SILICON (Si) IN SOLAR PANELS

SMART ENERGY COUNCIL

SILICON (Si) IN SOLAR PANELS

EXECUTIVE SUMMARY

Silicon is the core semiconductor material underpinning more than 95% of the global solar photovoltaic (PV) market. Although it represents only 3–5% of a module's mass, silicon's high purity, energy-intensive production, and critical functional role make it a strategically important material within the solar supply chain. Across Australia's rapidly expanding solar fleet, this equates to an estimated 120,000–240,000 tonnes of embedded high-purity silicon, forming a valuable future secondary resource.

In operation, silicon is chemically inert and non-toxic, and poses no significant environmental or health risk once encapsulated within PV modules. However, upstream production and downstream processing introduce key stewardship challenges. Mining, refining, and wafering generate respirable crystalline silica (RCS), a hazardous dust linked to silicosis and lung cancer. Poorly controlled recycling can also release silica-containing dust. Robust dust mitigation, engineering controls, and worker protection are therefore essential across the silicon lifecycle.

The environmental burden of silicon PV is dominated by polysilicon purification, one of the most energy-intensive steps in module manufacturing. Facilities located in coal-dependent regions have higher embodied emissions, though ongoing improvements — such as renewable-powered production and thinner wafers — are reducing impacts. Despite upstream intensity, crystalline silicon PV systems achieve strong climate performance, with energy payback times of 1.7–2.7 years and life-cycle emissions of 30–45 g CO_2-eq/kWh, far below fossil fuel generation.

End-of-life (EoL) considerations are becoming increasingly urgent. Global PV waste could reach 78 million tonnes by 2050, including 2–4 million tonnes of recoverable silicon. Australia's early solar adopters mean EoL volumes will rise sharply from the 2030s onward. While each module contains less than 1 kg of silicon, national-scale flows translate into tens of thousands of tonnes of recoverable material, offering opportunities to reduce reliance on imported polysilicon and support domestic manufacturing ambitions. Advanced recycling technologies can recover up to ~96% of silicon, alongside high-value aluminium, copper, silver, and glass.

Globally, solar PV is now the dominant driver of silicon demand, consuming 75–97% of total polysilicon production. Supply remains heavily concentrated in China, which controls more than 80–90% of production across polysilicon, ingots, wafers, cells, and modules. This concentration reinforces the importance of secure and diversified supply chains for Australia's clean energy transition.

Addressing silicon stewardship holistically — alongside aluminium, glass, silver, and copper — will maximise circular economy outcomes, strengthen supply chain resilience, and support Australia's transition to a sustainable and sovereign renewable energy system.

SILICON (Si) IN SOLAR PANELS

SMART ENERGY COUNCIL

1. SILICON IN SOLAR MODULES

Silicon is the core semiconductor material in today's solar industry. Around 95–96% of global photovoltaic (PV) module shipments use crystalline silicon (c-Si) technology, with cells made from high-purity polysilicon ingots and wafers.

A standard c-Si module is a layered composite structure of tempered glass front sheet, encapsulant (usually EVA[1]), silicon solar cells (mono or multicrystalline), backsheet (polymer or glass), aluminium frame, junction box, copper wiring, small amounts of silver and other metals.

By weight, typical c-Si modules contain ~3–5% of Silicon (cells). Despite being a small fraction of the mass, the silicon is high-purity, high-value material, and its production is energy-intensive, making it central to both the economics and environmental footprint of solar PV.

1.1 Silicon per Standard Rooftop Panel

A typical modern 60-cell rooftop module weighs between 19–22 kg, with a silicon content varying from ~0.6–1.1 kg per panel. This range varies slightly depending on wafer thickness (now often 120–150 µm, compared with >200 µm a decade ago), cell technology (mono PERC, TOPCon, and heterojunction designs reduce silicon per watt) and module power class (higher-efficiency modules use less silicon per watt due to thinner wafers and better passivation). Overall, industry-wide trends toward thinner wafers and improved cell efficiencies have reduced the silicon intensity of PV modules while increasing their output.

1.2 Silicon per kW of Installed Capacity

Silicon demand is often expressed relative to energy capacity rather than panels. For current high-efficiency modules, it is around 3–6 kg of silicon per kW installed. Historically, silicon intensity was much higher. For example, in the early 2000s the amount of silicon in solar modules was ~13–16 kg/kW, driven by thicker wafers and lower cell efficiencies, and in 2015–2020 it was about 7–10 kg/kW. This dramatic reduction — nearly a 70% decrease over two decades — has been a major driver of solar PV cost declines.

1.3 National-Scale Silicon Stock in Australia

Australia surpassed 40 GW of cumulative solar PV capacity by the end of 2024, with ongoing growth across both rooftop and utility-scale systems. Using the 3–6 kg/kW silicon intensity range it can be assumed that approximately 120,000–240,000 tonnes of silicon are embedded in Australia's installed PV fleet.

This represents one of the largest concentrated material stocks of high-purity silicon in the country. Which means that Australia has an important future secondary resource base that will become available gradually from the 2030s onward as early-generation systems reach end of life. A potential feedstock for emerging domestic silicon or solar manufacturing initiatives, provided efficient recovery pathways are established.

2. HEALTH AND ENVIRONMENTAL CONSIDERATIONS

2.1 Health risks

In finished crystalline silicon modules, the silicon is bound within solid wafers, encapsulated between glass and polymers, and not readily bioavailable. Current evidence and reviews indicate that silicon in c-Si modules is not a major direct toxicity concern compared with heavy metals or organic additives. Most concerns around PV module toxicity focus on other components (e.g. potential lead in solder, fluorinated backsheets, and some thin-film chemistries), and studies consistently find that PV module waste is far less toxic than fossil fuel wastes such as coal ash or oil sludge.

The main health risk is not from installed panels, but from dust created when silicon-containing materials are cut, crushed or ground, especially during quartz mining and silica refining, wafer slicing and sawing, mechanical shredding of waste modules, and cutting of high-silica construction products. Inhalation of respirable crystalline silica (RCS) dust can cause: risks to humans, such as irreversible scarring and stiffening of lung tissue, lung cancer, chronic obstructive pulmonary disease (COPD), and kidney disease.

Australian regulators now treat RCS as a priority workplace hazard, with exposure standards around 0.05 mg/m³ (8-hour TWA) and strong emphasis on

1 EVA (Ethylene Vinyl Acetate)

dust suppression, engineering controls, and respiratory protection. For PV specifically, risk arises if panels are crushed, sawn or sandblasted without adequate controls in recycling or demolition environments. These risks are manageable via:

- Wet cutting or enclosed mechanical processes
- Local exhaust ventilation
- Respiratory PPE
- Avoiding pulverisation of intact modules where possible (prefer disassembly and controlled delamination)

2.2 Environmental Impacts

The environmental considerations associated with silicon in PV modules stem primarily from upstream manufacturing processes, rather than from elemental silicon itself. Silicon in its final wafer form is chemically stable, non-toxic, and inert; however, producing solar-grade polysilicon requires energy-intensive refining steps that dominate the environmental footprint of c-Si solar technologies.

The production of solar-grade polysilicon — especially via the conventional Siemens process — involves high-temperature chemical vapour deposition within energy-demanding reactors. This results in several environmental impact categories, such as high electricity consumption, fossil resource depletion, freshwater use, and ozone formation and photochemical smog. Despite these upstream impacts, continued improvements — such as shifting manufacturing to renewable-powered grids, adoption of more efficient fluidised-bed reactor (FBR) technologies, and reductions in wafer thickness — are helping to significantly reduce the embodied carbon intensity of PV modules.

2.2.1 Carbon Performance and Energy Payback

Even when considering current global supply chains, c-Si PV systems maintain excellent life-cycle environmental performance relative to fossil-based electricity, with Energy Payback Time (EPBT) of ~1.7–2.7 years in high-irradiance locations such as Australia. This means systems produce more energy than was consumed to manufacture them within this short period.

Life-Cycle Greenhouse Gas Emissions are calculated to be approximately 30–45 g CO_2-eq/kWh, depending on manufacturing origin, module type, and balance-of-system components. For comparison, coal-fired generation typically exceeds 800–1,000 g CO_2-eq/kWh, and gas-fired generation typically sits at 400–500 g CO_2-eq/kWh.

This demonstrates that, despite energy-intensive silicon purification, PV systems still deliver substantial net climate benefits over their operational lifetime.

2.2.2 End-of-Life Environmental Risks

Environmental risks associated with silicon PV at end of life do not arise from the silicon itself — which is inert and not a leaching hazard — but rather from associated module components and large waste volumes. Rapid growth in global and Australian PV deployment means large quantities of glass, polymers, and metals will reach end of life from the 2030s onward. Without proper management, PV modules contribute to landfill pressures and long-term storage constraints.

While silicon is environmentally benign, other components may release small quantities of metals under inappropriate disposal conditions, such as lead and tin (from solder), silver (from cell contacts) and copper (from wiring and ribbons). Laboratory studies show that, under certain acidic or extreme conditions, these metals can enter leachate streams. These risks are minor compared to hazardous waste streams such as batteries, but they underscore the importance of avoiding uncontrolled landfilling.

The mitigation of those impacts can be achieved through proper recycling infrastructures with well-designed PV recycling systems that can significantly reduce or eliminate end-of-life environmental risks through material separation and recovery (glass, aluminium, copper, and increasingly silicon and silver), controlled thermal or chemical delamination that prevents dust generation and limits emissions, diversion from landfill, avoiding accumulation of large volumes of composite e-waste and reduced need for primary material extraction, lowering upstream environmental pressures and emissions. Effective stewardship frameworks — such as Extended Producer Responsibility (EPR), accredited recyclers, and material traceability — ensure that end-of-life PV modules are processed under conditions that protect human health and the environment while maximising resource recovery.

3. RECYCLING PATHWAYS AND PROCESSES FOR SILICON-BASED MODULES

Although each individual PV module contains only around 1 kg of silicon, the cumulative volume embedded across Australia's installed fleet is substantial, creating a strategically important future resource. Recovering this silicon offers several significant benefits: it reduces reliance on imported polysilicon at a time when Australia has no commercial-scale refining or wafering capacity; it preserves the considerable embodied energy associated with silicon purification, one of the most energy-intensive stages of the PV value chain; and it directly supports the circular manufacturing ambitions outlined in APVI and CSIRO's national silicon action plans. Moreover, when silicon recovery is integrated with the established retrieval of aluminium, glass, copper and silver, overall recyclate value improves and recycling operations become more economically viable.

Recycling of c-Si PV modules is usually broken into two stages: (1) mechanical disassembly and delamination, and (2) material recovery (including silicon).

- **Mechanical Disassembly:** This consists in the removal of external hardware such as aluminium frame, the junction box and the cables (recovered as clean aluminium and copper fractions). Then the next step is cutting or shredding the remaining parts of the panel (basically the "sandwich" of glass, backsheet, EVA and cells) to manageable sizes for the next stages.
- **Delamination:** This step breaks the bond between glass, polymers, and cells. The main methods used are mechanical delamination (shredding, crushing and separating by density, screening, magnetics, eddy-current, etc.), thermal delamination (heating modules to decompose EVA and soften backsheet) and/or chemical/solvent delamination (use of organic solvents or chemical solutions to dissolve encapsulant and backsheet.

Many industrial flowsheets use hybrid combinations of mechanical + thermal or mechanical + chemical steps to balance cost, material quality, and environmental performance.

Once cells are separated, silicon recovery typically involves the removal of non-silicon layers first (etching the anti-reflective coating and stripping silver and aluminium contacts using wet chemical processes), then the silicon wafer recovery (they can be intact or broken, depending on the process), and finally the re-melting or downgrading of silicon (technically possible but must meet strict purity and defect standards). Advanced recycling methods report silicon recovery rates up to ~96% under optimised conditions, though economic viability depends on scale, energy inputs, and co-recovery of metals and glass.

3.1 Scale of Future Silicon Flows From EoL PV

Global projections indicate that EoL PV waste from c-Si modules could reach approximately 78 million tonnes by 2050, driven by the rapid expansion of solar deployment since the early 2010s and the maturing of systems installed during that period. This waste stream represents one of the largest emerging categories of engineered materials globally, concentrating substantial volumes of glass, aluminium, polymers, copper, silver, and a smaller but still critical share of high-purity silicon.

Given that silicon typically accounts for 3–5% of total module mass, the projected EoL volume equates to approximately 2–4 million tonnes of recoverable silicon worldwide over the coming decades. This material, purified to near-semiconductor grade during original manufacturing, embodies significant energy investment and therefore carries high strategic value. If effectively recovered, it could become a meaningful secondary source of silicon feedstock, easing long-term pressure on virgin polysilicon supply chains and supporting the transition toward more sustainable manufacturing models.

3.2 Global Demand for Silicon Driven by Solar PV

Polysilicon — the ultra-high-purity silicon used to produce wafers — is the fundamental feedstock for both the semiconductor and PV industries. Over the past decade, however, the rapid global expansion of solar power has dramatically reshaped demand patterns. Recent market assessments show that solar PV now consumes approximately 75–80% of all polysilicon produced worldwide, with the semiconductor industry representing only a small fraction of total demand. This shift reflects not only the scale of solar deployment but also improvements in semiconductor manufacturing that reduce silicon intensity.

Forecasts for 2025 reinforce this trend. Global demand for solar-grade polysilicon is projected at around 1.38

million tonnes, compared with only ~33,500 tonnes for semiconductor-grade material. In volume terms, this means that around 97% of all polysilicon produced is expected to be used for solar cells, firmly establishing PV as the dominant driver of the silicon value chain.

The polysilicon market itself continues to expand on the back of escalating solar installations. Industry analysts estimate the market value at USD 10–11 billion in 2024, with strong growth projected through 2030–2033 as annual PV additions reach unprecedented levels. This expansion is supported by the transition to larger wafer formats (M10 and G12), increasing module efficiencies, and the acceleration of global decarbonisation policies — all of which sustain high polysilicon demand despite ongoing reductions in silicon use per watt.

While polysilicon demand has globalised, supply remains heavily geographically concentrated. China currently accounts for over 80% of global manufacturing capacity across the polysilicon, ingot, wafer, cell, and module stages. Some analyses place China's share of polysilicon production even higher, at approximately 90–95%, creating a highly centralised and vertically integrated supply chain.

This concentration creates several market and environmental challenges:

- **Price volatility:** Oversupply cycles, often driven by rapid capacity expansions in China, can cause sharp fluctuations in polysilicon prices.
- **Energy-intensive production:** Many polysilicon facilities — particularly in regions such as Xinjiang — draw electricity from carbon-intensive grids, increasing the embodied emissions of PV modules.
- **Regulatory shifts:** Recent Chinese government policies introducing minimum energy-efficiency and technology standards for polysilicon plants are expected to force the retirement of older, less efficient facilities. These changes could influence global availability and pricing over the next decade.

Because solar PV now dominates polysilicon consumption, global PV deployment trajectories effectively dictate long-term silicon demand and, by extension, capital investment, capacity planning, and sustainability strategies throughout the silicon supply chain. This interdependence means that any disruption in polysilicon production — whether geopolitical, environmental, or regulatory—has direct implications for global PV deployment and the pace of renewable energy transitions.

4. SILICON DEMAND IN AUSTRALIA

4.1 Silicon Demand To Solar Panels in Australia

By late 2024, Australia had installed more than four million rooftop PV systems, representing approximately 25 GW of distributed capacity. When combined with large-scale solar farms, Australia's total installed PV capacity now exceeds 40 GW, placing it among the most solar-intensive electricity systems globally. Despite this scale, Australia currently has no commercial-scale polysilicon, ingot, wafer, or cell manufacturing capacity, meaning that almost all silicon used in the domestic solar fleet is imported in finished modules. This dependence reflects historical market dynamics: Asia — notably China — dominates every stage of the silicon solar supply chain, from quartz refining to wafering and module assembly.

However, this reliance is beginning to be strategically reassessed. Several national studies — including the APVI "Silicon to Solar" project and the CSIRO Australian Silicon Action Plan — have mapped pathways for developing a domestic silicon value chain. These analyses highlight Australia's natural advantages, such as abundant high-purity quartz, renewable energy potential for low-carbon refining, and emerging industrial capabilities in solar module assembly and recycling. They also outline scenarios in which Australia could progress from raw material extraction toward intermediate or advanced manufacturing, provided sufficient policy support, infrastructure, and industry coordination.

In this context, Australia's expanding PV fleet represents a significant embedded demand for high-purity silicon, currently fulfilled entirely through international supply chains. Understanding this demand is crucial for planning future domestic capabilities and for evaluating opportunities to integrate recycled silicon from EoL modules.

4.2 Silicon From Solar Panels: Future Secondary Resource

The earliest waves of Australian rooftop solar installations — dating back to the late 2000s and early 2010s — will begin reaching end of life during the early to mid-2030s, based on typical module lifetimes of 25–30 years. This will trigger a rapid and sustained increase in the volume of PV modules entering the waste and recycling stream.

Even though each module contains only 0.6–1.1 kg of silicon, the aggregate volume across Australia's

>40 GW fleet equates to tens of thousands of tonnes of recoverable silicon over the coming decades. When combined with the much larger flows of glass, aluminium, copper, and polymers, this represents a significant future stock of secondary materials. Harnessing this resource provides several system-wide benefits:

- Reduced reliance on imported primary materials by supplying part of the demand for silicon and aluminium domestically.
- Opportunity to anchor local manufacturing or re-manufacturing, especially if Australia develops capabilities for wafering, module assembly, or advanced material recovery.
- Alignment with circular economy objectives—ensuring that high-purity materials already embedded in the energy system are not lost to landfill.

A coordinated national approach to PV waste management, collection networks, accredited recycling facilities, and material traceability is therefore essential to unlocking the value of these secondary flows.

5. IMPLICATIONS FOR STEWARDSHIP AND POLICY

Silicon in PV modules poses unique stewardship challenges compared with other materials. Although silicon itself is inert and non-toxic during operation, significant risks occur during upstream production and downstream processing. Mining, refining and wafering can generate respirable crystalline silica, a hazardous dust linked to silicosis and lung cancer, while poor recycling practices can also release silica-containing particulates. Effective stewardship therefore requires strong dust-control measures and worker protections throughout the supply chain.

Environmentally, the main concern is the high energy intensity of polysilicon purification, particularly in regions reliant on coal-fired electricity, which increases the embodied emissions of PV modules. Policy responses should encourage low-carbon polysilicon sourcing, promote energy-efficient refining technologies, and incorporate life-cycle emission standards into procurement and regulatory frameworks.

5.1 Circularity and Strategic Material Recovery

Despite these challenges, silicon offers significant opportunities for circularity. If supported by appropriate policy measures, these secondary silicon flows can not only complement imported polysilicon, reducing strategic reliance on highly concentrated overseas supply chains, but also preserve the significant embodied energy already invested in purification, supporting the development of local solar manufacturing capabilities, particularly wafering or remanufacturing pathways that require refined silicon inputs

Advanced recycling technologies, described in the previous sections, are already capable of achieving high silicon recovery rates, but economic feasibility depends on having sufficiently large and predictable volumes, robust collection systems, and strong market signals favouring secondary materials.

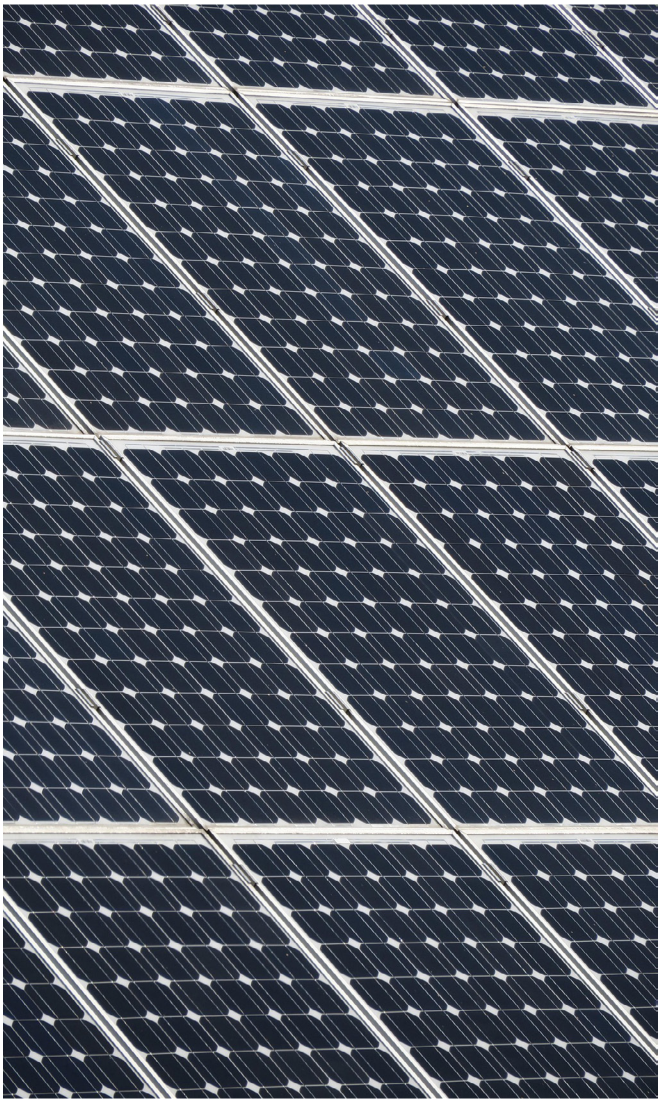
5.2 Policy Priorities for Australia

Australia is well positioned to harness the benefits of silicon circularity, but doing so requires coordinated action across government, industry, and the recycling sector. Key policy and system-design levers include:

- **Integrating APVI and CSIRO pathways into national planning:** Australia's leading research initiatives — the APVI Silicon to Solar study and the CSIRO Australian Silicon Action Plan — have already outlined credible pathways for domesticising parts of the silicon value chain. Policy frameworks should explicitly incorporate the role of future EoL silicon streams in these pathways, ensuring that recycled material is recognised as a potential input into emerging manufacturing capabilities.
- **Strengthening EoL regulations and Extended Producer Responsibility (EPR):** Effective stewardship requires regulatory settings that not only recognises silicon as a material of value, alongside glass, aluminium, copper, and silver, but also mandate or encourage dust-controlled processing environments to manage RCS risks during module dismantling and recycling. It should also require material declarations and traceability, ensuring high-value fractions — including silicon — are routed to appropriate treatment facilities rather than low-grade waste processors. These measures would support both environmental safety and economic recovery outcomes.
- **Building recycling capacity for future waste volumes:** Australia must prepare for a significant increase in

PV waste from the 2030s through the 2050s, aligning recycling infrastructure development with projected waste curves. This includes scaling mechanical, thermal, and chemical recycling technologies, supporting regional collection networks and logistics systems, ensuring recyclers have access to the capital and supply certainty required to deliver high-recovery operations and leveraging recycling to create domestic employment and new green industries.

Finally, silicon stewardship should not be viewed in isolation. Silicon recovery intersects with aluminium, glass, silver, plastics, and broader circularity frameworks. Integrated stewardship will be essential to ensuring that Australia maximises economic value, reduces environmental impacts, and strengthens the resilience of its clean energy transition.



6. REFERENCES

Latunussa, C.E.L. et al. (2016) Analysis of Material Recovery from Silicon Photovoltaic Panels. Joint Research Centre, European Commission.

IRENA & IEA-PVPS (2016) End-of-life Management: Solar Photovoltaic Panels. International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems Programme.

Deng, R. et al. (2019) ‘A techno-economic review of silicon photovoltaic module recycling’, Renewable and Sustainable Energy Reviews, 109, pp. 532–550.

Chen, P.-H. et al. (2023) ‘Comprehensive review of crystalline silicon solar panel recycling: From historical context to advanced techniques’, Sustainability, 16(1), 60.

Latunussa, C.E.L. et al. (2016) ‘Life Cycle Assessment of an innovative recycling process for crystalline silicon photovoltaic panels’, Solar Energy Materials & Solar Cells, 156, pp. 101–111.

IEA-PVPS (2024) Trends in Photovoltaic Applications 2024. IEA Photovoltaic Power Systems Programme.

IRENA & IEA-PVPS (2016) End-of-life Management: Solar Photovoltaic Panels. (also cited above – used for 60–78 Mt PV waste by 2050).

Ardente, F. et al. (2019) ‘Resource efficient recovery of critical and precious metals from waste silicon PV panels’, Resources, Conservation and Recycling, 145, pp. 152–162.

Rathore, N. et al. (2022) ‘Strategic overview of management of future solar photovoltaic panel waste’, Waste Management & Research, 40(8), pp. 1149–1163.

Mordor Intelligence (2025) Polysilicon Market – Size, Share & Forecast (2024–2030).

Technavio (2024) Polysilicon Market Analysis, Size, and Forecast 2024–2028.

Fortune Business Insights (2024) Polysilicon Market Size, Share, Analysis, Industry Outlook & Forecast 2024–2032.

Reuters (2025) ‘Top China polysilicon firms plan to shut a third of production capacity, set OPEC-style output quotas, GCL says’, Reuters, 31 July 2025.

Reuters (2025) ‘Wacker Chemie’s quarterly profit slumps on weak solar-grade polysilicon volumes’, Reuters, 30 April 2025.

The Verge (2024) 'Biden administration raises tariffs on solar materials from China', The Verge, 12 December 2024.

Chen, P.-H. et al. (2023) 'Comprehensive review of crystalline silicon solar panel recycling', Sustainability, 16(1), 60. (mechanical, thermal, chemical routes).

Preet, S. et al. (2024) 'A comprehensive review on the recycling technology of silicon-based PV panels', Journal of Cleaner Production (in press / early view).

Wei, G. et al. (2025) 'Review of c-Si PV module recycling and industrial feasibility', Environmental Science: Advances, Royal Society of Chemistry.

He, C., Zhuo, Y. & Shen, Y. (2026) 'Improving particle separation and recovery of valuable materials from end-of-life solar panels', Resources, Conservation & Recycling, 225, 108594.

Deng, R. et al. (2019) 'Recent progress in silicon photovoltaic module recycling processes', Resources, Conservation & Recycling, 146, pp. 1–12.

Latunussa, C.E.L. et al. (2016) 'Life Cycle Assessment of an innovative recycling process for crystalline silicon photovoltaic panels', Solar Energy Materials & Solar Cells, 156, pp. 101–111. (also cited under composition).

Kim, Y. & Lee, J. (2022) 'A review of recycling methods for crystalline silicon solar panels', International Journal of Engineering Research & Technology (IJERT), 11(4).

Safe Work Australia (2025) Model Code of Practice: Managing risks of respirable crystalline silica in the workplace.

Safe Work Australia (2018) Health Monitoring: Guide for Crystalline Silica.

Cancer Council Australia (n.d.) Silica dust and cancer.

News.com.au (2024) 'Popular kitchen item has been banned from importation into Australia', news.com.au, 2024 – context on engineered stone and silicosis.

Peng, J., Lu, L. & Yang, H. (2013) 'Review on life cycle assessment of energy payback and greenhouse gas emission of solar photovoltaic systems', Renewable and Sustainable Energy Reviews, 19, pp. 255–274.

Hsu, D.D. et al. (2012) 'Life cycle greenhouse gas emissions of crystalline silicon photovoltaic electricity generation: Systematic review and harmonization', Journal of Industrial Ecology, 16(s1), pp. S122–S135.

Louwen, A. et al. (2016) 'Life-cycle greenhouse gas emissions and energy payback time of current and prospective silicon heterojunction solar cell designs', Progress in Photovoltaics: Research and Applications, 24(4), pp. 517–531.

Kooshan, A. (2024) A Life Cycle Analysis of Monocrystalline Silicon PV Panels. MSc thesis, University of Calgary (or relevant institution).

Clean Energy Council (2025) Rooftop Solar and Storage: Biannual Report (July–December 2024). Clean Energy Council, Melbourne.

Clean Energy Regulator (2024) 'Australia reaches 4 million small-scale renewable energy installations', Media Release, 3 December 2024.

APVI (2025) National Survey Report of PV Power Applications in Australia – 2024. Australian PV Institute, Sydney.

IEA-PVPS (2025) 'Australia' in IEA-PVPS Members – Country Profiles.

PV Magazine Australia (2025) 'Australia installs 5.2 GW of solar in 2024', pv-magazine.com, 20 November 2025.

TaiyangNews (2025) 'Australia's cumulative solar PV capacity surges past 40 GW', TaiyangNews, 21 November 2025.

APVI (2024) Silicon to Solar: Foundations for Solar PV Manufacturing in Australia – Overview Report. Australian PV Institute.

CSIRO (2023) Australian Silicon Action Plan. Commonwealth Scientific and Industrial Research Organisation.

Australian Government, Department of Industry, Science and Resources (2022) 'CSIRO silicon plan a welcome contribution', Media Release by Minister Ed Husic, 9 December 2022.

Future Energy Skills (2023) 'Australian Silicon Action Plan (ASAP)', Future Energy Skills summary article, 31 January 2023.

APVI / ARENA (2023) APVI Silicon to Solar Study – Project Page and Reports. Australian Renewable Energy Agency Knowledge Bank.