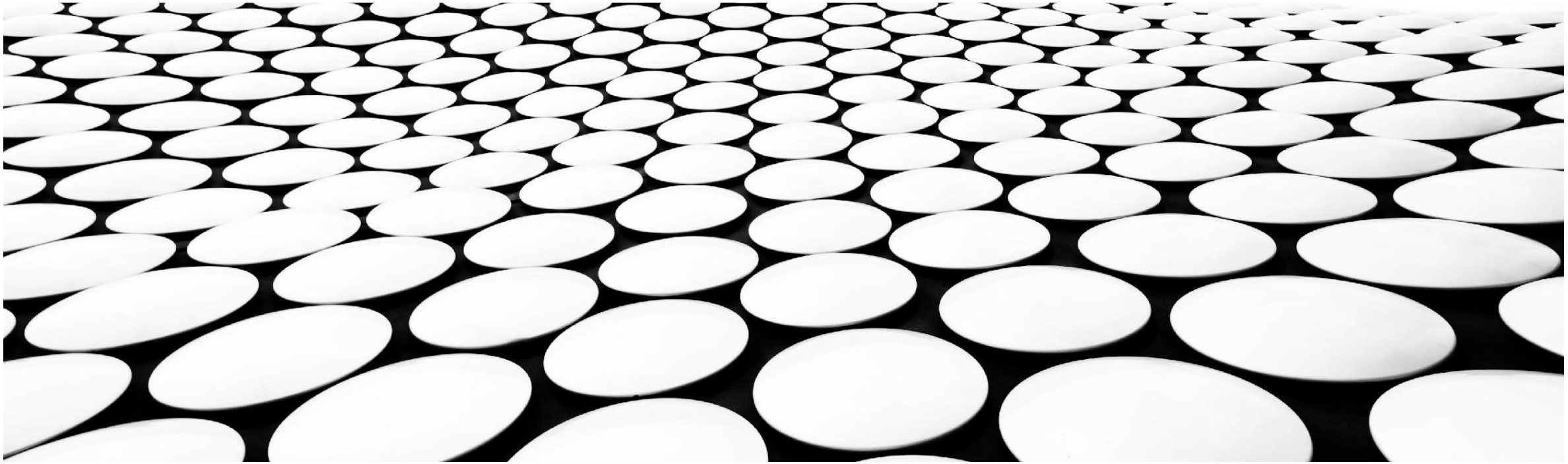
RECYCLING (REUSE) OF PHOTOVOLTAIC PANELS

March 2022

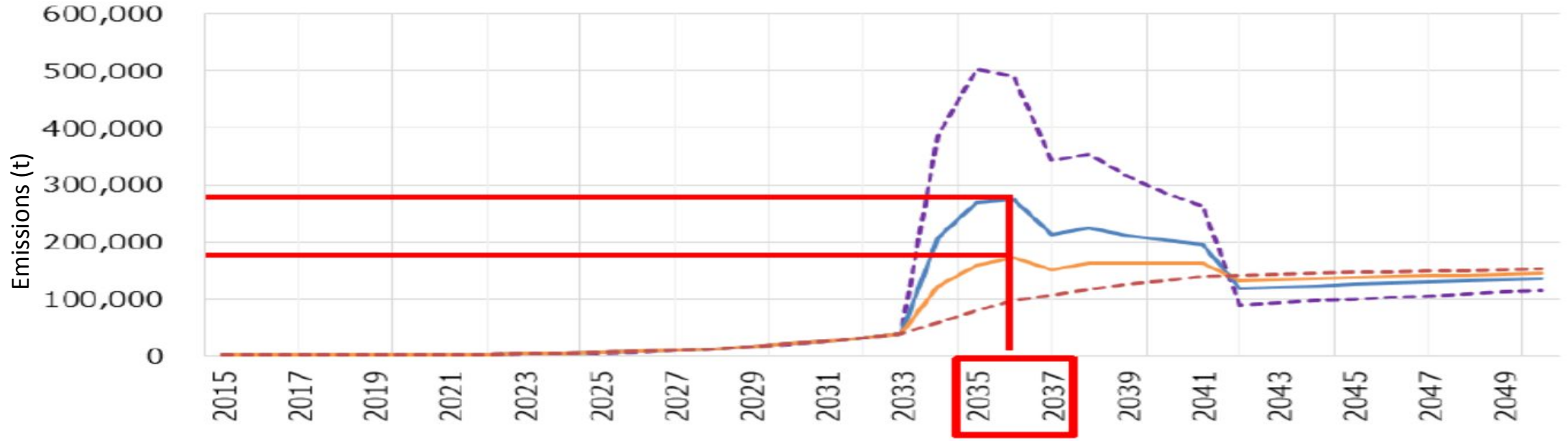
SHINRYO CORPORATION



Company Profile

Name	**Shinryo Corporation**
Head office	3-9-22, Kurosaki, Yahatanishi-ku, Kitakyushu City, Fukuoka Prefecture, 806-0021
Est.	October 1, 1964
Representative	ETO Toshiro, President
Capital	JPY 500 million
Stockholder	Mitsubishi Chemical Corporation
Sales	JPY 24.4 billion (forecast for FY 2021)
No. employees	Approx. 1,300
Main businesses	Circular economy and 3Rs, fine chemicals precision cleaning and surface treatment, wafer reclaiming, contract plating (electronic component processing), healthcare
Locations	□Fine chemicals□□Aomori, Fukushima, Fukuoka □Electronics□□Iwate, Yamagata, Mie, Fukuoka, Kumamoto, Miyazaki □Circular economy□□Fukuoka, Kagoshima, Mie
Group companies	**Recycle Tech Co., Ltd.** (81%), GEMtek (Suzhou) Co., Ltd. (100%)

WASTE PV PANELS: EMISSIONS IN JAPAN



	2020	2025	2030	2036
Projected emissions (B), (C)	Approx. 3,000 t	Approx. 6,000 t	Approx. 22,000 t	Approx. 170,000 to 280,000 t
Percentage of the final amount of industrial waste disposed in FY 2015	0.03%	0.06%	0.2%	1.7 to 2.7%

(Source) NEDO estimates

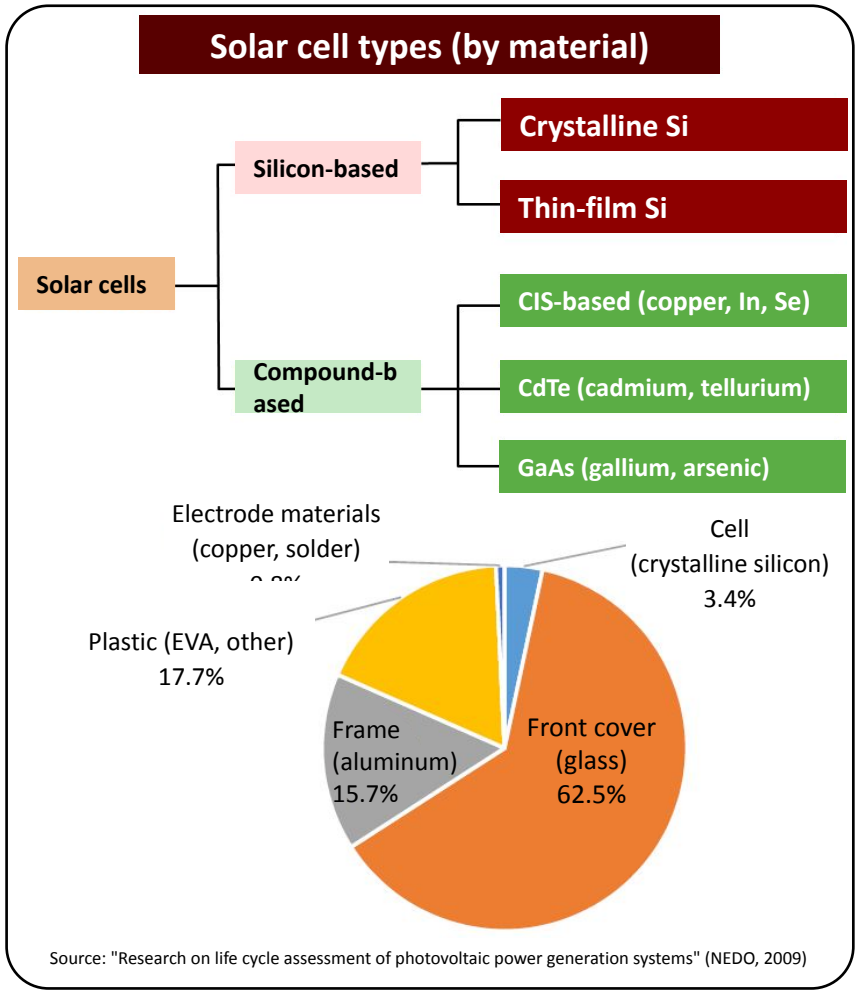
Source: Excerpt from "November 2018 Measures for the disposal of photovoltaic power facilities and equipment", Agency for Natural Resources and Energy

The volume of PV panels will peak around 2035 to 2040 with approximately 170,000 to 280,000 tons (10 to 17 million panels) disposed per year, which is equivalent to 1.7 to 2.7% of the final disposal sites for industrial waste.

PV Recycling: Challenges & Background

- Currently, PV waste is mostly landfilled.
- The structure of PV panels differs by material.

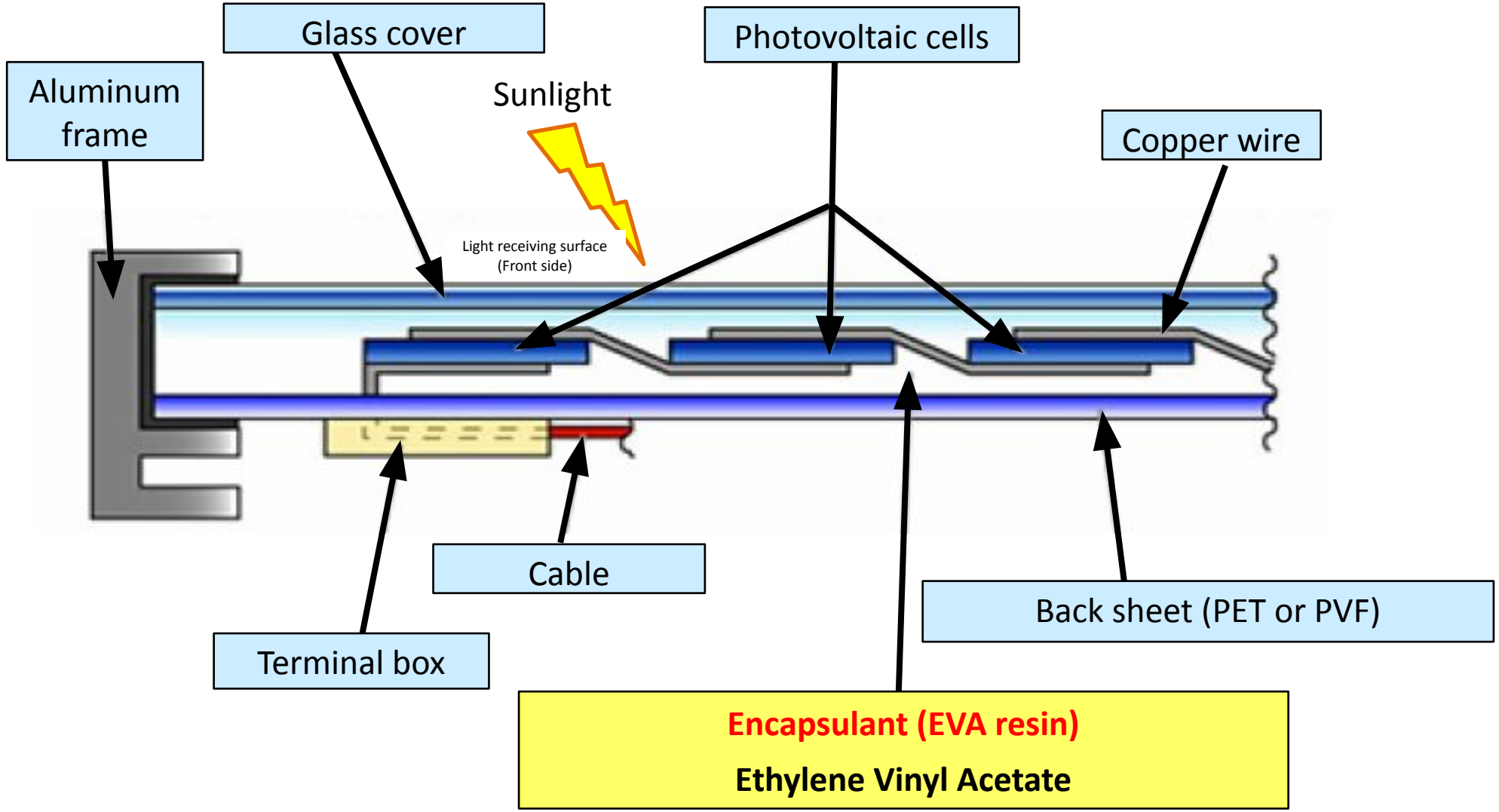
⇒ Low-cost, versatile recycling methods must be developed that are compatible with an environmental- and recycling-oriented society



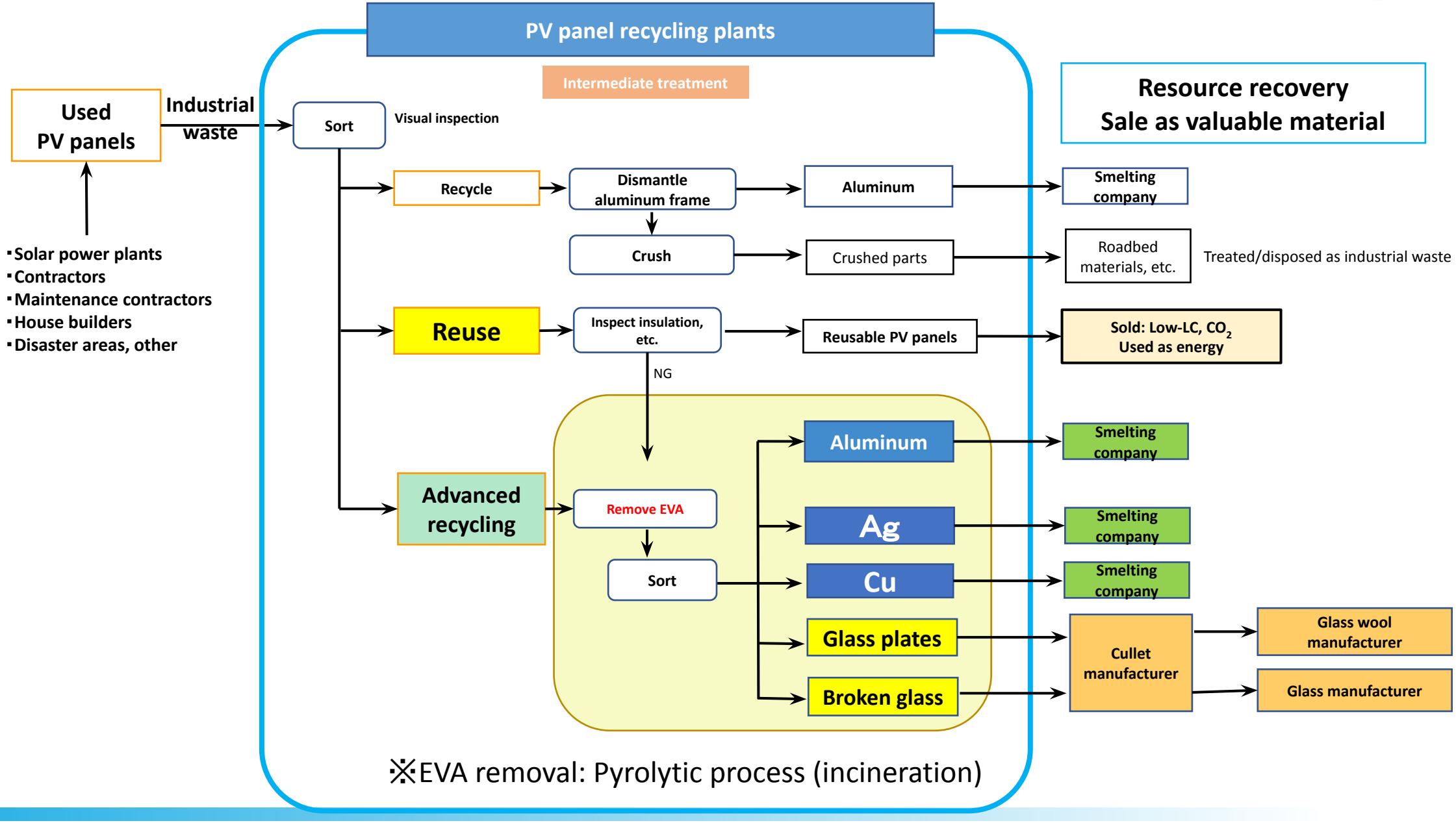
1. Arrival of the era of mass disposal
2. Demand for a social system
3. Low cost ⇒ Business profitability
4. Quality and stability ⇒ Business continuity
5. Versatility ⇒ Compatible with different PV (Crystalline Si, thin-film Si, CIS solar systems)
6. High recycling rate ⇒ Environmental circularity

Need to develop treatment methods that are low-cost and versatile with high recycling rates

Typical Example of PV Panel Structure (Crystalline Si system)



RECYCLING PV PANELS



※EVA removal: Pyrolytic process (incineration)

PV PANEL RECYCLING: TREATMENT FLOW

<Treatment process>

Acceptance

Primary firing

Secondary firing

Sorting ①

Sorting ②

Sorting ③

FY 2010 to FY 2017 NEDO project

FY 2017 Ministry of Environment demonstration project

FY 2020 Ministry of the Environment demonstration project

Facilities

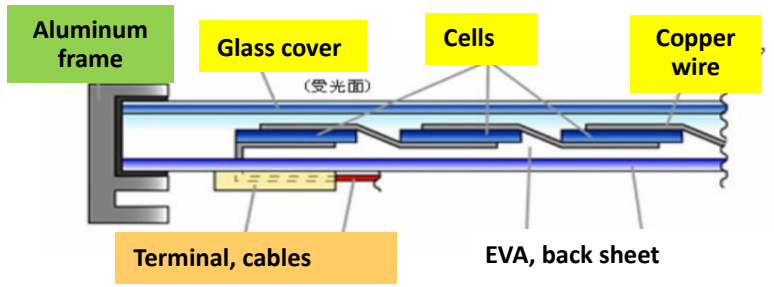
Firing furnace

Sieving machine

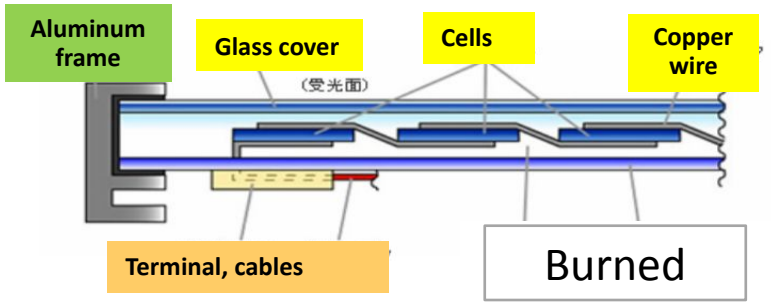
Pneumatic sorter

Air table

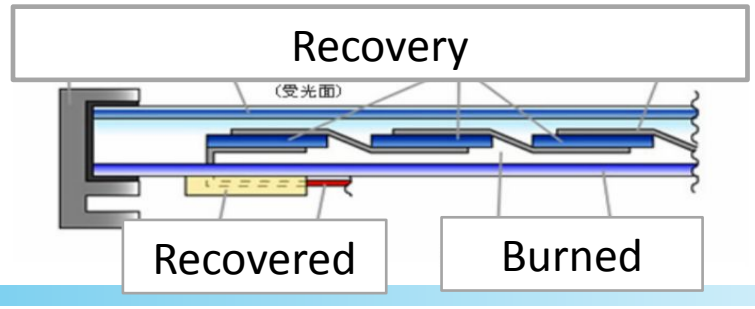
Recovery of recyclable materials



Firing



Sorting



Sold

Sales destination for valuable materials

<Metal recycling companies>

Aluminum frame

Terminal, cables

<Refining companies>

Cell (Ag)

Copper wire (Cu)

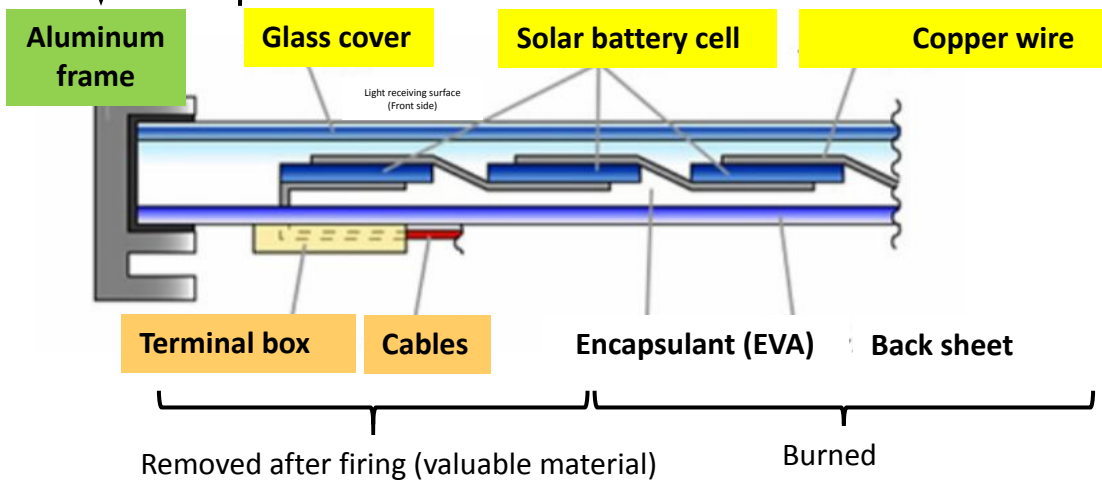
<Glass cullet manufacturers>

Glass

PVR EVA PYROLYSIS PROCESS

Removed after firing (valuable material)

Recovered during sorting process (valuable material)



Removed after firing (valuable material)

Burned

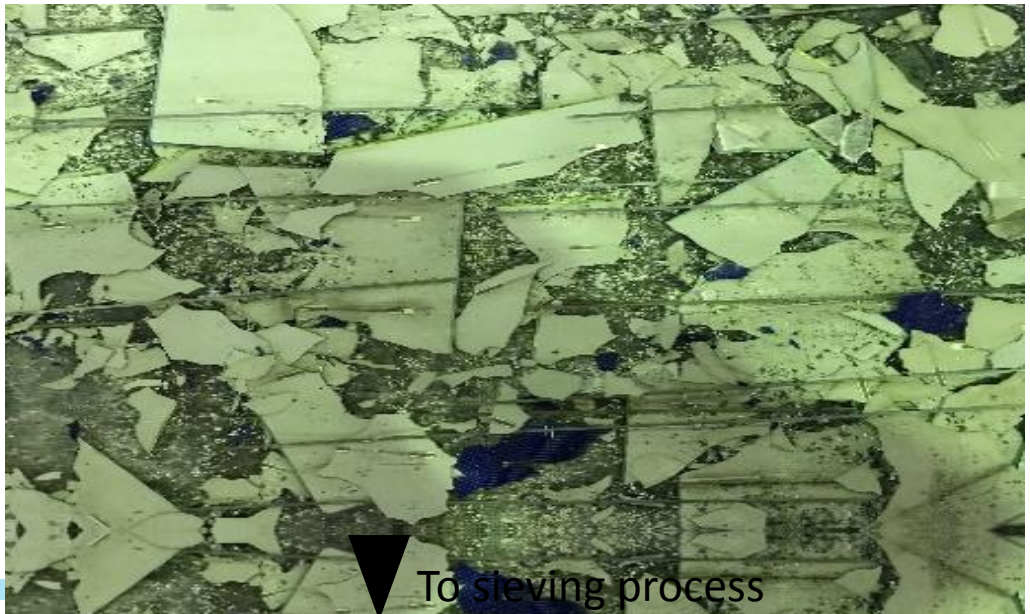
PV panel

Front panel

Back panel

Firing furnace (image)

Condition of PV panels after firing



To sieving process

PVR ADVANCED SORTING PROCESS

Sieve (Sorting ①)

Pneumatic sorter (Sorting ②)

Air table (Sorting ③)

Recovered valuable materials

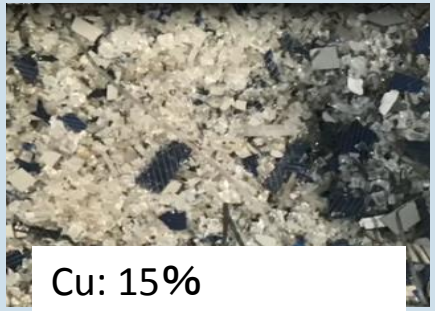
Copper wire 4.0%

Cu: 55.2%
Ag: 8,539g/t

Silicon cells 7.3%

Cu: 1.9%
Ag: 5,683g/t

Silicon cells, other 2.2%



Cu: 15%
Ag: 3,291g/t

Glass cullet 86.5%

Glass: 99.999%

EVALUATION OF PV GLASS CULLET

※Evaluation and review conducted by glass wool manufacturer, Oneworld Co., Ltd.

- Production of glass wool prototypes **from 100% PV glass** (manufactured to the point of an insulation product) in a small-scale plant (raw materials: 2 tons). Also includes an assessment of the composition and performance of insulation materials.

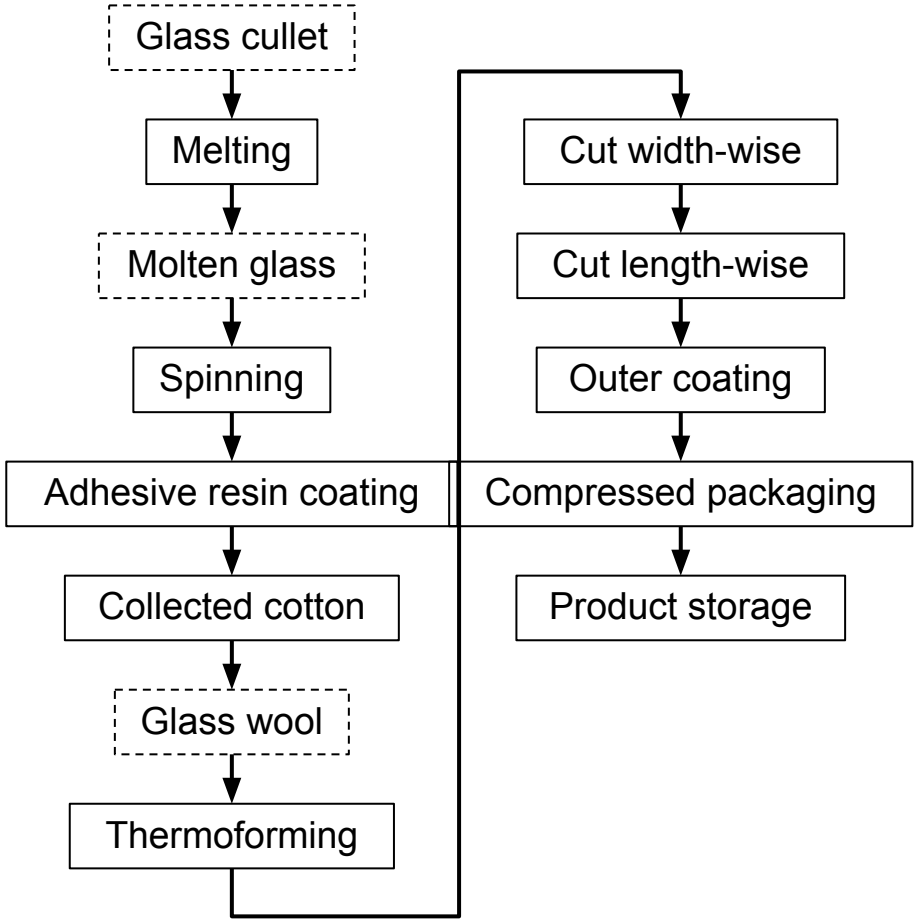


Fig. Prototype process flow

No abnormalities in appearance (left: PV raw material prototype, right: OW raw material product)

External view of insulation prototype
(left: PV glass, right: window glass)

Table: Results of thermal conductivity of prototype (insulation)

	PV raw material prototype	Regular raw material product
Test results from the Japan Testing Center for Construction Materials	λ＝0.040	λ＝0.041
	（0.00403）	（0.00410）

PV Panel Advanced Recycling Plant

Processing capacity: 90,000 panels/year (projected)

Recycling rate = 99%

Mega solar

Panel production factory

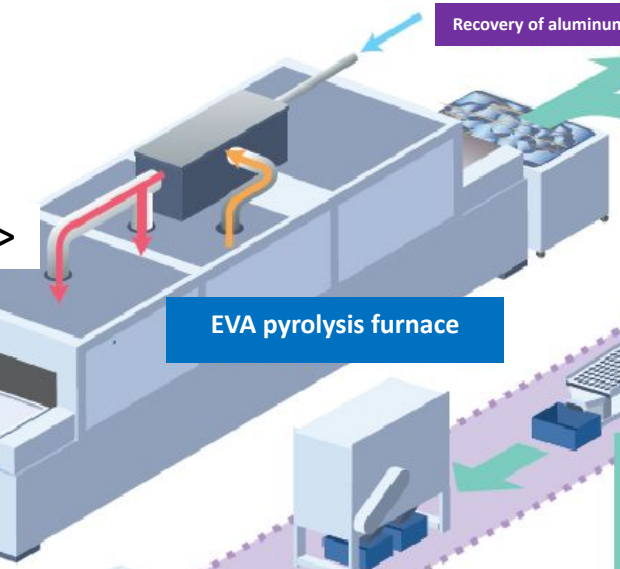
Detached house

Thin-film Si system

Crystalline Si system

<Thermal recycling>

EVA pyrolysis furnace



<Resource recovery>

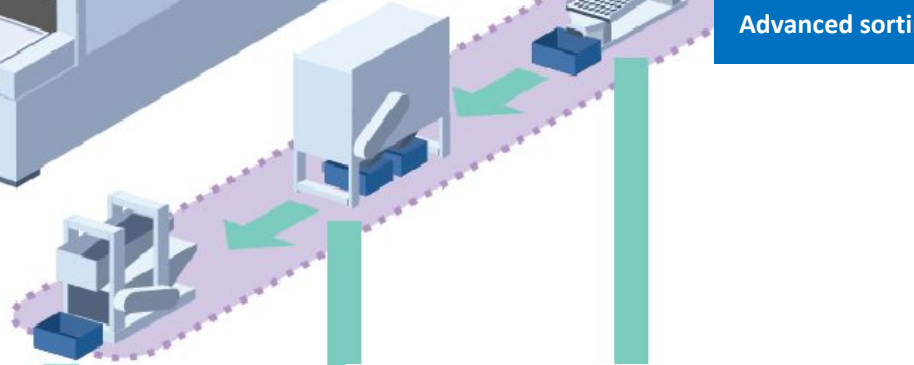
Recovery of aluminum frames and sheet glass

Aluminum frame

Recycled sheet glass

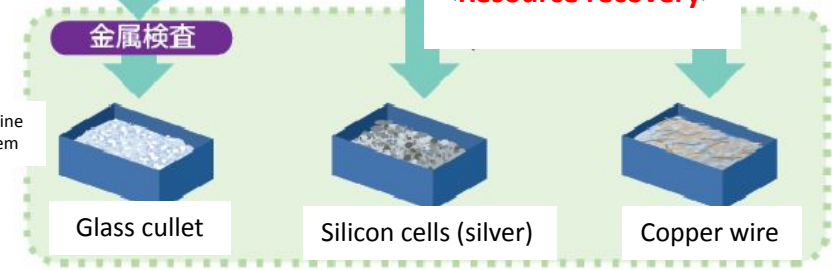
Advanced sorting of glass, cells, copper wires

Advanced sorting line



<Resource recovery>

金属検査



Glass cullet

Silicon cells (silver)

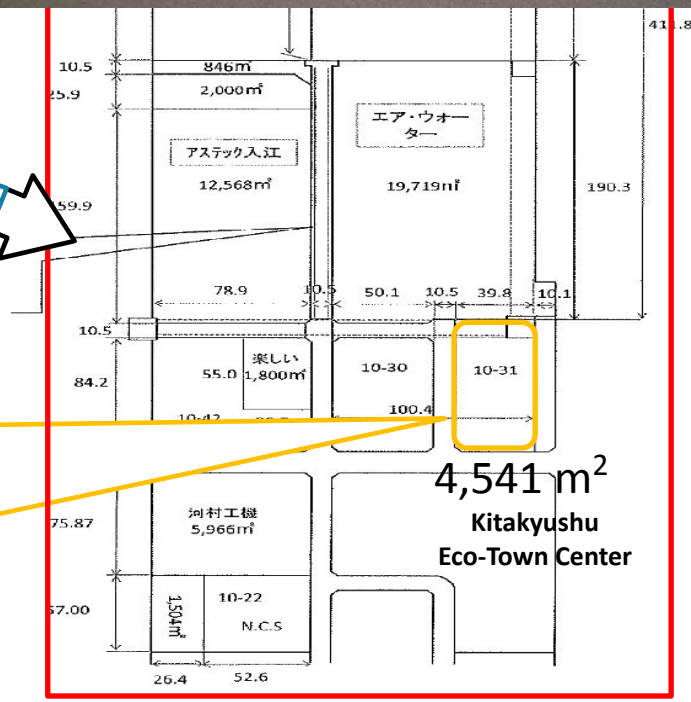
Copper wire

Features of Shinryo's System (Firing Process + Advanced Sorting)

	Features
Versatility	Compatible with various PV modules (crystalline Si, thin-film Si, CIS systems) Compatible with PV broken glass modules.
High recycling rate (99% and above)	Material recycling rate: 82% (99% and over for glass, aluminum, cells, wires) With the inclusion of heat recovery, the overall recycling rate is 99% and over.
Increased CO_2 reduction effects	CO_2 reduction effect during the production of glass wool is significant because cover glass, which has a high weight ratio, can be recycled into glass wool (potential of sheet glass is currently under investigation). Processing a 1-MW mega solar power plant using Shinryo's system reduces CO_2 emissions by approximately 200 tons. If recycled into sheet glass, the reduction effect is even higher.
Energy efficiency (Heat recovery systems)	Excellent energy efficiency because energy for the EVA resin removal process can be covered with the use of heat from EVA combustion (80% to 90% covered)

PLANNED CONSTRUCTION SITE

Start of operations in April 2022



Shinryo (Recycle Tech)
PV reuse and recycling
Planned site for new plant