SEIA Solar Energy Industries Association®

A Vision for Implementing the **Circular Economy** in the Solar and Storage Industry

Introduction

This document outlines the strategic vision and actions that the Solar Energy Industries Association (SEIA) will pursue to support the solar and storage industries' implementation of a circular economy in an aggressive but reasonable timeframe. The actions articulated in this document serve as a roadmap for SEIA members, all participants in the solar and storage industries, policymakers, and other industries with whom SEIA will collaborate to make progress on essential activities that will bring the United States closer to a circular economy.

Background

Many industries, sectors, and companies are adopting business practices that help create a circular economy where economic growth can be decoupled from resource consumption. Global realities are causing extreme tension in resource-intensive economies given that most of the world's resources are finite and demand for those resources is accelerating. A circular economy requires us to rethink how we can sustainably use and reuse resources. It challenges us to shift from being driven by output to instead be driven by efficiency, so we generate less output while doubling down on products that are recyclable, reusable, and more sustainable.

Solar coupled with storage will help power a circular economy since it is the quintessential regenerative energy source. However, the solar and storage industry does not want to just power a circular economy. We want to put circular economy principles into practice in our own industry. By rethinking solar and storage manufacturing, the life cycle of products used in solar projects, and managing end-of-life products, we can broaden the positive environmental impact and the economic potential of our industry.

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The need to embrace the circular economy is clear. The falling cost of solar energy has made renewable energy accessible to more people than ever before and has resulted in an exponential increase in solar adoption. More than 1.6 TWdc (or 1600 GWdc) PV modules have been installed globally through the end of 2023 (including over 200 GWdc in the U.S., through Q1 2024). Eventually, the inventory of PV modules will reach the end-of-service point and will need to be managed. Some estimates indicate that between 28 and 40 million metric tons (Mt) of PV modules will reach end-of-service by 2050.

The way we manage those products already in service, as well as all future products, will ensure that we grow in a manner that is economically and environmentally sustainable and allow us to achieve all the inherent benefits of a circular economy, including:

Resource efficiency – ensure that we achieve as much economic activity with as few resources as possible.

Economic growth – reduce costs and create unprecedented economic growth, the durability and success of which is not predicated on the unlimited availability of raw materials.

Energy security and dominance – ensure that the United States has access to abundant domestic supplies of clean and affordable energy.

Greenhouse gas (GHG) reductions – help decarbonize the economy using solar energy and storage.

Air quality improvements – improve local health and environment using solar and storage.

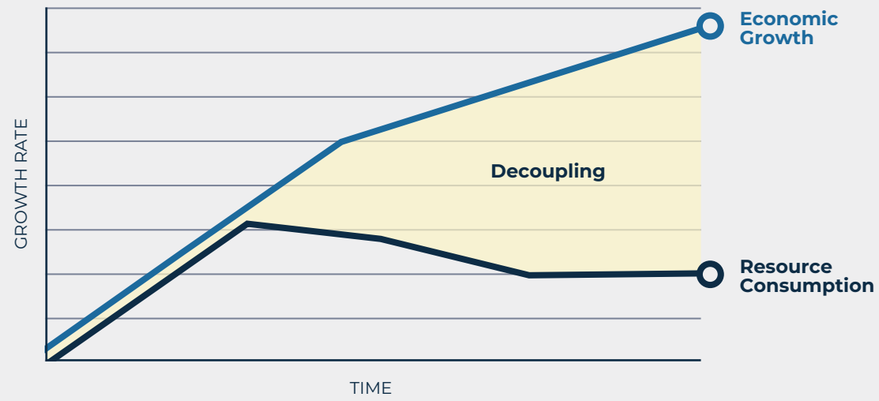
Strengthening supply chains – reduce demand for critical minerals and other materials through the recovery and reuse of materials from end-of-service products, and capture all the economic, environmental, workforce, and geopolitical benefits associated with those reductions.

Affordable energy – provide affordable energy by decoupling economic growth from resource consumption.

Risk mitigation – reduce the risks associated with a linear economy, including legal liabilities, environmental risk, supply chain disruptions, and economic downturns related to raw materials.

Creating jobs and supporting local economies – develop an ecosystem where solar and storage manufacturing, energy generation, energy consumption, and resource recovery from solar and storage products create many local jobs and bolster local communities with circular business models.

Decoupling in a Circular Economy



Vision

01.

The solar and storage industry will prioritize implementation of the circular economy in the manufacturing of solar and storage products and the installation of those products in energy-generating projects by:

- Minimizing inefficiencies and waste by-products to bolster domestic supply chains
- Circulating products and materials at their highest value for as long as possible
- Conserving natural resources

02.

SEIA and the solar and storage industry will lead by example. Circularity will be incorporated into all programs and activities so that full implementation of the circular economy occurs naturally and becomes inevitable.

03.

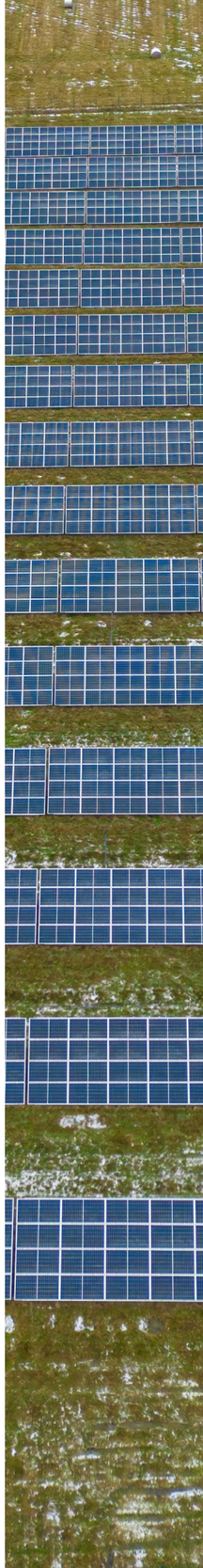
Specific outcomes of the industry's circular economy prioritization will include:

- Meaningful improvement in "circularity" on a year-over-year basis
- Increased supply of recovered materials from the solar and storage industries into domestic supply chains, including materials that are predominantly supplied by foreign countries
- Continuous improvement in systems and materials used by the solar and storage industry
- Forging strong collaborations with other industries to implement circular economy approaches capable of providing high-quality recovered materials into domestic supply chains

Thought Leadership

SEIA will support the solar and storage industry as they implement a circular economy by providing or facilitating thought leadership, technical assistance, and collaborative partnerships with key stakeholders to facilitate the adoption of the following five circular economy business models:

- **Resource Recovery.** Using waste byproducts from one process or product as a feedstock in another process or product. It also broadly describes the processing of end-of-life products to make new raw materials and products, such as through remanufacturing, reuse, or recycling.
- **Circular Supply Chains.** Reducing the consumption of raw materials, increasing utilization of high-grade materials that can be reused and recycled, or the procurement of renewable materials into the supply chain.
- **Products as a Service.** Distributed generation solar and energy storage systems are most commonly leased from third-party owners, such as the original installer if they offer that service, and the output of the product is purchased by the customer. This allows the third-party owners to maintain and monitor the system performance and how the product's materials are performing. This feedback is important to manufacturers in case warranty claims are filed and helps them to pinpoint any issues with materials in their supply chain, create long-term service relationships with their owner customers, and assist in product end-of-life processes.
- **Product Life Extension.** Maintaining, repairing, upgrading and renovating products in commerce at their highest and best use for as long as possible so that products become waste far less often.
- **Sharing Platforms.** Maximizing the use of underutilized or surplus capacity by sharing products or assets. Community solar is an excellent example of a sharing platform.



Action Plan

Collaboration with diverse stakeholders and policymakers will create a strong foundation for the solar and storage industry to fully implement the circular economy. By working with companies in the solar and storage industry, government agencies, the solid waste industry, academia, nongovernmental organizations, and all participants in the value chain, we can mitigate uncertainty in the market, bolster domestic manufacturing and supply chains, and promote economic growth through circularity.

The following are action items, organized by objective, that will help the solar and storage industry achieve its goal of leading by example and fully implementing a circular economy:

Minimizing Inefficiencies and Waste By-Products to Bolster Domestic Supply Chains (including design, maintenance, sharing, reuse, repair, refurbishment, remanufacturing, and, as a last resort, recycling)

Develop Circular Economy Standards for the Solar & Storage Industry	
Who	Solar Energy Industries Association (SEIA)
What	SEIA is developing accredited national standards to help ensure that solar and storage systems have been ethically, sustainably, and responsibly sourced, manufactured, transported, installed, operated, and recycled, including the following related to circular economy: • **SEIA 601:** Solar and Energy Storage Equipment Decommissioning Standard (in development) - decommissioning plans and requirements for solar and energy storage equipment including removal, handling, logistics, contracts, land rehabilitation and other aspects necessary to address the project removal in an environmentally and socially responsible manner. • **SEIA 602:** Solar Equipment Minimum Requirements for Recyclers (in development) - outlines the minimum requirements that solar equipment recyclers must meet and will include business, operational, and auditing requirements. • **SEIA 603:** Solar Equipment End-of-Performance/End-of-Life Management Standard (in development) - provide requirements for labeling, testing, sorting, handling, and logistics for reuse, refurbishment, and recycling of solar equipment.

Develop Circular Economy Standards for the Solar & Storage Industry *(continued)*	
When	All three ANSI standards currently in development will be published by the end of 2026. After each standard is published, an education program and certification program will be implemented within three months.
How	SEIA will convene the standards technical committees that will draft and publish ANSI standards specified accompanied by training and certification programs that educate industry and enable participants to showcase their commitment to a circular economy through independent certification.

Provide Manufacturer Assistance to Create Demand for Recovered Raw Materials	
Who	SEIA, manufacturers and other stakeholders, state and Federal governments.
What	Provide financial incentives and/or technical assistance to manufacturers that utilize secondary (recovered) raw materials in products, thereby reducing demand for virgin raw materials, particularly those which are vulnerable to supply chain disruptions and the absence of which would have significant consequences for the economy or national security.
When	Beginning in Q4 2025, engage SEIA members and other stakeholders, as appropriate, to develop legislative proposals. Look to introduce legislation in targeted jurisdictions in 2026.
How	Work with SEIA members and other stakeholders to identify market barriers facing manufacturers that wish to use secondary raw materials in their products; craft a legislative proposal with broad stakeholder support; pursue introduction and consideration of legislation in state legislatures and Congress.

Maintain Existing Research & Development Workstreams	
Who	Academia, solar industry, DOE labs, SETO
What	Stakeholders should continue to support R&D workstreams that are currently in development and provide real-world solutions to complicated problems, including but not limited to: • Alternate materials in solar and storage products (e.g. work being done by National Labs and manufacturers). • Engineering product designs to maximize refurbishment, repair, remanufacturing, and recycling (e.g. DOE/NREL/SI2/SEIA PV/ BEST project).
When	Starting Q4 2025 with ongoing monitoring.
How	Track existing R&D projects in the pipeline and work to remove any barriers preventing timely completion of the projects.

Establishing New Lines of Research & Development	
Who	Academia, solar industry, DOE labs, SETO
What	Stakeholders should support new R&D opportunities to assist with key technical and commercial challenges, including but not limited to: • Messaging and validation program to ensure that post-consumer recycled content is evaluated and meets certain metrics for use as raw materials in manufacturing. • Alternate uses for hard-to-recycle materials.

Establishing New Lines of Research & Development *(continued)*	
When	Identify specific projects in Q3 and Q4 2025 and look for R&D funding starting in 2026.
How	Engage with SEIA members and other stakeholders, as appropriate, to identify specific R&D projects that should be initiated (including the goals and objectives of the research) and identify potential sponsors for the work.

Model Contract Language for Financial Assurance Related to Project Decommissioning	
Who	SEIA and the surety bond industry
What	Develop template/boilerplate contract language that solar and storage project developers and the surety industry can use when establishing financial assurance for the decommissioning of solar and storage projects, helping to reduce legals costs while promoting consistency across multiple projects in multiple jurisdictions.
When	Convene the SEIA workgroup in Q4 2025, Identify the appropriate dialogue participants from the surety industry in Q4 2025 and look to develop model contract language in 2026.
How	Convene a working group of SEIA members to evaluate the potential outcomes that should be included in model contract language. Once an industry position is established, SEIA should establish a direct dialogue with associations representing the surety industry to develop template/ boilerplate contract language that can satisfy financial assurance requirements for project decommissioning for a wide variety of projects.

Approaching Zero Waste-To-Landfill Solar/ Storage Manufacturing	
Who	SEIA, solid waste industry, and service and logistics providers
What	Create a compendium of zero waste-to-landfill best practices that can be implemented in solar and storage manufacturing facilities to significantly curtail or eliminate landfilling.
When	Convene the working group in Q4 2025 and publish the best practices in 2026.
How	Convene a working group to identify the typical waste streams present in the manufacturing sector and create a “menu” of best practices that manufacturers can use to manage those materials while significantly curtailing or eliminating the need for landfilling; make the best practices available to all SEIA members.

Consistency of Siting/Handling Requirements for PV Recycling Facilities	
Who	SEIA, in collaboration with local and state stakeholders and waste management groups
What	Develop model siting and handling guidelines for PV recycling facilities.
When	Initial evaluation can begin in early 2026.
How	Evaluate the current landscape of siting/handling requirements for PV recycling facilities; identify areas where consistency of requirements would provide benefits to all stakeholders; develop recommendations for state and local governments on how to manage siting and handling of PV recycling facilities.

Develop a Framework for a Network Of Solar & Storage Equipment Collection Sites to Increase Logistical Efficiency	
Who	Solar Energy Industries Association (SEIA), solid waste industry, logistics providers, and others in the circular economy value chain
What	Working with the solid waste industry and logistics providers, lay the foundations to create a regional and/or national networks of collection sites that increase logistical efficiencies, minimize costs, and increase the flow of products for use in the circular economy, whether for refurbishment, reuse, remanufacturing, recycling or any other circular economy business model.
When	Develop white paper in 2026 and socialize the concept with receptive stakeholders.
How	SEIA will convene a work group of members to develop a white paper on how a network of collection sites for solar and storage equipment can be developed and implemented to save costs and facilitate circularity. The white paper will include recommendations for the next steps, including the identification of specific stakeholders to engage.

Circulating Products and Materials at their Highest Value

(keep materials in use for as long as possible, either as a product or when that can no longer be used, as components or raw materials)

Provide Thought Leadership & Sharing Best Practices	
Who	Solar Energy Industries Association (SEIA)
What	Host a circular economy conference for the solar and storage industry to communicate effectively with SEIA members and all participants in the solar and storage value chain.

Provide Thought Leadership & Sharing Best Practices (continued)	
When	SEIA will convene the content committee in February 2025 and hold the conference in Q4 of 2025.
How	SEIA will design, develop, and convene a first-of-its-kind sustainability conference for our industry in the U.S. We will accomplish this through the convening of a content committee consisting of industry participants including members and through the collaboration of multiple SEIA teams.

Legislative & Regulatory Advocacy	
Who	SEIA working with State and Federal governments
What	Streamline, harmonize, and/or support legislation and regulatory requirements at the local/state/federal levels to make resource recovery easier and less expensive than land disposal.
When	Evaluate the landscape of regulations and legislation related to circular economy by Q4 2025 and develop recommendations for future advocacy efforts by the end of 2025 or early 2026.
How	SEIA will engage members and other stakeholders, as appropriate, to evaluate a broad landscape of regulations or legislation that either supports circularity in the solar and storage industry or makes implementing a circular economy more difficult. SEIA will develop legislative and regulatory recommendations, which can be folded into broader SEIA advocacy efforts at the state and Federal levels.

Model Decommissioning Standards	
Who	SEIA, interested stakeholders, state and local governments
What	Develop model decommissioning standards to ensure fair, safe, protective, and affordable decommissioning standards across multiple jurisdictions.
When	TBD (the timing should be aligned for consistency with SEIA 601 standard finalization).
How	SEIA will convene a dialogue of stakeholders to develop acceptable standards that can be used as a model for adoption in state and/or local legislative and regulatory settings; SEIA will then work with stakeholders to pursue introduction and adoption model decommissioning standards in state and local governments.

Approaching Zero Waste-To-Landfill Installations/Projects	
Who	SEIA, solid waste industry, and service and logistics providers
What	Create a compendium of zero waste-to-landfill best practices that can be implemented in solar and storage project installations of all sizes and types to significantly curtail or eliminate landfilling.
When	Convene the working group in Q1 2026 and publish the best practices in 2026.
How	Convene a working group to identify the typical waste streams present in project installations and create a “menu” of best practices that manufacturers can use to manage those materials without relying on disposal; make the best practices available to all SEIA members.

Develop & Demonstrate the Concept of Circular Hubs that Focus on Synergies of Supply & Demand for Recovered Raw Materials	
Who	SEIA, other manufacturing sectors, government agencies
What	Demonstrate how solar and storage manufacturing and project development can provide the backbone of a Circular Hub. Successful hubs will reduce logistics and transportation costs by pairing supply and demand in proximal geographic locations. These hubs can facilitate a circular economy by utilizing the outputs of one business model as the inputs for other business models, with the entire system powered by solar energy.
When	Develop white paper in 2026 and socialize the concept with receptive industry and government participants.
How	Develop a white paper that can be used as a roadmap for successful development of a Circular Hub. This work will begin by conducting a mapping exercise to identify attractive geographic locations based on transportation infrastructure, manufacturing capacity, opportunities for landfill diversion, and other relevant factors.

Conserving Natural Resources (support natural processes and leave more room for nature to thrive)

Develop Installation & Permitting Standards for the Solar & Storage Industry	
Who	Solar Energy Industries Association (SEIA)
What	In addition to SEIA Standards 601, 602, and 603 described earlier in this document and that are already in development, SEIA may develop future ANSI standards to address installation and permitting standards, including: • Agrivoltaic design and installation standards in partnership with agricultural-focused standards development organizations to design projects with circular economy principles in mind. • Assess and develop recommendations for stormwater run-off standards for large utility-scale projects. • Assess and determine other natural resources approaches that help preserve soil, water, forestation, and reduce greenhouse gases.
When	The ANSI process for new standards is likely to take 1-2 years. After each standard is published, an education program and certification program will be implemented within three months.
How	SEIA will convene the standards technical committees that will draft and publish ANSI standards specified accompanied by training and certification programs that educate industry and enable participants to showcase their commitment to a circular economy through independent certification.

SEIA Solar Energy Industries Association®

Leading the Transformation to a Clean Energy Economy.

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