CU-PV

Cradle-to-Cradle sustainable PV modules

Policy Brief

2016

EXECUTIVE SUMMARY

CU-PV FOCUS

Cu-PV or "Cradle-to-cradle sustainable PV modules", is a research & development project financed by the 7th Framework Programme, running from 2012 to 2015. The project consortium consists of 7 market stakeholders and research institutes. The participants represent a variety of equipment technology providers, market experts and researchers with in-depth knowledge in PV Modules, recycling and waste management and plating technology.

Cu-PV aims to maximize resource productivity and reduce pollution in PV production, through minimizing use of critical resources such as energy (by reducing silicon consumption and improving the conversion efficiency), silver and lead, while simultaneously maximizing recycling possibilities, by introducing design for recycling in this sector, and collaborating over the value chain for improvements in recycling.

An expensive curiosity in labs and on space satellites in the 1980s, solar photovoltaics or PV module installations have become a challenger to conventional electricity generation technologies. Solar power has shown in the recent years its ability to adapt to most climates, system sizes and regulatory frameworks all over the world. Every day, large utility-scale solar PV systems are built on all continents and tenders reveal how cheap and competitive PV electricity has become.

In comparison to other energy generating techniques, Photovoltaics (PV) is one of the most promising options: no emission of any matter into the environment during operation; extremely long operation period (estimated average: 25 years or longer); no noise generation; minimum maintenance; and robust reliable technology.

A large part of solar power development until the end of 2014 has been driven by financial incentives or ad hoc support schemes. Low and decreasing prices are changing the mentalities of policy makers across the world, and the recognition that solar PV is a low-cost, low carbon power source, which will become a significant part of the electricity mix of the future, is spreading fast.

By the end of 2014, almost 88 GW or 8 million tonnes of PV modules were installed in Europe. According to Solar Power Europe the European market could reach a total installed capacity of 158 GW by 2019, an almost 80% increase compared to 2014. Collection and recycling of end-of-life PV modules will need to be given attention to protect and further reduce the low environmental footprint of PV.
Therefore, to allow the wide-spread treatment of PV modules tapping into the circular economy, the Cu-PV Partners present this policy brief. It elaborates on:

- assessment of the regulatory frameworks for recycling, and possible improvements
- assessment of the recycling technologies, and possible improvements

The Extended Producer Responsibility implemented by the European WEEE Directive 2012/19/EU oblige Producers and Importers in each country of the European Union to organize the collection, transportation and recycling & treatment, and the financing of these operations, for their PV modules.
The current recycling process aims to recycle more than 80% of the PV module by weight. The process flow begins with the disassembly of the aluminum frame and the junction box. This frameless PV module consists then of the active silicon cell encapsulated in a layer of EVA polymer, laminated to the tough polymer back sheets as well as the glass front sheet.

In a current state of the art recycling process the module may be crushed in a hammer mill. It will fall apart into glass cullets, back sheet pieces, wiring and silicon solar cells. The pulverization results in both smaller and larger materials which may be sorted for recycling. The principal difficulty encountered regarding the recycling of photovoltaic modules is financial and related to scale. The current recycling process and even more so envisioned alternative processes are costly and the waste volumes are still fairly low with regard to industrializing these processes.

In addition different experimental recycling processes have been evaluated, in the Cu-PV project as well as elsewhere, in order to find the strengths and weaknesses:
1) Shredding and incineration,
2) Thermal and chemical process,
3) Pyrolysis in fluidized bed reactor
4) Ultrasonic agitation and organic solvent.

In order to evaluate the current recycling methods and opportunities for improvement by design for recycling, one survey has been drafted in the project and disseminated to recycling companies and another survey to PV module manufacturers. The purpose was to ask their opinion about the technical and economic feasibility of new design methods and options for more complete recycling of PV modules. After analyzing the results of the surveys, recommendations were established for the design for recycling, for PV module components (frame, glass, junction box, EVA encapsulant, solar cells and the back layer).

The Cu-PV Partners invite the policy makers for the following improved policy frameworks:

I. Legislative framework
   1. WEEE Directive 2012/19/EU: realistic and achievable collection target for PV Panels.
   2. Promoting of Best Available treatment Technologies Not Entailing Excessive Costs (BATNEEC).
   3. Promoting Product Environmental Footprint Category Rules (PEFCR)
   4. Lowering the administrative burden towards the management of waste PV modules.

II. Technical framework
   Regarding treatment of PV modules support the Best Available treatment Technologies Not Entailing Excessive Costs (BATNEEC).

III. Sustainability
   Recognizing in public campaigns that PV modules contribute greatly to the prevention of waste due to the manufacturers' product guarantee of 10 years respectively performance guarantee of 20 years and more.

Recommendations relevant to PV module manufacturing include standardizing frame size, tagging, replacing EVA by thermoplastic encapsulant, and replacing poly vinyl-fluoride (Tedlar). Successful recycling will require a collective action by the PV industry.

As the lifetime of PV cells themselves may be much longer than that of PV modules and the manufacturing process of wafers and high-purity silicon feedstock requires relatively much energy, the reuse of cells, wafers, or silicon feedstock would be environmentally preferable, and efforts should be aimed at economic justification.

CU-PV POLICY BRIEF

"Cradle-to-cradle sustainable PV modules" represents the views of the 7 partners in the practice driven Cu-PV consortium. The policy brief was edited by Jan Clyncke (PV CYCLE), Maurice Goris and Bart Geerligs (ECN). The company-related information has been validated by the company representatives and the content reviewed by one of the experts invited to the Recycling workshop held on October 9, 2014 of the Cu-PV project.

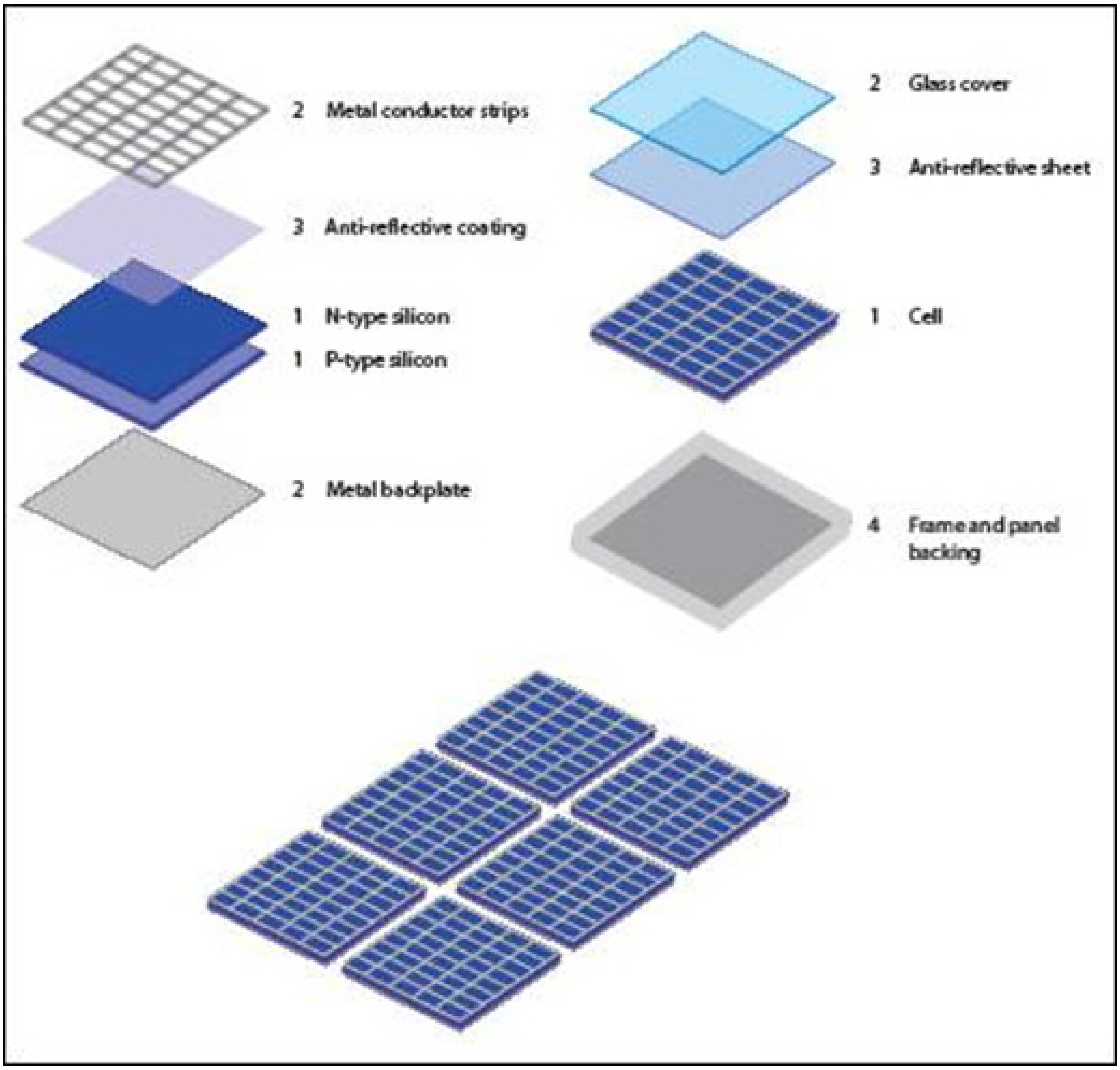

Figure 1 – overview of a photovoltaic cell, a photovoltaic module and its components

The above left shows the internal components of a photovoltaic cell.
The above right shows some principal internal components of a photovoltaic module.
The lower drawing depicts an array of photovoltaic cells in arrangement as in a photovoltaic module.

(Source: Massachusetts Technology Collaborative Renewable Energy Trust)

INTRODUCTORY PERSPECTIVE

Allowing the wide-spread treatment of PV modules tapping into the circular economy this policy brief will point out and elaborate that policy makers need to consider improved policy frameworks with attention to the following aspects:

I. Legislative framework
II. Technical framework
III. Sustainability

Within this Policy brief and the project, the Consortium only includes silicon-based PV modules into its scope. Therefore here one should not expect an insight into the recycling and treatment of non-silicon based PV technologies, nor of upcoming new PV technologies. For the latter it is moreover difficult to estimate their chances of success and market acceptance especially when forecasting technologies for the next 15 years.

GLOBAL PERSPECTIVE

Since 2000, the capacity of photovoltaic solar power has been multiplied by a factor of 100.

Figure 2 shows that over 178 GW was installed globally at the end of 2014, meaning that PV Installations continued their impressive growth. After years of tremendous developments, the market in Europe slowed down in 2013 and this trend continued in 2014. It can partly be explained by the influence of transitioning policies. With around 7 GW installed, in 2014 Europe as a whole was installing less solar power capacity than China or Japan individually, but more than the USA. However Europe is still a dominant player with more than 88 GW installed at the end of 2014.

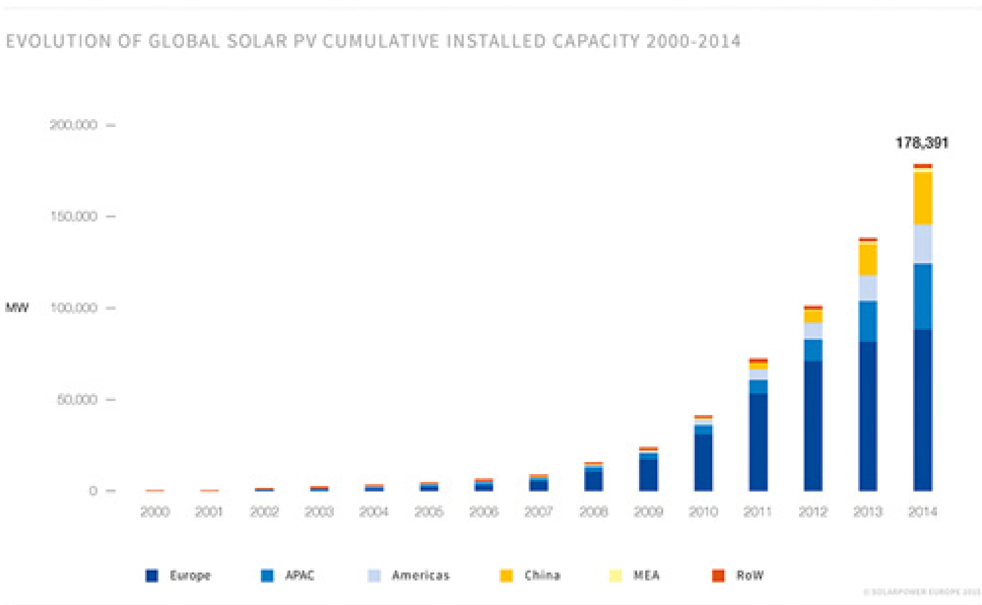

Figure 2 – Evolution of global solar PV cumulative installed capacity 2000 – 2014
(source: Global Market Outlook 2015-2019 by Solar Power Europe)

EUROPEAN PERSPECTIVE

The European solar market is in a transition phase from a period of high feed-in-tariff to an era of unsubsidized solar electricity.
To survive this transition phase, European solar players have gone through drastic system cost reductions.

Innovation in design, construction, and in the development of new products and new Business Models is a key differentiator in this difficult consolidation period.
Looking at the leading markets presented in Figure 3, the UK took the first place in Europe with 2.4 GW installed in 2014. Germany achieved to install 1.9 GW and still represents the second largest PV market in 2014. The one-time global PV leader was under pressure to adjust its support system, with new regulations leading to a 75% reduction of the market over two years (from 7.6 GW to 1.9 GW). France, the third largest European market in 2014 installed close to 1 GW, driven by tenders granted in the past and the growing distributed market.

Beside the top three countries, Italy is in a transition period with less than 400 MW installed despite a good regulatory framework. Considering markets driven by net-metering, the evolution was rather negative in Belgium and Denmark, while the Dutch market increased the annual capacity by 31% from 2013 to 2014. Portugal and Austria installed more than 100 MW.

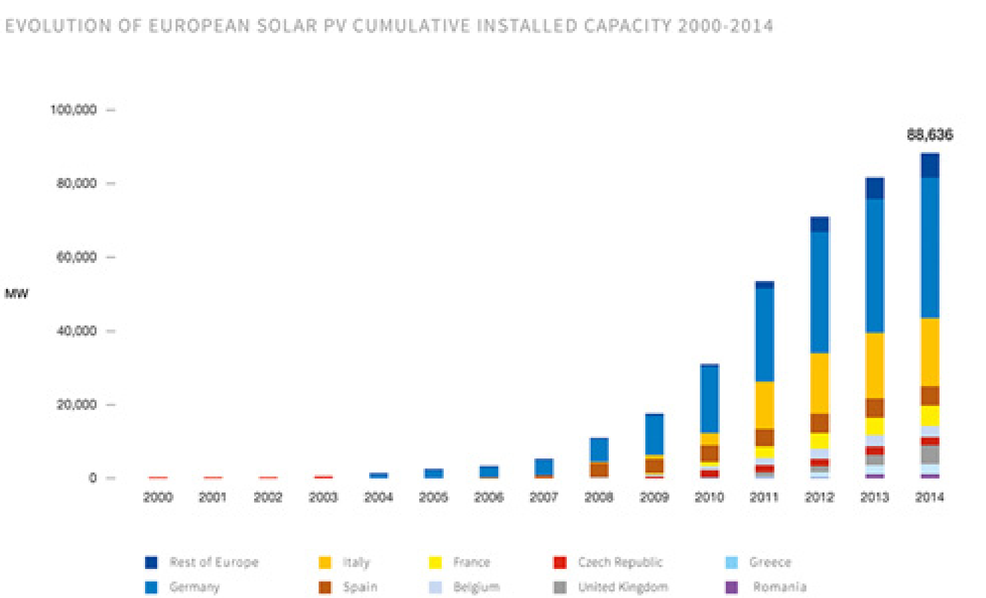

Figure 3 – Evolution of European solar PV cumulative installed capacity 2010 – 2014
(source: Global Market Outlook 2015-2019 by Solar Power Europe)

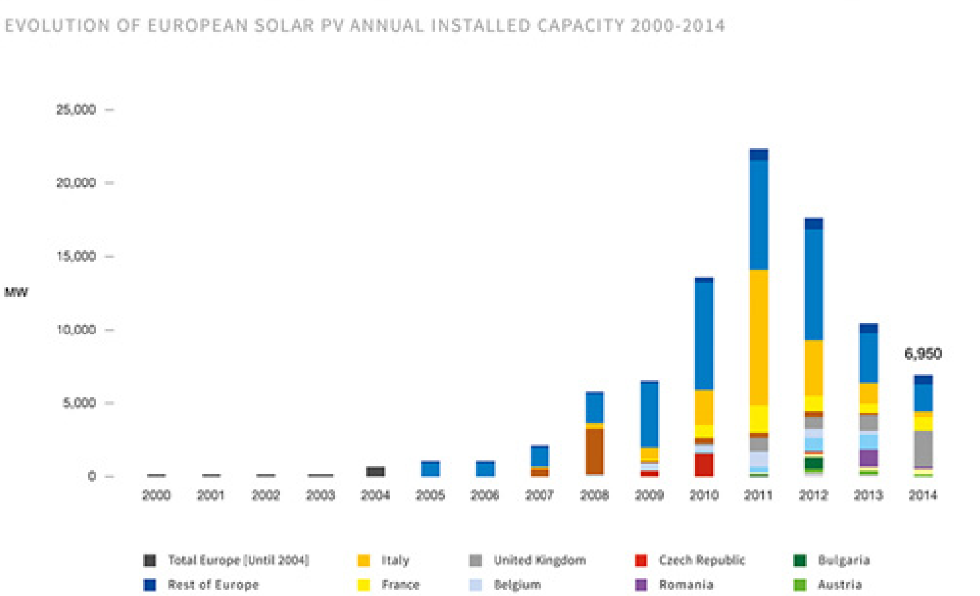

Figure 4 – Evolution of European solar PV annual installed capacity 2000 - 2014
(source: Global Market Outlook 2015-2019 by Solar Power Europe)

At the time this Policy Brief has been drafted no data related to 2015 was available. The authors estimate that in 2015 in Europe around 5 GW has been installed which brings the cumulative number up to 93 GW.

According to Solar Power Europe Figure 5 indicates that the European market could reach a total installed capacity of 158 GW by 2019, an almost 80% increase compared to today. In the Low Scenario, total installed capacity would be above 120 GW by 2019.

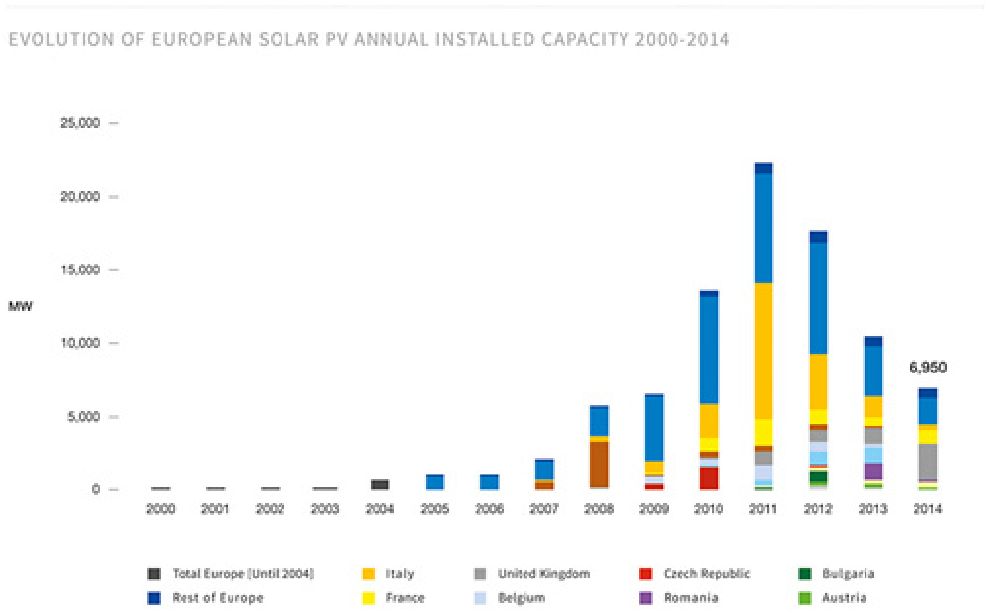

Figure 5 – European cumulative solar PV Market scenarios until 2019
(source: Global Market Outlook 2015-2019 by Solar Power Europe)

When converting Figure 3 into tonnage of waste one sees the major challenge for recycling and treatment of PV modules in Europe. The non-structural growth of solar PV neither enables nor attracts investment from the recycling and waste management industry.

Although there is already a potential of 88 GW or 8 Million tonnes of PV modules waste as of 2014, the long lifetime of the product and a return rate of less than one percent during the first 10 – 15 years of its lifetime are not supporting the ramp up of an economically viable recycling and treatment technology of PV modules yet.

PV modules are excluded from the scope of the ROHS Directive (Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment).

PV modules are under the scope of the WEEE Directive (Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on Waste Electrical and Electronic Equipment (WEEE).

Several technologies related to the treatment and recycling of PV modules exist on an experimental scale. The technologies vary from mechanical treatment or chemical treatment to cryogenic separation or plasma pyrolysis technology.
Today's most used treatment technology is shredding of PV modules in order to recover the glass, the aluminum, the copper and the materials of the junction box.

BUSINESS EXPERIENCES IN PV MODULE RECYCLING

The research into module recycling started at an international level at the beginning of the nineties, with companies like AEG and successors, Pilkington Solar International GmbH, BP Solar, Siemens Solar, Soltech, Solar Cells Inc. and institutes such as AIST (Japan), ECN (Netherlands), and BNL (USA) getting involved. Recycling companies have only recently begun to take an interest in these products as they have realized a **significant increase in waste will occur as from 2030 and beyond.**

Already at the beginning of the nineties, end customers asked producers and dealers for recycling possibilities; so the buyers of the first PV systems already showed a clear awareness of protecting the environment and retaining the value of modules at the end of their useful life.

Due to the then low quantities, concern was mainly focused on integrating PV modules into existing material cycles, drawing on technical developments and experiences from other industries.

In the meantime, in particular producers have obtained comprehensive expertise regarding the recycling possibilities of PV modules. For the foreseeable future, however, producer-specific processes will not be profitable as even the waste generated by major producers will not be sufficient to use the necessary recycling plants to their full capacity. In the meantime, waste management companies have started to take an interest in this sector; however, due to high failed investments in other waste areas in the past, they stay away from getting involved in specialized technology and favor the integration in existing recycling processes.

Table 1 shows processes that have been developed since the nineties.

Table 1: overview of some known recycling activities in the period 1990 – 2007

Operator	Treatment Process	Size/Stage of Development	PV Technology
Deutsche Solar AG	Thermal separation, chemical processing	Pilot Project, ecological consideration	Crystalline, thin film in laboratory
Solar Cells Inc.(currently First Solar), BNL	Thermal decomposition in Inert gas	Laboratory	Crystalline
Isofotón	Cell recycling Swelling Shredding Repairable module	Laboratory	Laboratory
AIST, Sharp, Asahi	Wafer recycling with mineral acids Solvent swelling (Cellsepa-Process) Repairable module	Laboratory	Crystalline
Photovoltech	Repairable module	Laboratory	Crystalline
BP Solar, Soltech, Seghers, ECN	Wafer recycling with mineral acids Wafer recycling in fluidized bed	Laboratory/Technical college	Crystalline
Pilkington Solar International	Thermal separation	Laboratory/Technical college	Crystalline
Siemens Solar, Shell Solar, Showa Shell	Ferrosilicon production High pressure water jet	Laboratory	Crystalline, thin film
Other	Module shredder, Mechanical separation Acid treatment Smelter, Concrete aggregates, road construction	Laboratory	Crystalline, thin film

NEW TECHNOLOGY DEVELOPMENTS: THE CU-PV PROJECT

The Cu PV Project has studied and analyzed thermal and chemical processing to extract module components intact from end-of-life PV modules for recycling or reassembly into new PV modules.

The objectives of this work were to identify the processes that consume few resources and have no or reduced use of toxic chemicals, and extract more value from the recovered materials.

The overall principle of the recycling processes investigated in this project involved separation of the backsheet from the laminate, followed by treatment of the laminate in order to separate glass and cells. Thermal treatment turned out to be a useful and promising process to allow recovery of silver and silicon. Several furnace processes were included in the studies by Technical Plating and ECN: pyrolytic fluidized bed reactor, a gas-fired incineration oven, etc. The new processes give better options for re-use of materials and return more value than the current recycling process. The overall economics of the new recycling processes were evaluated indicating that an economic benefit can be possible at sufficiently large scale. A semi-automated line was established based on some of the processes. This line can be used to test processes and assess economics at a larger scale, and create larger quantities of recycled materials to investigate re-use.

Economic insights

Within the Cu-PV project three different methods of recycling PV modules have been compared.

The first method developed by Technical Plating comprises a process flow in which the junction box, aluminum frame and backsheet are removed. The modules with broken glass are incinerated in a chamber furnace resulting in glass and solar cell fragments and tabbing material. From the modules with unbroken glass the encapsulant/cell sandwich is cut from the glass. The sandwich is incinerated in a chamber furnace and the glass is mechanically cleaned.

The second method, evaluated in the Cu-PV project by ECN, comprises a process flow in which, after removing junction box, aluminum frame and backsheet, the remaining module is heated in a fluidized bed reactor resulting in glass and solar cell fragments and tabbing material. This recycling method becomes more profitable when implementing the PV modules with thermoplastic as encapsulant newly designed within Cu-PV. It was proven that in recycling of PV modules with thermoplastic as encapsulant the cell breakage during recycling is drastically reduced.

The third recycling process was developed by Eurotron and ECN. This process cuts the solar cell from the glass resulting in complete solar cells that can be cleaned. This process is only possible for the newly designed PV modules using thermoplastics.

Within the Cu-PV project the economic feasibility of these three new recycling methods was investigated. When the amount of end-of-life PV modules exceeds a yearly amount of more than about 3000 ton (150.000 pieces), it was estimated that the recycling of these modules can yield a positive business case. Based on the assumption made in these calculations, the semi-automated process of Technical Plating has a good return on investment (ROI). This process is used for state of the art PV modules with EVA as encapsulant and yields no additional profit when thermoplastic is used in PV modules.

Recycling newly designed PV modules with thermoplastic as encapsulant using the recycling methods developed by Eurotron and ECN or the fluidized bed reactor, is projected to become more profitable than the recycling method of Technical Plating when the volume increases and the value of the recovered silicon can be realized. This is partly a result of the higher level of automation foreseen for these recycling processes. They require the highest investment, but with this investment the highest sales price is foreseen for the raw materials extracted from a PV module.

When the PV module is recycled according to these enhanced processes (read a higher “clean/pure” recycling percentage of the volume per module), this also has a positive impact on the ecological footprint of PV modules.

POLICY IMPLICATIONS AND RECOMMENDATIONS

1. Support for (current) recycling

The policy support for the current recycling and treatment activities regarding photovoltaic waste is limited.

Although the amount of waste is very low, the PV and waste treatment industry needs to find solutions for the future when huge amounts will come in. Therefore the development of treatment methods should continue and be further facilitated.

One of the barriers is that when the product is discarded – from a legal point of view – this is waste and thus falls under the scope of the waste legislation. The latter is quite regulated and requires a lot of administration.

However with very low amounts of discarded PV modules the administration and the compliance requirements of the waste legislation are a huge burden to find partners willing to test the treatment of discarded PV modules, to step into R&D-projects, or – most important – to invest in (large) economically scaled treatment process lines.

Recommendations:

- Enable the shipment of end-of-life PV modules as products which can be collected and taken back by using the Reverse Logistics mode. New PV modules are brought into the market by trucks and other transportation modes; instead of returning – after delivery – empty all these transportation modes this process can be optimized by allowing – without the strict administration related to waste – to ship back the discarded PV modules to decentralized intermediate storage points. Innovation can only be supported by policy makers who at the same time encourage an optimization of the logistics upstream and downstream, thus enabling innovative treatment solutions.
- Facilitate treatment of discarded PV modules in small quantities by reducing significantly the administrative burden
- Classify the glass sheets - from which prior the junction box and aluminum frame is removed - as Glass waste in non-dispersible form (B2020 Basel Convention) in order to achieve a business friendly transborder shipment of waste.

2. Lowering the administration around the Waste legislation for PV Modules

There is a lot of waste legislation related to the general waste management, the licensing of treatment plants, and the extended producer responsibility. This results in a very complex environment with consequences for the implementation of treatment solutions for PV modules.

Understanding, analyzing and implementing the requirements already need experts today while the volumes of waste will still be very small over the next 15 years.
Moreover the existing waste legislation does not reward the characteristics of a PV module as PV prevents lots of waste during many years.

Reducing the amount of waste generated at source, and reducing the hazardous content of that waste, is regarded as the highest priority according to the Waste Hierarchy established in Article 4 of the Waste Framework Directive. Waste prevention is closely linked with improving manufacturing methods and influencing consumers to demand greener products and less packaging.

The 7th Environment Action Programme 'Living well, within the limits of our planet' highlights the importance of waste prevention, indicating that there is considerable potential for improving waste prevention and management in the Union to make better use of resources, open up new markets, create new jobs and reduce dependence on imports of raw materials, while having lower impacts on the environment.

A couple of examples to support this:

a) The European Waste Catalogue (EWC)

The List of Waste is meant to be a reference nomenclature providing a common terminology throughout the Community with the purpose to improve the efficiency of waste management activities. The List of Waste (LoW) serves as a common encoding of waste characteristics in a broad variety of purposes like classification of waste and hazardous waste. Assignment of waste codes has a major impact on the transport of waste, installation permits, decisions about recyclability of the waste, or as a basis for waste statistics.

According to Decision 2000/532/EG, the List of Waste should be revised regularly on the basis of updated knowledge and, in particular, of research results.
As the photovoltaic panel is a completely new product, there is no reference in this EWC.

Therefore currently one tends to use the existing codes related to Waste Electronic and Electrical Equipment (WEEE).

This is workable for the PV industry. However, not all 28 EU-Member States are aligned in the view that the EWC for PV modules can be similar as for WEEE, and it is not the role of the PV or waste industry to convince all the member states to adopt this view. On European level the PV and waste industry miss support and a leading role by the competent authorities to pro-actively solve this issue immediately for all 28 EU-Member States.

Especially as the same European authorities are keen on correct data from the Member States regarding the collected amount of waste, especially the waste flows from products under Extended Producer Responsibility, this would logically be a priority.

b) The European Waste Shipment Regulation and the Basel Convention

Shipping waste from one country to another country within the European Union, and waste shipped in- and outside the European Union, is regulated under the Waste Shipment Regulation (WSR) (1013/2006/EU).

Some Member States within the European Union consider discarded PV modules as a Green listed waste under the Basel Convention (i.e. B2020), while others have the opinion that a PV module is not under one of the codes of the Basel Convention nor the codes applicable in the WSR.

This results in situations where the first type of countries consider discarded PV modules as "green listed " waste and thus shipping is allowed with a very limited number of administrative requirements while the second type of countries consider the same discarded PV modules as "amber listed" waste for which a huge pile of administration needs to be completed, a bank guarantee covering the amount of tons multiplied with the cost established by the country, and many more requirements apply.

For efficient processing, the very limited number of discarded PV modules which look for economically viable solutions and look for R&D-projects in which treatment and recycling is supported, often need to be shipped across country borders. This is hampered by the different opinions of the countries related to the classification of a discarded panel within the scope of the WSR.

c) PV module being considered as Electrical and Electronic Equipment (EEE) and WEEE

The legislator added the photovoltaic panel under the scope of the WEEE Directive (2012/19/EU).

The WEEE Recycling industry considers a PV module as a classical WEEE-product being plastics and metals while in reality a PV module is a laminated glass product.

Thus, to find today treatment solutions one needs the flat glass recycling industry, which does not have the appropriate waste codes in their permit to treat what is from an administrative point of view (see above re. the EWC) being categorized as WEEE.

A more harmonized implementation of legislation and a tailor-made approach for PV waste is recommended, as the waste coming from the PV industry is currently considered within the waste administration, at every level, as unknown or too exotic and thus no answers are available, while on the other hand solutions will be available when all countries apply the same administrative conditions.

<u>Recommendations:</u>

- The European Union is invited to organize a uniform legislation in all member states in regard to the classification of discarded PV modules.
- Make a distinction between silicon based and non-silicon based PV modules.
- Facilitate transportation of silicon-based PV modules, as well after as prior to removal of junction box, across the country borders to treatment facilities.
- Allow - under certain conditions – the shipment of end-of-life silicon-based PV modules as returned products to allow reverse logistics which then enables support for the search for innovative treatment solutions.

3. Research support

The European Photovoltaic Technology Platform is a European initiative which aims at mobilizing all the actors sharing a long-term European vision for photovoltaic. The Platform sets the European Strategic Research Agenda for PV for the next decade(s) and gives recommendations for implementation.

In addition, within the European Strategic Energy Technology Plan (SET-Plan) there is an industrial PV initiative, Solar Europe Initiative (SEI), which is to strengthen cooperation with member states.

There is attention for recycling and sustainability of PV in both instruments, in particular the insertion of priority B.6. under the chapter Quality in the PV Implementation Plan 2013 -2005 of the SEI Initiative Team, 'Development of design criteria facilitating low-cost efficient recycling processes according to relevant EU standards and directives for new designs for all PV technologies and Balance of System components. Development of easy-to-access recycling infrastructure available to all is included here'. Nevertheless, in practice, the Consortium notices a lack of concrete involvement towards recycling initiatives and the recycling and waste management industry.

Recommendation:

- The European photovoltaic industry and the waste and recycling management industry must work together in order to achieve the priorities listed in for example SEI-Implementation plan(s).
- Existing platforms within the PV industry having R&D in their scope must enable much better the coordination, exchange and dissemination of R&D projects related to recycling and treatment of PV modules.

4. Product environmental footprint

Assessing and displaying the environmental footprint of a PV module can be one of the options to enhance the development of improvements, and more generally, to steer the market. For example, consumers may prefer to purchase products which are labelled with a good (low) footprint, or legislation may be installed to require a state-of-the-art (or better) footprint for commercial products.

PEFCR

Over the past years, the European Commission has been working towards establishing a common methodological approach to enable Member States and the private sector to assess, display and benchmark the environmental performance of products, services and companies based on a comprehensive assessment of environmental impacts over the life-cycle ('environmental footprint').

A Product Environmental Footprint project was initiated with the aim of developing a harmonized environmental footprint methodology that can accommodate a broad suite of relevant environmental performance criteria.

Product Environmental Footprint Category Rules (PEFCR) aim at providing detailed technical guidance on how to conduct a product environmental footprint study. PEFCRs complement general methodological guidance for environmental footprint by providing further specification at the product level. PEFCRs will increase reproducibility and consistency in product environmental footprint studies.

Photovoltaic electricity generation is one such product for which the PEFCR is studied in a pilot project.

The most straightforward way to introduce design-for-recycling in PV modules might be putting emphasis on the allocation of benefits to a recyclable product (regardless of whether it contains recycled materials or not).

For introducing new recycling methods in the waste treatment industry, it seems to be advisable to put emphasis on the allocation of benefits to a product which incorporates recycled materials.

There is a chicken and egg problem in this. Since the amount of waste modules is still very low, in practice it will for many years be difficult to incorporate a high fraction of recycled materials in cSi PV modules. However, allocating benefits to a recyclable product will make assumptions about whether in the future appropriate recycling processes will be installed and applied. Also, it is a question how to assess "recyclability" of modules.

<u>Recommendation:</u>

- It may be most advisable in the PEFCR for PV modules, to put emphasis on the content of recycled materials. This will create an incentive to manufacture recyclable products, but it will avoid the issue of having to define what "recyclability" is.

5. Eco-design and Energy Labelling

The Eco-design Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of Eco-design requirements for energy-related products and the Energy Labelling Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products are the two pillars of the European policy for energy efficient products. Products covered by the Eco-design Directive can only be put on the European market if they fulfill minimal requirements. The European Commission will present a package consisting of a review of these two Directives and of a new Eco-design Working Plan 2015-2017 in 2015.

The draft preparatory study for the Eco-design Working Plan 2015-2017 considers PV modules and inverters used in PV Systems as a product eligible for Ecodesign measures.

POLICY SUMMARY AND RECOMMENDATIONS

For current recycling, there is a number of issues which have to do, in particular, with non-harmonized waste classification, and transport of waste across borders.

For future recycling, there is a useful initiative in the European Union for a common methodological approach to environmental performance of products. This can enhance the reduction of environmental footprint through novel PV module construction and recycling methods together with Product design requirement of the WEEE Directive 2012/19/EU.

The **recommendations** to manage the waste originating from the present nearly 100 GW installed PV modules or 8 million tonnes of PV modules in Europe and future additions, through the short, mid- and long term are the following:

I. Legislative framework

1. Realistic and achievable collection target for PV Panels (WEEE Directive).

2. Enable the shipment of end-of-life PV modules as products which can be collected and taken back by using the Reverse Logistics mode.

3. Facilitate the treatment of discarded PV modules in small quantities by reducing significantly the administrative burden

4.Classify the glass sheets - from which prior the junction box and aluminum frame is removed - as Glass waste in non-dispersible form (B2020 Basel Convention) in order to achieve a business friendly transborder shipment of waste.

5. A uniform legislation in all member states in regard to the classification of discarded PV modules.

6. Facilitate the shipment of silicon-based PV modules, after as well as prior to removal of junction box, across the country borders to treatment facilities.

7. Promoting Product Environmental Footprint Category Rules (PEFCR)

II. Technical framework

1. Regarding treatment of PV modules support the Best Available treatment Technologies Not Entailing Excessive Costs (BATNEEC).

2. Towards collection, allow a distinction between silicon based and non-silicon based PV modules.

3. The European photovoltaic industry and the waste and recycling management industry must work together in order to achieve the priorities listed in for example SEI-Implementation plan(s).

4. Existing platforms within the PV industry having R&D in their scope must enable much better the coordination, exchange and dissemination of R&D projects related to recycling and treatment of PV modules.

III. Sustainability

1. Recognizing in public campaigns that PV modules contribute greatly to the prevention of waste due to the manufacturer' product guarantee of 10 years respectively performance guarantee of 20 years and more.

2. Emphasize in the Product Environmental Footprint (PEFCR) for PV modules, the promotion of using recycled materials in the products.

Consortium:

Energy Research Centre Netherlands (NL), MECO (NL), IMEC (BE), XJET 3D (IDE), Technical Plating (ES), Eurotron (NL) and PV CYCLE (BE)

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FURTHER INFORMATION

Full project results at www.sustainablepv.eu
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