2.75/kg and produces aluminium billets for use by Australian manufacturers. This is effectively 'green aluminium' as it has 90 per cent less embodied energy than aluminium from virgin materials and ideal for companies engaged in correct Scope 3 emissions reporting.

We could produce 'green copper' the same way if there were any remaining, easily accessible copper melting facilities here. Currently 800,000 solar panel modules are being exported![5] (It is estimated that there would be 480 tonnes of copper in these modules with an estimated value of $3,360,000 if this figure is correct).

We can certainly produce 'green silicon' too, from recovered materials. 'Green' materials (metals) are not necessarily only those made from virgin feedstock (metal ores) using renewable energy rather than fossil fuels, they'd be much 'greener' if they were recovered and recycled using renewable energy.

Solar glass represents a particular opportunity. ARENA CEO Darren Miller has estimated that Australia will require 2 billion solar panels installed to meet our 2050 Net Zero target (*pers.comm*. Sundrive launch, Kurnell, NSW, 1st November 2023). As panels do not survive 20-25 years his estimate should be closer to 4 billion panels.

Unfortunately there's already insufficient sand available in on the planet to fulfil the construction industry's needs let alone to make the glass required for Australia's future solar panel needs[6]. Despite it's relatively low value, the availability of solar glass will no doubt be a critical limiting factor in Australia's clean energy transition and in Australia reaching its declared Net Zero targets.

It will be essential to recover and recycle glass from EoL panels into new solar glass.

The USA has recently invested in Qcells, a solar panel manufacturer to become the first US company to produce solar glass[7]. US company Solarcycle now has plans to to manufacture solar glass[8]. Until this investment was made through the Inflation Reduction Act of 2022[9], all solar glass has been made in China. Both Tindo and Sundrive import glass for PV panels from China.

Germany has already legislated that manufacturers should reduce emissions in parallel with national Net Zero targets. German glass manufacturers (e.g. Schott[10]) therefore understand that the use of methane for heat is no longer a tenable option and is developing technologies that use hydrogen as a replacement fuel for the generation of the large amounts of heat required for glass manufacture[11].

If Australia is to develop hydrogen production at facilities at e.g. Gladstone, Qld, perhaps the real opportunity is not to export the hydrogen in a very competitive market but to use it to establish a southern hemisphere solar glass manufacturing capability. I am aware of leading, global panel manufacturers, as well as emerging Australian manufactures who would welcome the opportunity to purchase Australian solar glass that could also be certified with valid modern slavery declarations.

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[5] *pers. comm* Smart Energy Council *Solar Module Product Stewardship: Reuse Desktop Study Draft Report launch*, Brisbane 26 August 2024

[6] Sand and Sustainability: 10 Strategic Recommendations to Avert a Crisis, UNEP 2022

[7] Qcells' Historic Investment Supported by Conditional Commitment for a Loan from the U.S. Department of Energy

[8] Solarcycle to build solar glass factory in Georgia, recycle Qcells panels, *Renewables Now*, 19 Feb 2024

[9] President Biden's Inflation Reduction Act (IRA) of 2022

[10] SCHOTT developing climate-friendly glass production using hydrogen, 2 May 2022

[11] SCHOTT produces optical glass with 100 percent hydrogen, 16 April 2024

NB: using recovered, crushed glass from EoL solar panel as a sand substitute in concrete is not a 'cyclic' reuse - it's a linear second use. It certainly doesn't facilitate circularity.

Other notes:

- A real economic analysis of the solar PV supply chain is required – full economic value created through recovery of materials – mining infrastructure, production costs, energy budgets, transport costs, emissions etc.
  - e.g. what are the comparable economies of recovering silicon from PV modules vs mining quartz?
  - what is the value of investment in nano-Si production from recovered Si - better to not destroy the Si in your recovery process using chemicals!
- true 'green' silicon is not Si that's been produced using hydrogen, it's low embedded energy Si. The same is true for aluminium and copper, glass etc.
- current considerations seem to be about the level of subsidy the Federal Government will provide to 'recyclers' for them to be able to undertake 'recycling' rather than have panels going to landfill (qv Minister Plibersek's announcement in parliament)
- the economics of any scheme should focus on the efficiency of materials recovery processes e.g. Cleanaway was unable to develop an economically efficient process as they could only achieve 60% materials recovery.
- it should not be '*we're trying hard; doing our best but our technologies don't recover sufficient value in materials (in fact some processes destroy potential value) to be economic – you'll need to subsidise us*'.
- the *Future Made in Australia* objectives should negate the typical Australian response to make 'some sales to foreign markets'.
- if the regulatory market is to provide support it should be directed to capacity building in value-adding recovered materials e.g. 'green' copper and 'green' aluminium as significantly lower embedded energy products for Australian manufacturers.
- ARENA understands this as a critical step in its 30:30:30 strategy:
  - i.e. If the materials required to make competitively priced Australian solar panels are available as 'green' materials from EoL panels, the cost of production of renewable energy from solar is reduced.

Attachments:

- SRC_Siemens_circular_July 2024.pdf
- SRC intro_v2.0_Oct 2024: End-of-life solar PV panels - Materials recovery for the circular economy