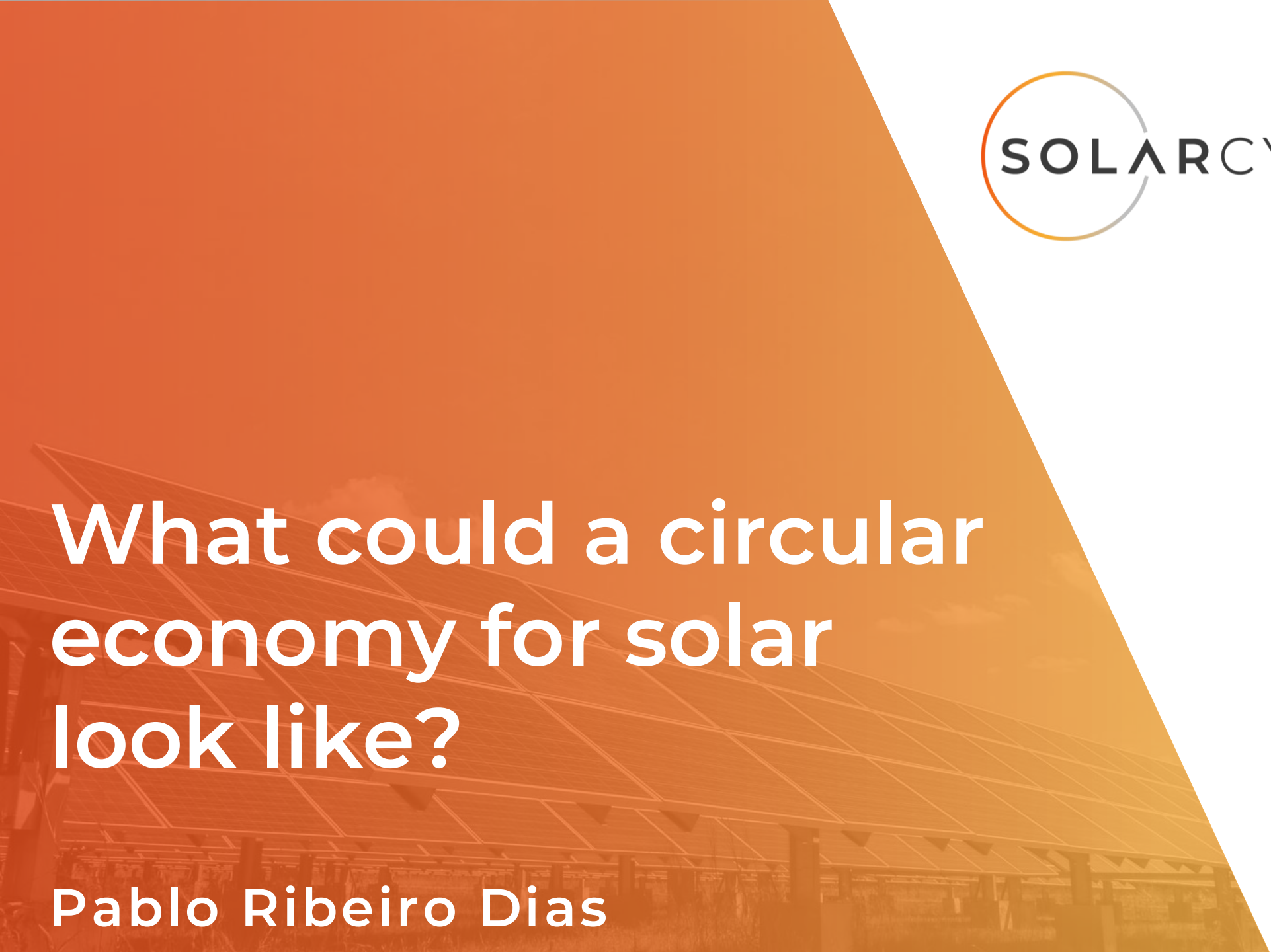


SOLARCYCLE

What could a circular economy for solar look like?

Pablo Ribeiro Dias

OCTOBER 2024

Confluence of factors

Building more solar requires resources
(Net Zero)

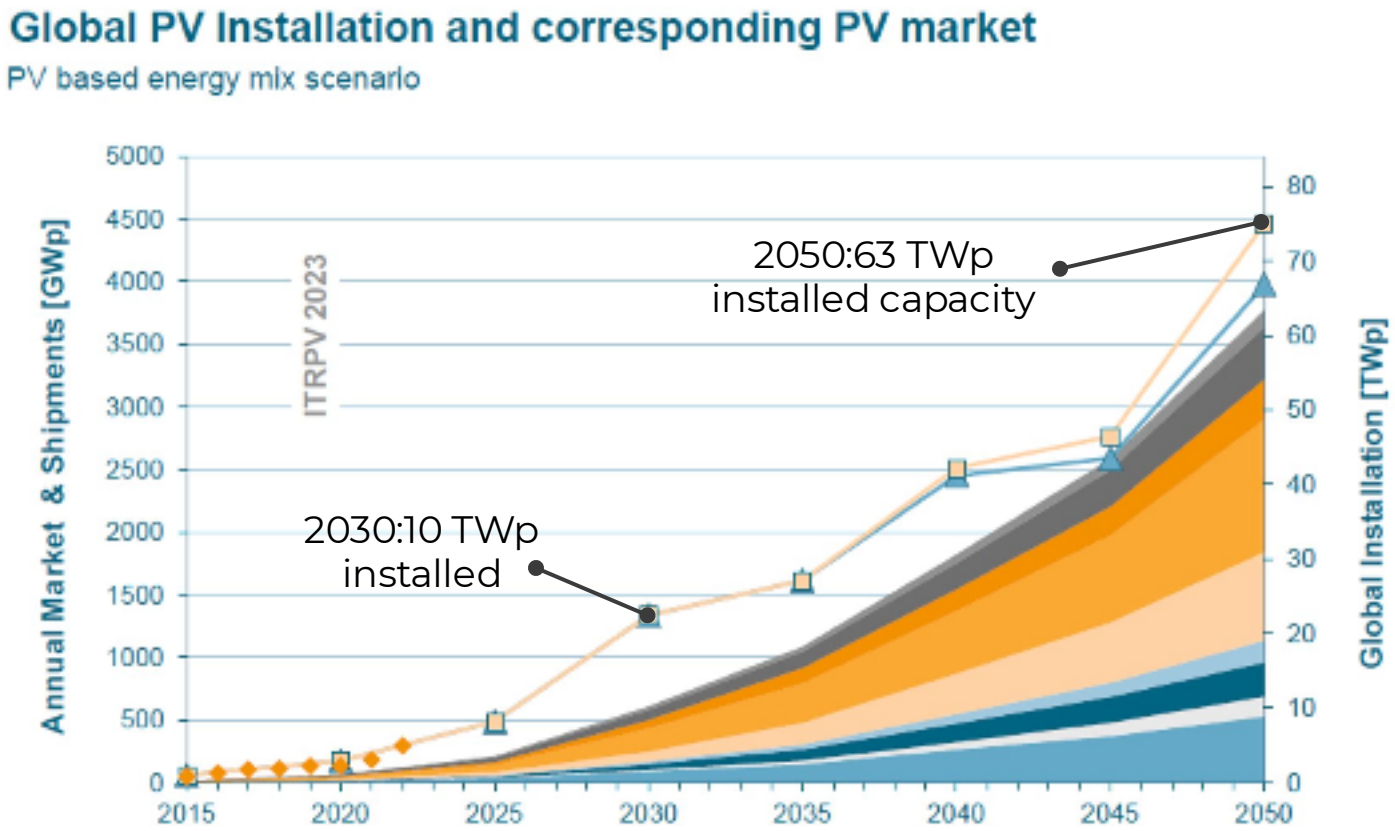
Recycling advancements
(More resource extraction and more resource available)

Negative views on solar
by media due to waste

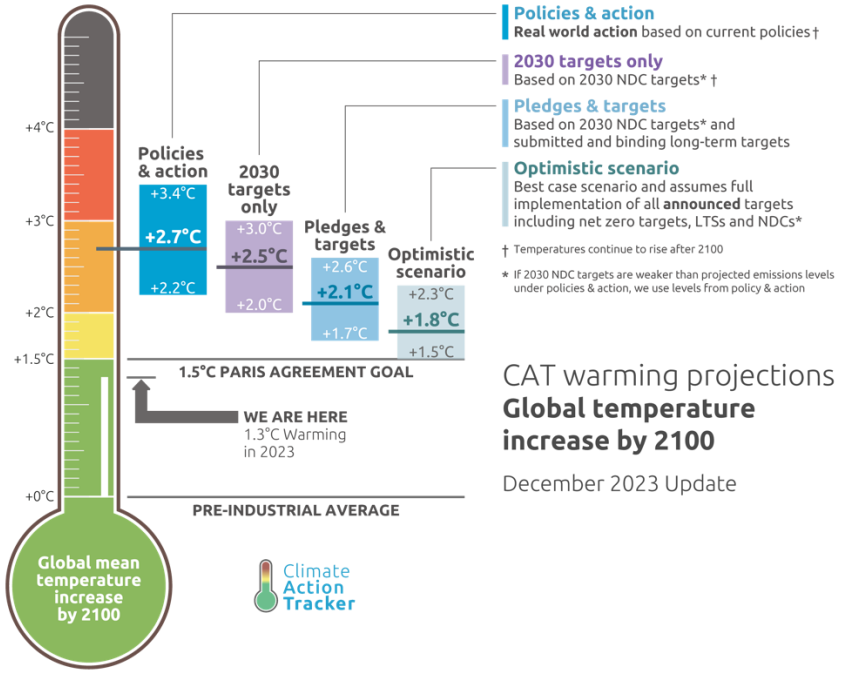
Learning Rate
decreases the resources needed per Watt

The Offtaker Market
(Where do materials go?)

Why are we here?



Source: Adapted from 2023 ITRPV – www.itrpv.net.



Source: Climate Action Tracker 2024

THE CHALLENGE

Today

~3 Billion

Panels in the World

Millions reaching EOL today.

We need to have between

34 – 140 Billion Panels

To achieve net zero. Lower bound based on IEA, and upper bound based on ITRPV Broad Electrification

*Assuming 450W per panel. Simplistic assumption, especially looking to the future. But assists in contextualizing.

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The Media

Harvard Business Review

The Dark Side of Solar Power

As interest in clean energy surges, used solar panels are going straight into landfill. by Atalay Atasu, Serasu Duran, and Luk N. Van Wassenhove

June 18, 2021

A black eye for green energy? Renewable energy growth brings mounting waste challenge

CBS NEWS

Grist

Solar panels are starting to die. What will w do with the megatons of toxic trash?

Most solar manufacturers claim their panels will last for about 25 years. That means the solar e-waste gl coming.

Los Angeles Times

California went big on rooftop solar. Now that's a problem for landfills

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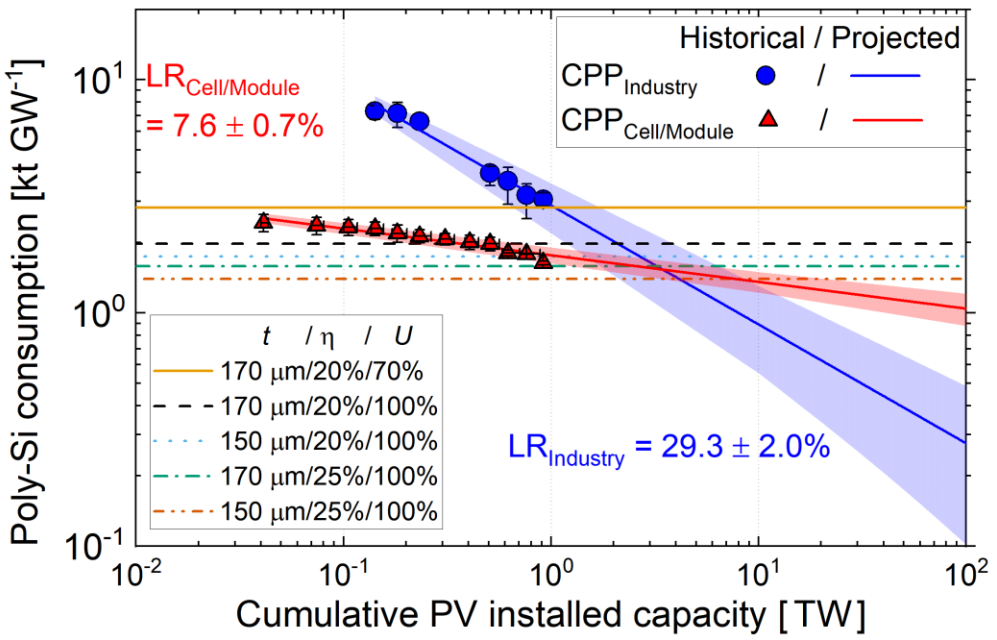
Material Consumption Over time (Silicon & Silver)

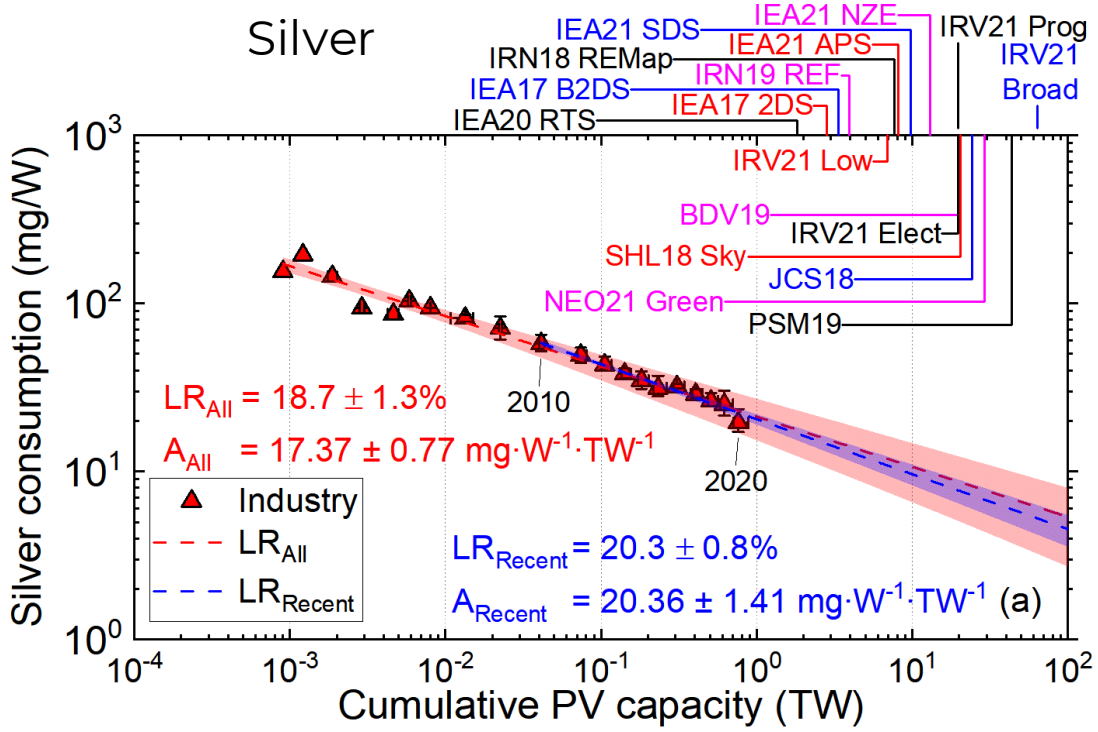
Material consumption per unit of power (CPP) (mg/W)

Silicon



Source: Hallam et al. 2022. https://doi.org/10.1002/solr.202200458

Silver



Source: Hallam et al. 2022. **https://doi.org/10.1002/pip.3661**

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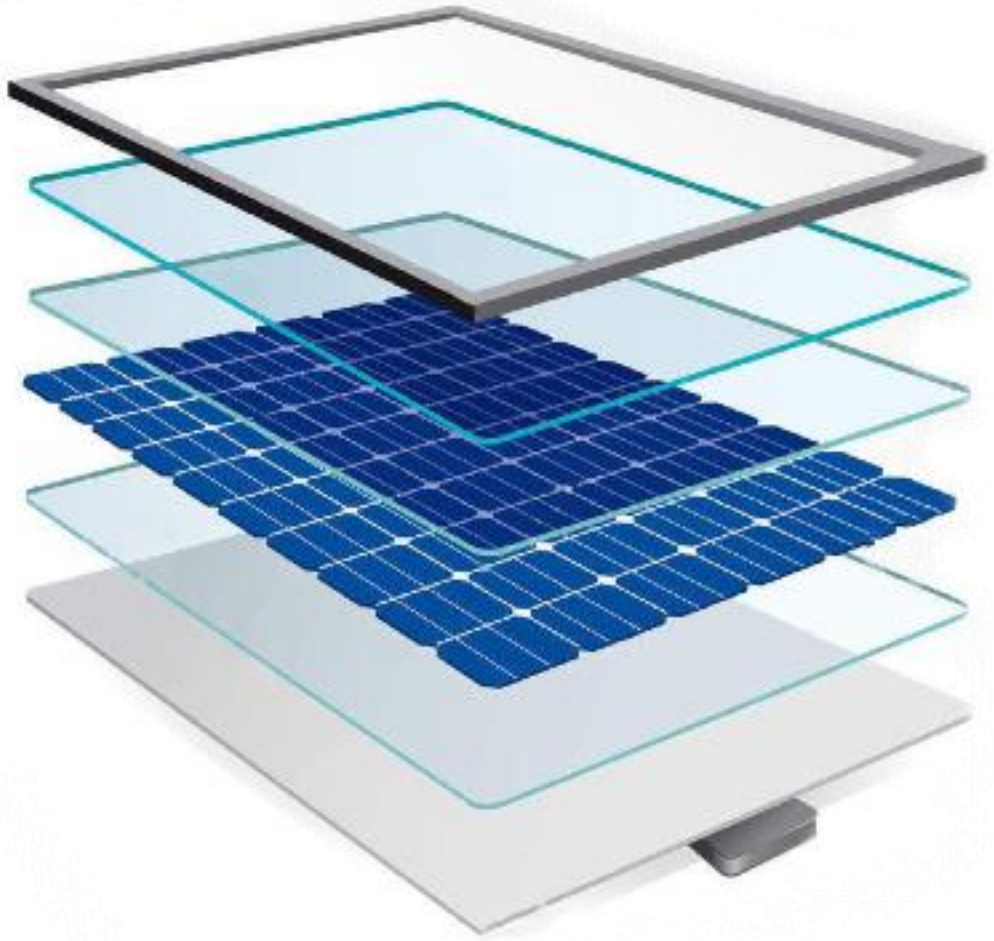
Increasing Rates in all Fronts



Aluminum frame

Glass

Precious metals

Plastics

Collection

Pre-Processing

End-Processing

EoL Recycling Rate

Source: Hageluken, 2012

Who are we competing with?

LANDFILL

Cost of landfill is still much cheaper than cost of recycling. The delta that exists today means that people need to want to recycle for it to take place

Our business model is that of extracting more value over time and lowering our operational cost to make the cost of recycle equal to that of landfill

Who are we competing with?

“RECYCLERS”

Other recyclers are welcome as SCI’s objective is to divert waste from landfill and put it back into the supply chain. HOWEVER

We have found “sham” recycling is much more common than originally assumed.

Confluence of factors

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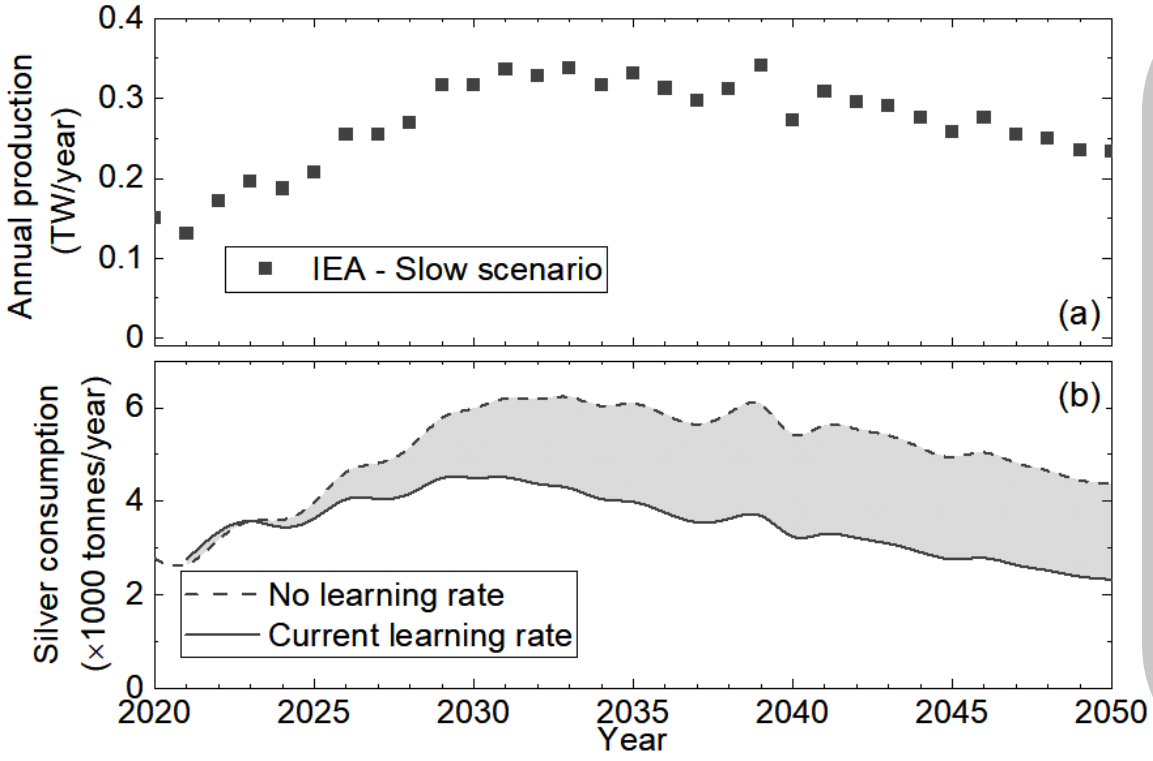
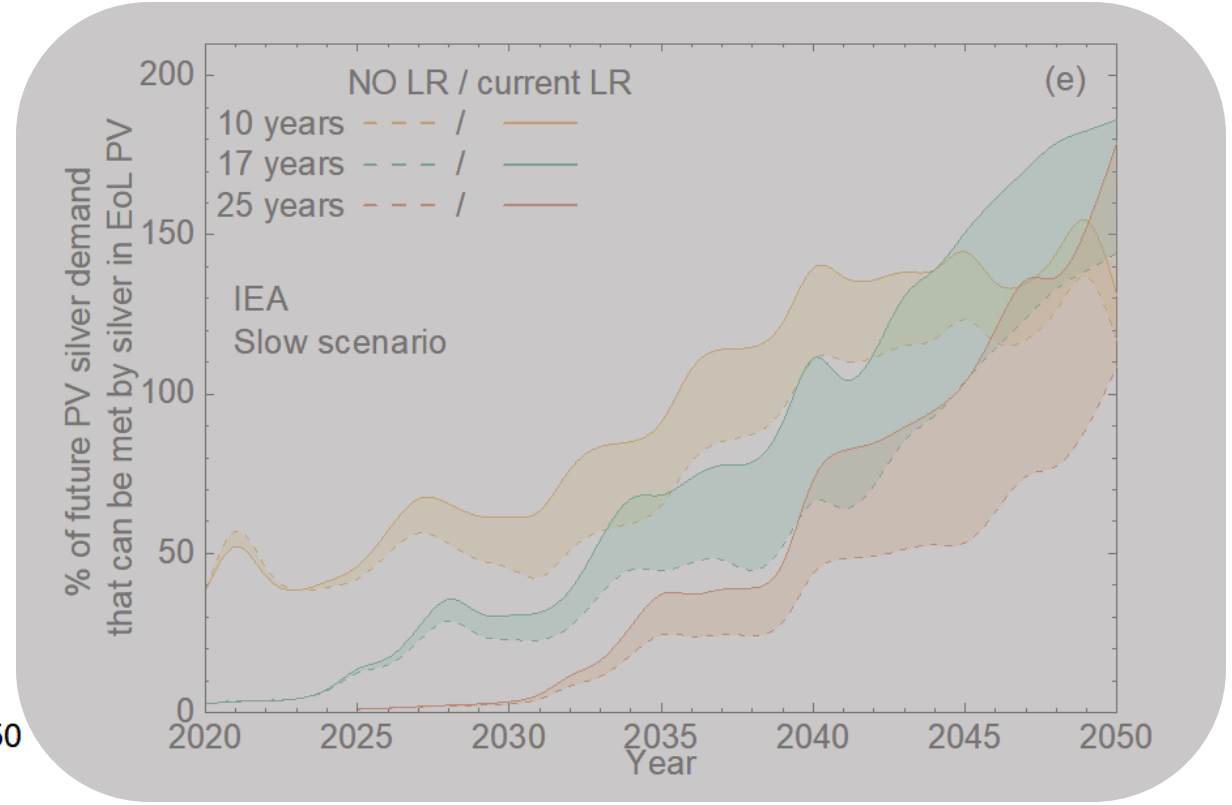
True Circular Economy (Ag):
Renewable Energy Leading by Example

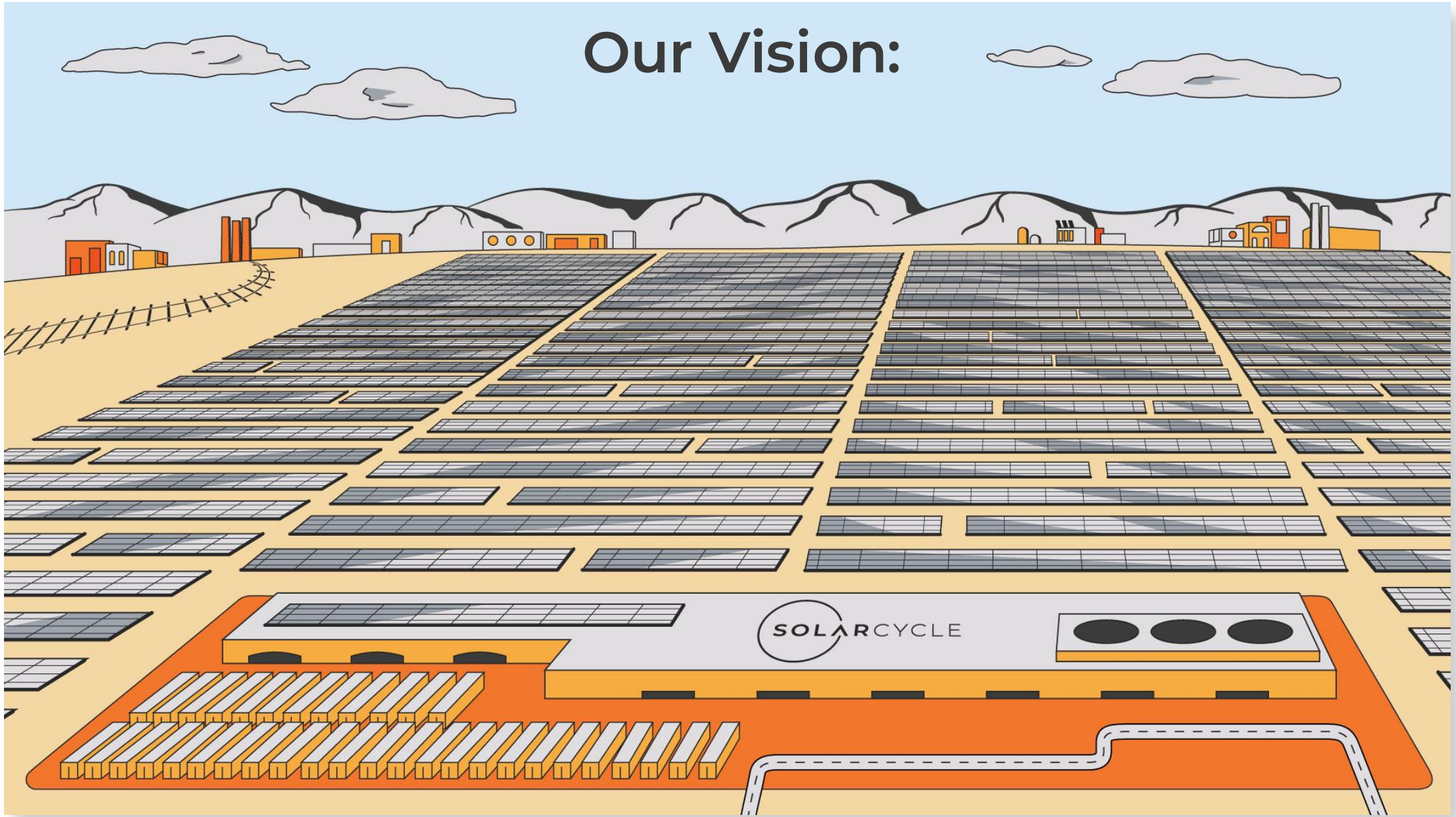
- A confluence of factors:
  - Need more solar, resource demand
  - But less resources per panel (or per Watt)
  - And more and better recycling





Source: Dias et al 2022, IEEE 49th Photovoltaics Specialists Conference (PVSC)

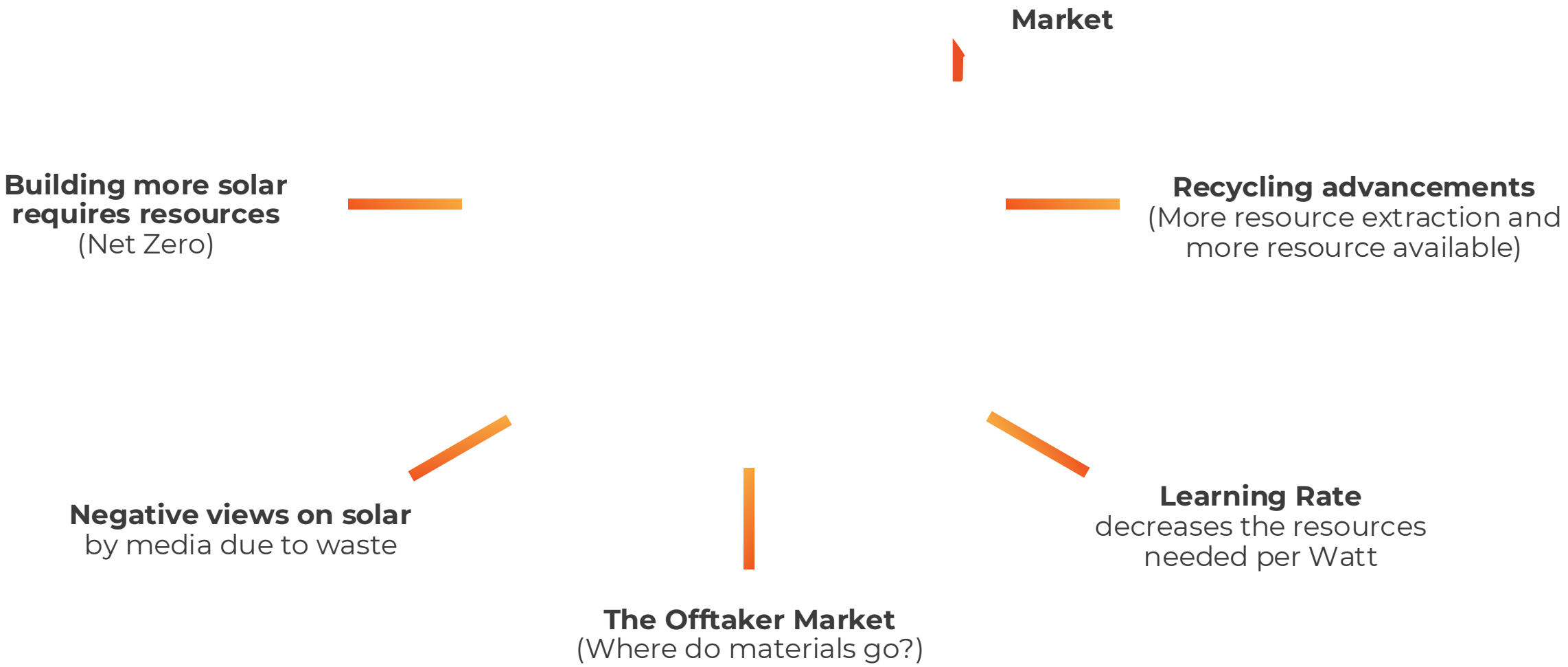
What would a circular economy for solar look like?



What would a circular economy for solar look like?

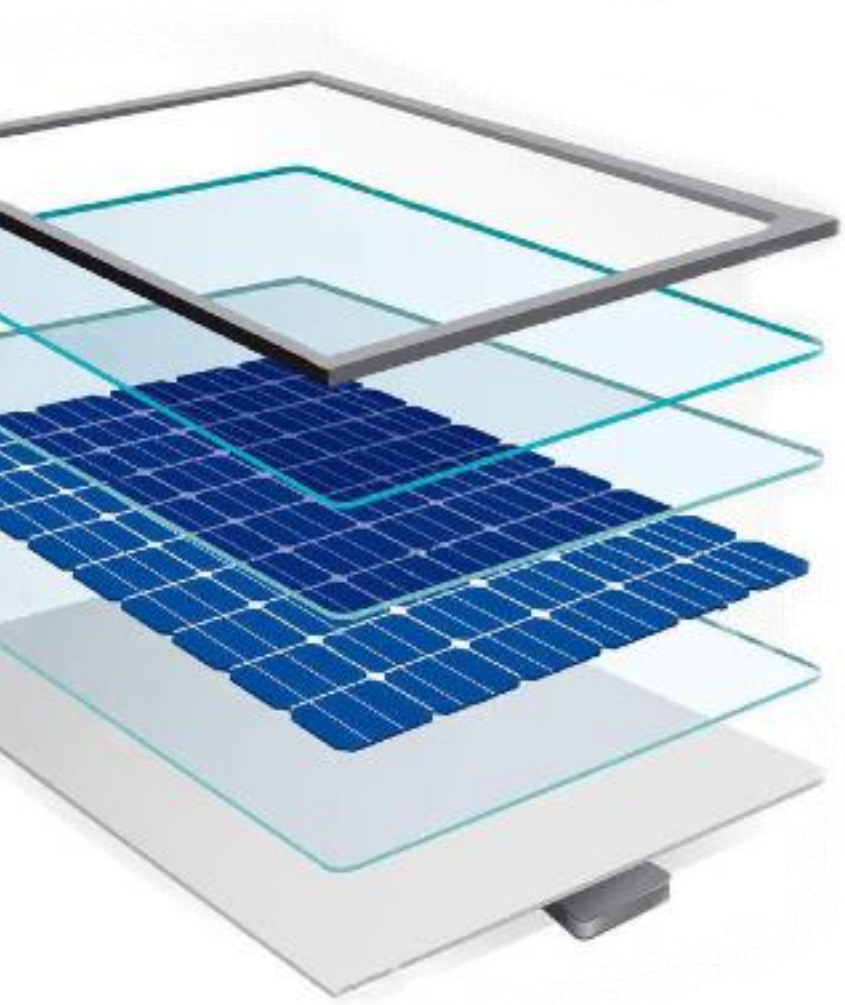
Our Reality:

But there is a catch



THE MISSING PIECE

Limited by the market



Aluminum frame ✓

Glass ✓ ?

Precious metals ✓

Plastics ⊘ ?

Use of Low Iron Glass

Rank	Industry
1	Solar
2	Display and Electronics
3	Construction/Architectural
4	Automotive
5	Aquariums
6	Packaging
7	Filler

Circular Economy Meets Renewable Energy

- Manufacturing rolled glass for PV
- Incorporating recycled glass
- ~30% less embodied carbon
- Powered by second hand solar panels
- Recycling on site

NEWS

Solarcycle to build recycled solar glass factory in Georgia, US

By Will Norman

February 19, 2024

PVTECH

HG Ventures

Investing in the Circular Economy

- In March 2023, HG Ventures co-led $30M investment round in SOLARCYCLE
- Only US company able to recycle at scale and derive value from materials extraction = key to actualizing circular economy
- Recyclable materials from panels worth $2.7B+ by 2030
- Industry tailwinds: accelerated solar deployment, regulation, corporate ESG, economics

Kip Frey, Managing Director, HG Ventures
Senior Advisor, New Ventures Group

SOLARCYCLE

Thank you

References

References

Collective, T. C. (2020, November 25). *Doughnut economics: A framework to explore circularity*. Circular Collective.
Reck, B. K., & Graedel, T. E. (2012). Challenges in metal recycling. *Science*, *337*(6095), 690–695. https://doi.org/10.1126/science.1217501
Climate Action Tracker. (2022). *Warming Projections Global Update*.
International Technology Roadmap for Photovoltaic. (2023). *2022 Results*. www.itrpv.net.
Lennon, A., et al. (2022). The aluminium demand risk of terawatt photovoltaics for net zero emissions by 2050. *Nature Sustainability*, *5*(4), 357–363. https://doi.org/10.1038/s41893-021-00838-9
Hallam, B., et al. (2022). The silver learning curve for photovoltaics and projected silver demand for net-zero emissions by 2050. *Progress in Photovoltaics: Research and Applications*, *31*(6), 598–606. https://doi.org/10.1002/pip.3661
Ruberti, M., & Massari, S. (2018). Are the World-Leading Primary Silver Mines Exhausting? *Sustainability*, *10*(8), 2619. https://doi.org/10.3390/su10082619
Team, G. &. R. (2021, May 25). Copper Depletion: Decades in the Making. *Goehring & Rozencwajg*.
Mirletz, H., et al. (2023). Unfounded concerns about photovoltaic module toxicity and waste are slowing decarbonization. *Nature Physics*, *19*(10), 1376–1378. https://doi.org/10.1038/s41567-023-02230-0
Hallam, B., et al. (2022). A Polysilicon Learning Curve and the Material Requirements for Broad Electrification with Photovoltaics by 2050. *Solar RRL*, *6*(10). https://doi.org/10.1002/solr.202200458
Preu, R., et al. (2020). The International Technology Roadmap for Photovoltaics and the Significance of its Decade-Long Projections. *37th European Photovoltaic Solar Energy Conference and Exhibition*, 420–426. https://doi.org/10.4229/eupvsec20202020-2cv.1.59
Hund, K. L., et al. (2023). *Minerals for climate action: The mineral intensity of the clean energy transition*. https://doi.org/10.1596/40002
Weckend, S., Wade, A., & Heath, G. (2016). *End of life management: solar photovoltaic panels*. https://doi.org/10.2172/1561525
Dias, P., et al. (2022). Estimating the lifetime of solar photovoltaic modules in Australia. *Sustainability*, *14*(9), 5336. https://doi.org/10.3390/su14095336
Hagelüken, C. (2012). Recycling the Platinum Group Metals: A European Perspective</I> *Platinum Metals Review*, *56*(1), 29–35. https://doi.org/10.1595/147106712x611733
IEEE PVSC 49 - Philadelphia, PA. (2023). https://ieee-pvsc.org/PVSC49/
Dias, P., et al. (2022). High yield, low cost, environmentally friendly process to recycle silicon solar panels: Technical, economic and environmental feasibility assessment. *Renewable & Sustainable Energy Reviews*, *169*, 112900. https://doi.org/10.1016/j.rser.2022.112900
Bellini, E. (2020). *Italian PV panels sent for recycling were instead smuggled to Syria and Africa*. Pv Magazine International.
IRENA (2023), Renewable power generation costs in 2022, International Renewable Energy Agency, Abu Dhabi.
Sun, X. (2019). Solar technology got cheaper and better in the 2010s. now what? *Wood Mackenzie*.