

# FROM WASTE DISPOSAL TO CLEAN POWER PLANT

Solar Landfill Closure Systems



**UNI-SOLAR.**

  
**SolarIntegrated**<sup>®</sup>  
An Energy Conversion Devices Company

# System Advantages

The Solar Landfill Closure System offers a broad range of benefits. These are the most important:

## Green image

By turning a former waste disposal area into a clean energy generating asset, the Solar Landfill Cover System allows to enhance the locations and owner / operators environmental image.

## Reduced costs

The avoidance of intermediate and structural fill layers as well as the vegetation cover greatly reduces the initial investment cost of the temporary or final cover.

Due to the lack of vegetation costs such for soil movements and plant replacement for surface stability measures do not occur.

Usually 25 % to 75 % of the area are suitable for the Solar Landfill Cover System. The greater this area, the lower the cost and the higher the income contribution due to the higher level of energy production.

## Controlled gas extraction

The Solar Landfill Closure System maximizes gas extraction for energy generation or flaring, by preventing uncontrolled greenhouse gas emissions into the atmosphere.

## Easy to maintain

Due to its direct accessibility the Solar Landfill Closure System is easy to maintain and surveil, allowing effective inspection, trouble shooting and control of the settling process.

## Leachate control

As the system basically closes off the waste disposal area from the surface, no additional leachate can evolve. The system promotes a clean water runoff and enhances water table sequestration as well as preventing ground water contamination.

## Prevention of landslides

For the same reason, i. e. closing of the landfill area from the surface, the Solar Landfill Closure Systems helps to prevent landslides and erosion as neither rainwater nor other atmospheric turbulences can influence the area's topographic set up. In Florida, three non-solar landfills with exposed geomembrane covers attached through anchor trenches survived three "direct hit" hurricanes in 2008. Building integrated photovoltaic systems with *UNI-SOLAR* PV-laminates are usually designed to withstand 190 km / h (120 mph) corresponding to hurricane class 3 and have withstood actual wind ratings of more than 298 km / h, i.e. 185 mph in Florida and South Pacific regions at the west coast of the USA.



## Don't Waste Time

### Immediate secondary usage

Solar Landfill Closure Systems offer the opportunity to use former waste disposal areas immediately after temporary or final closure on "new" unsettled and sloped landfills - converting it 15 to 25 years earlier to secondary usage.

### Adaptation to settling ground

Due to the flexible, unbreakable photovoltaic laminates integrated into a membrane liner solution the Solar Landfill Closure System can adapt to shifting terrain, allowing for land subsidence, different settlements and topographic instability.

### Income generation - cost reduction

The Solar Landfill Closure System allows to use the reserves accumulated for the aftercare period or closure to generate additional income through electricity sales, whilst substantially reducing temporary or final closure investments as well as operating and maintenance cost.

### Application fields

- Temporary / final cover of closed landfills
- Inactive / closed parts of working landfills
- Inadequately closed sites with leachate problems
- Mining / industrial waste disposals
- Water reservoirs with concrete / metal covers unable to tolerate weight or penetrations

### Europe

The European Landfill Directive requires the member states to reduce their waste by up to 65 % in 2016, leading to a large number of landfills required to be closed.

The landfill closure process in Europe requires two stages - the aftercare period of up to 25 years during which the landfill is capped and the area settles. Thereafter a final closure is installed, which usually requires re-naturation and transfer to public or communal use.

The Solar Landfill Closure System is an optimal solution for the aftercare period, using this time for clean energy generation with electricity consumption on site or fed into the grid at applicable feed-in tariff or general electricity rates.

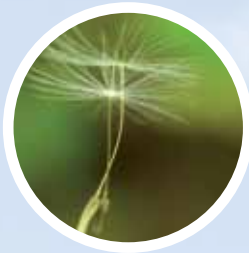
### North America

The regulations in the USA allow for alternate caps as final closure systems, implying that the Solar Landfill Closure System is an equally viable solution compared to conventional Subtitle C or Subtitle D final closure covers.

In North America another significant economic benefit of this system is the potential for additional waste disposal volume (air space) of up to 2 feet due to the elimination of the extra topsoil layer.



## The Art of Flexible Photovoltaics



### Lightweight

With only 3.6 kg/m<sup>2</sup> (0.7 lbs/sq ft) for the PV-laminate and no additional wind-loads due to flat, integrated installation the Solar Landfill Closure System does not apply point loads, penetrations or ballast.

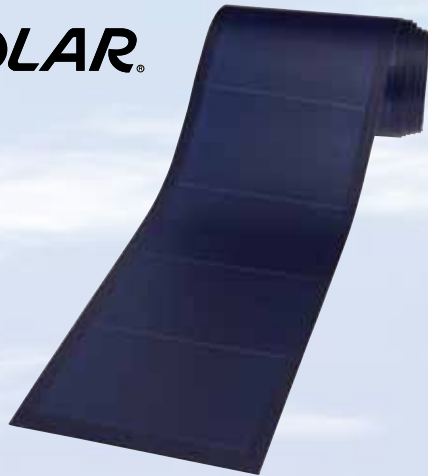
### Flexible

Because of the flexibility of both, the base membrane and PV-laminate, the Solar Landfill Closure System can be installed on uneven, shifting and sloped surfaces, and is easily handled during installation.



## THE *UNI-SOLAR*®

Triple-Junction thin-film solar cells made from amorphous silicon collect the sunlight according to its wavelength in three different semiconductor layers, allowing them to start energy collection from early in the morning to late afternoon and at diffuse light, i.e. when it is cloudy or overcast.



## PV-Laminate

Due to a lower temperature coefficient these cells are less affected by increasing module temperatures, perform better in hot conditions and do not require ventilation. Each cell is connected via bypass diodes, increasing performance in conditions of partial shade significantly as only the shaded cell is affected.



### Durable

The PV-technology from UNI-SOLAR is installed since more than 10 years and has been tested under severe conditions ranging from space, ocean to desert applications.

### Powerful

The combination of high quality materials and innovative technology powers stable and secure return on investment at lowest levelized cost of energy (LCOE).



*Their solar product is able to effectively adapt to our site layout and unique landfill terrain, including moving ground.”*

*Manlio Cerroni, President and owner of Colari Consorzio Laziale Rifiuti and Sorain Cecchini S.p.A*

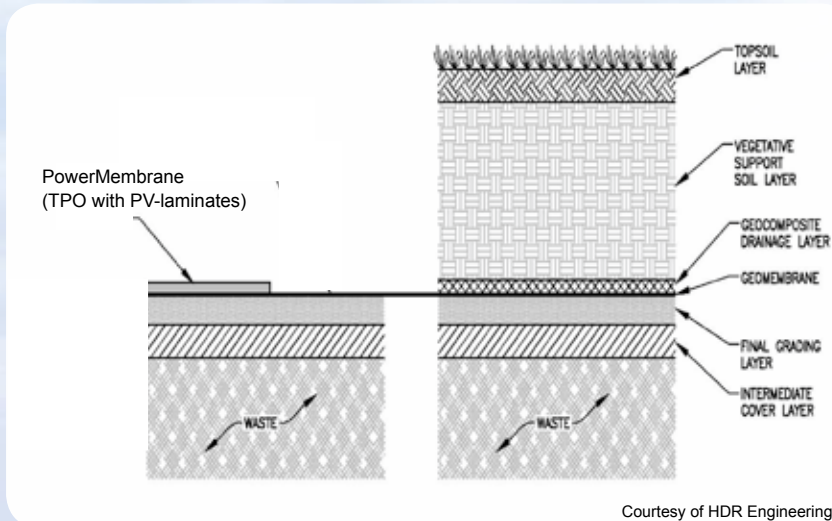


## The Solar Landfill Closure System

### The System

Up to the geomembrane layer, the Solar Landfill Closure System is built up in the same way as a general temporary or final landfill cover that is based on the usage of a geomembrane.

The photovoltaic elements are added by welding membrane integrated modules like Solar Integrated's PowerMembrane to the geomembrane, either directly on TPO geomembranes or via adapter strips in case of HDPE geomembranes.



### Construction

The Solar Landfill Closure system is basically constructed in five steps - clearing and grubbing the site - placing an intermediate soil cover, "bedding layer", over the waste mass - placing a final mineral layer to achieve uniform designed grades and benches - seam welding the geomembrane layers over the waste mass as one uniform monolithic cover secured by a site specific designed grid of vertical and horizontal anchor trenches - welding of the

PowerMembrane to the geomembrane in south, southwest or southeast facing areas for maximum energy yield.

Drainage collection trenches are planned in defined intervals. For the use on plateaus an alternative option to the PowerMembrane is the PowerTilt product, which combines flexibility with a defined orientation angle for maximum electricity generation.



## About Solar Integrated

Solar Integrated is a global solar solutions provider, combining various technologies to develop the best PV-system for every customer's specific needs for utmost reliability, productivity, financial performance and environmental benefits.

Solar Integrated is the roofing expert and draws on long-term experience in construction and project management. Combined with our incomparable team of experienced engineers, designers and service technicians Solar Integrated provides proven quality and dependable long-term performance.

Being part of ECD secures access to financial and technological resources, which allows us to further develop Solar Integrated's business activities and strengthens our market position as a turnkey EPC contractor of MW-size photovoltaic installations.

Our blue chip customer base includes Carrefour, Coca-Cola, Diesel, Honeywell, Metro, ProLogis, Toyota, Unibail-Rodamco, U.S. Air Force, and many more.

## About United Solar

United Solar is part of Energy Conversion Devices Inc. (ECD - NASDAQ:ENER) and is the leader in building integrated and commercial rooftop photovoltaics, one of the fastest growing segments of the solar power industry.

The company manufactures and sells thin-film solar laminates that convert sunlight to energy using proprietary technology. Our *UNI-SOLAR*<sup>®</sup> brand products are unique because of their flexibility, light weight, ease of installation, durability, and real-world efficiency.

Solar roofing systems using *UNI-SOLAR* brand products are generating clean electricity in more than 19 countries around the globe.

ECD also pioneers other alternative technologies, including a new type of nonvolatile digital memory technology that is significantly faster, less expensive, and ideal for use in a variety of applications including cell phones, digital cameras and personal computers.

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