From: Hill, Evan <ehill@Dewberry.com>
Sent: Thursday, March 14, 2019 12:31 PM
To: Wanda Parrish
Subject: FW: [External] RE: CdTe PV peer reviews
Attachments: Nover_2017_Jpn._J._Appl._Phys._56_08MD02.pdf; Sinha_2018_Jpn._J._Appl._Phys._57_019101.pdf; LobbyControl NTSA Report_EN.pdf

FYI and below.

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From: Andreas Wade [mailto:Andreas.Wade@FIRSTSOLAR.COM]
Sent: Thursday, March 14, 2019 12:01 PM
To: Hill, Evan <ehill@Dewberry.com>; Charlie Payne <cpayne@hirschlerlaw.com>
Cc: Karen Drozdiak <Karen.Drozdiak@FIRSTSOLAR.COM>; Parikhit Sinha <Parikhit.Sinha@FIRSTSOLAR.COM>
Subject: RE: [External] RE: CdTe PV peer reviews

This message originated from outside your organization

Hi Evan,

The full study is only available in German – however, the authors of the study (lead author: Jessica Nover) have published a summary of the results in the Japanese Journal of Applied Physics (see reference below). We have commented on those results in the same journal with a reply to their article. I am attaching both for your reference.

Nover, Jessica, Renate Zapf-Gottwick, Carolin Feifel, Michael Koch, Jörg W. Metzger, und Jürgen H. Werner. „Long-term leaching of photovoltaic modules“. Japanese Journal of Applied Physics 56, Nr. 8S2 (2017): 08MD02. https://doi.org/10.7567/JJAP.56.08MD02.

Sinha, Parikhit, und Andreas Wade. „Comment on "Long-term leaching of photovoltaic modules"“. Japanese Journal of Applied Physics 57, Nr. 1 (2018): 019101. https://doi.org/10.7567/JJAP.57.019101.

Below a summary on the main critic points on the study and the approach taken (as also reflected in our comment to the journal paper):

1. **The study basically demonstrated, that acidic solutions can leach out cadmium and tellurium from broken panels – this is exactly what we are doing in our recycling process, to recover the materials after we have broken the panels, to delaminate the monolithic structure which safely encapsulates the semiconductor layer throughout its lifetime.**

2. **The conditions which are used in the study are not representative of field conditions, nor are those in compliance with standard leaching tests (which are used by regulators to assess the risk of leaching):**
   - The Stuttgart study used non-standard leaching methods. First Solar has participated in multiple official and independent waste characterization studies, which confirmed that First Solar modules can be characterized as non-hazardous waste in Europe
   - The leaching study is not representative of field conditions:
     - Modules are more likely to crack rather than break into small delaminated 5 cm pieces.
     - It is unlikely that broken module pieces would remain permanently immersed at a constant pH for 360+ days.
     - In a dumping scenario, oxidative conditions would typically decrease as modules would be covered with other waste or dirt. CdTe is insoluble under oxidation reducing conditions.
     - The study concluded that leaching from broken module pieces was highest under acidic conditions however landfills have predominantly neutral to slightly basic conditions over their lifetime.
     - The study directly compares the leachate to conservative drinking water limits however fate and transport analysis is necessary to evaluate how leachate transforms and disperses in moving from the point of emissions to the point of exposure, prior to making comparisons with drinking water limits.
     - The New Energy and Industrial Technology Development Organization (NEDO) in Japan conducted a leaching study which is more representative of field conditions by using a leachate pH of 5 to simulate acid rain (rather than pH 3 which is too extreme) on cracked modules (rather than 5 cm pieces) with a quantity equivalent to 40 days of average rainfall (rather than constant submersion in 1 liter of acidic water). The NEDO study concluded that "there is no problem in the environmental effects."

   - The results of the Stuttgart study reflect an illegal dumping scenario and are not representative of normal PV end-of-life management practices:
     - It is unlikely that PV modules would be simply abandoned in the field since most countries have local permitting requirements which usually include stringent decommissioning and land remediation measures.
     - In Japan, end-of-life PV panels are treated under the general regulatory framework for waste management (the Waste Management and Public Cleansing Act) which defines wastes, industrial waste generator and handler responsibilities, industrial waste management including landfill disposal.
     - In the U.S., PV panels have to be disposed of in line with the Resource Conservation and Recovery Act which is the legal framework for managing hazardous and non-hazardous solid waste.
     - In Europe, recycling of all solar panels is mandated under the Waste Electrical and Electronic Equipment (WEEE) Directive.

   - We agree that recycling policies and regulations are needed worldwide and have a long-standing leadership in PV lifecycle management:

- We established the industry's first voluntary global prefunded module recycling program in 2005, and are the only PV manufacturer capable of offering global PV recycling services today.
- We proactively invest in recycling innovation to drive the cost of recycling down to the level where recycling is more economical than disposal.
- First Solar offers pay-as-you-go Recycling Service Agreements (RSA) which provide a convenient way of helping customers meet various regulatory and permitting requirements globally.
- In addition to minimizing environmental impacts, PV power plant decommissioning generates economic benefits. Recycling modules and structure components, e.g. copper, steel and aluminum, can create a net revenue of up to $1.58 per module area.

I think it is also important to understand, that the research team (as Fthenakis rightly pointed out) has a history – especially the head of the research group, Prof. Juergen Werner – and historically shown a strong bias against CdTe thin-film technologies. The reference made by Prof. Fthenakis on competitors funding that kind of research in the past, can be substantiated – I am attaching a memo from a German NGO (LobbyControl) on this history – which I think would be crucial to take into account to validate/interpret the statements made by Werner et.al. on this study – especially in the press articles which are flying around on this topic.

Please feel free to get back in touch, if you need any further information/background. Also don't hesitate to give me a call if needed. Copying our Senior Scientist Ricky Sinha as well, who was co-author of the published rebuttal comment.

Regards

Andreas Wade

From: Hill, Evan <ehill@Dewberry.com>
Sent: Donnerstag, 14. März 2019 11:40
To: Charlie Payne <cpayne@hirschlerlaw.com>
Cc: Karen Drozdiak <Karen.Drozdiak@FIRSTSOLAR.COM>; Andreas Wade <Andreas.Wade@FIRSTSOLAR.COM>
Subject: [External] RE: CdTe PV peer reviews

I am being asked to comment on the attached; however, this is just a summary article of the Stuttgart study. Dr. Fthenakis indicated at the meeting that he was familiar with this study and why it should not be considered. I am tasked with substantiating his claim. Can your team obtain the actual study and provide commentary as to the applicability?

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From: Charlie Payne [mailto:cpayne@hirschlerlaw.com]
Sent: Thursday, March 14, 2019 6:49 AM
To: Hill, Evan <ehill@Dewberry.com>
Cc: Karen.Drozdiak@FIRSTSOLAR.COM; Andreas.Wade@FIRSTSOLAR.COM
Subject: FW: CdTe PV peer reviews

This message originated from outside your organization

Evan,

Below is a link to the information regarding the safety of CdTe panels requested by the board of supervisors at this past Tuesday's meeting. I've also copied Karen Drozdiak and Andreas Wade from First Solar who can provide you any additional information you may require.

Thank you and please let me know if you have any questions.

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From: Karen Drozdiak [mailto:Karen.Drozdiak@FIRSTSOLAR.COM]
Sent: Wednesday, March 13, 2019 8:34 PM
To: Charlie Payne
Cc: Andreas Wade
Subject: [EXTERNAL] RE: CdTe PV peer reviews

Hi Charlie,

The email I sent you below bounced back because it was too large. I've uploaded the documents onto a OneDrive folder so that you can download them from there: https://1stsolar2-my.sharepoint.com:443/:f:/g/personal/fs109182_firstsolar_com/Es433jUmbv1EuKphrGgpJigBXsUBs1i8TZtxCVe6DegE1g?email=cpayne%40hirschlerlaw.com&e=364hbg

Let me know if you have any trouble accessing it!

Best,
Karen

Visit Dewberry’s website at www.dewberry.com

Long-term leaching of photovoltaic modules

2017 Jpn. J. Appl. Phys. 56 08MD02

(http://iopscience.iop.org/1347-4065/56/8S2/08MD02)

Japanese Journal of Applied Physics **56**, 08MD02 (2017)
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REGULAR PAPER

Long-term leaching of photovoltaic modules

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Some photovoltaic module technologies use toxic materials. We report long-term leaching on photovoltaic module pieces of 5 x 5 cm^2 size. The pieces are cut out from modules of the four major commercial photovoltaic technologies: crystalline and amorphous silicon, cadmium telluride as well as from copper indium gallium diselenide. To simulate different environmental conditions, leaching occurs at room temperature in three different water-based solutions with pH 3, 7, and 11. No agitation is performed to simulate more representative field conditions. After 360 days, about 1.4% of lead from crystalline silicon module pieces and 62% of cadmium from cadmium telluride module pieces are leached out in acidic solutions. The leaching depends heavily on the pH and the redox potential of the aqueous solutions and it increases with time. The leaching behavior is predictable by thermodynamic stability considerations. These predictions are in good agreement with the experimental results.

1. Introduction

Many different elution tests for waste characterization exist worldwide to quantify leached elements out of different wastes and to classify them into risk groups.[1–4] All these tests have different requirements regarding sample size, leaching solution and treatment method. For example, the European Standard EN 12457-4 for the characterization of granular waste materials demands distilled water as leaching solution.[1] In contrast, the Toxicity Characterization Leaching Procedure (TCLP), used in the United States, requires acetic acid and sodium hydroxide as solution with a pH = 4.93 ± 0.05.[2] For all these tests, leaching is only applied for 18 to 48 h. Therefore, the tests have to apply conditions (e.g., orbital shaking or end-over-end agitation) which simulate accelerated aging.

Nevertheless, it is not clear if these short leaching times allow meaningful predictions for the long-term leaching behavior. For example, leaching tests on copper indium diselenide (CIS), cadmium telluride (CdTe) and module pieces from crystalline silicon (c-Si), amorphous silicon (a-Si), and copper indium gallium diselenide (CIGS) also occurred only over a maximum of 48 h and the leaching results are low.[5–9] In these studies, the eluted amount of cadmium reached only 5.3 to 6.4%[6] and 0.6%.[9] Considerably higher amounts were achieved in our recent worst-case study which investigated leaching of milled module powder instead of whole module pieces.[10]

However, some studies reported also leaching results which are very close to the TCLP limits or even exceed them especially for lead from c-Si modules and cadmium from CdTe modules.[11–15] Steinberger showed also leached elements from broken and unbroken CIS and CdTe modules by natural rainwater.[16] In case of leaching broken modules, the limit of the German drinking water regulation is exceeded.[17]

Zimmermann et al. reported long-term leaching tests on CIGS and organic photovoltaic cells (OPV).[18] After four months of exposure, the authors measured substantial amounts of leached elements.

The potential risks of environmental pollution due to improperly discarded photovoltaic (PV) modules are addressed by so-called ecotoxical tests where bioassays with different species are conducted by using the leaching solutions from standard leaching tests.[19–22)]

Numerous studies dealt with life cycle analyses of PV modules starting with mining the raw materials, continuing with their processing, the actual manufacturing and operation of PV modules and ending with disposal or recycling.[23–27] According to the authors there are only few emissions during production and operation, but they did not consider in detail the potential risks posed by the disposal of used PV modules into landfills. Only the study by Cyrs et al. faced this important issue.[28] The authors stated that the health risk due to disposing CdTe modules in landfills is remote at current disposal rates. But if the rates increase markedly they suggested to revisit this question. However, all their evaluations of the potential risks were based on disposal into official lined landfills. They did not consider the possibility that PV modules could get disposed somewhere else in the environment.

Standard leaching tests are only performed over one to several days. In comparison, if modules or module pieces are — legally or illegally — dumped or landfilled somewhere, they certainly remain there for weeks, months, years, or, forever. Therefore, it is important to know if leaching occurs or not, what will be leached out, and how fast. Nevertheless, no studies are available about leaching tests of PV modules over a long period.

The present study reports on leaching of 5 × 5 cm^2 module pieces, cut out from commercial modules using either c-Si, a-Si, CdTe, or CIGS. So far, the experiments have lasted over 360 days without applying accelerating agitation. Even under these conditions, substantial leaching of toxic substances is observed. Thus, it is only a question of time until hazardous elements release into the environment if broken modules are improperly disposed.

2. Experimental methods

In order to identify the leaching mechanisms as well as potential weak spots in the modules, we analyze not only leaching of toxic substances like cadmium (Cd), lead (Pb), and selenium (Se), but also other elements: silver (Ag), zinc (Zn), tellurium (Te), indium (In), gallium (Ga), aluminum (Al), molybdenum (Mo), nickel (Ni), and copper (Cu). To obtain module pieces with well-defined sizes and edges, we

Table I. Composition of leaching solutions with pH values 3, 7, and 11 used in the experiments.

pH	E_H (V)	Chemical composition	Simulated environmental condition
3	0.62	15.4 g/l $C_6H_8O_7$, 2.8 g/l Na_2HPO_4, DI water	Acid rain[29]
7	0.56	3.7 g/l KH_2PO_4, 5 g/l Na_2HPO_4, DI water	Groundwater
11	0.33	0.04 g/l NaOH, DI water	Alkaline percolating water on waste disposal sites[30]

Table II. Total mass of elements in one module piece for c-Si, a-Si, CdTe, and CIGS.

Element	Total mass per 1 module piece ($5 \times 5\,cm^2$) (mg)			
	c-Si	a-Si	CdTe	CIGS
Ag	7.8 ± 0.9	2.2 ± 0.3	0.05 ± 0.005	1.2 ± 0.4
Sn	21.3 ± 1.1	31.0 ± 1.7	12.5 ± 3.9	19.1 ± 0.4
Zn				16.1 ± 1.6
Cd			14.9 ± 1.6	0.2 ± 0.001
Te			15.9 ± 1.1	
In				19.2 ± 0.7
Ga				0.7 ± 0.2
Se				8.2 ± 0.8
Al	167.2 ± 49.9			
Mo			13.0 ± 1.8	5.0 ± 0.2
Cu	254.2 ± 18.4	130.4 ± 16.7	74.5 ± 4.7	146.2 ± 5.7
Ni		1.0 ± 0.2		
Pb	15.9 ± 1.2			

apply water jet cutting to the following PV technologies: c-Si, a-Si, CdTe, and CIGS. All module pieces contain at least one solder ribbon, but no parts of the frame, module boxes or cables. In many cases, these solder ribbons contain the toxic heavy metal lead. In fact, even the thin film modules (a-Si, CdTe, CIGS) contain such solder ribbons in order to connect the first and last cell of the module with the module box. However, the analyzed thin film modules in this study do not contain any Pb.

All leaching experiments occur at room temperature using high-density polyethylene (HDPE) bottles supplied with the leaching solution with a volume of 1000 ml and two module pieces from the same technology. All experiments are conducted in triplicate. In order to create realistic conditions comparable to field conditions, the bottles are not agitated in this study.

Table I shows the chemical composition of the three different leaching solutions used in the experiments to simulate different environmental conditions. All of them contain deionized (DI) water. The measured pH values as well as the oxidation–reduction potential E_H of the leaching solutions, remain almost constant for the experimental duration of nearly one year. The E_H is measured with a platinum electrode against a silver/silver chloride reference electrode (Ag/AgCl) with a concentration of potassium chloride $c_{KCl} = 3\,mol/l$ at $T = 25\,°C$ according to DIN 38404-6 and converted to a potential against a standard hydrogen electrode.[31]

During the experiments, we periodically take samples with a volume of 15 ml from the liquids in the bottles to observe the time-dependent leaching behavior. To keep the initial volume of the leaching solution constant at 1000 ml, the volume is corrected after each sampling. These corrections are included in the measurement data by a factor which takes into account the amount of leached elements missing in the solution because of sampling. With inductively coupled plasma mass spectrometry (ICP-MS) the amount of eluted elements is determined according to ISO 17294-2.[32] Only dissolved substances are analyzed, precipitations in the solution are not measured as leached.

The leaching tests are still in progress and will continue until either the final test duration of two years is accomplished, or, alternatively, 100% of the elements are leached out.

Table II shows the total mass of measured elements contained in one module piece for each PV technology. To determine the mass, we mill the module pieces to a powder; digest it by adding acid and oxidizing agents and applying microwave irradiation. The digested samples are then analyzed by ICP-MS (PerkinElmer NexION 350X). For example, in the c-Si module piece, we find 15 mg of lead, which stem from the solder of the ribbons which connect the solar cell to the next one in the module.

3. Results

Figures 1(a)–1(d) give results of eluted elements after a time $t = 360$ days. Data are given with respect to the total mass (see Table II). The absolute concentrations of the eluted elements measured in the solutions given in mg/L are shown in Table III.

The results of Fig. 1(a) stem from leaching c-Si module pieces: Pb, Cu and Al are dissolved. Eluted Al from the back contact reaches 22% in acidic solutions. With around 0.1% level, Cu shows a low leaching. The amount of eluted Pb is 1.4%. Ag and Sn are not detected in the leachate. Figure 1(b) shows only leached Cu and Ni released from a-Si module pieces with a maximum value of $Cu_{a\text{-}Si} \approx 6.5\%$ and $Ni_{a\text{-}Si} \approx 55\%$ in acidic solutions.

Figure 1(c) shows the eluted elements from CdTe module pieces. In solutions with pH 3, 62% of Cd_{CdTe} is leached out after 360 days. In neutral solutions, the leaching is lower with $Cd_{CdTe} \approx 4\%$. Under alkaline conditions, Cd forms insoluble solid cadmium hydroxide [$Cd(OH)_2$] and therefore only low concentrations are found in the leachate by ICP-MS.

For pH 3, the amount of eluted Te with $Te_{CdTe} \approx 9\%$ is much lower than the amount of $Cd_{CdTe} \approx 62\%$. The back contact, molybdenum, in CdTe modules also shows substantial leaching: $Mo_{CdTe} \approx 71\%$ in acidic solution, $Mo_{CdTe} \approx 19\%$ in neutral solution, and $Mo_{CdTe} \approx 29\%$ in alkaline solution.

Figure 1(d) illustrates the elements detected in the solutions from leached CIGS module pieces. In acidic solution, eluted Zn (used in the ZnO front contact) reaches $Zn_{CIGS} \approx 43\%$ after $t = 360$ days. Cd from the cadmium sulfide (CdS) buffer layer shows lower leaching values than from CdTe module pieces. This lower leaching of Cd indicates that CdS is more stable than CdTe. Mo from the back contact shows similar leaching behavior like Mo from CdTe module pieces.

Table III. Concentration of eluted elements after $t = 360$ days in three different solutions with pH 3, 7, and 11. The given concentrations are based on two module pieces of the same module type per 1000 ml leaching solution.

Element	Concentration (mg/L)					
	c-Si			a-Si		
	pH 3	pH 7	pH 11	pH 3	pH 7	pH 11
Ag						
Zn						
Cd						
Te						
In						
Ga						
Se						
Al	71.96 ± 5.01		8.49 ± 0.42			
Mo						
Cu	0.27 ± 0.18	0.37 ± 0.08		16.1 ± 0.96	0.52 ± 0.05	
Ni				1.02 ± 0.16	0.07 ± 0.02	
Pb	0.45 ± 0.27		0.07 ± 0.04			

Element	Concentration (mg/L)					
	CdTe			CIGS		
	pH 3	pH 7	pH 11	pH 3	pH 7	pH 11
Ag						
Zn				13.20 ± 0.57	0.58 ± 0.07	
Cd	18.61 ± 0.94	1.25 ± 0.90	0.02 ± 0.008	0.08 ± 0.01	0.006 ± 0.003	
Te	2.92 ± 0.91	2.75 ± 2.58	0.10 ± 0.06			
In				0.21 ± 0.05		
Ga				0.05 ± 0.01	0.02 ± 0.001	0.01 ± 0.001
Se					0.02 ± 0.015	0.10 ± 0.05
Al						
Mo	18.62 ± 2.58	4.98 ± 2.92	7.69 ± 4.95	1.44 ± 0.36	1.39 ± 0.13	1.09 ± 0.36
Cu	4.59 ± 0.69	0.53 ± 0.06		8.93 ± 4.55	0.25 ± 0.04	
Ni						
Pb						

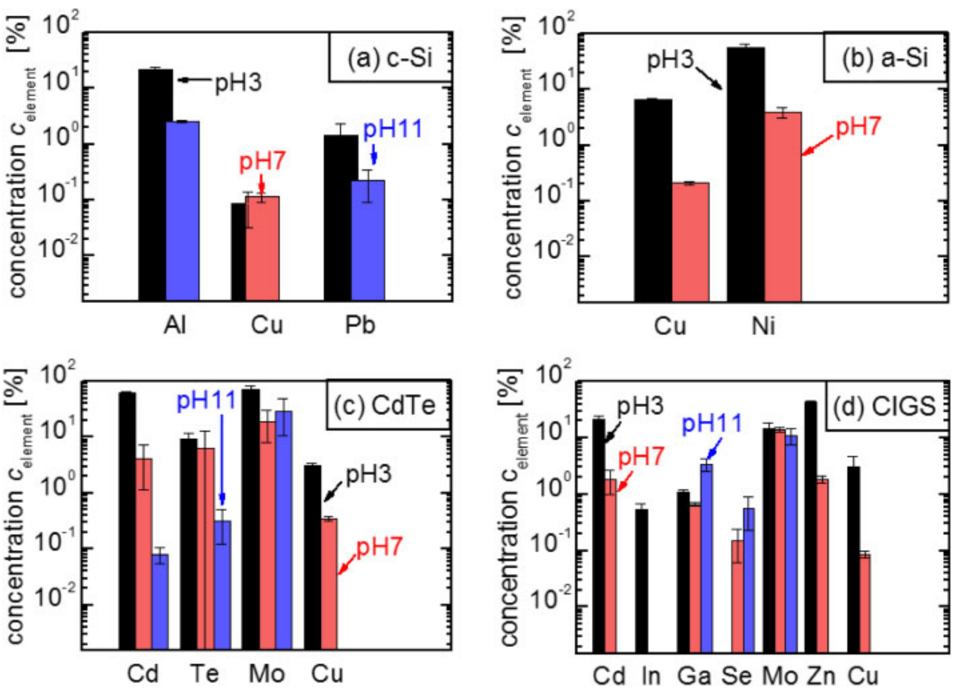

Fig. 1. (Color online) Amount of eluted elements after $t = 360$ days in three different solutions with pH 3, 7, and 11. (a) Al, Cu, and Pb from c-Si module pieces. (b) Cu and Ni from a-Si module pieces. (c) Cd, Te, Mo, and Cu from CdTe module pieces. (d) Cd, In, Ga, Se, Mo, Zn, and Cu from CIGS module pieces. The error bars stem from three identical experiments. The element Ag is not detected in the solutions.

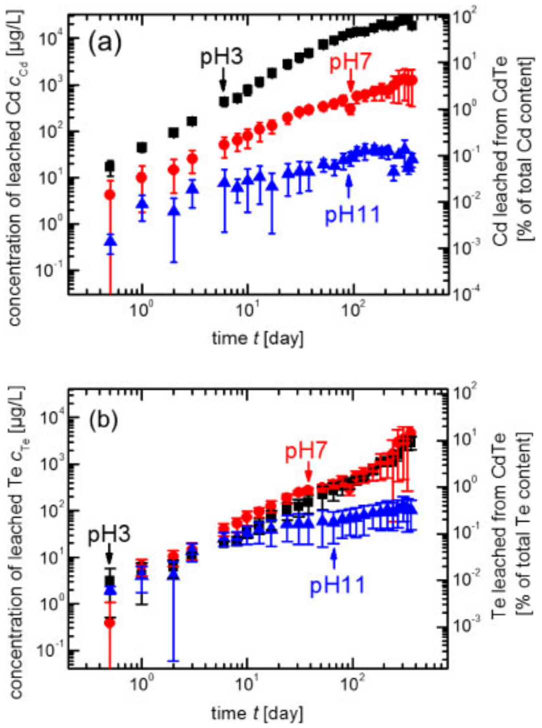

Fig. 2. (Color online) Time-dependent leaching of Cd (a) and Te (b) from CdTe module pieces within different pH solutions. Values are given as absolute concentrations in µg/L and as percentage of total content of the particular element.

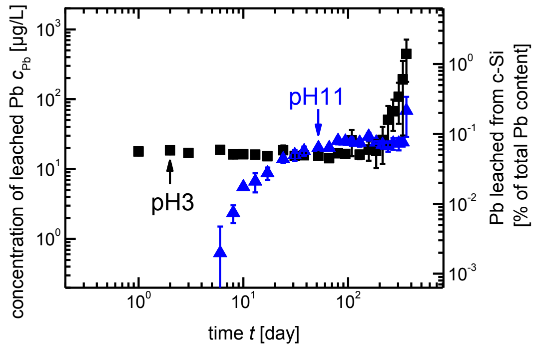

Fig. 3. (Color online) Time-dependent leaching of Pb from c-Si module pieces within different pH solutions. Values are given as absolute concentrations in µg/L and as percentage amount regarding the total content of the particular element.

The elements In, Ga, and Se from CIGS module pieces leach only in minor amounts.

Most of the analysed metals follow a cationic leaching pattern, which means that leachate concentrations decrease with increasing pH. In this study, the following elements show cationic behavior: Cu, Cd, Te, Mo, and Zn. The elements Al and Pb follow an amphoteric leaching pattern where leaching under neutral conditions is minimal but increases at acidic and alkaline conditions. The elements Ga and Se are the only metals where an oxyanionic leaching behavior is observed with considerable amounts measured only in alkaline solutions. With decreasing pH, the eluted amount of Ga and Se detected in the solutions also decreases.

As an example for the time-dependent leaching of the elements, Fig. 2(a) shows the leaching results of Cd from CdTe module pieces in the three different solutions. The percentage of eluted Cd is given with respect to the total Cd content as well as the absolute concentration measured in the solution. In all solutions, the amount of leached Cd increases with time. Under acid rain conditions with pH 3, almost 500 times stronger leaching is observed after one year when compared to the leaching after one day. Still, under groundwater conditions the leached Cd after 360 days is 100 times higher than after one day. These data show that experiments lasting only one or a few days, are by no means representative for dumped modules.

Even only one day of leaching of two module pieces in 1 l of acid rain and neutral solution is sufficient to exceed the World Health Organization (WHO) drinking water limit: for Cd the threshold limit is 3 µg/L.[33] Even under alkaline conditions (pH 11), it takes only three days to exceed this limit. After nearly one year, the Cd concentration c_{Cd} in acidic solutions is almost 20000 µg/L (62%), in neutral solutions $c_{Cd} \approx 1200$ µg/L (4%) and in basic solutions $c_{Cd} \approx 25$ µg/L (0.1%). After three days in acidic solutions, the CdTe modules pieces exceed the limit of the German legislation, which is set to 100 µg/L, for classification of hazardous waste.[1]

Figure 2(b) shows the leaching of Te released from CdTe module pieces within nearly one year. Under alkaline and groundwater conditions Te shows slightly higher concentrations than Cd. In acidic solutions, Te also behaves differently. Here, the measured amount is almost one order of magnitude lower than the Cd amount and it is in the same range as the leached Te under groundwater conditions.

Figure 3 shows the time-dependent leaching amounts of the toxic heavy metal Pb, which is released from the solder ribbons in c-Si module pieces. Only under acid rain and alkaline conditions, considerable amounts of Pb are detected in the leachate. Until day 241, the Pb concentration $c_{Pb} \approx 18$ µg/L (0.06%) is almost constant in acid solutions. After this time, the concentration increases dramatically up to $c_{Pb} \approx 446$ µg/L (1.4%). It seems that it takes nearly one year before considerable leaching starts to occur. We assume that the reason for this behavior could be related to the presence of Pb in an alloy with Sn. Studies showed that in the case of Pb–Sn alloys, tin is oxidized and enriched at the surface.[34–36] Therefore we presume that the tin oxide at the surface has to be leached first to uncover the Pb. Unfortunately, Sn is currently not measurable. We suppose that Sn precipitates in the solutions and further investigations are in progress.

Nevertheless, the Pb concentration exceeds the WHO limit of 10 µg/L for drinking water[33] from the first day in acid solutions. In alkaline solutions, a similar behavior is observed only with a slight delay in the increase in concentration and a slower increase at the beginning.

4. Discussion

Our study compares the four major commercial photovoltaic technologies c-Si, a-Si, CdTe, and CIGS for their long-term leaching behavior in three environmentally relevant aqueous solutions. The results show high leaching of toxic elements like Cd, released from CdTe module pieces. Two further hazardous elements, Te and Pb, are leached only in minor amounts, but Pb shows a considerable increase after 241 days of leaching. Nevertheless, also low- or non-toxic metals like Mo, Zn, and Al are detected in high amounts in the leachate.

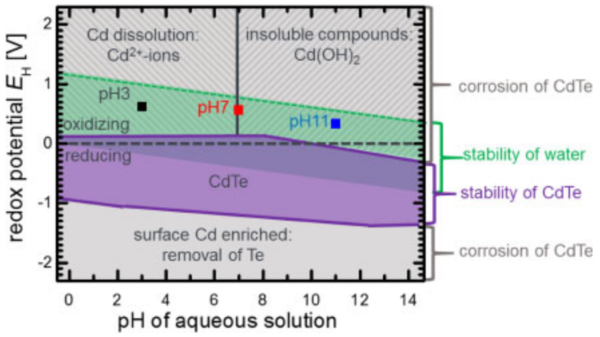

Fig. 4. (Color online) Highly simplified potential-pH (Pourbaix) diagram for CdTe in aqueous solutions at $T = 25\,°C$ showing only predominant Cd species.[6] Stability and corrosive regions of CdTe are shown. Measured redox potentials in solutions with pH 3, 7, and 11, which are used in the leaching experiments, are located at oxidizing redox potentials E_H.

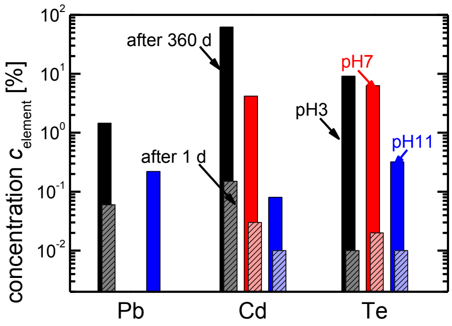

Fig. 5. (Color online) Amount of eluted toxic elements as Pb, released from c-Si module pieces, and Cd and Te out of CdTe module pieces after $t = 1$ day (hatched bars) and after $t = 360$ days (solid bars) in different solutions.

Table IV. Typical E_H values (in mV) of waters in various environments.[37]

Environment	E_H range
Rain water	+400 to +600
Freshwater lakes, ocean water	+300 to +500
Oilfield brines	−300 to −600
Water in wetlands	+100 to −100

4.1 Stability of CdTe

The leaching results for CdTe are in good agreement with thermodynamic calculations. To explain the leaching behavior of elements, not only the pH of the aqueous solutions is important, but also the redox potential E_H highly affects the leaching.

Figure 4 shows a simplified redox potential E_H–pH diagram for CdTe in aqueous solutions according to Zeng et al.[6] This diagram shows the stability limits of CdTe according to pH and E_H and the corrosion regions with the predominant species. The measured redox potentials E_H of our leaching solutions are all in the oxidizing regime. These values lie in the range of reported E_H values of different types of water in various environments (see Table IV).

Under reductive conditions, CdTe is thermodynamically stable in aqueous solutions within the whole pH range of the stability regime of water. In contrast, under oxidative conditions occurring naturally in any freshwaters, the compound CdTe is no longer stable. Under oxidative and acid conditions, Cd^{2+} ions are formed and can be measured in the solutions. For Te, the predicted species are insoluble Te and tellurium dioxide (TeO_2) within the stability region of water (not shown in the figure). These insoluble tellurium species explain the difference between the high Cd amount and the lower Te amount measured as dissolved in the leachate. Under oxidative and alkaline conditions, the predominant species of Cd are insoluble cadmium hydroxide [$Cd(OH)_2$] and for Te the predominant species are different tellurite ions for example hydrogen tellurite ion ($HTeO_3^-$), hydrogen tellurate ($HTeO_4^-$) and TeO_3^{2-}. Therefore, a higher amount of Te than Cd is measured in alkaline solutions.

4.2 Environmental poisoning

If broken PV modules are dumped in the environment where they may get in contact with water, metals or metal compounds which are supposed to be stable can elute from these modules. Our leaching study indicates that the highest risk for a contamination with metals released from PV modules occur under acidic and oxidizing conditions. It is presumed that most metals are present in their ionic form with an increased mobility. But even under groundwater conditions, considerable amounts of leached metals are measured after nearly one year. For Cd and Pb, the leaching amounts still lie above the WHO limits for drinking water. Only under alkaline conditions the results show a lower risk for leaching toxic substances, because the toxic substances are in their immobilized forms and precipitate for example as $Cd(OH)_2$. But nevertheless it is not negligible that small amounts of Cd can be also detected in alkaline solutions and these values exceed the WHO limits. Metals which show also higher leaching amounts in alkaline solutions are Al, Ga, and Mo, but they are considered being low or non-toxic. Molybdenum for example is actually a trace element and essential for human health.

4.3 Short-term versus long-term leaching

Figure 5 reveals a substantial difference between short- and long-term leaching: We show the amounts of eluted toxic elements as Pb, Cd, and Te out of PV module pieces after one day and after nearly one year in the analysed solutions. Under all conditions, acid rain, groundwater and alkaline landfilling, the leached amounts increase clearly after one year. For Cd and Te under acid rain conditions, the difference between short- and long-term is almost three orders of magnitude. In neutral solutions, the long-term results show an increase of nearly two orders of magnitude and for alkaline conditions an increase of more than one order of magnitude is reported.

For the leaching of Pb out of c-Si module pieces under acid rain conditions, a percentage increase of more than 2000% is obtained. After one day, no Pb is detected in alkaline solutions, but after nearly one year a concentration of $c_{Pb} \approx 70\,\mu g/L$ is reached, which is equivalent to 0.2% regarding the total mass of Pb.

Compared to the TCLP leaching test from Zeng et al. on pure CdTe powder, where 6.4% of the total Cd amount was leached after 18 h in acid solutions,[6] our measured Cd amount after one day is lower. This result is understandable: Our present study uses module pieces with an intact layer construction, they are not milled to a powder and we do not apply any agitation.

Compared to the leaching test results according to EN 12457-4, where 0.1% Pb, 0.6% Cd, and 0.5% Te was measured after 24 h in neutral solutions,[9] our results are also slightly lower. This is due to the smaller size (<40 mm) of the leached module pieces in this standard test and the end-over-end agitation for an accelerated aging parameter.

Nevertheless, if the leaching amounts of the toxic substances Pb, Cd, and Te from PV modules are low at the first day of leaching or lower than the regulatory limits according to standard tests, it is not likely that these values stay constant with ongoing leaching. Our study clearly proves that it is important to consider the long-term behavior of leaching and the possibility that after a certain time 100% of the toxic material will be leached out. To prevent environmental pollution due to a release of toxic heavy metals by dumping or landfilling broken PV modules, strict recycling policies and regulations are needed worldwide. Alternatively, toxic materials in PV modules simply could be omitted.

5. Conclusions

This study proves substantial leaching of toxic elements out of pieces cut from commercial photovoltaic modules. After 360 days, around 1.4% of lead from c-Si module pieces and 62% of cadmium from CdTe module pieces are leached out and found in water-based solutions. A substantial difference between short- and long-term leaching exists: for CdTe modules, for example, the eluted Cd amount after 360 days is 500 times higher than the amount measured after one day. Therefore, we challenge the meaningfulness of short-term leaching tests of 18 to 24 h with respect to environmental issues. In addition to toxic elements, other substances also are strongly leached out: Al from c-Si module pieces, Mo from CdTe module pieces, and Zn from of CIGS module pieces. Therefore, the layers containing these elements represent weak spots in the modules and indicate penetration paths for the water-based solutions. The leaching results not only show a strong influence of the pH of the leaching solutions on the leaching behavior, but also indicate that the redox potential has a considerable effect. Regarding these parameters, pH and redox potential, the leaching behavior can be predicted by thermodynamic stability calculations, which are in good agreement with our experimental results for the compound CdTe.

So far, our study has used leaching *without* applying any accelerated aging parameter — for example agitation, increased temperatures, applied voltages or illumination.

Nevertheless, high amounts of toxic heavy metals are measured in the leaching solutions. Two module pieces with a size of $5 \times 5\,cm^2$ are enough to exceed the WHO limits of drinking water for Cd after only one day of leaching in acid as well as neutral solutions. For Pb it takes also only one day of leaching in acid solutions to exceed the WHO limit.

In future, we will investigate what will happen to dumped modules or module pieces under more stressful conditions: For example, increased temperatures and illumination — which are natural conditions for any photovoltaic module — will probably lead to even higher leaching and even faster emission of toxic materials from photovoltaic modules into the environment according to studies on leaching kinetics regarding heavy metals.[38,39]

Acknowledgments

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1) EN 12457-4:2002, Part 4 (2002).
2) US Environmental Protection Agency, SW-846 (2013).
3) CCR, Title 22, Division 4.5, Chap. 11, Article 5, Appendix II (1991).
4) JIS K 0102:2016 (2016).
5) A. Finke, A. Kriele, W. Thumm, D. Bieniek, and A. Kettrup, Chemosphere **32**, 1633 (1996).
6) C. Zeng, A. Ramos-Ruiz, J. Field, and R. Sierre-Alvarez, J. Environ. Manage. **154**, 78 (2015).
7) G. Okkenhaug, NGI Rep. No. 20092155-00-5-R (2010).
8) H. P. Arp, NGI Rep. No. 20100446-00-2-R (2010).
9) M. Kranert, M. Koch, K. Fischer, and J. W. Metzger, Photovoltaikmodule – Umweltfreundlichkeit und Recyclingmöglichkeiten, Untersuchungen zur Einordnung von Abfällen aus der Anwendung von PV-Modulen (2012) [in German]. Available at http://www.iswa.uni-stuttgart.de/ch/forschung/index.html.
10) R. Zapf-Gottwick, M. Koch, K. Fischer, F. Schwerdt, L. Hamann, M. Kranert, J. W. Metzger, and J. H. Werner, Int. J. Adv. Appl. Phys. Res. **2**, 7 (2015).
11) P. D. Moskowitz and V. M. Fthenakis, Sol. Cells **30**, 89 (1991).
12) R. E. Goozner, W. F. Drinkard, M. O. Long, and C. M. Byrd, Conf. Rec. 26th IEEE Photovoltaic Specialists Conf., 1997, p. 1161.
13) C. Eberspacher, Rep. Workshop Photovoltaics and the Environment, 1998, p. 17.
14) M. H. Patterson, A. K. Turner, M. Sadeghi, and R. J. Marshall, Sol. Energy Mater. Sol. Cells **35**, 305 (1994).
15) V. M. Fthenakis and P. D. Moskowitz, Prog. Photovoltaics **3**, 295 (1995).
16) H. Steinberger, Prog. Photovoltaics **6**, 99 (1998).
17) Verordnung über Trinkwasser und über Wasser für Lebensmittelbetriebe (Trinkwasserverordnung — TrinkwV), Bundesgesetzblatt, Teil I **66**, 2612 (1990) [in German].
18) Y.-S. Zimmermann, A. Schäffer, P. F.-X. Corvini, and M. Lenz, Environ. Sci. Technol. **47**, 13151 (2013).
19) N. R. Brun, B. Wehrli, and K. Fent, Sci. Total Environ. **543**, 703 (2016).
20) N. Espinosa, Y.-S. Zimmermann, G. A. dos Reis Benatto, M. Lenz, and F. C. Krebs, Energy Environ. Sci. **9**, 1674 (2016).
21) C. M. Motta, R. Cerciello, S. De Bonis, V. Mazzella, P. Cirino, R. Panzuto, M. Ciaravolo, P. Simoniello, M. Toscanesi, M. Trifuoggi, and B. Avallone, Environ. Pollut. **216**, 786 (2016).
22) M. Tammaro, A. Salluzzo, J. Rimauro, S. Schiavo, and S. Manzo, J. Hazardous Mater. **306**, 395 (2016).
23) V. M. Fthenakis, Renewable Sustainable Energy Rev. **8**, 303 (2004).
24) V. M. Fthenakis, H. C. Kim, and E. Alsema, Environ. Sci. Technol. **42**, 2168 (2008).
25) V. M. Fthenakis and H. C. Kim, Sol. Energy **85**, 1609 (2011).
26) P. Sinha, V. L. Trumbull, S. W. Kaczmar, and K. A. Johnson, in *Photovoltaics: Synthesis, Applications and Emerging Technologies*, ed. M. A. Gill (Nova Science, New York, 2014) Chap. 2, p. 37.
27) V. M. Fthenakis and H. C. Kim, Thin Solid Films **515**, 5961 (2007).
28) W. D. Cyrs, H. J. Avens, Z. A. Capshaw, R. A. Kingsbury, J. Sahmel, and B. E. Tvermoes, Energy Policy **68**, 524 (2014).
29) K. Huang, G. Zhuang, C. Xu, Y. Wang, and A. Tang, Atmos. Res. **89**, 149 (2008).
30) A. Dellantonio, W. Fitz, H. Custovic, F. Repmann, B. Schneider, H. Grünewald, V. Gruber, Z. Zgorelec, N. Zerem, C. Carter, M. Markovic, M. Puschenreiter, and W. Wenzel, Environ. Pollut. **153**, 677 (2008).
31) DIN 38404-6:1984 (1984).
32) ISO 17294-2:2003, Part 2 (2003).
33) World Health Organization (WHO), Guidelines for Drinking Water Quality (2011).
34) S. Cho, J. Yu, S. K. Kang, and D.-Y. Shih, J. Electron. Mater. **34**, 635 (2005).
35) R. J. Bird, Met. Sci. **7**, 109 (1973).
36) T. Farrell, Met. Sci. **10**, 87 (1976).
37) R. M. Garrels and C. L. Christ, *Solutions, Minerals and Equilibria* (Harper & Row, New York, 1965).
38) M. K. Jha, A. Kumari, P. K. Choubey, J.-C. Lee, V. Kumar, and J. Jeong, Hydrometallurgy **121–124**, 28 (2012).
39) M. Gharabaghi, M. Irannajad, and A. R. Azadmehr, Sep. Purif. Technol. **86**, 9 (2012).

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COMMENTS AND REPLIES

Comment on “Long-term leaching of photovoltaic modules”

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Comment on "Long-term leaching of photovoltaic modules" [Jpn. J. Appl. Phys. 56, 08MD02 (2017)]

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In their recent publication, Nover et al. evaluate long-term leaching of photovoltaic (PV) modules.[1)] Based on their experimental results, the authors argue for strict recycling policies for PV modules to prevent environmental pollution due to a release of heavy metals by dumping or landfilling broken PV modules. While recycling is the preferred end-of-life treatment route for PV modules with regard to both environmental and resource efficiency considerations,[2)] critical assumptions that underlie the study's conclusions would benefit from clarification.

The experimental methods in Nover et al. include placing two $5 \times 5\,\mathrm{cm}^2$ module pieces from commercial PV modules (c-Si, a-Si, CdTe, CIGS) in 1 L of pH 3 ("acid rain"; see discussion below on representativeness), pH 7 ("groundwater"), and pH 11 ("alkaline percolating water on waste disposal sites") solution for $t = 360$ days. The authors use the results of their long-term leaching tests to challenge the meaningfulness of standardized short-term (regulatory) leaching tests. However, the objective of regulatory leaching tests is to characterize waste for disposal, and the authors' waste disposal leaching results (pH 11) do not indicate exceedances of regulatory waste limits in Japan, Germany, and the U.S. (Table I), with the exception of Mo and Se for Germany. With regard to a previous risk assessment of PV disposal by Cyrs et al. that indicated limited health risk, the authors characterize their study as evaluating disposal in official lined landfills, whereas the U.S. EPA DRAS model used in that study assumes that there is no liner, or that the liner has failed.[3)]

For the pH 3 long-term leaching test, the authors use a combination of 15.4 g/L citric acid ($C_6H_8O_7$), 2.8 g/L sodium hydrogen phosphate (Na_2HPO_4), and deionized (DI) water to simulate acid rain. The basis for selection of pH 3 is data from severe acidic precipitation in Shanghai, China in 2005.[4)] The pH value of 3 is considerably lower than annual average pH of rainfall in Japan (pH 4.51–4.96; years 2003–2007),[5)] Germany (pH 4.11–5.45; years 1982–2014),[6)] and the U.S. (pH 4.27–6.66; years 2003–2016.[7)] In addition, the primary acidic ions associated with acid rain, including in the Shanghai study, are SO_4^{2-} and NO_3^-. For example, the U.S. EPA Method 1312 synthetic precipitation leaching procedure (SPLP) simulates pH 4.2 or 5.0 rain with a 60/40 weight percent mixture of sulfuric acid/nitric acid (H_2SO_4/HNO_3) in water. In contrast, Nover et al. simulate acid rain with citric acid, an organic acid that is used in waste characterization testing (California waste extraction test; WET) and not found in acid rain. The authors also do not explain how they maintained pH at a constant level over 360 days, when earlier leaching studies found that intrinsic pH levels in leaching solutions with PV module samples are higher than the original acidified levels.[8)]

While the authors' intent in using citric acid is to achieve the target acid rain pH value of 3, citric acid is also known to have additional effects on leaching of elements due to chelating of metal ions. For example, citrate can chelate with Cd^{2+} through a tridentate ligand and form soluble complexes such as $Cd(C_6H_5O_7)^-$ and $Cd(C_6H_6O_7)^0$ that would not be present in acidic rainwater.[9,10)] The formation of a Te-citrate complex also increases Te solubility in aqueous solutions in a manner not representative of acid rain.[11)] Citric acid also acts like a blowing agent in giving off CO_2 and water when

Table I. Comparison of long-term waste disposal leaching results[1)] with non-hazardous waste limits.

	Simulated environmental condition	Concentration (mg/L) of eluted elements after $t = 360$ days in solution with pH 11				Regulatory limit for non-hazardous waste (mg/L)		
		c-Si	a-Si	CdTe	CIGS	U.S.[a)]	Germany[b)]	Japan[c)]
Al	Alkaline percolating water on waste disposal sites	8.49 ± 0.42	—	—	—	—	—	—
Ag		—	—	—	—	5	—	—
Cd		—	—	0.02 ± 0.008	—	1	0.1	0.3
Cu		—	—	—	—	—	5	—
In		—	—	—	—	—	—	—
Ga		—	—	—	0.01 ± 0.001	—	—	—
Mo		—	—	7.69 ± 4.95	1.09 ± 0.36	—	1	—
Ni		—	—	—	—	—	1	—
Pb		0.07 ± 0.04	—	—	—	5	1	0.3
Se		—	—	—	0.10 ± 0.05	1	0.05	0.3
Te		—	—	0.10 ± 0.06	—	—	—	—
Zn		—	—	—	—	—	—	—

a) 40 CFR 261.24.
b) Waste Catalogue Ordinance Abfallverzeichnis-Verordnung (AVV).
c) Waste Management and Public Cleansing Law.

heated.[12] Although the experiments by Nover et al. were conducted at room temperature, they indicate future work involving increased temperatures and illumination which would produce blowing agent effects associated with citric acid that are not found in acid rain.

The results of the pH 3 long-term leaching data show higher leaching rates of Cd in CdTe PV than Pb in c-Si PV, though earlier work by the authors[13] and a publication cited by the authors[8] indicate similar to higher levels of Pb leaching from c-Si PV in acidic conditions compared to Cd from CdTe PV. Because PV module compositions and structures differ between manufacturers, it may not be appropriate to generalize experimental results to a broader technology class (c-Si, a-Si, CdTe, or CIGS). For example, Nover et al. indicate that samples were prepared by water jet cutting but do not indicate the status of the glass-laminate encapsulation structure of the samples. Experimental testing of a non-encapsulated module would be expected to produce much higher rates of leaching than a standard encapsulated module. Field testing of the durability of PV module encapsulation under aggressive waste handling (crushing with a heavy-duty landfill compactor) also indicates that the glass-laminate encapsulation is maintained under those conditions.[14]

Although the authors indicate the absence of prior long-term leaching tests, a similar long-term acid rain test was conducted by Steinberger on CdTe and CIGS PV modules.[15] Whereas Nover et al. used pH 3 citric acid solution to simulate acid rain, Steinberger used actual rainwater by placing 10 mm PV module pieces in outdoor boxes in Munich, Germany and sampling rainfall eluate weekly. As shown in Fig. 1, the long-term leaching results using actual rainwater are lower than in the citric acid solution of Nover et al., with the exception of Mo and Se for CIGS PV and Ni for CdTe PV.

Steinberger also considered module breakage rates (1/200 or 0.5%) when interpreting leaching results. Typical module breakage rates from field data are ~0.04%/year and mainly consist of stress and impact fractures in which modules remain intact with a number of glass fractures or cracks.[16] For example, a prior PV module leaching study commissioned by NEDO in Japan tested intact PV modules with 1 to 5 cracks using a quantity of simulated acid rain (pH 5) equivalent to 40 days of average rainfall.[17] The field duration of broken modules is also dependent on operations and maintenance practices such as routine inspections and power output monitoring which are used to identify and remove modules that are nonfunctioning potentially due to breakage.

When interpreting the long-term leaching results, the Nover et al. study also makes direct comparisons between leachate and WHO drinking water limits,[18] which assumes that the leachate is a direct source of drinking water, whereas any leachate would need to first migrate to a source of drinking water (e.g., potable water well). As such, fate and transport analysis would need to be conducted to evaluate how the leachate transforms and disperses in moving from the point of emissions to the point of exposure, prior to making comparisons with drinking water limits.[19] For example, if leachate results are directly compared to WHO drinking water limits, exceedances are found for Se from CIGS module pieces (0.1 mg/L leachate compared with 0.040 mg/L WHO drinking water limit) which Nover et al. indicate leach only in minor amounts. While the adequacy of the drinking water limits is not in question, fate and transport analysis is a prerequisite to making comparisons to these limits.

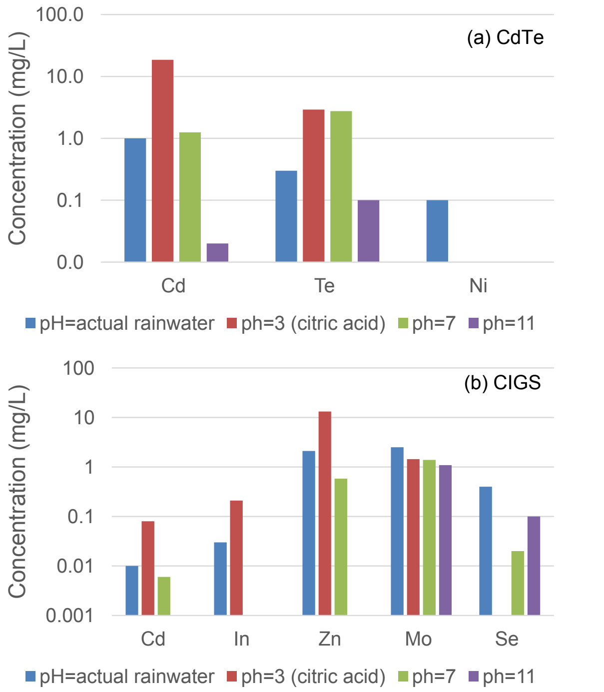

Fig. 1. (Color online) Long-term PV module leaching results from Steinberger using actual rainwater[15] and Nover et al. with pH 3, 7, and 11 solutions.[1]

1) J. Nover, R. Zapf-Gottwick, C. Feifel, M. Koch, J. W. Metzger, and J. H. Werner, Jpn. J. Appl. Phys. **56**, 08MD02 (2017).
2) S. Weckend, A. Wade, and G. Heath, IEA PVPS Tech. Rep. T12-06 (2016).
3) W. D. Cyrs, H. J. Avens, Z. A. Capshaw, R. A. Kingsbury, J. Sahmel, and B. E. Tvermoes, Energy Policy **68**, 524 (2014).
4) K. Huang, G. Zhuang, C. Xu, Y. Wang, and A. Tang, Atmos. Res. **89**, 149 (2008).
5) H. Akimoto, Ministry of Environment Tech. Rep. JFY2003-2007 (2009).
6) Web [http://www.umweltbundesamt.de/sites/default/files/medien/384/bilder/dateien/2_abb_entw-ph-wert_2016-06-22.pdf].
7) Web [http://nadp.sws.uiuc.edu/data/ntn/].
8) H. P. Arp, NGI Rep. No. 20100446-00-2-R (2010).
9) M. Dakanali, E. T. Kefalas, C. P. Raptopoulou, A. Terzis, T. Mavromoustakos, and A. Salifoglou, Inorg. Chem. **42**, 2531 (2003).
10) E. T. Kefalas, M. Dakanali, P. Panagiotidis, C. P. Raptopoulou, A. Terzis, T. Mavromoustakos, I. Kyrikou, N. Karligiano, A. Bino, and A. Salifoglou, Inorg. Chem. **44**, 4818 (2005).
11) T. Ishizaki, T. Ohtomo, and A. Fuwa, J. Electrochem. Soc. **151**, C161 (2004).
12) J. Stehr, Gummi Fasern Kunststoffe **68**, 12 (2015).
13) R. Zapf-Gottwick, M. Koch, K. Fischer, F. Schwerdt, L. Hamann, M. Kranert, J. W. Metzger, and J. H. Werner, Int. J. Adv. Appl. Phys. Res. **2**, 7 (2015).
14) P. Sinha, V. L. Trumbull, S. W. Kaczmar, and K. A. Johnson, in *Photovoltaics: Synthesis, Applications and Emerging Technologies*, ed. M. A. Gill (Nova Science, New York, 2014) Chap. 2, p. 37.
15) H. Steinberger, Prog. Photovoltaics **6**, 99 (1998).
16) P. Sinha and A. Wade, IEEE J. Photovoltaics **5**, 1710 (2015).
17) Central Research Institute for the Electric Power Industry, Fiscal 1998 Report on the Results of Work Entrusted to the Renewable Energy and Industrial Technology Development Organization (1999).
18) World Health Organization (WHO), Guidelines for Drinking Water Quality (2011).
19) P. Sinha, R. Balas, L. Krueger, and A. Wade, Environ. Toxicol. Chem. **31**, 1670 (2012).

Initiative für Transparenz und Demokratie

study – November2010

Nina Katzemich/ Ulrich Müller

The Non Toxic Solar Alliance – the creation of a lobbying agency

The lobbying dispute over solar cells shows the failure of the EU lobby register

A heated lobbying dispute has raged in Brussels in recent months over environmental regulations for solar modules. During this period a dubious lobbying association emerged, the "Non-Toxic Solar Alliance", which was founded by and is controlled by a Berlin lobbying agency, but which attempts to present itself outwardly as a charitable initiative composed of scientists, solar companies and civil society. Who is behind this initiative? One thing is clear: It succeeded in inflaming a political debate in the European Parliament, although its goal, its structure and its financial background remain nebulous. The case of the NTSA also shows that the EU Commission's voluntary lobby register does not make the practice of lobbying transparent enough.

Contents

1. Heated debate on heavy metals in solar modules

Largely unnoticed by the wider public, a heated lobbying dispute has raged in Brussels in recent months over environmental regulations for solar energy. The background to the debate is the upcoming revision of the *EU Directive for the Restriction of Hazardous Substances in Electrical and Electronic Equipment* (*RoHS for short).* At the end of 2009, the Swedish Presidency of the Council had proposed that the Directive, which in particular relates to consumer goods such as mobile phones, toasters or CD players, be extended to all electronic equipment. Thus, solar modules, which sometimes also contain heavy metals (for example, lead in the interconnection of the individual cells) would also be affected. In particular, however, thin film solar cells would be affected, which to date have largely been manufactured based on cadmium telluride semiconductors. These represent about 20 percent of the modules found on the market. Cadmium is carcinogenic, and how far the cadmium telluride compound used is also carcinogenic, and therefore a risk to consumers, and how securely the cadmium telluride in the solar modules is protected from leakage, is controversial among scientists.

It is certain that a ban on solar modules containing cadmium would inflict massive damage, especially on one company based exclusively on the production of thin film technology solar cells containing cadmium telluride: the US company "First Solar", which by now also has several production sites in Germany.[1] This company has experienced strong growth in recent years with its PV module production. The inclusion of solar modules in the Directive would de facto signify an EU-wide sales ban on First Solar. According to the solar journal Photon, First Solar has therefore massively upgraded its "political representations in Brussels and Berlin in recent months"[2] and conducted intensive lobbying with all institutions involved.

The company's argument for exemption of photovoltaics from the scope of the Directive is: Solar modules must be viewed on a level with other energy production technologies, not with household appliances such as toasters and pocket calculators, because coal-fired power stations, for example, emit cadmium into the environment in large total annual quantities. First Solar also refers to tests in which they had investigated the feasibility of possible leakage of cadmium telluride into the environment. The company argues that it has created its own recycling system for its solar modules which should provide recovery and safe disposal of the cadmium-containing modules.

Here the "Non-Toxic Solar Alliance" (NTSA) comes into play. Founded in December 2009 specifically to influence the debate, it has conducted massive lobbying in recent months for inclusion of photovoltaics in the Directive, and

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1 There are further companies based on the cadmium telluride technology, e.g. Calyxo or Q-Cells. But their cadmium telluride based production is clearly less or only in its inception.

2 Photon, the solar power journal, New Players or Camouflage Organisation?, Volume 5/2010, p.19.

thus for a ban on all toxic substances in photovoltaic installations, with at best very short-term transition phases. Their argument: Any sustainable energy such as solar energy, which will in future find its place on millions of roofs and surfaces, must not use substances in which there is no certainty as to whether they could cause environmental or personal harm. Furthermore, the initiative considers the exclusion to date of photovoltaics containing heavy metals from the Directive to confer a competitive disadvantage for companies using no heavy metals.

2. Why are we investigating the Non-Toxic Solar Alliance?

Both players in recent months have conducted such massive campaigns that the delegates and their colleagues whom we approached as part of our research found their lobbying campaigns to be annoying. The lobbying by the company First Solar, which could largely decide the “lobby struggle” around the “Waste Electrical and Electronic Equipment Directive (WEEE Directive)” in its favour, certainly also merits a closer look: In all probability, the Parliament will, on the 24th November, decide on the continued existence of the exception for photovoltaics for the next ten years. The possibility of First Solar having acted likewise, using dubious methods (see Box on First Solar lobbying), cannot be excluded.

With its research on the NTSA LobbyControl expressly wishes not to take sides in terms of content. We did not participate in the dispute on the RoHS Directive. However, we decided to carry out a study of the Non-Toxic Solar Alliance (NTSA).[3] The reason for this is that the NTSA conducts a tainted form of lobbying whereby it sells itself as something which it is not: It sells itself as a charitable initiative mainly supported by scientists and members of civil society, while it is in fact the invention of a lobbying agency[4]; it deceives the public regarding its true goals and members; and in the final analysis it remains unclear as to how it is financed. Despite all these uncertainties, it has succeeded, through lobbying at the European Parliament and the European Council, in bringing the debate over photovoltaics in the Waste Electrical and Electronic

3 This research is taking place at our own initiative and is financed from the normal LobbyControl budget. There is no external financing for this paper. In general, LobbyControl does not accept any company donations and is not associated with any of the solar companies or lobby agencies involved. Details on our financing are provided at www.lobbycontrol.de/blog/index.php/initiative/unsere-finanzierung/

4 It is also worth mentioning that both the Federal Solar Industry Association and the European Photovoltaic Industry Association (EPIA) distanced themselves early on from the NTSA – even before the NTSA itself first became a noticeable subject of reporting or of enquiries. SourceN: BSW background paper on “Non-Toxic Solar Alliance”, March 2010 (no longer online, available from LobbyControl), EPIA letter of 13 January 2010, available from LobbyControl.

Equipment Directive to the boil[5]. It was thus able to influence a political debate without it at all being clear who the sender of its message was.

The NTSA only enrolled in the Brussels lobby register on 26 May 2010, after our first enquiry. They had been conducting their lobbying work since around January 2010. Even without this registration, they were therefore able to conduct dialogues with numerous delegate bureaus and organisations. This also shows that the voluntary approach of the Brussels lobby register has no effect with regard to organisations that may not be transparent. Even with registration in the lobby register the NTSA declarations about their organisation and financing remain contradictory. The lobbying agency behind the NTSA, Bohnen Kallmorgen and Partners, has not been registered. Therefore, their principals remain in the shadows. With its non-transparent behaviour the NTSA is not only a "good" example for the non-transparent lobbying methods criticised by ourselves, which we are consistently observing in Brussels: It is also one further proof of the failure of the voluntary Brussels lobby register.

Digression: Lobbying by First Solar

By its own assertions, in 2009 First Solar spent between €100,000 and €150,000 on lobbying in Brussels.[6] In addition, the company is represented in its lobbying by lawyer Dörte Fouquet of the Kuhbier law office. On environmental and energy policy questions Fouquet rates as 'well connected'. Interestingly, the Kuhbier law office performs lobbying work not only for companies and economic bodies in relation to state institutions such as the EU Commission, but conversely also works for the EU Commission and the Federal Ministry of the Environment.[7] Furthermore, First Solar also revealed to LobbyControl that they are supported in their company communication by the international and controversial PR agency Burson-Marsteller.[8]

5 In the judgement of one member of the European Parliament, other major questions also falling under the Directive – on PVC and a fireproofing agent – also passed through without attracting anybody's attention..

6 Entry of First Solar into the voluntary EU lobby register on 9.3.2010 under https://webgate.ec.europa.eu/transparency/regrin/consultation/displaylobbyist.do?id=05233891201-35 (eventually accessed on 22.11.2010)

7 Kuhbier enrolled in the voluntary EU lobby register. The EU Commission and the BMU are listed there for 2008 as clients at below 10% of the total turnover (for lobbying at EU level), First Solar as client at between 20 and 30%. For the stated turnover of €404,000, the commission of First Solar was thus between 80,800 and €121,200. Kuhbier has not yet registered any data for 2009 and 2010 (status: 22.11.2010). Source: Enrolment Kuhbier sprl law firm in the EU Register of 7.3.2010 under https://webgate.ec.europa.eu/transparency/regrin/consultation/displaylobbyist.do?id=36022793305-77

8 Burson-Marsteller has worked for the Argentinian military junta and Romania's Ex-Dictator Nicolae Ceausescu, among others, and for companies such as the chemical giant Union Carbide after the catastrophe in the Indian Bophal.

The First Solar contacts in the scientific field are also interesting. In its argumentation for the harmlessness of cadmium telluride solar cells, the company relies in particular on investigations by the Brookhaven National Laboratory, which according to the specialist journal Photon were commissioned by First Solar.[9] The investigations were checked in 2005 with others from the Joint Research Center of the European Commission (peer review), and the Federal Environment Ministry moderated the review. The leading scientist of the Joint Research Center, Arnulf Jäger-Waldau, wrote a public letter on the harmlessness of the cadmium telluride modules along with Dr. Vasilis Fthenacis of the Brookhaven National Laboratory Center in 2009. In 2010 he appeared as an interview partner in a promotional video of First Solar.[10]

Amendment proposals were also made in the European Parliament to permanently exclude solar cells from RoHS. One of these came from Horst Schnellhardt, a CDU delegate from Sachsen-Anhalt. First Solar and Messrs. Calyxo GmbH both have production facilities there and both produce solar cells with cadmium telluride. Calyxo invited Mr. Schnellhardt e.g. in May 2010 on a works visit which also clearly served the lobbying work in the context of the RoHS Directive.[11]

3. Who is the "Non-Toxic-Solar Alliance" (NTSA)?

The Non-Toxic Solar Alliance association was founded in Central Berlin on 14 December 2009 – at the premises of the lobbying agency[12] Bohnen Kallmorgen & Partners[13]. Jan Kallmorgen, one of the agency partners, was elected chair of the initiative at the foundation meeting.

Outwardly, the Non-Toxic Solar Alliance appears to be a civil society non-profit initiative. Thus, the home page der NTSA (www.ntsa.eu) operated by Bohnen Kallmorgen & Partners stated : "*The Non-Toxic Solar Alliance e.V. (NTSA) is a privately backed, not-for-profit initiative registered in Berlin. Its founders and supporters are scientists, researchers, solar industry representatives and members of the civil society concerned about the use of potentially toxic*

[9] See Sollmann, Dominik/ Podewils, Christoph: How dangerous is cadmium telluride? In: Photon, March 2009, pp. 52-59.

[10] http://www.youtube.com/firstsolareurope, finally opened on 16 November 2010

[11] MEP Schnellhardt (CDU) visits Calyxo and welcomes cost reductions in photovoltaics. Press report by Calyxo of 21.5.2010, http://www.calyxo.com/de/home/unternehmensmeldung/index.html, accessed on 18.11.2010.

[12] So-called lobbying or public affairs agencies advise companies or associations against payment when introducing their interests into policy. They propose strategies, conduct lobbying dialogues and campaigns and thus have political know-how and contacts which they provide to clients.

[13] Bohnen Kallmorgen and Partners was established in 2006 by Dr. Johannes Bohnen and

substances in the production of solar photovoltaic (PV) modules and the long-term safety of consumers and the environment.“ [14]

It is thus stated that the founders and supporters are scientists and representatives of the solar industry and civil society who are concerned about the environment and consumers. This image is certainly misleading, as our research shows. Before we examine this more closely, the activities of the NTSA first need to be outlined.

The focus of these activities has been lobbying and public relations against cadmium telluride solar modules as part of the negotiations concerning the European Household Waste Directive, RoHS for short. In addition to this lobbying there is also a so-called NTSA Research Group, whose activities will be illuminated in greater detail later. The NTSA e.V. has met with Brussels decision-makers and with environmental associations, to win these over to its goal. In so doing, the lobbying in Brussels was undertaken by Bohnen Kallmorgen & Partners, with the support of the public affairs network Finsbury International Policy & Regulatory Advisers, FIPRA for short. Of these, their German “special adviser” Clemens Betzel in particular, was active on the NTSA, plus one further staff member, Elisabeth Carolyi. In addition, the free-lance lobbyist and former green EU delegate Frank Schwalba-Hoth took part in lobbying for the NTSA. With his environmental political contacts he acted as a door opener. Unfortunately he did not respond to enquiries by LobbyControl.

In their lobbying dialogues the NTSA had a study in their bag, which they had commissioned and paid for from DIW econ, the subsidiary of the German Institute for Economic Research (DIW). This study concerns the question as to whether an extension of the RoHS Directive to photovoltaics would negatively impinge on the competitivity of the European photovoltaic industry. It comes to the conclusion that such is not the case. It is striking that the study financed by the NTSA directly pursues the question of what effects a ban on the use of cadmium telluride in the production of PV modules could have on the photovoltaic industry, but does not ask the effects of the ban on, for example, similarly toxic lead. Furthermore, the NTSA commissioned a position paper and a further study from the Wuppertal Institute for Climate, Environment and Energy[15], which once more checks current laboratory tests of cadmium telluride modules and reaches the conclusion that they represent a risk and should be replaced. This study relies upon two different tests: One of these was undertaken by the Norwegian Geotechnical Institute and commissioned by Messrs, REC, SolarWorld, Wacker, and Photovoltech. All these companies use silicon technology

Jan-Friedrich Kallmorgen. Kallmorgen had earlier been Investment Manager for Goldman Sachs, then active for the German Council on Foreign Relations. His biographical data does not in our view reveal any environmentally political background.

[14] As could be read on the original version – meanwhile revised – of their home page (29.3.2010).

[15] In a statement to LobbyControl the Wuppertal Institute emphasizes that the “Task in the position paper was to present the for and against argumentation, insofar as this can be derived from the published information, in an open and unbiased manner. From our own assessment of the information situation, we then reached an evaluation which in this case corresponds to the NTSA stance in RoHS matters.“ (Statement of 23.11.2010). The papers are online under http://www.ntsa.eu/Downloads_Links.html

in their production, and commissioned the tests from the Norwegian Geotechnical Institute for their own purposes. The second tests originate from the Sierra Analytical Lab, commissioned by the Non-Toxic Solar Alliance, as the study header shows. All studies mentioned on the home page were thus commissioned and (co-) financed by the NTSA itself or by companies which are campaigning for a ban on the cadmium telluride technology in Europe. Naturally, those commissioning the studies very often sweep the NTSA under the table in their argumentation: An example of this can be seen in their abstract in German "GefahrendurchdieVerwendungvonCadmiumundseinen VerbindungeninPhotovoltaicproducten" of October 2010 ("Dangers through the use of cadmium and its compounds in photovoltaic products").

The NTSA has also enjoyed great success with its public relations. Among other things, the radio broadcaster Deutschlandradio, the daily newspapers Die Welt, FAZ, Bild and most recently the Süddeutsche Zeitung, the TV journal Plus Minus and the online information portal of the Association of German Engineers (VDI), have taken up the debate on the EU Directive and the proceedings with photovoltaic modules containing heavy metals. They predominantly portray the Non-Toxic Solar Alliance as an initiative that is especially supported by scientists. It appears that in its public relations the NTSA has set particular store on this aspect. Two of the articles mention that Jan Kallmorgen belongs to the "advisory bureau" Bohnen Kallmorgen & Partners. But readers do not learn what type of advising is involved, namely that Bohnen Kallmorgen & Partners is a lobbying agency, which Jan Kallmorgen manages as one of the partners. They are even less likely to enquire whether this activity and Jan Kallmorgen's chair of the NTSA have anything to do with each another.

4. Contradictions in self-portrayal

If we shift from the outer appearance of the initiative to the inside view, the image of the NTSA changes considerably :

Who is responsible for the initiative?

In contrast to how it is often reported, and as the appearance of the NTSA suggests, the initiative for the NTSA came not from the scientists but from the PR agency Bohnen Kallmorgen & Partners itself. Jan Kallmorgen also approached Professor Jürgen Werner, the chairman of the NTSA Research Group, as Werner confirmed to LobbyControl.

Professor Werner's name is not unknown in the field of photovoltaic research. The Director of the Institute of Physical Electronics of Stuttgart University has also long represented to the (specialist) public the thesis that the risk of cadmium in photovoltaics is underestimated. Jan Kallmorgen has responded to him in his reader letters to the solar power journal "Photon", in which he expressed criticism of the fact that in his eyes the journal had made too much hype about the cadmium-based technology for photovoltaic module construction. He therefore expressly selected him for his initiative. He was able to obtain the Professor's collaboration in the Non-Toxic Solar Alliance. In turn, Werner spoke to further scientists and now ranks as one of the co-initiators of the Alliance.

Prof. Werner was certainly not at the foundation meeting of the NTSA. A look into the foundation minutes of the association reveals that all founding members of the NTSA were staff members of Bohnen Kallmorgen & Partners, and that neither scientists, representatives of the solar branch nor members of "civil society" were present. The NTSA is thus at its core an initiative of the lobby agency Bohnen Kallmorgen & Partners.

In an answer to a LobbyControl question, the chairman of the association Jan Kallmorgen justifies the foundation of the association on his own with his own colleagues as follows: "To allow the association NTSA e.V. to be registered rapidly and without complication, members of BKP declared themselves ready to function formally as founding members. On this basis, further members and supporters were then gained, who are listed on the NTSA website. There was therefore no misleading of the public, but a pragmatic process to enable NTSA e.V to act promptly within an adequate legal framework."

In his written answer to our second enquiry, Kallmorgen certainly cannot name any NTSA meeting at which non-BKP members also participated. Furthermore, it is striking that the membership list on the NTSA website indeed mentions Kallmorgen himself as a member, but not the six other agency members from the foundation meeting. The picture of the NTSA outwardly communicated is totally different from the true story of its origin.

Inner and outer goals of the NTSA

A closer inspection reveals a different picture of the NTSA from the one presented to observers on its web home page, not only in regard to membership, but also to its goals.

Thus, the foundation minutes of the association of 14.12.2009 do not talk of protecting consumers and the environment from toxic heavy metals. But rather, according to the minutes the intention is "an association to represent the interests of manufacturers of heavy metal-free solar cells. The aim of the Alliance should be to exert influence on the new edition of the *EU Directive 2002/95/EU for the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS)* and to prevent an exception agreement being included for CdTe panels. The association should unite the interests and arguments of the players involved and effectively communicate them within the framework of the formal advisory process of the EU between Council and European Parliament."[16]. The same goals emanate from an internal Bohnen Kallmorgen & Partners paper with the title "*Conducting an RoHS/CdTe lobbying campaign*", which is dated back to 3 December 2009 and is available at LobbyControl.

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[16] Minutes of the association foundation on 14 December 2009 at 12:00 in Karlsplatz 7, 10117 Berlin, Charlottenburg district court

Here a completely different Non-Toxic Solar Alliance e.V. is presented to us. This does not pretend to represent scientists and concerned citizens, but simply to represent the interests of manufacturers of cadmium-free solar cells. Nor does it wish to fight more generally against exceptions for heavy metals in the RoHS Directive, but quite specifically against exceptions for cadmium telluride panels.

The non-profit-initiative, which, in collaboration with scientists, solar entrepreneurs and members of the civil society, cares about environmental aspects in the photovoltaics sector, gives way here to another image: From this strategic paper, the NTSA sounds more like a lobbying organisation which, beneath the cloak of a civil society initiative, represents or wishes to represent the interests of sections of the solar industry, possibly with the goal of eliminating competition which is unpopular due to its cheap production process. After all, the company First Solar currently represents major competition for the other market participants, precisely in times when price pressure is increasing due to excess capacity, and the Federal Government has decided on a reduction to subsidies for solar energy. The DIW Econ study used (and financed) by the Non-Toxic Solar Alliance in the lobbying also contains, as already described, a pointed emphasis on cadmium-telluride modules.

Indeed our research shows that Bohnen Kallmorgen and Partners were, by their own statements and comments by solar companies, unsuccessful in the acquisition of supporting firms (see Financing section below). In the final analysis it remains unclear who really is behind the NTSA. The NTSA has a misleading self-portrayal: To pass itself off as a non-profit-initiative, when it actually would like to be a lobbying organisation for industrial interests, corresponds precisely to the non-transparent form of lobbying which transparency initiatives such as LobbyControl and its European network ALTER-EU have been criticising for years.

The role of the Research Group

Whereas the NTSA e.V. is concerned with policy, and more precisely lobbying, the NTSA Research Group represents the repeatedly emphasised scientific part of the NTSA. The home page states that the NTSA engages in the scientific discussion on the replacement of toxic materials in photovoltaics. What indeed it exactly does or which role the sometimes prestigious scientists play in the NTSA Research Group remains unclear. The NTSA of course invokes them publicly, but they themselves have to date not actually made any appearance in the work of the initiative.

The home page of the NTSA emphasizes that the NTSA e.V. and its Research Group are two legally separate entities (http://www.ntsa.eu/About_Us.html). In a telephone conversation, Professor Werner also said that they operated on a division of labour principle – he was responsible for the research, Jan Kallmorgen for policy. The scientists seem not to be involved in the daily lobbying routine of the NTSA e.V.

The Research Group has obviously made no contribution to date to the expertise used by the NTSA in the lobbying. The DIW Econ study was already completed when the NTSA with its Research Group had just been founded four days previously. The second study also was allocated externally, to the Wuppertal Institute. Nor were the scientific members gained for the financing: None of the scientific members pays membership contributions, as Professor Werner affirmed in writing.

Thus which purpose they actually serve in the NTSA and what insight they really have into the goals, background and financing of the NTSA both remain unclear. None of the scientists were present at the foundation meeting, and so it is therefore not even clear who of them in reality is aware of the outwardly non-communicated orientation of the initiative, to wish to be a representative of the interests of solar companies[17].

Up to now, the scientists have apparently only played a role in the publicity work of the NTSA. One exception is Dr. Daniel Dahm, likewise a member of the Research Group. He seems to have given intensive advice and support to the political work of the NTSA. He works as an adviser and designates himself an ecologist, geographer and activist. Among other things, he obtained the study from the Wuppertal Institute for the NTSA (which again checks current laboratory tests on cadmium modules and reached the conclusion that they represent a risk and should be replaced) plus a statement from the Federation of German Scientists, in which the latter commits itself against an exception in regulation for solar energy in the Waste Electrical and Electronic Equipment Directive[18]. Daniel Dahm is or was also personally active in both institutions.

Financing

One central open question remains, which is where the NTSA gets the money from to pay for its activities. It refers on its home page chiefly to its enrolment in the Brussels lobby register, which it undertook on 26 May 2010. Here it states that its total budget is €48,000 and it receives this money from member contributions. But this is inconsistent with its home page, which states it is financed by private donations. Jan Kallmorgen has in turn informed us in writing that the costs for communications and lobbying are covered by Bohnen Kallmorgen and Partners. Three diverging declarations — which do not exactly contribute to a clarification of the question of financing. In the lobbying conversations, representatives of the NTSA said the NTSA is financed by private donations, from Bohnen Kallmorgen & Partners among others. This information seems to have sufficed for many delegates. Some of their contacts in politics and NGOs naturally wanted the question of financing answered somewhat more concretely, and received differing answers. One employee of the European Parliament, who refused to talk to the group without

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[17] None of the members apart from Professor Werner and Daniel Dahm answered our enquiries, which went out to practically all members.

[18] http://www.vdw-ev.de/index.php?option=com_content&view=article&id=117%3Arohs-europaeische-verhandlungen-zur-restriction-of-hazardous-substances-directive&catid=1%3Aactuelles-und-veranstaltun-gen-der-vdw&Itemid=2&lang=en,finally opened on 16.11.2010

further information, finally received the answer that it involved a “business development scheme”. This would mean that the NTSA was concerned with positioning itself in the solar sector with the effort to include photovoltaics in the RoHS and to acquire new clients.

This answer corresponds with the insider’s view of the NTSA, whereby it indeed wanted to become a lobbying organisation for the cadmium-free producing solar industry. Considerable confusion was thereby caused during lobbying dialogues: A member of the NTSA Research Group and a Brussels lobbyist of NTSA e.V. both declared to delegates and the press that the solar firms Solarworld, Inventux and Dyesol would be supporting the work of the initiative. These reports were quickly denied again – a misunderstanding had occurred whereby the role of these enterprises had been wrongly interpreted at the start. It is correct that the NTSA requested numerous solar companies to support them. Solarworld, Inventux and many other solar firms to which LobbyControl applied for clarification in writing that the NTSA received absolutely no financial support from them. Only from the Australian solar company Dyesol does it appear any support was given. Indeed, at our request Jan Kallmorgen informed LobbyControl recently that Dyesol had indeed announced a small donation of up to €5,000, but the money had as yet not been received. Between Dyesol and the NTSA there are also personal relations, however: Clemens Betzel, the Fipra lobbyist for the NTSA, went to Dyesol in June 2010 as Chief Executive Officer.[19]

If it really was the goal of the NTSA to position itself as a lobby for the cadmium-free producing solar companies, this has obviously failed, unless the companies approached have not told the truth. A number of companies producing without cadmium have started their own appeal to include photovoltaics in the Directive Waste Electrical and Electronic Equipment Directive. Some of these companies, Solarworld, REC, Bosch, Wacker and Photovoltech, were in dialogue early on with the NTSA. However, their appeal was circulated in Brussels by a different agency: “The Brussels Office”. LobbyControl does not know why they decided against a collaboration with the NTSA.

The fact that the NTSA is nevertheless continuing and can financially continue its work brings once more into play a theory advanced from the start by various media and observers: Possibly there is yet another player in the background.

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[19] http://www.dyesol.com/german/index.php?page=NewsArticle&archiveitemid=65&ar-chiveitemdatetime=2010-07-05%2015:53:41&archiveitemstart=1&archiveitemtotal=18&archiveitemlimit=6,finally opened on 16.11.2010. Betzel was already formerly engaged as a representative for Dyesol: thus he appears in the delegation list of the European PhotoVoltaic Industry Association EPIA for the climate conference in Copenhagen 2009. See Provisional list of participants, unfccc.int/resource/docs/2009/cop15/eng/misc01p02.pdf, p. 133. According to written information from EPIA he was there as a Dyesol representative.

Rumours about financing

Two rumours probably persist, the most conspicuous of them regarding the financing: On the one hand, Frank Asbeck, founder and CEO of Germany's largest solar company, Solarworld, is financing the NTSA from his private means. In favour of this, Frank Asbeck, who himself uses silicon in production, has repeatedly expressed his views at length, being publicly critical of cadmium telluride technology. The press spokesman of Solarworld GmbH has denied this rumour in writing. Also important is the suggestion that the company First Solar attempted to repeatedly shift the NTSA into proximity with Solarworld.

The second rumour purports that it was not rival companies that supported the NTSA, but a hedge fund. This gambled on a deterioration in First Solar shares. In order to start their decline on the stock market, the NTSA was brought into being or at least supported. A ban on cadmium technology in Europe, one of the most important sales markets for solar power, might have devastating consequences for the company First Solar. Clemens Betzel, lobbyist for the NTSA with Fipra himself mentioned this rumour in conversation with the solar journal Photon, only to then immediately deny it again.[20] This rumour is likewise difficult to prove, or to sweep aside. A hedge fund does not need to account for what shares it possesses and how it invests them. Such an operation in regard to a company worth around 8 billion euros on the stock market could definitely be lucrative.[21]

BKP indeed has good relations with financial investors and hedge funds. Jan Kallmorgen was formerly Investment Manager for Goldman Sachs and is currently chief executive of the European Group for Investor Protection (EGIP), a lobby platform for financial investors and hedge funds, which like the NTSA trade under the same office address as Bohnen Kallmorgen and Partners.[22] For example, in 2007 EGIP organised a circle "Privatisation in Germany" to promote a sale of the Berliner Landesbank to one strategic investor instead of via a flotation. According to the special service Platow letter of 12.3.2007, the background was that in anticipation of a high compulsory offer, hedge funds had bought LBB shares. With a flotation, however, the compulsory offer was cancelled and the hedge funds had badly speculated.[23]

We asked an American hedge fund about its connections with Bohnen Kallmorgen & Partners and a possible financial support for the NTSA. However,

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[20] New Players or Camouflage Organisation? In: Photon, the solar power journal, volume 5/2010, p.20.

[21] The stock market value naturally changes according to the current rate. In the last 12 months, this has fluctuated considerably between 98.71 US$ and 152.74 US$. See among others http://www.finanzen.net/actien/First_Solar-Actie, accessed on 23.11.2010.

[22] See the web page www.egip.org. Also at EGIP on the web page it is unclear that the organisation is operated by the agency BKP. Only in the CV of Jan Kallmorgen is his function as partner at BKP mentioned, without, however, making clear that he manages EGIP in his function for BKP.

[23] Landesbank Berlin – Hedge funds disposed against possible flotation. Platow letter of 12.3.2007

the fund did not wish to comment on this. Kallmorgen emphatically denies a financing of the NTSA by a hedge fund. In his reply to LobbyControl he writes: “NTSA e.V. has not received and will not receive any financial support from hedge funds, either directly or indirectly.”[24]

5. Conclusion: Non-transparent and dubious lobbying

The Non Toxic Solar Alliance (NTSA) is a case study about Brussels lobbying. Numerous lobby players influence both policy and public opinion there without it being clear who is the originator of the message. The NTSA has been able to conduct lobbying for months on end without the political players or the public learning who actually finances it or for whom it is actually speaking in practice. This also remains unclear after its entry in the lobby register on 26.5.2010.

The NTSA is non-transparent and its external presentation misleading

The NTSA passes itself off as a “not-for-profit-initiative” supported mainly by scientists and with the charitable goal of achieving a production of photovoltaic modules free of toxins for the sake of the environment and consumer protection.

However, anyone looking into the founding of the NTSA will find it is a lobbying organisation which was founded by the lobbying agency Bohnen Kallmorgen & Partners. The goal internally was not given out as protection of the environment, but to represent the interests of manufacturers of heavy metal-free solar cells. The scientists who dominate the initiative in its external presentation, the members of the Research Group currently play practically no role in the real NTSA, nor do they provide any financial or scientific contribution to the work of the NTSA. It appears otherwise in public relations, where they are placed in the foreground. The scientists themselves may be completely convinced that cadmium telluride ought not to be used in the solar sector and their commitment serves the environment. According to our research they have no real insight into the financing of the NTSA and for their part are only there at the initiative of the lobbying agency BKP, which then raises the question as to how far they themselves have a complete picture of the NTSA.

At many levels the NTSA is neither transparent nor honest in its external presentation:

> **Financing**: Whoever is ultimately financing the initiative remains lurking in the shadows. Outwardly the NTSA presents itself as though financed either by donations (answer to first enquiry of LobbyControl) or by membership contributions (entry in the EU lobby register). Yet donations and member contributions are two different things. But the contradictions go further: when pressed, the NTSA cannot clearly say who the donations or member contributions are supposed to come from. It falls back on the position that the costs of the campaign are covered by the lobbying agency BKP itself. Likewise, our research reveals that the NTSA has written to numerous solar firms as to whether they would like to support the campaign. However, it

[24] NTSA reply to the second enquiry from LobbyControl, 1 June 2010.

seems to have had no success with this. Nevertheless, the campaign is proceeding, with unclear financial background.

Founders: For the public it is undetectable that the NTSA initiative has emanated from a lobbying agency. Instead the impression is given that we are dealing with an initiative of scientists, civil society and representatives of the solar economy. Neither on the web page of the NTSA nor in the entry in the EU lobby register can it be discerned that the agency Bohnen Kallmorgen and Partners both founded and supports the initiative.

Aim: Outwardly, a solar sector without toxins is always mentioned, but de facto the campaign only aims at the cadmium telluride technology. Other heavy metals such as lead play practically no role.[25] In the first editions of the web page and a self portrayal used in lobbying dialogues, the NTSA claimed it represented no industrial interests. By contrast, the foundation minutes and an internal strategy paper states the goal as being to represent the interests of manufacturers of heavy metal-free solar cells. However, in our estimation the question remains open as to whether possibly this variant too is ultimately a camouflage for an unknown principal of Bohnen Kallmorgen and Partners.

It is certain that with its self portrayal, the NTSA leaves the public in the dark about its background and its true goals, and thus contravenes ethical rules such as the Code of the Brussels lobby register.

Lack of transparency rules favours manipulative lobbying

According to estimates, around 15,000 –20,000 lobbyists work in Brussels. No clear assertions can be made as to how high the number actually is. Although the European Commission did indeed introduce a lobby register in 2008, the registration is voluntary, and there is not any genuine incentive to date to enrol in the register. Even though the European Commission advertises that around 3,000 lobbying organisations have meanwhile enrolled in the register[26], according to the estimates of our European network ALTER-EU, this does not involves more than perhaps 40 percent of the lobbyists resident in Brussels. Substantial names such as CIAA, the powerful lobbying organisation of the drinks and foodstuffs industry, or influential major corporations and major banks such as Nestlé, Eon, Deutsche Bank or Royal Bank of Scotland are missing. These examples show that whoever wishes to work in the shadows can do so undisturbed, despite the lobby register. Anyone who in fact enrols is under absolutely no obligation to account for the accuracy of his figures

[25] Lead only emerges marginally in the position paper of the Wuppertal Institute, which was commissioned by the NTSA.

[26] A distinction is to be made between lobbying organisations (companies, agencies, associations, NGOs etc.) and individual lobbyists which the figure of 15,000 – 20,000 refers to. This is the total number of individual persons who work in the organisations.

as the European Commission does not check them, however absurd they may be. The lobby register is therefore flawed and incomplete, and does not reflect a realistic picture of the Brussels lobbying scene. This enables organisations such as the NTSA to operate easily in Brussels without naming their real principals and finance sources. Thus BKP indeed registered the NTSA – with a six months delay – but not itself. This trick of a partial registration is possible due to the voluntary nature of the EU lobby register. Hence BKP was able to conceal the actual principals and financiers. Furthermore, the NTSA benefits from imprecise requirements for the data to be disclosed and missing checks. The link with the lobbying agency BKP is vacant in the entry, although BKP de facto founded, and according to its own declarations, financed the initiative.[27]

We repeatedly observe in Brussels how ostensible "not-for-profit-initiatives" are founded by lobbying agencies, with the money from companies who do not wish (or wish only marginally) for their names to emerge in a specific debate [28]. Clearly, a compulsory lobby register also has its limits. But the compulsion to have to name its principals and financiers[29] would obviously have hampered the NTSA's non-transparent practice. Linked with this naturally is also a culture of diligence by those addressed in politics and administration, for example, denial of a dialogue to organisations who do not enrol in the register. Furthermore, the media should critically screen organisations like the NTSA. In the coverage of the NTSA the true backgrounds of the initiative are underexposed.

The problem of the lobbying agencies

Although the NTSA ultimately did not manage to insert photovoltaics into the RoHS Directive, it was definitely successful. Different players reported to us that the NTSA at least managed to make the debate on the inclusion of the solar sector the main topic in the debate on the overall Directive. In addition, as one observer reported to us, many Parliamentarians had hesitated or allowed themselves to be unsettled by the arguments of the NTSA.

The dispute concerning the environmental repercussions of cadmium telluride solar cells was, in the process, a battle for the division of the European solar market, which is suffering intense price pressure under the contraction of state subsidies. In the direct light of this economic component the non-transparent operation of the NTSA is problematical in our view: in the

27 As a comparison: In the USA the lobby register is compulsory and lobbying coalitions would have to designate financiers above €5,000 by name if they are engaged in lobbying and involved in its preparation. This would also apply in this case to BKP.

28 Hence the outwardly neutrally research body "Bromine Science and Environment Forum" was founded by commission of the four largest bromine producers in the world, to prevent a political ban on bromided fire-proofing agents. Behind the "Campaign for Creativity", ostensibly founded by artists, musicians and designers, which was used for software patents, in reality were concealed the companies Microsoft and SAP, and others.

29 With the risk of genuine sanctions for false declarations.

final analysis, our research has been unable to clarify plainly whether an assault (via an alleged environmental initiative in reality an economic/financial attack) was intended on a concrete solar technology and on one firm in particular.

At the same time, the debate on the use of cadmium telluride is definitely reasonable and necessary. But it must be conducted transparently and requires independent studies which are financed neither by cadmium telluride users nor by silicon-based photovoltaic companies, nor by non-transparent organisations such as the NTSA.

The case of the Non Toxic Solar Alliance shows in particular the problematical operation of lobbying agencies such as Bohnen Kallmorgen and Partners, who are themselves active as political entrepreneurs and whose principals, backgrounds and motives are often difficult to make out. At the same time, these agencies are profiting from the voluntary nature of the Brussels lobby register and the total lack of transparency rules for lobbyists in Germany. It is therefore a central political challenge finally to pass through compulsory transparency rules which compel lobbying agencies to disclose their principals and financing.

Contacts

The study is an independent investigation by LobbyControl. LobbyControl is a charitable association which wishes to elucidate power structures and influential strategies in Germany and the EU.

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