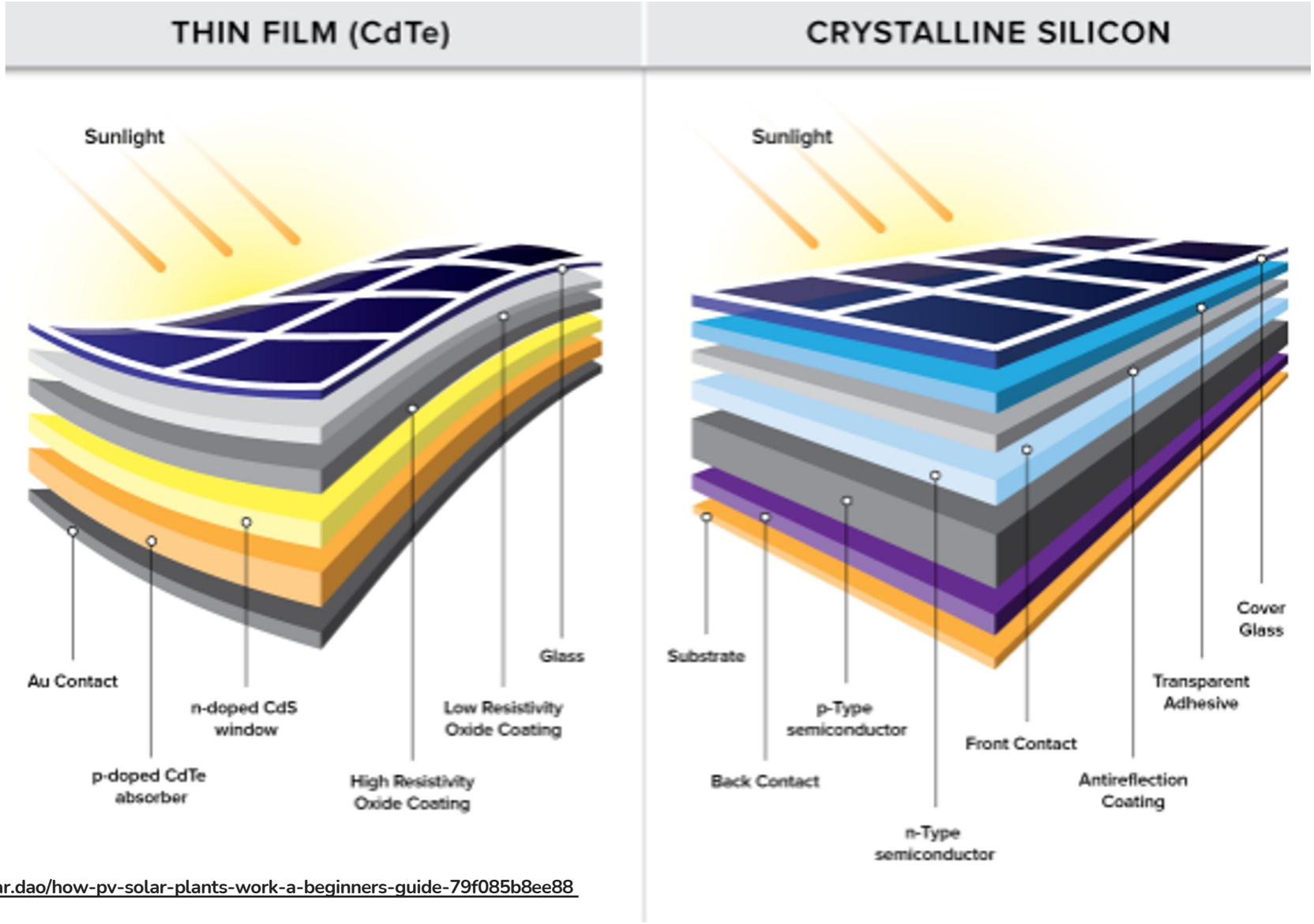
Green Energy Waste and What We Can Do about It

By Noah Getz

Photovoltaic Panels

Photovoltaic (PV) panels are essential for reducing the world's production of carbon dioxide, but we must figure out how to increase the lifespans of PV panels, how to avoid mining virgin materials, and how to reuse and recycle parts after they fail.

The Most Common Materials Used to Create PV Panels

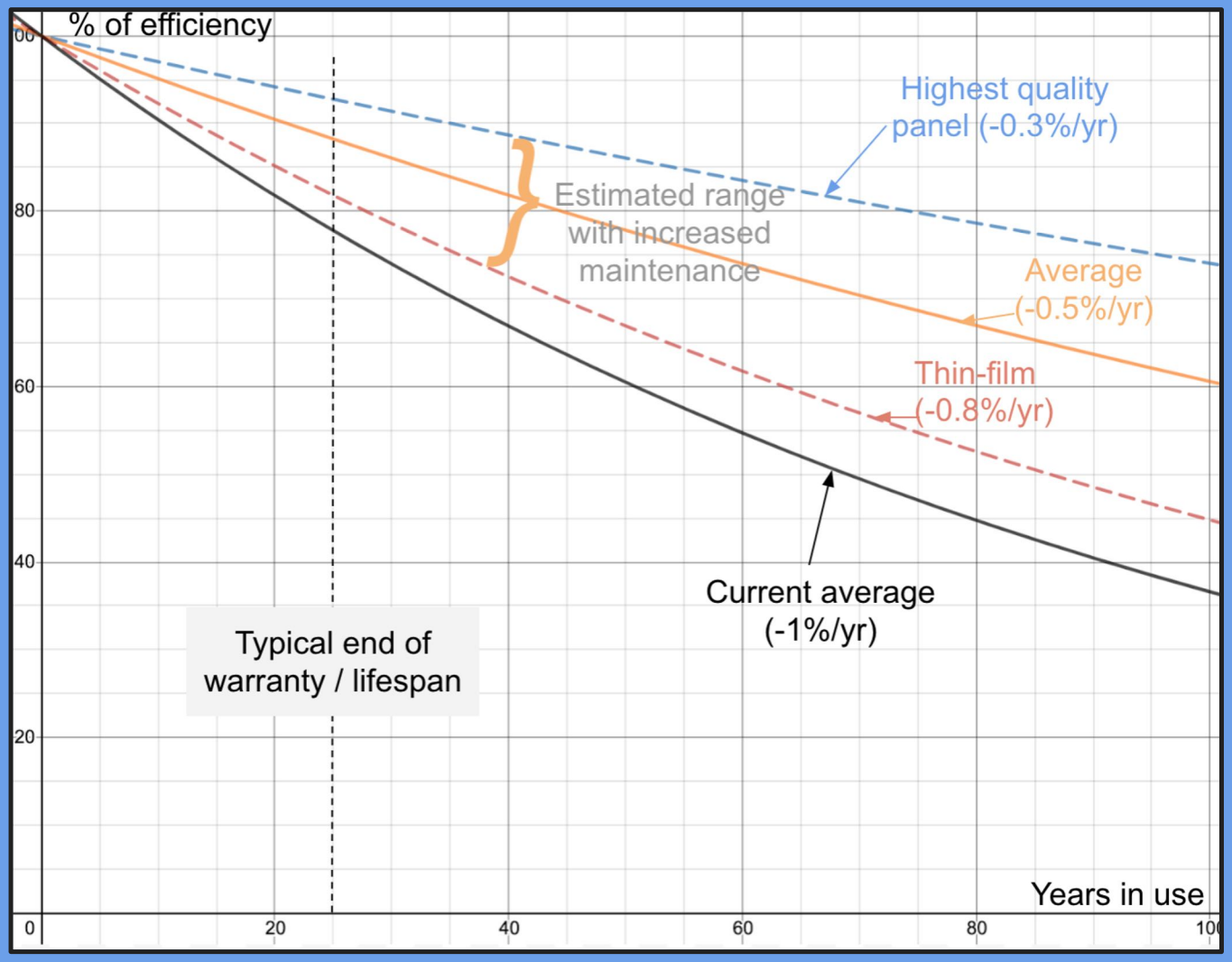


Source: https://medium.com/@solar.dao/how-pv-solar-plants-work-a-beginners-guide-79f085b8ee88


An Emerging Crisis
Virtually all countries classify photovoltaic panel waste as “general waste.”
16

60,000,000

Greenmatch predicts that 60 million tons of PV panels will fill landfills by 2050, useless we develop and implement robust recycling programs for those PV panels.



The Effects of Maintenance on PV Degradation

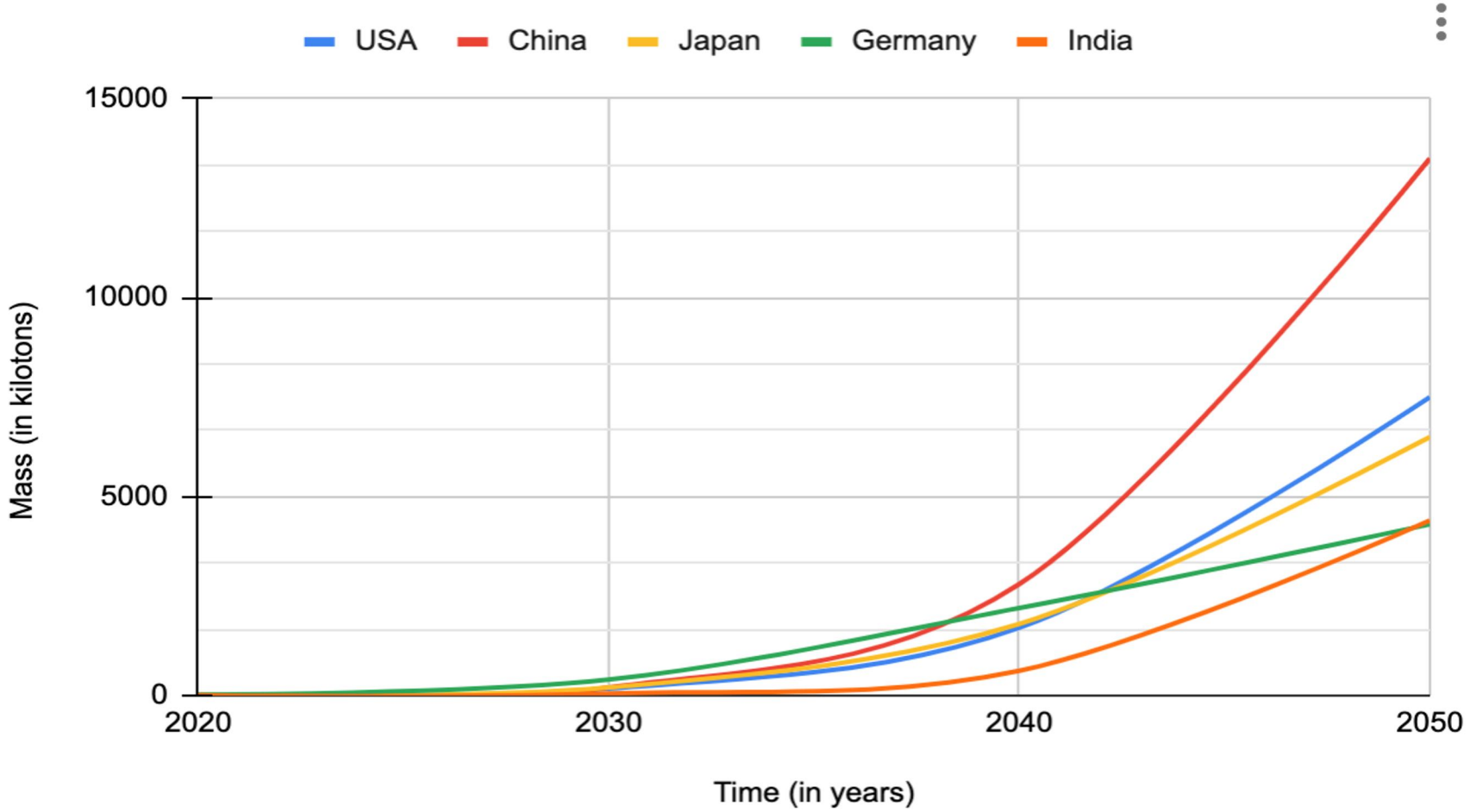
Sources:

https://www.engineering.com/DesignerEdge/DesignerEdgeArticles/ArticleID/7475/What-Is-the-Lifespan-of-a-Solar-Panel.aspx

https://www.sunrun.com/go-solar-center/solar-articles/how-long-do-solar-panels-really-last

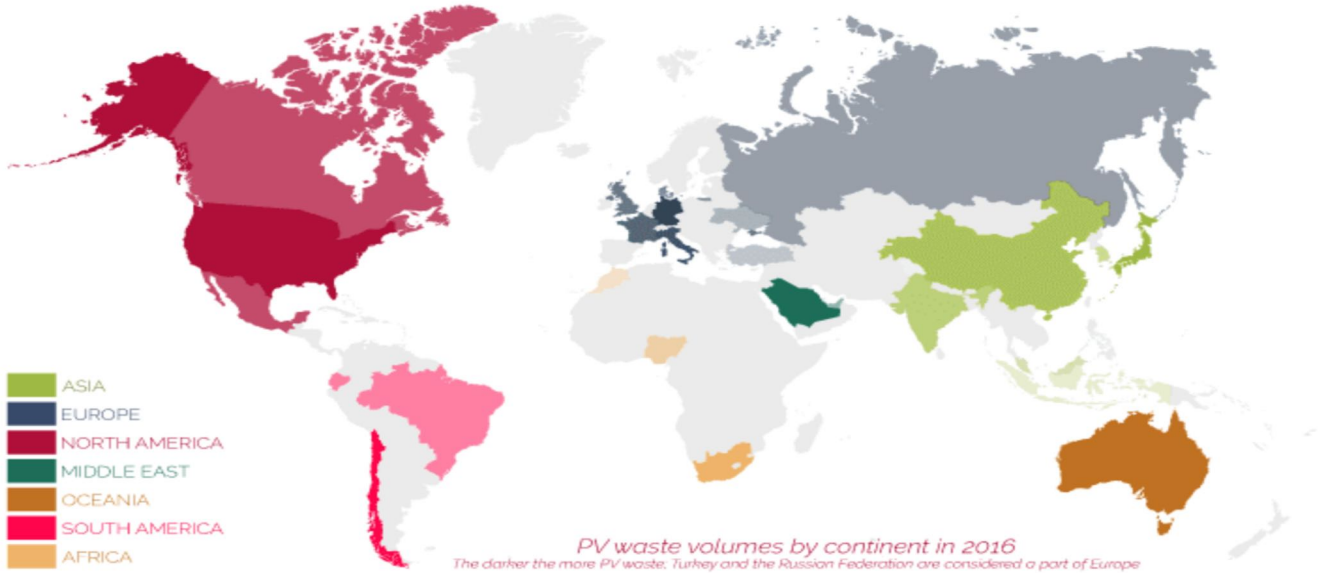
Desmos online graphing calculator

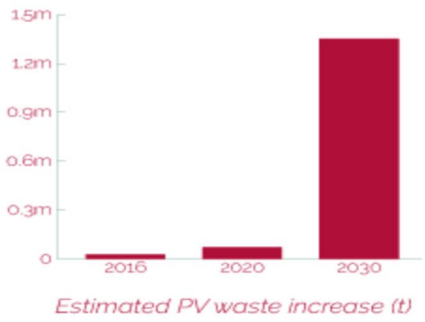
Biggest Economies' Future Estimated Solar PV Waste



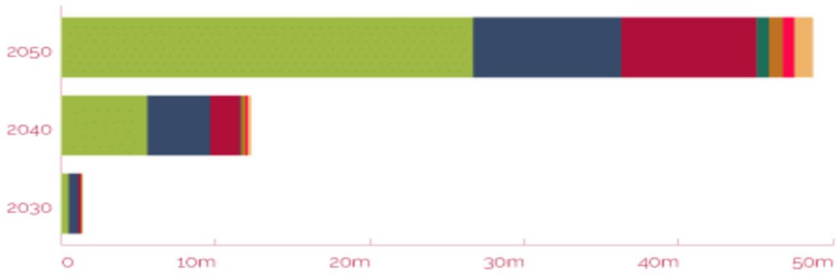
Source: https://www.greenmatch.co.uk/blog/2017/10/the-opportunities-of-solar-panel-recycling, https://www.google.com/maps/d/u/0/viewer?mid=1g4J5np6uhrHh-PmC-K4fB7QmJvU&ll=23.31536172565115%2C40.50981101205775&z=2

Estimated Global PV Waste in the Coming Decades



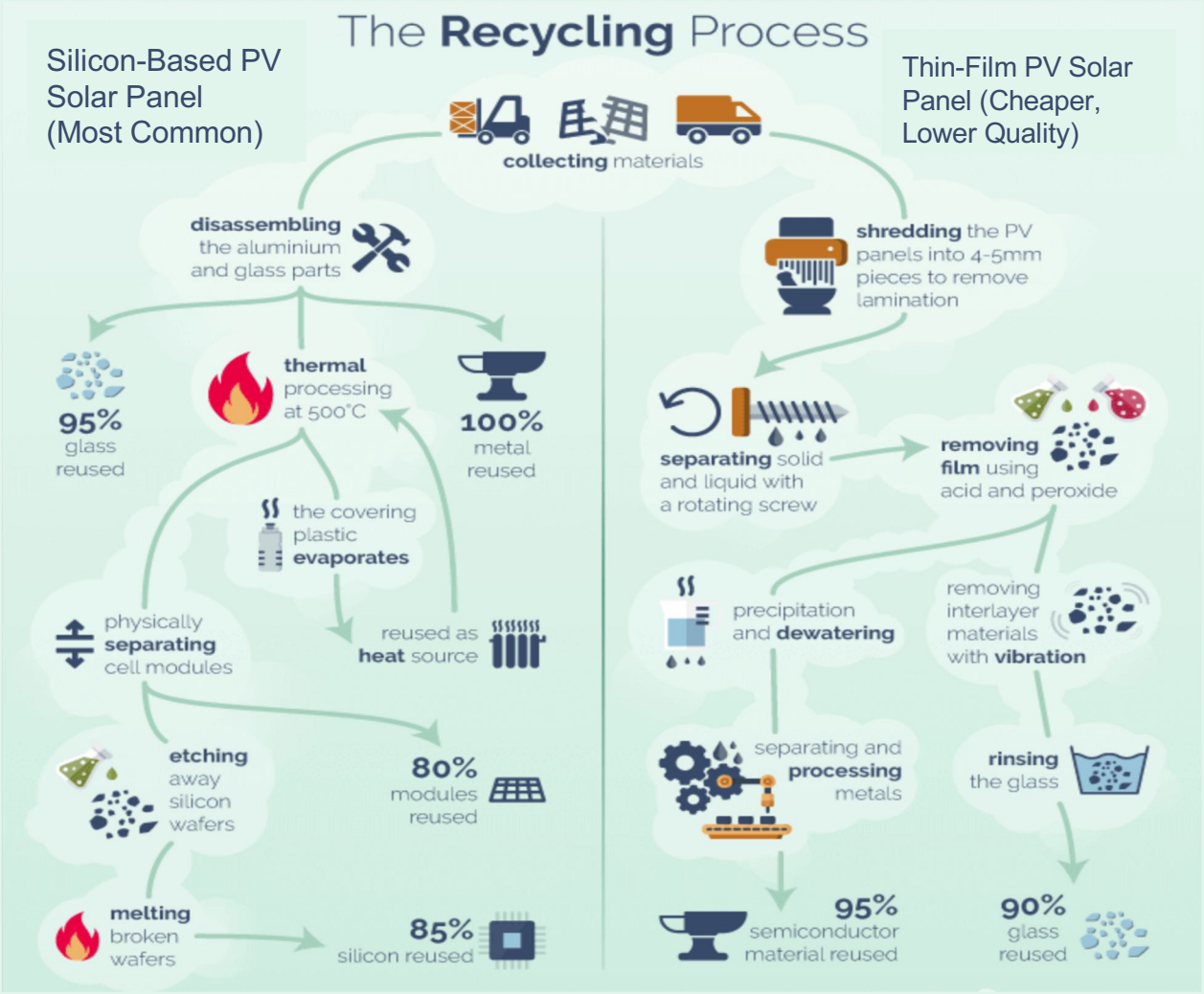


Estimated PV waste increase (t)



Estimated PV waste volumes by continent in the coming decades (t)

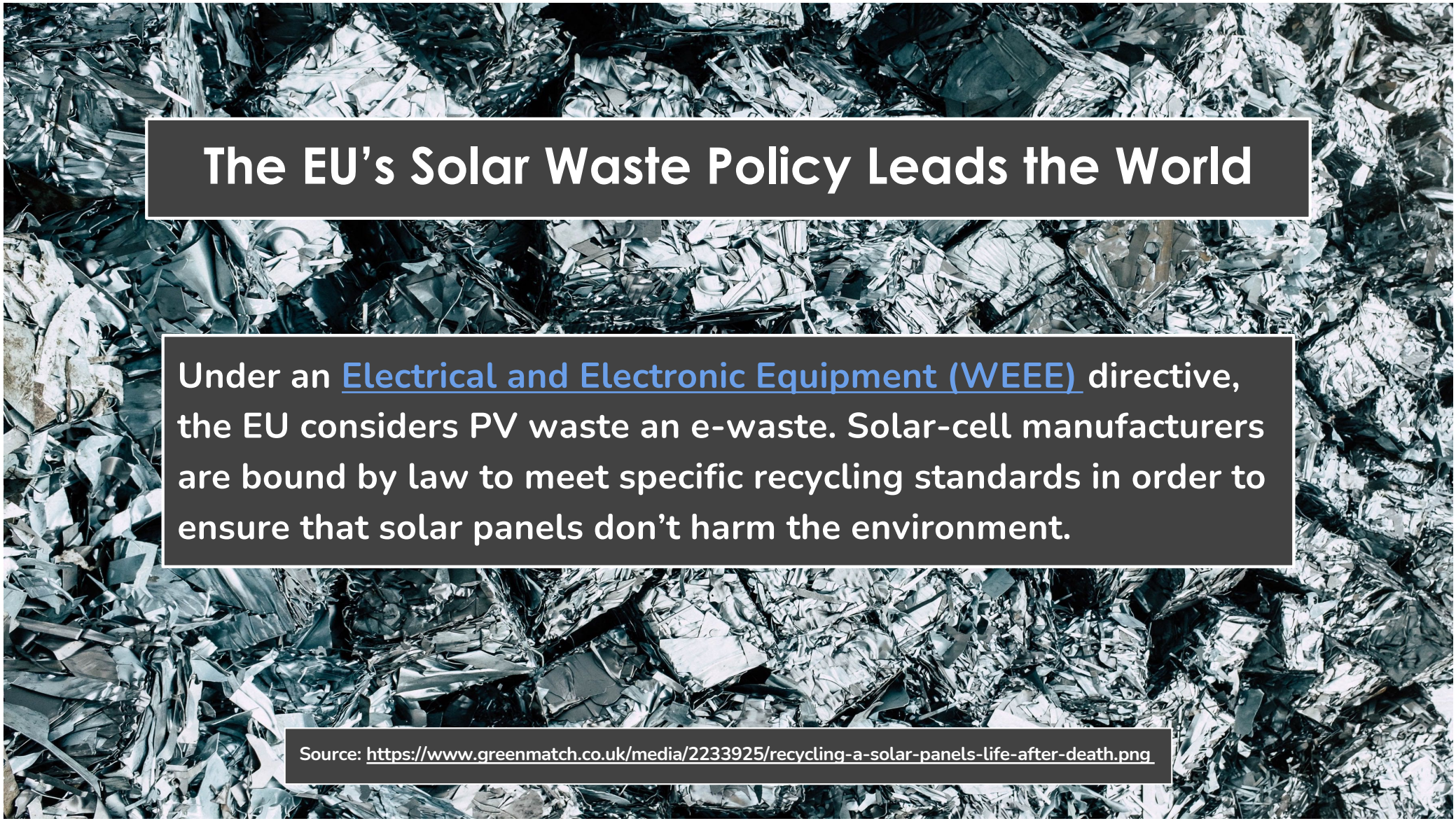
Source: greenmatch


The Recycling Process
Silicon-Based PV Solar Panel (Most Common)
Thin-Film PV Solar Panel (Cheaper, Lower Quality)
collecting materials
disassembling the aluminium and glass parts
shredding the PV panels into 4-5mm pieces to remove lamination
95% glass reused
thermal processing at 500°C
100% metal reused
separating solid and liquid with a rotating screw
removing film using acid and peroxide
the covering plastic evaporates
reused as heat source
physically separating cell modules
precipitation and dewatering
removing interlayer materials with vibration
etching away silicon wafers
80% modules reused
separating and processing metals
rinsing the glass
melting broken wafers
85% silicon reused
95% semiconductor material reused
90% glass reused

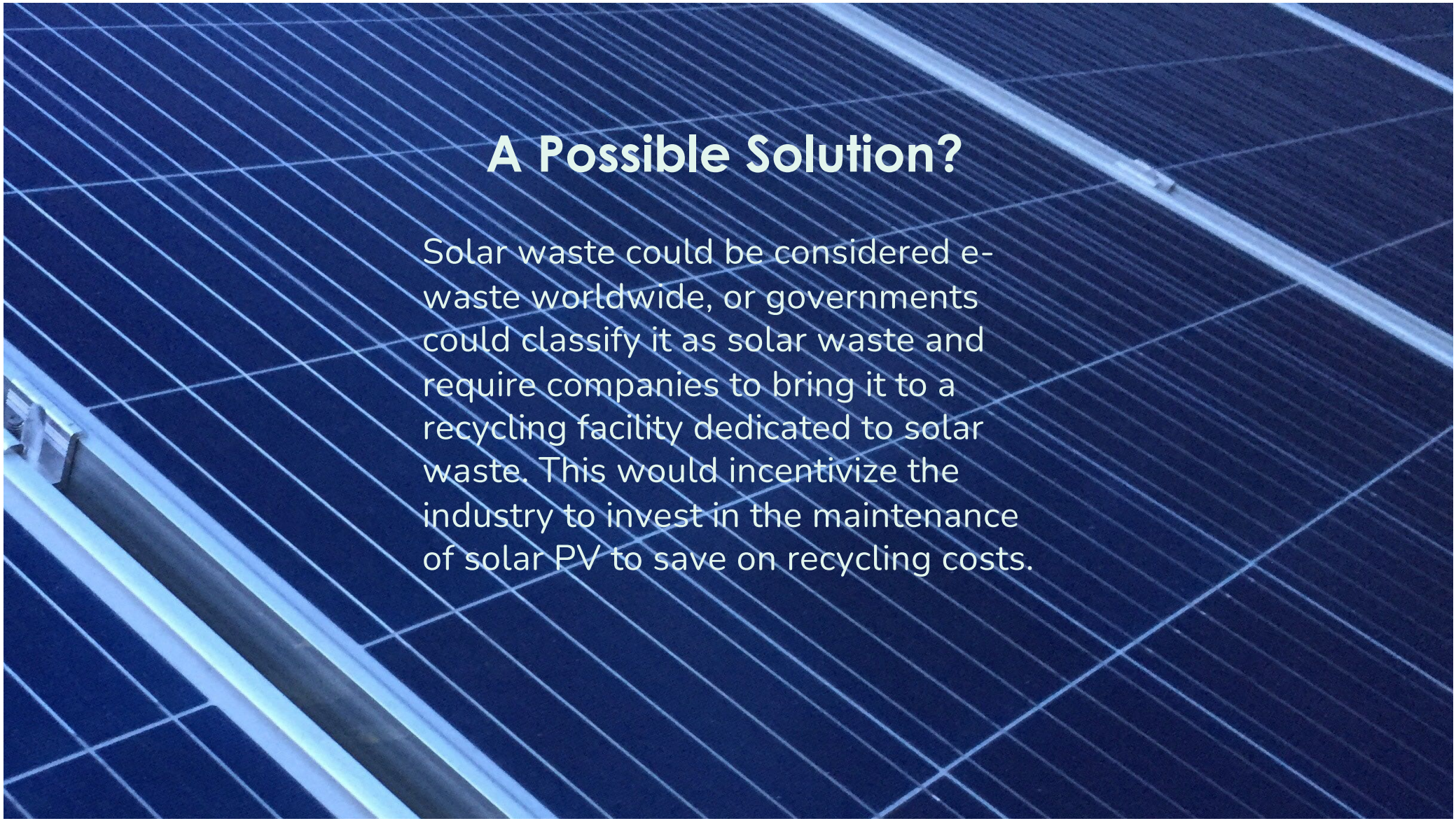
- Ideally, 96% of the solar panel would be reused to produce new solar panels.
- By 2050, 2 billion new panels could be made with the expected 60 million tons of broken panels.
- That’s $15 billion in recycled materials and 630 GW in extra electricity capacity.

The EU's Solar Waste Policy Leads the World

Under an Electrical and Electronic Equipment (WEEE) directive, the EU considers PV waste an e-waste. Solar-cell manufacturers are bound by law to meet specific recycling standards in order to ensure that solar panels don't harm the environment.



Source: https://www.greenmatch.co.uk/media/2233925/recycling-a-solar-panels-life-after-death.png

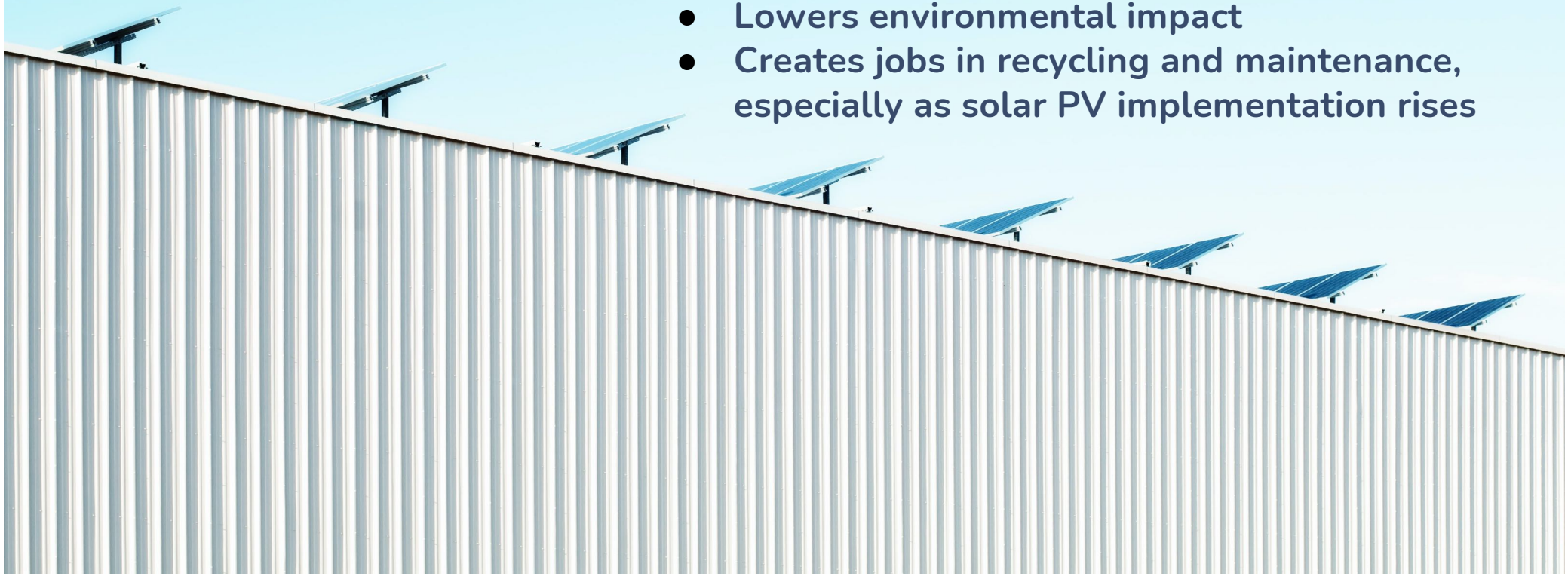


A Possible Solution?

Solar waste could be considered e-waste worldwide, or governments could classify it as solar waste and require companies to bring it to a recycling facility dedicated to solar waste. This would incentivize the industry to invest in the maintenance of solar PV to save on recycling costs.

Pros of Increased Maintenance & Recycling

- Longer lifespan
- Cheaper for solar owners
- Reduces extraction of virgin materials, increasing profits for panel manufacturer
- Lowers environmental impact
- Creates jobs in recycling and maintenance, especially as solar PV implementation rises



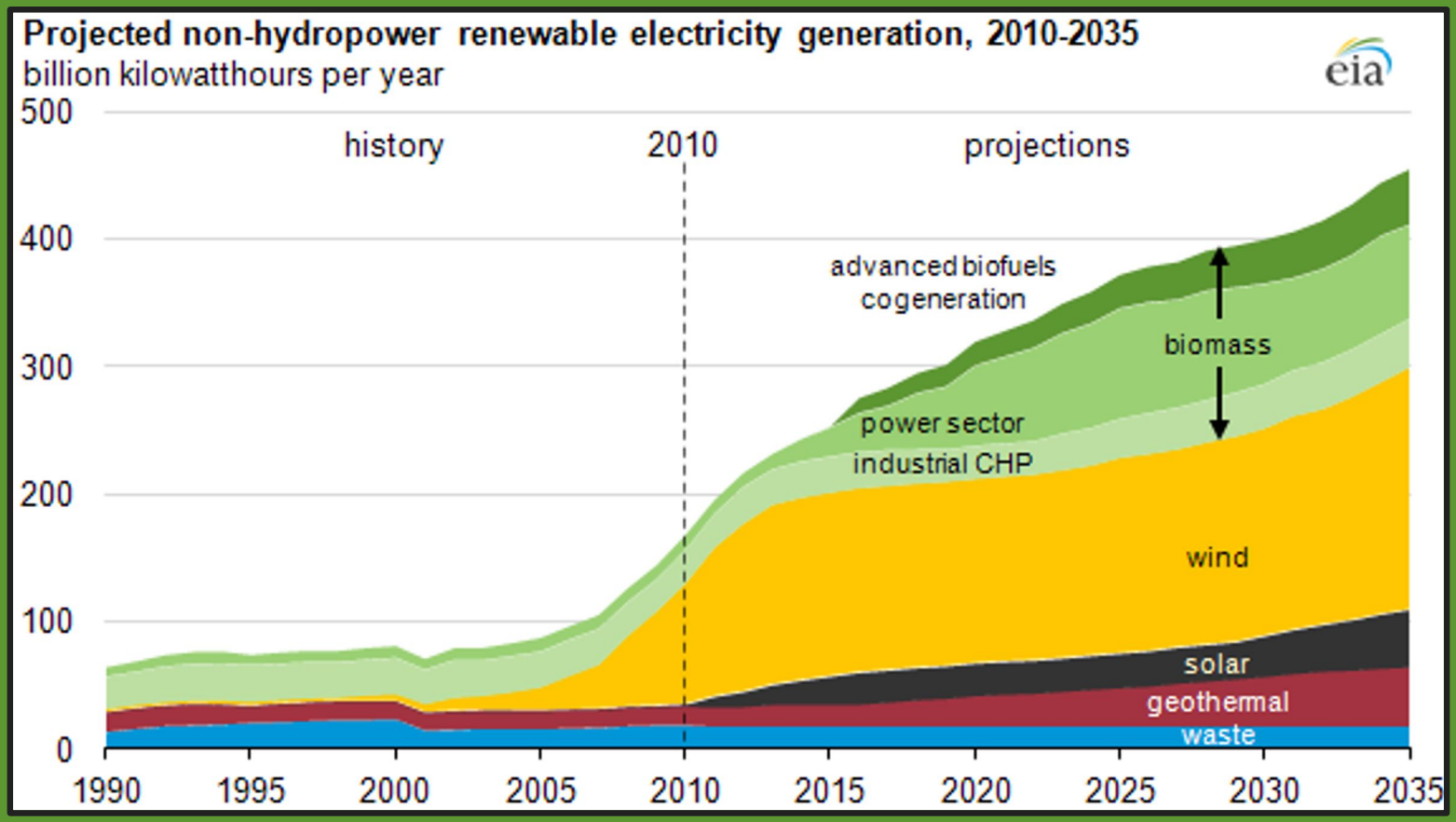
Cons to Increased Maintenance & Recycling

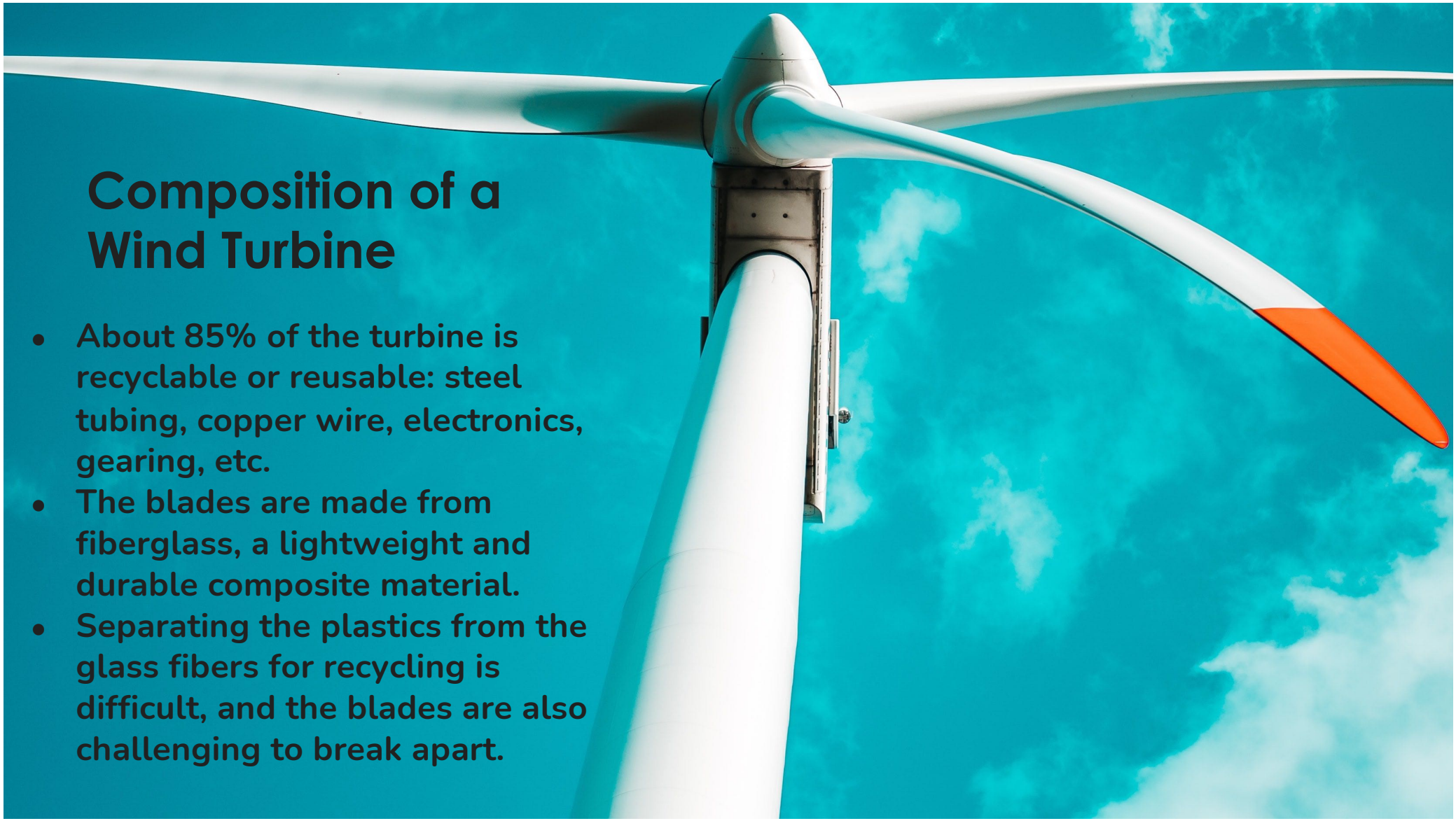
- Longer lifespan reduces sales for solar PV manufacturers, but the likely growth in solar PV use will increase markets for PV panels.
- Maintenance costs will be passed to the consumer, making solar PV more expensive, potentially lowering demand, unless governments increase solar subsidies.
- Due to their many individual parts, recycling solar PV is expensive, potentially more expensive than extracting virgin materials, but we must also factor in extraction's high environmental cost.
- Fewer jobs in mineral extraction, which could be counteracted by more jobs in PV recycling.

Wind Turbines

Wind Energy: A Growing Industry

Onshore wind energy capacity will increase 57% by 2024.





Composition of a Wind Turbine

- About 85% of the turbine is recyclable or reusable: steel tubing, copper wire, electronics, gearing, etc.
- The blades are made from fiberglass, a lightweight and durable composite material.
- Separating the plastics from the glass fibers for recycling is difficult, and the blades are also challenging to break apart.

What Happens to Wind Turbine Blades Now?

According to Bloomberg Green, they are piling up in landfills:

“Built to withstand hurricane-force winds, the blades can’t easily be crushed, recycled, or repurposed. That’s created an urgent search for alternatives in places that lack wide-open prairies. In the U.S., they go to the handful of landfills that accept them, in Lake Mills, Iowa; Sioux Falls, South Dakota; and Casper, where they will be interred in stacks that reach 30 feet under. [...] In the European Union, which strictly regulates material that can go into landfills, some blades are burned in kilns that create cement or in power plants. But their energy content is weak and uneven and the burning fiberglass emits pollutants.”

We Need a Solution!

An industry cannot be sustainable or renewable if it sends millions of metric tons of plastic waste to landfills annually.

The solution is using materials that are more sustainable than fiberglass.

Material: Thermoplastics

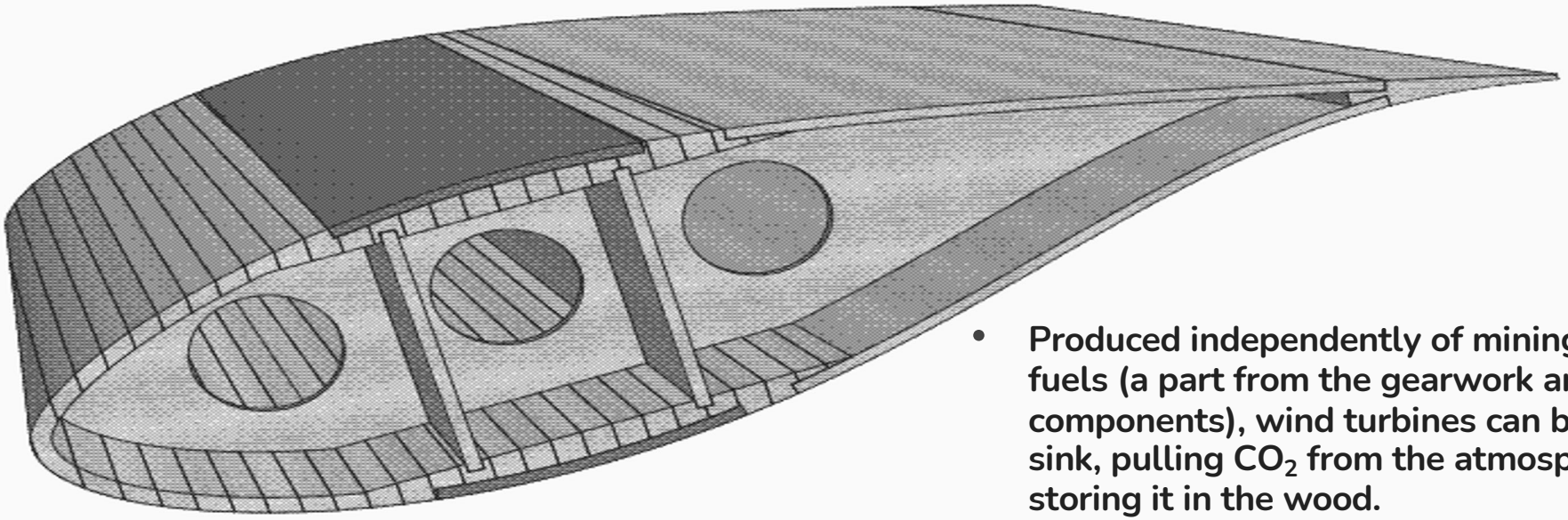
Thermoplastics can be melted and reused.

Pros: It's possible to recycle the blades into new wind turbine blades, even on-site.

Cons: Weak and stiff, so the blades cannot be larger than 9 meters.

Source: https://solar.lowtechmagazine.com/2019/06/wooden-wind-turbines.html

Material Study: Wood



- Produced independently of mining and fossil fuels (a part from the gearwork and electric components), wind turbines can be a carbon sink, pulling CO_2 from the atmosphere and storing it in the wood.
- To reduce potential energy spent on resource transportation, wind turbines could be built in a forest that could provide the wood for future wind turbines, making extraction, processing, and assembly local.
- By having the entire cycle on-site, the wind turbine industry could be a prime example of a circular economy.

Source: https://solar.lowtechmagazine.com/2019/06/wooden-wind-turbines.html

Today's wind turbine blades are longer than 10 meters. They're HUGE!

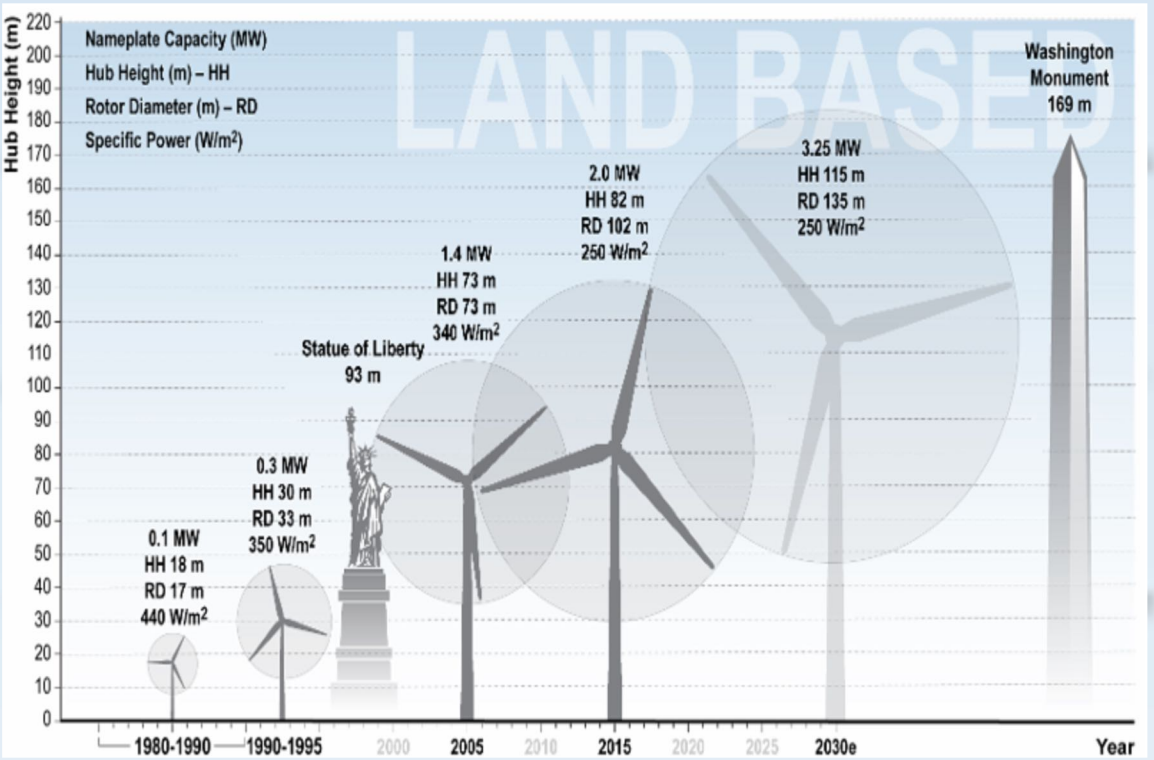
Source: Berkeley Lab, Wind Energy Technology Data Update: 2020 Edition, Page 37. Photo: James Gignac

Limitations of Thermoplastics and Wood: Blade Length

When manufacturers reduce blade length so they can use more sustainable materials, the power produced decreases exponentially.

Manufacturers would have to use exponentially more materials to make up for the lost energy.

Using more materials makes wind turbines economically unfeasible and, more importantly, more energy intensive.



Source: https://cdn.arstechnica.net/wp-content/uploads/2016/11/2a981f17-4bd5-43e1-9bad-aad6407f26eb.png

New Material: Laminated Veneer Lumber Reinforced with Carbon Composite Spears!

Laminated veneer lumber is a material made from wood that is peeled off trees and glued together in thin layers.

The flexibility of wood makes it hard to limit elastic deflections in very large rotor blades, so manufacturers must reinforce the laminated veneer lumber with carbon composite spars.

The plastic isn't intertwined with wood in the blade but clearly separated from it, facilitating re-use, incineration, and recycling.

Source: https://solar.lowtechmagazine.com/2019/06/wooden-wind-turbines.html

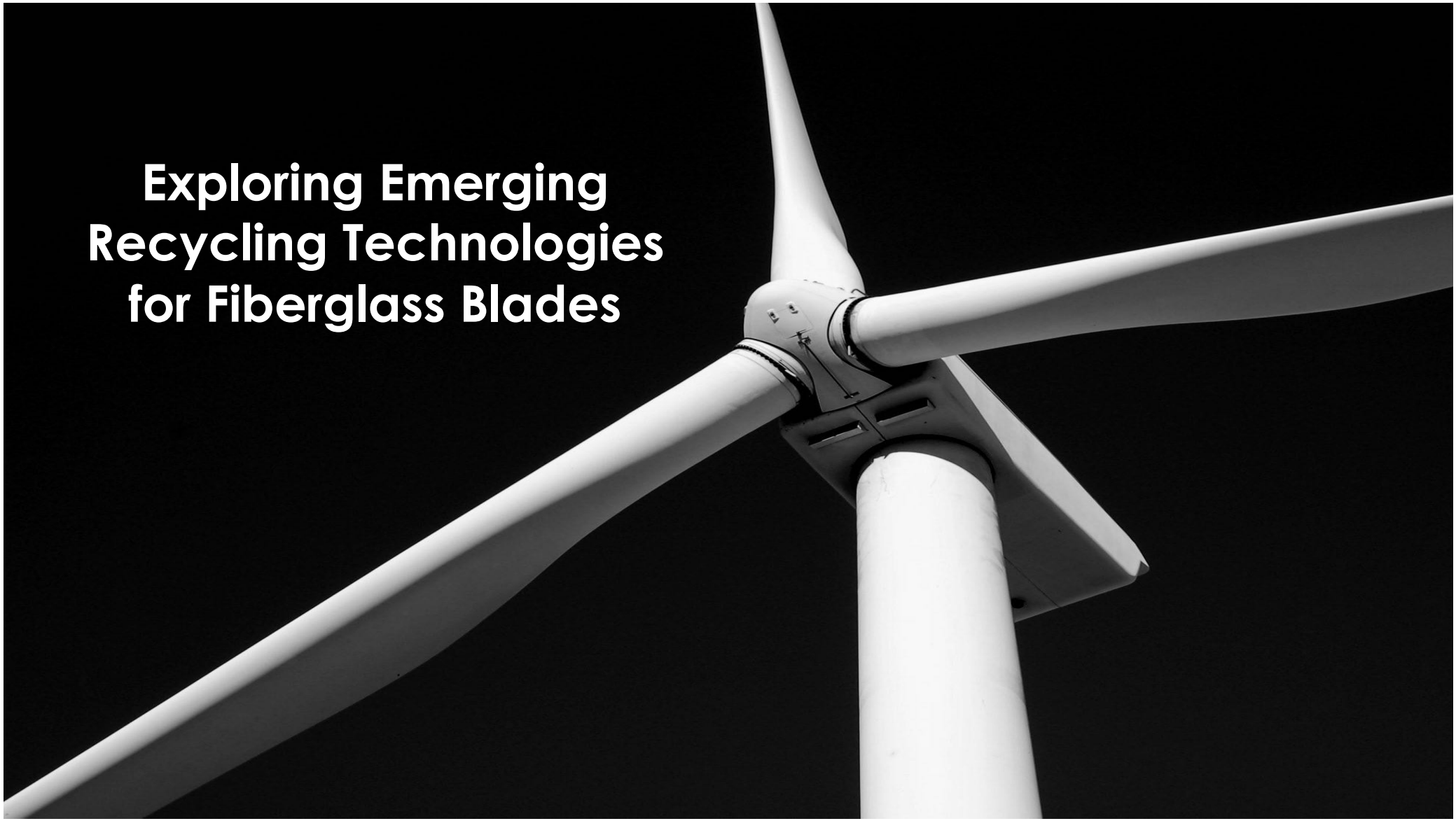
Cons of Laminated Veneer Lumber

According to a study at UMass Amherst, a 61.5 meter blade “made of laminated wood veneer panels would be 2.8 times heavier than a plastic blade (48 versus 17 tonnes) and have a laminate of over 50 cm thick.”

Possible does not mean practical: heavier blades demand a much stronger turbine, increasing costs and resource use.

Source: https://solar.lowtechmagazine.com/2019/06/wooden-wind-turbines.html

Exploring Emerging Recycling Technologies for Fiberglass Blades



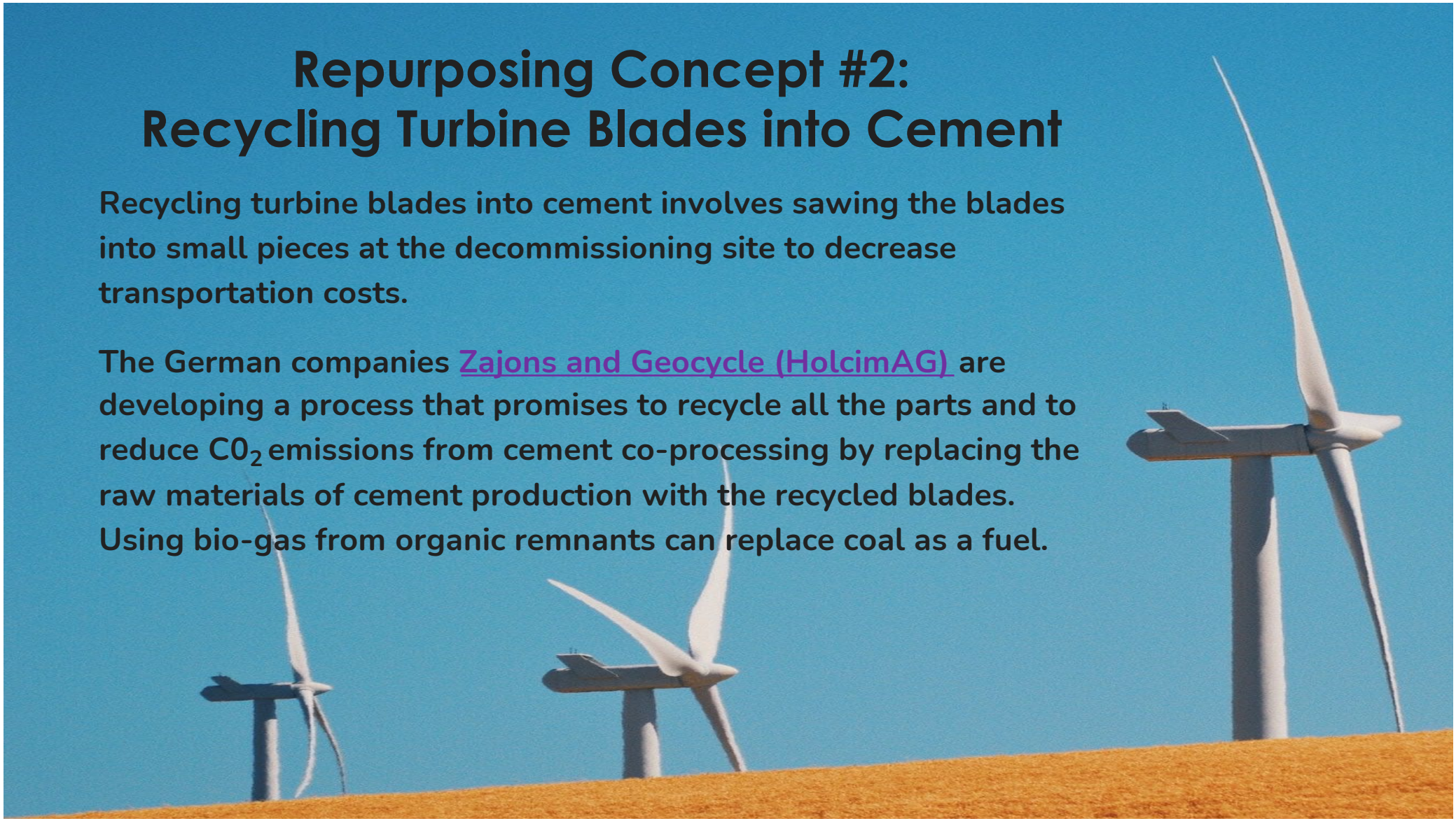
Repurposing Concept #1: Using Blades In Civil Structures

Decommissioned blades can be used in civil engineering projects such as powerlines, towers, or roofs for low-cost housing. In Northern Ireland, Re-wind, a collaboration of American and Irish universities, is developing repurposing concepts is considering piloting them for use in pedestrian bridges along greenways.

Repurposing Concept #2: Recycling Turbine Blades into Cement

Recycling turbine blades into cement involves sawing the blades into small pieces at the decommissioning site to decrease transportation costs.

The German companies Zajons and Geocycle (HolcimAG) are developing a process that promises to recycle all the parts and to reduce $C0_2$ emissions from cement co-processing by replacing the raw materials of cement production with the recycled blades. Using bio-gas from organic remnants can replace coal as a fuel.



Repurposing Concept #3: Producing Pellets & Boards from Blades

In 2019, Global Fiberglass Solutions began producing EcoPoly Pellets, a product made from decommissioned wind turbine blades.

EcoPoly Pellets can be transformed into a variety of products, including warehouse pallets, flooring material, or parking bollards.

Based on its demand forecasts, Global Fiberglass Solutions anticipates processing 6,000 to 7,000 blades per year at its two plants in Texas and Iowa.

Why Haven't We Widely Implemented These Recycling Methods?

Simply said, there isn't enough market demand for recycling turbine blades to incentivize the creation of the facilities.

Countries must implement policies to create the need. That includes banning blade waste and creating recycling subsidies.

What Can We Do About It?

- Encourage local elected officials to fund initiatives, divert fossil fuel subsidies toward research, and develop wind power and solar PV recycling.
- Donate to research organizations and nonprofits devoted to creating greener materials and processes.

Acknowledgements

Thank you to all the photographers whose photos I used!
Links to the websites, photos, and photographers:

Website: https://unsplash.com/

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