

Circularity in Solar Energy Systems to reduce Solar Waste Materials

BY

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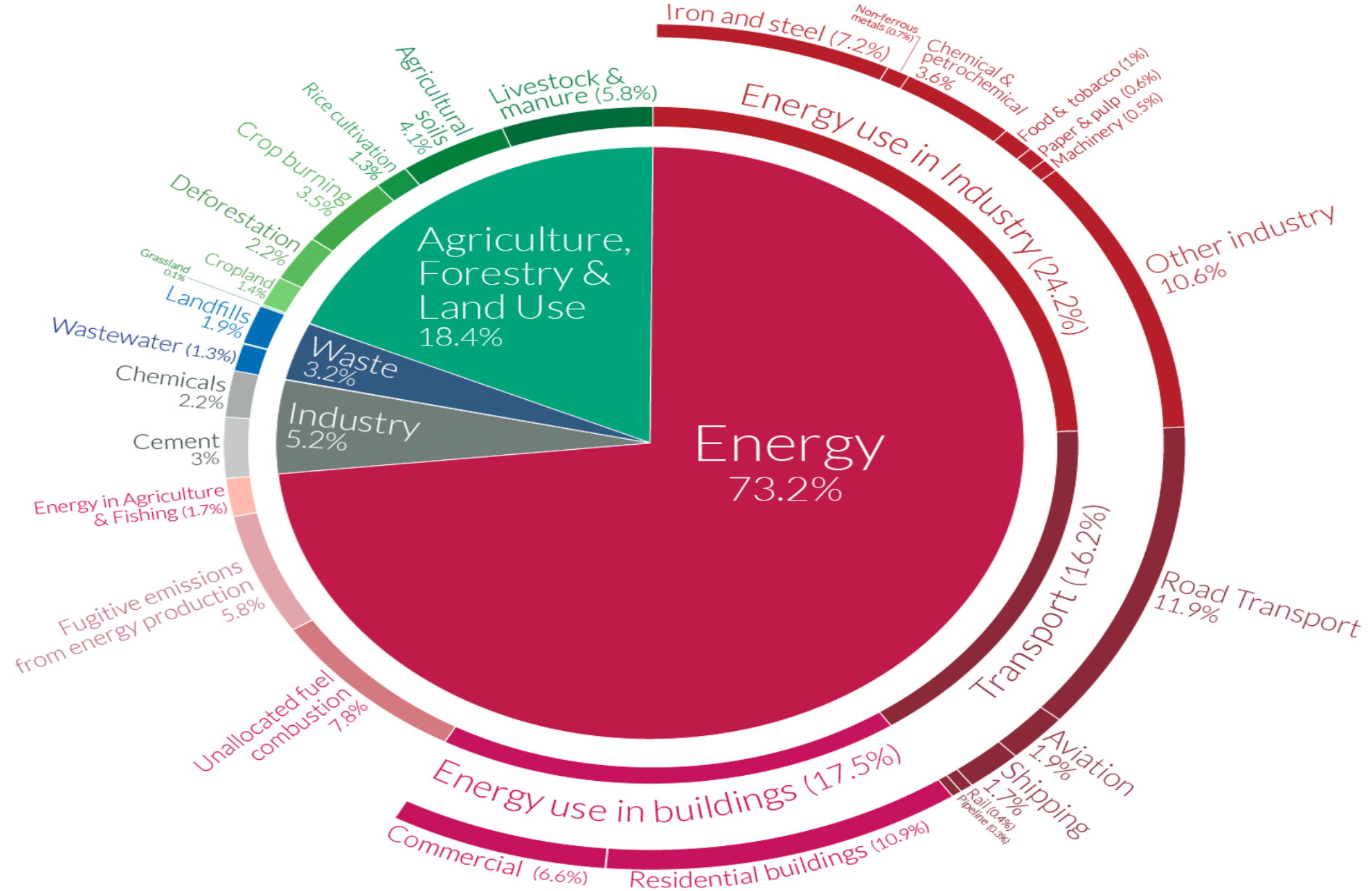
Our Sun

- The sun has about 5 billion years left before it becomes a red giant
- The 70 percent of solar energy the Earth absorbs per year equals roughly 3.85 million exajoules (10^{18} joules).
- In other words, the amount of solar energy hitting the earth in one hour is more than enough to power the world for one year.

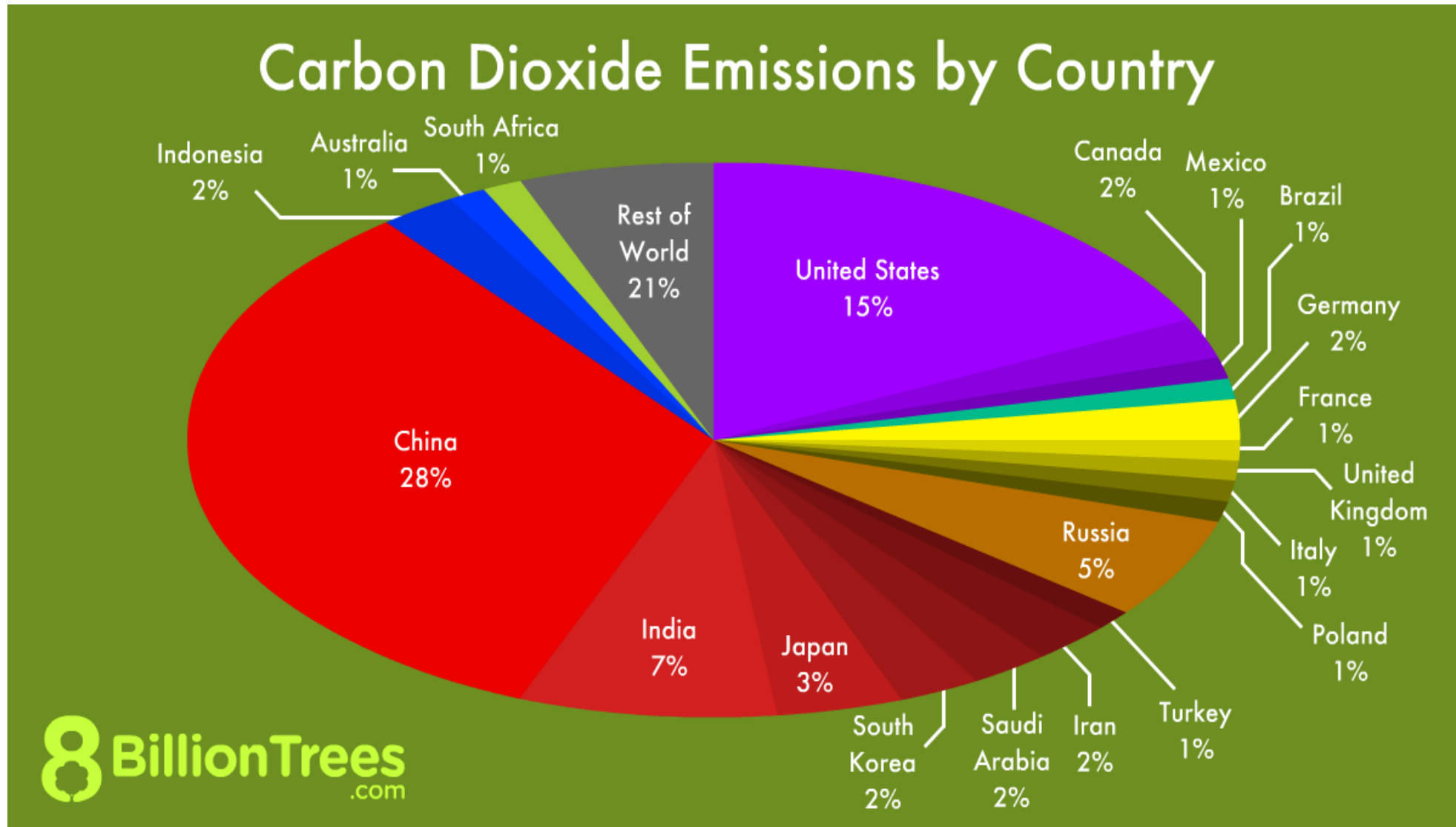


Global greenhouse gas emissions by sector

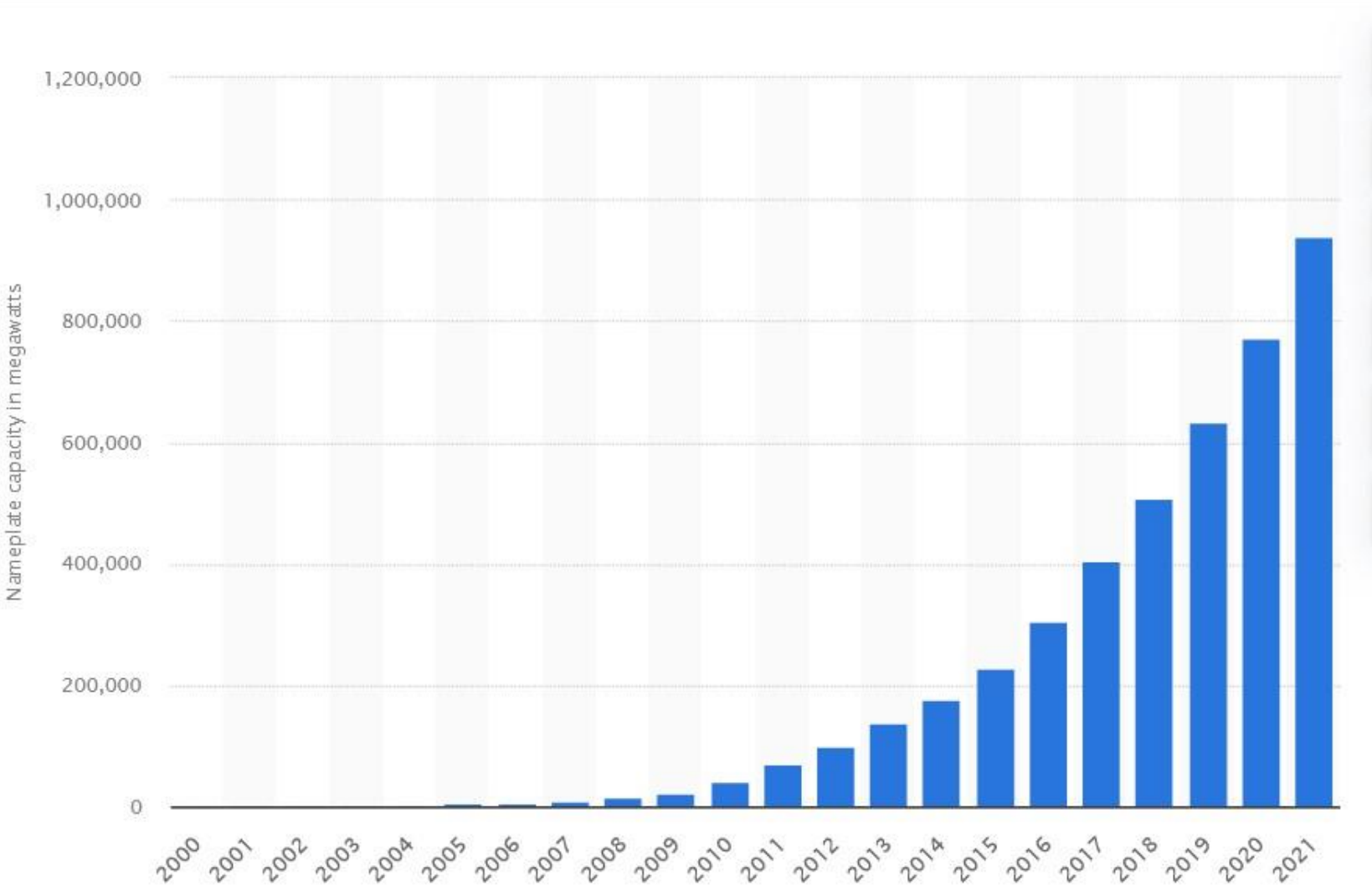
This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO₂eq.



Global Carbon Footprint



Global Solar Power Capacity



<https://www.statista.com/statistics/280220/global-cumulative-installed-solar-pv-capacity/>

Definition of Solar Waste

Solar waste — **the electronic waste generated by discarded solar panels** — is sold as scrap in the country

According to a report by the **National Solar Energy Federation of India (NSEFI)**, India could generate over 34,600 tonnes of cumulative **solar waste** in India by 2030.

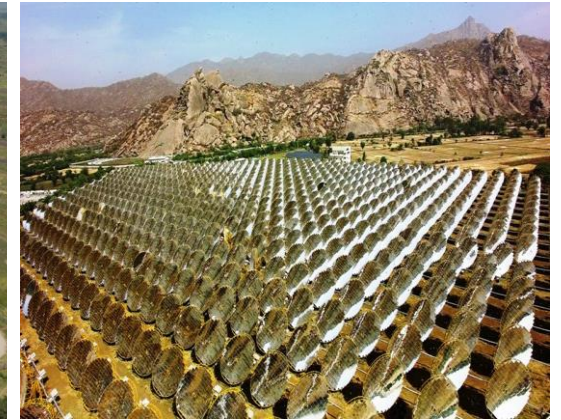
It can increase **by at least four-five-fold by the next decade**. India should focus its attention on drafting comprehensive rules to deal with solar waste.



Source: [Down to Earth, Jan 2022](#)

What is a Solar Power System ?

- Solar power works by converting energy from the sun into power. There are two forms of energy generated from the sun for our use – electricity and heat. Both are generated through the use of solar panels, which range in size from residential rooftops to 'solar farms' stretching over acres of rural land.
- There are three basic types of solar power systems: grid-tie, off-grid, and backup power systems.
- Each system type requires unique equipment that is compatible with the application.



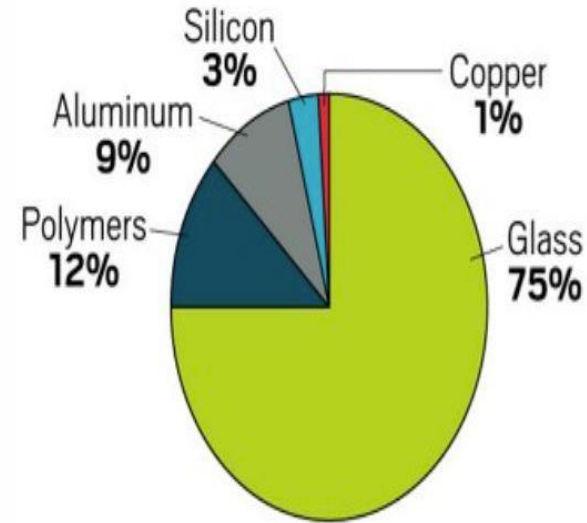
Top-Left: Pavagada Solar Park, Tumkur
Top-Right: India One Solar Power Plant, Mount Abu
Bottom: Rooftop solar water heater

Composition and Cost of 1MW of Solar Waste

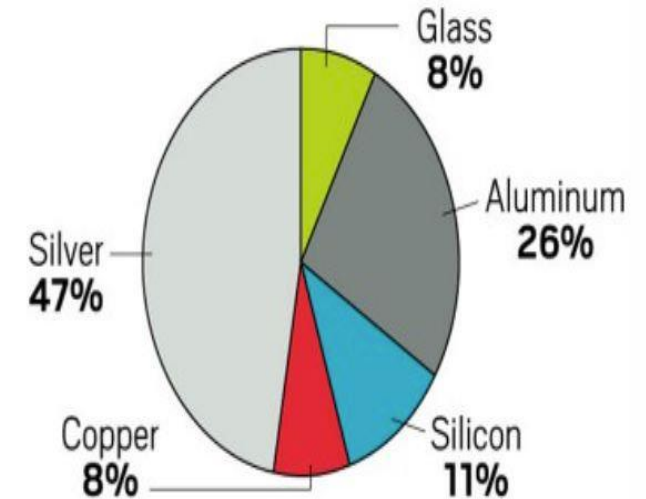
Weight and value of materials in 1MW solar installation

Material	Weight (in Kgs)	Value (in \$)
Glass (75%)	60,000	26,604
Polymers (12%)	9,600	10,368
Aluminium (9%)	7200	86,464
Silicon (3%)	2,400	3,656
Copper (1%)	800	26,604
Silver (<1%)	~ 80	~ 145,933
Total	80000	332,556

Materials in a typical silicon photovoltaic cell



Distribution of materials by mass



Distribution of materials by value

Source: Martin Bellman/Icarus. Note: Silver is less than 1% of the mass.

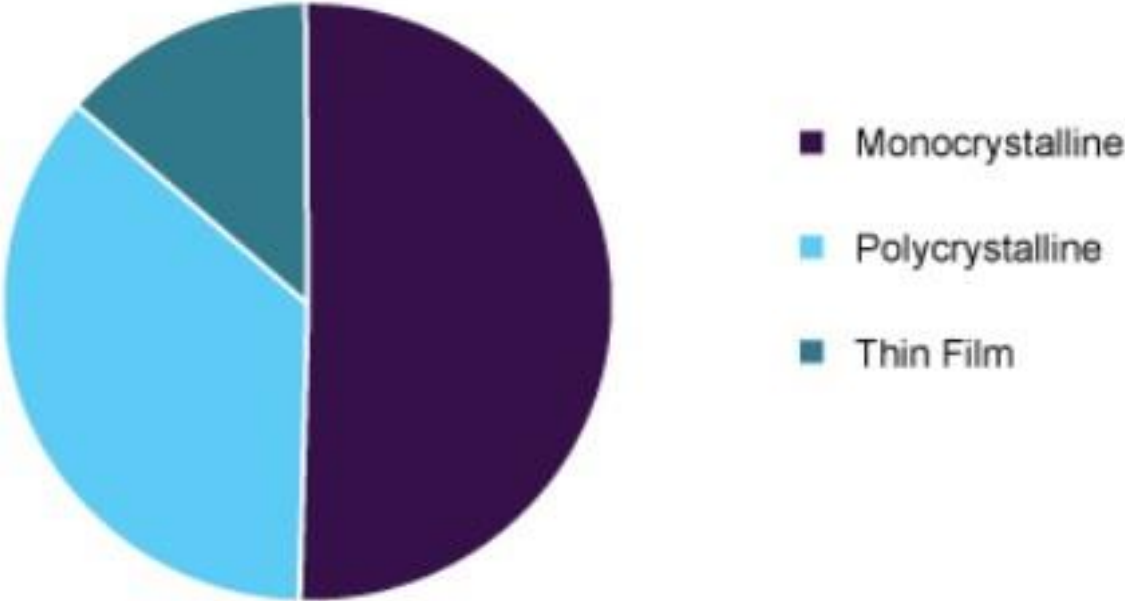
250w solar panel weighs approx. 20 kgs

<https://pubs.acs.org/doi/pdf/10.1021/acscentsci.2c00214>

<https://www.energytrend.com/solar-price.html>

Silver needed is approx. 100g per 1kW panel

Global solar panel recycling market share, by product, 2019 (%)



Source: www.grandviewresearch.com

<https://www.grandviewresearch.com/industry-analysis/solar-panel-recycling-market>

Solar Panels Waste Projections (in Million Tons)

Sl.No	Name of Country	2020	2030	2040
1	North America	14,440	1,89,500	19,05,000
2	Europe	27,600	6,26,500	40,80,000
3	Asia	26,645	4,82,200	55,80,000
4	Latin America	305	6,750	93,000
5	Middle East and Africa	1,060	18,100	2,94,000
6	Oceania	2,000	30,000	3,00,000

Country Wise Cumulative Waste Volumes of PV Panels by 2050 in Million Tons

Sl.No	Country	Cumulative Waste Volumes of PV Panels by 2050, (in Million Tons)
1	China	20
2	U S	10
3	Japan	7.5
4	India	7.5
5	Germany	4.3

Key Drivers for Solar Panels Recycling

Policy and Economic Drivers	Market Drivers	Social Drivers	Environmental Drivers
Implementing business models for take-back, Collection Schemes	Cost Savings from reuse and recycling of materials	Reducing Human Health risk	Reducing Energy Payback Time
Increasing Landfill Cost	Balancing demand and supply gap of raw materials	Opportunities for job creation	Ensuing appropriate EoL management via evidence of product and material impacts.
Introducing Strict regulations and Policies such as Product Stewardship			

Key Barriers for Solar Panels Recycling

Policy and Economic Barriers	Market Barriers	Social Barriers	Environmental Barriers
Lack of adequate legislative Framework	Insufficient Volume of EoL products and waste streams	Lack of consumer willingness to return EoL Solar Panels	Energy Intensive recycling Process
Lack of Profitability to recycle – Recycling Cost \$20-\$30 per solar panel against \$2-\$3 send it to a land fill	Poor Market confidence in refurbished and recycled solar panel		Emissions and Pollution generated during recycling
Lack of incentives for collection and recycling	Unorganised and fragmented supply chain		
	Lack of adequate collection centres and Recycling plants		

Projected Value of Recycled Solar Waste

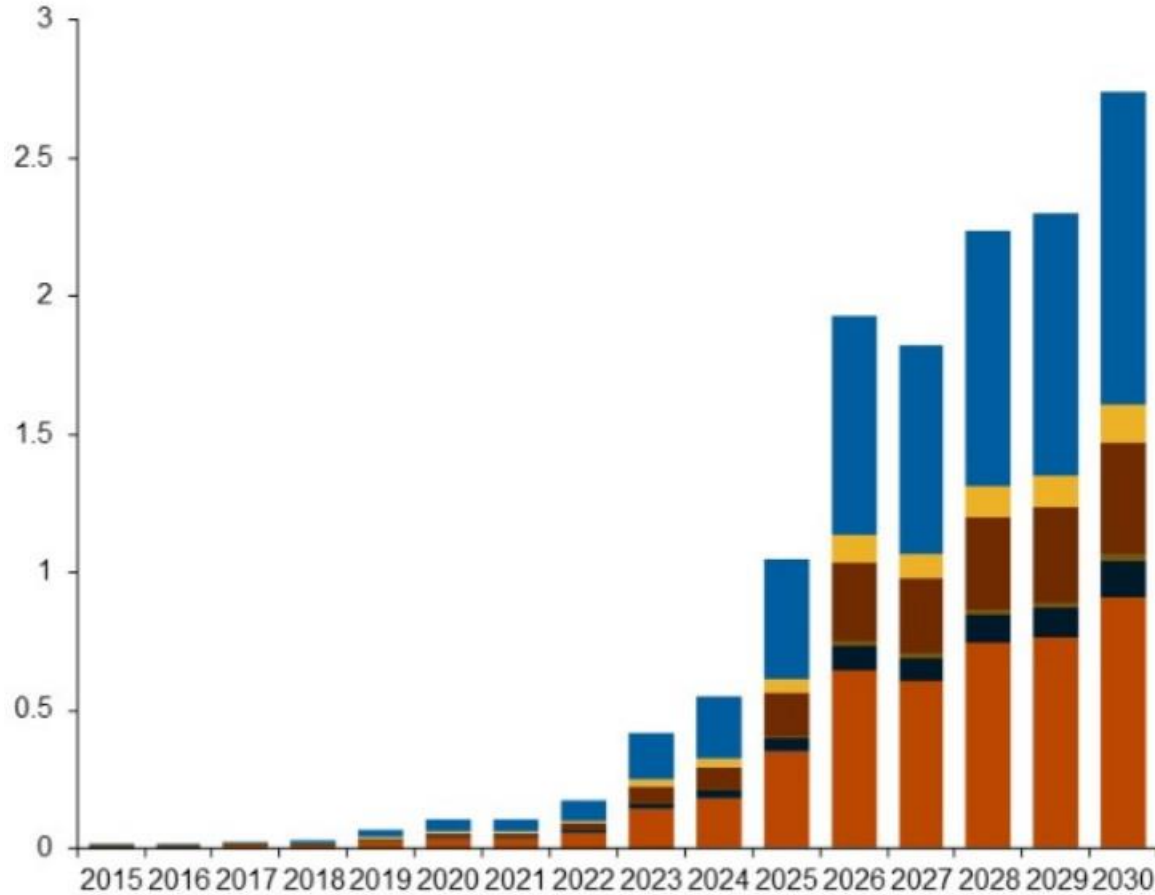
Estimated PV panel recyclable material value*

Billion USD



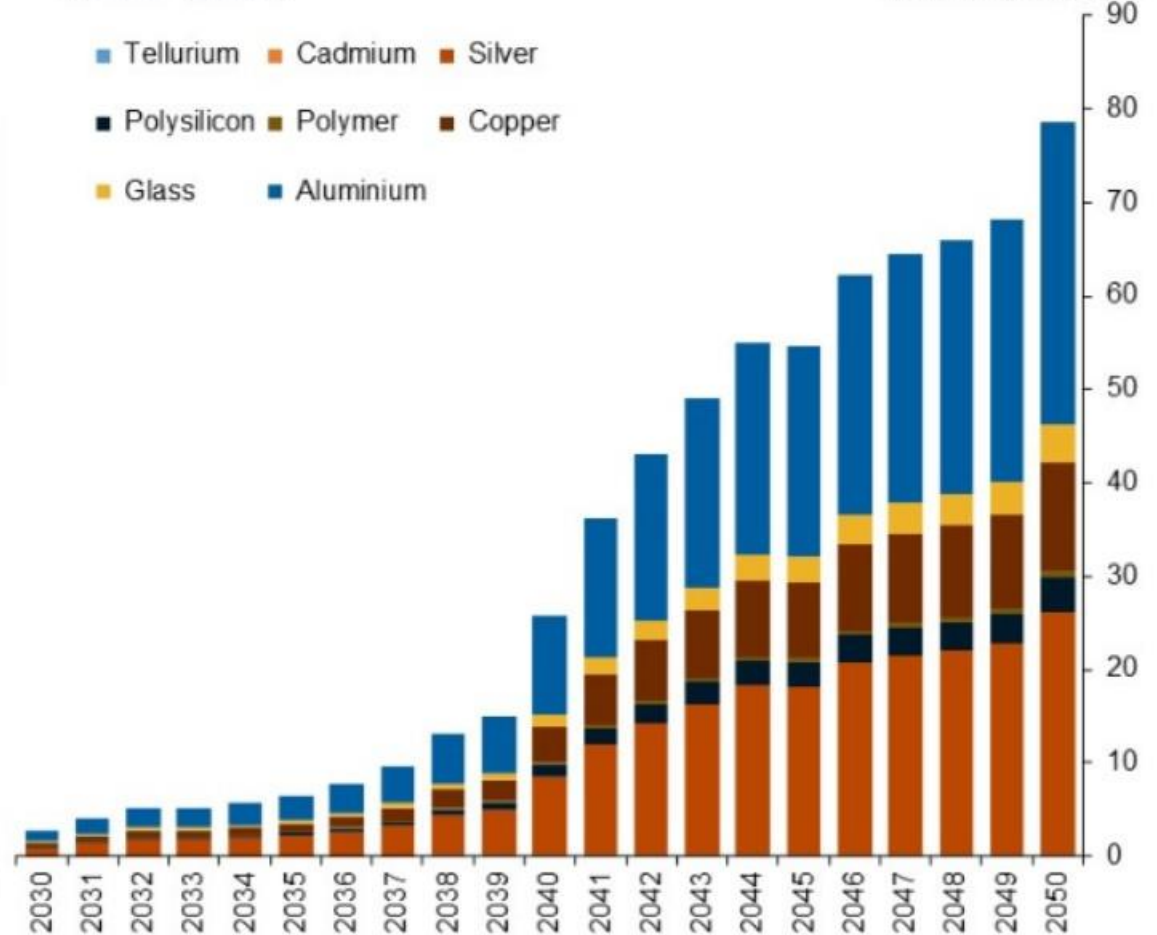
RYSTAD ENERGY

2015-2030



2030-2050

- Tellurium
- Cadmium
- Silver
- Polysilicon
- Polymer
- Copper
- Glass
- Aluminium



*Forecasted value from material recovered from PV panels as current implementations reach end-of-life

Source: Rystad Energy SolarSupplierCube, EnergyScenarioCube, Rystad Energy research and analysis

THANK YOU