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Arizona Republic

Published 6:01 a.m. MT Sept. 24, 2024 | **Updated 6:01 a.m. MT Sept. 24, 2024**

YUMA — Adam Saghei walks among hundreds of discarded solar panels, collecting dust instead of power under the relentless Arizona sun at the We Recycle Solar facility.

The rows of stacked panels towering over him are a visible reminder that even the greenest technologies face a growing waste problem.

"There are hundreds of millions of solar panels installed in the U.S. today," Saghei says. Globally, the country ranks second only behind China in solar energy production.

"And one of the things that comes with that is waste," he says.

As CEO of the first and largest U.S. recycling plant solely dedicated to processing end-of-life solar panels, Saghei estimates that roughly 10% of discarded panels are recycled while about 90% still end up in landfills.

Although solar energy does not produce air pollution or greenhouse gasses, the waste from worn panels can pose a significant environmental risk. If panels aren't properly handled, toxic contaminants can leach into soil and water, creating potential hazards for ecosystems and communities.

As Saghei explains the composition of solar panels, he uncovers several containers filled with fragments of crushed materials.

Solar panels are mostly made of glass, which accounts for 75% of their weight and is highly recyclable. But they also contain plastic and metals like aluminum, copper, silver, tin, lead and cadmium, among others.

The typical lifespan of a solar module is more than 25 years. Even after that, many can continue converting sunlight into energy, although at a reduced output compared to when they were new.

Many of the panels WRS receives can have a second life because their solar cells remain functional and can be sold at a fraction of the original price, often in overseas markets.

"About 60% can actually be reused, refurbished, and redeployed," Saghei says.

WRS also receives surplus products from overstocked projects and reintroduces them into the market. The company strives to minimize waste, reuse as much as possible and reduce the environmental impact of renewable energy technology.

"Reduce, reuse, and recycle," Saghei says that's the goal.

**More solar in Arizona:** Biden plan would expand solar energy projects on public lands in Arizona, other states

## The recycling process is mostly automated

At the WRS plant, a large robotic arm lifts a heavy panel and places it on a conveyor belt, where the materials separation begins. Powerful magnets isolate the metals from the glass and separate them from each other by type.

"If managed and handled properly, you can get up to 60% recovery," Saghei says.

A few years ago, this process was largely manual, with workers painstakingly disassembling panels by hand, but today, the operation is almost entirely automated.

Despite advancements in efficiency and accessibility, the solar industry still has room for improvement, especially in enhancing durability or managing waste at the end of a panel's life cycle.

"Manufacturers are coming to us, and ask, 'How do we design a solar panel for end of life?'" says Saghei. "They're looking at making solar panels more recyclable, and use more recycled material within their production line."

Silicon has traditionally been the most commonly used semiconductor material in solar cells, resulting in more rigid and heavy panels, complicating recycling.

"The silicon back sheet of the panels would probably be the most difficult and challenging material to separate," says Saghei. As research and development evolves, “we are looking to utilize it in yoga mats or sneakers," he says.

New solar cells, manufactured from alternative materials, can now be printed, similar to how newspapers are printed, offering greater flexibility, increased efficiency and reduced costs.

Saghei is optimistic about the future of solar energy and is proud to be part of an industry actively seeking solutions. For him, the challenge isn't just about recycling but about designing solar panels with their entire lifecycle in mind.

**Adding solar capacity:** 'Blue-green economy': Work to start on installing solar panels over Gila River canals

## The next generation of solar technology

In southeast Tempe, Arizona State University's Macro Technology Works has developed as an electronics research incubator. The building is topped with solar panels covering every roof, even shading the parking lot. The neighboring establishments also align with this trend, creating a technology-driven zone that looks like a glimpse into the future of solar energy.

While the idea of solar panels covering every parking lot in Arizona may seem ideal, the initial investment is steep, according to Nick Rolston, an ASU professor of electrical, computer and energy engineering.

"One of the big challenges of solar is that all of the money has to be put upfront," says Rolston. "With older technologies, you pay as you need the fuels, but with solar, you must have the panels completely made up at the front. And that's a huge investment."

He saw the high solar energy prices as an opportunity to improve the industry. This motivated him to create the Rolston Lab, part of the Ira A. Fulton Schools of Engineering. He and his team focus on making photovoltaic technologies more reliable, affordable, durable and stable.

The lab's projects range from developing new materials to enhance solar panels' efficiency, lifespan, accessibility, and recyclability to finding multifunctional uses.

"Because the climate is changing so rapidly already, there is a need to have additional uses for these devices," Rolston says.

One example is installing solar panels above crops to shield them from extreme heat or placing them over water reservoirs to reduce evaporation and prevent water loss. The Rolston Lab aims to address as many gaps as possible.

"We have the benefit of being at the early stage, so we can design these materials and devices to be circular, reliable, recyclable, and reusable," says Rolston.

**Solar and water:** Arizona utilities have long rejected covering canals with solar panels. Here's why that may change

## Better regulations to drive a more sustainable future

While industry advancements are promising, experts believe stronger regulations are essential. Meng Tao, another professor at ASU's School of Electrical, Computer and Energy Engineering, has dedicated his research to improving solar panel design and increasing material recovery for recycling. His goal is to enhance economic circularity.

Tao believes Arizona is uniquely positioned to become a national leader in the solar industry. With its abundant sunshine and growing renewable energy sector, the state could set a standard for addressing the end-of-life challenges associated with green technology.

Tao says the green energy transition regulations need to emphasize circularity. Otherwise, manufacturers will continue prioritizing the lowest-cost approach, often leading to wasteful practices.

"In 25 years, it will be our responsibility to deal with this waste," says Tao.

And it's not just solar panels that are at risk of becoming a disposal problem. Tao notes that electric vehicles, energy storage systems and batteries also have finite lifetimes. If these products are not designed with end-of-life solutions in mind, they will contribute to an increasing waste burden.

Tao envisions more students who are driven to tackle these problems and want to find opportunities to make a positive environmental impact while achieving economic success.

Saghei emphasizes the importance of balancing profitability with environmental responsibility.

"Landfilling is always going to be less expensive," he says. "But when you consider the long-term environmental costs, it's clear that recycling is the better path."

Saghei agrees with Tao that policy will play a key role in the industry's transformation. If regulations with this approach were implemented, "the number will drop to the opposite net effect," he says. "90% of panels will go to recyclers instead of landfills."

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*Environmental coverage on azcentral.com and in The Arizona Republic is supported by a grant from the Nina Mason Pulliam Charitable Trust.*