



## **Circular Solar Wind**

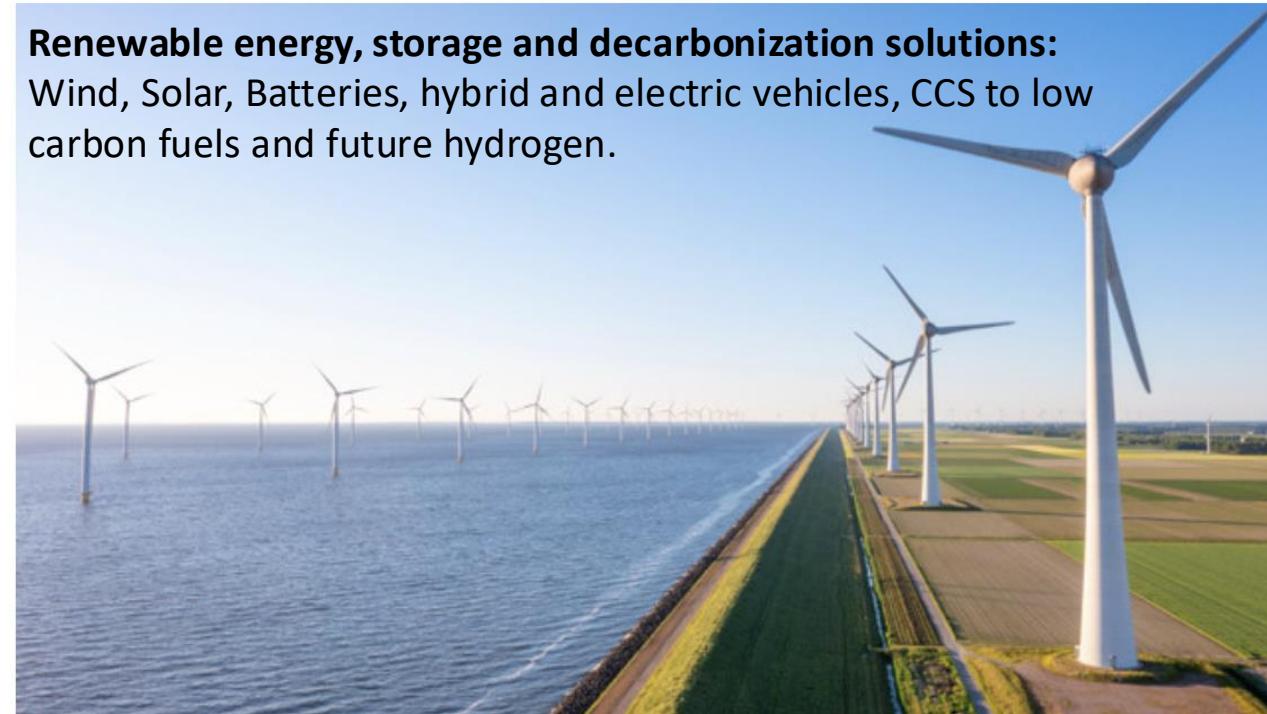
**Improving lifecycle and potentially reaching 100% wind blade, nacelle repurposing and recycling rates:**

1. Reducing corrosion.
2. Circular Solar Nanorocks placed below turbines protect farmland: soil, groundwater and wildlife.
3. With solar-battery farms; generating 15% extra solar yield.
4. Innovations for sustainable concrete.
5. OCTOPUS drones.
6. REEs critical mineral streams from generators.

# **Circular Solar Wind:** What if the problems with wind are solutions for: solar-battery projects, pollution control infrastructure, innovative circular concrete and drones (UAVs)?

## **Renewable energy, storage and decarbonization solutions:**

Wind, Solar, Batteries, hybrid and electric vehicles, CCS to low carbon fuels and future hydrogen.



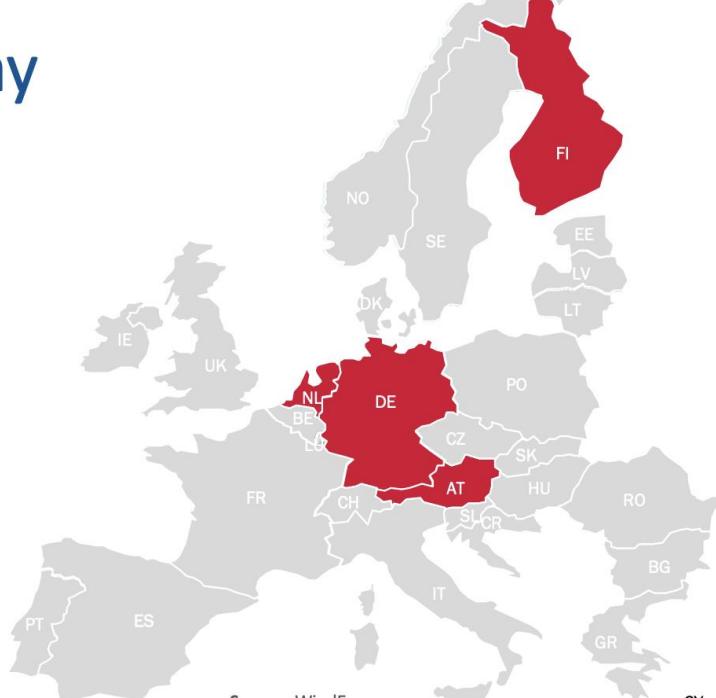
## **Problems:**

- Recycling rates of blades average at around 90%.
- Those opposing wind point to their impact on landfills.
- Failures include from corrosion, oil leaks and lightening strikes causing fires, composite plastic debris polluting land or water to foreign adversary cyber attacks causing problems (ex. Russian attack on Enercon Wind in Germany, same day invasion of Ukraine, February 2022).
- PFAS contamination is of major concern for its impact on soil, plants, wildlife, waterways, drinking water.
- Wind Europe called for a landfill by 2025.

## **Current Solutions:**

- Downcycled as a SCM for concrete, where it competes with lower cost virgin material.
- Used as WtE fuel; which emits plastic, toxic emissions and its a low BTU value at a cement kiln versus other alt fuels (Ag waste – tyres).
- Recycling, including chemicals, are available but at a high cost.
- Repurposing, into bridges to e-bike infrastructure are useful and effective.

# Landfill ban today

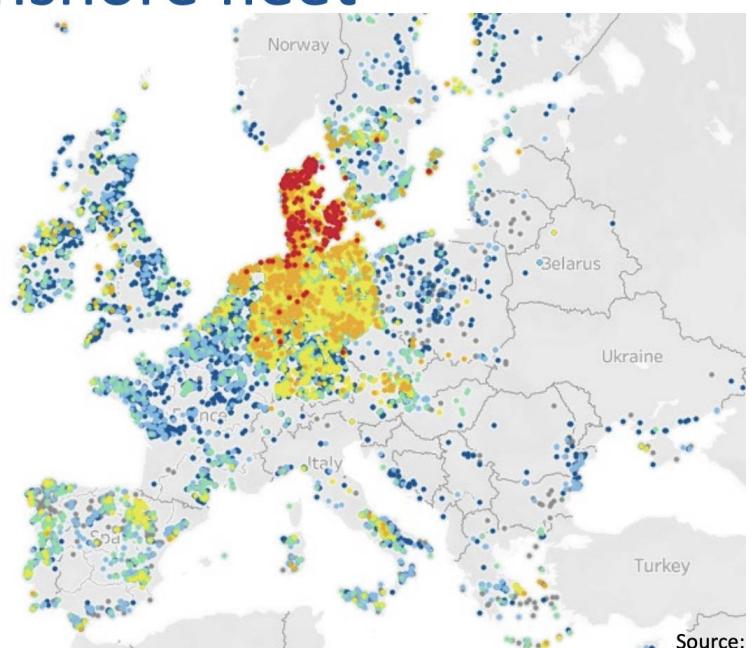


Wind  
EUROPE

## An ageing onshore fleet

Age (group)

- 30+ years
- 25-29 years
- 20-24 years
- 15-19 years
- 10-14 years
- 1-9 years
- Null



Our 600+ members make wind energy work

Wind Turbine manufacturers



Wind farm developers



Power utilities



Component manufacturers



Digital solutions & service providers



EPC, installation and logistics



Financial & legal services



Research institutes



Energy buyers



Wind  
EUROPE

+ NATIONAL WIND ENERGY ASSOCIATIONS

Wind  
EUROPE

# USA, California Wind Recycling Policy:



Wind turbine recycling is under further review. ———  
Where currently materials are exported out of state:  
such as Wyoming, Iowa, Texas. California often  
follows EU policy.

Building a circular economy can fill product and material gaps such as:

- High-value materials with increasing volumes (e.g., food waste, emerging energy transition technologies such as batteries, solar panels)
- Materials with limited value as a resource (e.g., single-use plastics, multi-layer packaging)
- Other materials with service gaps (e.g., non-standard organic waste, urban wood waste, appliances, tires, small electronics such as vaping devices)
- Materials with solution gaps (e.g., disaster debris, recreational vehicle and temporary encampment materials, wind turbines, medical waste, litter and illegal dumping, residuals)

Not all materials and products in California have clear recycling or composting solutions. The Zero Waste Plan offers a path for managing these hard-to-recycle materials through source reduction, while continuing to improve and develop new solutions for recycling.

Figure 2: Circular Economy

## Circular Economy

To value: Take, make, return, remake



**Policy and Regulation**

A. Review and refine existing policies, programs, regulations and statutes to align incentives and requirements with materials' highest and best use

1. Review and update key materials management targets, definitions and rules across state agencies and policies to align on definitions that drive materials to be used for highest and best use at each decision point.

2. Review existing statutes, regulations, and policies across state agencies to identify and address gaps / overlaps where policies are misaligned with optimal, circular behavior (e.g., policies that prevent reuse due to building code, food safety, etc.)

B. Adopt a California circular materials management framework to develop and implement policies that prioritize source reduction, waste prevention, and proactive circular materials management

1. Prioritize source reduction by using a circular-first lens in policy design and implementation and materials management within CalRecycle

2. Adopt state-wide strategy and associated policies to address influx of sources of high volume and/or valuable waste, or materials of concern

3. Incorporate circular considerations into design of policies influencing material consumption / generation

**Project Circular Solar** focuses on research, innovation and products for current recycled, new potential products, supporting and scalable globally for the UN Zero Waste Initiative, Renewable Energy, CDR (carbon dioxide removal) targets:

Materials:

**Recycled glass**, to support [SB1013](#) Bottle Bill and for SB54 this project ensures higher rates of overall glass recycling eliminating "single use" in glass packaging.

**Wind turbines** composite fiberglass blades, nacelles which can fall under this bill that just passed, [SB235](#) ("other similar valuable materials within products"). This bill includes requesting CalRecycle to take under consideration the opportunity CA has with EoL materials from energy which contain critical minerals, metals, such as REE (rare earth elements), and other materials, that are exported out of state for their recycling, businesses. Circular Solar takes it next level, with the ability to reuse, repurpose whole EoL wind blades, nacelles into negative emissions solar-battery power plants. Pitch deck with live tests [available here](#)

**Concrete, certain construction waste:** [SB596](#) which is for low carbon cement, this may include circular concrete materials.

**Certain single-use plastic packaging:** [Sb54](#)

**Nanotechnology for environmental remediation, carbon removal:** which supports and should qualify for [SB285](#)

**Circular Solar's first concrete, glass example in a road installed in Fairfield in 2008 which was an early real-life example supporting: SB1013, SB596, SB285:**

<https://youtu.be/l7ydpFWBpGo>

To increase consumer participation of recycling, innovation is required where consumers feel moved to make additional effort. By seeing recycled glass materials cooling surfaces reflecting sunlight, heat back up into the atmosphere or into solar panels, simulating high albedo value fresh snow, this both cools the ground and surface (such as rooftops which means energy efficiency in the home; less A/C use) and produces higher solar efficiency. By adding these cooling, recycled products around roads, highways, ports or waterways (solar canals for example) along with carbon management nanotechnology, to break down exhaust emissions to toxic tire dust (6PPD-Q fatal to Coho Salmon, Trout), knowing it offers various climate, environmental, energy benefits; consumers will try harder to recycle.

Additionally, Circular Solar is patent-pending for this technology added to Wind turbines in use, as carbon removal wind energy and negative carbon solar farms.

# Cyber threats impact Wind adding to additional EoL materials:

Nov 7, 2022  
Meg Egan  
Control Systems Cybersecurity Analyst  
Meghan.egan@inl.gov

## Cyber Threats to Renewable and Distributed Energy Technologies

INL is managed by Battelle Energy Alliance for the US Department of Energy | **INL** Idaho National Laboratory

INL/CON-22-69152

### Renewable Energy Cyber Incidents

- 2014: **SolarWorld AG**: Chinese cyber espionage for economic advantage
- March 5, 2019: **sPower**: Denial-of-service attack
- Feb. – April 2020: **Azerbaijani wind turbines**: PoetRAT malware
- April 18, 2020: **EDP Renewables**: Ransomware
- June 2021: **Invenergy**: REvil ransomware
- August 2021: **ERG**: LockBit 2.0 ransomware
- Sep. 2021: **Swedish renewable manager**: LockBit 2.0 ransomware
- Nov 19, 2021: **Vestas**: LockBit 2.0 ransomware
- Feb. 24, 2022: **Enercon**: Russian state-sponsored SATCOM attack
- March 31, 2022: **Nordex Group**: Conti ransomware
- April 11, 2022: **Deutsche Windtechnik**: Ransomware
- April – June 2022: **South China Sea wind turbines**: Chinese ScanBox malware
- August 28, 2022: **GSA**: BlackCat ransomware

IDaho National Laboratory

February 24, 2022, around 30,000 satellite communication (SATCOM) terminals were hit by a Russian cyber-attack, causing them to stop working. This included SATCOM modems in 5800 wind turbines across 1217 wind farms operated by ENERCON.

This DOE report is cited at the bottom of site page : "albedo effect, environment "

### Current Adversary Capabilities

- Russia:
  - "Particularly focused on improving its ability to target critical infrastructure including ICS"
  - Utilizing cyber as a foreign policy lever, including as deterrence and as a military tactic
- China:
  - "Almost certainly capable of launching cyber attacks to disrupt critical infrastructure services"
  - Broad, persistent espionage threat



IDaho National Laboratory

### Current Adversary Capabilities

- Iran:
  - "Opportunistic approach to cyber attacks makes critical infrastructure owners susceptible to being targeted"
  - Successful targeting in Israel reflects growing willingness to take risks
- Criminal Actors:
  - "Innovating targeting to focus on victims whose business operations lack resilience or whose customers cannot sustain service disruptions, driving ransomware payouts up"



IDaho National Laboratory

[Link to Cherise's letter to the U.S. Department of Commerce for sec. 232 Wind investigation](#), where only two letters addressed cybersecurity (GE is the other). Included are recommendations from this presentation, including drones for care and maintenance, potential defense drones to protect assets

## How to treat end-of-life turbines ?

Keep parts for longer.

Design for easier dismantling and recycling.

Minimise number of materials in design manufacture.

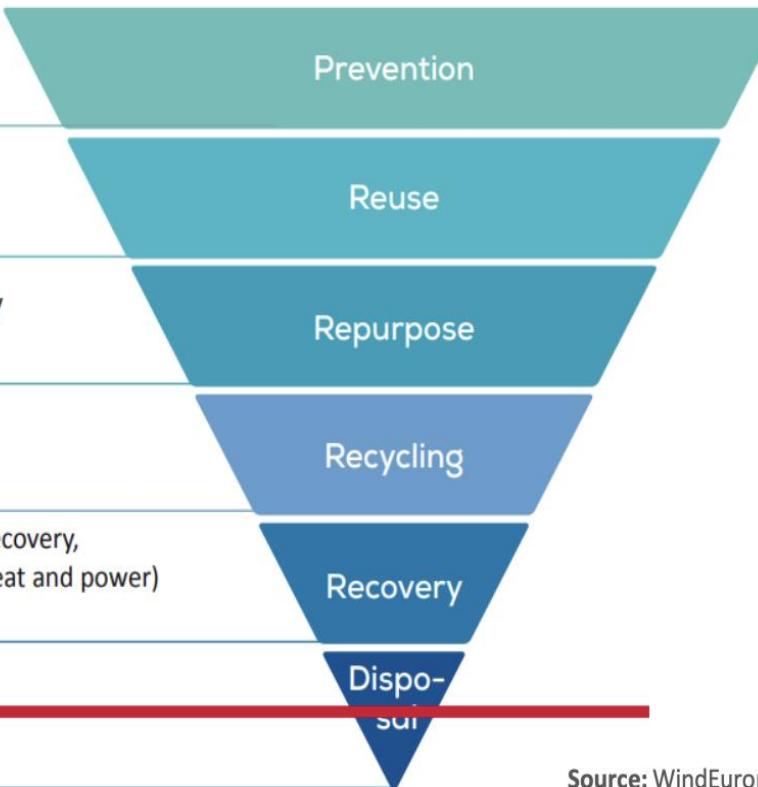
Check, clean, repair, refurbish, repair whole items or spare parts.

Re-use an existing part for a different application, usually of lower value than the original.

Convert waste into a new substance or product.  
Includes composting if it meets protocols.

Includes anaerobic digestion, incineration with energy recovery, gasification and pyrolysis which produce energy (fuels, heat and power) and materials from waste.

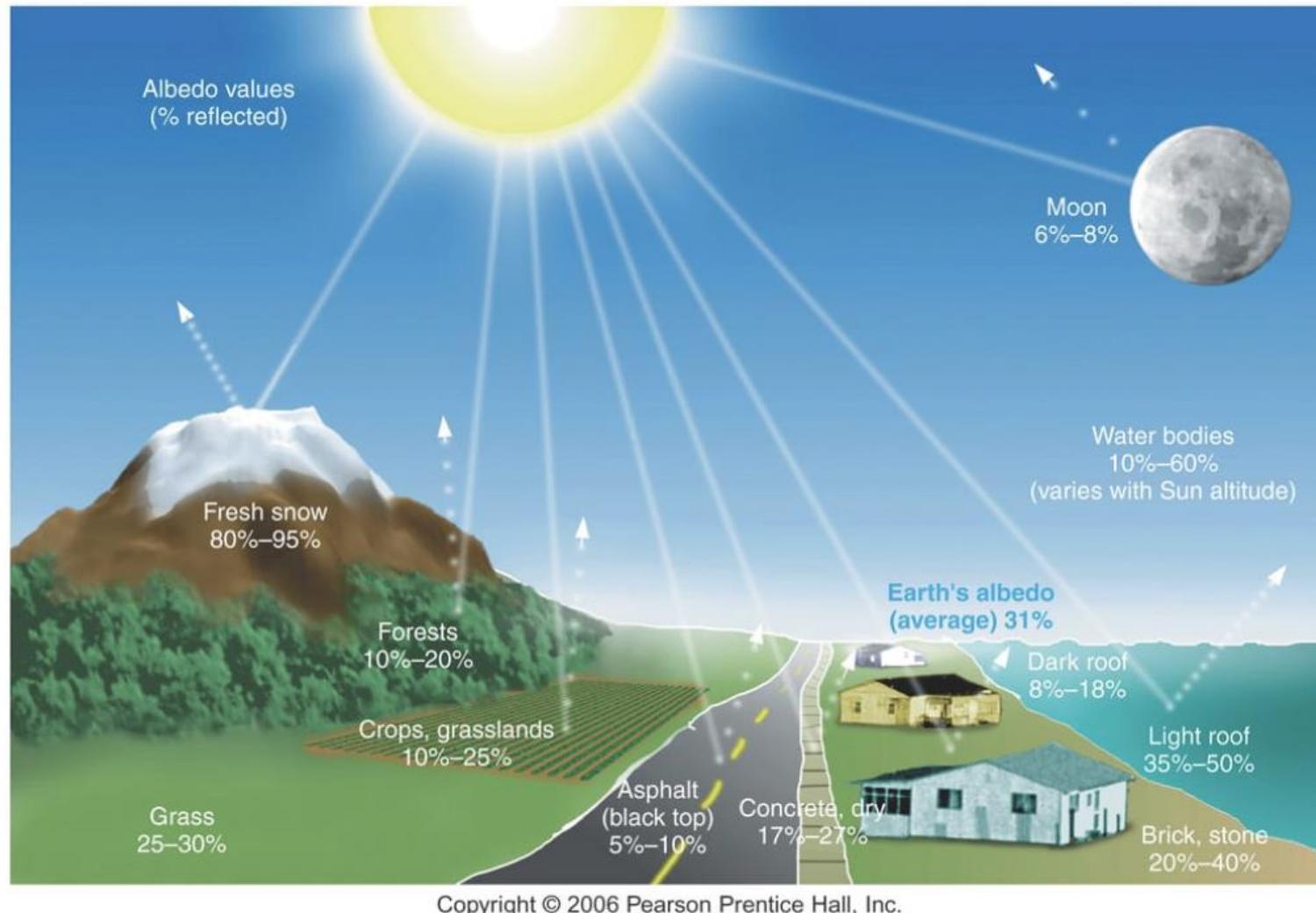
Landfill and incineration without energy recovery.



### Circular Solar closes the loop on Wind – to 100%!

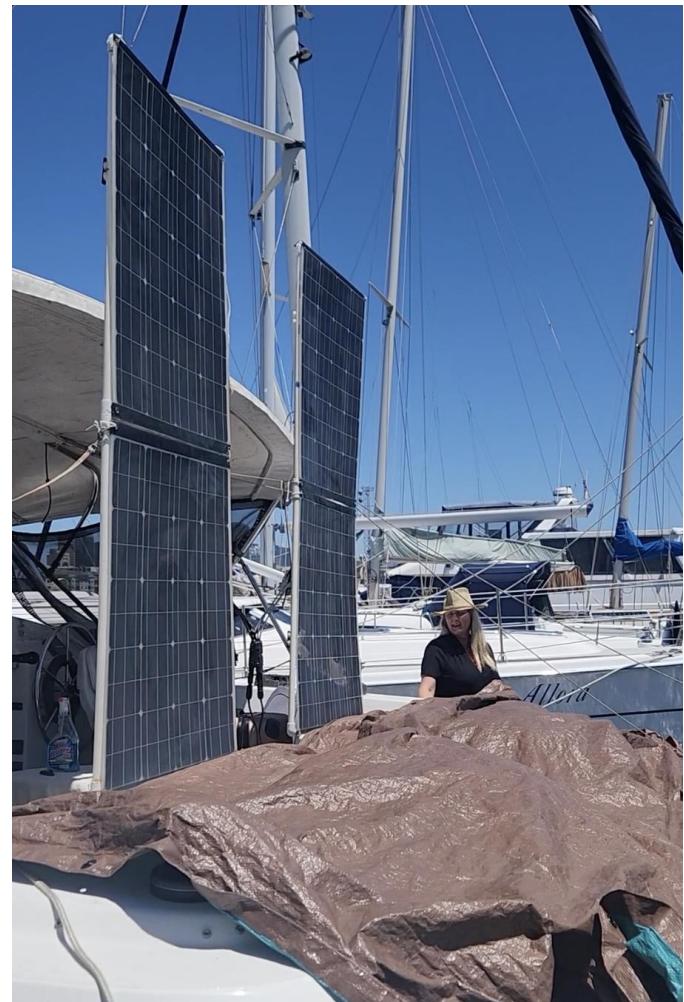
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**Science and physics behind Circular Solar from albedo values and albedo effect:** Wind composites can become reflective, high albedo value fresh snow and repurposed below solar panels or downcycled into concrete. Where 3-dimensional solar power generation – unlocks the full potential of bifacial solar panels with albedo effect products by Circular Solar.

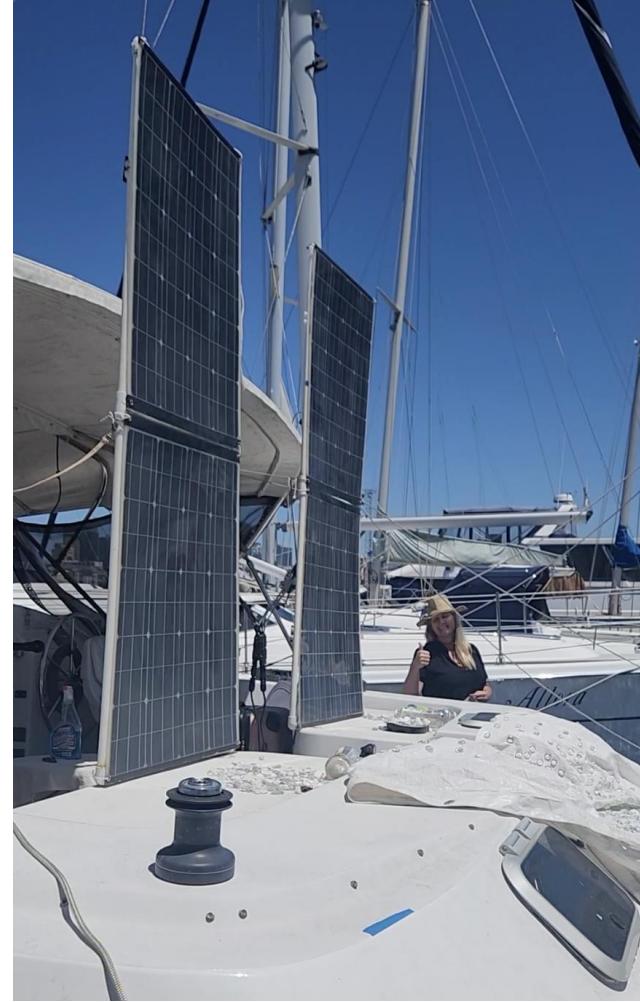


*Albedo, the percentage of available sunlight reflected back into space, varies from surface to surface. Photo: Pearson Prentice Hall Inc.*

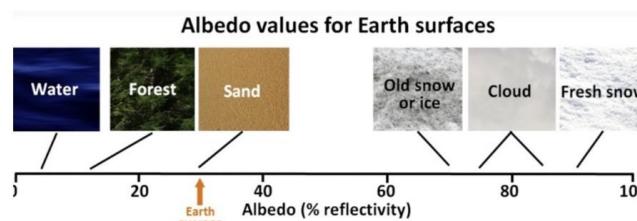
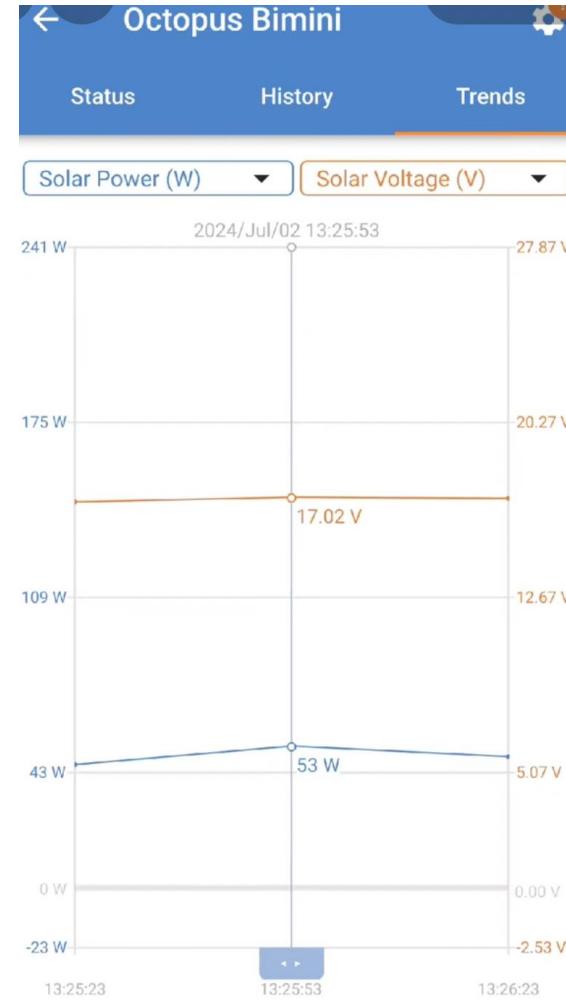
# Near Summer Solstice, sun is directly over-top, panels facing North and South, albedo effect changes:



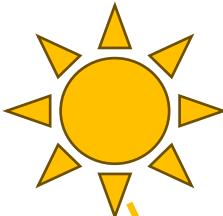
Brown 43 watts



White composite, glass  
53 watts, 24% increase  
[Live video](#)



## Solar Tests, September 26th 2022 nearly 5pm, sun off to the side, backside tests



Asphalt output  
is 40 Watts:



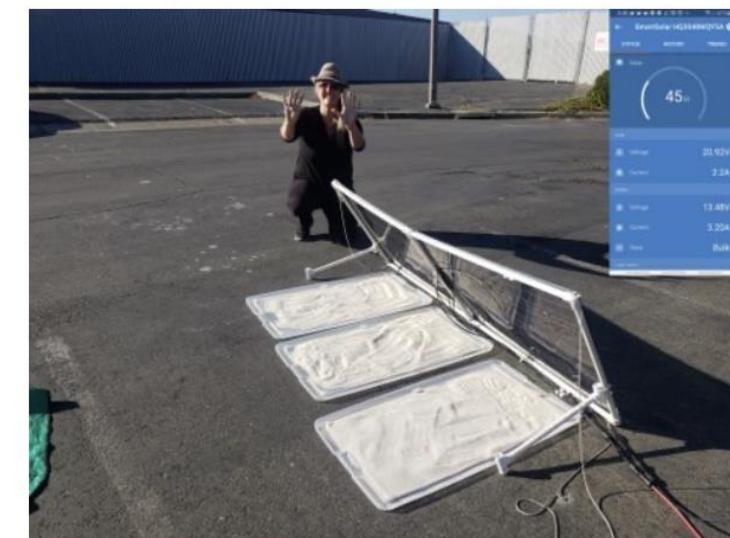
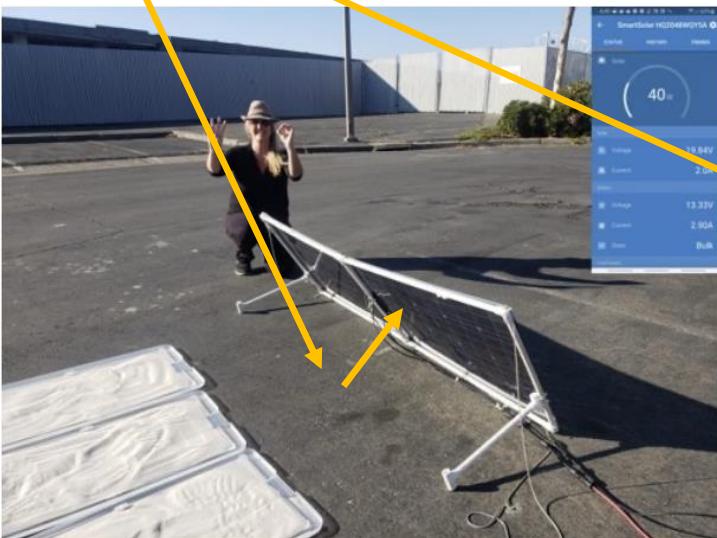
Recycled Glass  
Mulch 45W



White Quartz  
Sand 45W



Brown Tarp  
41W, Green  
42W



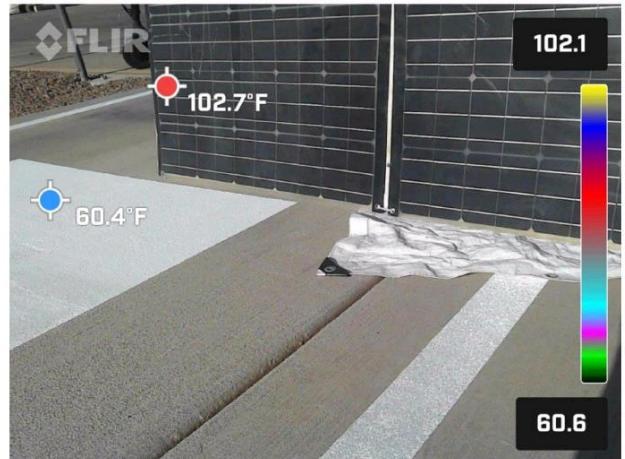
[Short video of materials/test setup](#)

[Then video tested/metered on floating minigrid](#)

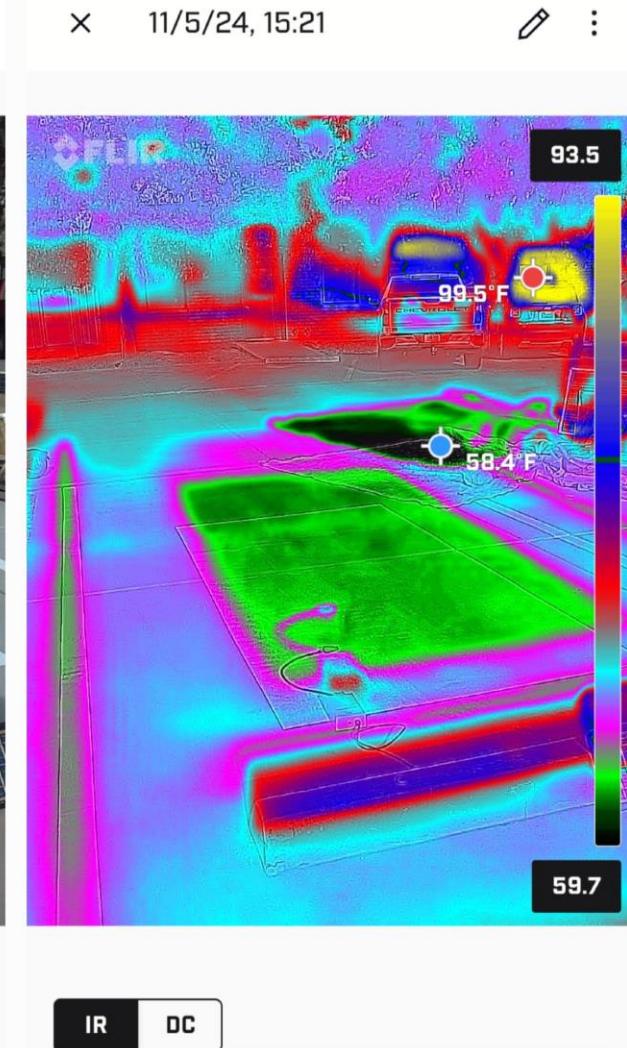
# CDR cooling sustainable concrete: for solar or autonomous EV wireless vehicle BESS to AI data-centers:

Hot concrete in Arizona (location below) will stay cooler when EVs, park or charge over the space. Both wired but especially future wireless induction charging remains cooler, thus improving charging efficiency and component, battery lifecycle, due to less heat losses as the product is reflective and has a cooler UHI (urban heat island effect).

Circular Solar is also a data-center rooftop, reflective, circular, CO<sub>2</sub> removal product, as seen here over concrete, it is almost as cool as the plastic tarp



[Wireless induction  
pad over concrete](#)



**AI Data-centers: Circular Solar is an [an Epri-Open Ai Consortium Member](#):** as a potential “use-case” pilot with utilities and hyperscalers with four use-cases: 1. as a CDR project. 2. as a PPA with the highest possible daily solar yields. 3. Our product for data-center infrastructure, especially cooler rooftops by reducing airborne dust buildup, retaining high albedo effect to reduce interior water use for cooling as seen in previous slide. 4. Which can breakdown PFAS in the event of leak within the data-center or as pollution outside the building; see side five for pollution breakdown which includes PFAS water and airborne pollution from Radius Recycling (automobile shredder residue [ASR PFAS](#)).

1. Coolest, CDR carbon removal rooftop (less water required for interior cooling).
2. Cooler EV charging spaces for employees or autonomous fleets (slide 12) which doubles as higher efficiency, faster charging vehicle to data-center).
3. Circular Solar Wind: EoL wind blades repurposed below solar panels, with CDR (slides 7-10). Texas and California have wind blades being decommissioned now ideal this project.



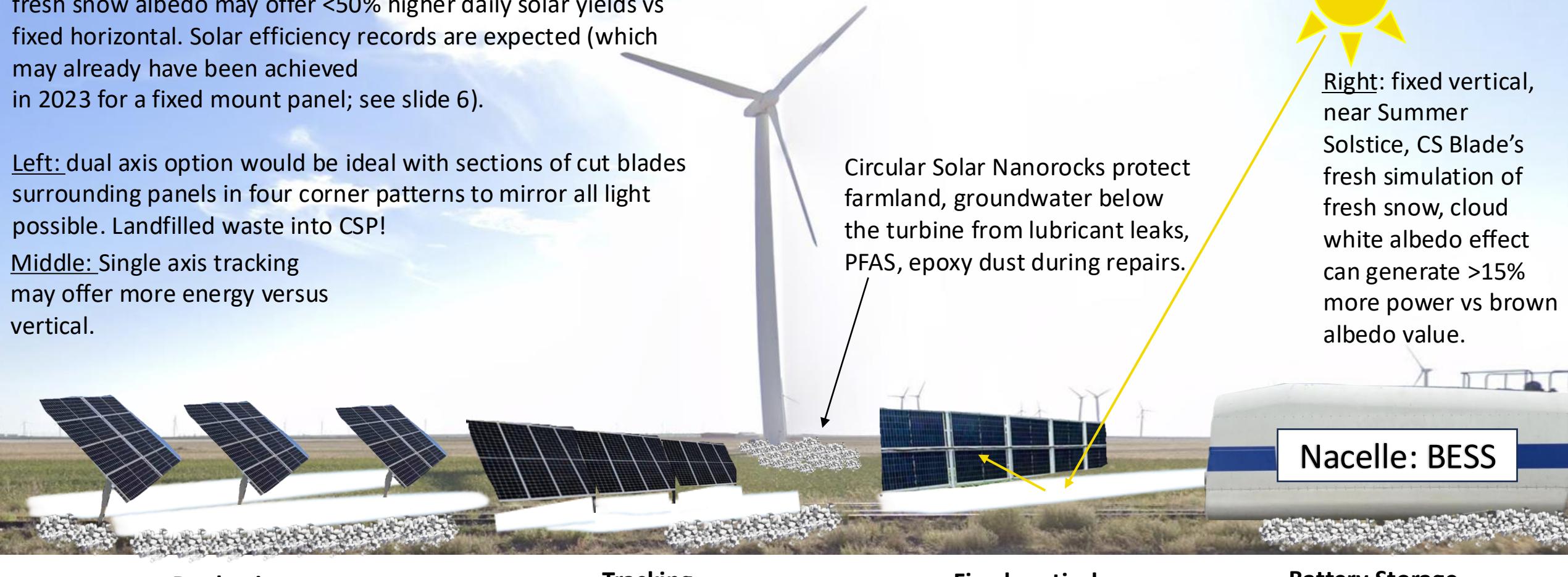
The Lancium Clean Tech data center campus is being constructed by contractor DPR Construction in Abilene, Texas, with Crusoe Energy as its developer.

# Circular Solar CDR Wind: blades and nacelle's repurposed solar-battery microgrids:

Left: Dual axis circular CSP (concentrated solar power) where fresh snow albedo may offer <50% higher daily solar yields vs fixed horizontal. Solar efficiency records are expected (which may already have been achieved in 2023 for a fixed mount panel; see slide 6).

Left: dual axis option would be ideal with sections of cut blades surrounding panels in four corner patterns to mirror all light possible. Landfilled waste into CSP!

Middle: Single axis tracking may offer more energy versus vertical.



Dual-axis

Tracking

Fixed vertical

Battery Storage

**Microgrids Powering:** AI Data-Centers, Agriculture Equipment, Barns, Highway Charging Stations, Rail Depots, Mine Sites and more.

# Business case for a .25 MW Circular Solar Hybrid Wind Farm produces 15% additional solar yields:



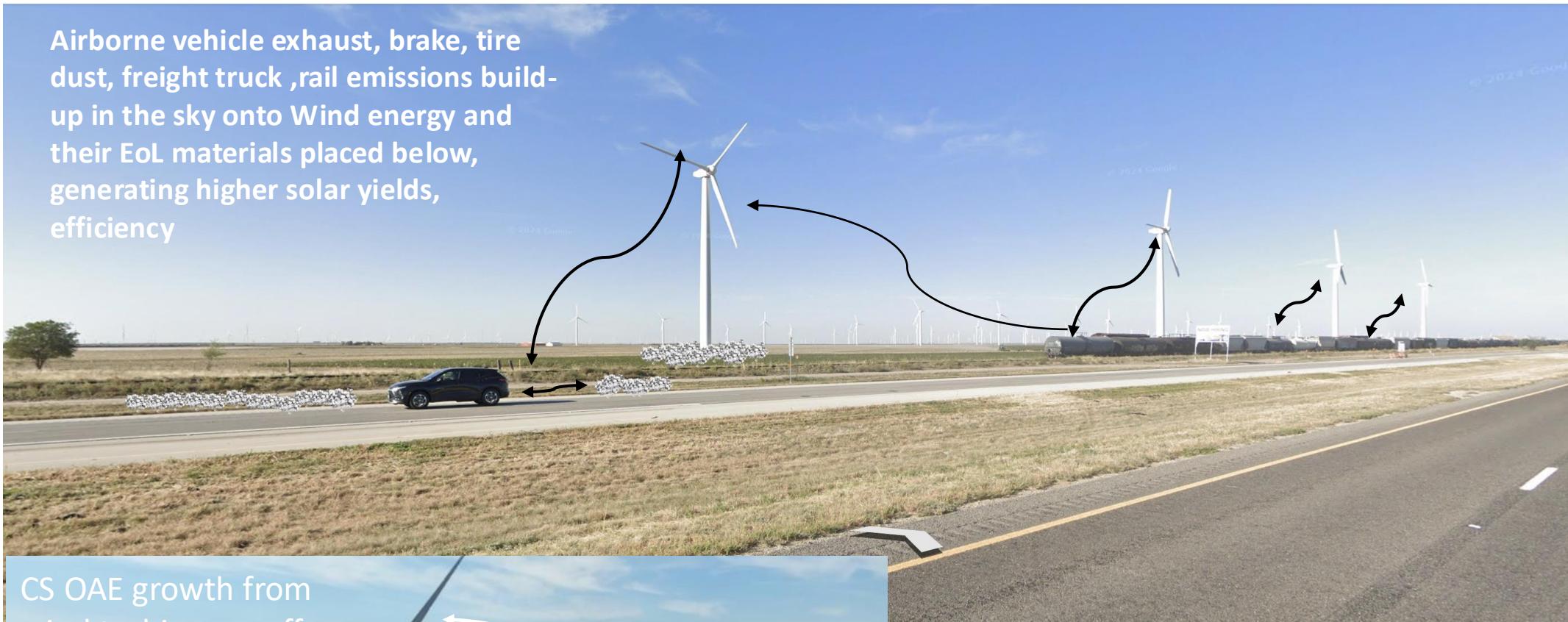
1. JV on the new PPA project, Wind operator and CS takes a portion of the revenue on the new PPA.
2. 70% of wind decommissioning costs are used onsite (5% to land-owner, 25% Circular Solar IP fee).
3. On average these are smaller .25 MW solar farm: \$50–\$60/MWh (2025 US average with credits).
4. 15% higher yield: (levelized cost) LCOE drops ~13% (to \$43–\$52/MWh).
5. For a 1 MW farm over 25 years (total ~50,000 MWh base): Annual savings ~\$14,000–\$16,000

In effective cost per MWh. A .25 MW: \$3,500 - \$4,000/annual savings OR approx. 13 – 15% less solar panels are required for the farm, OR additional power feeds EV charging station. This is the highest value/ lowest cost Wind blade, nacelle repurposing project. Circular Solar could retain 30% of EoL recycling market, which is projected to have \$1B market value by 2030, Circular Solar could capture \$300M. [Watch the measured](#) micro test generate 18% higher yield, plus pollution control.

*Circular Solar is seeking \$2.5M seed, \$1M FOAK funding (which includes a .25MW - .5MW pv-bess CS farm).*

# Circular Solar pollution management to reduce corrosion, failure and CDR nanorocks; Lifecycle extension:

Airborne vehicle exhaust, brake, tire dust, freight truck, rail emissions build-up in the sky onto Wind energy and their EoL materials placed below, generating higher solar yields, efficiency



[Demo video](#) of exhaust emissions onto the materials, improving solar efficiency.

CS OAE growth from wind turbine runoff, and shoreline



< **Shipping CDR**, here is Port of Rotterdam, NL. Circular Solar would love to pilot here because we've already proven the technologies working, removing any wind pollution buildup and emissions buildup by as demonstrated by Port of Oakland. Improving plant, soil health (2008 example [in a road](#)) and now ocean alkalinity restoration; [12-month example of algae bloom and restoration](#) and [here](#) and visual [of ship emissions](#)

Rotterdam is a bunker hub for fossil fuels – high emitter.

4/2025: IMO agrees to a [global carbon pricing: \\$100 or \\$380](#).

# Circular Solar's CDR, pollution management product, method for Regenerative Agriculture, protecting soil health:

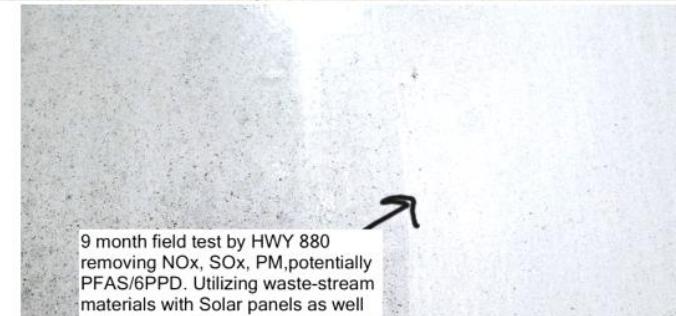


9 – 21 months pollution buildup and runoff



Circular Solar on the right side

Circular Solar Nanorocks: Pollution control to improve soil health and water quality



Polluted runoff:  
Algae bloom marine growth, toxic seaweed.

21 months of airborne pollution buildup

R: Circular Solar nanotechnology removal

Cleaner stormwater runoff:  
Less pollution, toxins and calcium nitrate byproduct grows healthy carbon capture seaweed.



Two months pollution wiped off, note the water is now brown.

Pollution sources: Port, 880 freeway, Recycler automobile metal shredder residue.

Environmental protection to support Mining & AI's SPEED Act (NEPA permit reform).

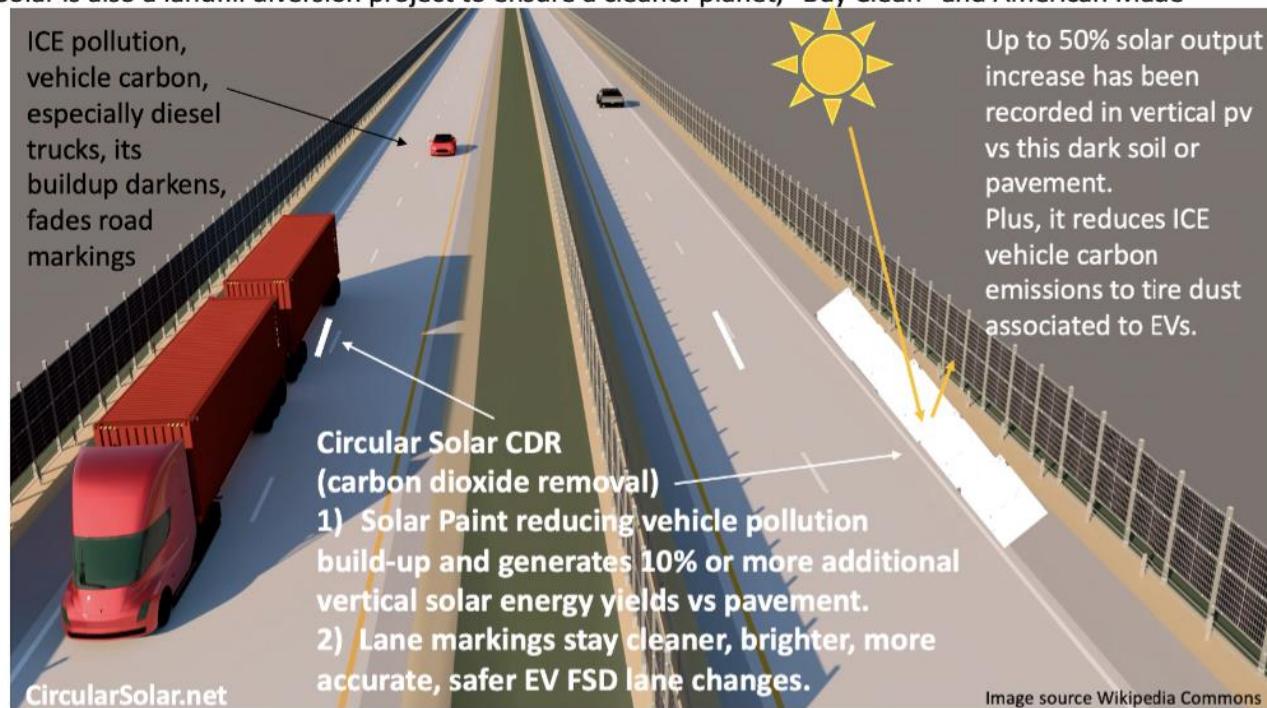


# Updated field test R&D for Circular Solar CDR Highway applications:

For road safety, brighter, cleaner more reflective road markings for road safety, especially at night, including for improving autonomous vehicle, FSD, accuracy thus safety. For CS Highway PV, cooler AI DC wireless EV charging

**Circular Solar CDR Highways:** Increasing canopy or vertical solar efficiency and vehicle safety with brighter, cleaner road markings. This helps keep EVs, such as Tesla FSD safer when using "Auto Lane Change" because the reflective markings stay cleaner, brighter in low light, dirty when high carbon pollution events, or something covering the pavement.

Circular Solar's vertical efficiency record is 50% higher output vs dark albedo when the sun is directly over top vertical pv. Circular Solar is also a landfill diversion project to ensure a cleaner planet, "Buy Clean" and American Made



With the real-life multi-month pollution control results in mind, Scale to road markings and highway PV verify it works and provides environmental protection. These roads can include recycled Wind composites as an SCM.



Road marking field test (on OCTOPUS, by a road, not on it). We see the normal pollution buildup is darker, making lines less reflective during the day but especially at night. Circular Solar treated road markings will improve safety for all vehicles and drivers. However, this can improve autonomous vehicle accuracy.

Also note the road is cooler with Circular Solar, by about 5F+.

## Heat stress on cattle is a growing problem:

In Kansas during the 2022 heatwaves, there were 2,000 cattle deaths.

In Europe, due to heat stress, dairy cows milk yield may decrease by about 2.8% and farmers may expect financial losses in the Summer season of about [5.4% of their monthly income.](#)

Circular Solar Wind Canals or Cattle Shade can mitigate this problem. And in-use Wind could add the carbon, dust, toxin, heavy metal removal coating for healthier water runoff sequestered in the soil, farm, creek below.



Kansas officials say weather conditions made it hard for cows to cool down in an intense heat wave. Here, cattle graze near wind turbines in Hays, Kansas, in 2017.

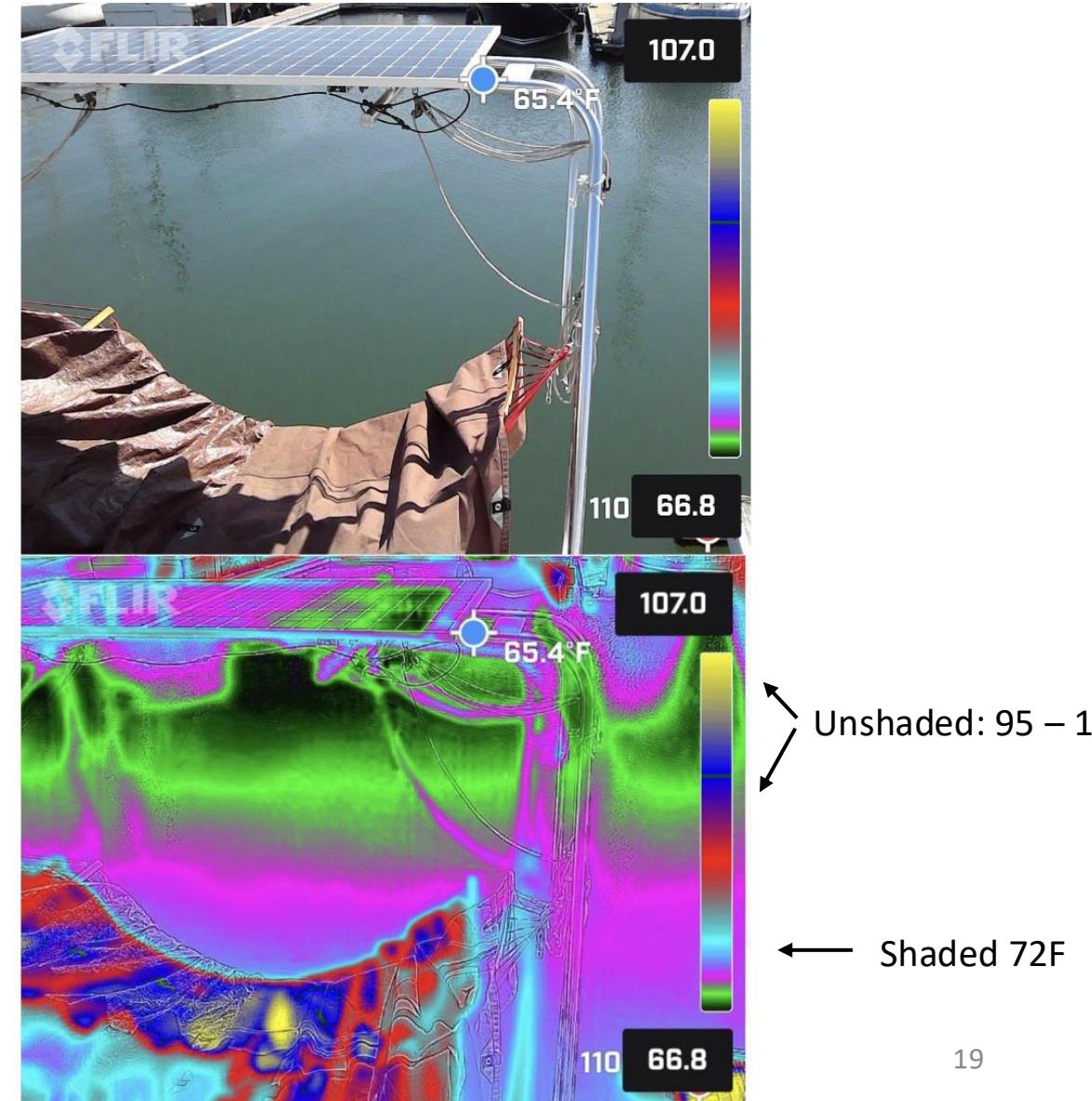
*Daniel Acker/Bloomberg via Getty Images*

**Circular Solar Wind Agrivoltaic:** the shade will reduce cowhide temperatures by up to 30F. This may be the only safe Agrivoltaic for cattle, with no concern of cattle leaning against, breaking solar panels.

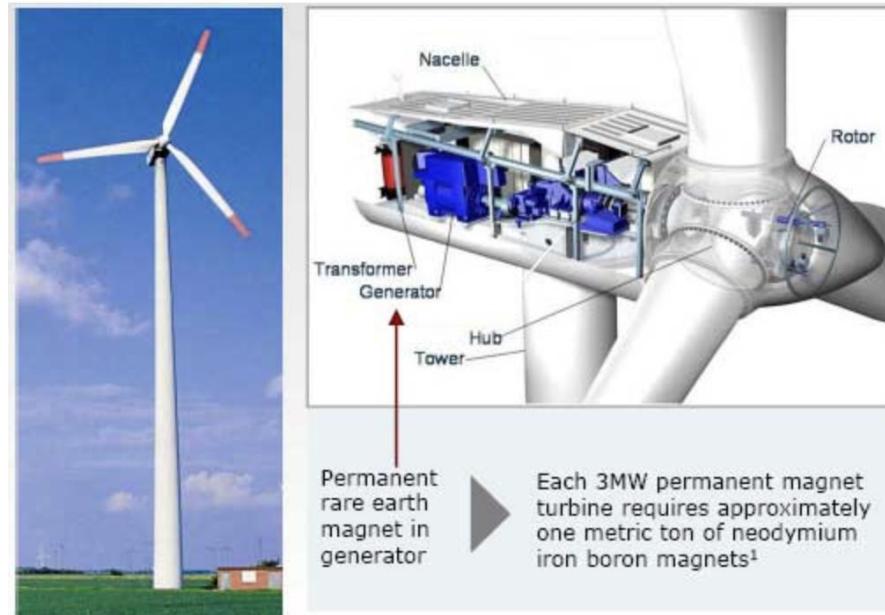
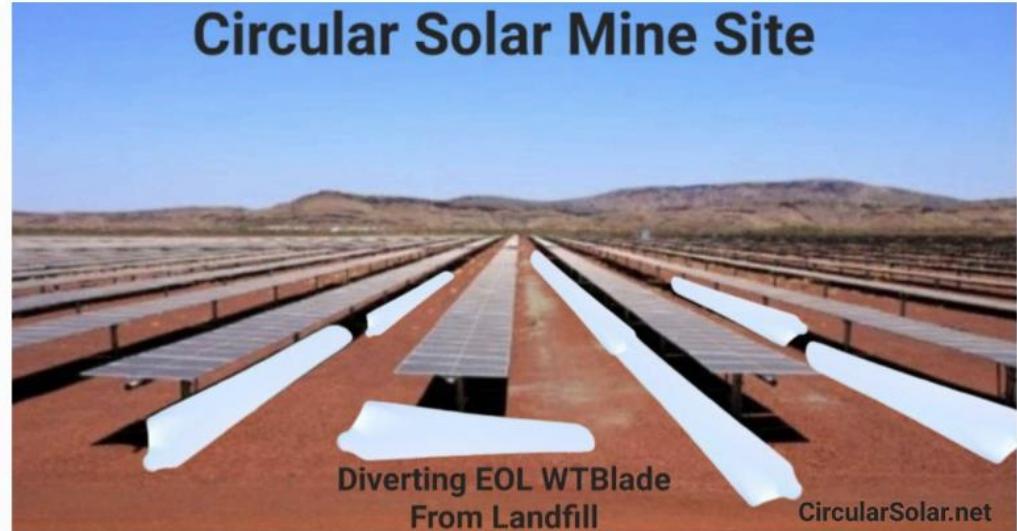


## Our prototype and thermal up to 30F cooler surfaces temperatures from wind, solar canal shade:

The shade cools off cattle, farm equipment, drones and water (providing colder water and less water evaporation), healthier marine ecosystem. CDR ERW (enhanced rock weathering) with limestone, recycled concrete can be added.



**Mine sites, landfill diversion** can accept hazardous EoL composite waste and recycling, process e-waste streams; such as REE magnets from nacelle generators (and first pitched to a mine site in 2010), manufacture drones onsite; with using DPA (defense production act funding).



### Graphical Abstract

This work outlines a process for the recovery of rare earth elements from permanent magnets from wind turbines. Pyrometallurgical and hydrometallurgical methods are employed to produce a concentrated rare earth solution. Finally, these elements are selectively precipitated yielding a mixed rare earth oxalate. This process demonstrates the efficient and quantitative recovery of these critical metals.



**Recycled wind e-waste and composites: may help supply-chain some drone parts, supports thermal management and powered by “Circular Solar Wind” farms for: Agriculture, Data-Center, Energy uses.**

**Ukraine, UK to Co-Produce Octopus-100 Interceptor Drones**

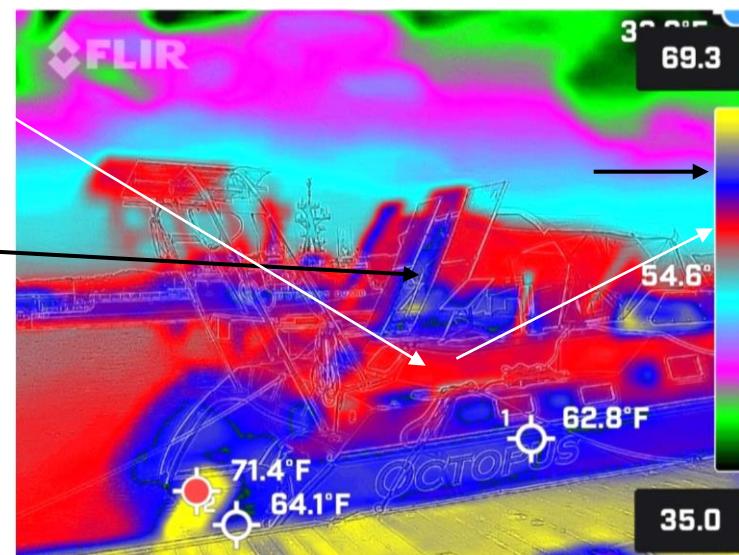


The newest systems are to be deployed on the borders of NATO allies as part of the [so-called “drone wall”](#) to deter the increasingly frequent intrusions of Russian aircraft and drones into NATO airspace.

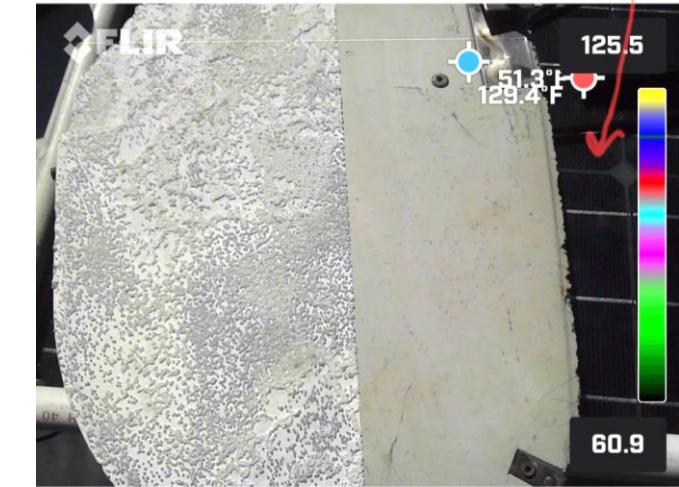


Ukrainian interceptor drone in 2025. Photo credits: Militarnyi

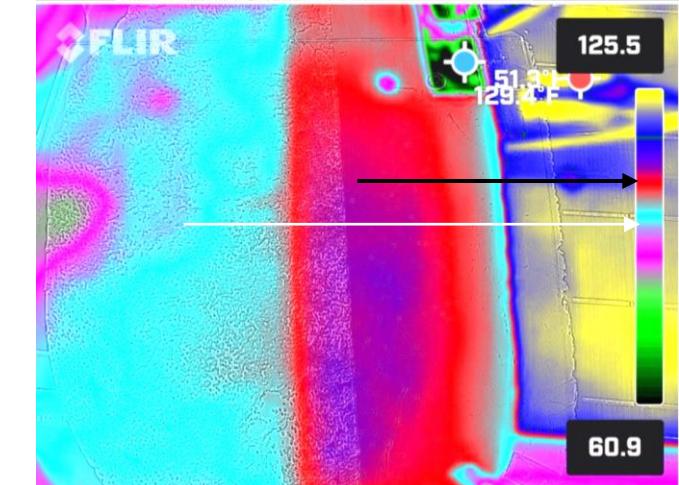
In the future, the OCTOPUS drones could also become an element of missile defense to protect military installations and critical infrastructure in the UK.



Wind composite like drones, white albedo 8F cooler versus offwhite



Black plastic solar panel up to 120F

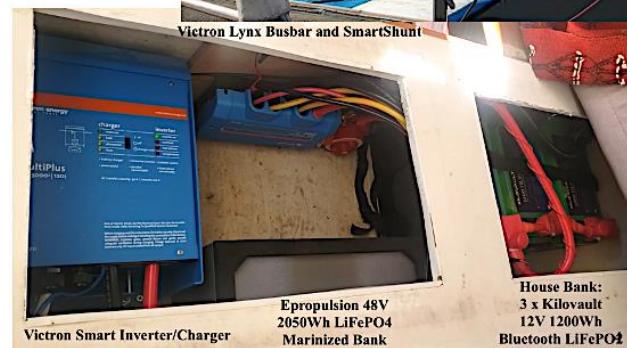




2010 offshore composite vessel simulating offshore wind failure – into floating remote minigrid testbed OCTOPUS



**OCTOPUS Testbed:** 1 kW of solar: 3.6kW BESS, 3.3kW BESS for motor, components, Starlink stored in nacelle or blades. Scale-up to 80' length floating solar-blade powerplants: 20kW solar – 60kW BESS charging station for E-vessels



**Smart city example by Siemens** and arrows are locations well suited to Circular Solar CDR project, products:



**Circular Solar is an Epri OPAI Consortium Member:** as a potential technology provider to big tech and utilities, globally

**OPAI Participants**

**AI and Energy Technology Partners**

**Academia & Other Strategic Partners**

**Energy Partners**

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Stop sharing Hide

EPRI

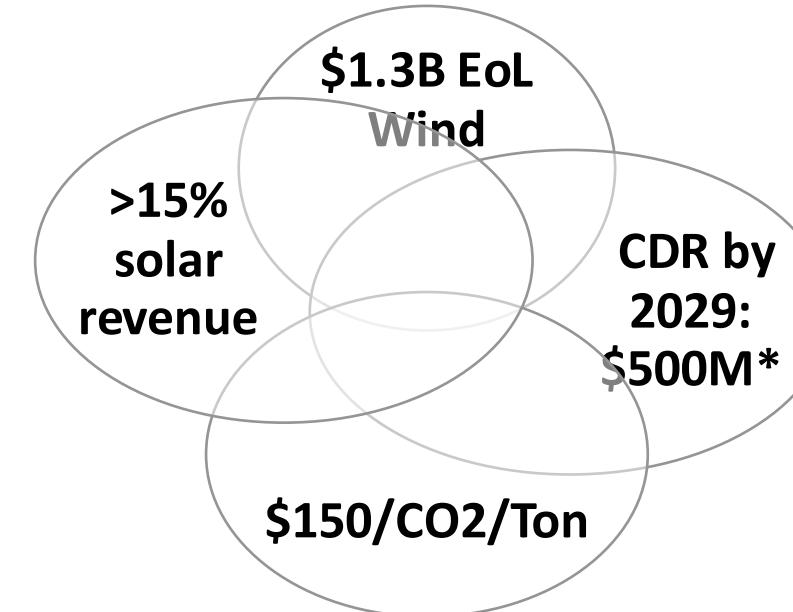
Of the three recycling values, let's focus on reusing/recycling EoL wind blades, for project Circular Solar CDR, where there will be 500,000 tons by 2030, at a 5.6B value by 2033.

This waste to energy and carbon removal breakthrough could attain 25% of the market share, or \$1.3B by 2033.

Circular Solar generates an additional 15% or more solar efficiency/daily yields.

Hosts a new, growing industry, as CDR infrastructure, which seeks a \$100/ton/CO2 removal by 2030.

Solar is the highest demand renewable energy source and this generates record efficiency.

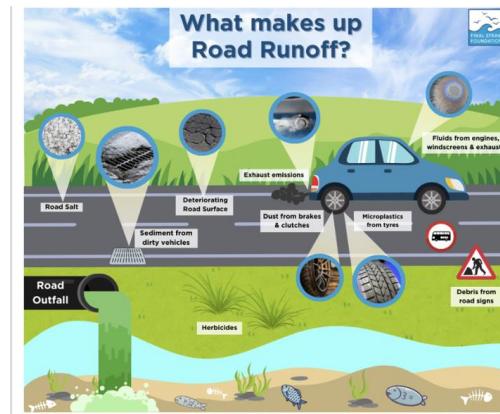


Circular Solar is a viable solution as the answer to three industry problems: recycling EoL wind (glass, concrete), CDR (carbon dioxide removal) as a co-benefit, lower cost of Wind (reducing EoL Wind recycling costs): cashflow, divert materials from landfill, CO2 emissions avoidance (scope 3-4) from transporting 2Ton/12T EoL\*, solar efficiency increases boosts revenue to lower the cost of hybrid wind-solar-battery microgrids.

\*For example; in California where all blades are shipped out of state to TX, WY, OK, IA where about 1,400 miles of diesel trucking for <20 tons of wind blades. On avg. [3.2 tons of carbon per 1,000 miles diesel trucking](#) each load to landfill or recycler is about 4.5 tons carbon emissions. Circular Solar CDR avoids this carbon, scope 4, plus annual tons removed in the project thereafter.

\*CDR is expected to be a [\\$25B market by 2029](#); Circular Solar CDR products make up 2% CDR market it's \$500M market share.

# Summary of products, innovations, Seed and FOAK capital request, next steps:



## Circular Solar could become a 2026 Unicorn startup:

1. Highest possible solar yields in a ground mounted solar farm with recycling Wind blades and with Nanorocks; 15 – 30% additional solar yields. Or another perspective is a 28% efficiency perovskite solar farm works at 32% - 35% efficiency.
2. Pollution control or CDR (carbon dioxide removal) project for environmental protection. With airborne misting/water dust control, Nanorocks around mine sites and AI data-center construction, farmland and DOT highway shoulders and rip-rap erosion control rocks.
3. Seed & FOAK fund: \$2M seed and \$500k FOAK funds. Use of funds are to repay pre-seed \$750K, 18-month runway to Series A, two micro Circular Solar Wind FOAK pilots in Texas (for in person assessment for an Epri OPAI member U.S. and Europe/UK utility, energy developers) and two small pollution control Circular Solar Nanorock pilots: Florida for G20 and Antalya COP31.
4. Community benefits: homeless to housed workforce development program and a new gap filled for CA 2026 Zero Waste Plan.

Pre-money value \$9.5M. Wind recycling industry is expected to be \$1B+ by 2030, CS could retain 30% marketshare. CDR market value is about \$2B, by 2030 \$50B. Solar, Solar-Battery continue to grow in demand, 15% higher yields with CDR; m/v: \$200M

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- Team Circular Solar LLC, at CircularSolar.net is a small team under 5 people.
- Recycling solution to improve Wind recycling rates by at least 5% to 95%, goal 100%.
- Next steps, pilots in Europe, USA, Middle East.



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