

PROJECT

RESOLVED – RECOVERY OF SOLAR VALUABLE MATERIALS, ENRICHMENT AND DECONTAMINATION

URL: <http://www.resolved.bam.de>

DURATION

2004 - 2007

PROJECT TYPE

Project within the 2004 EU-programme LIFE-Environment
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SCOPE

The use of renewable energy technologies, such as photovoltaics (PV) should be sustainable and environmentally compatible and therefore protect the environment from risks and damaging impacts.

Regarding the growing number of installed photovoltaic systems, the end-of-life management of the pv-modules will become increasingly important. Thin film panels contain hazardous substances that may harm the environment if they are not recycled or disposed properly after reaching the end of their service life. Heavy metals, for example, can be toxic as well as carcinogenic or teratogenic. Processing methods for the recycling of PV thin film modules have to take these facts into account.

Currently the available recycling techniques usually utilise chemicals such as acids for a wet-chemical treatment of end-of-life modules. The aim of RESOLVED was to identify and test alternative methods for a wet-mechanical treatment in order to reduce the consumption of chemicals in the recycling of thin film modules. Furthermore, the recovered Cadmium-Telluride (CdTe) and Copper-Indium-Diselenide/Disulfide (CIS) should be helping to save scarce resources especially for limited elements such as tellurium and indium.

OBJECTIVES

The project RESOLVED investigated the recovery of semiconductors material as secondary raw material and the decontamination of the residues of the PV thin film modules. These goals were achieved by testing and optimising existing technologies for the recycling process as well as for the enrichment of the semiconductor materials. The target is to re-use the enriched recovered material in the production of new PV modules. Special efforts were made to look into life cycle analysis, process sustainability, economical aspects, and resource availability.

RESULTS

- Two dismantling processes - mechanical and thermal - were tested in order to liberate the semiconductor films for further wet mechanically treatment. A hammer mill and a gyro-wheel mixer were used for the mechanical treatment. An enrichment of semiconductor material in the finer fractions could be observed. A further enrichment of CdTe could be reached by a subsequent hydrocyclone classification, but this classification step was relatively intricate.

The thermal treatment was performed in a temperature range between 450 °C and 500 °C to destroy the EVA (ethylene-vinyl-acetate)-layer, that separates the front glass from the active pv-module layers, Module pieces (30 cm x 30 cm and 10 cm x 10 cm) of CdTe and CIS modules were thermally opened in a laboratory scale oven at BAM. After thermal impact the module is divided into two glass plates – one glass with the semiconductor films on its surface and one clean glass. Thermally opened module pieces were further treated by vacuum blasting to separate the semiconductor material. Vacuum blasting was performed by a German service provider and showed good results in semiconductor material removal with minimal glass abrasion.

- The feasibility of further wet processing steps by attrition in intensive mixers of different sizes and also by flotation were demonstrated. After a treatment in intensive mixers (Eirich intensive mixer), the highest enrichment of CdTe as well as CIS material was determined in the finest fractions.

Flotation was chosen to separate the semiconductor material from the rest of the particle mixture and to get a pre-concentrate for the final purification. The flotation tests placed the emphasis on the enrichment of the valuables tellurium from the CdTe and indium from the CIS module material. Flotation fundamentals such as zeta-potential for pure CdTe and pure glass were determined, several flotation chemicals (frothers and collectors) were examined and their usage optimized.

- For the monitoring of the different processing steps and quality control with regard to non-destructive large scale analysis two methods were applied for the analytical characterisation of the different material fractions: tube-excited energy-dispersive X-ray fluorescence spectroscopy (EDXRS) and Instrumental photon activation analysis (IPAA). The results of the measurements of cadmium and telluride as well as of other heavy metals that are constituents of PV-modules (e.g. copper) were comparable to results of the conventional measurement methods. The advantage of the tested methods is the possibility to examine comparatively large sample quantities. Thus a higher representativeness especially for inhomogeneous mélanges of materials can be achieved.
- In RESOLVED a LCA was performed using impact assessments that were based on a selection defined in the CML 2 Baseline 2000 method, extended with the Non-renewable Energy Use indicator (NREU) as evaluated by the Cumulative Energy Demand method. Since some data for details of the different recycling steps were missing, some assumption had to be made and the results of the LCA have to be considered with caution.

From the results of the LCA it could be concluded that the mechanical opening of the modules had clear environmental advantages in comparison with the thermal opening of the modules and the whole procedure had also clear environmental advantages compared to landfilling and incineration options. Although there were uncertainties in the LCI data for wet separation and missing data for sandblasting it is not expected that improved data would change this conclusion. Also it has been made clear that recovery of tellurium, indium and - to a lesser extent - silver from spent PV modules is vital if we want PV capacity to grow to globally significant levels.

CO-ORDINATOR

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VIDEOS

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MAIN PUBLICATIONS

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