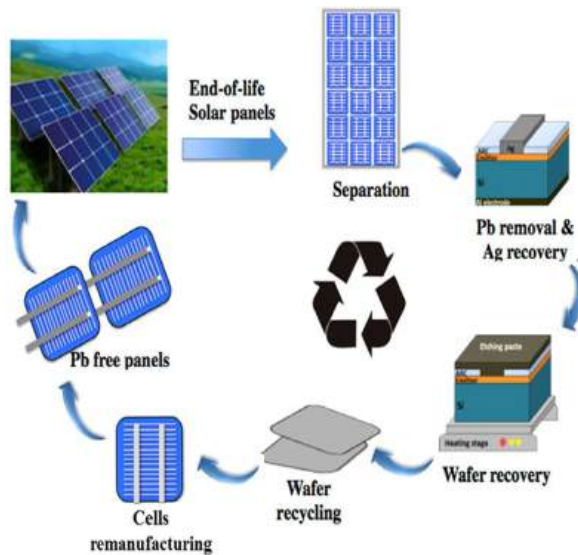


PLUS from SURPLUS for US

Circularity for Solar Panels



presented at:
SAARC Energy Centre

*Malaviya Solar Energy Consultancy,
Pune, BHARAT (India)*

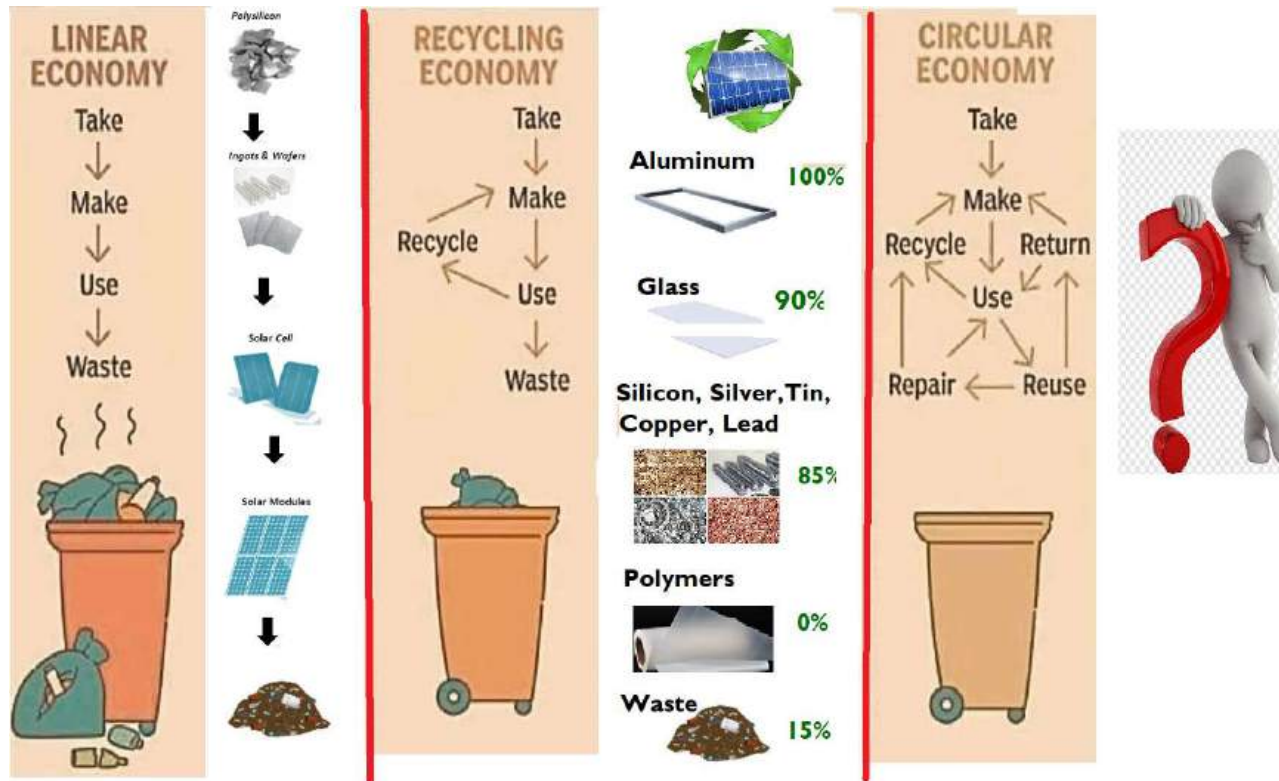


info@malaviya.in





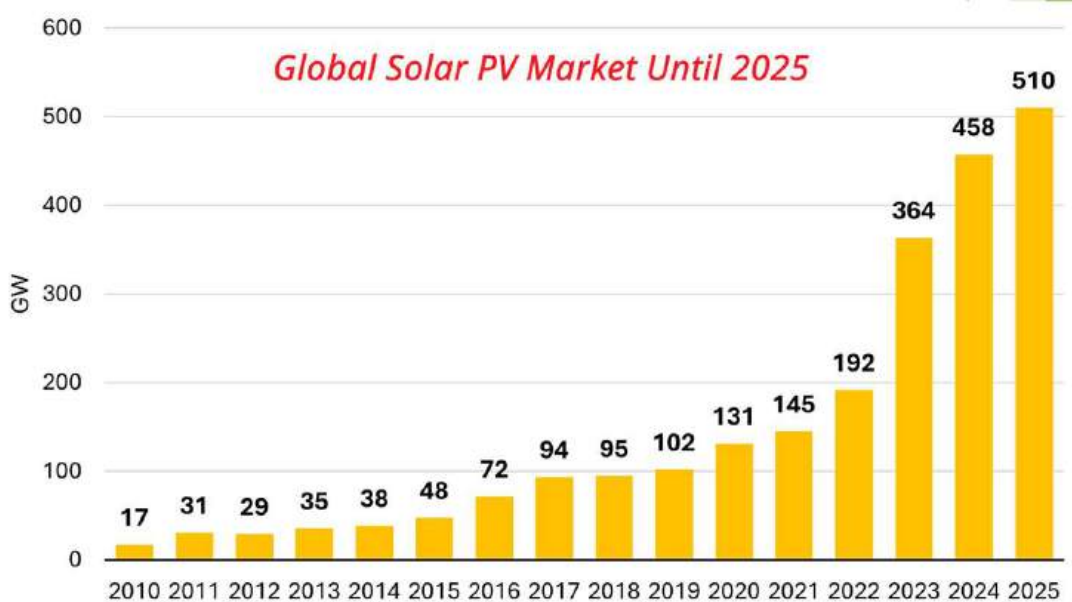
Linear, Recycling & Circular Economy



Adopting Circular Economy crucial to address Global Warming, reduce import dependency and address health of mining workers

Global Scenario

- ❑ As per International Renewable Energy Agency Photovoltaic Power system (PVPS) global Solar PV market at end of 2025 was 2,970 GWp that consumed about 187 million tons of raw materials
- ❑ Global market for materials recovered from recycled Solar PV panels is projected to reach \$810 million by 2030, \$6 billion by 2040, and exceed \$20 billion by 2050

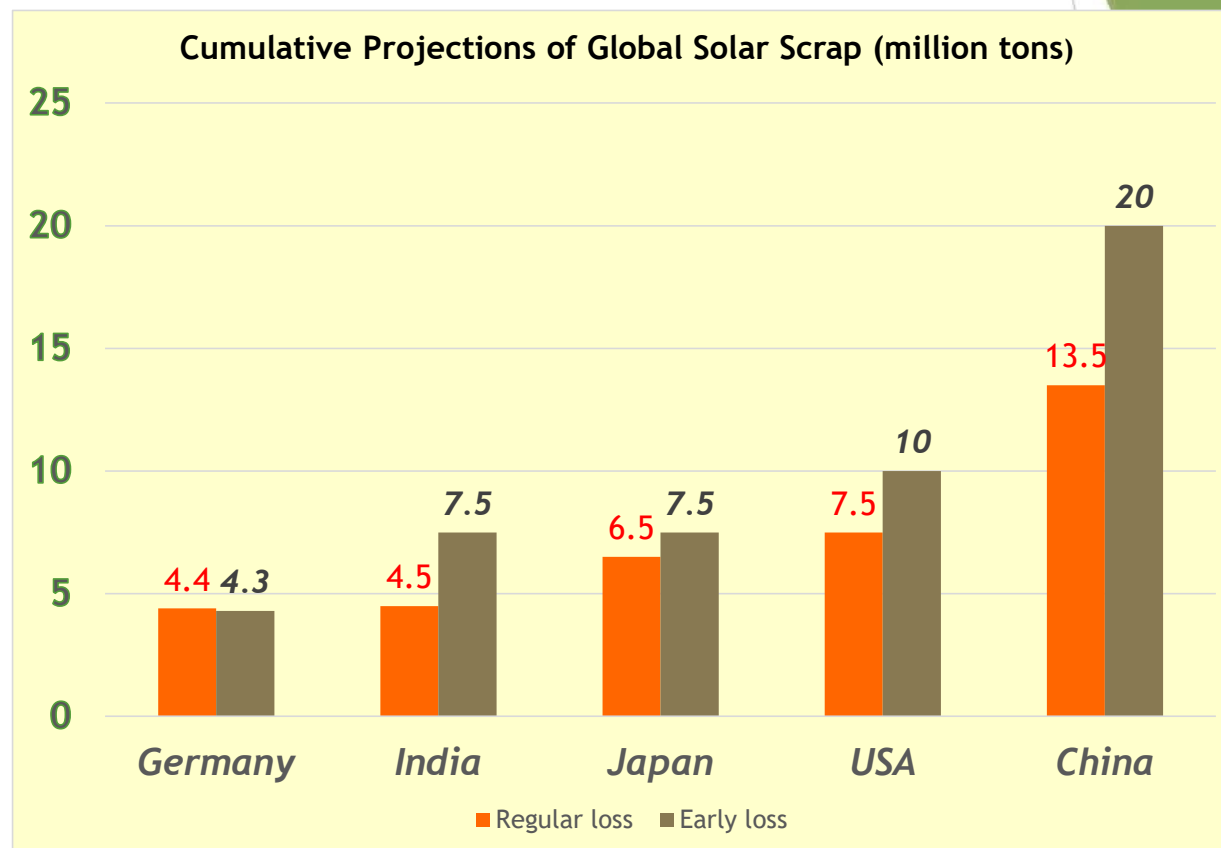


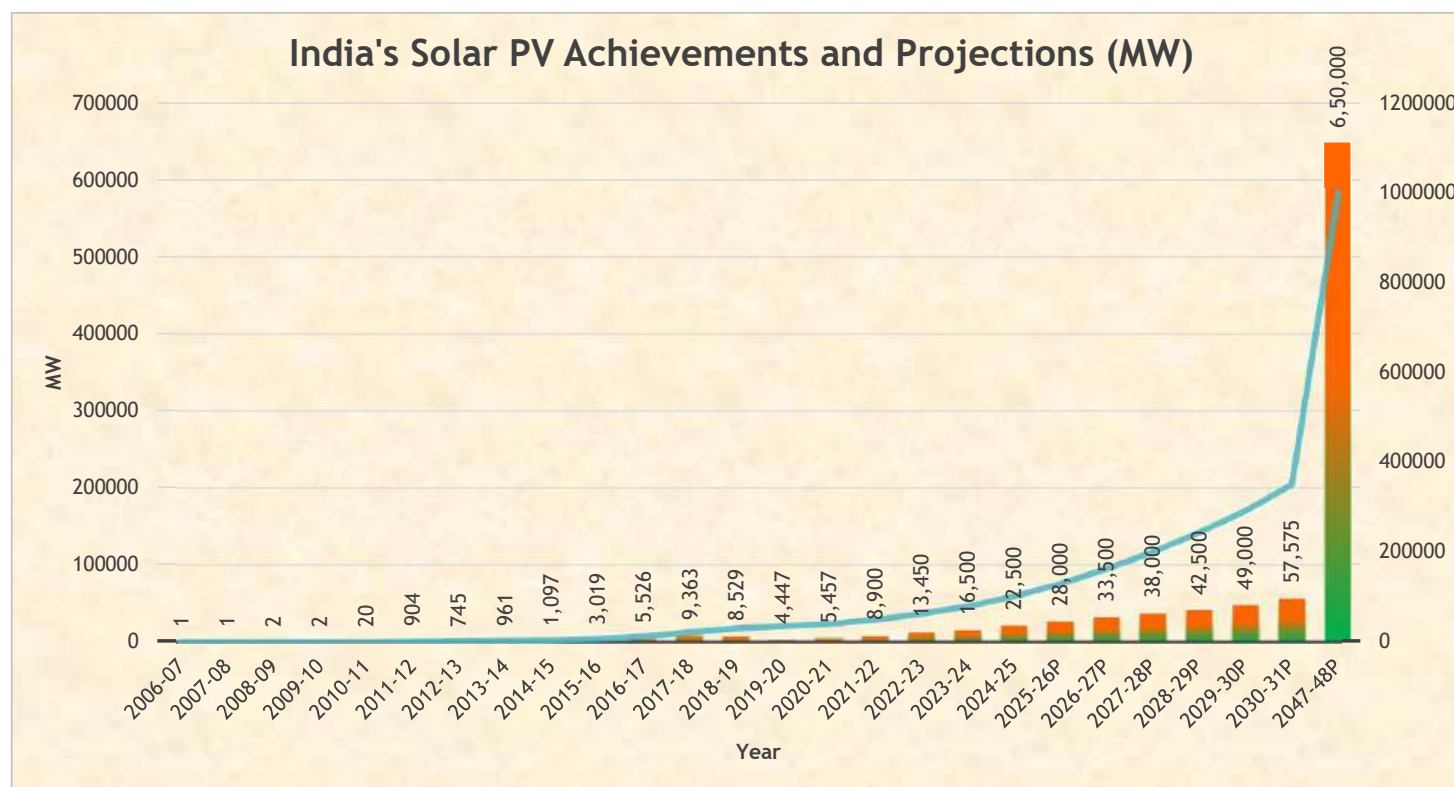
source: IRENA



India in Top 5 Solar Scrap Generator by 2050

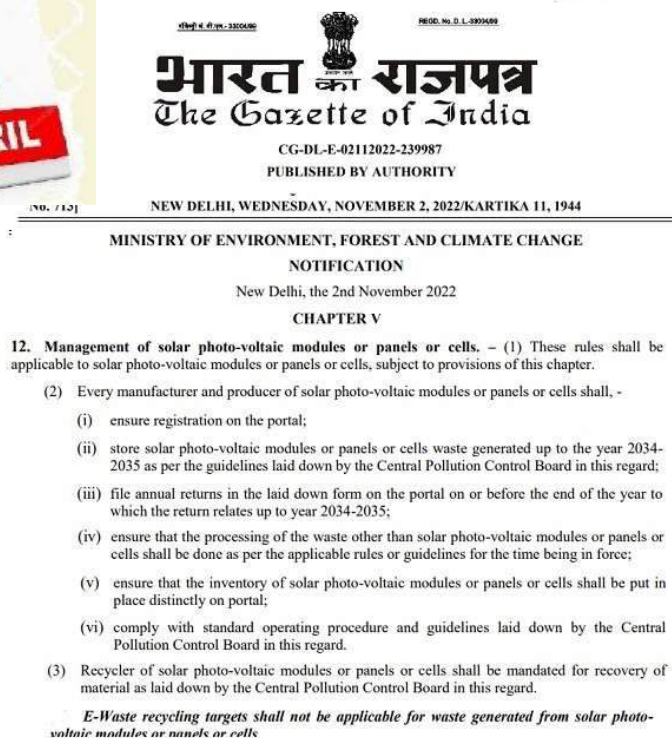
As per International
Renewable Energy Agency
Photovoltaic Power system
(PVPS) worldwide solar
module waste would grow
to 78 million metric tons
by 2050 and India will be
amongst top 5 countries







Solar Panels & Cells in E-waste Guidelines



In 2022 India made Solar panels & cells mandatory to safely dispose at end-of-life under E-waste regulation & generate Extended Producer Responsibility (EPR) certificates.

Producers:

- *Manufacturers*
- *Branding under OEM,*
- *Importers and*
- *Second-hand traders*

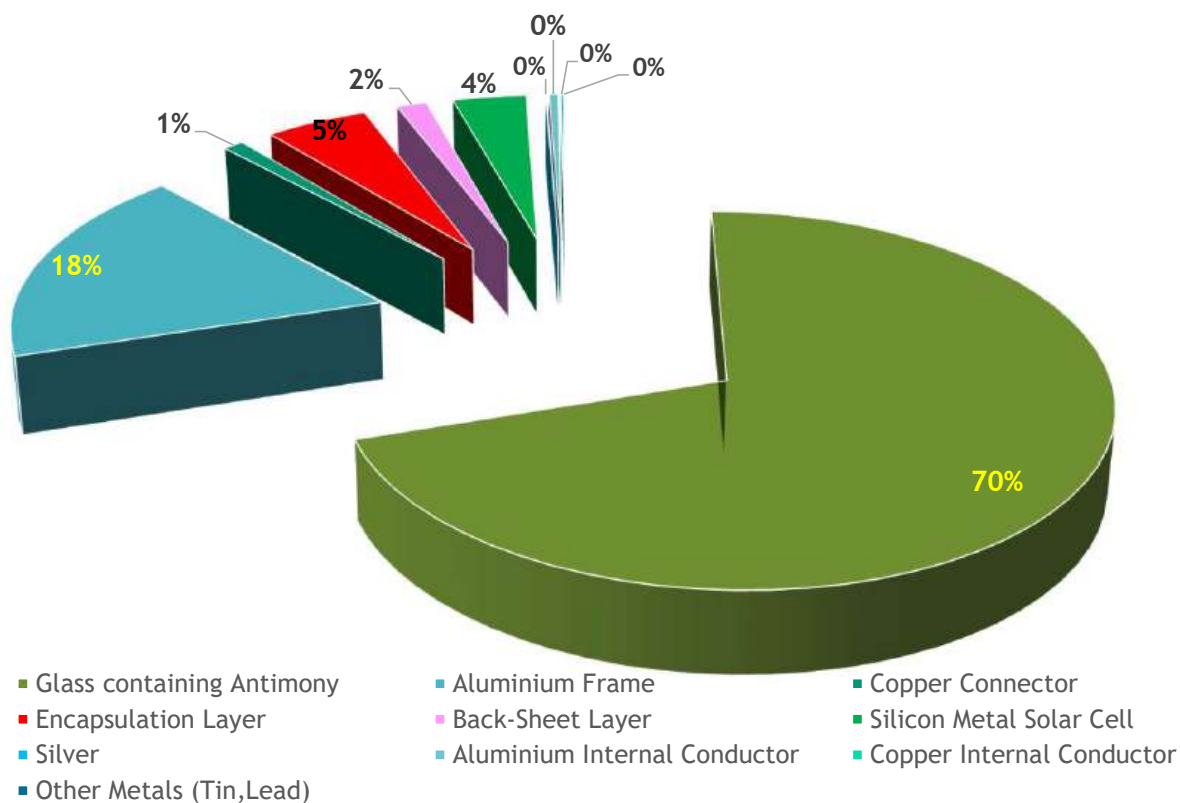




Share of Raw Materials in Typical c-Silicon PV Module

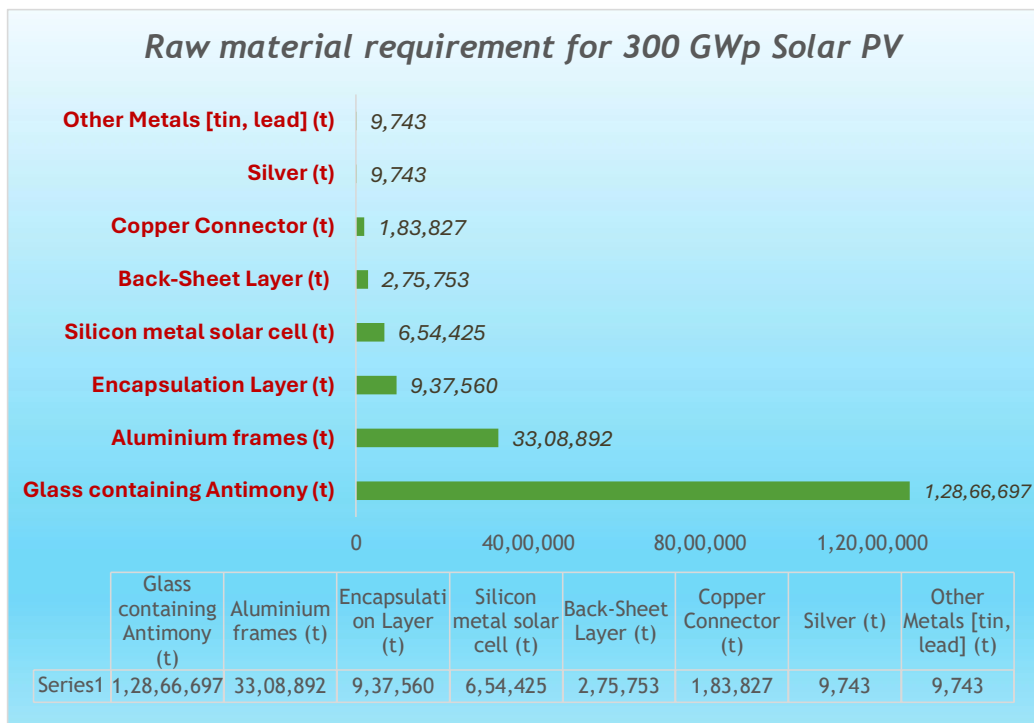


Share (%) of raw materials in silicon PV module





Colossal Raw Material Requirement for fulfilling 300 GWp target using c-Si cells



By 2030 the 300 GWp calls for
glass (12.8 million tons),
aluminum (3.3 million tons) &
Silicon+copper+silver (1 mil. tons)

Majority raw materials
used in making of Solar
PV modules in India
have metals categorised
as “Critical Minerals”



Critical Minerals and Import Dependency



Critical /net importer minerals of Solar PV in 		
Aluminium		Net importer
Silver		Net importer
Lead		Net importer
Silicon		Critical mineral
Copper		Critical mineral cum Net importer
Tin		Critical mineral
Phosphorus		Critical mineral

Malaviya Solar Energy Consultancy



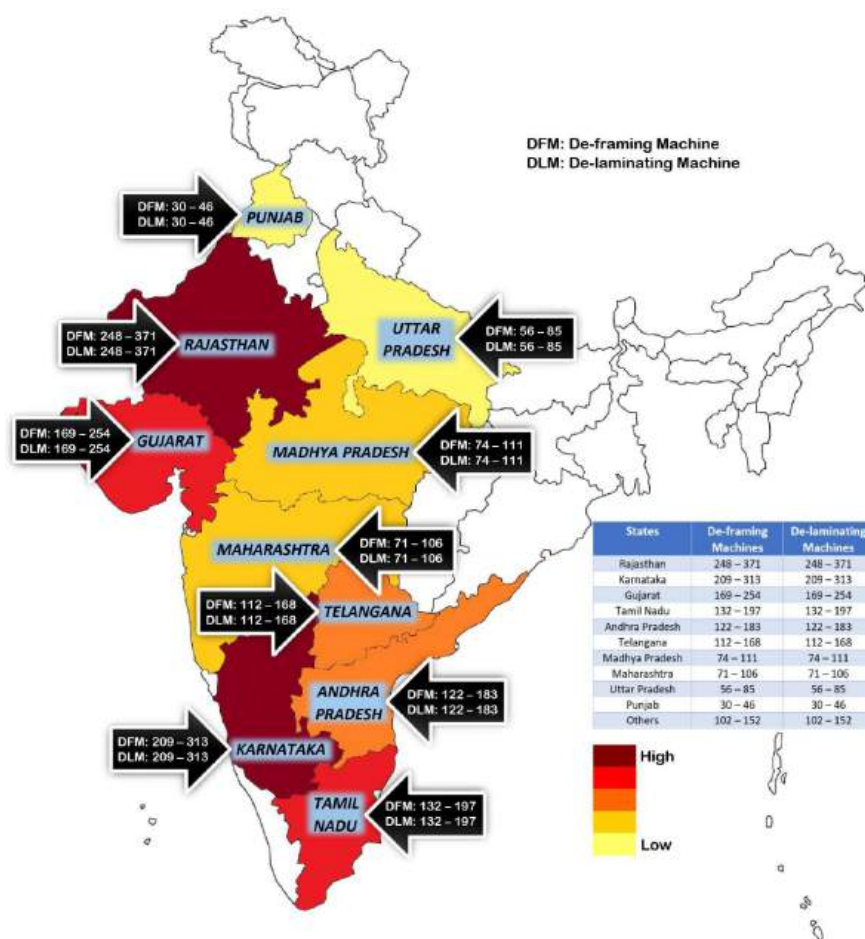
Anticipated Material Recovery until 2047 (tons) through Circular Economy (Regular Loss)



Raw material	Glass containing Antimony (t)	Aluminium frames (t)	Encapsulation Layer (t)	Silicon metal solar cell (t)	Back-Sheet Layer (t)	Copper Connector (t)	Silver (t)	Other Metals [tin, lead] (t)	Aluminium internal conductor	Copper, Internal Conductor (t)	NETT
Requirement (tons)	1,28,66,697	33,08,892	9,37,560	6,54,425	2,75,753	1,83,827	9,743	9,743	97,433	2,09,572	1,85,53,645
Recovery %	98%	100%	0%	98%	0%	98%	98%	98%	100%	100%	
Nett recovery post recycling	1,26,09,363	33,08,892	0	6,41,337	0	1,80,150	9,548	9,548	97,433	2,09,572	1,70,65,843



Potential States in Bharat (India) for Recycling



End Use of Recycled Materials

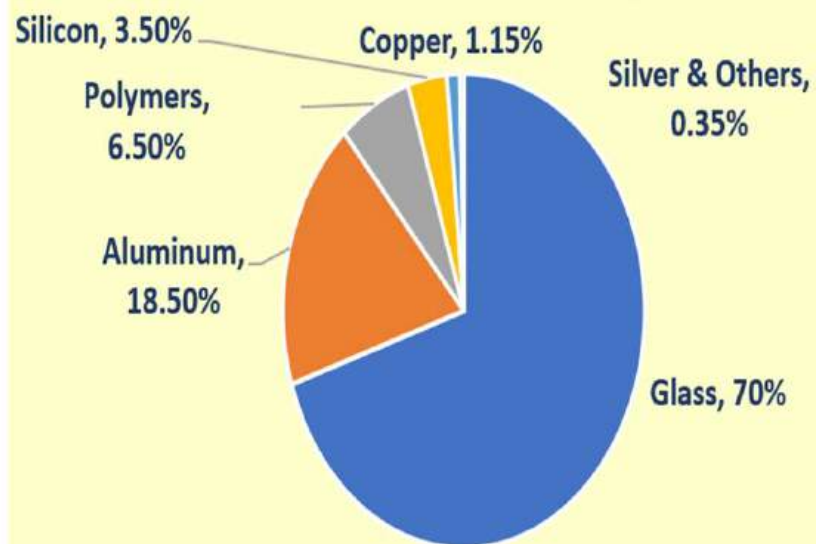


Solar PV Module	% by net weight	Use of recovered material
Glass	70%	Primary white glass, packaging material, fibre insulation material
Aluminum frame, internal conductor	18%	Primary aluminum
Copper connector, internal conductor	1%	Primary copper, feedstock material
Polymer-based adhesive (EVA) encapsulation layer	5.1%	Incineration, Diesel fuel (pyrolysis), plastic tyres, roads, etc.
Back-sheet layer (based on polyvinyl fluoride)	1.5%	
Polymer casing	0.5%	
Silicon metal	3.56%	Metal grade silicon
Silver	0.053%	Primary silver
Other metals (tin, lead)	0.053%	Primary metal

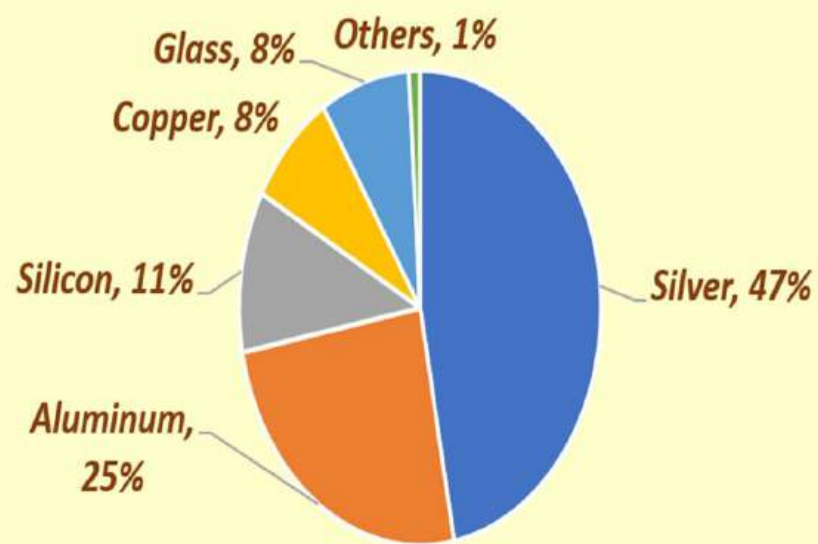


Materials by Mass and Value

Distribution of Material by Mass



Distribution of Material by Value



MSC India Strong Case Early Loss & RE-powering

► PV modules likely degrade earlier than typical 25 years of life in India thus incremental replacement

Causes include:

- Broken glass,
- Cracked cells or ribbons
- Cracked back-sheet
- Panel discoloration
- Technological advancements (RE-powering)
- **Reduced power output**



RE-powering big business in future owing to Early Loss & rapidly evolving superior cell technologies



CPCB - EPR Certificate Formula



Central Pollution Control Board (CPCB) [<https://www.cpcb.nic.in>] Producer Management rules

- (i) Ensure registration on the portal;
- (ii) Store Solar PV modules and cells waste generated up to the year 2034- 2035
- (iii) File annual returns at the end of the financial year (April - March)
- (v) Inventory of Solar PV modules & cells shall be put in place distinctly on portal

Recycler of Solar PV modules & cells shall be mandated for recovery of material & generate extended producer responsibility (EPR) certificate using the formula:

$$\text{QEPR} = Q_p \times C_f$$

QEPR - quantity eligible, Q_p - quantity of end product & C_f - the conversion factor

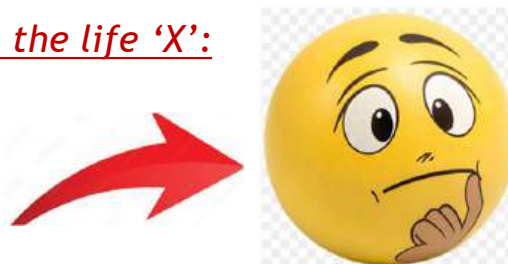
Percentage of Solar panel & cell waste to be recycled against the life 'X':

Year 1: 60% of the quantity placed in a year 'Y' (Y-X)

Year 2: 70% of the quantity placed in a year 'Y' (Y-X)

Year 3: 80% of the quantity placed in a year 'Y' (Y-X)

Year 4 onwards: (likely 90%) of the quantity placed in a year 'Y' (Y-X)





Employment Opportunities Anticipated per MW in Recycling Chain



Activity	Type of labour	Recycling employment opportunities per MW (mandays)
Aluminium de-framing and scrap selling	Un-skilled	2
De-laminating and white glass crushing	Semi-skilled	2
Material extraction	Skilled	0.5
Polymer treatment	Skilled	0.5
Trading of re-claimed materials	Semi-skilled	2
TOTAL		7

India: Advantage Economics



<i>Mobile Data Cost per Gigabyte (GB)</i>		
USA		\$6.00
World Average		\$2.50
European Union		\$2.25
INDIA		\$0.07





How GREEN is really *Green Energy*?

- ★ Mining waste instead of earth addresses Climate Change
- ★ Recycling of Glass & Aluminium saves energy up to 75%
- ★ Recovered material can RE-POWER instead of landfilling
- ★ Creates employment opportunities
- ★ Makes country self-reliant



Solar Energy Waste Management



OBLITERATE



Energy Savings Recycling Glass & Aluminium



**Standard
production
1 kWp**

*Recycled
glass 1kWp*

3,100 kWh

1,225 kWh

**Glass takes over 4,000
years to bio-degrade**

**Energy constitutes 40% of
production cost in
aluminium processing**

*Scrap aluminium converted
to virgin aluminium
constitutes only 5%*

Critical Minerals Mission & Production Linked Incentives



Cabinet Decision: 29th January, 2025

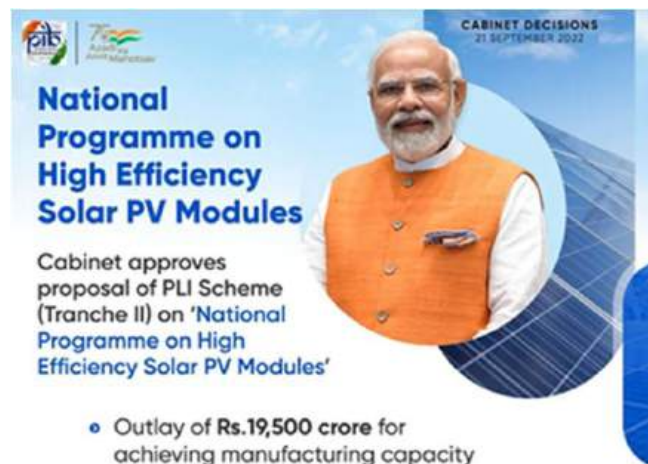


National Critical Mineral Mission

- Mission to establish effective framework for India's self-reliance in **critical mineral sector**
- Expenditure of **Rs.16,300 crore**
- Expected investment of **Rs.18,000 crore** by PSUs, etc.

Mission will:

- Promote the recovery of these minerals from overburden and tailings
- Encourage Indian PSUs and private sector companies to acquire critical mineral assets abroad and enhance trade with resource-rich countries
- Develop stockpile of critical minerals within the country

National Programme on High Efficiency Solar PV Modules

Cabinet approves proposal of PLI Scheme (Tranche II) on 'National Programme on High Efficiency Solar PV Modules'

CABINET DECISIONS
21 SEPTEMBER 2022

- Outlay of **Rs.19,500 crore** for achieving manufacturing capacity of Giga Watt scale
- Aim to build an ecosystem for **manufacturing of high efficiency Solar PV Modules**
- Solar PV manufacturers to be selected through transparent selection process



Right Intent Confusing Content (1)

- ▶ **SEPARATE RENEWABLE ENERGY WASTE policy**. Exempt from E-waste policy as not a consumer item
- ▶ Unorganised E-waste recyclers trapping Producers with EPR certificates
- ▶ Glass and Aluminium suppliers be also made accountable for EPR
- ▶ No clarity on retired orphan panels (100% imported) ownership
- ▶ Solar panel recycling be applicable post metal frame removal
- ▶ Scrap metals locally tradeable. Saves transportation
- ▶ Recycling target be 100%, real value in metals recovery
- ▶ Recovering metals from Solar cells secures Critical minerals
- ▶ Avoiding mining reduces CO2 footprint





Right Intent Confusing Content (2)

- ▶ Subsidise initial 1,00,000 tons Solar panels to make recycling attract gradually reduce subsidies
- ▶ “Pollution Tax” on Solar panels as cover for meeting recycling costs
- ▶ Ban re-furbishing Solar modules as technically cannot be repaired.
- ▶ Producers Collectively support established Recyclers instead of respective PV module manufacturers setting independent facilities
- ▶ No clarity on Insurance clearance if ‘Early Loss’
- ▶ TSDF (disposal) cost not defined
- ▶ Design future panels be recycling-friendly
- ▶ Producer Responsibility Association (PRA) - single umbrella for Solar panel Circularity



Roadmap Ahead

- ▶ Analyse real time life cycle emissions of PV module from raw material procuring to landfill disposal/ RECYCLING
- ▶ Green Chemistry approach from present rudimentary methodologies for sustainable transition to circularity
- ▶ Portable RECYCLING owing to vast geography of India saving logistic costs
- ▶ Estimate employment (India offers cheapest skilled labour)
- ▶ Identify the socio-economic benefits
- ▶ *Make India Global benchmark for sustainable recycling*





Environment Social Governance

Putting in Action

Environmental, Social & Governance (ESG)

Commence RECYCLING

not by LAW but as *MORAL RESPONSIBILITY*
to re-use the extracted materials.

If 'I' is replaced with 'WE'
even Illnes become WEllness





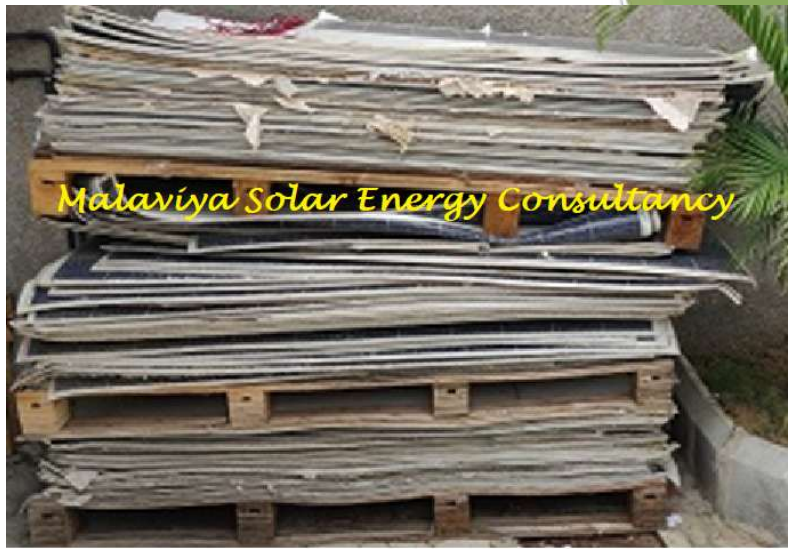
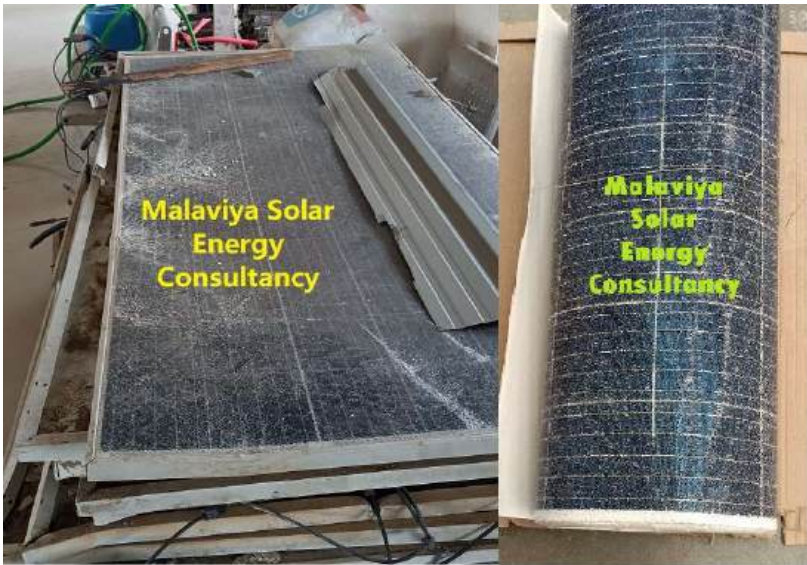
Indo-German Co-operation for Sustainable Recycling Facility in Asia



Malaviya Solar Energy signs
“Exclusive Agreement” with Lux
Chemtech, Germany under license
for Asian region for award winning
water-jet technology to separate
layers of PV panel and extract the
metals in non-hazardous manner with
recovery up to 98%



<https://www.ptinews.com/press-release/malaviya-solar-energy-obtains-exclusive-licensing-agreement-for-solar-panel-recycling-from-luxchemtech-germany/3168034>



Waste
isn't waste
until we
waste it

In nature there is no such thing
as waste. In nature nothing is
wasted; everything is recycled.

one profits most
who **SERVES WASTE**

WOW
Wealth Out of Waste

T R EASURE
ASH



3 R's



RECYCLE

REUSE

REGENERATE

or
REJECT



PLUS (Module Materials recovery by *Recycling*)

from

SURPLUS (*Solar power from Module Materials*)

for

US (*Producers and End-users*)



धन्यवाद
Thank You

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