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Photo: Kaco New Energy

## Markets & Trends

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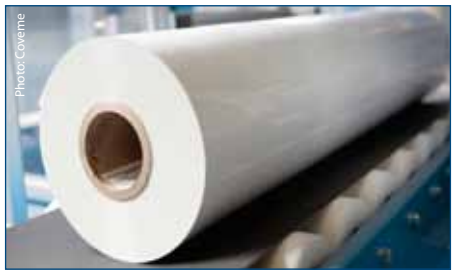
Photo: Coveme

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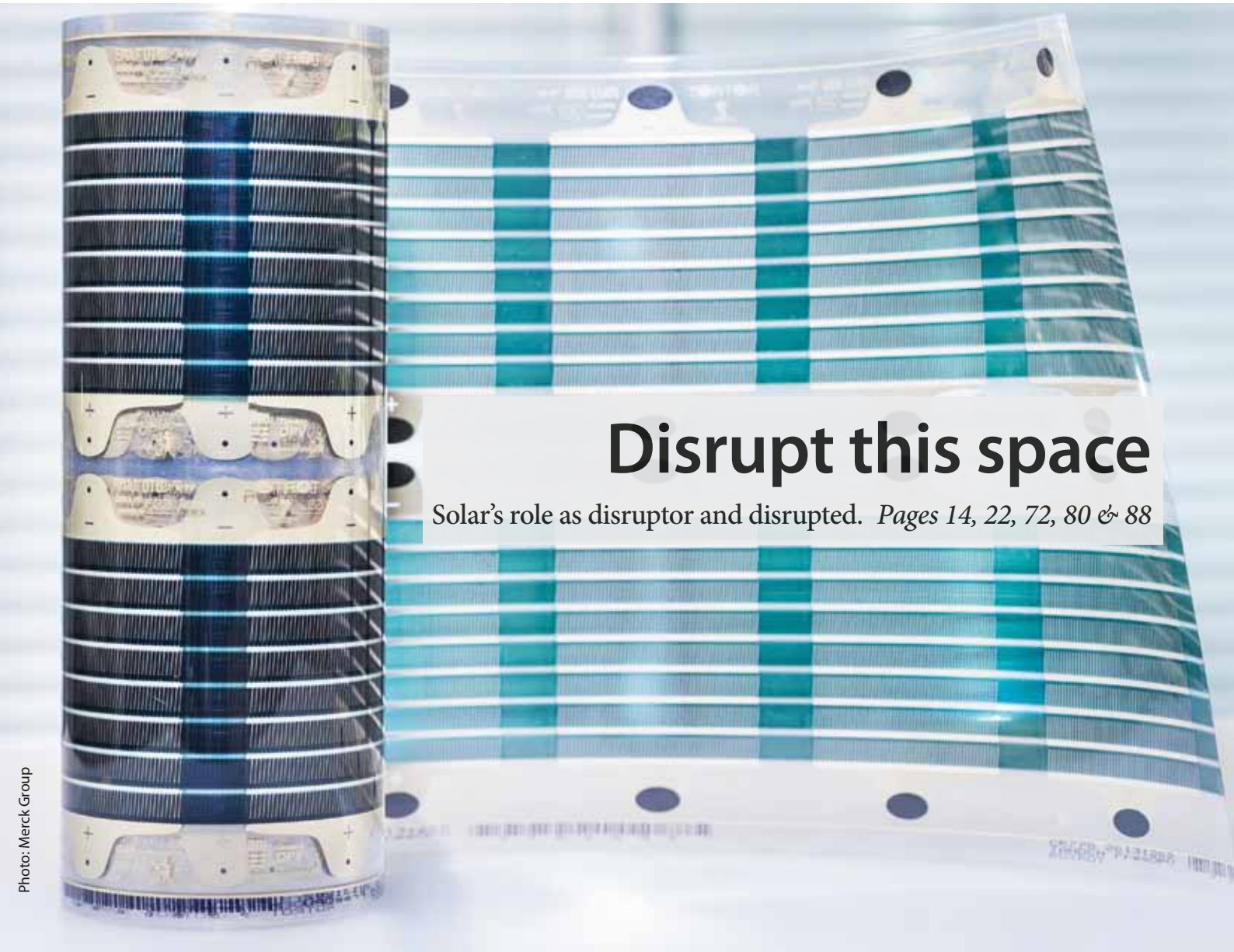

## Disrupt this space

Solar's role as disruptor and disrupted. *Pages 14, 22, 72, 80 & 88*

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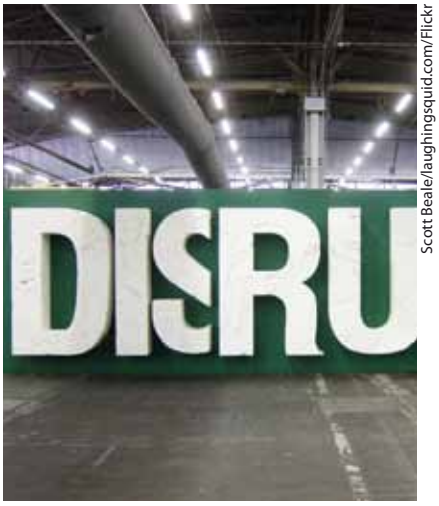

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## Industry & Suppliers

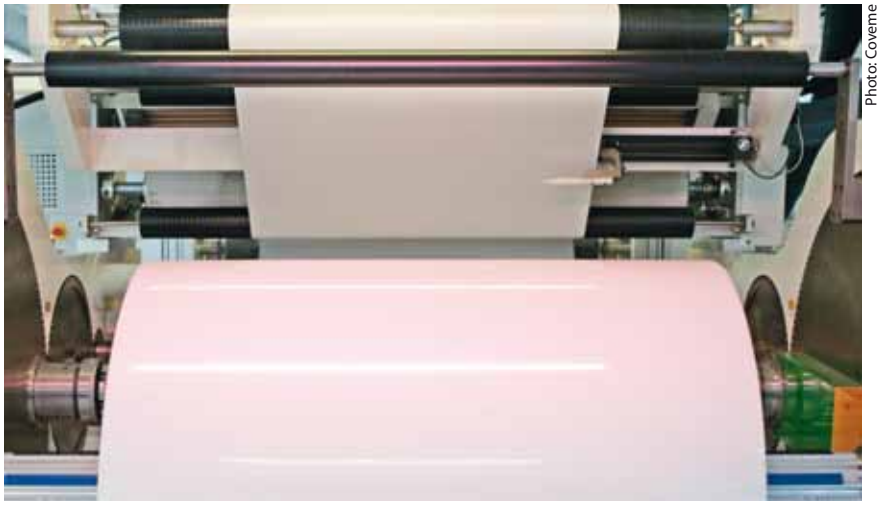

Photo: Coveme

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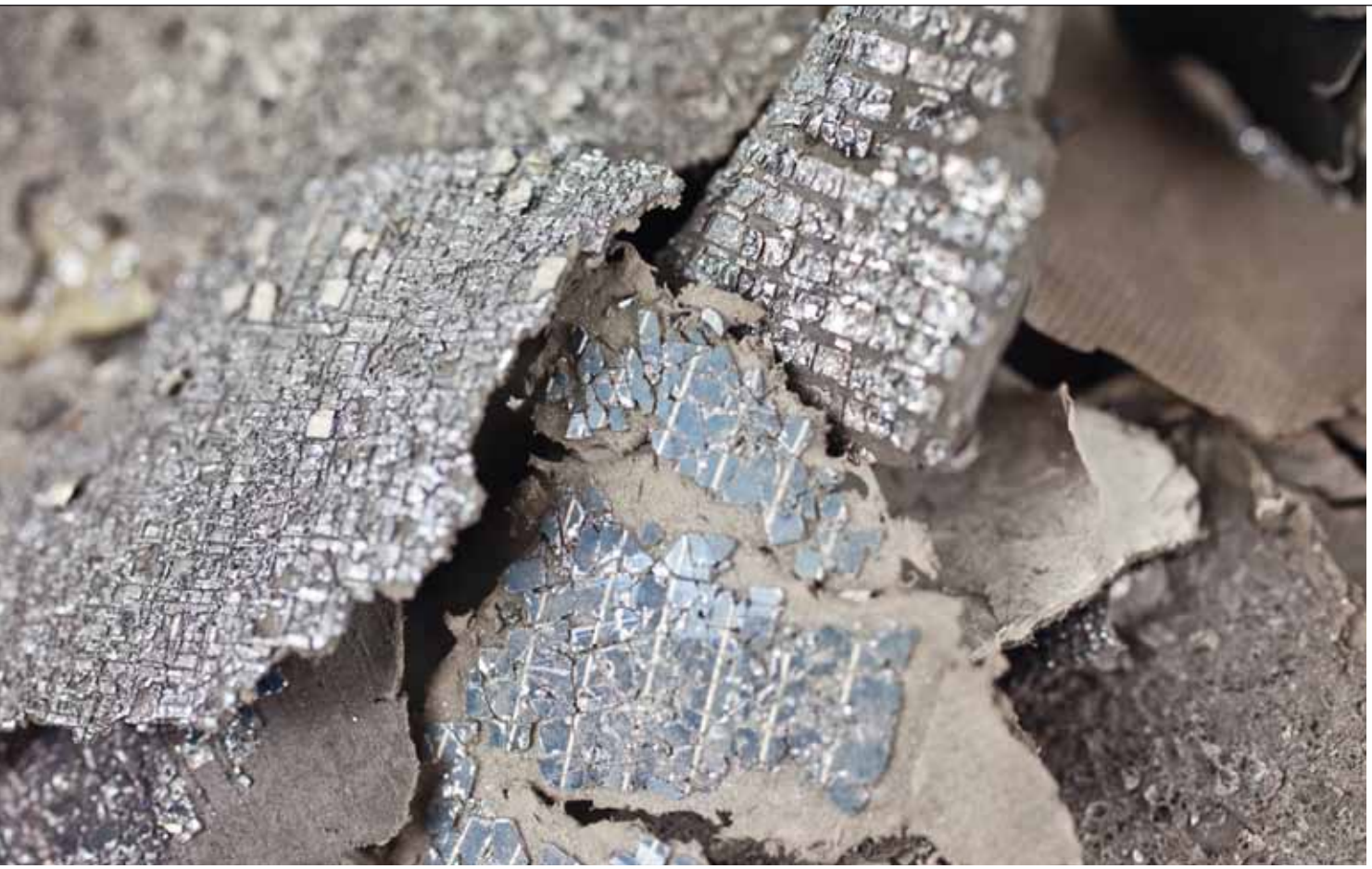

Photo: PV Cycle

The recycling of silicon used in PV modules can reduce the carbon footprint of production significantly.

# Keeping PV components "green"

**Sustainable PV:** Just as module efficiency does not depend only on cell architecture developments, so too does sustainable solar come right down to the components. This is the case from solar glass through to backsheets. The use of fluoropolymers in backsheets supplied to the industry has some worried about toxicity issues when modules come to their end of life.

Last November the Silicon Valley Toxics Coalition (SVTC) released its "solar scorecard," providing a ranking of 37 solar module manufacturers with regards to their actions and words when it comes to sustainability. The criteria the SVTC ranked the module producers on included emissions, water and energy efficiency, the use of conflict materials, and workers' safety and health.

The SVTC used both public information and responses to a detailed survey provided to manufacturers to carry out the ranking. Trina Solar, much to its delight, picked up the top spot on the ranking, with SunPower, Yingli, SolarWorld and REC rounding out the top five. While these producers would've been well pleased by the outcome, a darker note was struck by the fact that fewer module manufacturers responded to the survey than in previous years.

"Although the solar market has expanded sixfold since 2009, the market share of companies committed to reporting environmental practices has declined," said Sheila Davis, Executive Director of SVTC. "The rise of 'white box' solar manufacturers has the potential to drive a race to the bottom."

While environmental mishaps, such as the 2011 waste spill at JinkoSolar's factory in the Zhejiang province of China has attracted environmental headlines for the wrong reasons in the past, the suitability for modules for recycling at end-of-life is also an issue that is increasingly coming into focus.

"There are a lot of benefits [to recycling in the PV industry] and I think, even though we're not buried yet in a lot of end-of-life PV modules, there are defec-

Photo: Coveme spa

Coveme has developed fluoropolymer-free backsheets that it believes addresses environmental concerns while remaining competitive on price and performance.

tive and broken modules so I think there are a lot of opportunities from recycling," said Dustin Mulvaney, an assistant professor at San Jose State University and technical advisor to the SVTC.

The benefits to the industry in having a robust recycling infrastructure in place are many, according to Mulvaney. These include the prevention of potentially toxic e-waste contaminating air, soil and water suppliers, the chance to recycle rare metals, and a vast reduction of carbon footprint when compared to manufacturing modules from scratch.

"To me the main issue is preventing an e-waste crisis and solar panels do have the perfect recipe for e-waste, that being valuable metals embedded in toxic materials. So they definitely pose that threat," Mulvaney explained.

## Beyond active layer

Potentially valuable materials are present in modules of all types, including silver in c-Si modules, tellurium in CdTe modules and indium in CIGS modules, which are all rare. But there are also toxins including arsenic, cadmium telluride, hexafluoroethane, lead, and polyvinyl fluoride. And the presence of these goes far beyond the composition of the active PV layer. Polyvinyl fluoride, a type of fluropolymer, is present in some backsheets. IHS analyst Karl Melkonyan notes: "Its availability rapidly established it as a highly-popular alternative to Tedlar, both in single and double fluoropolymer constructions." (See full interview pp. 58-59)

At present there are no cost-effective methods for the recycling of fluropolymer backsheets. While there are methods for breaking down the robust chemical structure of fluropolymer, if the method is excessively expensive there is little sense in the industry pursuing it. European solar recycling body PV Cycle's Alina Lange said that while technically there are few challenges to recycling as much as 95% of components in a PV module, economics are important.

"At PV Cycle we watch out for what is called 'Best Available Techniques Not Entailing Excessive Costs' (BATNEEC), allowing our scheme to be effective and cost efficient at the same time," Lange explained.

If it is not recycled, fluropolymer disposal can either take the form of incorporation into landfill or incineration. Both have their risks. Fluorosis, caused by the excessive intake of fluorides in water or through inhalation, can lead to cases of osteofluorosis. Osteofluorosis can cause skeletal changes, including the fracture of bones or pitting or damage to teeth. This and associated conditions are most common in India and China, as a result of industrial pollution or accidental contamination, and UNICEF estimates: "Fluorosis is endemic in at least 25 countries across the globe. The total number of people affected is not known, but a conservative estimate would number in the tens of millions."

It should be noted that cases of fluorosis are most commonly associated with industrial production techniques, the burning of coal as an indoor fuel, and the drinking of contaminated tea or groundwater, but not related to PV backsheet disposal. However, with an estimated tens of millions of square meters of fluropolymer backsheets in module production, the presence of fluorine and its disposal is an issue that may have to be faced by global PV.

"I would imagine that there are some chlorine-based chemicals that are being incinerated that would pose an issue," said the SVTC's advisor Dustin Mul-

Photos: PV Cycle

Glass can be recycled by third-party providers.

Modules may contain backsheets that utilize fluoropolymers.

vaney. "But it is not a topic that is getting much attention and I am not aware of any published literature on the topic." Mulvaney added that paradoxically, incineration of some materials in recycling might in fact result in environmental kudos rather than a kick in the pants.

"Interestingly when you incinerate plastic, often your product gets to claim that it is recycling what it is burning," said Mulvaney. "And that is because they often incinerate for energy recovery. So they will burn plastic, get some energy back out of that plastic and then – under the rules for claims about recycled materials – they are allowed to say this product is made with 5% recycled materials, because you are able to do energy recovery."

## Fluoropolymer alternatives

Polyethylene Terephthalate (PET) composite layers are an increasingly common alternative to fluoropolymer backsheets and IHS reports that it is growing in popularity. Italy's Coveme began working with PET backsheets in 2007, leveraging its strategic experience in polyester and related chemicals.

Alessandro Anderlini is the Photovoltaic Division Manager at Coveme and he says that the company's decision to develop PET technology was largely driven by a desire to avoid the use of fluorinated films.

"Solar is a renewable energy market and all of the materials involved should be of the maximum environmental and renewable material and non-polluting," said Anderlini. "All the wasted PET from Coveme backsheet processing is recycled by specialized companies that can reuse this material for making other consumables, like textile fibers and non-woven fibers," said Anderlini. "All the by-products generated by Coveme production processes, like VOC from adhesive solvents, are burned to generate heat that finally is used for other facilities of Coveme's production plant in Zhangjiagang, China. Coveme uses a technology based on RTO or Regenerative Thermal Oxidation."

Anderlini believes that there is a "big chunk" of the PV industry using backsheets containing fluoropolymer, but that the PET-based market is growing.

"The roadmap is 100% in favor of polyester films," explained Anderlini, "which are already more cost competitive, and this gap will only increase in the future."

## WEEE directive

The debate about challenges posed by PV components at a module's end-of-life has been occurring against the backdrop of the EU's Waste Electrical and Electronic Equipment (WEEE) directive. The directive is designed to manage the increasing volumes of waste from modern consumer and industrial electronics. The new WEEE Directive came into force in February 2014. Some EU member states have not yet transposed the directive into national law, while others have allowed for transition periods.

In August last year France signed the WEEE into law with regards to PV modules resulting in, "a legal obligation for France-based companies to organize the take-back and recycling of their discarded products returned to them by consumers and professionals," in the words of PV Cycle.

In terms of hazardous materials, the EU's RoHS directive applies. RoHS stands for the restriction of the use of certain hazardous substances in electrical and electronic equipment. PV Cycle's Alina Lange notes though, that PV modules have been, "explicitly excluded" from the RoHS Directive.

"PV modules have been proven safe for man and nature and no PV technology commercially available on the PV market today meets the criteria of hazardous waste," explained Lange. "PV Cycle was founded in 2007 for and by the PV industry with the commitment of an industry that understood the value of sustainable life cycle management – from green energy production to sustainable waste management."

PV Cycle members tend to be, "bigger, international companies which show a very high commitment to sustainable waste management," according to Lange. PV Cycle's latest priority has been in expanding its membership base by communicating its message to small and medium sized manufacturers. It is a system, and message, that the Silicon Valley Toxics Coalition looks to with some envy.

"I think that it [the end of life issue] is being dealt with appropriately in Europe, but I am not sure that the industry is being very well evolved on the issue in the U.S.," said SVTC advisor Dustin Mulvaney. "I think what the European industry has done with PV Cycle is a really nice step forward and I would like to see something like that in the U.S."

In November 2014 PV Cycle hit the milestone of 10,000 metric tons of collected waste PV modules, having made collections in 20 different European countries, across 350 collection points. ◆

Jonathan Gifford