

A VOLUNTARY TAKE BACK SYSTEM FOR PV MODULES IN EUROPE

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ABSTRACT: The average lifetime of PV modules can be expected to be more than 25 years, there is no waste problem at present but an increasing amount of end-of-life modules and rejects from production can be observed with the rapid market growth. As a consequence of the European waste policy manufacturers and importers are responsible for the waste treatment of their products. The end-of-life costs of PV modules even today contribute significantly to the costs of PV systems with about 0.1 – 0.4 €/W_p. To minimize these costs a dedicated recycling solution was established at Deutsche Solar AG as a service activity. A voluntary take back system for the PV industry is introduced that can grow with future logistic and module recycling demands, save costs and avoid the need for early waste regulation by the authorities. An externally monitored foundation is proposed to manage the take back system, arrange reverse logistic, keep track of the waste streams and publish subsequent statistical data on performance and costs and will be a competent consultation partner of manufacturers and authorities with a good eye on PV waste treatment needs.

Keywords: Recycling, PV Module, Environmental Effect

1 INTRODUCTION

Several companies and research institutes worldwide have been working on technologies for recycling crystalline silicon solar cells and thin film modules during the last decade with excellent results. At the last conference first results from the operation of Deutsche Solar AG's (a subsidiary of SolarWorld AG) newly developed thermal recycling pilot plant dedicated to PV modules of any technology were presented [1]. The capacity of the pilot plant is sufficient to recycle the collectable end-of-life modules in Europe at present. The implication of present and near future European legislation was analysed in the European integrated Project "Crystal Clear" [2 – 6]. In Germany the federal environmental agency conducted a study on the status of PV module waste, emerging streams and classification of the waste. Similar activities can be observed on an European and a global level [7 – 10]. In the European Union there is the possibility that spent PV modules are considered to be electronic waste despite this waste is not (yet) categorised in the WEEE and ROHS [11 – 12]. A forecast when PV waste will be covered by the above mentioned directives can not be given today, they were not considered in the recently proposed revision of the ROHS. Both at Federal Ministry for the Environment, Nature Conservation and Nuclear Safety in Germany and at the European Commission a dialog was started with the PV associations and the PV industry to gain more transparency on the implications of present waste regulations on PV.

2 WASTE REGULATIONS

Several new EU-directives trend clearly to waste avoidance, recycling and eco-design requirements. The EU is favoring a strategy for sustainable product development and high value reuse and recycling solutions to achieve lower energy pay back times and save resources by reuse and recycling of wafers, silicon and other material. Pure mass recovery quotas as set today in the present regulations will not be sufficient any longer.

The average lifetime of today's PV modules can be surely expected to be more than 25 years. Thanks to this there is no waste problem at present but despite this an increasing amount of end-of-life modules can be observed. Though the scope of waste legislation and its implication on photovoltaics is in principle quite clear (like the "Closed Substance Cycle and Waste Management Act" and the "Commercial Waste Ordinance" in Germany, the "Integrated Product Policy" approach of the European Commission) several waste treatment companies seem to be uncertain about the correct practicable procedures. Especially in the context of the correct applications of

- waste codes,
- possible recycling solutions,
- final disposal opportunities (heavy metal emission categories of PV modules and their adequate classification for the selection of the proper landfill sites),
- need for pre-treatment according to the waste storage ordinance in Germany in force since 1st June 2005.

2 RECYCLING SOLUTIONS

Several recycling solutions were or are under development worldwide [1, 2, 7, 15 – 18]. Within the frame of the EU-project Crystal Clear recyclability of new materials and products is tested and the results are fed back for the development of best practice sustainable products [19, 20]. The first commercial module recycling activity is an open service for the European PV industry (at pilot plant scale, ~1 MW_p/year and shift). Nearly all commercial types of modules can be separated, modules based on compound semiconductors are dismantled on a research level at present. The process is described elsewhere [1, 2, 6].

3 THE VOLUNTARY TAKE BACK SYSTEM

3.1 Legal background

The contents of hazardous substances listed in the annexes of the new regulations (WEEE and ROHS) will

dominate the costs of collection, waste treatment, recycling and monitoring in the future. For this reason a proactive approach is proposed closely together with the PV-industry, associations, politicians, European and national authorities and the technical adaptation committees. A working group has been established to tailor a regulatory framework with a good eye for the present and future needs of the fast growing PV industry. Thanks to this the setup of a voluntary take back system for PV products (PV-TBS) is strongly supported by associations, environmental governments and several companies.

In the environmental action program of the EU the manufacturer liability is obligatory meaning that the costs of final treatment of end of life products will be financed by the manufacturers and importers. With the EuP directive an environmental impact monitoring of new products will be required (input/output tables or LCA).

A cost effective alternative to a fully regulated system is the establishment of a voluntary take back system in co-operation with the authorities. The system will be organized per contracts between manufacturers, dealers and utilization companies or per organizations and societies in association with an adequate logistic system. External monitoring will have to be set to control the activities of such an organization. It will be financed by escrow funds and manufacturers' and importers' provisions or insurances.

Most of the module waste today is considered to be industrial waste. The necessary efforts on waste treatment can therefore be concluded from the European list of wastes (Table I).

For this type of waste a general recycling quota of 85% can be easily fulfilled by recycling the glass and metals from a module. The recovery of high value material like silicon and silicon wafers that consumed a lot of energy during production is not encouraged by present legislation though technically and economically feasible. A change in legislation is essential so that cost effective high value recovery and recycling processes are more favored versus low value processes (e.g. shredder, metallurgical furnaces etc.) that can recover only impure fractions of materials [7,8].

TYPE	CODE	REMARK
Cryst. Si	200136	Municipal waste, used electrical equipment
	160214	Industrial waste from electrical equipment
Cd-containing modules¹	200135*	Discarded electrical equipment containing hazardous components
	160213*	Discarded equipment with hazardous components
Amorphous silicon modules	170202	Construction and demolition waste – glass

¹Presently the EU's Cadmium directive 91/338/EEC does not prohibit the use of cadmium containing PV modules, because in CdS and CdTe the cadmium is *non-metallic*.

Table I: List of waste relevant to PV modules [7,8], * means hazardous waste

3.2 Present Situation

Most of the end of life products are production

losses, transportation or installation damage and other defects typically covered by the usual 25 years warranties. Thanks to this the end users' contract partners (retailers, installation companies) will be present at the PV generator to check the system and replace defective parts. De-installation of the modules has to be done carefully to avoid unnecessary further damage, thus reducing the module's recycling value. This is of extreme importance since de-installers are frequently more interested in getting the metals from the support structure and the frames for resale without taking any notice on further recycling or waste treatment issues. Such modules typically are completely destroyed and sent for disposal at lowest allowable costs. The metal parts sold to secondary metal dealers, paying more or less for the de-installation. If the modules will be deposited of at least in Germany a pre-treatment to reduce the polymer content is necessary, the residues can be deposited at increasing costs suffering from the heavy metal contents potentially contaminating the ground.

3.3 Organisation of the Take-Back-System

A take-back-system can easily be organized via a transport back to the distributors, the manufacturers or finally the recycling sites. For larger systems it can easily be organized via a central call center at moderate costs. To ensure a successful and high value reverse logistics refunding systems are considered to be initially added to the sales price of the system.

The costs charged to the manufacturers will be moderate as high value recycling can be predominantly financed by reselling of the wafers, silicon, glass, aluminum, silver etc. The costs are dominated by the de-installation and the reverse logistics varying from 0.02 to 0.40 EUR/W_p, in the case of hazardous waste costs higher than 1.20 EUR/W_p are possible.

3.4 Foundation "Joint PV Take Back System", (PV-TBS)

The system organises the collection, repair, reuse, recycling or disposal of spent PV-products including modules of any type, inverters, metal support structures etc. in accordance with the national legislation and the approval by the authorities (fig. 1).

It will be founded by manufacturers and importers of PV products in Europe and should be supported by the associations. The prescribed obligations are distributed among 3 groups of people. The first group consists of the end users who have to return spent modules to the retailers or a collection point of public waste disposal services. The latter two groups are obliged to accept the returned products free of charge. Commercial end users also have the possibility of coordinating collection points with the respective collection and recycling system. Manufacturers and importers of PV products are, in turn, obligated to take back these products from the retailers, public waste disposal services and the commercial end users free of charge and to treat or dispose of them appropriately. This obligation is delegated to PV-TBS as a service provider for the collection and recycling of PV products.

A manufacturer is anyone who manufactures PV products or has PV products manufactured in the European country regardless of which brand name the products carry, if any. If there is no brand name, the person who first puts them into circulation in said Country is deemed to be the manufacturer. An importer

is anyone who imports PV products at any level into the European country and puts them into circulation there for the first time. For this reason the following groups should join the foundation:

- Every manufacturer/importer of PV products
- Every company distributing its own trade mark
- Every company that imports products with PV
- Every company that manufactures and/or imports PV-run appliances and/or puts them into circulation in a European country.
- Every company that packages appliances together with PV and puts them into circulation in Germany.

All of the above points also apply to mail order businesses. Small appliances like watches, pocket calculators, solar battery chargers, solar lanterns are already be covered by the WEEE.

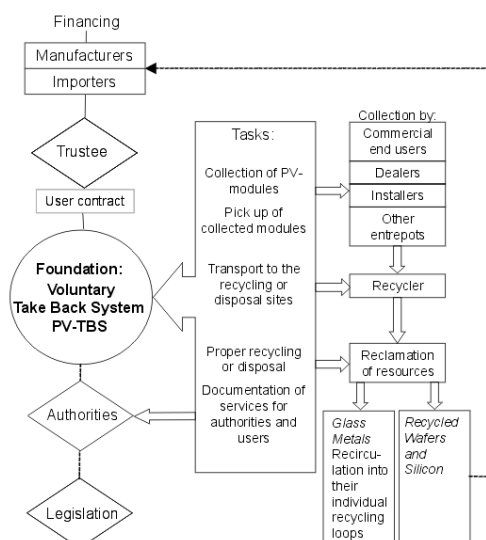


Figure 1: Organisation of the PV-Take Back System

3.5 Draft User Contract

The duty of the foundation is the operation of a collection and recycling system for spent PV products in accordance with the public obligations and the foundation contract. General duties of the user are:

- payment of the fee to the trustee for the PV products put into circulation in the country;
- making the data required pursuant to the countries laws and user contract available to the trustee appointed by the foundation;
- instructing consumers via the appliance user manuals on the demands for high value recycling and environmental or possible safety issues.

Ascertainment of the fee:

- The fee for PV products put into circulation in a country must be paid in accordance with the list of contribution. It is updated regularly.
- The list of contribution is broken down into power and weight categories, type groups and systems.
- The prices are calculated on the basis of the current logistics and recycling costs and the corresponding return rate and a certain percentage of “free riders”.
- The fee is calculated by multiplying the unit prices by the quantity of PV products brought into circulation.
- If particular services are provided by the users themselves, a reduced fee may be agreed.

- Special fees are possible in certain cases like unreasonably high costs for the return and recycling.

PV-TBS as a non-profit organisation must disclose its services and the corresponding expenditures annually. The list of contribution will be adjusted according to the expenditures occurred. It has to guarantee its users:

- blanket coverage of trade, commercial end users and public waste disposal services with suitable collection and transport system,
- the take-back of the collected PV products,
- sorting of the products into the various systems insofar as it is required for recycling or disposal,
- transportation of the products to the recycling and disposal facilities,
- recycling and disposal of the PV products,
- extensive and reviewable documentation of the services for the regional authorities in accordance with the demands.

Furthermore, it is responsible for extensive public relations work on PV product waste treatment and recycling issues. Through regular public reports, press, media, environmental campaigns and other activities, consumers and partners of PV-TBS, e.g. retailers, commercial end users, manufacturers and importers as well as the retailers or public waste disposal services are informed and educated to support the high acceptance of PV energy. PV-TBS will promote the continuous optimisation of the sorting processes and the creation of new recycling opportunities within research and development projects.

4 MODULE COLLECTION

At present no special collection system for end of life modules is established. Modules are mostly disposed as industrial or municipal waste (glass or construction and demolition material) what was acceptable for the small amounts in the past. A big share of today’s defective PV systems is returned to the contract partner (installation company) so that a cost efficient voluntary take back system can easily be organized using this well established distribution network of modules. Though it has not yet been organized systematically a lot of module manufacturers already take back their end of life modules on request not necessarily for recycling but for analysis and finally disposal. Recycling of such modules can be done at about the same amount as disposal costs, (mainly transportation costs), especially if single modules have to be collected from remote areas (high dispersion).



Figure 2: Recommended packaging of end of life modules to avoid further damage (examples)

The collection of spent modules from first generation installations showed up to be difficult because in most cases the modules were thrown from the roofs directly into a container, in several cases the modules were crushed to pieces to get a compaction, the inquiries for recycling were often received after everything was finished. In several cases there was no chance to get even the transportation organized and paid. For this reason it is important to communicate to needs for proper recycling to installation and demolition companies, municipal waste sites and waste treatment companies and of course to the owners of PV systems (fig. 2).

5 CONCLUSIONS

Spent solar modules are not a waste problem today and considered to be industrial waste in most cases. It is expected that future changes in legislation under the "polluter pays" principle will define the requirements of a take back system. To enhance the beneficial impact of photovoltaic on the environment a voluntary take back system in Europe will be started promoting cost efficient and high value recycling solutions. This system can easily be adjusted to future demands. The collection of statistical data will further contribute positively to the economics, the sustainability and public acceptance of PV energy.

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