Implementation of the first landfill cover sealing with integrated photovoltaic power plant

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Abstract

Photovoltaic power plants are an attractive afteruse for the wide surfaces of closed landfills. It is a land recycling in combination with a climate friendly energy generation. For conventional PV-plants expensive and resource-consuming steel frames are necessary, which are built on top of a high amount of soil and other construction material. A patented system developed by the author based on a compound of geomembrane and flexible thin film solar cells combines the function of landfill surface sealing and photovoltaic power plant in one element. The installation applies approved landfill techniques and supersedes steel frames. The project preparation started in 2005, when patents had been granted and first publications were made. The construction of the first pilot plant is supported by the German environmental fund (DBU) and started in September 2008 with samples made of roof membrane-PV-module compounds. Later-the development of durable and reliable

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HDPE compounds was successful. The final version of these compounds was installed in 2009 and 2010 and turned out to be the best solution for landfill application.

Keywords

Photovoltaic power plant, landfill, landfill surface sealing, resources, waste management

1. Introduction

Photovoltaic power plants are an attractive after use for the wide surfaces of closed landfills. It is land recycling in combination with climate friendly energy generation. Large grid connected solar energy plants have already been built on more than 30 landfills in Germany, providing a total capacity of over 22 MWp. But all of them are conventional PV plants. For conventional PV-plants expensive and resource-consuming steel frames are necessary, which are built on top of a high amount of soil and other construction material.

In the course of a project funded by the German Federal Environmental Fund (Deutsche Bundesstiftung Umwelt, DBU) and the operator of the landfill "Leppe", the "Bergische Abfallwirtschaftsverband" (BAV), a new photovoltaic landfill cover system has been proven. Its core element is a composite of an impermeable membrane and flexible thin film solar cells. The project preparation started in 2005, when patents had been granted and first publications were made. Product development was done in co-operation with the company agru that acquired the production license and has production facilities in Austria and the USA.

In this research project test fields were built in September 2008 on the German landfill "Leppe" near Engelskirchen. On these fields different combinations of solar cells and geomembranes are compared regarding durability, suitability for practice and electrical capacity.

2. Remuneration for solar energy

2.1 Legal Basics

Since April 2000 the feeding-in of renewable energy in Germany has been regulated by the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, EEG). In August 2004 the revision of the EEG became effective. The act comprises amongst other features a regulation for the remuneration for energy derived from photovoltaic and wind energy plants. Photovoltaic plants with a capacity of up to 5MW are aided by an increased feeding-in remuneration.

The amount of the remuneration is regulated in a differentiated way. If the plant is completed in 2010 the basic remuneration amount is 31Cent/kWh. With every year of later completion, the remuneration decreases by 8%. This remuneration is guaranteed for 20 years of operation plus the remaining months of the year when operation started. Therefore, an extremely solid basis for economic calculations is given. The high remuneration is essential for economically operation of PV plants in Germany because of the low amount of sun radiation. In Mediterranean countries sun radiation and hence the energy yield of PV plants is about 50% higher than in Germany.

2.2 Regional aspects and economics

There are clear regional differences in the global irradiance and thus in the energy recovery of PV plants. Southern countries on the northern hemisphere receive much more solar radiation than northern countries do (opposite on the southern hemisphere). Table 1 and Table 2 give an overview about the global radiation in different regions. Examples for the European situation can be found in Table 3.

Table 1 Approximate average annual global radiation in North America

Region	Canada South and Central	USA NE	USA Central	USA far SW	Mexico	Brazil South	Brazil Rest	Argentina North
kWh/m²	1000-1400	1200-1400	1400-1600	1800-2000	1800-2200	1600-2000	1800-2400	1600-2000

Table 2 Approximate average annual global radiation in Australia, Asia, Africa

	Australia without Tasmania			Asia				Africa
Region	Vic-toria	NSW, southern QLD, SW	Rest	India, Pakistan, Iran: Central and South	SE	Central	China: East and Central	
kWh/m²	1400-1800	1600-2000	2000-2400	1800-2200	1400-2000	1000-1600	1000-1400	1800-2400

As electricity yield of a PV-plant and the regional solar radiation have a nearly linear relation, global radiation is a determining factor for the economic performance of a PV plant. Hence, it is essential to use long term local sun radiation data from a reliable weather station close to the plant for the calculation of profitability. **Table 3** shows the profitability of a 1MWp PV plant under the different natural and legal conditions of some European countries within the period of guaranteed remuneration. Economic efficiency may be significantly increased by tax aspects (not considered here).

Table 3 Examples for economic results of a 1MWp plant in 2010 independent of technique. Condition: Southern landfill slope with optimal inklination (Kuehle-Weidemeier, 2007). No liability for the correctness of these values is taken. Local situation differs and has to be considered!

Country	**Unit**	**Germany**	**France**	**Italy**	**Spain**
Installed Power	MWp	1	1	1	1
Remuneration	Euro/kWh	0.2537	0.314	0.3457	0.32
Global radiation (on flat surface)	kWh/m²	1050	1200	1400	1600
Approximate energy yield (considering performance ratio and benefit from module inclination)	kWh/kWp	926	1059	1235	1411
Years of guaranteed remuneration (operation starts July)	a	20.50 (20 + remaining months in the first year of operation	20	20	**25**
Investment costs	Euro	2,700,000	2,700,000	2,700,000	2,700,000
Income from sold energy in the time of guaranteed price	Euro	4,700,000	6,650,000	8,540,000	11,290,000
Costs for design, repair, insurance, maintenance	Euro	550,000	550,000	550,000	680,000
Yield / annual rate of return considering described costs (no financing costs)	%	2.7	6.3	9.8	11.7

4. Pilot plant and intended investigations

4.1 Investigation programme

The research component of this project deals with the following issues:

- Installation and connection of the liners
- Impact of settlements on the system (damages, corrugation formation, etc.)
- Applicability to re-lift and re-laying after heavy settlements
- Different energy generation and dust deposit at two different slopes (1:3 and 1:10)
- Long-term durability (incl. the influence of chemical and physical impacts)
- Influence of different support materials (e.g. colour ⇒ warming up) on the degree of efficiency of the solar modules
- Influence of different coefficients of thermal expansion
- Comparison of the efficiency of different solar module types

4.2 Implementation of the pilot plant

As a first step, a conventional crystalline reference field and test fields based on various available roof membrane laminates were installed.

Figure 1. Position plan of the test fields

A major challenge of this step was the connection between the roof membrane materials and the HDPE landfill membrane. Lots of techniques and materials were tried. A welded direct connection between the roof membranes and the HDPE landfill cover was not possible. One manufacturer supplied an old double-layered adapter sheet that was on store from the 1990es and that allowed welding one side with the roof membrane and the other side with the HDPE membrane. Roof membranes from other manufacturers were connected by self made adhesive adapters (made of a PE membrane geotextile compound, the geotextile was glued to the textile bottom side of the roof membrane) in connection with rivets. Some of the roof membrane test fields were installed on top of the HDPE landfill membrane, while others were inserted in “windows” that were cut in the HDPE landfill cover.

Figure 2. Various roof membrane composites on HD-PE landfill cover and crystalline reference fields (second from right side) on the steep slope

In parallel, the development of a composite consisting of a sturdy HDPE landfill membrane and flexible solar cells started. The technical development was done in co-operation with agru, a leading HDPE-membrane manufacturer.

Generations of prototypes we developed and tested in laboratory and on site until a durable connection between PE-HD membranes could be achieved that was reliable under varying climate and especially temperature conditions to guarantee decades of flawless operation.

Figure 3. Scheme for application of the solar sealing liners (DepoSolar®)

The first prototype (Figure 4) with a 3m module looked good already, but the compound could not resist the high thermal expansion coefficient of HDPE, which was not really a surprise. Especially when using 6m modules, the weakness became quite obvious. Many tests were made with variations of mechanical connecting technology, plastic mixtures, reinforcement and different types of modules (Figure 5).

Figure 4. Early prototype of HD-PE liner with laminated PV-module (3m length)

Figure 5. Various types of (HD)PE liners with laminated PV-module (6m length)

Finally, a combination was found, that survived all laboratory and landfill application tests and seems to be better than the compounds with roof membranes. (Figure 6). The modules are embedded in the HDPE membrane and hence an edgeless product with an even surface was created. In difference to currently available roof membrane compounds this avoids any weak points where modules could be peeled off.

Figure 6. First emplaced sample of the final version of HDPE compounds

Compared to roof membrane composites the HDPE composite has many advantages: The material is physically and chemically better feasible for landfill conditions and can be easily attached (welded) to other HDPE landfill sealing components. The material is long time landfill approved and well known to landfill operators. After the end of life of the solar cells, the high quality HDPE membrane has the potential to become a component of the final landfill sealing system (refer to chapter 6). PV plants made of flexible thin film modules require an area of about 7.4-10 acres for an installed power of 1 MWp. Costs per MW are similar to conventional PV-plants..

A full size pilot plant with the HDPE composite that was scheduled to be built in spring 2010, had to be postponed because of a reshaping of the landfill surface that will require the complete removal and later reinstallation of the PV plant..

Figure 7. Allocation of the individual test fields (final design) with HDPE compounds (fields with hatching behind), roof membrane compounds and crystalline reference fields (drawn as unfilled grids).

Test fields (roof membranes, PE-HD membranes and crystalline reference) are equipped with temperature and calibrated solar radiation sensors, landfill settlement measuring points and optional deformation sensors. Energy production of each field is continuously logged. The evaluation of this data will be subject of a later extension of the research project and can not be presented at the moment.

5. First practical experience (Pilot plant)

In the comparatively short operation time between 6 and 18 months no major problems appeared. In the area with low inclination (6-8%) sedimentation of dust and soil particles were observed in wave troughs (Figure 8). It is now investigated if a 90° rotation of the modules will improve this situation (Figure 9). In total, the final version of the newly developed HDPE membrane and PV module compound seems to be the best solution for landfill application.

Figure 8. Dirt accumulation in wave troughs of the modules (low inclination area).

Figure 9. Modules orientated crosswise the inclination.

6. Application after end of life of the solar cells

If the support layer of the combined PV plant consists of an accredited landfill sealing liner, there is the potential to use the combination PV plant / sealing liner as a crucial functional element of the final landfill sealing after the utilisation of the PV plant has ended. In accordance to the German legal regulation a combined sealing system existing of geomembrane and a multi-layered (cohesive) mineral sealing element is demanded for class 2 MSW landfills. Alternatively, equivalent systems with a different configuration are permitted.

Various investigations (e.g. Melchior, 1993) have shown that cohesive mineral sealings on the landfill surface have the tendency to exhibit cracks from shrinking and thus the impermeability (or the low permeability) is decreased. For this reason and also because of economic advantages the cohesive mineral layer of the surface sealing has often been replaced by a (mineral) capillary barrier. This system allows the integration of the PV-geomembrane-compound. Figure 10 shows two variants of a surface sealing system with integrated PV plant liner in comparison to usual system. The PV plant liner replaces the already required geomembrane.

Information: The combination of flexible solar cells used in the DepoSolar® system and the combined capillary barrier system from Sehrbrock (Figure 10) are both patent-protected.

Figure 10 Integration of the innovative PV plant as a sealing element in two variants of an alternative combined sealing system for a landfill of class II compared to a previously legally demanded system (TASi)

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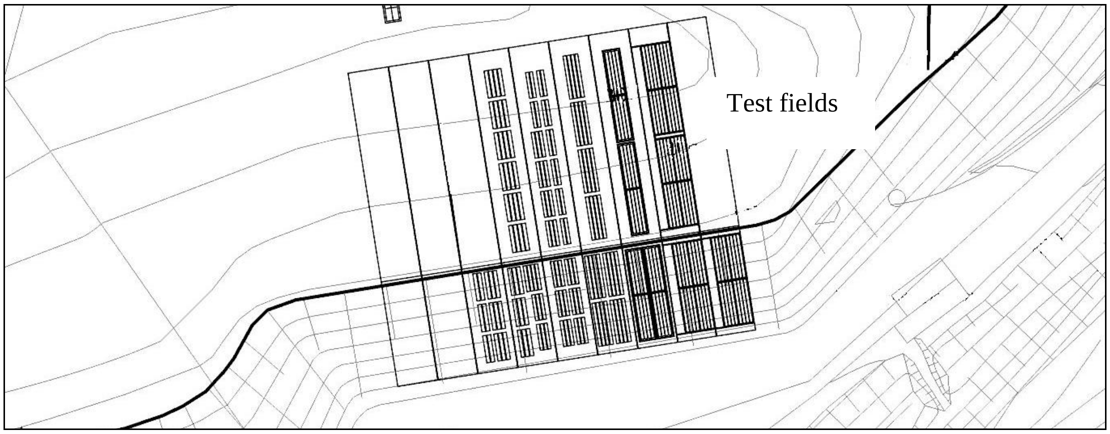
Attachment



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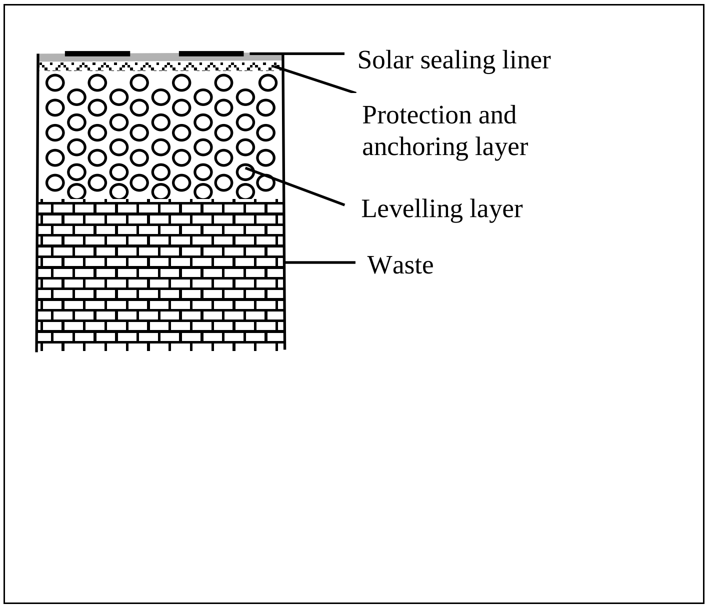

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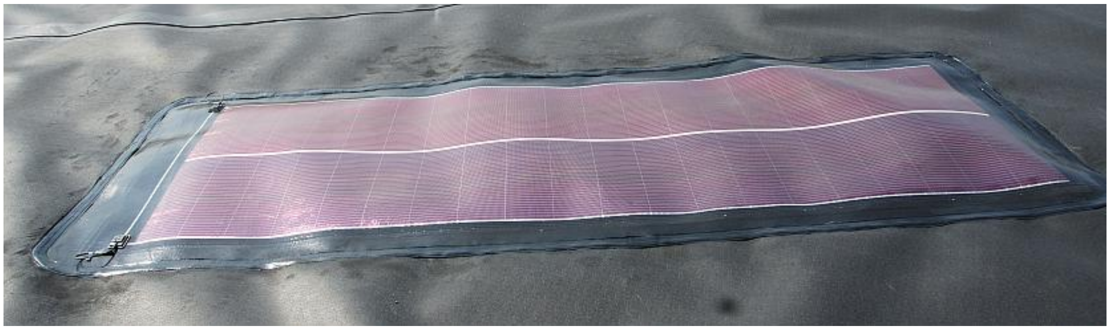
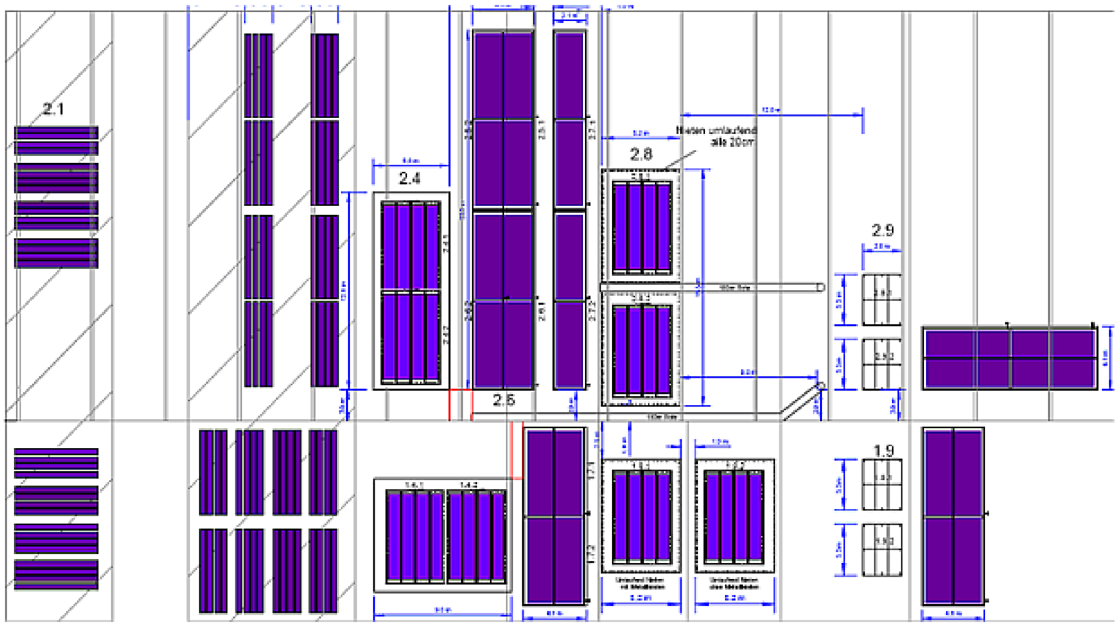


Figure 6. First emplaced sample of the final version of HDPE compounds



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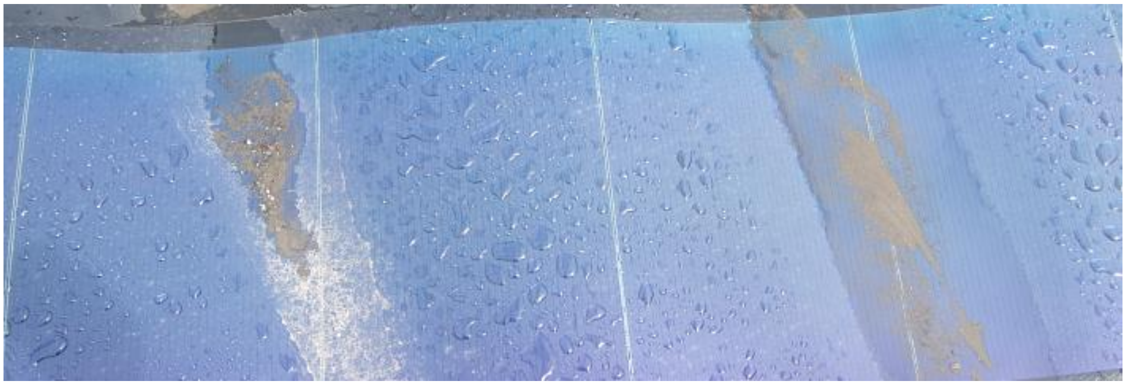

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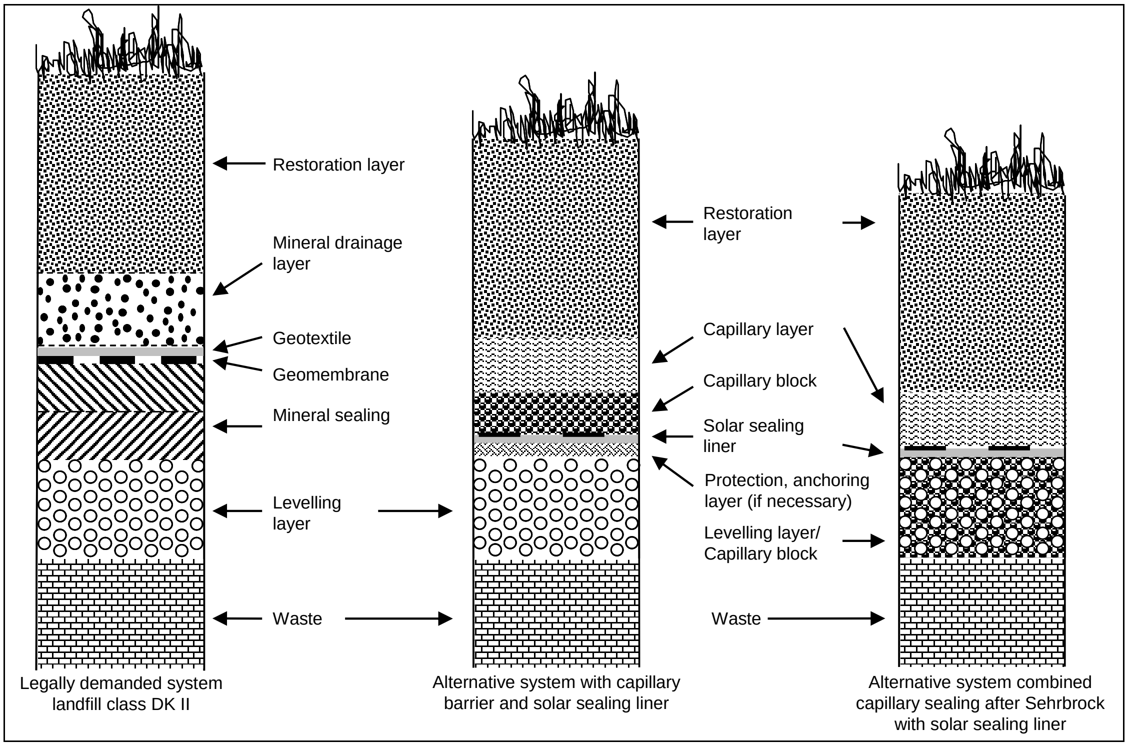

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Primjena prvog prektrivnog brtvenog sloja s ugrađenim fotovoltnim postrojenjem na odlagalištu

Matthias Kuehle-Weidemeier[2]

Sažetak

Fotovoltna postrojenja su atraktivna za korištenje na velikim površinama zatvorenih odlagališta. Ona predstavljaju reciklažu tla kombiniranu s energetskom generacijom klimatski prihvatljivom. Za konvencionalna fotovoltna postrojenja potrebni su skupi čelični okviri, koji se ugrade na vrh velike količine zemlje i drugog građevnog materijala. Patentirani sustav koji je osmislio autor, a koji se temelji na mješavini geomembrane i fleksibilnog filma solarnih ćelija objedinjuje funkciju površinskog brtvljenja odlagališta i fotovoltnog postrojenja u jedan element. Instalacija koristi odobrene odlagališne tehnike i nadomješta čelične okvire. Priprema projekta započela je 2005. godine, kada je dodijeljen patent i kada su napravljene prve publikacije. Izgradnju prvog pilot postrojenja podržao je Njemački fond za zaštitu okoliša, a sama izgradnja je započela u rujnu 2008. godine uzorcima napravljenim od mješavine površinske membrane i fotovoltnih modula. Kasniji su se uspješno razvile trajne i pouzdane HDPE smjese. Konačna verzija ovih spojeva instalirana je 2009. i 2010. godine, te je izgledno da upravo ona predstavlja najbolje rješenje za uporabu na odlagalištima.

Ključne riječi: Fotovoltno postrojenje, odlagalište, površinsko brtvljenje odlagališta, resursi, gospodarenje otpadom

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1. Uvod

Fotovoltna postrojenja su vrlo zanimljiva za korištenje na velikim površinama zatvorenih odlagališta. Ona predstavljaju reciklažu zemlje u kombinaciji s proizvodnjom energije. Velika mreža povezanih solarnih postrojenja je već ugrađena na više od 30 odlagališta u Njemačkoj, ukupnog kapaciteta od 22 MWp. Ali sva ta postrojenja su konvencionalna fotovoltna postrojenja. Za konvencionalna fotovoltna postrojenja potrebni su skupi čelični okviri, koji se ugrade na vrh velike količine zemlje I drugog građevnog materijala.

Tijekom projekta financiranog od strane Njemačkog fonda za zaštitu okoliša (Deutsche Bundesstiftung Umwelt, DBU) I operatora odlagališta “Leppe”, “Bergische Abfallwirtschaftsverband” (BAV), postavljen je novi pokrovni sloj s fotovoltnim postrojenjem. Njegov glavni element je kompozit nepropusne membrane I fleksibilnih tankih solarnih ćelija. Priprema projekta započela je 2005. godine, kad su dodijeljeni patenti I napravljene su prve publikacije. Razvoj proizvoda je napravljen u suradnji s tvrtkom agru koja je ishodila potrebne dozvole I koja posjeduje proizvodna postrojenja u Austriji I SAD-u.

Tijekom istraživanja sagrađena su testna polja u rujnu 2008. na njemačkom odlagalištu “Leppe” blizu Engelskirchen-a. Na ovim poljima uspoređene su različite kombinacije solarnih ćelija i geomembrana u odnosu na trajnost, održivost u praksi i u odnosu na električni kapacitet.

2. Naknada za solarnu energiju

2.1 Pravne osnove

Od travnja 2000 napajanje obnovljivom energijom u Njemačkoj je regulirano Zakonom o izvorima obnovljive energije (Erneuerbare-Energien-Gesetz, EEG). U kolovozu 2004 na snagu su stupile izmjene i dopune EEG. Zakon uključuje između ostaloga, regulaciju naknade za energiju iz fotovoltnih postrojenja i vjetrenjača. Fotovoltna postrojenja kapaciteta do 5MW su potpomognuta povećenjem naknade za napajanje.

Visina naknade regulirana je diferenciranim načinom. Ako je postrojenje izgrađeno u 2010. godini osnovna naknada iznosi 31Cent/kWh. Svake sljedeće godine izgradnje, naknada se smanjuje za 8%. Ova visina naknade je zagarantirana za 20 godina rada plus broj mjeseci u godini kad je postrojenje pušteno u pogon. Na taj način je dana solidna baza za ekonomski izračun. Visoka naknada je izuzetno bitna za ekonomsko opravdani rad fotovoltnih postrojenja u Njemačkoj zbog male količine sunčeva zračenja. U mediteranskim državama sunčevo zračenje, pa stoga i povrat energije iz fotovoltnih postrojenja, je oko 50% viši nego u Njemačkoj.

2.2 Regionalni aspekti i ekonomija

Postoje jasne regionalne razlike u globalnom zračenju i stoga i u energetskoj oporabi fotovoltnih postrojenja. Južne zemlje na sjevernoj zemljinoj hemisferi primaju puno više sunčevog zračenja nego sjeverne zemlje (obrnuto na južnoj hemisferi). Table 1 i

Table 2 daju prikaz globalnog zračenja u različitim regijama. Primjeri za Europu dani su u Table 3.

Tablica 4 prosječno godišnje globalno zračenje u sjevernoj Americi

Regija	Kanada južna i centralna	SAD SI	SAD Centralna	SAD far JZ	Meksiko	Brazil južni	Brazil ostatak	Argentina sjever
kWh/m²	1000-1400	1200-1400	1400-1600	1800-2000	1800-2200	1600-2000	1800-2400	1600-2000

Tablica 5 prosječno godišnje globalno zračenje u Australiji, Aziji, Africi

	Australija bez Tasmanije			Azija				Afrika
Regija	Vic-toria	SJZ, južni QLD, JZ	ostatak	Indija, Pakistan, Iran: Centralni i južni	JI	Centralna	Kina: istočna i centralna	
kWh/m²	1400-1800	1600-2000	2000-2400	1800-2200	1400-2000	1000-1600	1000-1400	1800-2400

Kako povrat električne energije iz fotovoltnih postrojenja i regionalno sunčevo zračenje imaju gotovo linearan odnos, globalno zračenje je odlučujući faktor za ekonomsko opravdanje rada fotovoltnih postrojenja. Dakle, najbitnije je koristiti dugoročne podatke o lokalnom sunčevom zračenju s pouzdane meteorološke stanice u blizini postrojenja za izračun profitabilnosti. **Table 3** pokazuje profitabilnost 1MWp-og fotovoltnog postrojenja pod različitim prirodnim i pravnim uvjetima za pojedine Europske zemlje unutar perioda garantirane naknade. Ekonomska efikasnost može se značajno povećati porezima (nije razmatrano u ovom slučaju).

Tablica 6 Primjeri ekonomskih rezultata za 1MWp-no postrojenje u 2010, ovisno o tehnici. Uvjeti: Južni kosina odlagališta s optimalnim nagibom (Kuehle-Weidemeier, 2007). Lokalne situacije se razlikuju i moraju se uzeti u obzir!

Zemlja	**Jedinica**	**Njemačka**	**Francuska**	**Italija**	**Španjolska**
Instalirana snaga	MWp	1	1	1	1
Naknada	Euro/kWh	0.2537	0.314	0.3457	0.32
Globalno zračenje (na ravnoj površini)	kWh/m²	1050	1200	1400	1600
Približan energetski doprinos (uzimajući u obzir omjer rada i dobrobiti)	kWh/kWp	926	1059	1235	1411
Godine osigurane naknade (rad počinje u srpnju)	a	20.50 (20 + preostali mjeseci u prvoj godini rada	20	20	**25**
Investicijski trošak	Euro	2,700,000	2,700,000	2,700,000	2,700,000
Dobit iz solarne energije tijekom vremena osigurane naknade	Euro	4,700,000	6,650,000	8,540,000	11,290,000
Troškovi projektiranja, popravka, osiguranja, održavanje	Euro	550,000	550,000	550,000	680,000
Dobit / godišnja brzina povrata uzimajući u obzir opisane troškove	%	2.7	6.3	9.8	11.7

4. Pilot postrojenje i namjenski istražni radovi

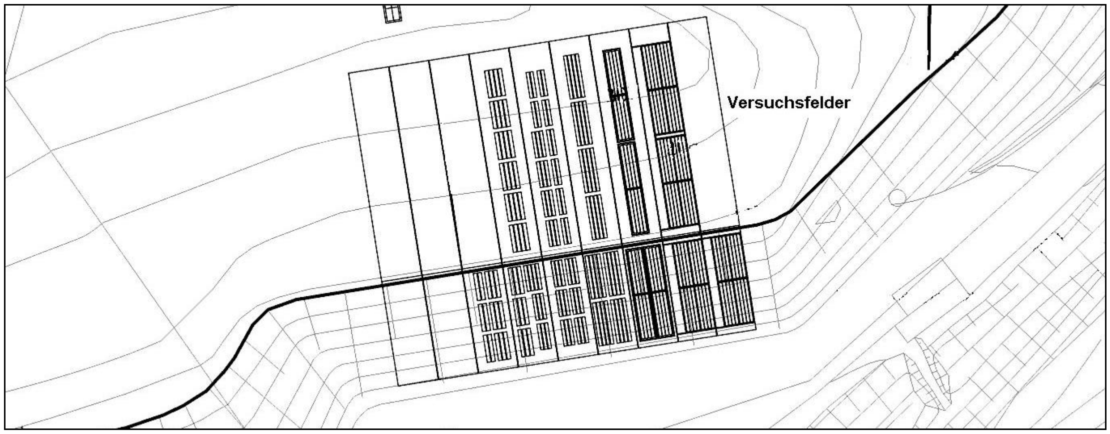
4.1 Program ispitivanja

Istraživačka komponenta ovog projekta odnosi se na sljedeće:

- Instalacija i povezivanje slojeva
- Utjecaj naselja na sustav (oštećenja, nabiranje, itd.)
- Mogučnost ponovnog dianja i postavljanja nakon velikih slijeganja
- Različita proizvodnja energije i taloženje prašine na dva različita nagiba (1:3 i 1:10)
- Dugoročna trajnost (uklj. Kemijske i fizičke utjecaje)
- Utjecaj različitih potpornih materijala (npr. boja ⇒ zagrijavanje) na stupanj učinkovitosti solarnih modula
- Utjecaj različitih koeficijenata termičke ekspanzije
- Usporedba učinkovitosti različitih tipova solarnih modula

4.2 Primjena pilot postrojenja

Prvi korak je bila instalacija konvencionalnog kristalnog referentnog polja i testnog polja na osnovu različitih dostupnih krovnih membranskih ploča.



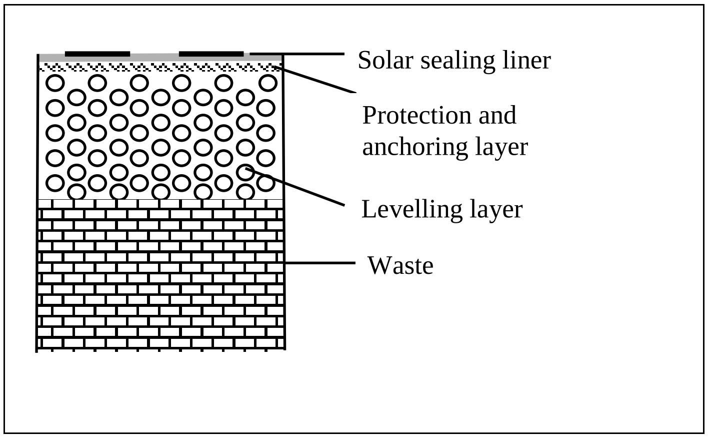
Slika 1. Položaj testnih polja

Najveći izazov u ovom koraku bilo je povezivanje krovnih membranskih materijala i HDPE odlagališne membrane. Isprobane su mnoge tehnike i materijali. Direktno spajanje krovnih membrane i HDPE membrane zavarivanjem nije bilo moguće. Jedan proizvođač dostavio je dvostranu prilagođenu ploču koja je na skladištu od 1990ih i s kojom je moguće varenje jedne strane s krovnom membraneom i druge strane s HDPE membranom. Krovne membrane od drugih proizvođača povezane su adhezivnim adapterima (od PE membranskog geotekstilnog sastojka geotekstil je zalijepljen na donju stranu tekstila krovne membrane). Pojedina testna polja krovnih membrana instalirana su na vrh HDPE odlagališne membrane, dok su ostala ugrađena u “prozore” koji su urezani u HDPE odlagališni pokrov.

Slika 2. Različiti kompoziti krovne membrane na HD-PE odlagališnom pokrovu i kristalna referentna polja (druga sdesna) na velikom nagibu

Usporedno je započet razvoj mješavine koja se sastoji od čvrste HDPE membrane i fleksibilnih solarnih ćelija. Tehnički razvoj je napravljen u suradnji s agru, vodećim proizvođačem HDPE-membrana.

U laboratoriju i na gradilištu smo razvili i testirali generacije prototipova dok nismo postigli trajnu povezanost između PE-HD membrane koja je pouzdana kod različitih klimatskih uvjeta, a posebno temperaturnih uvjeta, kako bi se osigurala desetljeća besprijekornog rada.



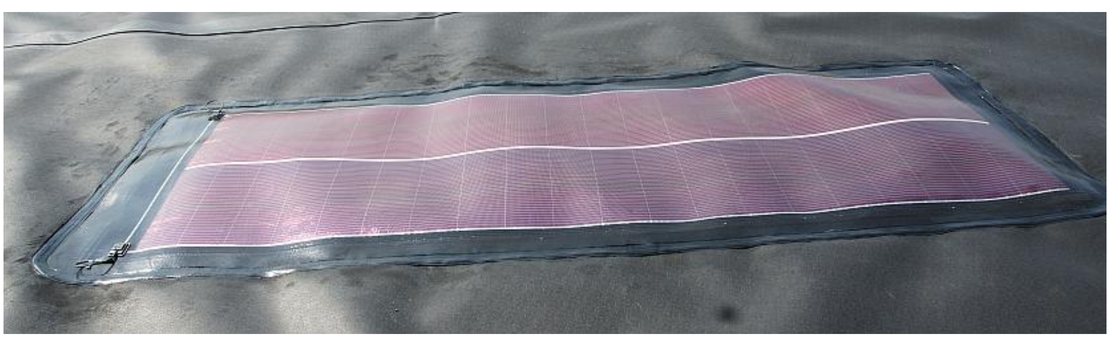
Slika 3. Shema primjene solarnih brtvenih slojeva (DepoSolar®)

Prvi prototip (slika 4) s 3m modulom izgledao je dobro, no nije mogao izdržati visoki termički koeficijent ekspanzije HDPE-a, što nam i nije predstavljalo neko iznenađenje. Kad smo koristili 6m module, slabost je postala još očitija. Napravljeni su mnogi testovi s različitim tehnologijama mehaničkog povezivanja, plastičnim kompozitima, učvršćivanjem i različitim tipovima modula (slika 5).

Slika 4. Rani prototip HD-PE sloja s pločastima fotovoltnim modulom (3m dužina)

Slika 5. Različiti tipovi (HD)PE slojeva s pločastim fotovoltnim modulima (6m dužina)

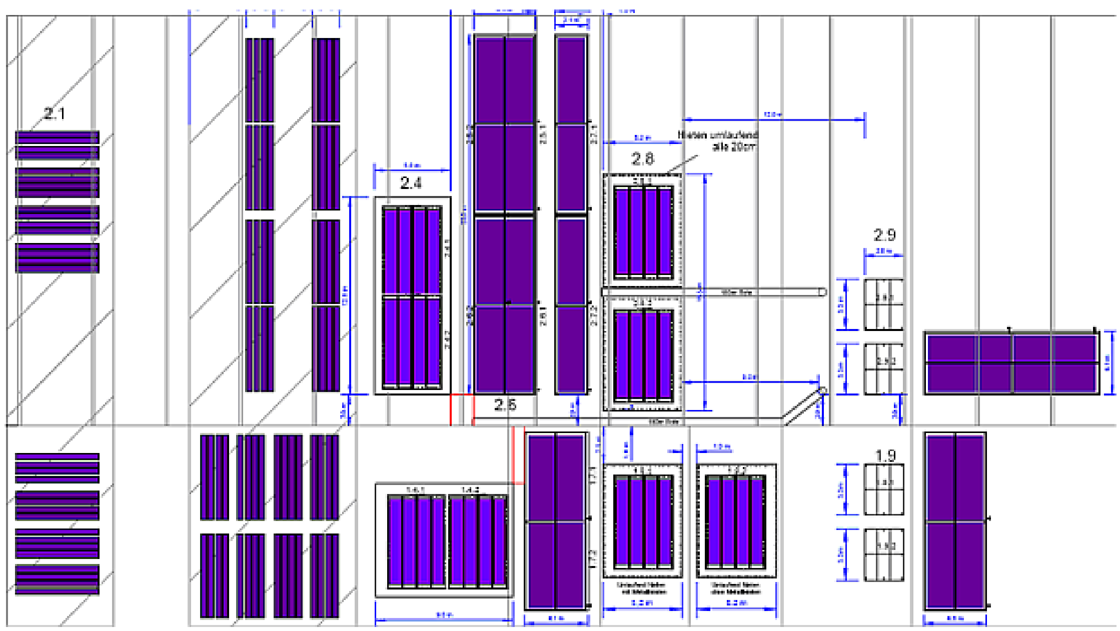
Konačno je pronađena kombinacija koja je izdržala sve laboratorijske i odlagališne testove (slika 6). Moduli su ugrađeni u HDPE membranu i stvoren je proizvod bez rubova, ravne površine. Za razliku od trenutno dostupnih primjera krovne membrane s ovim proizvodom izbjegavaju se slabe točke na kojima se moduli mogu oguliti.



Slika 6. Prvi položeni uzorak konačne verzije HDPE kompozita

U usporedbi s kompozitom krovnom membranom HDPE kompoziti imaju mnoge prednosti: materijal je fizički i kemijski lakše izvediv za odlagališne uvjete i može se lagano zavariti na druge HDPE komponente odlagališnog brtvljenja. Materijal je poznat djelatnicima na odlagalištima. Nakon završetka trajanja solarnih ćelija, HDPE membrana ima potencijal postati komponenta završnog brtvenog sloja odlagališta (poglavlje 6). Fotovoltna postrojenja napravljena od fleksibilnih tankih filmova modula trebaju površinu od oko 7.4-10 njiva za instaliranu snagu od 1 MWp. Troškovi po MW su slični onima za konvencionalna fotovoltna postrojenja.

Pilot postrojenje u najvećoj veličini s HDPE kompozitom koje je trebalo biti izgrađeno u proljeće 2010. godine, odgođeno je zbog preoblikovanja površine odlagališta što zahtjeva potpuno uklanjanje i ponovno instaliranje fotovoltnog postrojenja.

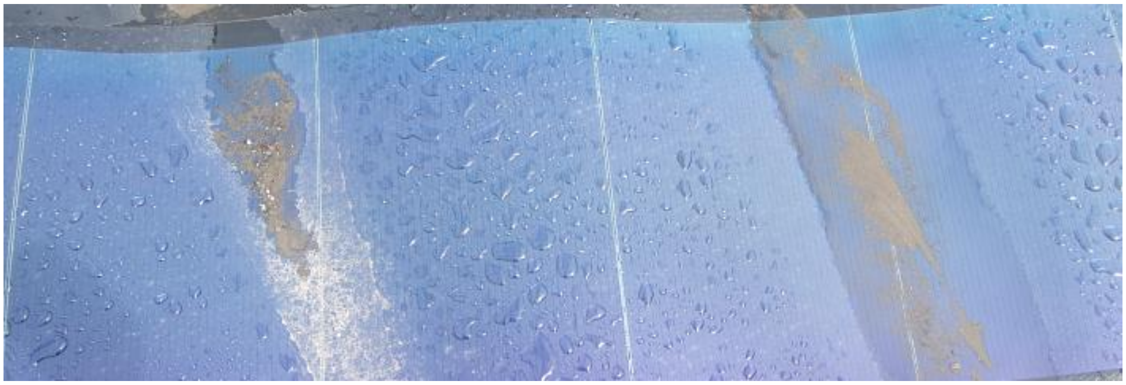


Slika 7. Alokacija individualnih testnih polja (konačni projekt) s HDPE kompozitima, kompozitima krovne membrane i kristalnim referentnim poljima (ucrtani kao nepopunjena mreža).

Testna polja (krovne membrane, PE-HD membrane i kristalne reference) su opskrbljene temperaturnim i kalibriranim senzorima sunčevog zračenja, točkama mjerenja slijeganja odlagališta i senzorima optimalne deformacije. Proizvodnja energije svakog polja se kontinuirano evidentira. Procjena ovih podataka će biti predmet daljnjeg proširenja projekta i trenutno ne može biti prezentirana.

5. Prvo praktično iskustvo (Pilot postrojenje)

U razmjerno kratkom periodu rada, između 6 i 18 mjeseci, nije došlo do nekih većih problema. Na području malog nagiba (6-8%) promatrano je taloženje čestica prašine i zemlje (slika 8). Trenutno se ispituje da li bi rotacija modula za 90° popravila situaciju (slika 9). Ukupno, konačna verzija novo-razvijene HDPE membrane i fotovoltnih modula predstavlja najbolje rješenje za primjenu na odlagalištima.



Slika 8. Akumulacija prašine u serijama valova modula (područje niskog nagiba).

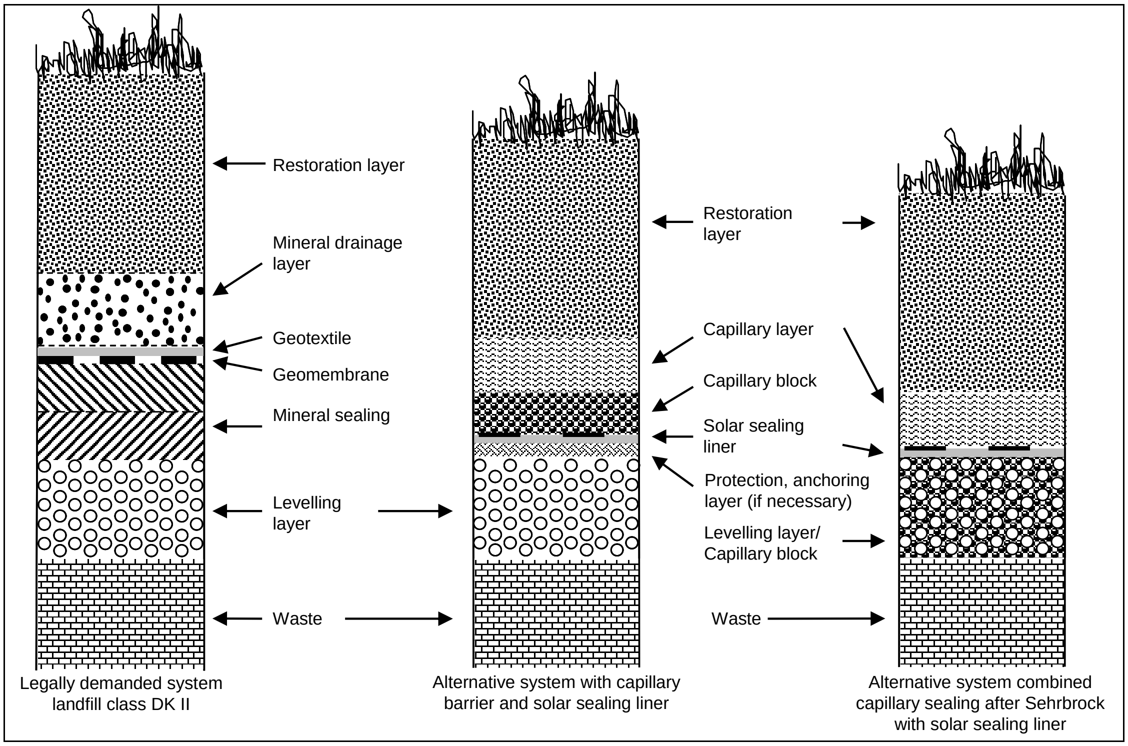
Slika 9. Moduli orijentirani dijagonalno na nagib.

6. Primjena nakon završetka trajanja solarnih ćelije

Ako se potporni sloj kombiniranih fotovoltnih postrojenja sastoji od akreditiranog brtvenog sloja odlagališta, u tom slučaju postoji potencijal za korištenje kombinacije fotovolnog postrojenja / brtvenog sloja kao krucifijalnog elementa završnog brtvljenja nakon završetka iskorištavanja. Prema njemačkoj legislativi, korištenje kombiniranog sustava brtvljenja koji se sastoji od geomembrane i više-slojnog (kohezivnog) elementa mineralnog brtvljenja je zahtjev za 2 odlagališta komunalnog otpada. Alternativno su dozvoljeni jednakovrijedni sustavi različite konfiguracije.

Nekoliko istraživanja (Melchior, 1993) pokazala su da kohezivna mineralna brtvljenja na površini odlagališta imaju tendenciju da na njima nastanu pukotine. Iz ovog razloga i zbog ekonomskih prednosti, najčešće se kohezivni mineralni sloj površinskog brtvljenja zamjenjuje (mineralnom) kapilarnom barijerom. Ovakav sustav podnosi integraciju fotovolnih postrojenja i kompozita geomembrane. Slika 10 pokazuje dvije varijante površinskog brtvljenja s integriranim fotovolnim postrojenjem u usporedbi s uobičajenim sustavom. Sloj fotovolnog postrojenja zamjenjuje geomembranu.

Informacija: Kombinacija fleksibilnih solarnih ćelija korištenih u DepoSolar® sustavu i kombiniranog sustava kapilarnih barijera od Sehrbrock (slika 10) su zaštićeni patenti.



Slika 10 Integracija inovativnih fotovolnih postrojenja kao brtvenog elementa u dvije varijante alternativnog kombiniranog brtvenog sloja na odlagalištima II kategorije u usporedbi s ranije zakonom zahtijevanim sustavom (TASi)

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