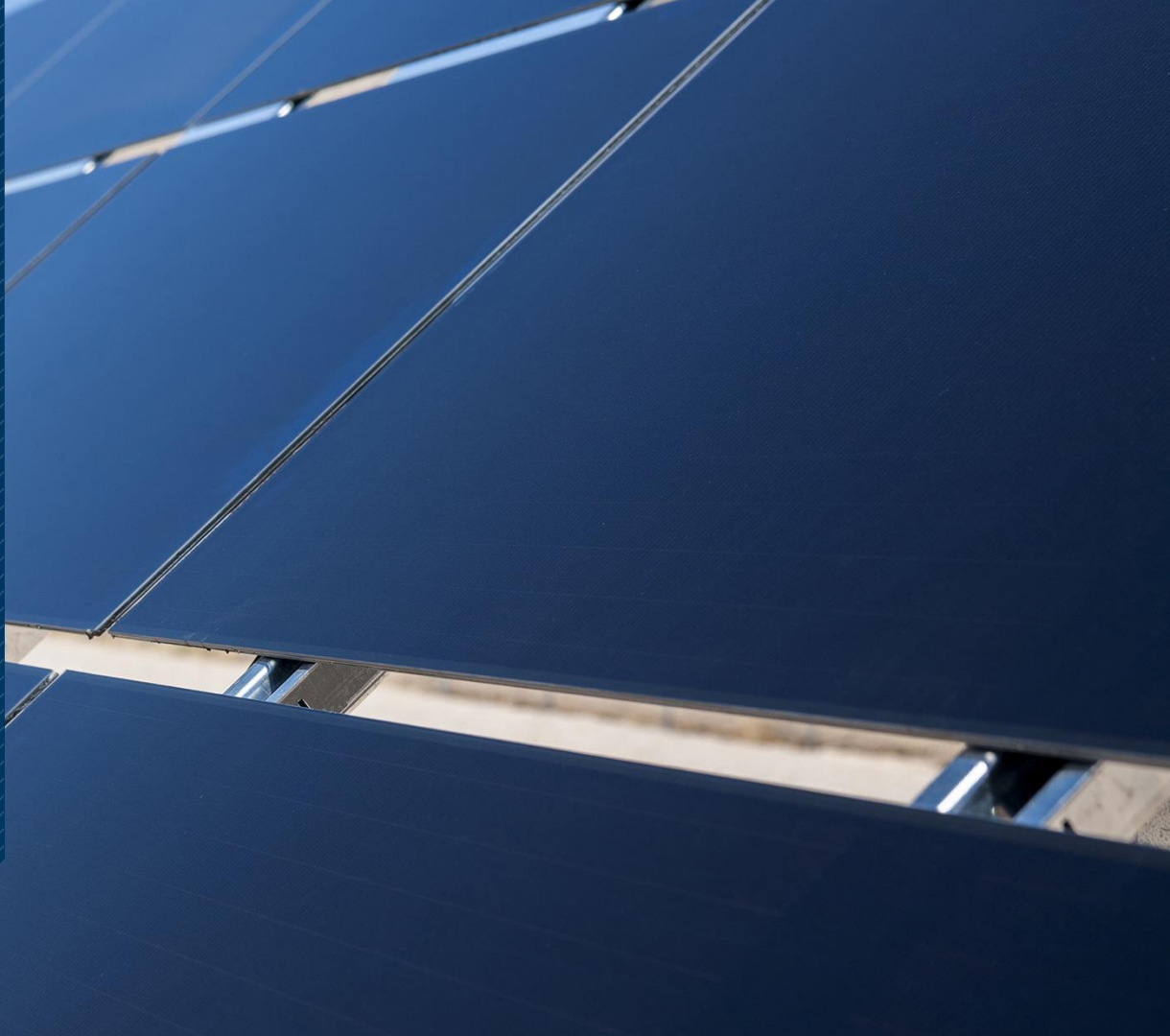


ENABLING A VIRTUOUS
CYCLE

LIFE CYCLE MANAGEMENT IN PHOTOVOLTAICS

Sukhwant Raju
Director Global Recycling



OUTLINE

1. Introduction to First Solar
2. A Short History of PV Recycling at First Solar
3. Life Cycle Benefits of High Value Recycling



INTRODUCTION TO FIRST SOLAR

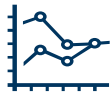
FIRST SOLAR AT A GLANCE



Over **20 GW** sold worldwide and over **\$14.5B** in project financing facilitated



Partner of choice for leading utilities and global power buyers since 1999



Solar energy that is **economically competitive with fossil fuel**



Strongest **financial stability & bankability** in the industry



FIRST SOLAR AT A GLANCE



History of solar innovation with **world record efficiency**



High-efficiency technology with a **proven energy advantage**



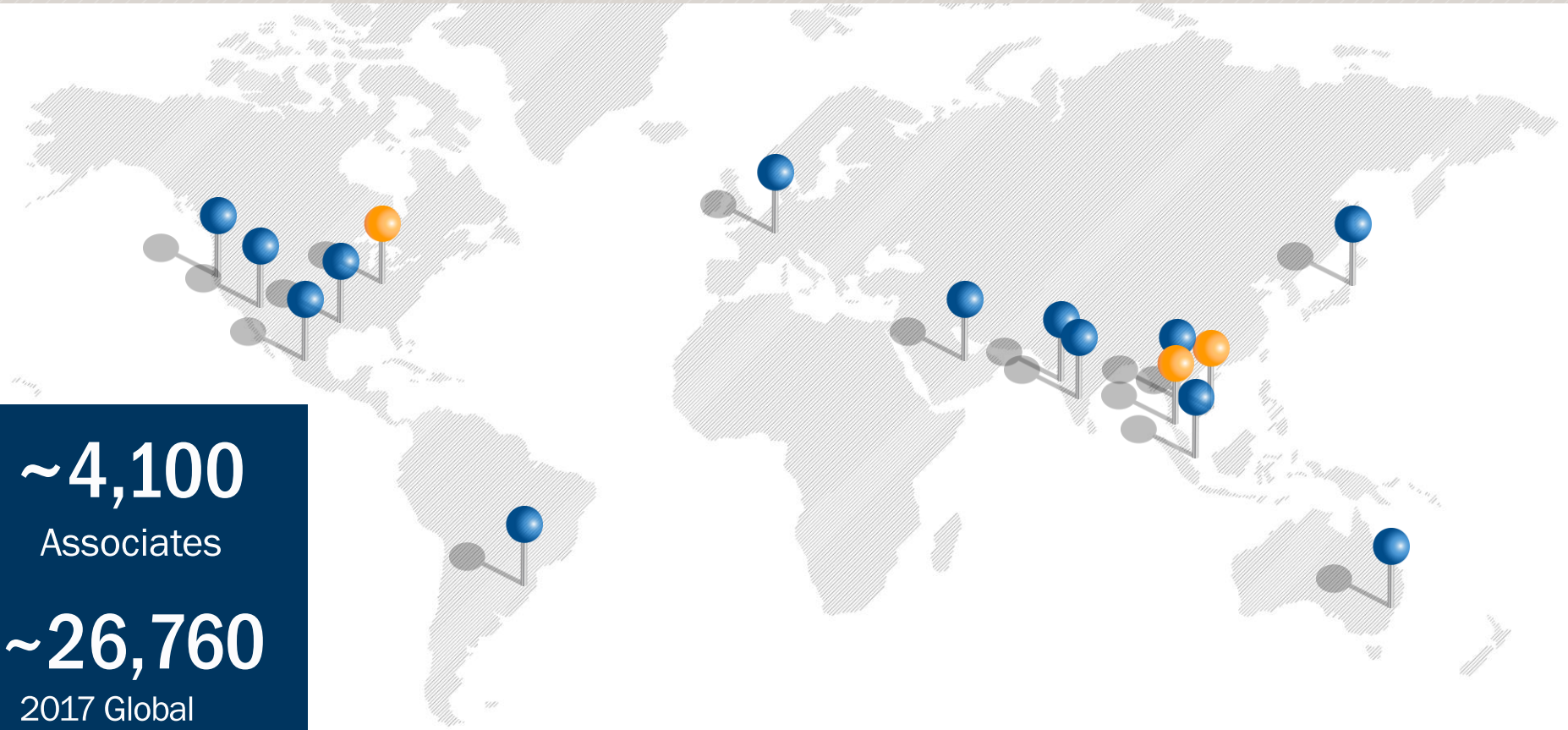
Lowest environmental impacts
generating clean electricity with
NO carbon emissions or air pollutants



GLOBAL OFFICES & MANUFACTURING

~4,100
Associates

~26,760
2017 Global
Supply Chain Jobs



TRUSTED AND BANKABLE PARTNER

CORPORATE RENEWABLES



UTILITY-SCALE



DEVELOPERS & EPC



O&M



“We create **enduring value for our customers** through innovation, customer engagement, industry leadership and operational excellence.”

— Mark Widmar
First Solar CEO



SHORT HISTORY OF PV RECYCLING AT FIRST SOLAR

FULLY INTEGRATED RESPONSIBLE PRODUCT LIFE CYCLE APPROACH

Material Sourcing



Converting mining byproducts into a stable semiconductor

Product Design



Designed for high-value recycling

Manufacturing



Manufacturing with less energy, water, and GHG emissions

Product Use



Faster CO₂ reductions and greater return on energy invested

Collection & Recycling



Recovering over 90% of materials at end-of-life for new PV modules

A SHORT HISTORY OF PV RECYCLING

First Global
Collection and
Recycling
Program (2005)

Ökopol Study
(2007)

PV CYCLE
(2007)

WEEE Directive
(2012)

EN50625: PV
Recycling
Standard
(2017)

Binding
Treatment
Ordinance in
Germany
(2019)

First Solar provides free of charge collection and environmentally responsible recycling of this solar module. Please do not dispose of this product in any manner before contacting First Solar via:

- the Web: www.firstsolar.com/recycling
- telephone: **1.866.456.8938** (North American Toll free) **+800.433.32.333*** (International Freephone)
- *For more details on dating codes please visit First Solar's website.
- email: recycling@firstsolar.com

First Solar bietet für dieses Solarmodul die Möglichkeit zur kostenlosen Rücknahme und umweltgerechten Wiederverwertung. Bitte kontaktieren Sie First Solar, bevor Sie das Produkt entsorgen.

First Solar ofrece gratuitamente la recogida y el reciclaje responsable de este producto de módulo solar. Por favor, no elimine de cualquier modo los residuos de este producto antes de ponerse en contacto con First Solar.

La First Solar raccoglie gratuitamente questo modulo solare e lo ricicla nel rispetto dell'ambiente. Non getti via questo prodotto prima di aver contattato la First Solar.

First Solar assure gratuitement la collecte et le recyclage de ce module solaire de manière écologique et responsable. Merci de ne pas vous débarrasser de ce produit de quelque façon que ce soit avant d'avoir contacté First Solar.

First Solar παροχει δωρεάν συλλογή και περιβαλλοντολογικά υπεύθυνη ανακύκλωση της παρούσης ηλεκτρικής μονάδας. Αποφύγετε την απόρριψη του προϊόντος με οποιοδήποτε τρόπο χωρίς επικοινωνία με τη First Solar.

 www.firstsolar.com

STUDY ON
THE DEVELOPMENT OF
A TAKE BACK AND
RECOVERY SYSTEM FOR
PHOTOVOLTAIC PRODUCTS

FUNDED BY BMU
GRANT NUMBER 03BAF002

CO-FINANCED BY EPIA / BSW-SOLAR

November 2007



DIRECTIVE 2012/19/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 4 July 2012
on waste electrical and electronic equipment (WEEE)
(recast)
(Text with EEA relevance)

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

FINAL DRAFT
PrEN 50625-2-4

May 2017

English Version

Collection, logistics & treatment requirements for WEEE - Part 2-4: Treatment requirements for photovoltaic panels

Expérience de collecte, logistique et traitement pour les déchets électriques et électroniques (DEEE)
Partie 2-4: Expérience de traitement des panneaux photovoltaïques

To be completed



Enabling a **level playing field** for the collection, treatment and recycling of photovoltaic panels in the EU has accelerated the learning curve for the industry. To ensure further progress and enable a sustainable recycling and recovery value chain, a **viable secondary resource market outlet** is of paramount importance.

WHY DOES HIGH-VALUE PV RECYCLING MATTER?

Crucial to managing large future PV waste volumes

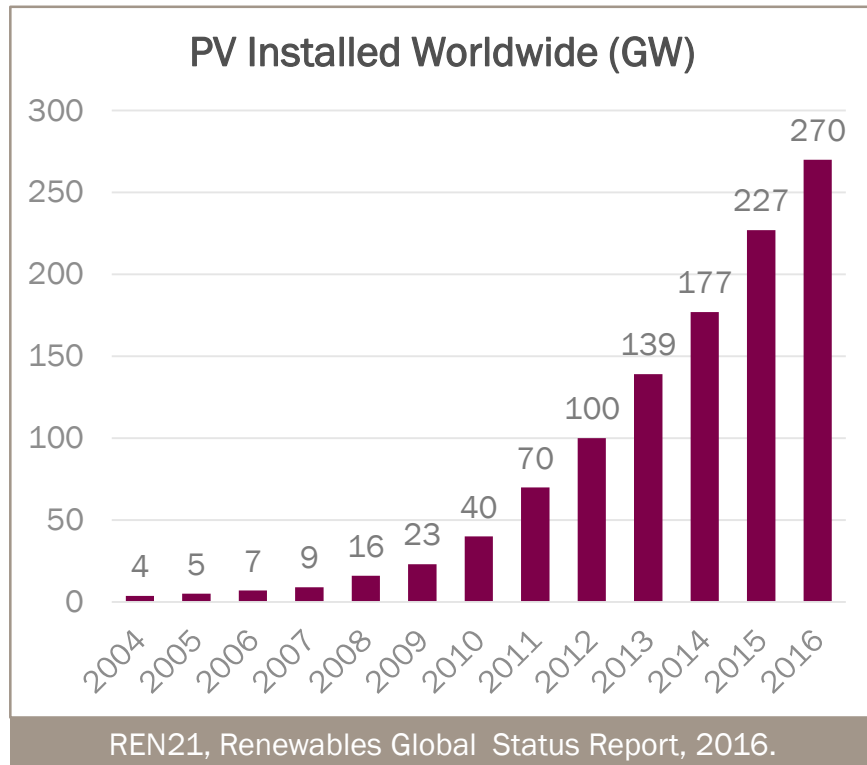
- Over 300 GW PV installed worldwide

Recycling is important for all PV technologies

- Environmentally sensitive materials are common in the industry (Pb, Cd, In, Se, Ag...)

Provides socio-economic and environmental benefits

- Minimizes life cycle impacts
- Reclaims valuable and energy intensive materials
- Creates jobs and economic benefits
- Recoverable value could exceed \$15bn by 2050



Recycling **maximizes resource recovery and increases the sustainability of PV.**

CIRCULAR ECONOMY: BEYOND WASTE

TYPICAL RECYCLING RATES



AUTOMOTIVE

~75%



INFORMATION
TECHNOLOGY

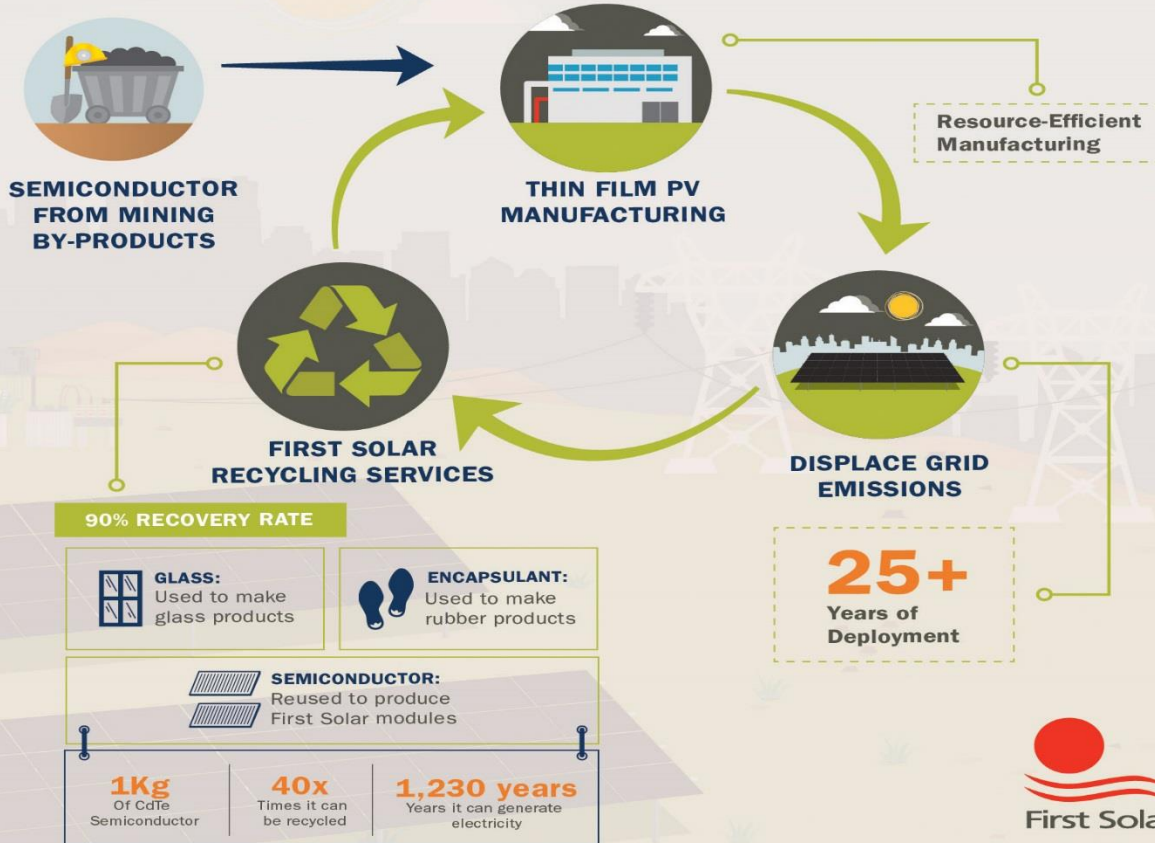
~45%



FIRST SOLAR
MODULES

~90%

THE VALUE LOOP

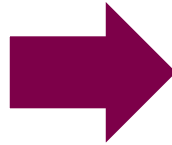


[FIRSTSOLAR.COM/SUSTAINABILITY](https://firstsolar.com/sustainability)

FIRST SOLAR'S RECYCLING PROCESS DESIGN PROGRESSION

V1 Recycling (2006)

- Based on the mining industry
- Batch process
- Moving glass and liquid from process to process
- Volume output – 10 tons/day
- Capital investment - \$5M



V2 Recycling (2011)

- Based on the chemical industry
- Batch process
- Based on keeping the glass fixed and moving the liquids thru the material
- Volume output – 30 tons/day
- Capital investment - \$7M

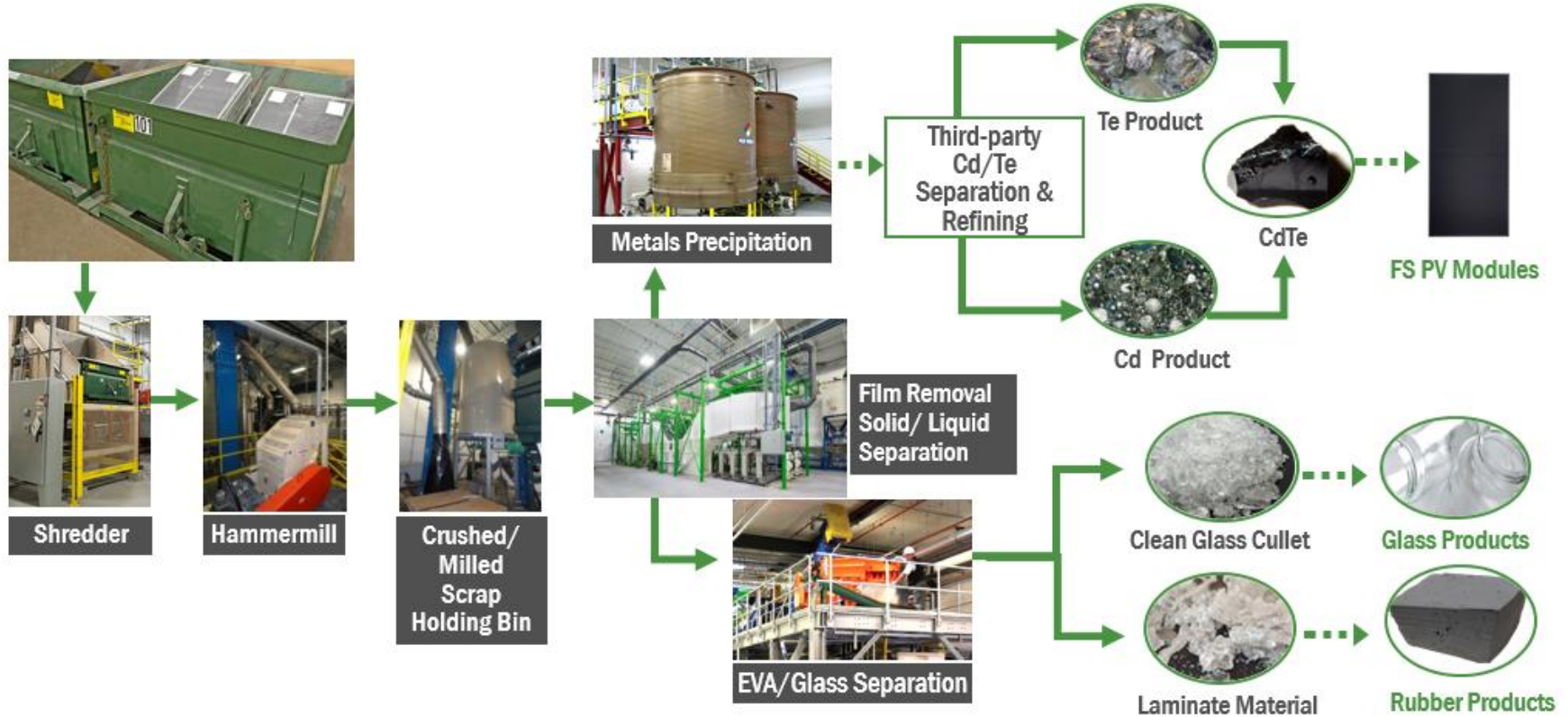


THIRD GENERATION CONTINUOUS PROCESS RECYCLING (2015)

- More efficient 7/24 operations
- Compact plant with smaller footprint
- Increased daily recycling capacity from 30 tons to 150 tons/day capacity
- Requires 30% less capital, chemicals, waste and labor
- Achieves superior glass and semiconductor purity



FIRST SOLAR MODULE RECYCLING PROCESS



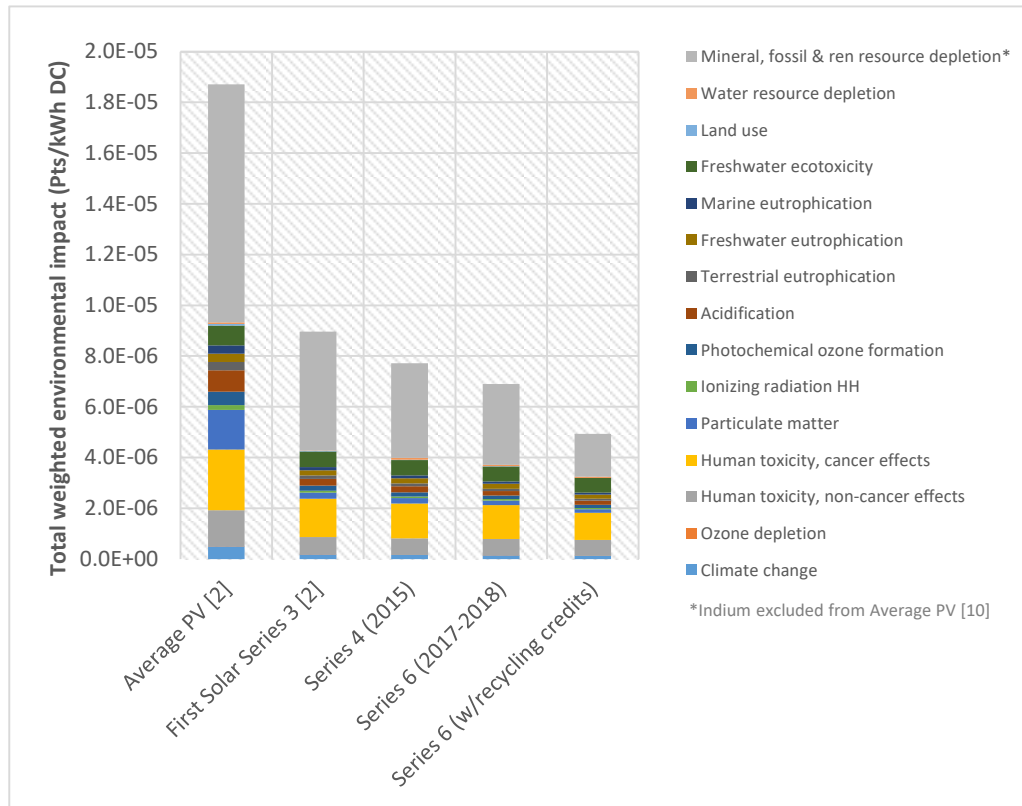
+ 90% Recycling of Semiconductor Material and ~ 90% Recycling of Glass



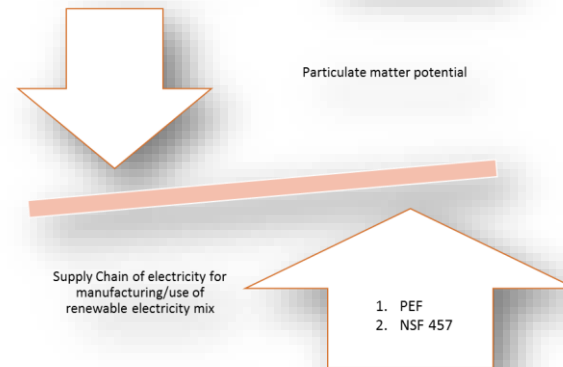
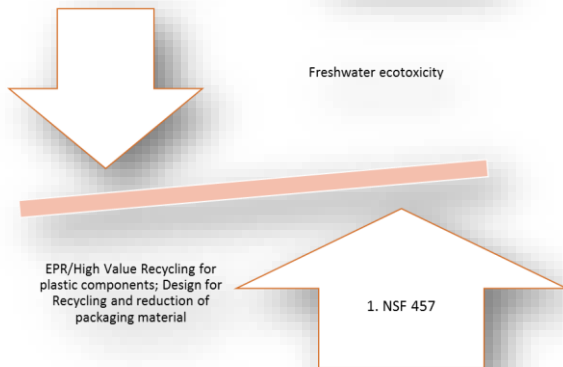
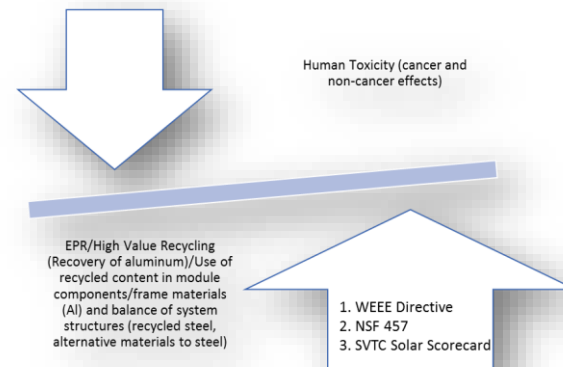
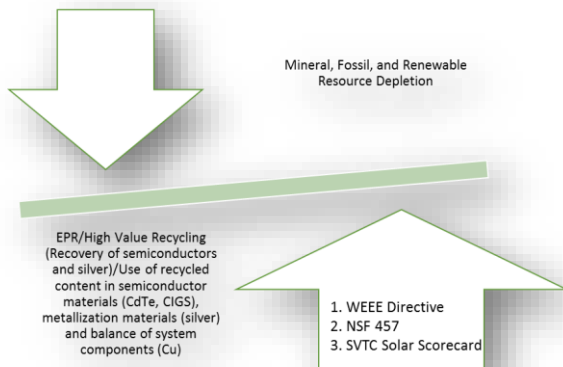
LIFE CYCLE BENEFITS OF HIGH VALUE RECYCLING

BENEFITS OF HIGH VALUE RECYCLING

Measures that enable and encourage circular economy and the decarbonization of the supply chain of electricity would help to effectively relieve some of the major hotspots by addressing resource depletion (through recycled content) and reducing emissions from fossil-fuel based electricity generation.



ENABLING MORE SUSTAINABLE PHOTOVOLTAICS



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First Solar®