Inquiry into solar panel reuse and recycling in Australia

Standing Committee on Climate Change, Energy, Environment and Water

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Introduction

This inquiry should be approached from the standpoint of public purpose. The underlying purpose is not the deployment of solar panels as an end in itself. It is the reduction and replacement of fossil fuels by energy systems that are genuinely low in whole of life emissions, materially responsible, physically resilient, and capable of providing reliable electricity over long time horizons. The Committee's terms of reference are broad enough to accommodate that wider question because they extend beyond disposal practices to current and projected waste volumes, comparative costs, environmental benefits, energy security, domestic capability, barriers to scale, alternative policy options, and any other relevant matter.

For that reason, solar panel reuse and recycling should not be examined as though waste appears only at the end of a neutral technological chain. Waste volumes, replacement cycles, recycling burdens, land use impacts, and system integration costs are shaped upstream by the physical and operational characteristics of the technology itself. If a technology has a shorter service life, requires repeated replacement over long planning horizons, depends on very large deployment footprints, and creates additional demands for storage, transmission, and system flexibility, those matters are directly relevant to the scale and nature of the waste challenge now before the Committee.

This submission proceeds from a simple proposition. Solar should be assessed not only as a source of electricity, but as a material system with a whole of life carbon footprint, a physical footprint, a replacement cycle, and a set of externalities. The Committee should not assume that all technologies that are lower carbon than coal and gas are therefore equivalent in long term environmental performance or equally fit for purpose as major pillars of decarbonisation.

Solar is low carbon relative to fossil fuels, but that is not the end of the question

It is important to state clearly that solar is much lower carbon than coal and gas. Any serious submission should acknowledge that point.

But that acknowledgement does not dispose of the real issue. The relevant question is not whether solar is lower carbon than fossil fuels. It plainly is. The relevant question is whether solar is comparatively fit for purpose once the full whole of life picture is considered. On that question, the published evidence is less flattering. Major official reviews place solar above onshore wind on lifecycle emissions, while the literature on nuclear continues to place it in a very low lifecycle emissions range. On these assessments, solar is low carbon, but not among the lowest carbon options once the whole of life comparison is made.

Nuclear should also be part of the comparative frame. That does not mean nuclear is without cost or complexity. It does mean that solar should not be treated as interchangeable with nuclear in whole of life carbon and longevity terms.

The point of this submission is not that solar is high carbon in an absolute sense. It is that the category low carbon is too broad and too undemanding to answer the present inquiry. A technology can be lower carbon than coal and gas and still raise serious comparative questions about longevity, material throughput, land use, resilience, and recurrent waste.

The replacement cycle and the logic of recurrent solar waste

The Committee should give close attention to the replacement cycle inherent in solar deployment. Official material from the United States Department of Energy indicates that the average operational lifespan of a solar panel has increased over time and is now commonly framed in the range of 25 to 35 years. It also notes that some modules and system components are already entering the waste stream early because of weather damage, installation errors, manufacturing defects, repowering, or voluntary replacement. In other words, actual waste flows are not limited to neat retirement at the end of a theoretical service life.

By contrast, longer lived technologies can produce a very different material and waste profile over the same planning horizon. Over a 60-year system horizon, a solar heavy electricity system will ordinarily imply at least one major panel replacement cycle and potentially more where commercial repowering, weather damage, or premature retirement accelerate turnover.

That is directly relevant to this inquiry. Projected solar waste volumes are not merely a downstream problem of insufficient recycling logistics. They are also a foreseeable consequence of building a technology pathway around shorter lived equipment that must be replaced recurrently over time. If the Committee wishes to understand the future scale of solar waste, it should not treat lifespan and replacement rates as side issues. They are part of the core causal chain.

Large scale solar also has significant physical and system externalities

Large scale solar requires substantial land. Utility scale solar requires very large contiguous development footprints. These are not trivial land demands.

Land intensity matters because it creates trade-offs with agriculture, habitat, biodiversity, and landscape values. To the extent that large scale solar expansion intensifies those pressures, the end-of-life waste burden cannot be treated as the only environmental question. A technology with a large physical footprint also carries a larger land use and siting burden over time.

Intermittence is also material. Variable renewable generation introduces supply variability depending on weather conditions and time of day. Effective integration therefore requires greater flexibility across the whole power system, including dispatchable resources, grid enhancement, increased storage, demand side response, curtailment, and other balancing measures. This does not negate solar's value, but it does show that generator level comparisons alone can understate broader system demands.

Grid expansion is part of the same story. The more a system depends on geographically dispersed, weather dependent generation, the more network adequacy, connection, and reinforcement become critical. That in turn affects material use, planning complexity, cost, and the overall environmental footprint of the transition. The Committee need not resolve the entire electricity market debate to recognise that a technology requiring very large deployment and substantial integration support has a broader impact profile than a simple panel level emissions figure suggests.

Extreme weather vulnerability should also be considered. Solar systems can be made more resilient to severe weather, but resilience is not costless. Exposure to storms, flooding, hail, bushfire conditions, and heat stress has implications for durability, maintenance, replacement, and insurance, all of which can feed back into the timing and volume of panel retirement.

Whole of life system carbon footprint of grid scale solar

A proper assessment of solar's environmental performance cannot stop at the panel gate. The relevant question for public policy is the whole of life system carbon footprint of solar delivered reliably at grid scale. At low levels of penetration, solar can often be integrated with relatively modest system effects. But as penetration rises, reliable operation requires additional flexibility, including storage, firm capacity, demand response, curtailment, and network augmentation.

For that reason, panel only lifecycle estimates are incomplete for the purposes of this inquiry. The relevant measure is the combined footprint of the solar installation, associated balance of system infrastructure, the firming technologies required to make intermittent output reliable, the network works needed to connect and transport that output, the replacement cycle of those assets, and their end-of-life treatment.

This matters because the waste and recycling task before the Committee is not limited to solar panels in isolation. It is part of a wider material system that includes inverters, transformers, cabling, switchgear, mounting systems, civil works, substations, batteries, and other flexibility assets with their own embodied emissions and end of life consequences.

This does not mean that all transmission or firming should be attributed to solar alone. Network augmentation benefits the broader power system and storage can serve multiple technologies and system functions. But it does mean that a solar heavy pathway cannot be fairly described as low carbon by reference to module level emissions alone. Once firming, flexibility, replacement, and end of life management are included, the Committee is entitled to ask whether the whole system footprint remains fit for purpose when compared with other low carbon technologies that may require less recurrent replacement and less extensive integration support.

Why market incentives alone will not solve the recycling problem

The Committee should also confront the economic logic of the problem. Recycling will not occur at the necessary scale merely because it is desirable in the abstract. If it is cheaper to dump, export, stockpile, or buy new equipment than to recover, sort, process, and recycle old material, the market will tend toward the cheaper path. That is especially likely where disposal costs can be externalised, enforcement is weak, or the benefits of recycling accrue diffusely to the community rather than directly to the private actor making the immediate decision.

For that reason, the market cannot be assumed to solve the solar waste problem in a manner consistent with good public purpose. If recycling is left to private commercial incentive, it will be shaped by the same logic that helped produce the problem in the first place, namely the preference for the lowest private cost rather than the highest public value. In those conditions, recycling can be underprovided, evaded, distorted, or exploited. The likely result is dumping, sham recovery pathways, underinvestment in processing capacity, regional abandonment of waste, or dependence on unstable offshore arrangements.

That logic becomes even stronger once the full material chain is recognised. The relevant recovery task is not confined to panels alone. Grid scale solar involves the wider apparatus that makes intermittent generation usable, connectable, and reliable. The recycling and disposal challenge therefore extends to inverters, transformers, cabling, mounting structures, foundations, substations, batteries and other firming assets, together with associated network materials. A national recovery system built only around panels would leave a large share of the true waste burden unaddressed.

A federally owned domestic recycling enterprise

For those reasons, domestic recycling should be carried out through a federally owned enterprise with a clear public mandate. The purpose of such an enterprise would not be profit maximisation. It would be to ensure that end of life solar panels and associated infrastructure are collected, processed, recovered, and where possible reused or remanufactured in accordance with environmental standards, strategic material recovery, regional development, and good public purpose.

A federally owned enterprise would be better placed than a fragmented private market to coordinate collection, invest in processing capacity, standardise recovery pathways, prevent regulatory arbitrage, support regional hubs, build domestic technical capability, and maintain accountability over the full chain. It could also be tasked with recovering not merely the visible panel, but the wider material system associated with grid scale solar deployment.

In monetary terms, the Commonwealth has no need to wait upon prior taxation or borrowing in order to capitalise such an enterprise. As the issuer of the national currency, the federal government can provide the financial capacity necessary to establish and operate a public recycling authority where the real resources, workforce, equipment, logistics, and technical capability can be mobilised. The real question is not whether the Commonwealth can afford to create such an enterprise in financial terms. The real questions are whether the labour, engineering, transport, processing, land, and industrial inputs can be assembled, and whether doing so serves good public purpose.

That does not mean price signals and penalties are irrelevant. A recycling levy could still be imposed, not because the Commonwealth requires revenue in order to spend, but because levies can influence behaviour, create a visible discipline on market participants, and reinforce accountability across the supply chain. Such a levy should be paired with very large penalties for dumping, evasion, stockpiling, sham disposal, and other attempts to avoid proper recovery. If dumping remains cheaper in practice, the policy setting has failed.

Why this belongs in a solar waste inquiry

It may be said that these wider issues go beyond reuse and recycling. Respectfully, they do not. The Committee is expressly asked to consider projected waste volumes, comparative costs, environmental benefits, barriers, policy options, and any other relevant matter. A serious inquiry into solar waste should ask not only how discarded panels are managed, but why such waste volumes arise, how fast they are likely to grow, and whether those volumes are partly a function of policy choices about technology mix, service life, system architecture, and deployment scale.

Nor is the relevant recycling question confined to panels. Once solar is deployed at grid scale, the waste stream necessarily extends to the wider apparatus that makes intermittent generation usable, connectable, and reliable. That includes inverters, transformers, cabling, mounting systems, substations, batteries and other firming assets, together with network augmentation associated with connection and delivery. A Committee examining solar waste in any serious sense should not isolate the visible panel and ignore the rest of the material chain.

If the inquiry confines itself to collection logistics and recycling process design for panels alone, it risks treating solar waste as though it were analogous to ordinary packaging waste. It is not. It is the byproduct of a strategic energy choice involving very large material throughput over time. The proper question is therefore not merely how Australia can recycle more solar panels. It is whether policy has been sufficiently attentive to whole of life carbon performance, asset longevity, physical footprint, resilience, firming requirements, grid expansion, associated infrastructure waste, and system effects when promoting solar at scale.

The comparative frame matters here. Wind appears materially lower than solar on published lifecycle emissions estimates. Nuclear appears lower still in major reviews and is distinguished by much longer operating life. Those differences do not automatically decide technology policy, but they do matter when Parliament examines whether solar is fit for purpose as a major long-term pillar of decarbonisation and whether the resulting waste stream, including panels and associated infrastructure, is an incidental management issue or a structural feature of the pathway chosen.

Recommendations

The Committee should expressly recognise that the public purpose of this inquiry is not merely better waste handling, but support for a genuinely durable and environmentally defensible transition away from fossil fuels.

The Committee should treat solar waste as partly an upstream planning issue, not only a downstream recycling issue, because projected waste volumes are shaped by service life, repowering, storm damage, premature retirement, and the physical intensity of solar deployment.

The Committee should avoid assuming that all low carbon generation technologies are equivalent in whole of life terms. Whole of life carbon intensity, asset longevity, material throughput, land footprint, system integration demands, firming requirements, grid expansion, and resilience should all be treated as relevant considerations when assessing the long-term burden created by solar waste.

The Committee should recognise that the market will not necessarily deliver proper recycling outcomes where dumping, evasion, export, or replacement remain cheaper than recovery and reuse. A durable solution requires public authority, not mere reliance on commercial incentive.

The Committee should recommend the establishment of a federally owned domestic solar recovery and recycling enterprise with responsibility for panels and the wider associated infrastructure of grid scale solar systems, including related electrical and firming components where they enter the waste stream.

The Committee should recommend that future stewardship and recycling policy be accompanied by stronger attention to durability, longer service life, repairability, and resistance to premature replacement, so that waste minimisation begins upstream rather than at the landfill gate.

The Committee should recommend a national levy and penalty regime under which participants face strong financial consequences for dumping, sham disposal, stockpiling, or evasion, with penalties set at a level high enough to ensure that improper disposal is not the cheaper option.

The Committee should also encourage a more technology neutral decarbonisation framework in which solar is assessed alongside wind, nuclear, and other low carbon options on a whole of life system basis, rather than being insulated from comparative scrutiny by the mere fact that it is cleaner than fossil fuels.

Conclusion

The relevant public question is not simply how Australia can dispose of solar panels more efficiently after the fact. The deeper question is whether policy has adequately examined the full chain from technology choice to end of life consequence. Solar is lower carbon than coal and gas, but that does not place it beyond serious scrutiny. On the published evidence, solar generally carries higher whole of life emissions than onshore wind, shorter operating life than long lived nuclear assets, substantial land demands, exposure to intermittence and integration challenges, and a recurrent replacement burden that predictably feeds future waste volumes. Those are not peripheral considerations. They go to whether solar is fit for purpose as a dominant long term decarbonisation pathway.

For that reason, this inquiry should not be confined to the mechanics of recycling. It should also ask whether Australia's broader energy policy has given sufficient weight to whole of life system carbon performance, longevity, physical footprint, resilience, firming, grid expansion, associated infrastructure waste, and end of life consequences when promoting solar at scale. If those upstream questions are left unexamined, Australia may build an electricity system that is lower carbon than fossil fuels, yet still more waste intensive, more land intensive, and less durable than it needs to be.

A further and equally important question is institutional. If proper recovery is more expensive than dumping, and if private actors can externalise end of life costs while continuing to profit from sale and replacement, the market will not reliably produce the outcome the public interest requires. In that setting, a federally owned domestic recycling enterprise, backed by a levy regime and very large penalties for dumping and evasion, is not an ideological embellishment. It is a practical recognition that a strategic national waste stream associated with the energy transition should be governed in accordance with good public purpose rather than left to the lowest cost logic of disposal.

Cautionary note

Real world experience should temper abstraction. France has maintained a very low carbon electricity system for decades because of its large nuclear fleet, and the IEA continues to describe its electricity mix as very low carbon for that reason. Germany, by contrast, pursued the Energiewende as a renewables led and nuclear excluding transition, phased out nuclear in 2023, and has yet to achieve the same result. The lesson is not that renewables have no place. It is that policy should be judged by system outcomes, not aspiration. France stands as a real-life example of a model that delivered low carbon electricity at scale for decades. Germany stands as a warning that a renewables dominant and nuclear excluding pathway has not yet done so. We are running out of time. Australia should be very careful before locking itself into an approach that expands material throughput, recurrent waste, land intensity, grid dependence, and replacement cycles without first proving that it can deliver the fastest and most durable displacement of fossil fuels in practice. No country has yet built and sustained a deeply decarbonised national electricity system using wind and solar alone.