

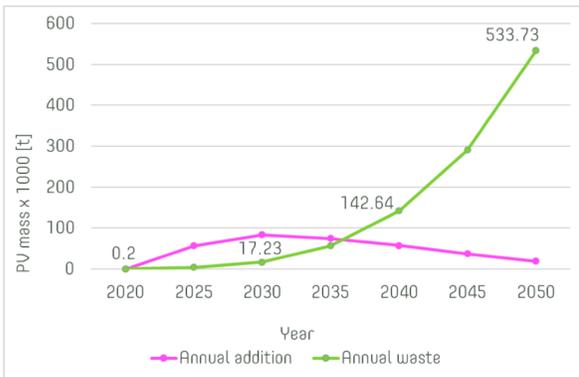
Photovoltaic Waste State of the Recycling Industry

Iloboca (a division of Lo&Bo Sagl)
for 22nd PV Swiss Congress
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<https://recyclinginside.com/wp-content/uploads/2024/01/solar-panel-recycling-landfill-1.jpg>

Facts 1 - PV addition and dismission historical data and forecast

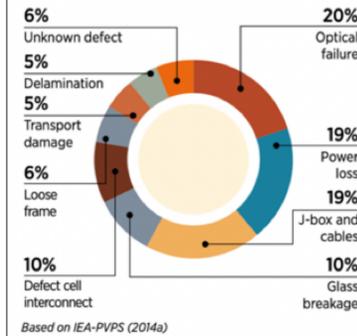


3.330.000 tons of PV module waste in Europe by 2030
(According to IRENA "End of Life Management - Solar Photovoltaic Panels" 2016)

17.000 tons of PV module waste in Switzerland by 2030
(according to IRENA, Swissolar and Winbach Consulting)

If the will is to avoid the waste export the Swiss recycling industry has to predispose at least two dedicated plants within the Confederation borders.

Facts 2 - The end of a PV module life



Average life of a PV panel is considered to last 25 years. Yet technical failures, along with technological obsolescence that goes together with lesser capacity to generate power compared to new generations, make modules installed 15, 20 years ago subject to early replacement.

Once a solar panel is considered useless its waste category is referred to in the recycling industry as **wEEE** (waste electrical and electronic equipment)

Facts 3 - The Swiss situation

The Swiss organization in charge of wEEE management is Sens E-Recycling, a foundation who's board is seated by the most important producer and distributor of electric and electronic appliances.

The PV waste issue is managed by Sens alongside Swissolar, the Swiss trade association for solar energy.

Since 2013 an Advanced Recycling Contribution is charged to the PV final users, Sens is the ultimate collector of such contribution. Sens, according to its role, turns the contribution into economic incentives addressed to the recyclers.

In fact there is no economic balance in managing the PV waste in CH at present time, it is not valuable setting up a PV module recycling plant in Switzerland, not until volumes will increase to the expected critical mass.

Sens has managed to set up a PV waste collection and exporting process that involves one recycling partner KWB Planreal AG, located in Widnau north Sankt Gallen. From there dismissed modules are sent for recycling treatment to Reiling GmbH, a German Recycling plant.

This economic venture is supported by the University of Applied Science of Bern and a pool made up by main Swiss PV manufacturers and vendors along with KWB and Reiling, all together partnering in **Swiss PV Circle**.

Sens and Swissolar cooperates in developing standard procedures in managing PV waste.



One of the strongest requirements to the recycler is to deploy a triage process in order to separate modules that are still reliably and safely capable of being reused.

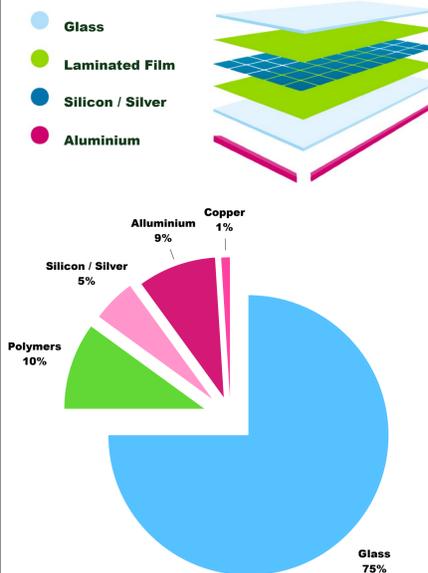
Sens appoints recycling partners according to its final goal, resumable in promoting, supporting and financing the most efficient recycling process in the best interest of the Confederation, and according to its strategic planning.

Facts 4 - Recycling Issues

PV modules produced in between 2000 and 2015 are those expected to grow soon the waste critical mass. They averagely consist in 20 Kg units, largely assembled in this framed laminated product and made up by this materials in this proportions.

Goal of the recycling industry is to separate materials for their best reuse. This is defined by circularity within the same production process.

Unfortunately in PV modules manufacturing proper circularity is far from being achieved. No module manufacturer re-employ materials recycled from PV waste treatment.



This is due to the extreme production process sensibility to purity of employed materials. This comes from the high technological grade of PV module manufacturing.

In the last two years we've been researching worldwide and studying most of the recycling equipment developer offers about PV waste recycling.

The most advanced among industrialized set ups we found offer this features:

- residual cable removal (manual)
- mechanical dismantling of the frame
- mechanical removal of the junction box
- mechanical delamination of the glass layer
- various processing of the PVC sealed active silicon connected cells

This last is actually the most challenging issue the most are struggling on. Many are experimenting with the use of physical and chemical processes to separate silicon and cell metal connectors.

Our observations on this approach lead us to consider that such operations are industrially not only expensive but difficult to control.

More: it is quite impossible as now to obtain the extreme purity grade required to silicon for it to be employed as semiconductor in electronic and solar applications from a recycling context.

In conclusion we may say that as today, with different quality level according to different process and to different approach to the same actions in the process, **the products (materials) that are recyclable from PV waste are:**

- copper and LDPE from cables
- aluminum from the frame
- HDPE and copper from junction box
- glass

Facts 5 - The Recycling Industry

Many as today are treating PV waste as common wEEE: grinding whole batches with some expedient along the process, particularly in product sorting.

Reiling GmbH among these and the Swiss PV waste along so far.

We've been deepening the offer of several equipment developers.

We focused on those offering industrialized equipment conceived and assembled expressly for PV waste processing.

Among the many we chose to present here 3 cases.

Hourly production capacity of the 3 processes is 60 modules per hour evenly.

Tialpi Spa is a spin-off of Sasil Srl, an Italian long time experienced company in mineral and glass treatment.

Tilapi Spa equipment is installed and in production in Biella, in the North East of Piemonte. First set up as a demo plant it was converted into production in 2023 according to the rising demand for recycling PV waste. It is certified ISO 9001 and 14001.

Their production line is qualified by several detailed actions, necessary to the overall quality of the process and the products.

Here we represent by stations only the main actions

Station	Action	Tool / Means	Products
1	Cut corners	circular saws	aluminium filings
1	Dismantle frame	mechanical dilator	aluminium profiles
2	Remove J-Box	mechanical cut	polymers, metal
3	Remove glass	thermo mechanical	grinded glass
4	Select glass	sifting, optical separation	glass waste / 1st / 2nd choice



Pros
Highest product quality >50% end of waste
High industrialization level
The most efficient among operative plants

Cons
The highest purchase and maintenance cost we met
Thermic station = energy consumption
Silicon cell layer is sent to landfill
R&D looks at chemical / physical solutions



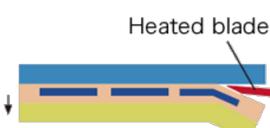
NPC

Incorporated (Matsuyama Japan - Wixom Michigan USA) developed as well machinery natively conceived for PV waste recycling.

NPC concept is very close to Tialpi. NPC is as well focused on glass but with a different goal: sorting it as a whole slab.

This took the developers to a different approach to glass delamination.

Instead of heating up the panel and remove the glass layer with a hammered rotor NPC heat up an angled blade that delaminates the glass slab from the sealed cell layer.



Pros
NPC is a solid company listed at Tokyo SE
Among other activity NPC develops and supplies PV module manufacturing equipment
Price = < 1/2 then what is asked by Tialpi

Cons
NPC is not present in Europe / machinery and spares ship from Japan / assistance is ?
Heated blade = energy consumption
Recycled whole glass slabs are not requested
Silicon cell layer is sent to landfill

TSGC Technology Inc. (Taiwan) is working on what we found to be the most sustainable way, yet they are still one step away from industrial deploy. TSGC is about to turn the key of the first industrial release in the San Diego area, in the USA.

TSGC approach relies on a central database where potentially all ever produced panels are filed according to the data sheet. Such a database has been fed by TSGC since the project started to be developed.

Once the equipment will be operative starting from California in US and possibly from Switzerland in Europe, the expected growing number of running machines will use and at the same time feed the DB according to a machine learning model.

Station	Action	Tool / Means	Products	Pros
1	Identification	Optical		Sized down to a 40' transportable module Compared to actual industrial plants: 95% energy saving 99% emission reduction
2	Remove J-Box	mechanical cut	polymers, metal	
3	Frame dismantling	mechanical	aluminium profiles	The equipment will be made available to recyclers "as a service". This unique approach of TSGC goes along with the centralized panel DB that allows the as well unique use of milling spindles.
4	Delamination	Milling spindles	Glass, polymers, silicon/metal	

Cons
So far a fully functional proof of concept is running in Taiwan, the first industrialized machinery is weeks from delivery
Industrial production endurance to be demonstrated
Business model attractive but to be sustained also by local assistance

