

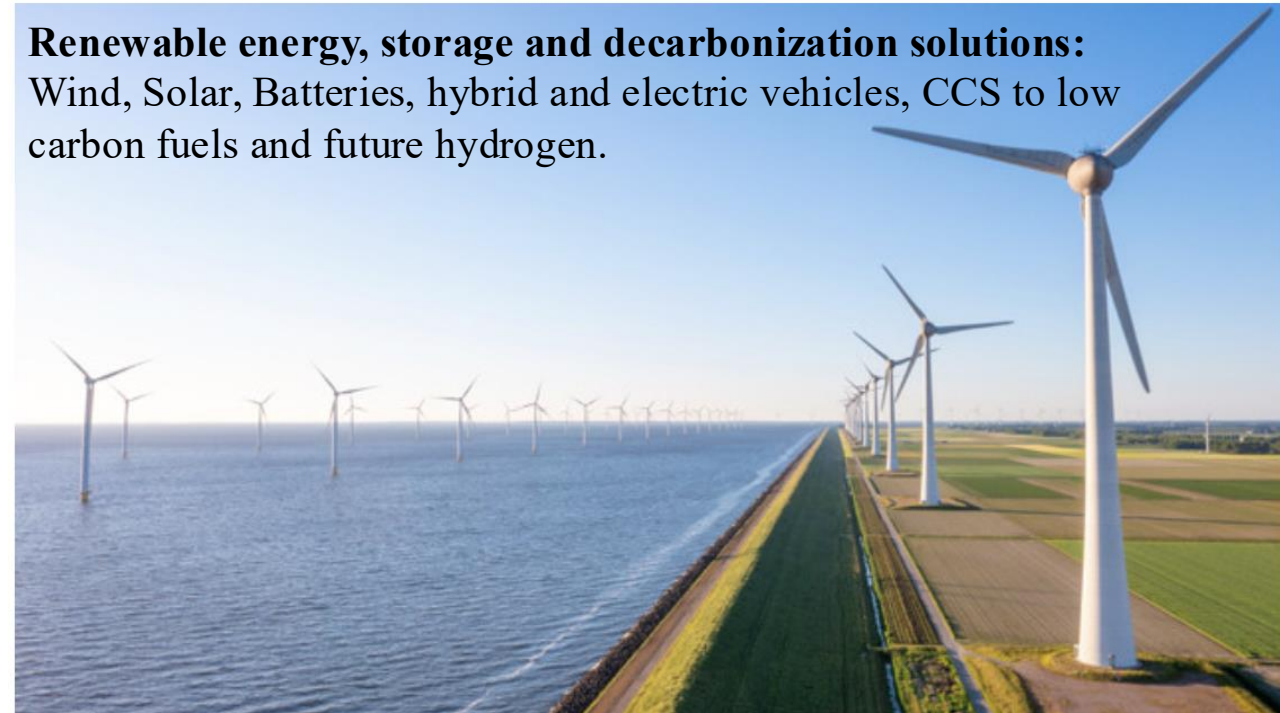


# *Circular Solar*

**Circular Solar Wind improving lifecycle and potentially reaching 100% wind blade, nacelle 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:**

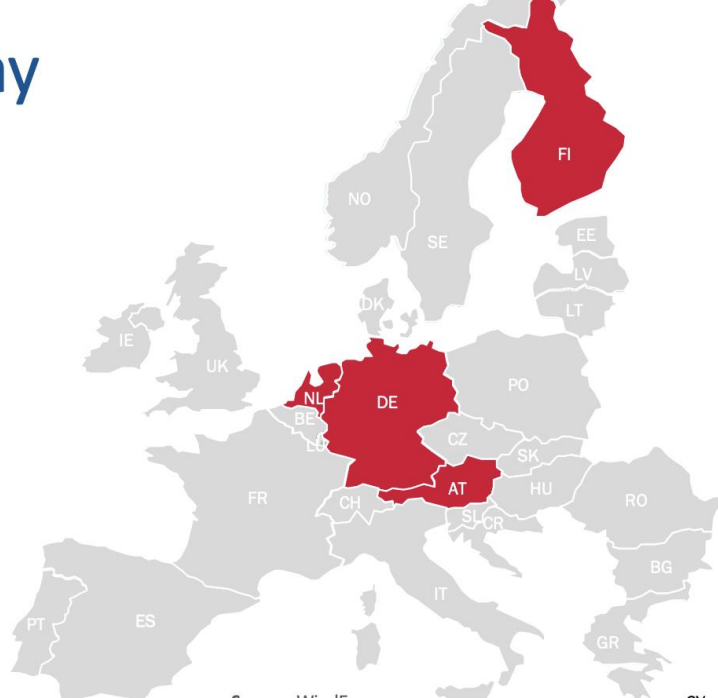
- Recycling rates of blades average at around 90%.
- Those opposing wind point to their impact on landfills.
- Failures include from corrosion, oil leaks and lightening strikes causing fires, composite plastic debris polluting land or water to foreign adversary cyber attacks causing problems (ex. Russian 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:**

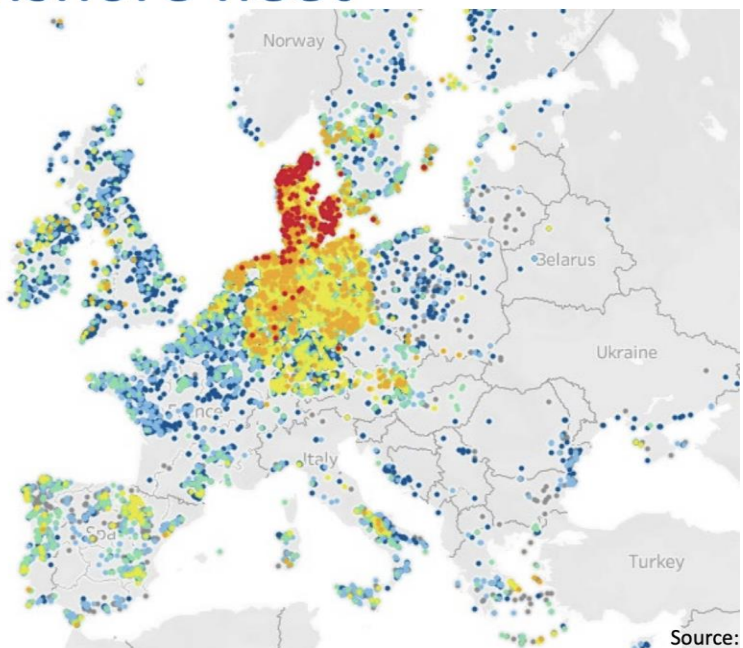
- Downcycled as a SCM for concrete, where it competes with lower cost virgin material.
- Used as WtE fuel; which emits plastic, toxic emissions and its a low BTU value at a cement kiln versus other alt fuels (Ag waste – tyres).
- Recycling, including chemicals, are available but at a high cost.
- Repurposing,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



# Landfill ban today



# 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	 ENERCON ENERGY FOR THE WORLD	 GE VERNova	 NORDEX	 acciona	 SIEMENS energy	 Vestas	
Wind farm developers	 acciona energia	 equinor	 EnBW	 Ørsted	 Shell	 REPSOL	 res power for good
Power utilities	 edf renewables	 ERG ENERGIE ENERGIES	 enel Green Power	 ENGIE	 Iberdrola	 RWE	 VATTENFALL
Component manufacturers	 LM WIND POWER	 Prysmian Group	 SMULDERS	 tpi	 winergy	 ZF	
Digital solutions & service providers	 Atos	 Hitachi Energy	 Schneider Electric	 SEMCO maritime	 ONVX hugo	 UL Solutions	
EPC, installation and logistics	 DEME OFFSHORE	 Jan De Nul	 MAERSK SUPPLY SERVICE	 Port of Amsterdam	 SAIPEM	 Van Oord Maritime integrity	
Financial & legal services	 Allianz	 Amiens	 AQUILA CAPITAL	 Green Graphics	 MACQUARIE	 DENTONS	
Research institutes	 DTU	 Fraunhofer ISI	 InnoEnergy Innovation Energy Research Institute	 TU Delft	 ULB UNIVERSITE LIBRE DE BRUXELLES	 Ghent University	
Energy buyers	 ArcelorMittal	 aws	 BASF We create Chemistry	 BOREALIS	 covestro	 EVONIK Leading Smart Chemistry	 Google

+ NATIONAL WIND ENERGY ASSOCIATIONS





# USA, California's new 2026 recycling plan which will influence other states:



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



Download PDF ►

**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/I7ydpFWBpGo>

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:

Nov 7, 2022

Meg Egan  
Control Systems Cybersecurity Analyst  
Megan.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



### 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”

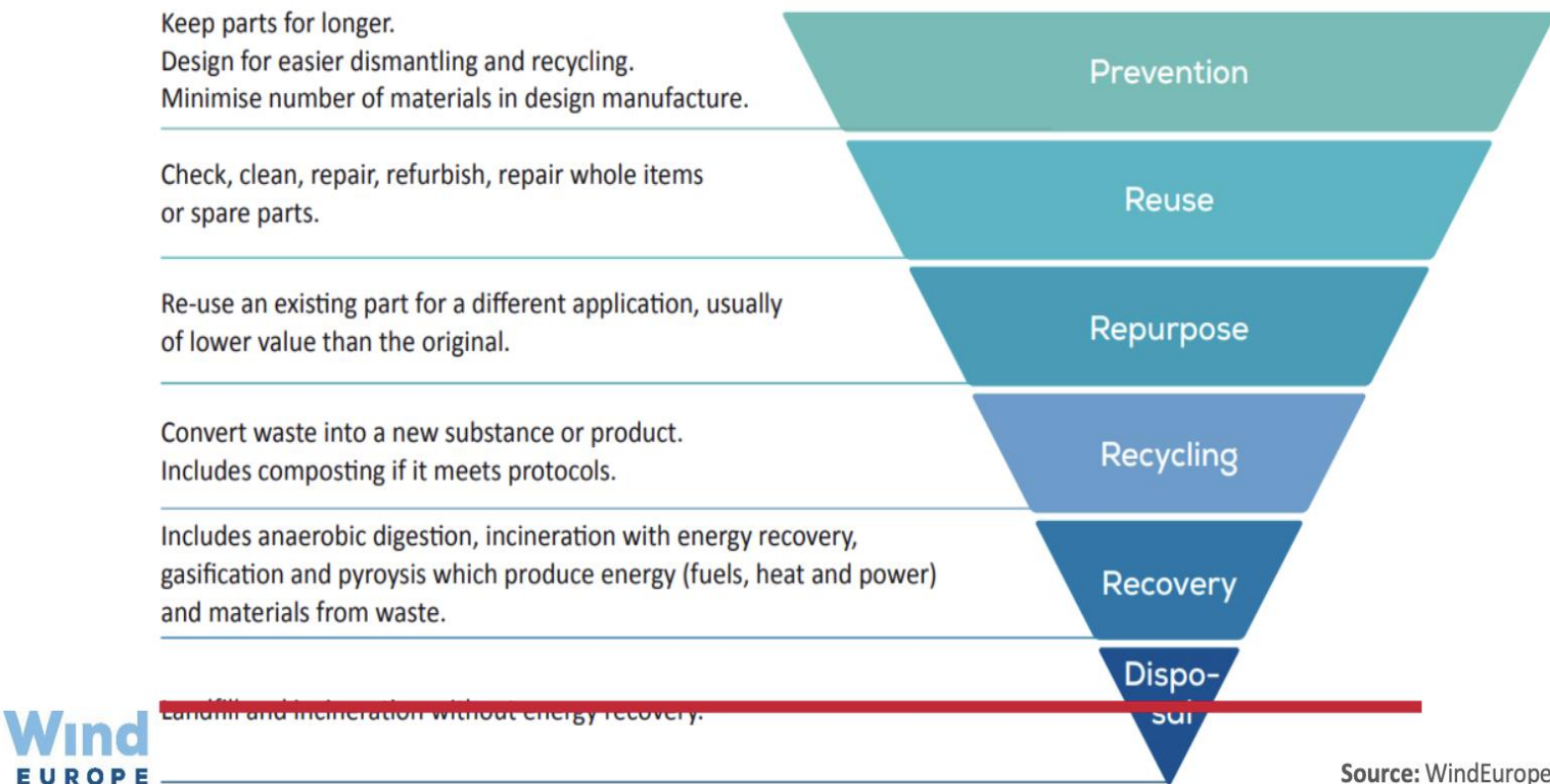


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[Link to Cherise’s letter to the U.S. Department of Commerce for sec. 232 Wind investigation](#), where only two letters addressed cybersecurity (GE is the other). Included are recommendations from this presentation, including drones for care and maintenance,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

# Will the Wind industry achieve 90% or 100% recycling rate?

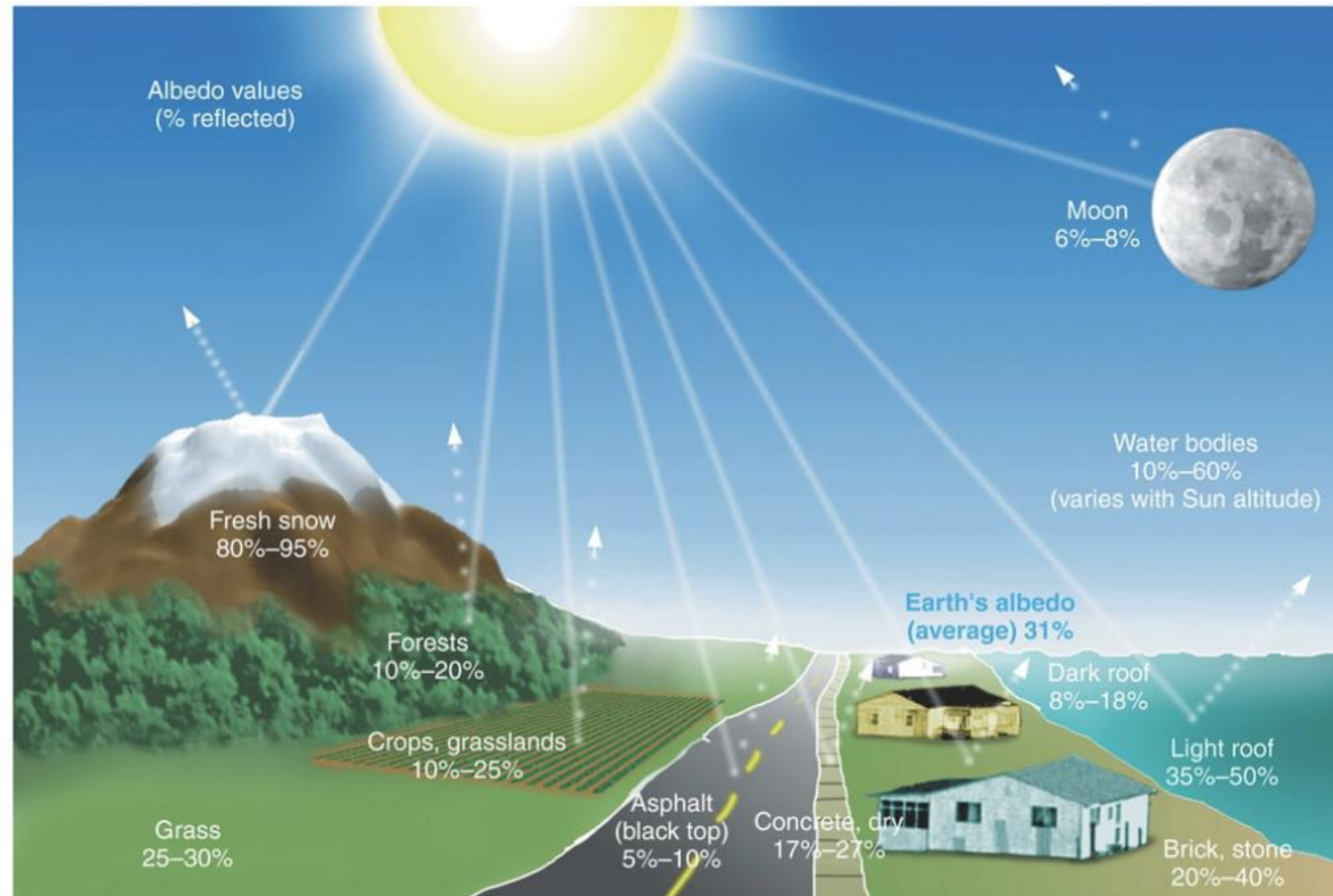
## How to treat end-of-life turbines ?



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

1. Reducing corrosion.
2. Circular Solar Nanorocks placed below turbines protect farmland: soil, groundwater and wildlife.
3. Solar-battery farms, safe cattle shade - Agrivoltaic.
4. Innovations for recycled concrete.
5. OCTOPUS drones
6. REEs critical mineral streams from generators.

**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.

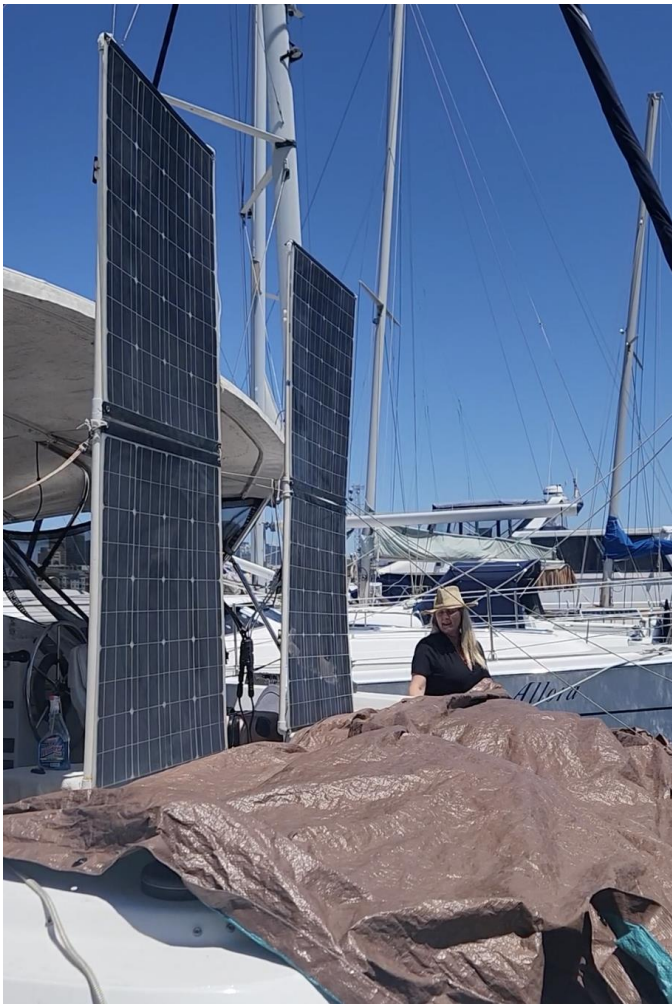


Copyright © 2006 Pearson Prentice Hall, Inc.

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



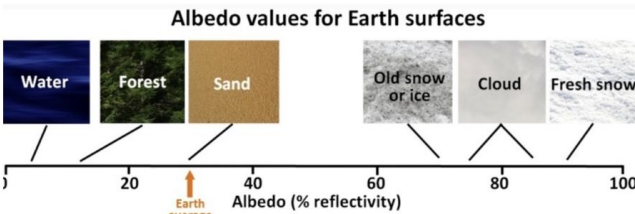
# Near Summer Solstice, sun is directly over-top, panels facing North and South, albedo effect changes:



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:



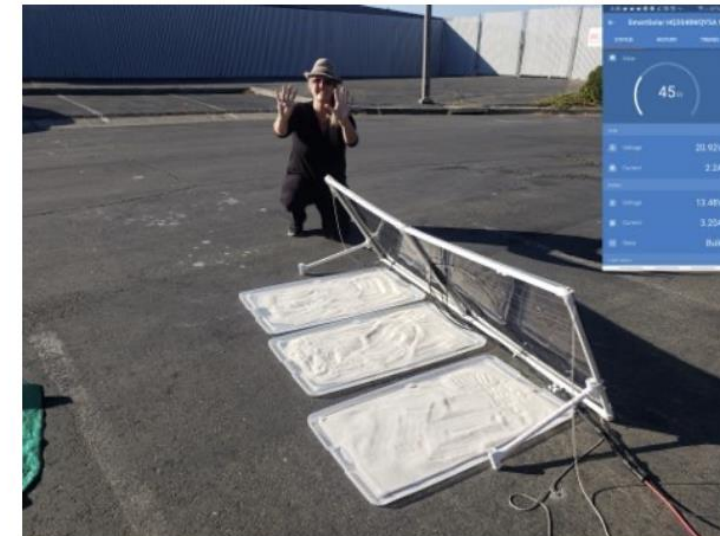
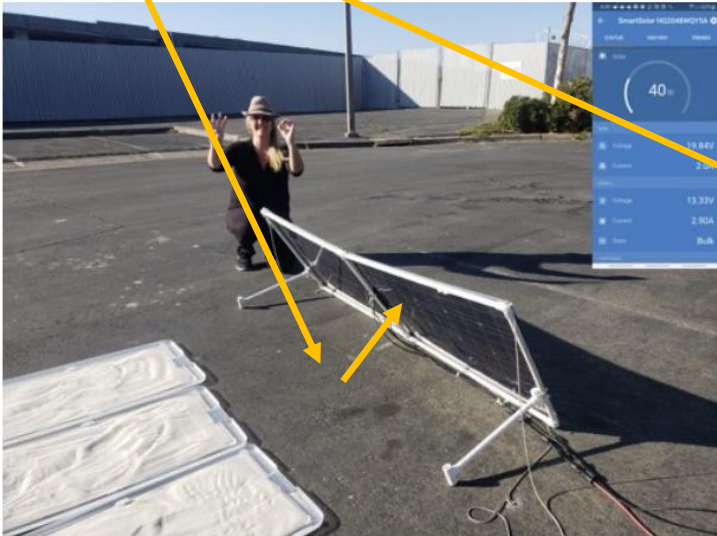
Recycled Glass  
Mulch 45W



White Quartz  
Sand 45W



Brown Tarp  
41W, Green  
42W



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

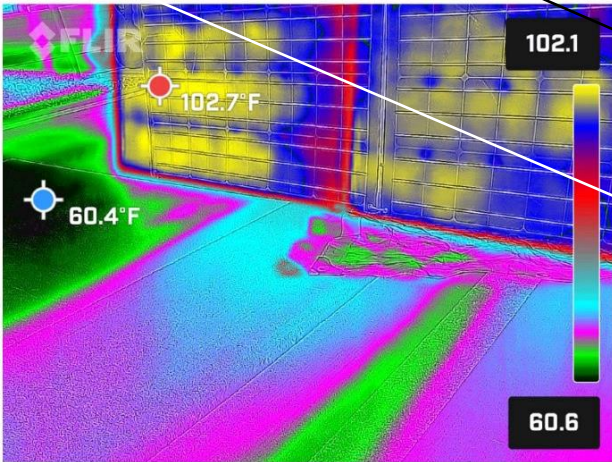
[Then video tested/metered on floating minigrid](#)



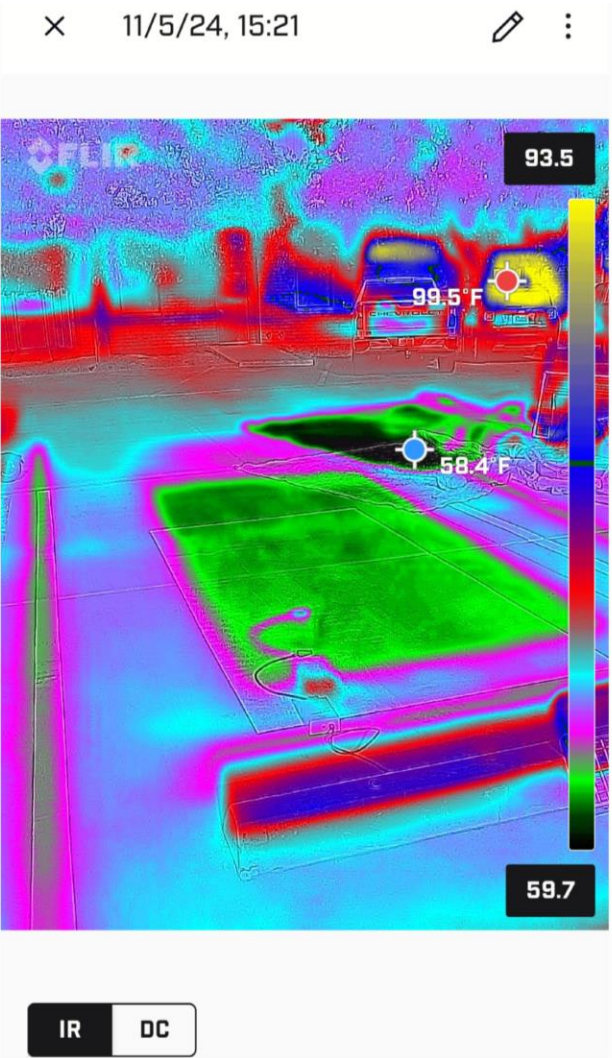
# CDR cooling concrete: benefiting solar or autonomous EV wireless vehicle BESS to AI data-centers:

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, CO2 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:

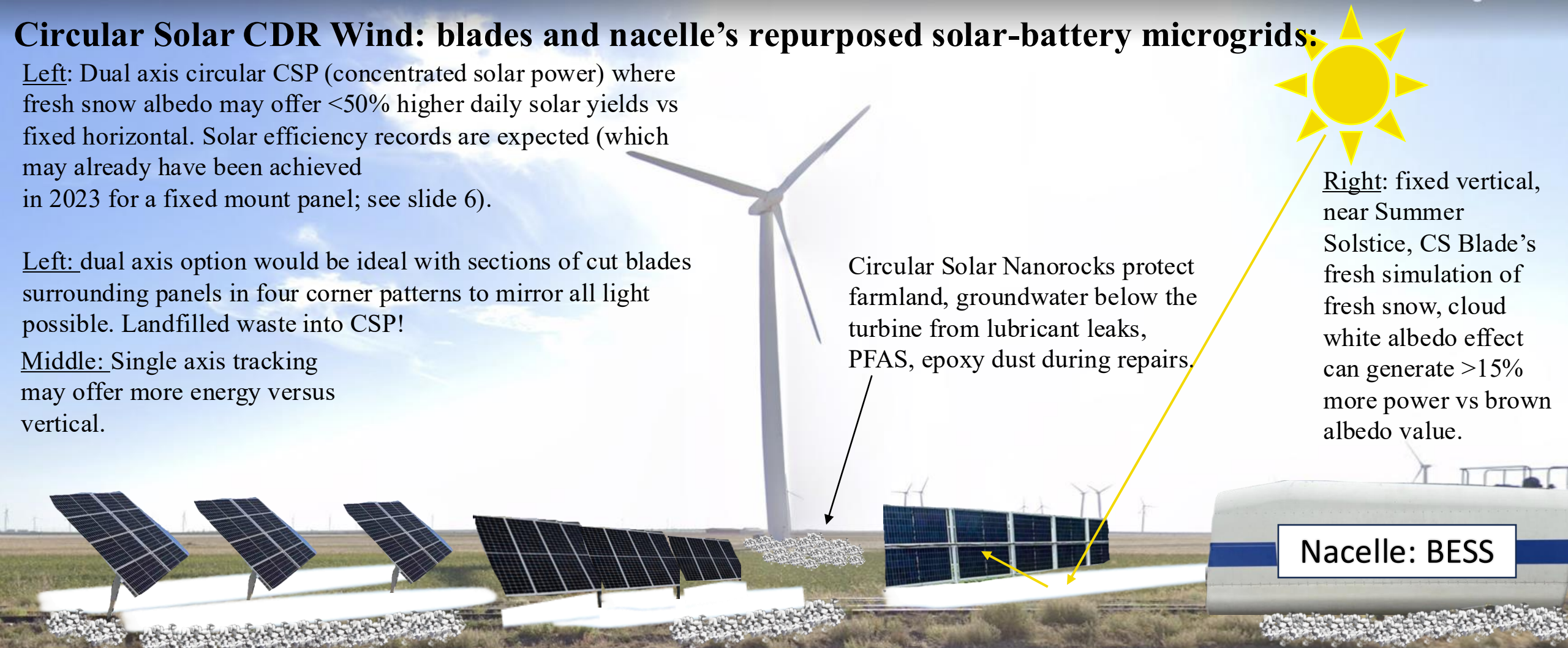
Left: Dual axis circular CSP (concentrated solar power) where fresh snow albedo may offer <50% higher daily solar yields vs fixed horizontal. Solar efficiency records are expected (which may already have been achieved in 2023 for a fixed mount panel; see slide 6).

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.

Circular Solar Nanorocks protect farmland, groundwater below the turbine from lubricant leaks, PFAS, epoxy dust during repairs.

Right: fixed vertical, near Summer Solstice, CS Blade's fresh simulation of fresh snow, cloud white albedo effect can generate >15% more power vs brown albedo value.



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

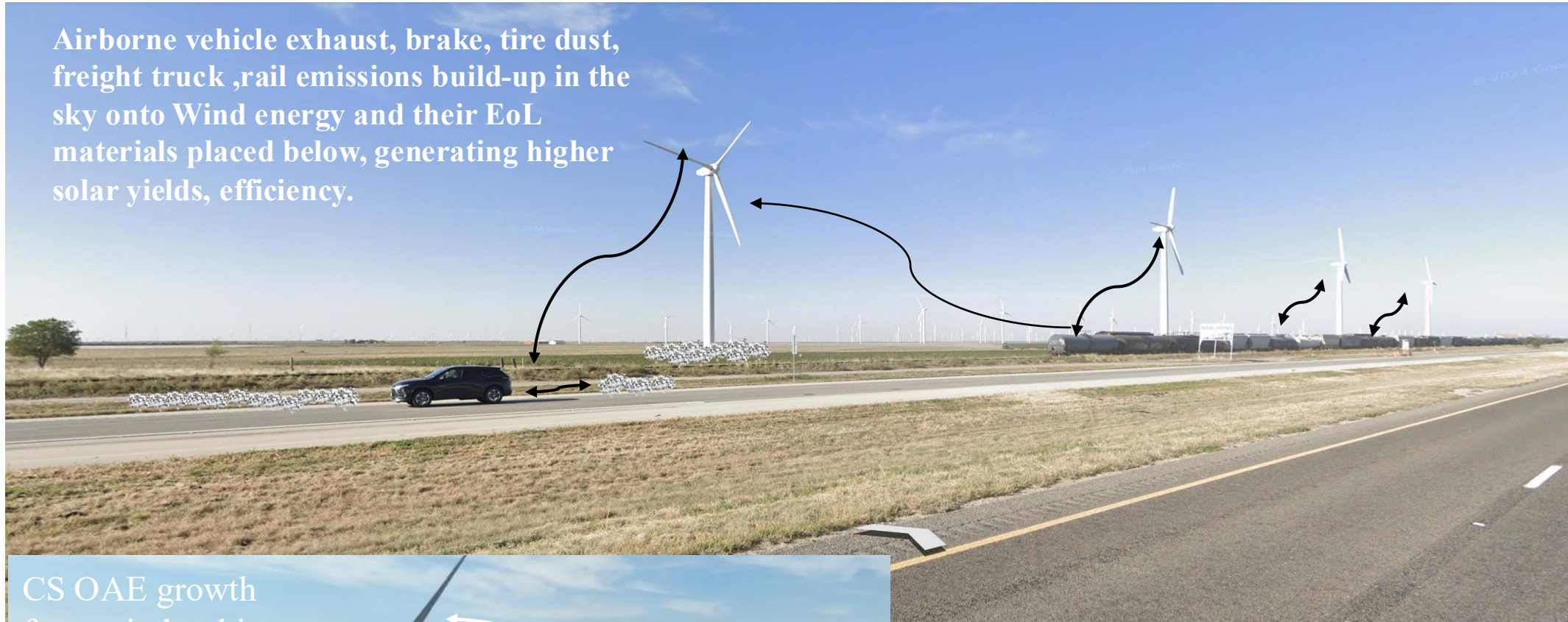
In effective cost per MWh. A .25 MW: \$3,500 - \$4,000/annual savings OR approx. 13 – 15% less solar panels are required for the farm, OR additional power feeds EV charging station. This is the highest value/ lowest cost Wind blade, nacelle repurposing project. Circular Solar could retain 30% of EoL 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 \$3M seed, \$1.2M FOAK funding (which includes a .25MW - 1MW pv-bess farm).***



# Circular Solar pollution management to reduce corrosion, failure and CDR Nanorocks:

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.

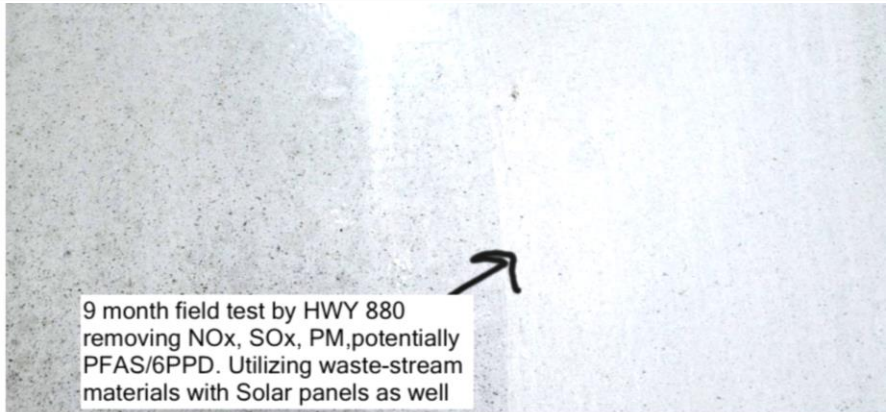
4/2025: IMO agrees to a [global carbon pricing: \\$100 or \\$380](#).



Corrosion reduction for Offshore Wind: Circular Solar OAE seaweed is cleaner than Vattenfall ex.:



Left side Pollution  
stormwater runoff: algae  
bloom toxic marine growth



9 month field test by HWY 880  
removing NOx, SOx, PM, potentially  
PFAS/6PPD. Utilizing waste-stream  
materials with Solar panels as well



Cleaner stormwater  
runoff: less pollution,  
calcium nitrate  
byproduct, healthy  
carbon capture  
seaweed growth



21 months of airborne  
pollution buildup

R: Circular Solar  
nanotechnology removal



# 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, heavy metal removal coating for healthier water runoff sequestered in soil, farmland, waterways.



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.

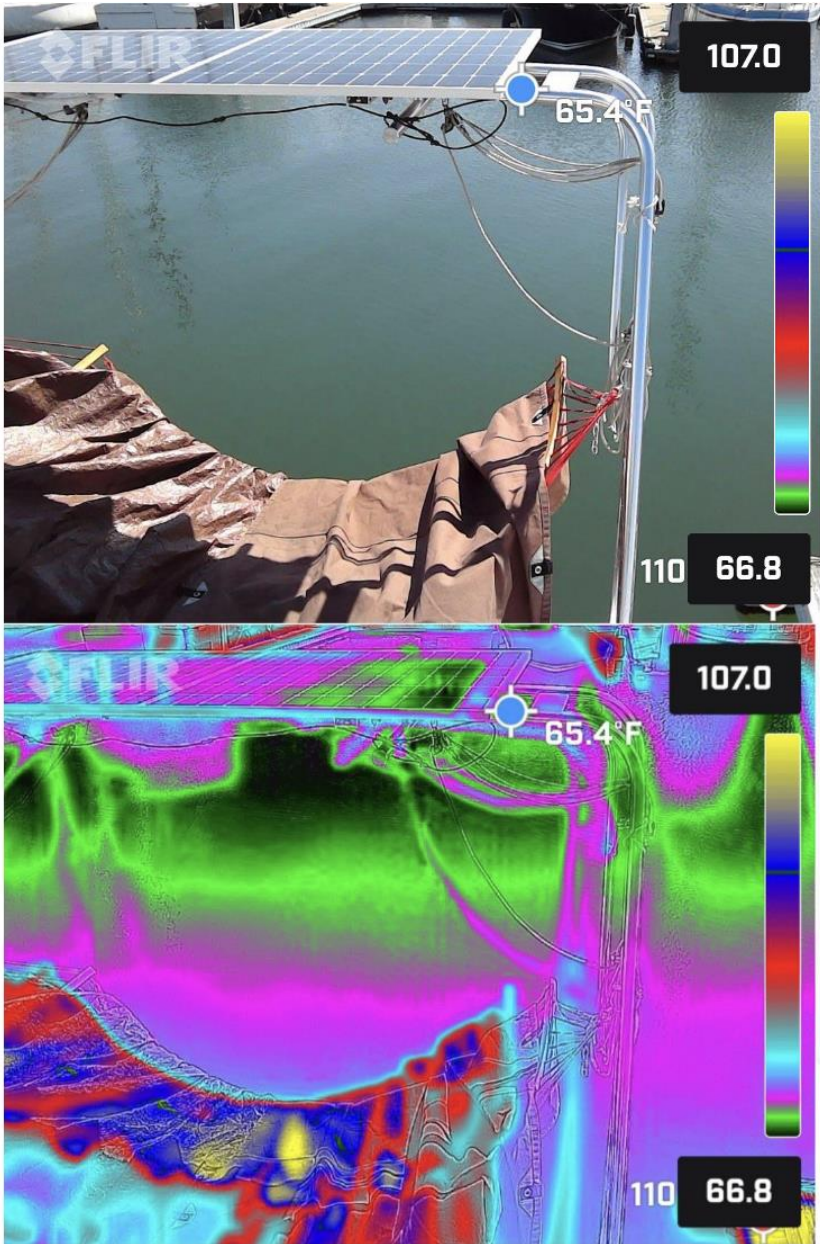
*Daniel Acker/Bloomberg via Getty Images*

**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.





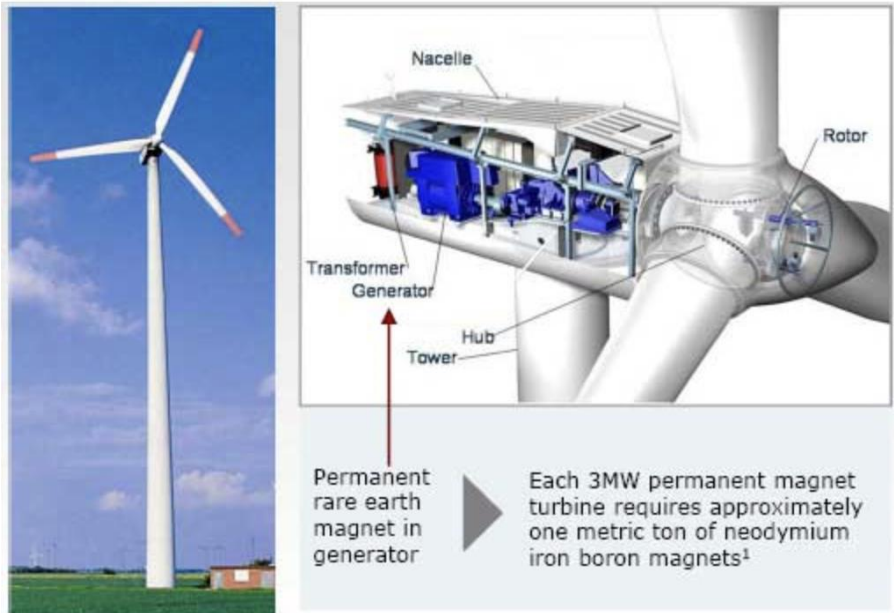
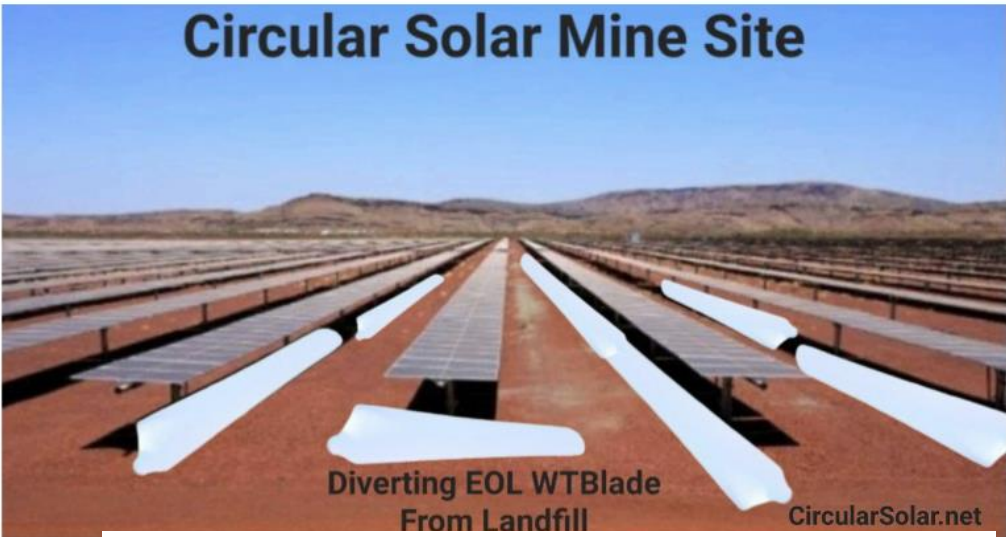
Our prototype and thermal tests reveal up to 30F cooler surfaces temperatures from solar panel shade which is mounted onto reflective white composite simulates high albedo value snow. The shade cools off cattle and provides colder and less water evaporation, healthier marine ecosystem. CDR ERW (enhanced rock weathering) with limestone, recycled concrete can be added.



How does shade over this waterway or a solar canal benefit fish behavior?  
[Let's see here](#)

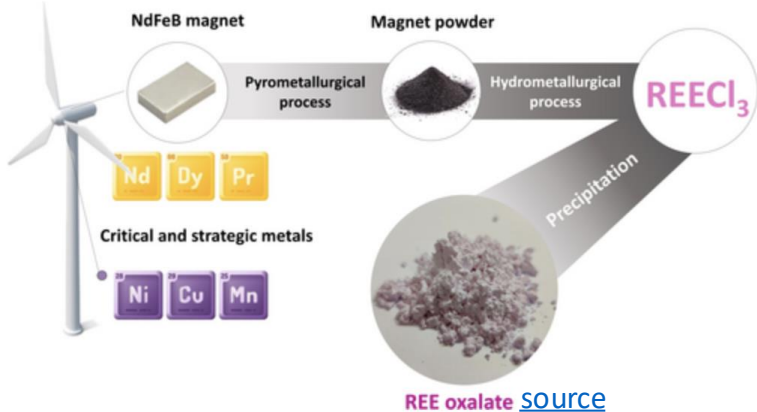


**Mine sites, landfill diversion** can accept hazardous EoL composite waste and recycling, process e-waste streams; such as REE magnets from nacelle generators (and first pitched to a mine site in 2010), manufacture drones onsite; with using DPA (defense production act funding).



### Graphical Abstract

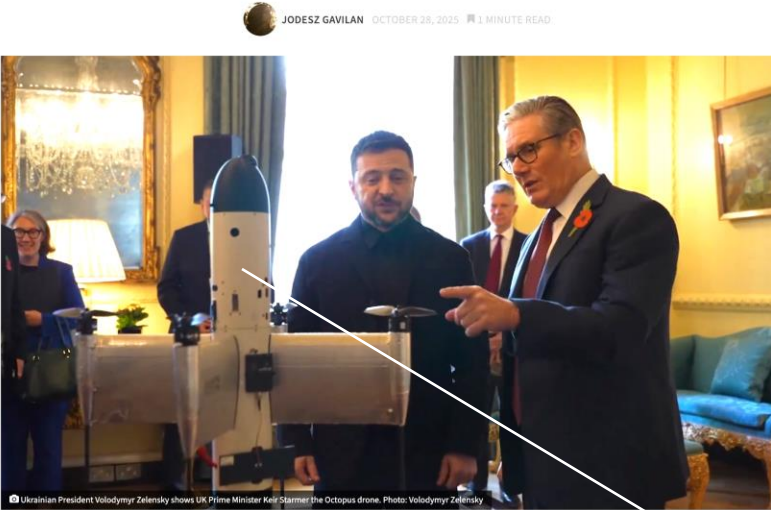
This work outlines a process for the recovery of rare earth elements from permanent magnets from wind turbines. Pyrometallurgical and hydrometallurgical methods are employed to produce a concentrated rare earth solution. Finally, these elements are selectively precipitated yielding a mixed rare earth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

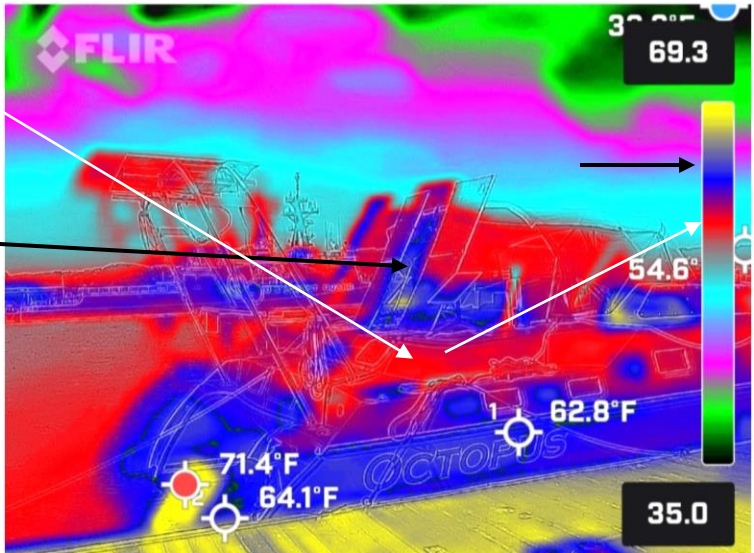


The newest systems are to be deployed on the borders of NATO allies as part of the so-called “drone wall” to deter the increasingly frequent intrusions of Russian aircraft and drones into NATO airspace.



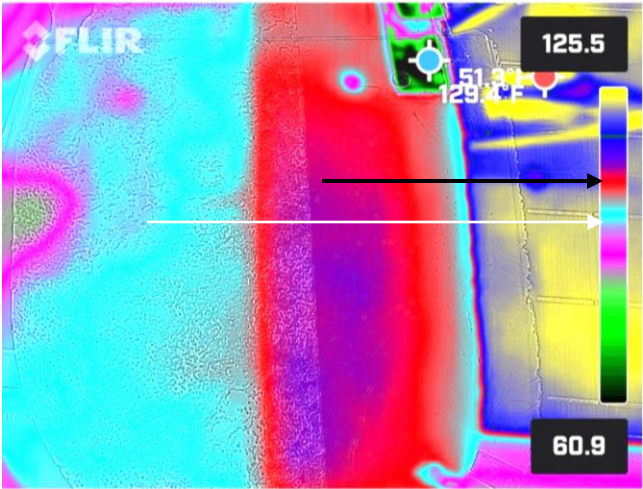
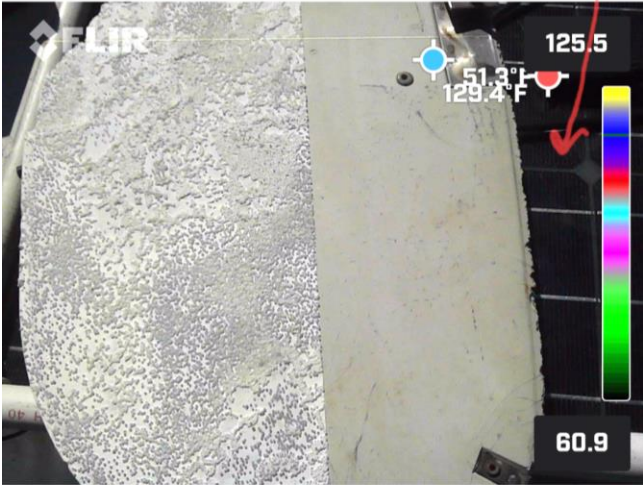
Ukrainian interceptor drone in 2025. Photo credits: Militarym1

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

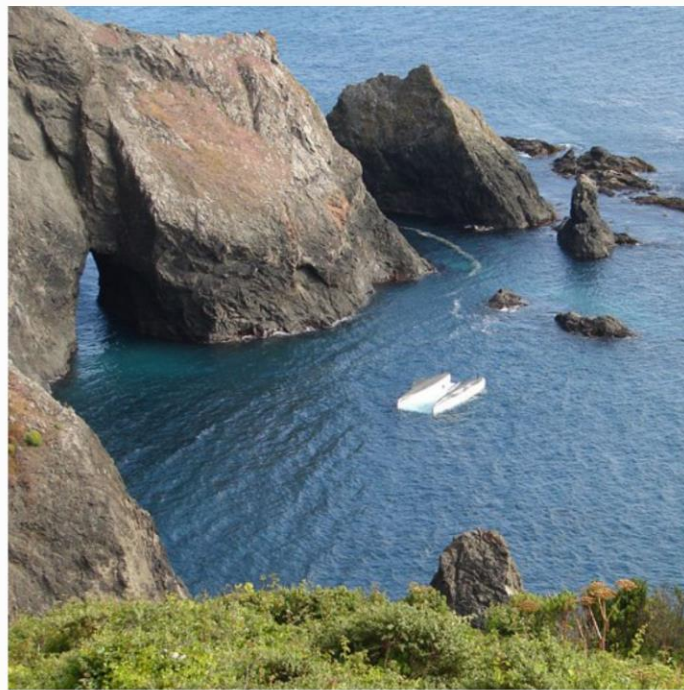
Black plastic solar panel up to 120F



[Letter to DOC Sec. 232 Wind includes adding drones to protect Wind assets.](#)

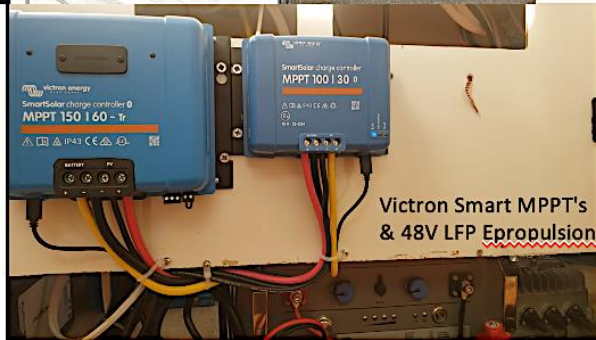


2010 offshore composite vessel simulating offshore wind failure – into floating remote minigrid testbed OCTOPUS





**OCTOPUS Testbed:** 1 kW of solar: 3.6kW BESS, 3.3kW BESS for motor, components, Starlink within nacelle 40 sq ft. Scale-up to 80' length floating solar-blade powerplants: 20kW solar – 60kW BESS charging station for E-vessels

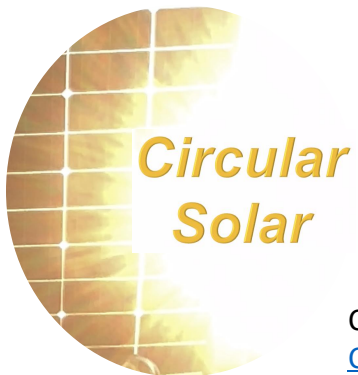








- 
- Team Circular Solar LLC, at CircularSolar.net is a small team under 5 people.
  - Recycling solution to improve Wind recycling rates by at least 5% to 95%, goal 100%.
  - Next steps, pilots in Europe, USA, Middle East.



Cherise Petker, Founder, Circular Solar LLC  
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