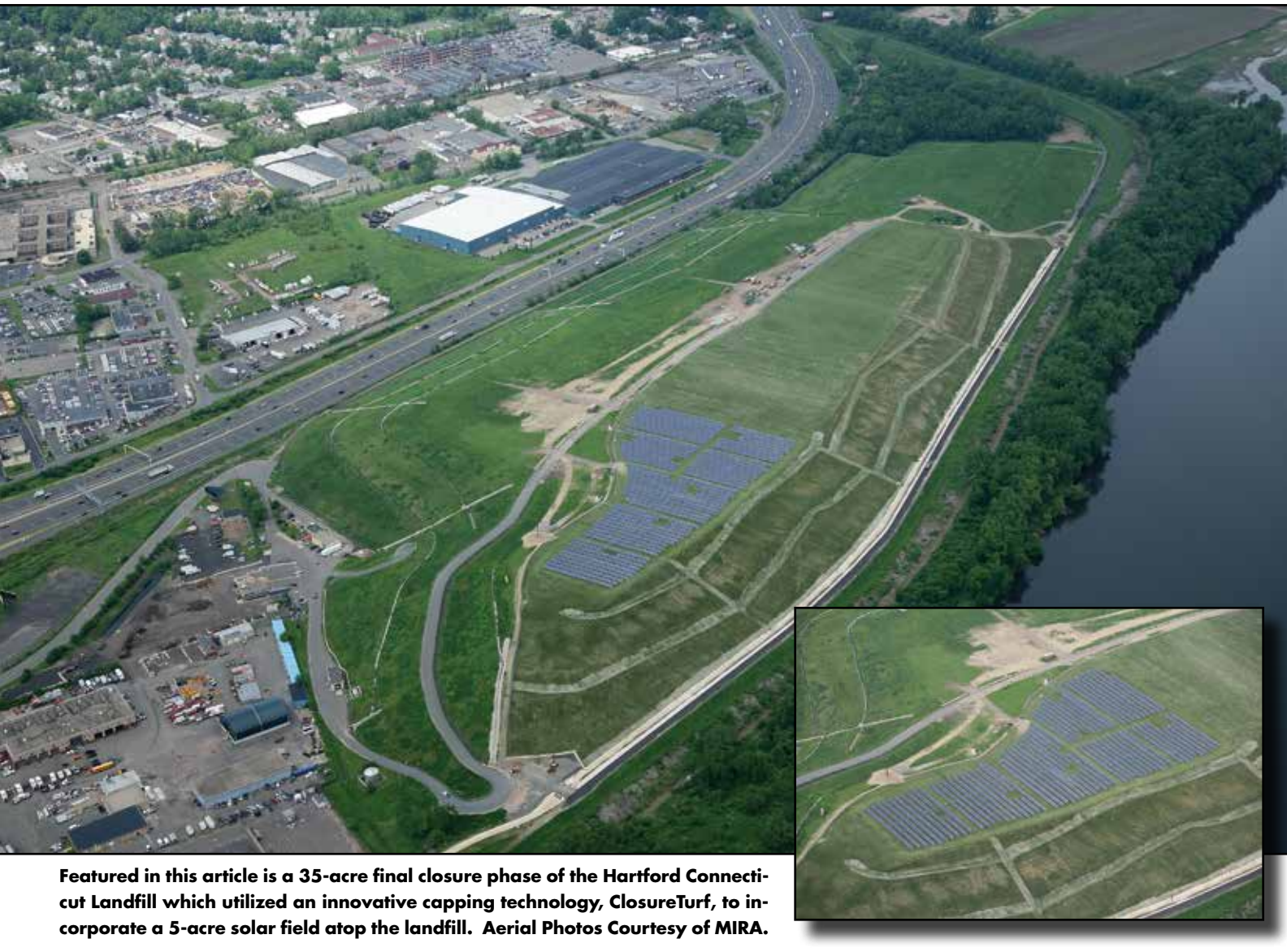
Landfill Turned into Solar-Powered Generation Facility



Featured in this article is a 35-acre final closure phase of the Hartford Connecticut Landfill which utilized an innovative capping technology, ClosureTurf, to incorporate a 5-acre solar field atop the landfill. Aerial Photos Courtesy of MIRA.

A growing trend for renewable energy land use involves the installation of Photovoltaic (PV) solar arrays on closed landfills, undevelopable land, or potentially contaminated land.

The Hartford Landfill, in Hartford, Connecticut, which is approximately 96 acres in size, began operation in the 1940s, and for many years was considered an eyesore. In 2007, the Connecticut Resources Recovery Authority, now known as the Materials Innovation and Recycling Authority

(the Authority), began the process of capping and closing the landfill. By 2011, only 35 acres remained uncapped.

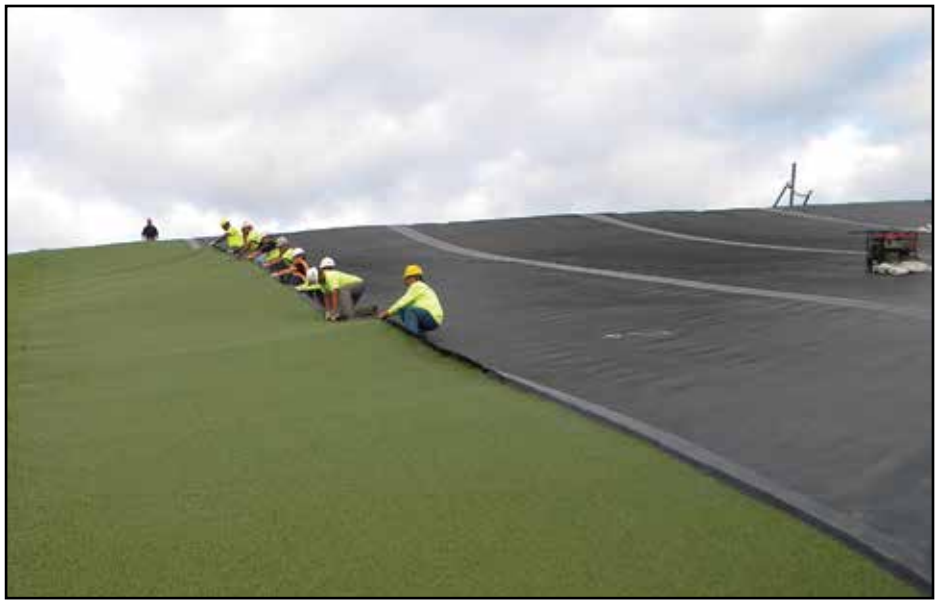
Also around the same time, an innovative final closure technology, known generally as an Engineered Synthetic Turf (EST) System, gained approval for use as a final closure system in the waste containment industry, and had previously not been used to support a PV solar array. The EST System introduced the idea of a "geosynthetic erosion layer" as part of a final cover system in lieu of a vegetative cover when compared to the traditional method. There are three main components of an EST System: a high-friction structured geomembrane overlain by an engineered synthetic turf, which is infilled with sand or a binded infill depending upon the magnitude and type of erosive forces present in site specific locations. Generally speaking, this System is becoming more widely accepted for use as an alternative cover since it meets or exceeds regulatory requirements mandated by the EPA, and can be less costly to construct and maintain for site owners over time. Additional advantages include superior erosion and wind resistance, long-term geomembrane integrity, ease of accessibility, it is quick and easy to install, and offers several economical benefits throughout its life cycle.

The Authority and its consultant, Fuss & O'Neill, reviewed possible landfill capping technologies and narrowed options down to three choices. The first option was to cap the site with a traditional vegetative cover. The second option was to cap the landfill with an exposed thermoplastic polyolefin (TPO) membrane, which is commonly used in the roofing industry, and the third option was an EST System called ClosureTurf®. In 2013, after an in depth evaluation of proposals received, the Authority approved the installation of the EST System technology as the final membrane cap for the solar electric generating facility at the Hartford Landfill, making it a one-of-a-kind in the industry to date to incorporate this capping system technology and the deployment of a PV Solar array on a landfill.

Benefits

The EPA's Re-Powering America's Lands Initiative endorses the reuse of mining sites, landfills, and potentially contaminated properties for renewable energy generation. Specifically, the EPA notes that there are several benefits for pairing PV solar facilities with MSW landfills.

- Green initiatives may be an economically feasible alternative for sites with significant cleanup costs or low real estate development demand, particularly for sites that are not well suited for commercial or residential re-development.
- Landfill owners are given the opportunity to generate revenue from what might be otherwise undevelopable land.
- Such sites are usually located near roads and electricity distribution infrastructure.
- Landfills may already be zoned for renewable energy.
- Landfills are usually located in areas with large populations, which tend to have high energy demand.
- Landfills are typically constructed with large areas of minimal grade (0-2 percent at the top), which is ideal for ballasted racking PV solar arrays.
- Such areas are usually offered at lower land costs when compared to open space with industrial zoning
- Landfills have the ability to accommodate net metered or utility scale projects.



After the geomembrane is placed, the engineered turf is quickly and easily installed by simply sewing roll edges together and laying it on top of the underlying geomembrane for instant aesthetic appeal.

Therefore, landfill owners are required to demonstrate through adequate engineering analyses to regulators that waste contained in a landfill with the addition of a PV solar array on site will have a net zero impact to the environment.

Design Challenges

As the EPA notes, the feasibility of placing a PV solar array on a landfill is significantly more delicate when compared to land masses that do not pose a threat to the environment. Additionally, the foundation for the PV solar array at a landfill must also maintain, with no loss of integrity, the functional requirement of a landfill cap, which is a mound of decomposing waste that constantly changes in content type and shape due to the natural process of decomposition (settlement).

Therefore, landfill owners are required to demonstrate through adequate engineering analyses to regulators that waste contained in a landfill with the addition of a PV solar array on site will have a net zero impact to the environment. This is first accomplished by focused evaluation on three key areas of the application during a feasibility study. Findings must demonstrate that direct contact with waste will not occur at any point in time, water infiltration into the waste pile is minimized and will

Close-up of the AGRU Super Gripnet where you can see the integral drainage studs on the top of the geomembrane. When the engineered turf is placed on top of the geomembrane, the drainage studs form a void space creating a drainage layer within the System itself where stormwater is managed across a facility.

also not increase, and the effectiveness of the landfill's gas and stormwater management systems are not compromised. Additional conditions to consider:

- Understanding the settlement of the landfill over time – weight load/ limit capabilities of a landfill.
- Constraints on the footing/ foundations of the PV solar panels and racking systems.
- Additional stormwater controls required.
- Vegetation establishment after PV solar array placement.
- Changes to a long term care and maintenance plan of the PV solar array and facility.

Specifically at the Hartford Landfill, the president of the Authority appointed an evaluation team to thoroughly consider these additional design criteria to select the best option for capping the landfill given the critical situation at hand:

- The technology should have a proven track record.
- The solution would need to be able to withstand prolonged exposure to the elements.
- Any replacement needs, should failure occur, must be economically feasible in terms of cost, time, and effort.
- The chosen technology must be able to withstand foot and vehicular traffic.
- The product should be aesthetically pleasing.

Evaluating Closure Technologies

After an in-depth review of responses to its request for proposals for the construction of a final cover system and 1 MW Solar EGF and approval granted from the state solid waste department, on May 30, 2013 the evaluation team recommended that ClosureTurf® be implemented for a successful project. The following sections provide further discussion in areas of importance that the team focused their decision making process as three closure technologies are evaluated.

Geomembrane Liner and Potential Exposure to the Environment

Based on the EPA's MSW landfill regulations, the owner/operator of a landfill is responsible for conducting post-closure care on a site for 30 years after closure. During the process of selecting a membrane to use in conjunction with the solar installation at the Hartford site, the evaluators cited as one benefit the fact that the EST System option utilizes an LLDPE membrane that has a proven track record in landfill closure applications, which a TPO membrane does not. Both options were determined to be superior to the traditional vegetative cover however, because they are not subject to erosion since the two to three feet of vegetated cover on top of the membrane is not present. If the geomembrane is covered with a vegetative layer as is the case with the traditional method, it requires constant upkeep and ongoing maintenance (mowing, replanting, etc.) for it to perform as a landfill cap. Add the presence of PV solar panels to a vegetative cover, and an accelerated deterioration of cover integrity is introduced even as early as during construction because the PV solar panels create shade making it even more difficult to establish vegetation. This del-

eterious effect on the underlying vegetation propagates and compounds erosion issues of the denuded soils indefinitely of a traditional cover system introducing concerns with its ability to maintain a stable base for PV solar panels over time. The EST System on the other hand, is not influenced by the reduced sunlight and does not require excessive maintenance.

Settlement and Slope Stability

Landfill settlement and slope stability must be considered when choosing a final cover system that will also be used to support a PV solar array according to the EPA. Predicting how a landfill will settle is very difficult to do as it is largely dependent upon understanding specifics of the waste mass being covered and the rate at which it will decompose. All landfills settle, so the goal is to minimize the potential for settlement over time, while also improving predictability prior to placement of a PV solar array. Vegetative soil covers (2 to 3 feet in depth) introduce additional loads and weight, which extend deep into the waste mass, creating additional settlement over time well beyond construction. In contrast, EST and exposed geomembrane closures do not generate additional loading into the future, and the stresses that they do create are point loads that do not penetrate more than a few feet into the waste mass.

For the Hartford Landfill, the potential selection of the traditional vegetative cover was also of concern because it had proven to be difficult on previous closure phases to establish vegetation, maintain on slopes, and therefore contributed to many costly erosion problems and slope failures. On landfills, sliding of a soil-based cover system along steep side slopes is of primary concern, particularly after major storm events or in seismic sensitive areas. The EST System being essentially soilless, significantly increases veneer stability when compared to vegetative covers.

While the exposed TPO geomembrane cover had not been previously used at the facility and was not a technology that the owner had past experience with, it was noted that the smooth surfaces of the TPO could potentially introduce interface friction characteristics between it and the underlying soils unsuitable for slope applications when trafficked. Concern was also raised about how slippery the TPO would be when wet compounding safety issues. For operations and maintenance of the PV solar array to be placed at the Hartford Landfill, ease of and access to PV solar panels and gas system monitoring locations is critical for on-going management of the green energy power generation facility into the future, as landfill operators need access by persons on foot or in emergency or maintenance vehicles. The third option being the EST System, is trafficable by rubber tire vehicles or on foot without damage to the LLDPE geomembrane component because of the protective overlain geosynthetic erosion layer.

Aesthetic Appeal

Community involvement is always encouraged by the EPA when planning the installation of a renewable energy project. Specifically, the EPA notes that "Solar PV projects may, at times, raise concerns or face opposition due to perceived or real visual impacts of the arrays and support structures." With this in mind, the evaluators at the Hartford site also considered the aesthetic appeal of the closure technology they were to select. Aesthetically, the vegetative cover and the EST options both had more visual appeal than the TPO op-

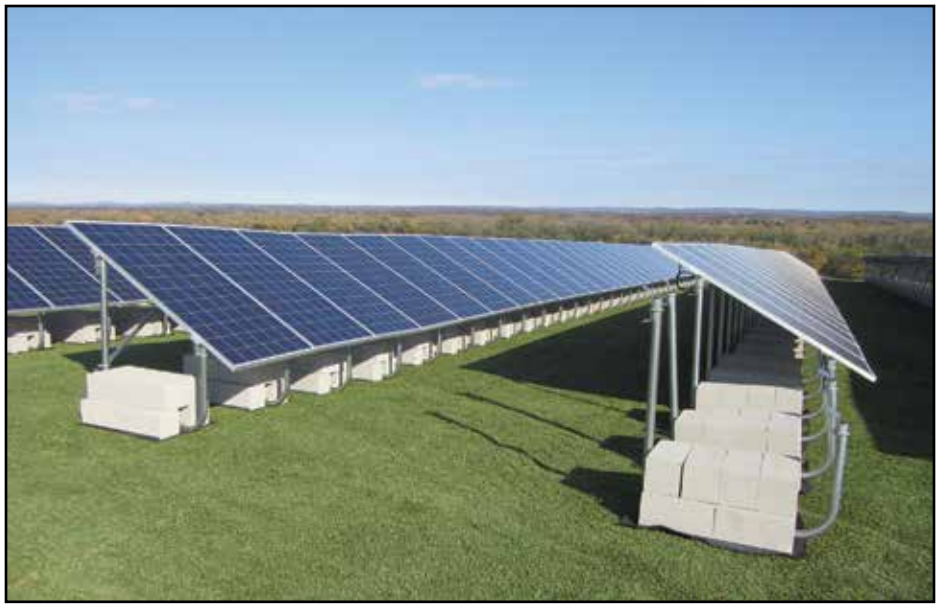
tion which was extremely important as the landfill faces a main highway, I-91. The geosynthetic erosion layer of the EST System looked like grass, however did not require the high maintenance of a traditional vegetative cover to maintain the aesthetic appeal, making the EST System significantly more economically feasible and sustainable.

Increased Efficiency of Solar Power Generation

While dust control is usually a requirement during construction at landfill sites, in the case of the long-term operations of PV solar arrays, the elimination of dust remains an important factor well beyond when installation is complete. Evaluators for the Hartford site immediately recognized that dust could be an issue with a traditional soil cover, particularly during times of drought, and that excess cleaning of the PV solar panels during such times would be needed for maximum efficiency. In contrast, the TPO option and the EST System are soilless; therefore the site would experience increased efficiency of power generation due to the lack of dust buildup on panels.

Stormwater Controls

The presence of PV solar panels on top of a landfill require additional stormwater controls that were not previously considered as each panel acts as a mini roof during rain events, causing sheet flow off the front edge of panels. For a vegetative cover, this will compound already troublesome erosion challenges therefore; additional storm water controls are needed to minimize exposure to erosion which always compromises PV solar panel footing integrity. Therefore, solar panel arrays typically placed on soil surfaces require a gutter system which lines the front edge of panels in an effort to prevent erosion. On the other hand, using an EST closure does not require a gutter system since the geosynthetic erosion layer is truly erosion resistant. Rather, surface water runs off the edge of PV solar panels and will percolate through the geosynthetic erosion layer, and then run along the top of the structured geomembrane component without producing scour of the PV solar array foundation. The exposed TPO membrane has no means for stormwater management at all. The use of the geosynthetic erosion layer helps improve the runoff water quality and prevents the erosion and deformities that might occur with a traditional soil cover.



PV solar arrays panels being installed and ballasted on the System without the need for any penetrations into the cap.

Additionally, under the Clean Water Act (CWA), stormwater discharges from closed landfills are subject to National Pollutant Discharge Elimination System (NPDES) permitting. Soil covers are expected to erode over time and therefore their sediment deposits must be managed. With traditional vegetative cap covers, this is typically addressed by the use of sediment ponds which allow the sediment to settle and the water collected to be treated. Quantifiably exactly how much of a positive impact using an EST System, consisting of a geosynthetic erosion layer that does not erode, will have on stormwater quality is somewhat unknown because data has been difficult to collect. However intuitively, without the presence of a soil cover that can experience excessive erosion and sediment loss during any storm event, stormwater runoff from an essentially soilless technology is noticeably cleaner with less treatment required.

Construction Advantages

With an EST System, it is economically feasible to close an entire landfill or as little as one acre at a time because it does not require large amounts of machinery or heavy construction whereas vegetative and exposed geomembrane options do. Rapid, low impact development can be achieved with the EST System, eliminating the potential for thousands of truck trips for soil placement and a much smaller carbon footprint. Being that the Hartford landfill is located in a metropolitan area, the approximate 95,000 cubic yards of dirt that would have been needed to complete construction of the traditional cover system would have been disruptive to the local community in several ways.

The cost for installation of an EST System averages about $105,000 (non prevailing wage) per acre, to include materials and can be installed at a rate of 1 to 1.5 acres per layer per day. In comparison, the exposed geomembranes can cost about the same, and the traditional vegetative cover can cost on the order of $150,000 per acre if soils are not readily available on site. Both the exposed geomembrane and vegetative covers install at half the rate and both may create opportunities for owners to collect additional revenue if the space gained by removing the need for a soil cover is transferable into additional permit capacity.

Long Term Maintenance Costs

The EPA cites "long-term durability and survivability of [the] cover system" as an essential factor to consider when choosing products for the installation of renewable energy technologies, particularly since site owners are responsible for maintenance and repair over several decades. When comparing the three options, evaluators

concluded that the traditional vegetative cover would have expensive ongoing maintenance costs, such as mowing, watering, and replanting should erosion or drought occur whereas the TPO and EST Systems did not. The vegetative cover also would generate more operations and maintenance activities for the PV solar array itself because the presence of soil would introduce vulnerability vegetation maintenance issues and washouts after storm events of the PV solar array, and it would also require more cleaning of the solar panels due to dirt buildup on the solar panels over time.

The TPO exposed geomembrane option was also evaluated, and it was determined that potential repairs could be costly, as it was anticipated that at some point during the service period, the cover would need to be replaced due to wind uplift, whether that involved repairing the membrane and thousands of linear feet of anchor trenching, or having to replace the TPO membrane with another cover type completely. (In general, exposed geomembranes are known to not be as durable in service when compared to those that are in covered applications.) In contrast, potential repair options to the third option, the EST System, would involve simple and small localized patching activities of the geosynthetic erosion layer only.

Projected Outcome

The closure at the Hartford Landfill is substantially complete and the PV Solar Array was online June 2014 (four months ahead of schedule). 35 of the 96 acres are encapsulated in the EST System technology. The five-acre solar field sits atop ClosureTurf, while the remainder is covered with soil and appropriate vegetation. The EST System enabled MIRA to leave intact the landfill's environmental-protection systems, including its gas-collection system. This facility is the first landfill-based solar energy-generating facility in Connecticut, which will generate up to one megawatt of electricity, enough to power about 1,000 homes when operating at full capacity.

Conclusion

In today's world, sustainable and environmentally friendly solutions that address the need for energy independence are highly desirable, and finding the right solution for landfill closures and other erosion protection applications where the stakes are high requires attention to detail. The pairing of solar installments with landfill closures is a viable solution to the increasing need for more green energy. A geosynthetic membrane landfill cap such as the one described here provide durable, stable surfaces that are easily maintained, can support vehicular traffic, prevent erosion, and reduce dust, while the solar panels produce green energy that helps countries such as the US continue to move toward sustainability and energy independence. **L&W**

by Melissa Grace

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