

THE UNITED STATES VS. CHINA: THE SILICON SOLAR BATTLE

THE SILICON SOLAR PV CELL WAS INVENTED IN AMERICA, YET WE NOW HAVE NO HAND IN ITS PRODUCTION. HOW DID WE LET CHINA DOMINATE SOLAR MANUFACTURING?



A worker inspecting cells at a Trina Solar factory in China in 2015. Tomohiro Ohsumi/Bloomberg via Getty Images

AN engineer, a chemist and a physicist walk into a lab on April 25, 1954. The next day, *The New York Times* publishes a front page story that their invention “may mark the beginning of a new era, leading eventually to the realization of one of mankind’s most cherished dreams — the harnessing of the almost limitless energy of the sun for the uses of civilization.”

Daryl Chapin, Calvin Fuller and Gerald Pearson worked at the famed Bell Labs in the 1950s and are credited with creating the silicon PV cell. This American invention ushered in an era of American ingenuity — from satellites and space travel to independent power production on Earth. With so much American technical experience, how is it that 70 years later, the United States has very little influence on the silicon solar cell? How did China come to dominate the solar PV manufacturing market?

U.S. WINS THE RACE, BUT NOT THE MARATHON

To begin, one must follow the path of the silicon solar cell after it left Bell Labs. First it found a home on American satellites (Russia’s Sputnik 1 used silver-zinc batteries for power in 1957; America’s Vanguard 1 used six silicon solar cells in 1958). The 1960s saw more gains in efficiency, but commercialization was slow to catch on. The 1973 oil crisis pushed the U.S. Congress to pass bills that would force the country to make solar more viable and affordable for the general public. U.S. energy companies — which at that point had mostly dealt with oil and gas — began opening solar research divisions. One of those companies, Atlantic Richfield Company (ARCO), was very successful with its photovoltaics product development.

ARCO Solar achieved many global industry firsts, including being the first

panel manufacturer to hit 1 MW of yearly production (1980) and the first to install a megawatt-scale solar project (1982). Through a series of acquisitions, ARCO eventually becomes SolarWorld Americas (a subsidiary of German SolarWorld AG), and the technological legacy lived on at its silicon cell and panel manufacturing plant in Hillsboro, Oregon.

SolarWorld is a central theme in the story of the downfall of American solar manufacturing. Whether SolarWorld deserves the blame is a matter of personal opinion, especially among those entrenched in the U.S. solar industry in the early 2010s.

SolarWorld Americas became the nation’s punching bag after it filed a trade petition in October 2011 (along with six unnamed solar companies) asking the U.S. government to prevent Chinese solar companies from dumping cheap solar panels into the U.S.

Archive photo of solar cells at SolarWorld's Oregon manufacturing facility.



market. Many in the U.S. solar industry denounced SolarWorld as anti-affordable solar and against fair competition. They claimed the young U.S. solar industry couldn't grow without cheaper solar panels. The U.S. government, though, saw SolarWorld's point that China's cheap panels were preventing U.S. solar manufacturers from competing in the market, and the U.S. levied antidumping and countervailing (AD/CV) duties against Chinese solar companies.

China retaliated with its own tariffs on American-made polysilicon and propped up its domestic production. Ten years later, American polysilicon production for the solar market is still deflated and China now holds 80% of the world's polysilicon supply (nearly half coming from the Xinjiang province). There are no silicon solar cell manufacturers in the United States, and SolarWorld Americas — with its historic influence on the U.S. solar industry — is out of business.

Once a solar manufacturing powerhouse, the United States (and the rest of the globe) now depends on China for its solar supply chain.

THE ORIGINS OF THE FIGHT

In 2011, when SolarWorld Americas made its official complaint to the Dept. of Commerce citing unfair trade practices by

China, the U.S. manufacturer participated in every step of solar panel manufacturing — it melted and shaped polysilicon into ingots, sliced the ingots into wafers, doped the wafers into cells and finally assembled the cells into finished solar panels. The company had just started a significant investment into advanced mono-PERC solar manufacturing when SolarWorld's locked-in polysilicon supply contracts were priced considerably higher than what China was offering, said Desari Strader, then-head of government affairs for SolarWorld Americas.

"They were beating us on the cost of production," Strader said of Chinese suppliers at the time. "We had just finished ramping up [to mono-PERC]. Of course the Chinese could come and dump [cheap panels] in the U.S. It was super easy. Then everyone is screaming that you can't compete with [Chinese module prices.] Yeah, you're right. We can't compete with slave labor."

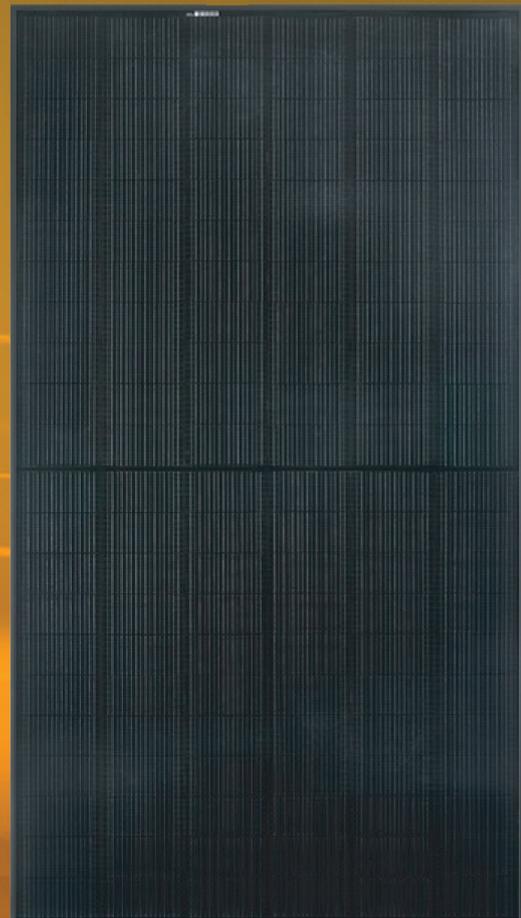
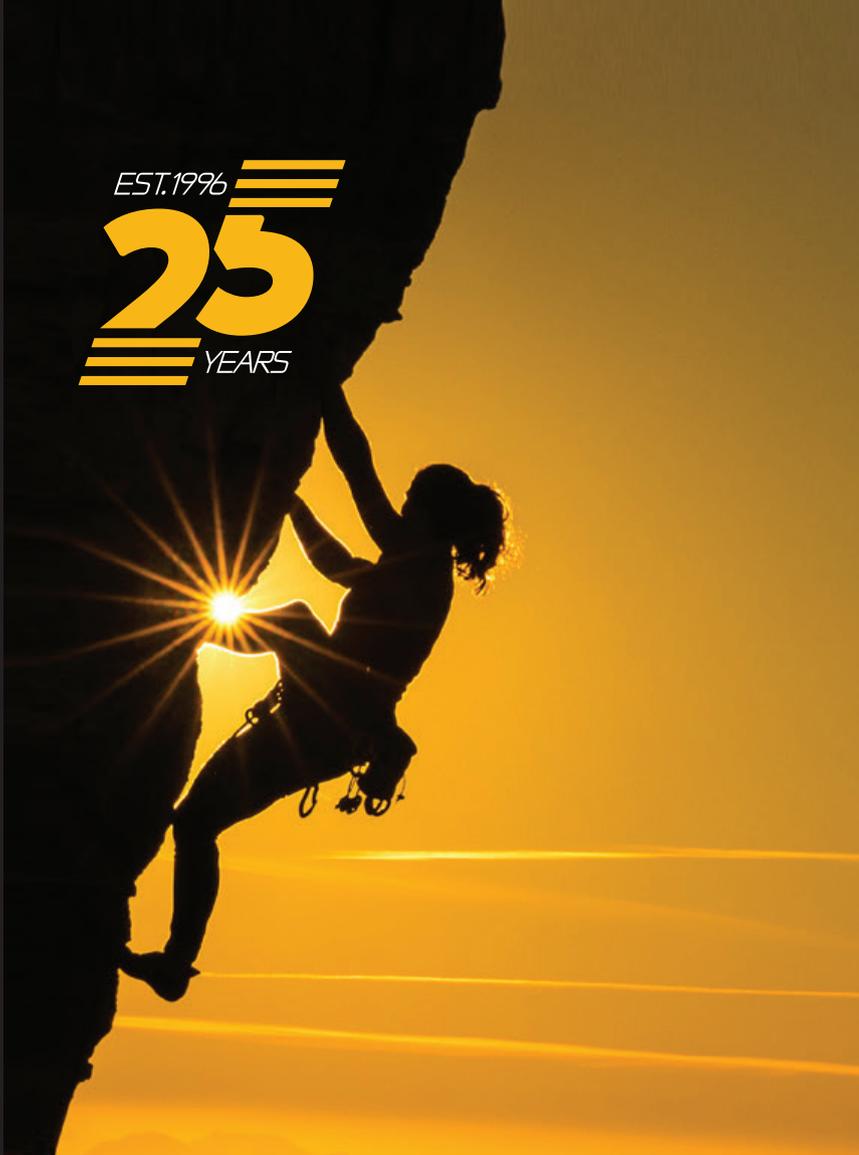
The Xinjiang province of China has long been associated with alleged human rights abuses. The United States and many other international democracies believe that China is forcing those of the mostly Muslim Uyghur population into labor camps in the Northwest portion of the country. The situation is being described as an ethnic and religious genocide of the Uyghur people. Xinjiang became a polysilicon manufacturing hotspot in the late 2000s, after China established an economic plan that prioritized solar and polysilicon development, and subsidized local manufacturing. Soon enough, Chinese companies were churning out cheap solar panels, boosted by state-funding — and possibly forced labor.

"If 30% of the cost of a panel is your polysilicon, and you're not paying wages, [of course] they were beating us on the cost of production," Strader said.

IF 30% OF THE COST OF A PANEL IS YOUR POLYSILICON, AND YOU'RE NOT PAYING WAGES, [OF COURSE] THEY WERE BEATING US ON THE COST OF PRODUCTION.

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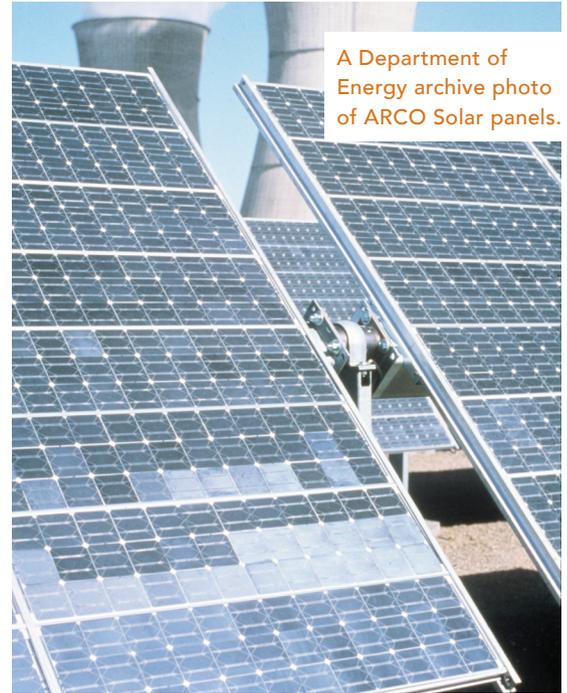
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Strader said that once there was no way to avoid American-made SolarWorld modules (with high-priced polysilicon contracts) being more expensive than Chinese imports, SolarWorld moved forward with the court case to protect not only its investment in cutting-edge PERC technology, but also American solar manufacturing.

An opposition group called the Coalition for Affordable Solar Energy (CASE) quickly formed, fronted by SunEdison founder Jigar Shah (who today works at the Dept. of Energy). CASE membership said that any duties on imported solar modules would increase system prices and hurt the growing solar installation workforce — which was significantly larger than the U.S. solar manufacturing pool.

“SolarWorld is looking to single-handedly kill U.S. solar jobs, which are primarily in solar installation, not in solar cell or panel manufacturing,” Shah said in a statement back then. “The government shouldn’t reward or protect one German company that is not fitting into the thriving global solar industry. It also should not punish the American companies that have found a job-creating niche in that same industry. The prosecution of this trade case is not going to solve the problem of promoting American manufacturing — it will just disrupt the industry.”

SolarWorld responded to the backlash (in *Solar Power World* in Dec. 2011): “While subsidies are not inherently improper, it is illegal for a nation to use them to ramp up domestic production to grow



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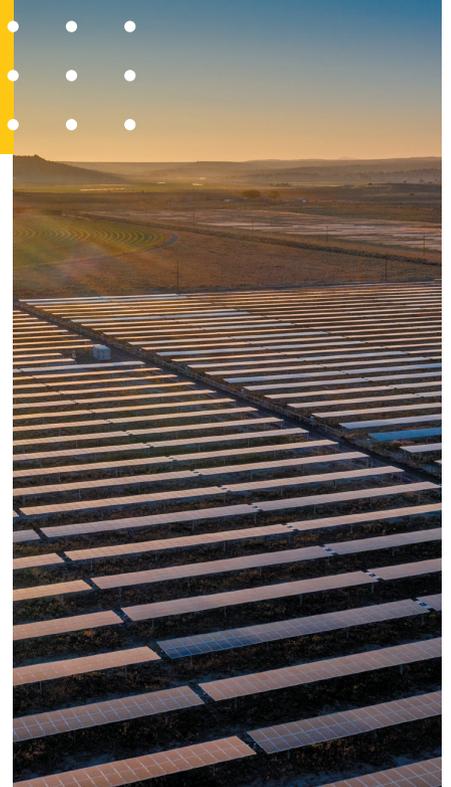
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well beyond the needs of domestic consumption and then dump exports at prices below production costs into a foreign economy with the effect of destroying that foreign economy's market and industry.

"Such is precisely what China is doing."

In 2012, the Dept. of Commerce imposed AD/CV duties on U.S. solar cell imports from Chinese manufacturers ranging from 23 to 35%. For any Chinese company that didn't agree to have their bill of materials investigated by the United States, the duty was a hefty 250%.

Thus started the trend of Chinese module manufacturers shipping solar wafers to Taiwan to be made into solar cells and then back to China for module assembly to avoid the tariffs. U.S. solar module prices were not drastically affected by the anti-dumping taxes.

What was affected was the American polysilicon industry.

POLYSILICON GETS A RAW DEAL

"SolarWorld filed those trade cases for modules and cells. Then China retaliated and put it against us [polysilicon producers]," said Chuck Sutton, VP of FBR polysilicon sales and an employee at REC Silicon for 30 years. The three U.S. polysilicon producers still affected by this saga are Hemlock Semiconductor Operations, REC Silicon and Wacker Chemie AG.

In direct retaliation to the U.S. tariffs on imported Chinese solar cells, China in 2013 placed its own high duties on American-made polysilicon. At the time, it was reported that the United States produced 24% of the global polysilicon market. The large majority of REC's U.S. polysilicon production was supplied directly to China — its Moses Lake, Washington, facility (which catered to solar) exported

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80% of its polysilicon to China, while its Butte, Montana, plant (which largely supplied the electronics market) exported 50% of its product to China.

Also at the time, Hemlock had a facility in Michigan and was working on a new plant in Tennessee. Wacker was also in the middle of building its own \$2.5 billion polysilicon manufacturing plant in Tennessee. Hemlock closed its Tennessee venture in 2014 while Wacker continued with its investment although the polysilicon market bottomed out. Along with REC Silicon, the three once-competitors released a joint statement in 2019 claiming that the effective ban from the Chinese market resulted in the U.S. polysilicon market shrinking from \$1 billion in 2011 to \$107 million in 2018.

Although initially shut out of the Chinese market, American polysilicon suppliers could still work with other countries and found decent supply need with Korean and Taiwanese solar wafer and cell companies, until China restricted imports from those countries,

too. Not only was China ramping its own production of polysilicon, it was also overtaking the global solar wafer and cell supply chain.

Outside of China, solar wafer and cell manufacturers are limited. There's NorSun in Norway (currently less than 500 MW), LONGi in Malaysia (~1 GW), JA Solar in Vietnam (~1 GW), Meyer Burger starting up in Germany (~1 GW), and possibly a few smaller outfits in Taiwan — maybe 4 GW in total. Meanwhile, the three U.S. companies have much larger production capacities (probably around 23 GW at full capacity). And this isn't considering any polysilicon production in Europe.

"Our issue right now is there is no ingot wafer capacity, or at least not enough, outside China," Sutton said. "You're looking at 20 to 40 GW of polysilicon trying to fight for 4 GW [of wafer production]."

This oversupply situation forced REC to shut down its Moses Lake plant in 2019. Its Montana plant is still making polysilicon, but only for the electronics

OUR ISSUE RIGHT NOW IS THERE IS NO INGOT WAFER CAPACITY, OR AT LEAST NOT ENOUGH, OUTSIDE CHINA.

market. If China doesn't allow American imports, and if a non-Chinese solar supply chain doesn't get set up soon, Sutton said REC will invest more in next-generation lithium-ion battery technologies that use silicon. The company currently is testing this new venture on a pilot line in Moses Lake.

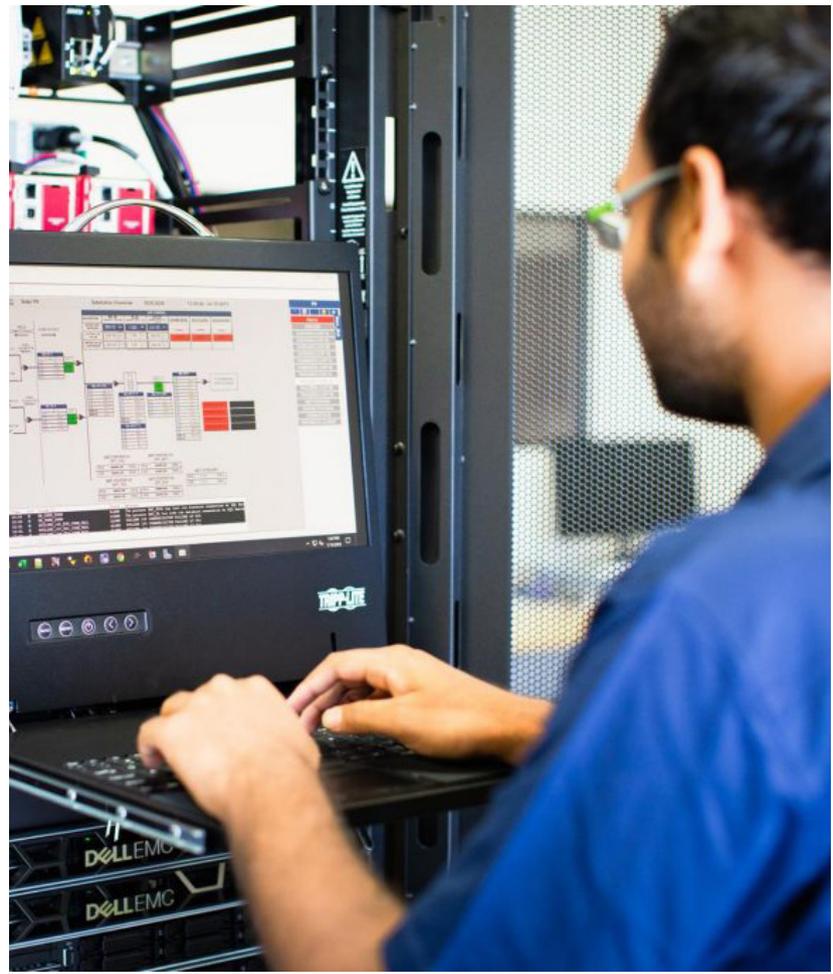
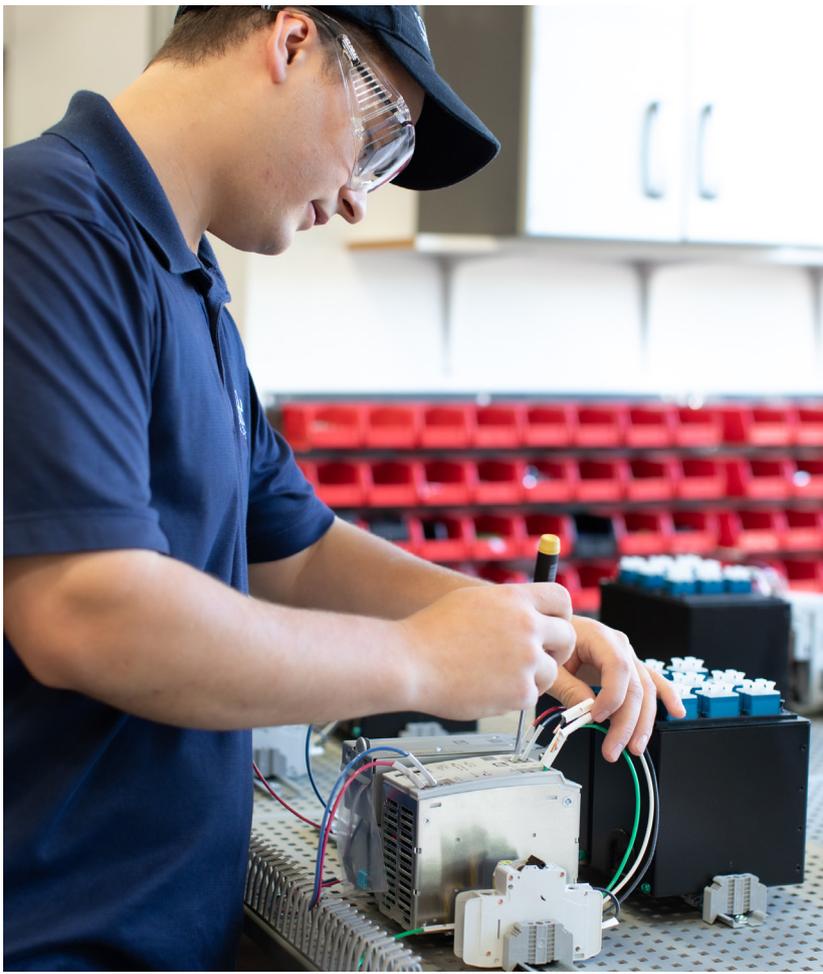
But in order for silicon-doped lithium batteries to turn into significant contracts for REC, "we need the electric vehicle market to take off, but likewise, China is dominating that market," Sutton said.

CAN AMERICA GET ITS SOLAR GROOVE BACK?

In June 2021, the United States escalated the now 10-year battle with China over



Archive photo of polysilicon ready to be formed into ingots at SolarWorld's Oregon manufacturing facility.



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polysilicon and solar. U.S. Customs and Border Protection (CBP) issued a Withhold Release Order (WRO) on silicon-based products made by Hoshine Silicon Industry Co. located in Xinjiang, in a stand against products using forced labor entering the global supply chain.

Hoshine produces industrial silicon, which can find its way into polysilicon products. Although the United States isn't a huge importer of Hoshine silicon (only \$6 million in direct imports last year), Hoshine does supply silicon to several Chinese firms whose polysilicon undoubtedly ends up in solar cells and panels entering the United States. CBP officials confirmed its ban includes finished solar panels containing Hoshine materials.

While this WRO isn't wholly a reaction to the solar industry (silicon is in a lot of semiconductors and electronics that the federal government uses every day), its long-term effects could start a shift to non-Chinese solar supply chains. Desari Strader, the former head of government affairs for SolarWorld Americas, thinks so. She is the founder of U.S. solar manufacturing startup Violet Power. Many on the Violet Power leadership team have deep ties to the U.S. solar industry and SolarWorld — including one-time CEO Charlie Gay, who previously was CEO of ARCO Solar and helped SolarWorld transition to mono-PERC technology.

Violet Power made a big splash in 2020 when it announced it would have 500 MW of solar cell and 500 MW of solar panel manufacturing in Washington State by 2021, with an eventual scale to 5 GW of annual production. It was a bit of a premature announcement, with the company underestimating how difficult it would be to establish a non-Chinese supply chain.

But now Violet Power has regrouped and plans to be the first falling domino that forces a more domestic supply chain. If Violet Power can absolutely commit to a large amount of solar cell



Archive photo of ingot ready to be cut into wafers at SolarWorld's Oregon manufacturing facility.

production, then other U.S. startups will have the guarantee of a major customer and can begin making wafers and ingots domestically.

"The mission is this: We owned this technology; we built this technology. It was birthed out of Bell Labs. It powered the first satellite dishes. We're bringing our technology not only home, but to scale with a U.S. supply chain," Strader said.

All Violet Power needs is other players to step up.

"We were never going to limp into this with 1 GW [of cell production]. You have to go 3 to 5 GW out of the gate to get all the other upstream/downstream players ramping back up with you," Strader continued. "The timeline is nine to 12 months for a module line [to get started], six to nine months for wafer, ingot is 18 to 24 months. The only way they can do that is knowing they have at least one cell company to feed into. That's what Violet Power is going to be."

A federal manufacturing tax credit would also help tremendously. The Solar

Energy Manufacturing for America Act introduced in the Senate this year would provide tax credits for American manufacturers at every stage of the solar panel manufacturing supply chain, from production of polysilicon to solar cells to fully assembled solar modules.

The suggested credits to manufacturers include: 7-¢/W for solar panels, 11-¢/W for integrated modules, 4-¢/W for PV cells, \$12/m² for silicon wafers and \$3/kg for solar-grade polysilicon.

"The manufacturing tax credit has to go through if the U.S. is going to do anything on climate change," Strader said.

The proposed tax credit has already led one company to announce U.S. module manufacturing plans. Convalt Energy purchased the equipment at the former SolarWorld plant in Oregon and is moving it to New York to set up a 700-MW module assembly plant that will open in 2022. But without wafer and cell production in the United States, it still has a Chinese solar supply problem.



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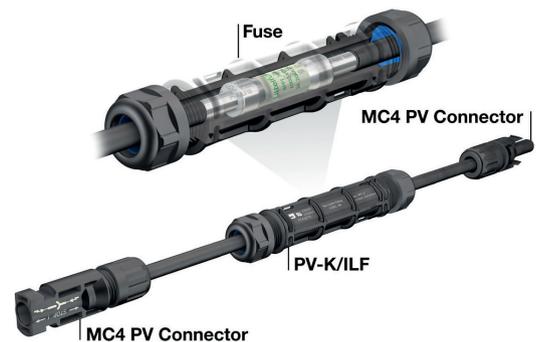
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“There’s a missing gap. The ingot wafer is a missing gap,” REC Silicon’s Sutton said. “You have people on one end that say we need to let more cells into the U.S. to do this 20 GW [of solar installations] we need. Then you have those people that want to put in cell lines but they want wafers, which can only come from China right now. So, you have this gap.

“They want to have these U.S. facilities, but your choice for supply is very limited,” Sutton continued. “For these people to be successful, they either need to accept that’s the way it’s going to be, or we need to get together and invest in ingot and wafer production,” Sutton concluded.

In August 2021, California solar panel assembler Auxin Solar and former solar cell producer Suniva filed a petition with the U.S. International Trade Commission to extend safeguard tariffs on imported solar cells and panels through 2026. Within the court

documents, Auxin stated that with continued tariffs (which initially began in 2018 from a completely different case not discussed here), it could bring wafer production stateside. Suniva claims that only with extended tariffs can it restart its dormant solar cell production facility in Georgia.

Clearly there are ambitious companies out there, but the future of the U.S. solar manufacturing industry will likely depend on government support — through subsidies, tax credits and competitive tariffs.

Back in 2011, Gordon Brinser, then-president of SolarWorld Americas, pondered in an op-ed: “The U.S. solar market and solar installations will continue to grow with or without China’s unfairly traded goods. Solar is here to stay. The only question is whether U.S. solar manufacturing will still have a role.”

Ten years later, the United States is still trying to sort that out. **SPW**

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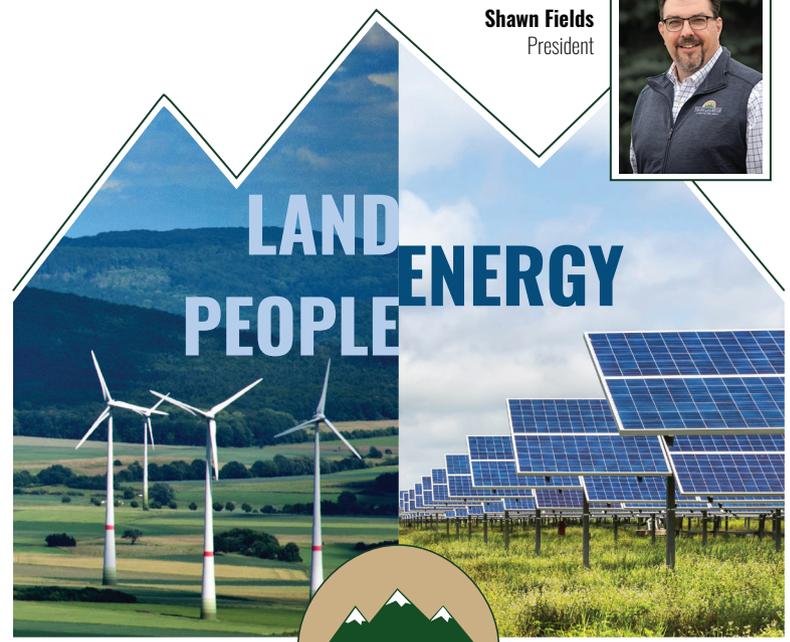
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