RE-ALLIANCE

Retirement age renewables – delivering for Australian communities

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FRONT COVER IMAGE

Tom Gunthorpe, mixed livestock, cattle and fine wool breeder, Kangiara, Bango Wind Farm, NSW.

DESIGN AND LAYOUT

Fireside Agency

About the Renewable Energy Alliance

The Renewable Energy Alliance (RE-Alliance) is an independent not-for-profit working to deliver a responsible and rapid shift to renewable energy that actively contributes to the strength of our regions. We listen to and build the capacity of regional communities to lead the shift to renewables. We bring these crucial insights to our advocacy with government and industry, and we centre solutions-focussed, regional voices in the national narrative on renewables.

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Crudine Ridge Wind Farm, Squadron Energy

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Executive Summary

Australia's shift to renewable energy is well underway, with renewable penetration in the National Energy Market reaching 43% in the first quarter of 2025. Expectations of the growth of the industry remain high, even as some of the earliest projects start to retire. In consequence, attention is now turning to how to sustainably retire wind, solar and battery storage assets as they come to the end of their operational life.

Over the next decade, more than 1 gigawatt (GW) of wind, solar and battery storage projects along Australia's east coast will reach retirement age. That might sound like a lot, but by April 2025, 27.5 GW of large-scale wind and solar energy and another 26 GW of rooftop solar was powering homes and industries across Australia. Our analysis finds that by 2045, 12.5 GW of renewables across the country could be approaching the age of retirement.

As a greater number of projects approach retirement, the way that project owners plan, manage and complete end-of-life processes is coming under increased public scrutiny. In light of previous recycling industry failures and poor decommissioning practices in extractive industries, such as mining and oil and gas, communities are looking for evidence that the renewables industry will 'do right' by them, and that Australia will have enough capacity and expertise to reuse, recycle and recover materials from retiring renewable sites.

In reviewing the current regulatory and contractual settings, RE-Alliance identified that Australia does, generally, have end-of-life management requirements that apply to retiring renewables. For individual projects, planning for retirement must balance technical feasibility, contractual requirements with host landholders, policy and legislative requirements, industry practices, commercial considerations, and evolving landholder and community expectations. Those expectations increasingly include the provision of financial assurance.

There are significant financial, social and environmental opportunities in planning strategically and sustainably for retirement of renewable energy projects. Government and industry must take the lead and, in consultation with host landholders and local communities, work together to nurture and develop leading practices around retiring renewables.

There are three main options for renewables at retirement: refurbishment, repowering and decommissioning. Refurbishment is when components are upgraded to newer ones. Repowering means replacing old technology on the same site with newer, more efficient models, and/or mixes of technology, usually with a higher output. Decommissioning refers to a complete dismantling of the assets, removing equipment and rehabilitating the site, where needed.

While this report began as a deep dive into decommissioning, it has extended into an emerging discussion on repowering. In mid 2024, energy industry consultants GHD estimated that 1.7 GW of Australia's retiring wind generation projects could potentially be repowered to supply 6 GW from those same sites, with one third of the number of turbines. Despite the clear potential, when RE-Alliance reviewed a snapshot of de-identified existing landholder agreement clauses for this project we noted there were no specific clauses for repowering (or refurbishment). There is also no identifiable detail on repowering in planning frameworks.

In addition, it is not possible to have a conversation about the retirement of renewables without addressing the reuse and recycling of materials. We acknowledge the significant amount of work that is taking place in this space, the complexity of the task and the organisations doing it.

Australia is at an opportune juncture to ensure renewables refurbish, repower or retire right. Our **Framework for Action** makes recommendations for governments and industry to deliver consistent, high quality outcomes for the retirement of renewables. The Framework for Action is built on the research undertaken for this report and stakeholder input regarding what is happening now and the pathways that will improve retirement outcomes. Some of the recommendations may require further analysis that considers how any additional costs of action would deliver improved policy outcomes, sustainable material reuse and recovery, and stronger host landholder and public confidence in renewables retirement.

Our recommendations fall within five key areas:

- **Identify opportunities for refurbishment.**
- **Make repowering easier.**
- **Improve confidence in decommissioning.**
- **Provide leadership on reuse and recycling.**
- **Enhance environmental outcomes.**

Ensuring renewables retirement is done well will require collaboration and investment from industry, government and community – including input from community leaders and landholders in this work is key. Communities and landholders need better information and clear guidance on how the system works and reassurance on what the future will hold. This includes ensuring that all relevant safeguards are in place for people and nature. Thankfully, Australia is starting to get on the front foot and has time to get retirement right – provided governments, industry and communities work together to establish clear guidelines and protections. Our report charts a path for industry and government to do this.

Recommendations

IDENTIFY OPPORTUNITIES FOR REFURBISHMENT

Refurbishment of existing projects can extend the life of assets, delay the need for new construction and installation, reduce waste, and extend benefits for host landholders and the community, while utilising existing grid connections. This would help sites deliver the maximum benefit possible from the financial and community investment made in establishing renewables projects.

Recommendations for government:

- State, territory and federal governments should proactively support the extension of existing projects, where appropriate.
- The Australian Energy Market Operator (AEMO) should consider how it addresses and takes account of the potential for life extensions through refurbishment.

Recommendations for industry:

- Project owners and industry peak bodies should articulate policy or market settings that are acting as barriers to the refurbishment of renewables to generate the best energy production and environmental outcomes.

MAKE REPOWERING EASIER

In many situations, repowering sites will provide an opportunity to leverage high value renewable resources and good locations for energy production, without requiring additional land. Fewer new sites means a reduction in the environmental footprint of the shift to renewable energy. Repowering would also embed opportunities to maintain and continue to build on local economic, social and environmental benefits for host landholders, neighbours, communities and local governments.

Recommendations for government:

- The Federal Government should commission a comprehensive assessment of repowering potential for existing renewable locations, including the steps required and investment involved, and consult on this assessment with key stakeholders.
- Consent authorities should identify opportunities for faster assessment pathways for repowered sites, where environmental and social risks are the same or less than those of the existing project.

Flyers Creek Wind Farm, Iberdrola

IMPROVE CONFIDENCE IN DECOMMISSIONING

While the risks to host landholders from decommissioning activities are already very low, the reputational damage to the industry caused by any decommissioning failure would be extremely high. This has already been identified as a concern for landholders and local governments considering hosting renewable energy projects. Improving confidence here is crucial.

Recommendations for governments:

- The Federal Government should include criteria relating to decommissioning in the National Developer Rating Scheme.
- For existing projects, where financial assurance was not included in project conditions or host landholder commitments, state and territory governments should consider introducing a trailing liability requirement to provide assurance that end-of-life obligations will be met.

Recommendations for industry:

- Industry bodies should make a clear, explicit statement – for example through updating the Clean Energy Council 'Best Practice Charter' – that host landholders will not be left with financial or other burdens from decommissioning activities.
- Project owners and industry peak bodies should help to communicate what leading practice management of renewables retirement looks like, including for community engagement and communication, host landholder commitments, financial assurance, circularity commitments, land return and rehabilitation, and the delivery of any nature based outcomes.
- Project owners and industry peak bodies should increase transparency of decommissioning clauses and commitments in agreements. This would assist landholders and communities to understand what to expect from decommissioning and ensure greater take up of current leading practice for end-of-life activities in private agreements.
- Project owners should make public their commitments to provide financial assurances for host landholders for decommissioning and end-of-life activities.
- Project owners should seek reputable certifications of their commitments to leading retirement practices through frameworks such as 'CPVA Certified' or an updated Clean Energy Council Best Practice Charter.

Recommendations for industry and government:

- State and territory governments and industry should work together, in consultation with landholders and community stakeholders, to develop a consistent and industry-wide Financial Assurance Framework for decommissioning activities for new projects. This should build on current leading practice approaches and ensure that any framework is established in a way that does not erode the initial business case for investment at the capital heavy start of a project.

PROVIDE LEADERSHIP ON REUSE AND RECYCLING

The volume of material from decommissioned renewable energy sites will increase over time. Investing now in the development of appropriate markets for materials that can be reused and recycled will help to build social licence around decommissioning. Australia has a unique opportunity to maximise the reuse of materials across the renewable energy industry, by advancing recycling technologies and increasing industry and government cooperation.

Recommendations for government:

State, territory and federal governments should introduce or extend policy settings that support a circular economy for renewable energy projects and invest in addressing barriers to uptake. This requires focus on, and support for, innovation and research, from design to recovery, that will ensure processes continually improve over time. This would include:

- Addressing the barriers to cost effective reverse logistics, i.e. the process of moving goods backwards through the supply chain for reuse or recycling.
- Prioritising reuse before recycling, and creating end-markets for reused products.
- Establishing circularity requirements for renewable energy materials recovery through agreements or partnerships with manufacturers and suppliers.
- Supporting innovation to improve reuse and recycling efficiency across the full suite of renewable energy materials.

Recommendations for industry:

- Existing programs and proposals that demonstrate industry commitment to a circular economy, such as 'CPVA Certified' should be considered and, ideally, adopted by project owners as a matter of priority, and equivalent schemes for wind and battery technology should be developed or expanded.

Recommendations for industry and government:

- State, territory and federal governments and industry should work together to adopt a National Solar PV Product Stewardship Scheme, as proposed by the Smart Energy Council, and develop mandatory producer responsibility schemes in the areas of wind and batteries.

ENHANCE ENVIRONMENTAL OUTCOMES

Increasingly, communities and stakeholders are looking for project owners to ensure sites are not just 'returned to prior state', but 'returned to a better state'. Appropriate environmental protections and management are a key issue in obtaining social licence in many communities and this extends to the issue of retirement options. Opportunities for reducing new environmental impacts through refurbishment and repowering of existing assets follows the 'reduce' principle of circular economy, slowing the demand for raw materials and key components so that those resources can be spent more efficiently, resulting in a lower waste stream that could also lighten the reuse/recycling load. It can also contribute to 'avoidance' in biodiversity management and mitigation hierarchy by minimising the need for new project footprints.

Recommendations for government:

- All jurisdictions should develop and adopt model project approval conditions that set baseline expectations for end-of-life outcomes, without being overly prescriptive and limiting the development and uptake of improved technologies over time.

Recommendations for industry:

- Industry peak bodies should develop leading practice guidelines on the most common end-of-life options to assist host landholders to understand the type of outcomes they can expect following decommissioning.

Foreword

The renewable energy industry we know today can be traced back to the single wind turbines installed to supply electricity to remote areas like Thursday Island in Queensland, or to support industrial sites like Barwon Water's Black Rock Water Reclamation Plant in Victoria. Those small, early projects have been the first to hit retirement age. The first megawatt scale remote solar project, powering a copper mine in Western Australia, was retired in 2024. In the next couple of years, the first wave of grid-connected wind projects will join them. Over time, the number of projects reaching retirement age will grow, meaning it is vital that appropriate systems are in place to ensure that renewables at retirement will be done well. Doing renewables right has to include the post-production phase.

This report about renewables at retirement age has been produced by RE-Alliance to highlight the options and opportunities that are available to industry, governments and the community – including refurbishment, repowering, decommissioning, and reuse or recycling – and the work that needs to be done to ensure we have appropriate management systems in place when projects reach retirement age.

While individual project owners are confident that end-of-life activities will be managed well, there are genuine questions in Australian communities about how well retirement options will be managed at scale. Our research has identified that while there are conditions and obligations for project owners in existing state and territory planning requirements and in host landholder agreements, there remain a number of gaps, inconsistencies, and risks that need to be addressed in relation to the retirement of assets. Current arrangements create uncertainty for communities and a lack of clear, widely available information creates an "understanding gap" that risks being filled by misinformation and disinformation if these gaps and inconsistencies are not clearly addressed.

There is appetite across industry, community and environment groups, civil society, and governments to start working together to get the right settings in place for retiring projects. A collaborative approach is the best way to meet the needs of project owners, host landholders, local communities and the broader energy system.

This report serves as both a discussion paper about current options, gaps and risks, as well as an action framework for what we can do collectively to ensure retirement age renewables delivers for communities.

ANDREW BRAY
National Director
RE-Alliance

The evolving conversation on repowering and retirement

By April 2025, Australia's installed capacity of large-scale wind and solar energy across Australia had hit 27.5 gigawatts (GW).[1] Combined with over 26 GW of rooftop solar,[2] our large-scale and small-scale renewables are already meeting around 40% of Australia's electricity needs.[3] Wind, solar, battery energy storage systems (BESS), pumped hydro, and green hydrogen are all expected to grow in coming years. We're seeing bigger projects, higher energy outputs and new technologies taken to deployment. But as with all technologies, renewables have a finite lifespan. As we plan for growing renewables, we must also plan for their retirement.

This report addresses gaps in public understanding around retirement options for renewable assets, and how Australia can (and does) reuse and recycle materials. The report also highlights areas where more action is needed by industry, government, and other stakeholders to ensure that renewables retirement is done right.

Renewable energy project retirements are of increasing interest to regional communities[4] and governments. Communities and landholders have legitimate questions about the decommissioning process, but the lack of easily accessible information is leading to misinformation and disinformation about how renewables retirement will be managed. Clear answers need to be available for questions such as:

- What assurances are in place for host landholders for decommissioning?
- Can sites be reused (also known as 'repowered') when a project reaches the end of its technical life and what opportunities does that present? What assessments would need to be made?
- What happens to assets and associated infrastructure when they are removed and can they be recycled?
- How do we collectively ensure Australia has enough skills, capacity, and facilities in the right place to reuse and recycle larger quantities of renewables to support local industry?
- Will the land be returned to its prior use, or another agreed use?
- Do governments have the right policy settings in place to enable current leading practice?

THERE ARE THREE MAIN OPTIONS FOR RENEWABLES AT RETIREMENT: REFURBISHMENT, REPOWERING AND DECOMMISSIONING (TABLE 1)

TABLE 1: Three main options for renewables at retirement age

Refurbishment (or life extension)	Upgrading components of the existing assets and infrastructure at a renewables site to newer components.
Repowering	Replacing old technology on the same site with newer, more efficient models, usually with a higher output.
Decommissioning	Completely dismantling the assets and associated infrastructure, removing equipment, and rehabilitating the site, as agreed with the landholder.

Sources

1 RenewMap
2 Clean Energy Regulator as at 30 March 2025
3 Open Electricity
4 This wind farm is retiring, so what happens to its tonnes of steel?

COMMUNITY AND LANDHOLDER CONCERNS ABOUT DECOMMISSIONING

Historical failures in the decommissioning process across industries like mining and fossil gas extraction have left local environments with significant damage and communities without recourse for action.[5,6] This has created understandable mistrust about the decommissioning of renewable energy projects. Recent developments to strengthen decommissioning requirements and information for renewables (for example in Queensland and New South Wales) are welcome, but existing distrust and concerns remain a barrier to wider support for the shift to renewable energy.

RE-Alliance has been working across Australia for over a decade in regions where renewable energy is operating, under construction, or being proposed. While we have heard that many individual landholders are confident with how their agreements with project owners deal with decommissioning, some potential host landholders have cited a lack of confidence in decommissioning commitments as a reason not to host renewables on their land.[7]

A 2024 report from Farmers for Climate Action identified such concerns among their membership, stating that there were "no clear regulations on decommissioning", and noted a perception that this could leave renewable energy landholders with liability for any environmental damage caused.[8] The lack of publicly accessible information means that despite many mitigations, there are still concerns that the asset owner could 'go bust', be unable to fund and manage their decommissioning obligations, and leave this burden to the host landholder, or relevant state or territory authority.

Filling these information gaps will be crucial to bolstering community understanding around the shift to renewable energy and will help to prevent the circulation of misinformation and disinformation on decommissioning activities.

Sources

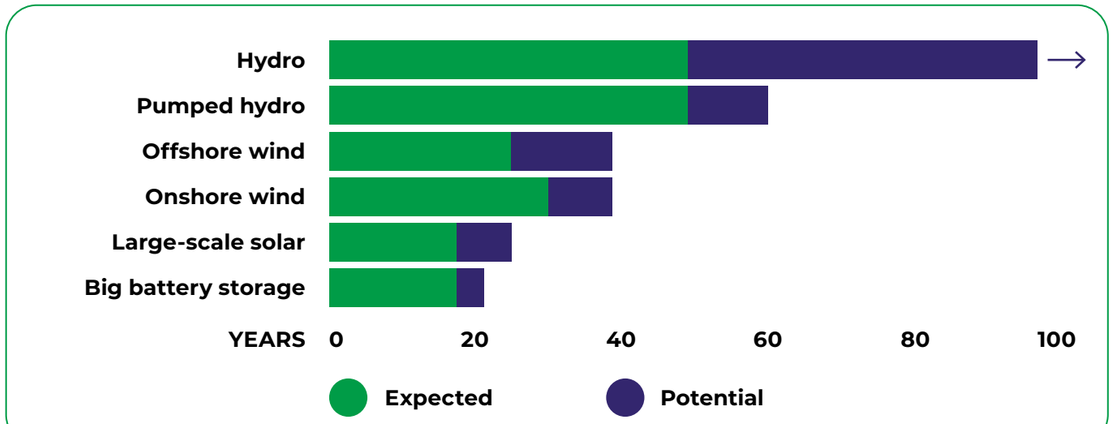
5 What should we do with Australia's 50,000 abandoned mines?
6 As gas runs out in the Bass Strait the debate over how to dismantle massive offshore rigs is heating up
7 Concerns over renewable energy clean-up bill turns some off wind turbines in rural communities
8 Farmers for Climate Action Renewable Energy in Farming Communities Summary Report September 2024

How many projects are reaching retirement?

HOW LONG DO RENEWABLE ENERGY TECHNOLOGIES LAST?

There is no specific retirement age for renewables. Like all technologies, the time to retire is when they are no longer working or can no longer be refurbished to continue working as required. Commercial or policy influences can also push out or bring forward the retirement time. From a sustainability perspective, getting as much use out of existing assets as possible is best, but there will be a diminishing return as power output or performance lessens with age.

FIGURE 1: Anticipated renewables retirement ages



Retirement age varies by technology, and is trending longer over time.

- **Hydro:** 50-100+ years
- **Pumped hydro:** 50-60+ years
- **Offshore wind:** 25-40 years
- **Onshore wind:** 30-40 years
- **Large-scale solar:** 20-25 years
- **Big battery storage:** +20 years

Clarke Creek Wind Farm, Squadron Energy

WHAT RETIREMENTS HAVE HAPPENED SO FAR?

Australia's renewable energy industry was pioneered in the 1980s. Those sites were mostly single or a small number of wind turbines installed to provide electricity to remote areas. They have been the first to hit retirement age, with decommissioning the most common outcome, as seen in Table 2.

TABLE 2: Renewable energy projects decommissioned or repowered (as at April 2025)

Year of first generation	Technology	Power output	Location	Retirement status
1987	Wind	360 kW	Salmon Beach WA	Decommissioned in 2000
1987	Wind	60 kW	Breamlea VIC	Proposed to be decommissioned in 2025
1993	Wind	2 MW	Ten Mile Lagoon WA	Decommissioned in 2022
1997	Wind	1 MW	Thursday Island QLD	Refurbished in 2024
1997	Wind	600 kW	Kooragang Island NSW	Dismantled in 2014 and reused at a poultry farm in Woolnorth, TAS[9]
1998, expanded 2003	Wind	0.75 MW plus 1.7 MW	King Island TAS	To be refurbished by 2027 and additional battery storage added[10]
2004	Wind	3.6 MW	Nine Mile Beach WA	Decommissioned in 2022
2016	Solar with BESS	10.6 MW solar with 6 MW / 1.4 MWh BESS	Meekatharra WA	Decommissioned in 2024

When installed, the oldest of Australia's larger and grid-connected wind farms were projected to operate for around 20 years, but in practice their service life is looking to be at least 30 years.[11] To date, none of the oldest grid connected wind farms have been retired and decommissioned but a number are approaching retirement age.

While decommissioning is common in residential rooftop solar in Australia, to date there are only a small number of large-scale solar installations being decommissioned earlier than their technical lifespan. For example, in 2024, Neoen announced the retirement of their 10.6 MW Degrussa Solar Farm, initially installed to cut diesel use at the Sandfire Resources copper mine in Western Australia.[12] At less than eight years old and comprising around 34,000 solar panels, with the closure of the copper mine, this solar farm was decommissioned long before its technical end-of-life. While Neoen expressed a preference for the reuse of the solar panels, immediate refurbishment options were lacking, illustrating the importance of solutions being available in advance of the end of the technical lifespan of the installations.

Sources

9 Kooragang Island turbine starts new life in Tasmania

10 Australia's oldest wind turbines back in action with a Danish facelift, and a major life extension

11 See for example Renew Economy One of Australia's oldest wind farms extends life to 30 years, and Renew Economy One of Australia's oldest wind farms turns 20 today, and will live on for another decade

12 Neoen calls time on pioneering off-grid solar and battery project, decommissions Degrussa

WHAT'S LIKELY TO RETIRE IN THE NEXT TEN YEARS AND BEYOND?

Our analysis of Australian Energy Market Operator (AEMO) data shows that over the next ten years the east-coast grid will see over 1 GW of wind, solar and BESS projects reaching their nominated retirement age (Table 3). Putting this in context, by April 2025, Australia had 27.5 GW of large-scale wind and solar energy across Australia and another 26 GW of rooftop solar, powering our homes and industries. Based on the nominated closure dates or projected lifespan at the time of installation, the oldest projects are the first grid-connected projects likely to retire, be refurbished or repowered in this timeframe.

TABLE 3: Oldest grid connected renewable energy projects across Australia (excluding hydro and projects less than 5 MW)

Year of first generation	Technology	Power output	Number of turbines /panels /units	Location	Owner (as at April 2025)	Status[13]
1998	Wind	5 MW	8	Crookwell NSW	Tilt Renewables	Projected closure date 2031
2000	Wind	12 MW	20	Windy Hill QLD	Ratch Australia Corporation	Projected closure date 2030
2000	Wind	9.9 MW	15	Blayney NSW	Tilt Renewables	Projected closure date 2031
2001	Wind	18.2 MW	14	Codrington VIC	Pacific Blue	To be decommissioned by 2027[14]
2001	Wind	35.4 MW[15]	18	Albany WA	Bright Energy Investments	Refurbished in 2020
2002	Wind	21 MW	12	Toora VIC	Ratch Australia Corporation	Projected closure date 2032
2003	Wind	33 MW	22	Starfish Hill SA	Ratch Australia Corporation	Refurbishment extended life to 2033
2003	Wind	52 MW	35	Challicum Hills, VIC	Pacific Blue	Projected closure date 2028
2004	Wind	140 MW	31	Woolnorth, TAS	Shenhua Clean Energy & Hydro Tasmania	Seeking approval for repowering
2005	Wind	81 MW	46	Lake Bonney (Stage I), SA	Iberdrola Australia	Projected closure date 2035
2005	Wind	91 MW	55	Wattle Point SA	ANZ Energy Infrastructure Trust	Projected closure date 2029
2005	Wind	46 MW	23	Millicent SA	Engie & Mitsui	Projected closure date 2035
2005	Wind	70 MW	35	Mt Millar SA	Australian Renewables Income Fund	Projected closure date 2030
2007	Wind	66 MW	31	Cathedral Rocks SA	ACCIONA Energia & Energy Australia	Projected closure date 2030
2012	Solar	10 MW	150,000 PV modules	Greenough River, WA	Bright Energy	Under expansion, to add 30 MW
2013	Solar	20 MW	83,600 PV modules	Royalla ACT	Dif Infrastructure IV Cooperatief UA	Projected closure date 2045
2015	Solar	102 MW	1,300,000 PV modules	Nyngan NSW	AGL	Projected closure date 2042
2018	BESS	30 MW / 9 MWh	12 units of 2.5 MW/ 0.75 MWh	Dalrymple SA	ElectraNet	Projected closure date 2030
2018	BESS	100 MW / 129 MWh	792 units of approx 200kWh using 189 inverters and 33 transformers	Hornsdale SA	Neoen	Expanded by 50 MWh in 2020
2018	BESS	25 MW / 50 MWh	400 units	Gannawarra VIC	Edify Energy	Projected closure date 2033
2018	BESS	30 MW / 30 MWh		Ballarat VIC	AusNet	Projected closure date 2033
2019	BESS	25 MW / 52 MWh	192 Tesla Powerpack 2.0, 104 Tesla Powerpack 2.5, 4 Tesla Powerpack 1.5, 48 Tesla inverters	Wattle Range SA	Iberdrola Australia	Projected closure date 2034
2019	BESS	6.1 MW	16,128 PV modules	Morgan SA	SA Water	Projected closure date 2031

Notes and sources on following page

Notes

13 Some projects have not provided expected closure dates. In these cases, the projected closure year used AEMO's assumed economic life of the technology, being 25 years for wind, 30 years for solar, and 20 years for BESS

15 At the time of commissioning, the Albany site had a power output of 21.6 MW from 12 x 1.8 MW turbines, which was expanded in 2011 to include 6 x 2.3 MW turbines at Grassmere.

Source

14 Pacific Blue reveals ageing Codrington Wind Farm decommissioning plans

Lake Bonney Battery, Iberdrola

Port Augusta Renewable Energy Park, Iberdrola

As shown in Figure 2, larger numbers of assets start to reach retirement age around 2030, highlighting the importance of government and industry collaborating to develop clear and consistent approaches to retirement age renewables in the current decade. By 2045 the amount of retirement age renewables will have risen significantly, nation-wide (Figure 3).

This highlights the importance of extending management systems for retirement that can operate efficiently and effectively at a national level. Understanding how to make the most of existing resources and project sites through refurbishment or repowering is also important.

FIGURE 2: Expected closure dates of existing utility wind, solar and battery capacity[16]

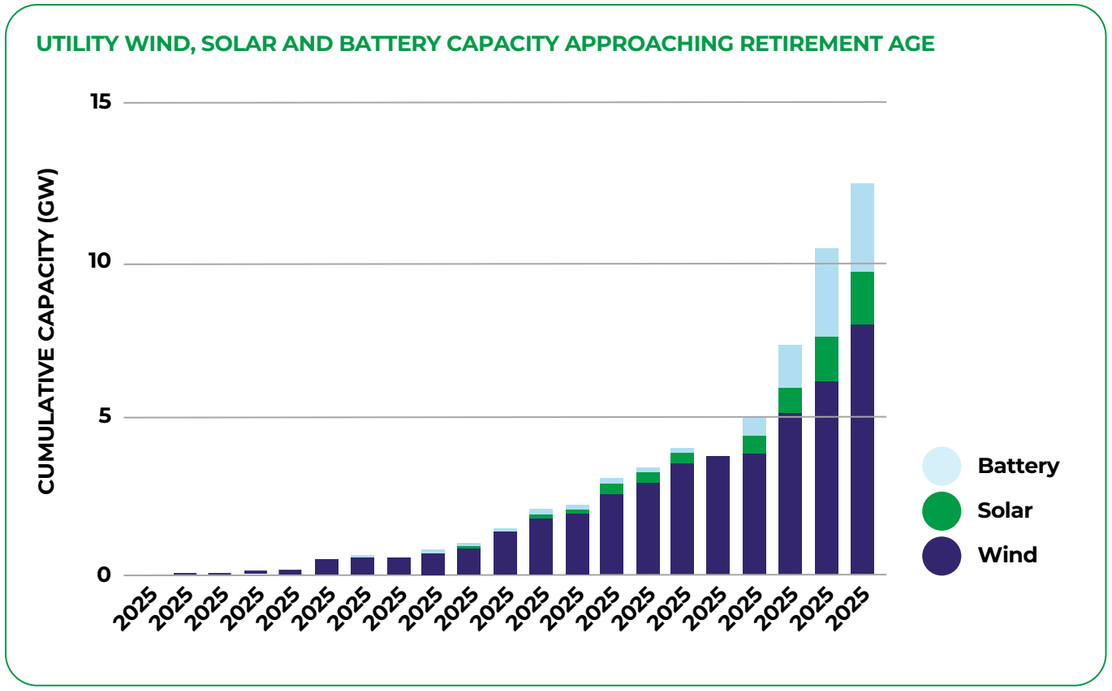


FIGURE 3: Scale of wind, solar and batteries likely to retire, be refurbished or repowered by 2045 by location[17]

NT	Wind	Solar	Battery
Size (MW)	0	5	40
Sites	0	2	3
Turbines/panels	0	15,000	–

NSW	Wind	Solar	Battery
Size (MW)	1,614	356	950
Sites	14	6	3
Turbines/panels	585	1.1m	–

WA	Wind	Solar	Battery
Size (MW)	1,047	10	627
Sites	17	1	12
Turbines/panels	443	30,000	–

ACT	Wind	Solar	Battery
Size (MW)	0	20	13
Sites	0	1	2
Turbines/panels	0	60,000	–

SA	Wind	Solar	Battery
Size (MW)	1825	362	342
Sites	20	12	13
Turbines/panels	746	1.1m	–

VIC	Wind	Solar	Battery
Size (MW)	2,707	143	715
Sites	29	2	7
Turbines/panels	1,025	430,000	–

QLD	Wind	Solar	Battery
Size (MW)	646	724	157
Sites	3	10	5
Turbines/panels	196	2.2m	–

TAS	Wind	Solar	Battery
Size (MW)	209	0	1
Sites	2	0	1
Turbines/panels	73	0	–

* Indicative number of panels based on assumed 3,000 panels/MW of AC real power capacity, based on several utility scale solar farms

Source

16 Figure based on data from RenewMap and own assumptions, namely that solar farms consist of 3,000 solar panels per megawatt of AC generation capacity (based on a sample of operational projects), and that where projects have not provided closure dates, the projected closure year will be consistent with AEMO's assumed economic life of the technology, being 25 years for wind, 30 years for solar, and 20 years for BESS.

Source

17 Figure based on data from RenewMap and own assumptions, namely that solar farms consist of 3,000 solar panels per megawatt of AC generation capacity (based on a sample of operational projects), and that where projects have not provided closure dates, the projected closure year will be consistent with AEMO's assumed economic life of the technology, being 25 years for wind, 30 years for solar, and 20 years for BESS.

What are the current retirement options and how are they managed?

As a greater number of projects get close to retirement, the way that project owners plan, manage and complete preferred project retirement options are coming under increasing public scrutiny. This section covers what is currently known about the makeup of these retirement options and how they are managed.

TECHNICALLY AVAILABLE RETIREMENT OPTIONS

The current range of technically feasible options for renewables retirement is outlined in Table 4.[18] For all methods, removed material should be transported for reuse or recycling, where possible.

TABLE 4: Technically feasible options for renewables at retirement age

Option	What this means	Methods used	Agreement, approvals and consultations
REFURBISHMENT	**A:** Assets need minor refurbishment (replacement of specific parts or components) and it is commercially viable to extend their operating life. **B:** Assets need major refurbishment, or even replacement, but it will be a like-for-like (MW) outcome. This level of refurbishment could extend operating life by 10 years or more in the case of wind farms (other technologies are less well known).	**For wind farms:** Replacing blades, rotor components or even swapping out the entire nacelle (the power generating unit behind the blades) and turbine to improve efficiency and extend operations by 10+ years. **For solar farms:** Replacing old panels with higher efficiency models, upgrading power inverters (the units that convert solar electricity for the grid) or making other project-wide system improvements. **For battery storage:** Installing newer, more efficient batteries within the existing infrastructure.	Host landholders Relevant consent authority AEMO Grid owner – either the transmission network service providers (TNSP) or distribution network service providers (DNSP) or both.
	Outcome • Generally delivers the same generation capacity as existed previously. • Refurbishment would require no changes to the electrical characteristics to avoid re-registration, potentially limiting opportunities. Additional MW can only be added where the additional capacity can be accepted into the grid. • Builds on existing host relationships with the ability for host landholder, neighbour, and community benefits to be renegotiated and sustained. • Reduces the need for additional site identification for new projects.		
REPOWERING	Assets are decommissioned and then replaced by newer or more powerful assets at the same site. Repowering can include new layouts, new grid connections and new assessments and approvals. Repowering may include technology changes or storage additions. For wind farms to be economically viable, this is likely to require a substantial increase in turbine size and physical footprint which may be challenging.	**For wind farms:** Significantly boosting electricity generation by replacing existing turbines with fewer, larger models. **For solar farms:** Significant boost to increasing electricity generation by replacing existing panels and their mounting frames with new, more powerful, higher efficiency solar modules (cells) along with bigger inverters to handle the increased power. **For battery storage:** Batteries may be repowered and their capacity expanded by installing new battery packs with higher performing or cheaper technology, and expanding the power inverters to handle higher storage and generation output.	Host landholders Neighbours Financiers Relevant consent authority AEMO Grid owner – either the TNSP or DNSP or both.
	Outcome • Expanded generation capacity with the potential for new configurations, including storage, on existing sites. • Likely to adopt higher efficiency and output technology, potentially requiring a smaller footprint. • Likely to have a lower number, but higher capacity, of turbines or panels reducing the need for additional site identification for new projects. • Builds on existing host relationships with the ability for host landholder, neighbours and community benefits to be renegotiated and sustained. • Potential to support a faster assessment pathway for expanded production, in areas where the social and environmental impacts of the repowered site will be equivalent to or less than impacts from the existing project.		

Source

18 For further detail on the retirement options for wind farms, see Clean Energy Council Winding Up: Decommissioning, Recycling and Waste Management of Australian Wind Turbines

TABLE 4: Technically feasible options for renewables at retirement age

Option	What this means	Methods used	Agreement, approvals and consultations
DECOMMISSIONING	Decommissioning sees generation and connection assets deconstructed and removed from the site and the agreed steps to 'return to use' undertaken by the asset owner. Land 'return to use' will likely include removal of assets down to a certain depth, topsoil cover up to a certain height and completion within an agreed timeframe.	**For wind farms:** A staged dismantling, construction and removal of associated infrastructure, or a controlled felling using explosives of each turbine. **For solar farms:** Removing solar panels from their mountings, those mountings from the ground and all electrical infrastructure. **For battery storage:** Removing all batteries, storage components and associated infrastructure.	Host landholders Neighbours Relevant consent authority Grid owner – either the TNSP or DNSP or both
	Outcome No further generation. No further landholder or community benefits generated.		

COMMERCIAL AND CONTRACTUAL AGREEMENTS

In the vast majority of cases in Australia, landholders host renewable energy projects on agricultural land, where it co-exists alongside ongoing farming activities.[19] This requires renewable energy project owners to have private agreements with host landholders with specialised long-term lease arrangements to build, maintain, operate and ultimately decommission their projects.

In researching this report, RE-Alliance was granted access to review de-identified decommissioning clauses from 18 wind, solar and BESS host landholder agreements, built over the last two decades. These sites are currently owned by companies that have strong interest in their corporate reputation, a long track record and extensive experience developing and operating renewable energy projects. The companies confirmed they are committed to best practice with regard to decommissioning, and will take on responsibility for decommissioning as committed to in their agreements.

Importantly, when ownership of the project changes hands, the private agreements with the landholders and the obligations in them continue to apply to the new project owner.

While our review of these 18 site agreement clauses is a limited snapshot of agreements that may exist, it nonetheless provides some insight into current agreements and decommissioning clauses (see Table 5).

The main insight from our review of these clauses is that there is broad alignment on the headline items for decommissioning, but variation in the range of outcomes provided for. Project owners noted that the variations may relate to when the project was developed (including the regulatory framework at the time), local geology, the number and size of components to remove, and outcomes of individual landholder negotiations. We were not made aware of any specific clauses for refurbishment or repowering in the agreements we reviewed.

Source

19 Clean Energy Council and Farmers for Climate Action Billions in the bush: Renewable energy for regional prosperity

TABLE 5: Summary of private agreement clauses for end-of-life and decommissioning across 18 projects

Private agreement landholder clause	Range of commitments		
Time allowed to decommission	6 months (180 days)	12 months	24 months
Soil depth for removal of equipment	0mm	300mm	300mm
Topsoil cover for concrete foundations and underground equipment	300mm	750mm	1,000mm
Environment/land rehabilitation	Make good any damage caused and return land to former use.	Environmental management plan and a draft rehabilitation sub-plan must be submitted for the entire site prior to construction.	Updated rehabilitation plan required to be submitted for approval to relevant authority 12 months before decommissioning, based on leading practice at that time.
Host landholder rights during decommissioning	The host landholder can request retention of any fences, gates etc, or can request their removal as part of the decommissioning process.	Host landholder receives a percentage of rent until decommissioning obligations are completed.	Host landholder receives rent during decommissioning phase. In the event of any failure to decommission assets within the agreed time, the host landholder can remove equipment and charge these costs back to the company.
Decommissioning bonds or other financial guarantee	None	Decommissioning bond, or financial security held in an escrow account (funds set aside beginning 10 years after start of operation and filled up over the project's operational life until needed and all conditions are met for its release), agreed with all host landholders.	Decommissioning fund established prior to construction, trust controlled by independent trustee and quantitative survey on net cost to decommission (cost to decommission minus assessed value of scrap (recyclable) material) undertaken at 10 years after start of operation. Fund shortfalls to be remedied by project owners and held in trust, as bank guarantee/letter of credit/insurance bond or similar.
Decommissioning assessments by project owner	None	Undertaken by project owner to inform decommissioning bond/escrow fund.	From the end of the certified project life or warranty period and re-done every five years from that point on.

REGULATORY REQUIREMENTS

Project owners are required to abide by legislative requirements set by the relevant consent authority and any local, state, territory or national regulations that apply to their activities more generally. We were reassured in reviewing the regulatory settings that Australia does, generally, have end-of-life management requirements that apply to retiring renewables. While there are some gaps, the key issue for public confidence is that there is low public visibility about what these requirements are. And, as so few sites have reached retirement, there is no lived experience yet as to how these requirements apply at scale in practice.

At the national level, renewables retirement is considered under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), workplace safety laws, and in specific legislation for offshore wind. Where an onshore or offshore project triggers an assessment under the EPBC Act due to its significant impacts on 'matters of national environmental significance', any approval may include rehabilitation requirements for end-of-life activities.

The Offshore Electricity Infrastructure Act 2021 (OEI Act) and associated regulations include specific requirements for offshore project owners to provide financial security for end-of-life activities including decommissioning and rehabilitation. As projects come online, the scale of the financial security will be informed by a management plan and may be provided in the form of a 'decommissioning bond' held by the Offshore Infrastructure Registrar or in another form specified by the regulations.

Sources

20 As at April 2025: Queensland Solar Farm Guidelines and State code 23: Wind farm development

21 *Land Use Planning and Approvals Act 1993* s. 60ZZG(2)(e)

Most states now require all onshore large-scale renewable projects to submit end-of-life plans as part of their development approval applications. For example:

- **Victoria** requires wind and solar farm project owners to include decommissioning and rehabilitation plans as part of their planning approval process, with a focus on returning the site to the original condition and showing how materials will be recycled or disposed of.
- **South Australia's** Hydrogen and Renewable Energy Act 2023 includes licencing, reporting, and provisions for decommissioning and site rehabilitation.
- **New South Wales'** development consents generally include conditions that require the development of a decommissioning and rehabilitation plan and the 2024 Renewable Energy Planning Framework and Private Agreement Guidelines specifically address decommissioning.
- **Queensland's** Wind Farm Code (State Code 23) requires decommissioning plans to be secured by bonds, financial guarantees or other mechanisms, and requires a decommissioning plan to be developed as part of the planning and approval process.[20] These settings also apply to solar projects.
- **Tasmania's** Environment Protection Agency (EPA) has developed standard approval conditions for relevant activities that include decommissioning requirements, and the EPA Board may provide advice to decision makers on requirements for site rehabilitation.[21]

Western Australia, the Australian Capital Territory, and the Northern Territory do not appear to have set requirements for decommissioning and site rehabilitation but host landholders may have decommissioning clauses in individual contracts.

In most states, more detailed decommissioning plans are further developed during operations, and revised decommissioning plans must be submitted to the relevant authority 12 months prior to decommissioning. Existing projects may have been approved prior to these regulations or be located in jurisdictions where these requirements are not in place meaning there is currently variation between projects and across the country.

CURRENT INDUSTRY PRACTICE

Industry practice for large-scale renewables at retirement is evolving, supported by a growing knowledge base from Europe and the United States of America (USA) on what can be done to refurbish or repower sites, and how to responsibly, sustainably, and safely decommission assets.

Internationally, repowering for onshore wind and solar is increasingly common practice. For example, Europe is proactively encouraging repowering. To make repowering faster, they amended an EU law to include a six-month permit-granting process for repowering sites in dedicated renewable energy areas.[22] There is also a focus on upcycling and repurposing, where old turbine blades have been used to produce furniture, boats, bridges, playgrounds, tiny houses, bike racks and more (see Options for Reuse and Recycling below).[23]

The USA has used performance-based incentive policies for renewable energy developments to encourage asset refurbishment. This drove product innovations that allow swap out and install of components on existing wind towers.[24] Solar panel reuse has been more common in the USA where the cost to install new solar energy is approximately four times more expensive than in Australia (as at April 2025) where installation costs are lowered through rebates such as our Renewable Energy Certificates (RECs) scheme.

Many international companies are now bringing their knowledge, experience and practice of reuse and recycling to Australia. For example, in the wind sector ACCIONA has sought expressions of interest for an Australian supplier to help find a use for their recycled turbine blade material. Their 'Turbine Made' program is focused on developing 'scalable solutions, diverting significant material from landfills and creating a foundation for sustainable industry transformation'.[25] Ørsted has committed – globally – to ensure no turbine blades are sent to landfill.[26] Independent of company or industry commitments, though, it is therefore important that a project owner and host landholder have a clear agreement on how their land will be left following decommissioning, including for foundations or other below-ground elements.

Already operating in Australia, 'CPVA Certified' is a world-first certification co-designed by a working group comprising local government, private enterprise and industry associations, led by Circular PV Alliance. The certification framework helps solar project owners embed circularity practices into the entire lifecycle and funding of the project. The certification sets the standard for leading industry practice, development approvals, overall project management, and community engagement activities. Leadership from the Australian solar industry has also pushed governments to co-invest in solar recycling technologies and capacity, through the Queensland solar stewardship scheme, and similar initiatives and partnerships in New South Wales, Victoria and South Australia.[27]

Australia currently has a recycling system for commonly used household batteries.[28] The existing system needs to be adapted and scaled up to incorporate residential solar batteries, electric vehicle batteries, and ultimately BESS scale batteries.

FINANCIAL ASSURANCE

From a landholder and community perspective, there is increasing knowledge about the potential benefits of having project owner commitments to financial assurance, such as decommissioning bonds, for retirement activities.

There are a range of financial assurance types available, and different forms of assurance may be the most appropriate in different situations. In all cases, financial assurances should be established in a way that does not erode the initial business case for investment at the capital heavy start of a renewable energy project.

Financial assurance to cover decommissioning and end-of-life costs is becoming more commonly adopted for new projects. Several leading project owners have publicly announced plans to include financial pledges for new projects to provide a strengthened level of assurance that there will be sufficient funds set aside to cover retirement activities.[29]

Sources *on following page*

FINANCIAL ASSURANCE APPROACHES FOR RENEWABLES AT RETIREMENT

A number of approaches are available to provide financial assurance to host landholders and governments for retirement activities. In all cases, funds are calculated, allocated and maintained from an appropriate point, until needed or all conditions are met for their release. Financial assurance types include, but are not limited, to:

Decommissioning bonds

A dedicated fund, that may be accumulated over a defined time period, funded by the project owner to cover the future decommissioning costs. Held by a third party, these bonds ensure that resources will be available when needed, regardless of the project owner's financial situation at that time.

Parent company guarantees

A contract between a landholder and the project owner's parent company, guaranteeing that the parent company will cover the cost of decommissioning if required, providing additional security if the project owner goes bankrupt.

Bank guarantees or letters of credit

A written agreement by a bank promising to pay for decommissioning if the project owner fails to meet their obligations.

Insurance products

An insurance policy covering the cost of decommissioning should the project owner fail to pay.

Trailing liabilities

Currently applied to offshore oil and gas projects, a trailing liability or obligation requires that even if a company or subsidiary goes bankrupt, the ultimate project owner still carries an obligation on behalf of the bankrupt entity to meet their decommissioning obligations. This approach has been implemented for offshore petroleum projects where liability will be enforceable by the Australian Government. For renewable projects to be covered by trailing liabilities, state, territory and federal governments would need to establish them as part of their regulatory frameworks.

Pooled funds

Industry-wide pooled funds held by a government entity may apply as part of the conditions of development approval. Such levies are set at a rate appropriate to the level of risk of decommissioning default, and may only be accessed in the case of a project owner being unable to meet their decommissioning obligations. As at today these levies are not in place for renewables, but do apply to other industries, including extractives like mining in NSW and Queensland.[30]

Sources

22 Accelerating the deployment of renewable energy

23 Wind Europe Europe not yet reaping the benefits of repowering old wind farms

24 GE Vernova says it has more than 1 GW of orders to repower US wind farms

25 ACCIONA Launches 'Turbine Made' Initiative For Recycling Wind Turbine Blades

26 Ørsted commits to sustainable recycling of wind turbine blades

27 See for example Solar recycling machine powers up as key export market closes to used Australian panels | RenewEconomy, Pioneering Australian "solar upcycling" start-up strikes deal with Italian energy giant | RenewEconomy and Solar recycling: eWaste outfit gets $5m equity boost to reboot panel processing plant | RenewEconomy

28 See for example Association for the Battery Recycling Industry

29 See for example Squadron Energy grows leadership team and commits to greater collaboration with regional communities, RWE's Campbell's Bridge Wind Farm, West-Wind post 'Does the landholder pay for decommissioning?' GPG's Paling Yards Wind Farm Decommissioning and Rehabilitation Plan and QBE's renewable energy project lifecycle insurance

30 See for example Financial Provisioning Scheme for resource activity environmental authorities

OPTIONS FOR REUSE AND RECYCLING

The development of a circular economy and effective reuse and recycling options have been identified as key to ensuring the resources needed to support the shift to renewable energy,[31] while minimising the need for new resource extraction.

There are already multiple operational solar panel recovery and recycling facilities. However Circular PV Alliance has found that in some jurisdictions with regulated landfill bans for solar panels, a portion of removed household scale solar panels can end up at scrap metal yards where only the aluminium frame is recovered with the remainder sent to landfill.[32] While environmentally concerning, this also means that the nearly 75% of the value of materials in a solar panel contained within the cells and glass is wasted. In the case of wind, options for recycling most materials exist today and there are examples of reuse of turbines prior to final end of life decommissioning.[33]

It is important that governments and industry move quickly to harmonise planning and regulation on project retirements for decommissioning, material recovery, re-use recycling or disposal, for all technologies.

REUSE

Wind operators looking to decommission turbines are finding growing interest in reuse and second life avenues. Solar panel reuse and second life markets are also growing. There is substantial potential for reuse of technology in advance of any efforts to recycle materials. This would ensure the energy from production of individual components is maximised and avoids any loss of materials or materials grade through recycling. Key challenges include implementing cost effective reverse logistics[34] and the lack of a standardised, robust testing regime for panel reuse, which is necessary to address any perceived concerns regarding panel safety, performance or quality.[35]

Significant retirement of domestic solar systems has led to the establishment of a number of pilots to inform effective stewardship programs,[36] as well as the development of training programs for de-installers.[37] For example, the Smart Energy Council's PV Solar Stewardship Pilot in Queensland is currently gathering data and insights to inform policies and investment needs for a nationwide solution for collection, reuse and recycling of solar systems. In the same light, the ACT Government recently funded a project to investigate and demonstrate the testing, refurbishment and reuse of second hand solar panels.[38] This is important work to ensure that Australia is well prepared to manage large-scale solar reuse and recycling by establishing reverse logistics pathways, identifying the potential scale of reuse for solar panels within Australia, and articulating the markets that will be required to create an effective national reuse system.

Sources

31 Recycling of Critical Minerals
32 Circular PV Alliance (personal communication, 28 April 2025)
33 For further detail on the retirement options for wind farms, see Clean Energy Council Winding Up: Decommissioning, Recycling and Waste Management of Australian Wind Turbines
34 The process of moving goods backwards through the supply chain for reuse or recycling
35 See for example PV Panel Re-Use Around the World: State-of-the-art – Overview Report
36 See for example PV Solar Stewardship Pilot
37 See for example Training and workforce development: Growing Victoria's clean energy workforce
38 The project team comprises PV Lab, the Australian National University (ANU), Circular PV Alliance, and Dow are currently preparing to install the refurbished solar panels at an ANU campus. For more information see CPVA Research Projects
39 Energy Fact Check 2025
40 WWF International Circular Economy and Critical Minerals Report Summary and Recommendations
41 Verity Tan, Rong Deng, Renate Egan, Solar photovoltaic waste and resource potential projections in Australia, 2022–2050, Resources, Conservation and Recycling, Volume 202, 2024, doi.org/10.1016/j.resconrec.2023.107316
42 What happens to wind farms in Victoria when turbines reach the end of their lives?
43 See for example National Waste Policy Action Plan 2024

RECYCLING

Renewable energy technologies are highly recyclable. Wind turbines are majority made from metal which has a high value when recycled.[39] Solar and battery housings and materials are also valuable. While it is not currently possible for the renewable energy sector to entirely avoid sending a small percentage of materials to landfill, governments are moving to reduce landfill access, or implement landfill bans for materials that are technically able to be recycled. There is an opportunity for improved economic, sustainability and commercial outcomes if we can get resource recovery right (see Table 6).

International demand for seven critical raw minerals can be reduced by almost 60% over the next 25 years through a mix of new technology, circular economy models, and recycling.[40] In Australia, it has been estimated, theoretically, that recycling of solar panel elements could supply 100% of the new panel silver and aluminium needs by 2045, eliminating the need for extraction of new materials.[41]

For metals, Australia already has well established, commercially competitive recycling service providers and mature logistics and supply chains. Specialised operators, collecting and processing 'scrap' metal at many locations around the country, including in remote areas, produce high value products from recycled materials. For the renewable energy sector, site features, location and transportation of materials impacts the total financial value from recycling.[42] However, in some cases, the value of decommissioned materials, including steel, copper and other metals, could partially, or largely offset the cost of decommissioning. For solar and batteries, Australian industry and governments are already investing in capacity for extraction of high value minerals and metals, but more work is required to ensure a comprehensive and cost-effective national system is in place.[43]

To minimise material losses through recycling – and for those materials not currently able to be recycled – there is a need to innovate and find commercial opportunities to reuse materials, as well as improve recycling processes, for retiring renewables.

TABLE 6: Infrastructure type and recycling / material recovery in Australia

	Able to be recycled / recovered	Major recyclable / recoverable materials	Recycling status – Australia (as at June 2025)	Biggest challenge to recycle	Landfill bans
	90%+	Steel, aluminium, copper, cast iron	High capability in metals recycling	Blades made of composite materials	No legislation for landfill bans
	95%+	Silicon, aluminium, steel, silver, glass, plastic, copper	~17% of household solar panels recycled. Further research required to maintain high quality recovery for all materials	Silicon, silver extraction from panels	Landfill bans (SA, VIC, ACT, NSW) Landfill bans coming (WA, QLD) No bans (TAS, NT)
	Up to 95%	Nickel, cobalt and other metals/ minerals	Only ~10% of Li-Ion batteries recycled but technically possible today	Safely storing, separating and extracting of different components	Landfill bans (SA, VIC, ACT, WA) Landfill bans coming (QLD, NSW) No bans but recycling supported (TAS, NT)

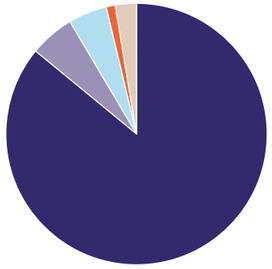
Sources *on previous page*

INNOVATIONS IN WIND TURBINE REUSE AND RECYCLING

Wind technology companies are increasingly pursuing innovative solutions for materials reuse and recycling. The majority of materials used in wind farms *(note 1)* already have a pathway for reuse and recycling.

CHART 1

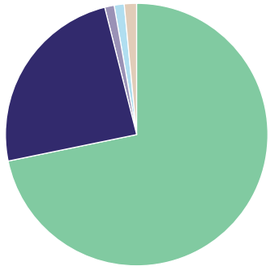
Materials in wind turbines



- Steel 85.9%
- Glass/Carbon Fibres 5.6%
- Polymer 4.7%
- Aluminium and Alloys 1.1%
- Other 2.7%

CHART 2

Materials in wind farms

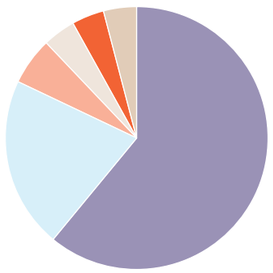


- Concrete 72.1%
- Steel 24.2%
- Glass/Carbon Fibres 1.3%
- Polymer 1.2%
- Other 1.2%

Work is continuing to identify new ways to manage the decommissioning of older and not yet recyclable materials. Older turbine blades made of composite materials are a key focus *(note 2)*. Turbine blades are currently being reused in cement co-firing in Europe and the USA, and this is being trialled in Australia. Industry is also adapting turbine design to minimise the use of non-recyclable materials and investigating ways to reuse and recycle all materials.

CHART 3

Composition of older fibreglass blades



- Glass Fibre 61%
- Epoxy Resin 21%
- PUR Adhesive 6%
- PVC Foam 4%
- Aluminium 4%
- Other 4%

Sources

Charts 1 & 2:
Vestas, Life Cycle Assessment of electricity production from an Onshore V162-6.2 MW wind plant, January 2023

Chart 3:
Vestas, Material Passport, Wind turbine blade model: V47, January 2023

Notes

1 Chart 2 'wind farm materials' include the wind turbines, foundations, site cabling (connecting the individual wind turbines to the transformer station) and site equipment (e.g. transformer station) up to the point of the existing grid

2 Management of composite materials is not solely an issue for the wind industry. The largest source of composite material waste globally is the building and construction sector.

Professional surfer Josh Kerr with world-first surfboard made from a retired wind turbine blade, Acciona

Recent research and development innovations include ACCIONA Energia repurposing blade material into footwear[44] and surf-boards.[45] Vattenfall in Norway is turning wind turbine blades into skis.[46] China is trialling a recycling process to transfer the high strength and corrosion resistance properties in turbine blades into cement and asphalt mixtures for use in road construction.[47] These innovations add to the many examples of blades being re-purposed for play equipment, bus shelters or other urban street furniture uses, but more work is required to ensure we have solutions at scale.

Beyond reuse, Vestas is investing in new materials that will chemically break down epoxy resin in current wind turbines into virgin-grade materials, maximising the recycling potential.[48]

Sneakers made from recycled wind turbine blades, Acciona

Skis made from recycled wind turbine blades, Vattenfall

Sources

44 Turning turbines into sneakers: a recycling idea takes flight

45 World-first surfboards made from old wind turbine blades

46 Making skis from old wind turbine blades

47 China plans to resurrect dead wind turbine blades to create crake-free roads

48 Vestas unveils circularity solution to end landfill for turbine blades

What are the gaps?

While there have been substantial improvements to planning for renewables retirement in recent years, our research has identified that a number of gaps remain. Here we discuss key issues that need to be addressed by industry and governments to provide community and stakeholder confidence in renewables retirement.

INFORMATION AND DATA GAPS

There is very little public information or data available about what project refurbishment, repowering, or decommissioning could mean for sites, host landholders, local communities and the energy grid, nor the legal requirements that relate to them. There is also an information gap around what happens to retirement age assets, what is in private agreements, and how government policies and regulation apply to retirement activities. Information that is available tends to be oriented to an industry audience and assumes existing knowledge and energy literacy.

While maintaining privacy in host landholder agreement-making helps the industry manage commercially sensitive matters, a lack of transparency over what such agreements cover limits the ability of local communities and other stakeholders to assess the quality of the agreement, including what is planned for asset retirement.

REFURBISHMENT

There is little information available on the priority being given to refurbishment options by industry, governments and energy market bodies. In consequence, there is little clarity on any work being done to ensure that the appropriate regulatory frameworks to support refurbishment are in place. Similarly, there is little support for community engagement in conversations about how refurbishment could play a role to extend existing benefit sharing arrangements, local employment opportunities or other partnerships established with the local community.

REPOWERING

In mid 2024, energy industry consultants GHD estimated that 1.7 GW of Australia's retiring wind generation projects could potentially be repowered to supply 6 GW from those same sites, with one third the number of turbines.[49] This assessment highlights Australia's repowering potential but was limited to wind farm repowering and was a theoretical, desktop analysis. A comprehensive assessment of repowering potential, and the costs involved, for all types of retiring renewables has not been done. The landholder and local community appetite for repowering has also not been assessed in a systematic way.

Committing to repower a project requires substantial information and lead times. For example, from a project owner perspective, establishing financial viability of repowering wind sites would require consideration of a multitude of factors that are currently difficult to access.

DECOMMISSIONING

It is positive to see project owners proactively addressing the decommissioning phase of their projects. Yet, while their commitments will, at a minimum, be sighted by relevant consent authorities as part of the assessment and approvals processes, they are rarely shared as publicly accessible documents.[50]

The lack of transparency and consistency in agreements makes it challenging for communities or landholders to determine what is leading practice in their situation. To overcome this information gap, NSW has published a guideline for private agreement making[51] with model clauses, including for decommissioning. Increased transparency in relation to decommissioning agreements will assist host landholders and communities to get information about what they can expect and ensure greater take up of leading practice for end-of-life activities in private agreements.

There is also a lack of knowledge across industry and communities about what decommissioning will or could cost. NSW has recently sought to address this gap through the provision of decommissioning calculators, however there has been no opportunity to test their accuracy in practice. Project owners we spoke to noted that determining the costs to decommission wind farms, solar farms or battery facilities is very site, technology, and time specific, making the provision of general information difficult. This will change as new end-of-life management plans are developed and grid connected projects start to go through retirement.

Sources

49 Repowering old wind farms could treble capacity using a lot less turbines

50 In a rare case, Winterbourne Wind Farm in NSW provided their decommissioning plan to a publicly viewable planning assessment process

51 Private Agreement Guideline

Image:
Port Augusta Renewable Energy Park, Iberdrola

POLICY GAPS

REFURBISHMENT

The AEMO Integrated System Plan Methodology (June 2023)[52] assumes that all new generators will be decommissioned at the end of their technical life. While such an assumption may be appropriate for system planning purposes, it provides no guidance to industry on the importance of minimising community and environmental impacts by ensuring that renewables deliver the maximum return possible from the materials used. Given the critical mineral shortages forecast for the coming decades, planning to maximise outputs from existing resources (particularly prior to improved reuse or recycling opportunities coming online) is crucial.

Decisions to refurbish or repower assets usually occur toward the end of the economic life of the project, and therefore may be outside the horizon considered by AEMO's ISP modelling. There is growing evidence from older existing wind farms and solar farms that refurbishment can support project life extension, and the rapid evolution of technology is leading to an increase in the durability of new sites, which is also expected to drive longer design lives. AEMO modelling and state and territory policies need to explore the system benefits this could create.[53]

REPOWERING

No Australian state or territory has yet addressed the potential for repowering renewable energy sites, nor have they considered the potential gains from enabling a more streamlined planning assessment path for repowering. To repower a renewable energy site in Australia today requires full decommissioning and removal of the existing assets, along with re-design and re-approval for new assets and infrastructure to be established on the existing site, as well as new grid connection approvals if generation capacity is increased, or if energy storage is added. This includes landholder and community consultation as well as additional environmental and regulatory approvals. This process will require long lead times and may prove too costly for some sites, especially if they are small in size and connected into the distribution network. Until these issues are addressed, the barriers to repowering will remain high, and the system modelling will continue to ignore it.

Source

52 ISP Methodology

Note

53 For example, upfront assumptions of refurbishment and repowering could see reductions in the levelised cost of energy of renewable energy projects, leading to improvements in the economics of these projects and the earlier entry of these projects in the modelling horizon. Similarly, if existing projects could be refurbished or repowered at less than the cost of new entrant generation, then the total system costs could be lower than modelled, or the modelling results could show more renewable energy entering the grid, faster.

DECOMMISSIONING

A number of state and territory planning schemes – including NSW and Queensland – have obligations relating to decommissioning that 'run with the land', i.e. the obligations are tied to the property itself rather than the property owner or a project owner that is hosted on a property. This could place host landholders in the position of having to enforce decommissioning obligations on a project owner. To reduce the risk of obligations falling to the host landholder, there is a clear need for 'backstop' measures in every jurisdiction to appropriately protect landholders in the unlikely event of abandonment.

A key component of this 'backstop' will be for governments to work closely with industry and stakeholders to identify appropriate policy interventions for decommissioning that will:

- Lower the burden on individual host landholders to negotiate private agreement terms while still encouraging project owners to innovate above standard terms in negotiation with landholders.
- Ensure project owners are all contributing – in a consistent way – to financial assurances that are held for future decommissioning activities, implemented at appropriate stages of a project's lifecycle, and considering how that financial cover is calculated, held and accessed.
- Improve consistency in the delivery of and outcomes arising from end-of-life asset management for host landholders, communities, energy market bodies and governments.
- Support landholders to make informed decisions about partnering with project owners that implement leading practice decommissioning activities.

Current government initiatives to assist landholders and community members to engage with the shift to renewable energy should include a greater focus on decommissioning. For example, the Federal Government National Developer Rating Scheme, that aims to provide landholders and communities with greater transparency about renewable energy project owners that propose new energy infrastructure in their area,[54] could include criteria related to retirement age renewables.

REUSE AND RECYCLING

Reuse or repurposing, and recycling of materials is a key issue for many communities and stakeholders. Everyday Australians know there are gaps across recycling services, so it is not surprising that community members are sceptical about what will happen to decommissioned assets. Questions about how much material will need to be managed, what type of material it is, and when and where it could be reused or recycled cannot be easily answered today. Policy makers have the opportunity to further encourage and support industry leadership locally, to ensure, and reassure the public, that materials are sustainably managed at the end-of-life. Development of cost effective reverse logistics also remains a key challenge in ensuring commercially viable reuse and recycling of renewable infrastructure.

While renewables companies are increasingly investigating innovative solutions for materials reuse and recycling, for a number of waste streams the renewable energy industry will remain a relatively small proportion of the total waste generated. In these cases, meaningful markets for reuse and recycled materials will rely on involvement and investment across multiple industries, creating an important coordination role for governments.

There are already some BESS systems that include product warranties and take-back agreements at the end of an asset's life.[55] However, development of a truly circular economy requires holistic consideration of how renewable energy systems are designed, constructed and operated, along with how the markets for refurbishment, reuse and recycling can operate at scale. At present, a system-wide framework for how this might function is missing, creating a risk that high value materials end up in landfill.

Sources

54 For more information see Fact sheet: Renewable energy developer rating scheme

55 See for example Battery Energy Storage System (BESS) Factsheet

GAPS IN INDUSTRY PRACTICE

There is currently no industry-wide statement on best practice for refurbishment, repowering or decommissioning.

DECOMMISSIONING

In relation to financial assurance for decommissioning, there is a gap between the emerging practice at new project sites and the commitments for older sites that will reach retirement age in the next two decades, and which (largely) do not have financial assurances in place. Given the evidence that concerns about decommissioning are a barrier for host landholders, this becomes an issue not only for individual project owners, but for the industry as a whole. It is unclear whose role it is to ensure the decommissioning of older sites will be financially covered, and that the activities to 'return to use' will meet contemporary community expectations.

In relation to environmental rehabilitation, it is difficult to find publicly accessible information on rehabilitation requirements for each jurisdiction, and what individual project owners have committed to delivering.

REUSE AND RECYCLING

While there has been some clear industry support for product stewardship arrangements, there are currently few companies that commit to a product stewardship framework that will ensure the best use of materials that have exceeded their operational life. Consistent industry ownership of product stewardship arrangements could be significantly improved on.

Port Augusta Renewable Energy Park, Iberdrola

A framework for action

It is encouraging that many project owners and industry led associations are already taking a leading role in developing decommissioning and reuse/recycling systems to meet growing demand. However, more needs to be done to provide host landholders and communities with the confidence that the shift to renewable energy will be managed responsibly at retirement, including for projects that were established under previous planning frameworks.

Here we propose a framework for action to proactively address gaps and improve retirement of renewables in Australia. In developing this framework we consulted with a number of renewable energy developers, industry peak bodies, environment organisations, circular economy advocacy groups and regional leaders.

This framework for action builds on the work already underway and ensures that industry and government can work together to deliver consistent, high quality outcomes for retirement age renewables and meet or exceed community expectations.

We recognise that some of the recommendations may require further analysis. To remove any barriers to urgently needed investment in renewables, future analysis should consider how any additional costs would deliver improved policy outcomes, sustainable material reuse and recovery, and stronger host landholder and public confidence in renewables retirement.

IDENTIFY OPPORTUNITIES FOR REFURBISHMENT

Why this is important:

Refurbishment of existing projects has the ability to extend the life of assets, delay the need for new construction and installation, reduce waste, and extend benefits for host landholders and the community, while utilising existing grid connections. This would help sites deliver the maximum benefit possible from the financial and community investment made in establishing renewables projects.

What to do next: Industry, governments, and AEMO should work together to agree on the commercial and market circumstances in which refurbishment is appropriate, and industry should start to engage with communities on the concept of refurbishment and what it means for host landholders and the broader community.

Recommendations for government:

- State, territory and federal governments should proactively support the extension of existing projects, where appropriate.
- AEMO should consider how it addresses and takes account of the potential for life extensions through refurbishment.

Recommendations for industry:

- Project owners and industry peak bodies should identify policy or market settings that are acting as barriers to the refurbishment of renewables to generate the best energy production and environmental outcomes.

MAKE REPOWERING EASIER

Why this is important:

In many situations, repowering sites will provide an opportunity to leverage high value renewable resources and good locations for energy production, without requiring additional land. Fewer new sites means a reduction in the environmental footprint of the shift to renewable energy. Repowering would also embed opportunities to maintain and continue to build on local economic, social and environmental benefits for host landholders, neighbours, communities and local governments.

What to do next:

To make the most of existing renewable energy sites, state, territory and federal governments should work with industry to investigate and adopt site repowering, where appropriate, while helping project owners, investors, host landholders and communities to understand the benefits, appetite, and options for repowering. These investigations must start with understanding the legislative reforms and incentives that might encourage and reward repowering plans to deliver better system outcomes and ongoing community benefits.

Recommendations for government:

- The Federal Government should commission a comprehensive assessment of repowering potential for existing renewable locations, including the steps required and investment involved, and consult on this assessment with key stakeholders.
- Consent authorities should identify opportunities for faster assessment pathways for repowered sites, where environmental and social risks are the same or less than those of the existing project.

Clarke Creek Wind Farm, Squadron Energy

IMPROVE CONFIDENCE IN DECOMMISSIONING

Why this is important:

While the risks to host landholders from decommissioning activities are already very low, the reputational damage to the industry caused by any decommissioning failure would be extremely high. This has already been identified as a concern for landholders and local governments considering hosting renewable energy projects. Improving confidence here is critical.

What to do next:

Governments should work closely with industry and other stakeholders to identify suitable policy instruments for decommissioning that will reduce the burden on individual host landholders to negotiate private agreements, ensure fair and consistent financial assurances from all project owners, improve consistency of end-of-life outcomes, and increase information transparency to support landholders to make informed choices about decommissioning.

Recommendations for government:

- The Federal Government should include criteria relating to decommissioning in the National Developer Rating Scheme.
- For existing projects, where financial assurance was not included in project conditions or host landholder commitments, state and territory governments should consider introducing a trailing liability requirement to provide assurance that end-of-life obligations will be met.

Recommendations for industry:

- Industry bodies should make a clear, explicit statement – for example through updating the Clean Energy Council 'Best Practice Charter' – that host landholders will not be left with the financial or other burdens from decommissioning activities.
- Project owners and industry peak bodies should help to communicate what leading practice management of renewables retirement looks like, including for community engagement and communication, host landholders commitments, financial assurance, circularity commitments, land return and rehabilitation, and the delivery of any nature based outcomes.
- Project owners and industry peak bodies should increase transparency of decommissioning clauses and commitments in agreements. This would assist landholders and communities to understand what to expect from decommissioning and ensure greater take up of current leading practice for end-of-life activities in private agreements.
- Project owners should make public their commitments to provide financial assurances for host landholders for decommissioning and end-of-life activities.
- Project owners should seek reputable certifications of their commitment to leading retirement practices through frameworks such as 'CPVA Certified' or an updated Clean Energy Council Best Practice Charter.

Recommendations for industry and government:

- State and territory governments and industry should work together, in consultation with landholders and community stakeholders, to develop a consistent and industry-wide Financial Assurance Framework for decommissioning activities for new projects. This should build on current leading practice approaches and ensure that any framework is established in a way that does not erode the initial business case for investment at the capital heavy start of a project.

PROVIDE LEADERSHIP ON REUSE AND RECYCLING

Why this is important:

The volume of material from decommissioned renewable energy sites will increase over time. Investing now in the development of appropriate markets for materials that can be reused and recycled will help to build social licence around decommissioning. By maximising local reuse and recycling, renewable decommissioning can build sustainable, economic opportunities that will benefit many industries.

What to do next:

Developing a truly circular economy will require the development of reuse and recycling technology across multiple industries, as well as in the domestic and large-scale renewable energy sector. State, territory and federal governments should continue to play a role in coordination, investing in and supporting reuse and recycling capacity, and enabling the growth of markets for reused and recycled materials.

Recommendations for government:

State, territory and federal governments should introduce, or extend, policy settings that support a circular economy for renewable energy projects, and invest in addressing barriers to uptake. This requires focus on, and support for, innovation and research, from design to recovery, that will ensure processes continually improve over time. This would include:

- Addressing the barriers to cost effective reverse logistics.
- Prioritising reuse before recycling, and creating end-markets for reused products.
- Establishing circularity requirements for renewable energy materials recovery through agreements or partnerships with manufacturers and suppliers.
- Supporting innovation to improve reuse and recycling efficiency across the full suite of renewable energy materials.

Recommendations for industry:

- Existing programs and proposals that demonstrate industry commitment to a circular economy, such as ‘CPVA Certified’, should be considered and, ideally, adopted by project owners as a matter of priority, and equivalent schemes for wind and battery technology should be developed or expanded.

Recommendations for industry and government:

- State, territory and federal governments and industry should work together to adopt a National Solar PV Product Stewardship Scheme, as proposed by the Smart Energy Council, and develop mandatory producer responsibility schemes in the areas of wind and batteries.

Image:
Accepted materials for recycling, Sims Metal

ENHANCE ENVIRONMENTAL OUTCOMES

Why this is important:

Increasingly, communities and stakeholders are looking for project owners to deliver not just ‘return to prior state’, but ‘return to a better state’. Appropriate environmental protections and management are a key issue in obtaining social licence in many communities and this extends to the issue of retirement options. Opportunities for reducing new environmental impacts through refurbishment and repowering of existing assets follows the ‘reduce’ principle of circular economy, slowing the demand for raw materials and key components so that those resources can be spent more efficiently, resulting in a lower waste stream that could also lighten the reuse/recycling load. It can also contribute to ‘avoidance’ in the biodiversity management and mitigation hierarchy by minimising the need for new project footprints.

What to do next:

There are opportunities for stronger project approval conditions for end-of-life rehabilitation that would adjust the current approach where environment and nature considerations are weighted towards the construction and operating stages.[56] Conditions would need to set strong baseline expectations for retirement without being overly prescriptive and limiting the take up of improved technologies as they become available. Delivering appropriate rehabilitation outcomes may require investment for a number of years after renewables decommissioning, for example revegetation projects would require multiple years of maintenance, which should be built into relevant conditions.

Recommendations for government:

- All jurisdictions should develop and adopt model project approval conditions that set baseline expectations for end-of-life outcomes, without being overly prescriptive and limiting the development and uptake of improved technologies over time.

Recommendations for industry:

- Industry peak bodies should develop leading practice guidelines on the most common end-of-life options to assist host landholders to understand the type of outcomes they can expect following decommissioning.

Source

56 Rebecca Hall, Elsa João, Charles W. Knapp, Environmental impacts of decommissioning: Onshore versus offshore wind farms, Environmental Impact Assessment Review, Volume 83, 2020, 106404, doi.org/10.1016/j.eiar.2020.106404.

Conclusion

To date, Australia's renewable energy industry has rightly been focussed on establishing the social, economic and environmental frameworks necessary to support new projects to enable the shift to renewable energy. While there is more work to be done in that space, it is time to start looking further ahead and planning for retirement of renewables as well.

The small number of remote renewable projects that have retired so far have attracted some public attention, but as grid connected projects approach retirement age, public interest and focus on what happens at end-of-life is growing. As the first wave of large-scale renewables move to refurbishment, are repowered or decommissioned, collaboration is required from industry, government and community alike to ensure the use of renewables is maximised and end-of-life renewables are part of a circular economy.

Planning for and scaling up to manage retirement options must be undertaken now. Work is already being done in this space but more is needed, not only to ensure that the renewable energy sector is sustainable throughout its lifecycle but to ensure that communities and landholders have the information they need to be confident in a renewable energy future.

This report seeks to elevate existing conversations and chart a path for industry and government to get on the front foot ahead of time. RE-Alliance invites industry, government and community leaders to work together to ensure retirement for renewables in Australia is done right.

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