

Developing MW-Scale PV Solar Installations on Closed Landfills

Puerto Rico Solar Transaction Forum
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SUNLIGHT + LANDFILLS = POWER

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Our Mission: PV Power Developments at Landfill Sites Using Simple, Fixed Tilt, Polycrystalline Solar Cell Technology.

Project Navigator, Ltd. Develops Clean,
Green PV Solar Power Systems at
Landfills and Brownfield Sites

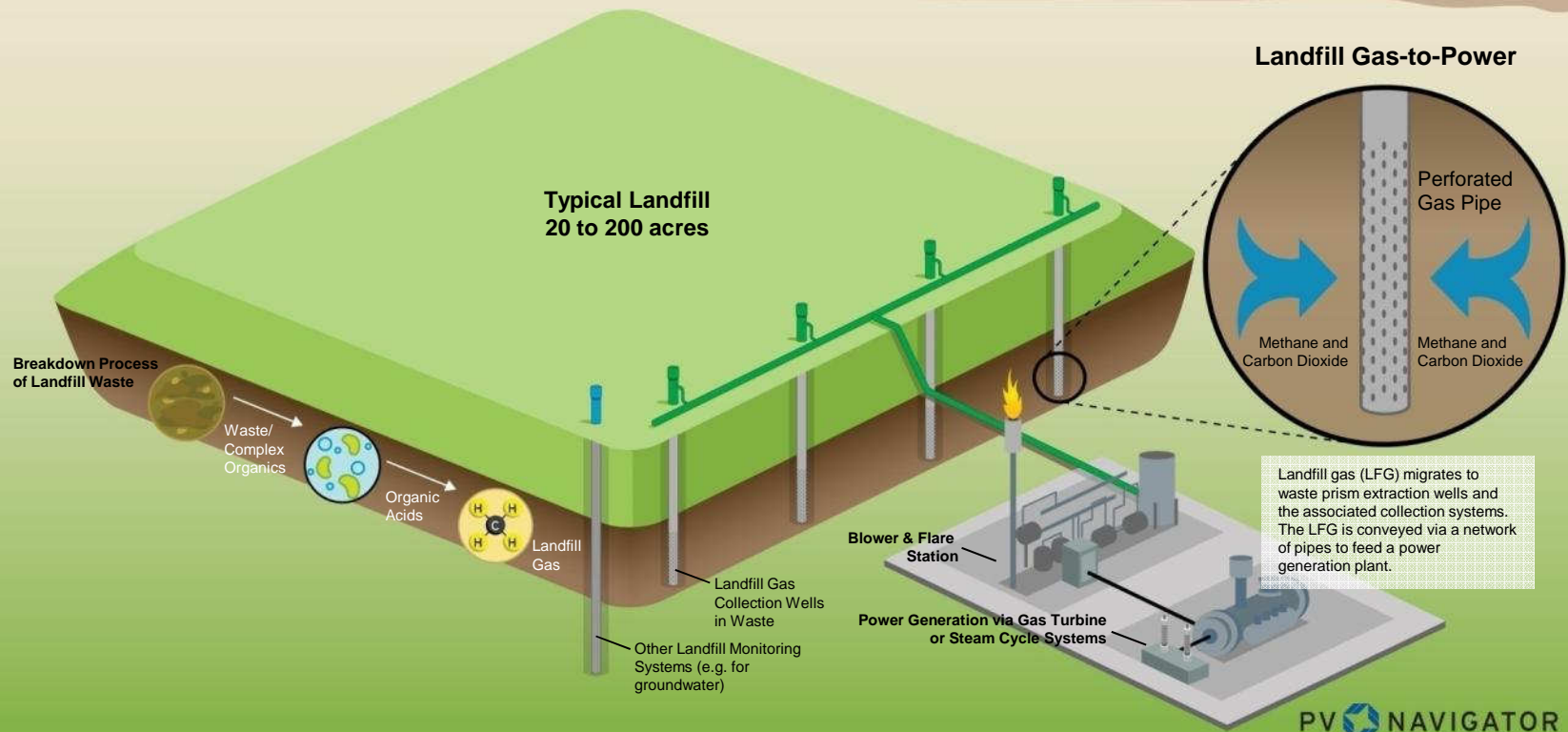
- 100,000's Acres of Landfill Cap Space is Available
- No Fuel Requirements
- No Moving Parts
- Long Operational Lifetime
- Low Maintenance
- No Emissions
- No Waste Products
- Minimal Impact on Landfill Cover
- No Noise
- Simple, Fast Construction
- Continually Improving Technology
- Regulatory Incentives

Team Values

- Cost-effective execution
- Use most efficient technologies
- Operate safely
- Operate collaboratively and as a good neighbor

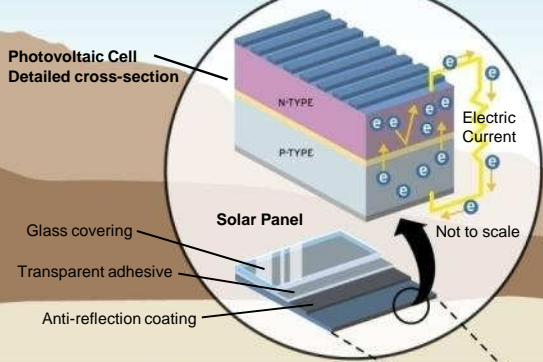
Large Scale Solar Facilities Face Permitting, Financing, and Interconnect Challenges.

Not so for PV Developments on Urban Located Landfills.



Landfill Sites are Excellent Platforms for PV Solar Facilities. Flat Acreage, Close to Load and Interconnect, Putting Otherwise Unusable Acreage Back to Use. *Projects are Technically Straightforward but Administratively Complex.*

The sun gives off about 400 trillion watts of power



PV Solar Power

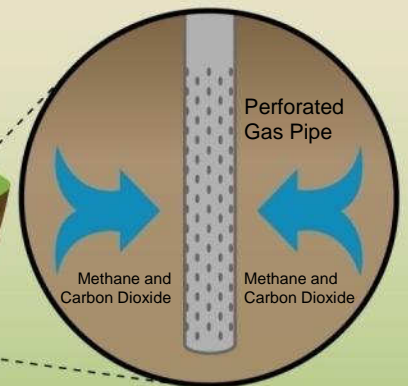
A photovoltaic (or PV) cell is a specially treated wafer of silicon, sandwiched between two thin contact plates. The top contact is positively charged and the back contact is negatively charged, making it a semiconductor.

- The n-type semiconductor has an abundance of electrons, giving it a negative charge, while the p-type semiconductor is positively charged.
- Electron movement at the p-n junction produces an electric field that allows only electrons to flow from the p-type layer to the n-type layer.
- When sunlight hits the solar cell, its energy knocks electrons loose from the atoms in the semiconductor.
- When the electrons hit the electrical field, they're shuttled to the top contact plate and become a usable electric current.
- PV panels are mounted in racking systems specially designed to accommodate landfill-specific requirements such as "no cap damage" and "waste settlement."

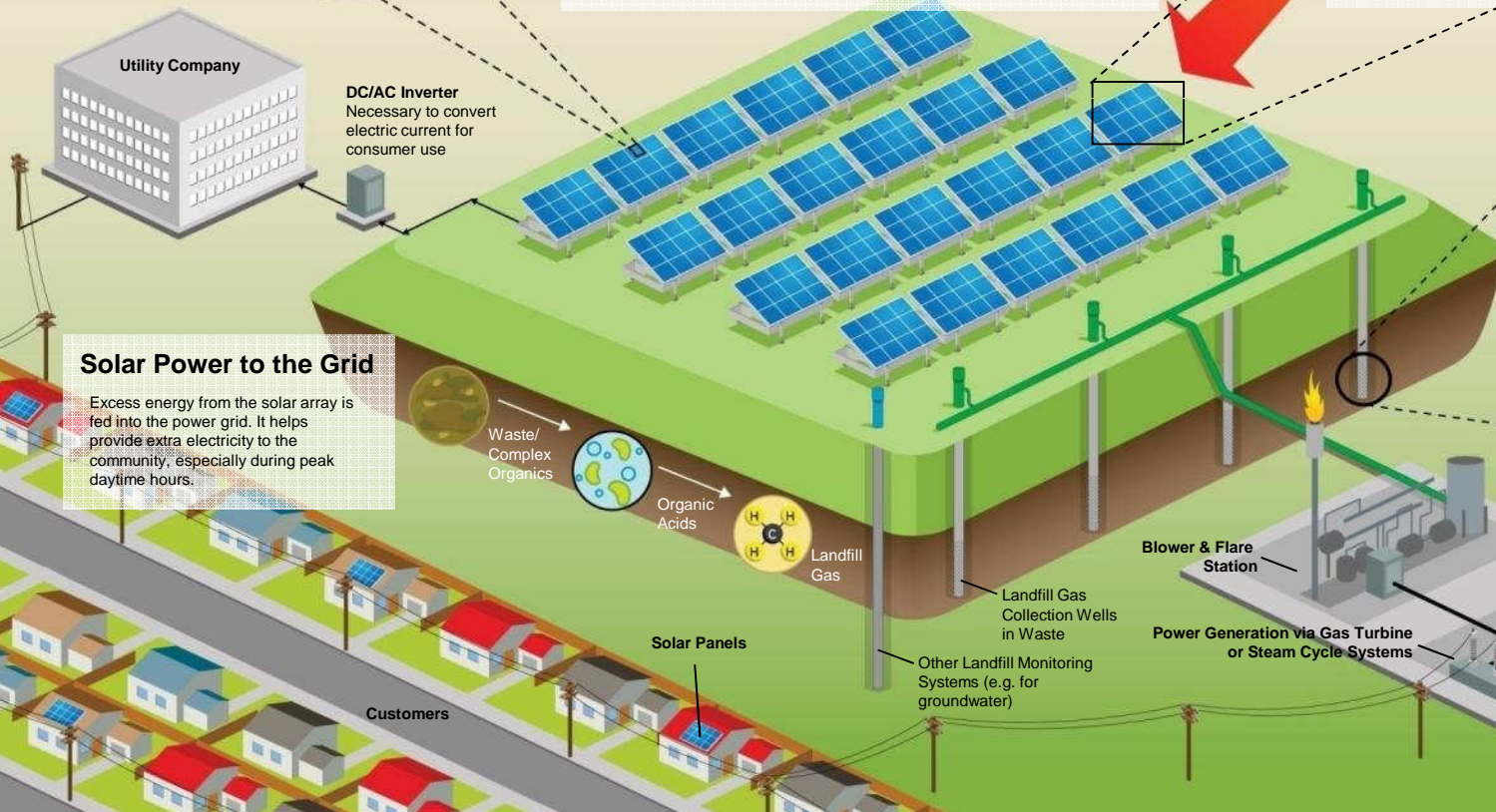


A typical racking module is 10ft. By 20ft. and generates 2.5kW. This translates to about 1MW from every 3-5 acres.

Landfill Gas-to-Power



Landfill gas (LFG) migrates to waste prism extraction wells and the associated collection systems. The LFG is conveyed via a network of pipes to feed a power generation plant.



According to U.S. EPA, There is No Shortage of Brownfields and Landfill Site Acreage Which Could be Suitable for Renewable Energy



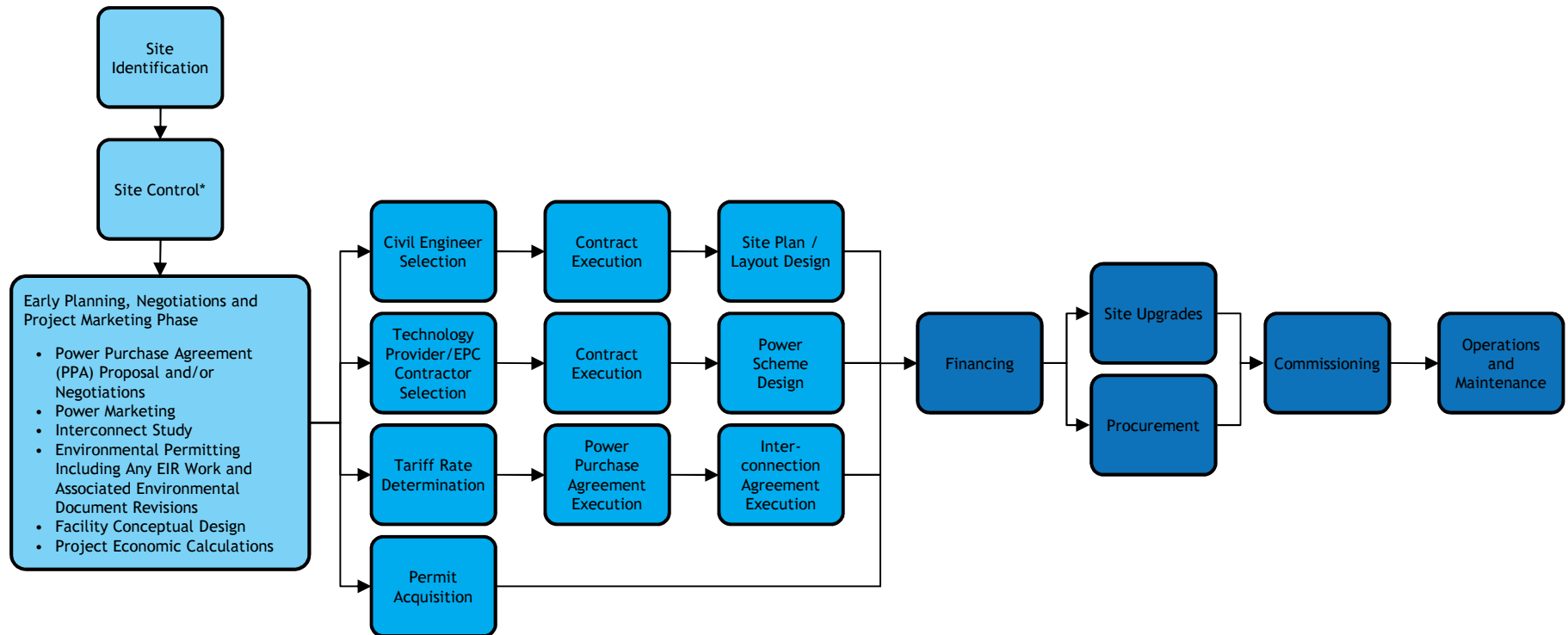
- Over 400,000 identified Brownfield sites in the United States
- 16 million acres are available for development of renewable energy
- That's enough land to generate approximately 3,175,000 MW
- 32 Landfill Sites identified in Puerto Rico with 1,300 acres available for development which could generate over 2,000 MW

Ref: www.epa.gov/renewableenergyland

A Landfill Site is a Good PV Development Candidate if Certain Screening Criteria are Met.



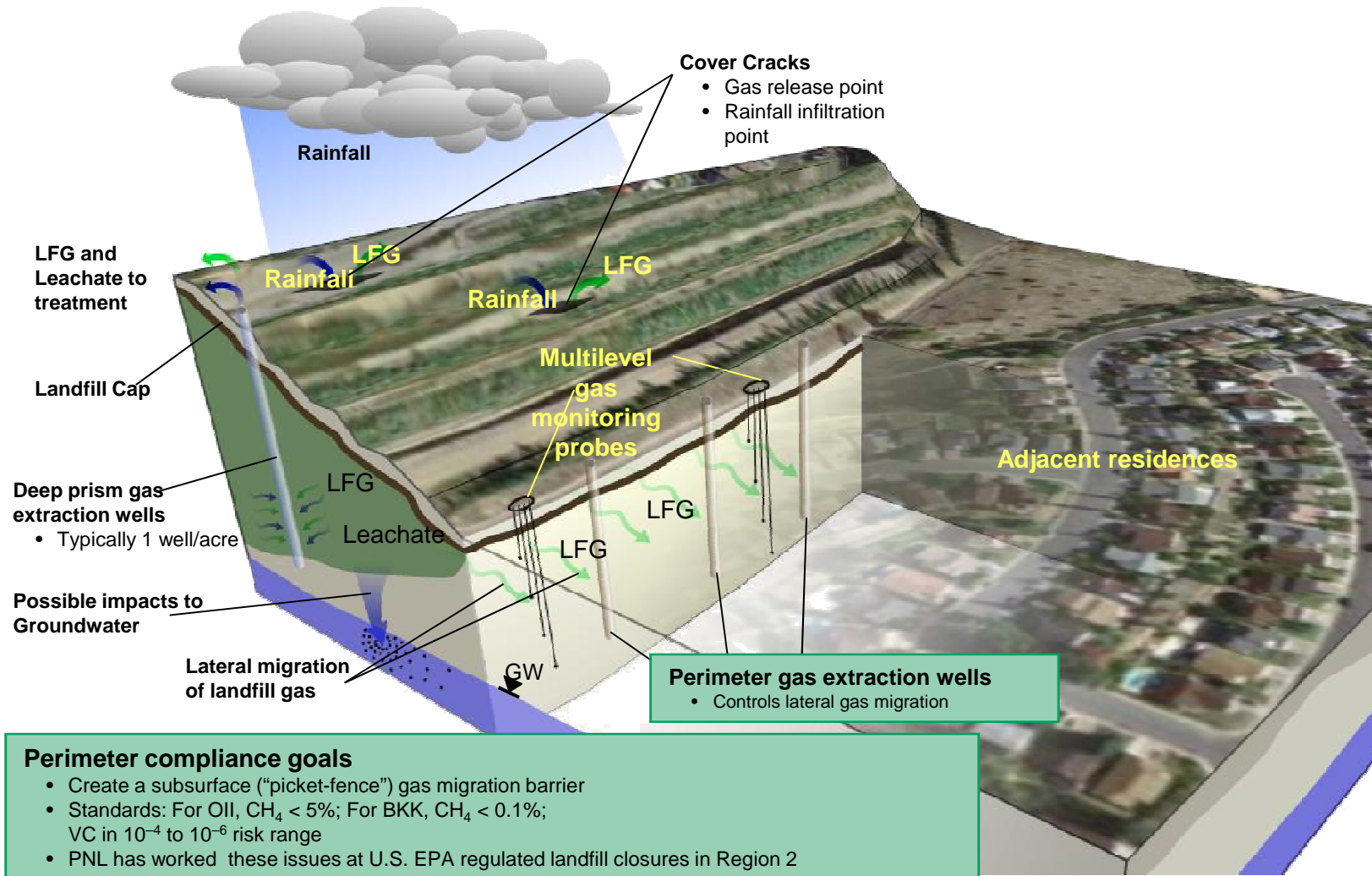
The Stages in PV Solar Power Plant Development. The Challenges Lie in the Front-End Permitting.



* Can be in form of an "option agreement" between landowner and solar project developer, or a longer term land lease. Option would convert to a land lease once the scope and economics of the proposed project are better defined, such as at the execution of a PPA.

To Construct a Solar Power Facility on a Landfill, the Solar Developer Needs to Also Have a Rigorous Understanding of Landfill Closure Engineering.

PVNavigator, LLC Provides this Integrated Capability.

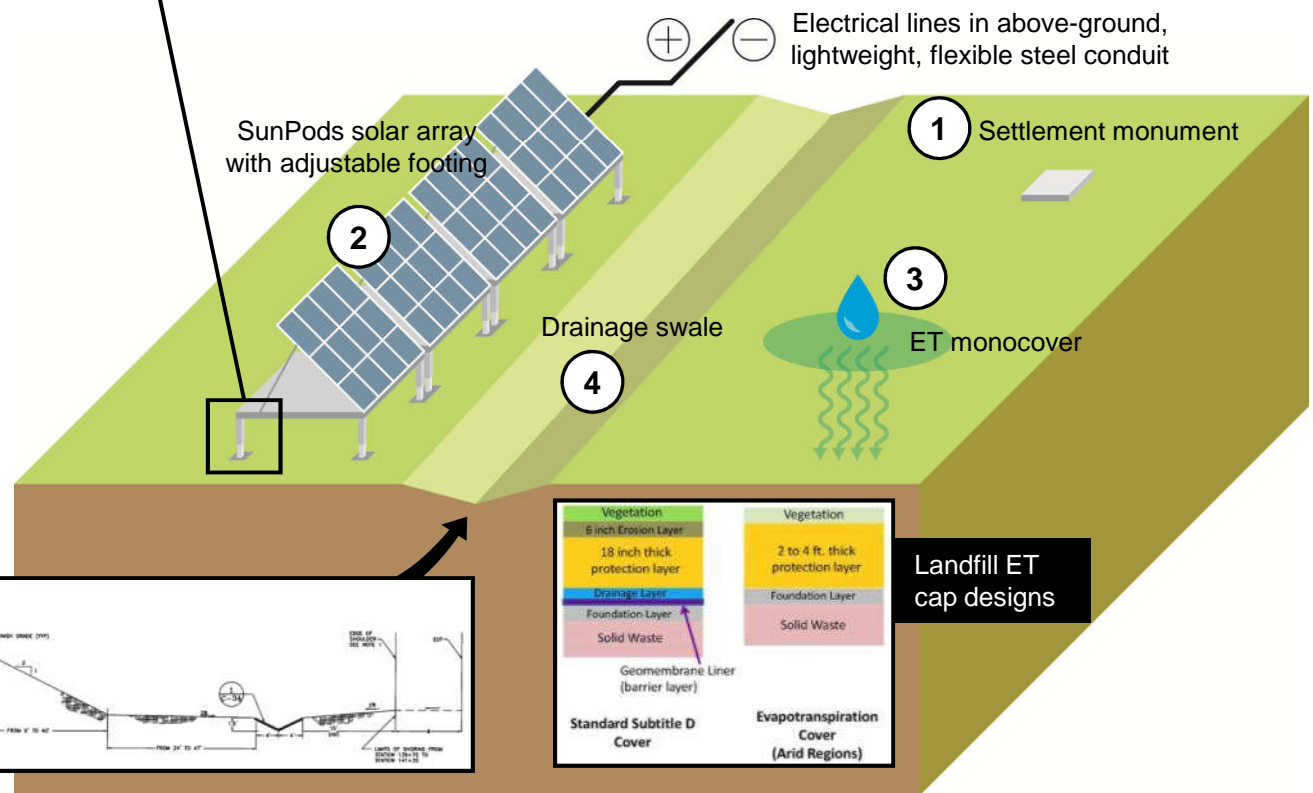


Key Design Criteria are Minimal Settlement & The Continued Need for Cap Functionality.

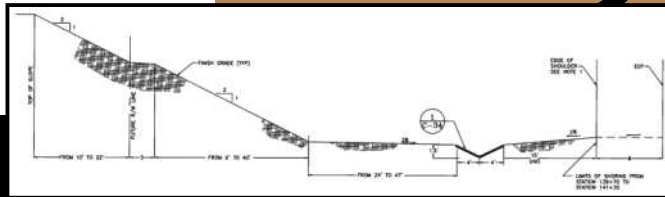
Design considerations include eliminating cap penetration, continued functionality of the ET cap, storm water management, wind design and insuring protectiveness during an earthquake event.

Design of PV Array will take into consideration:

1. **Settlement**
 - Total
 - Differential
2. **Panel placement on cap**
 - Spread footings
 - Anchors
3. **Continued performance of evapotranspirative (ET) cap**
 - Infiltration minimization
 - Vegetative growth
4. **Stormwater management**
 - No standing water
 - Runoff management
5. **Other**



Swale cross-section design



Landfill ET cap designs

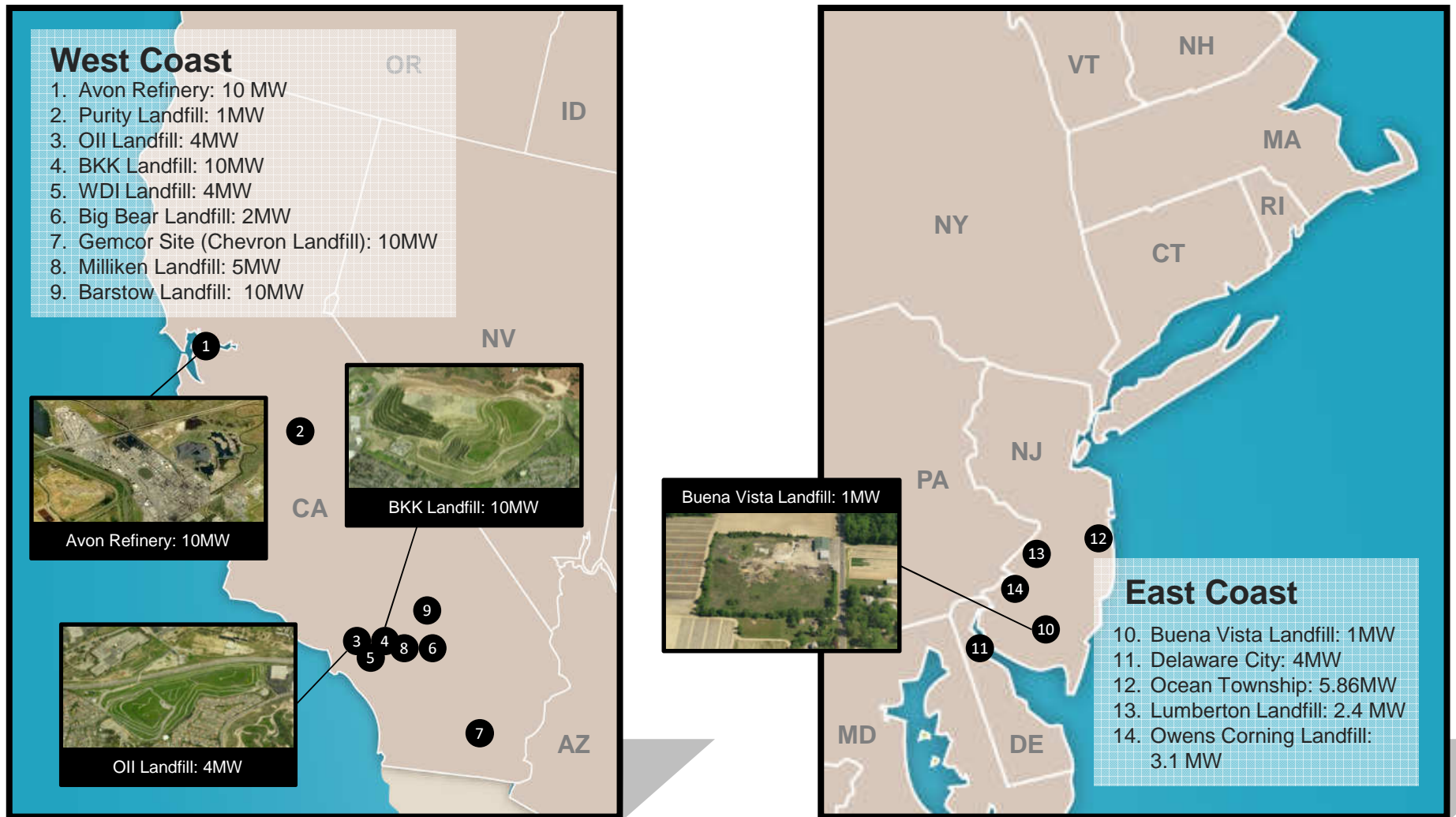
PV Navigator Prefers Prefabricated, Racked PV Systems Specifically Designed for Landfill Caps .

Features of SunPods Landfill PV Solar Unit

- 2.5 kW per array (as shown)
 - i.e. 400 arrays per MW
- Arrives prefabricated
 - Minimal onsite assembly
- 20 ft X 10 ft arrays
- Weighs 3,500 lbs, supported on a leveling support system
 - Eliminates landfill cap penetration
 - Self ballasting
- 10 Gauge steel frame
- Rated to 130 mph + wind speed
- Ready to connect
- Minimal maintenance



PVN's Mainland Solar Development Projects.



PVN Has a Partnership with Chevron Energy Solutions, Specifically for Landfill Projects.

Renewable Energy Solutions for Landfills



Turn your legacy landfill into a sustainable source of renewable power

Solid waste facility owners are looking for innovative ways to use their closed landfill sites. These inactive sites or "legacy landfills" carry costly, long-term operations, maintenance and monitoring (OM&M) responsibilities and often have limited redevelopment potential due to a combination of financial, geotechnical, environmental and regulatory concerns.

Legacy landfill sites are outstanding candidates for renewable energy platforms, giving owners the capacity to improve site sustainability, demonstrate responsible stewardship and generate renewable power for ready buyers.

Generate renewable power on your "legacy landfill" site to:

- Generate revenue
- Lower OM&M costs
- Improve site sustainability
- Offset long-term financial liability
- Mitigate risk
- Promote positive community relations
- Demonstrate responsible environmental stewardship

Potential Power Applications

- Direct landfill gas to energy
- Waste heat capture
- Solar farms
- Wind farms
- Stationary fuel cell generators

Renewable Energy Program Approach:

Chevron Energy Solutions and Project Navigator Ltd. have formed the "Landfill Renewable Energy Team" to help landfill owners develop their legacy landfills for renewable power generation. Our team possesses a unique and comprehensive breadth of experience in the construction of power generation facilities; the sales of generated power; landfill engineering, design and construction; geotechnical engineering; and landfill regulatory compliance. We have the combined expertise and capabilities to advise solid waste facility owners on the most appropriate energy generation technology for a particular landfill property and help the client navigate complex projects from planning to reality.

Possible renewable energy landfill strategies include direct landfill gas-to-energy systems, the capture of waste heat from existing landfill gas flaring facilities, stationary fuel cell generators, solar farms constructed on open landfill decks and slopes, and wind farms on geotechnically stable areas within landfill site property boundaries.



Planning

The team's planning services include assessment of the power generation potential of a particular site or sites and presentation of detailed technical evaluations. We look at site size and geometry; location relative to potential power and users and/or power infrastructure facilities; solar/wind potential; landfill gas generation rates and quality; existing site facilities and energy usage; and site regulatory status and restrictions.

Funding

We help owners identify potential funding sources, assisting and advising on Competitive Tariff Exempt Leases, Power Purchase Agreements (PPAs), Third Party Ownership options, Clean Renewable Energy Bonds (CREBs), and Certificates of Participation (COP). Our team can handle all of the details.

Involved with obtaining local, state, and federal grants and incentives.

Design and Regulatory Compliance

Once planning and funding are secured, we develop detailed engineering plans and specifications for the proposed renewable energy systems. Our plans clearly outline for the owner and other parties each project phase and how the proposed improvements are protective of existing landfill environmental control systems. Our regulatory compliance specialists can also provide support to the owner with regulatory agency interactions, to ensure a smooth approval process.

Construction

Construction at any landfill site can be a complicated undertaking. The team

possesses a proven understanding of landfill systems and will focus on ensuring that construction activities are completed with minimal impact to ongoing site OM&M and in compliance with all regulatory and site-specific guidelines. Our power generation engineers work on making certain that the installed system performs as intended and to the satisfaction of the landfill owner.

Operations

If needed, the team can provide long-term OM&M of the installed system. We will guarantee that the installed system is operated and maintained properly, in accordance with manufacturer's guidelines, and in a way that has the least impact possible to the landfill itself.

The Landfill Renewable Energy Team

Chevron Energy Solutions (CES) designs, constructs and operates facility projects, including infrastructure and renewable power systems that increase energy efficiency and lower water consumption, reduce energy costs, and assure reliable power for public infrastructure and businesses. Since 2000, CES has developed hundreds of projects involving energy efficiency or renewable power for education, government and business customers in the United States.

Project Navigator, Ltd. (PNL) is a privately held, environmental project management company with offices nationwide. Since 1997, PNL's team of project managers, engineers and scientists have developed a strong track record of creative, strategic problem solving for complex remediation problems. PNL has led project management responsibilities at many Superfund sites. PNL works at "raising the bar" in terms of project performance, whether it is focused on cost, scheduling, scope or innovation.

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Community Outreach and Project Advocacy is Conducted via Public Meetings...Where Resistance is Typically Found to be Low.

PV NAVIGATOR



A Proposed Renewable Energy Project at the Ocean Township's Landfill

10 MW PV SOLAR DEVELOPMENT, WARETOWN, NEW JERSEY



Who

- A development team anchored by Project Navigator, Ltd. (PNL) as the project integrator.
- PNL specializes in developing small scale distributed solar facilities on landfills.
- Design capabilities by Chevron Energy Solutions, and solar modules from SunPods, Inc.
- Environmental and landfill post closure document addendums by PNL and Brinkerhoff Environmental Services.

What

- A 10 MW PV solar development.
- Fixed tilt, rack mounted, self ballasting.
- Occupies 24 acres of landfill top deck areas.
- Racks are specifically designed for landfill cap installations.
- No long-term cap damage.

When

- All permitting and design completed by end of 2012.
- System installed and operational by end of 2012 (weather permitting and in conformance with landfill construction season).

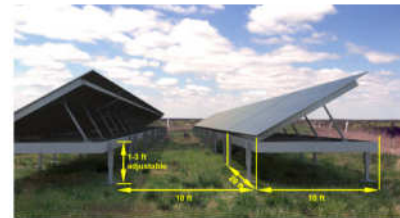
How

- PNL and the Township of Ocean enter into a land lease agreement which includes ability to use landfill top deck for 15 years.
- Project will be financed via a combination of debt and equity.
- PNL has excellent fund raising track record with major East and West Coast renewable energy funds.
- System economics will meet a 15% ROI criterion.



WWW.PVNAVIGATOR.COM

The Proposed Ocean Township's Landfill Solar Power Installation



Summary

In summary, we propose to build a 10 MW PV solar power facility using a combination of debt and equity financing. The structure of the business arrangement with the Township involves a land lease for a term of 15 years.

The design will use solar power panels which are rack mounted into fixed-tilt arrays specially designed to distribute the load on the landfill and be adjusted (typically annually) to account for future landfill settlement. The Township intends that the power generated from this project will be to support the local community's electrical supply, render this property more productive, and produce revenue for the Township.

Key Elements

- A 10 MW system, which will occupy the designated approximately 24 acres of the 127-acre landfill
- Full financing of the entire system
- Negotiation and execution of a long-term (15 year) PPA with Atlantic City Electric and lease agreement with the Township for the acreage required to host the facility
- Interface with all stakeholder regulatory entities such as NRCS, Pinelands Commission, Ocean County, NJDEP, Ocean Township to obtain all required permits and any environmental modifications that may be required
- Engineering and design of the entire system including the solar field, inverters and interconnect system
- Procurement of all systems including approximately 2,300 SunPods racked fixed-tilt solar panel systems
- Long term operation and maintenance of the solar facility, with a complete understanding of how a solar system needs to be maintained when located on a (differentially) settling landfill cap
- Development of a cooperative long-term working relationship with the Township, including total responsiveness to requests for facility tours (i.e. showcasing the Township as a 'green community') and project updates

Estimated Solar Project Schedule

No.	Activity	Q3 2011	Q4 2011	Q1 2012	Q2 2012	Q3 2012	Q4 2012
1	Lease Option Agreement w/Landfill Owner	X					
2	Business Structure						
3	Legal						
4	Power Purchase Agreement and Project Financing						
5	Final Design						
6	Permits						
7	Other Approvals (Interconnection)						
8	Site Preparation						
9	Equipment Delivery						
10	Installation						
11	Commissioning						
12	System Inspection						

Note: Actual construction time window will depend on weather conditions and condition of the cap.

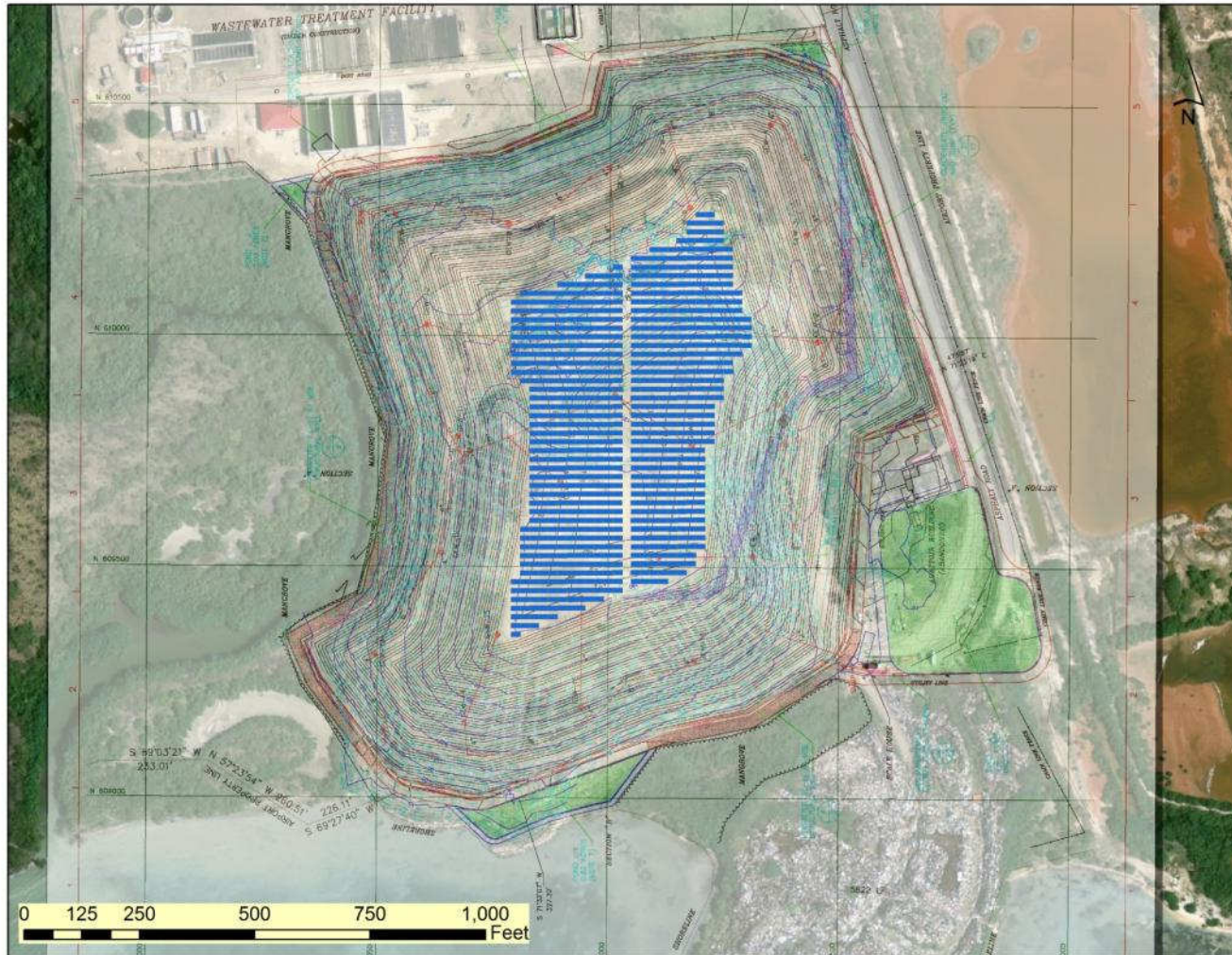
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Conceptual Plan for a 2MW PV Solar Installation on Top Deck of Capped, Closed Anguilla Landfill, St. Croix, USVI



PLAN

- Top deck development only
- PVN solar team will work with landfill closure design team (VI WMA) to formulate an integrated environmental closure/PV design
- Install 800 fixed tilt, polycrystalline solar racks on the landfill's capped top deck
- System capacity would be approximately 2.1 MW for Anguilla
 - Total landfill generation capacity could be augmented with a LFG to power system
- Facility would operate continuously for 25-30 years

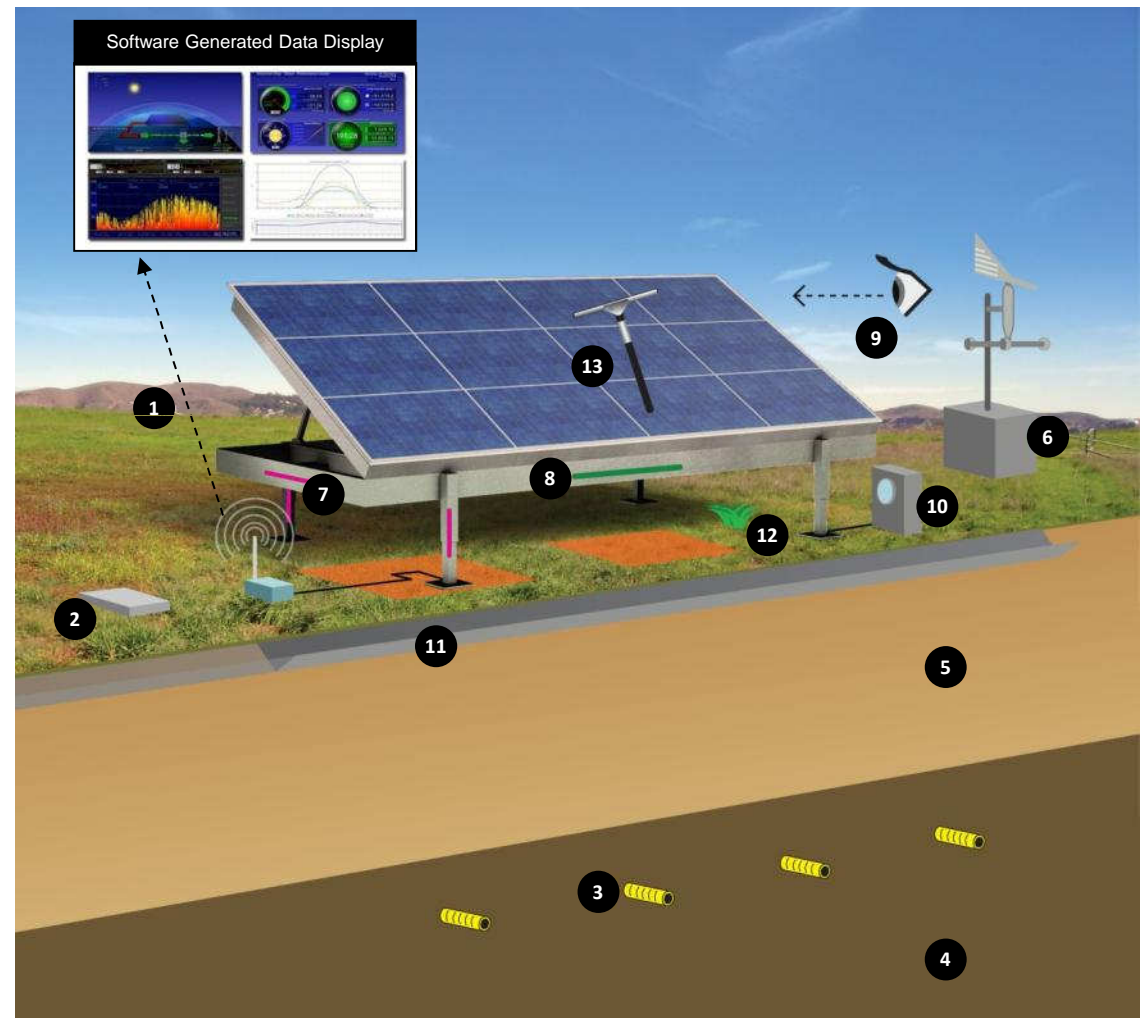
The California Energy Commission is Funding a 3 Year PVN Solar Pilot Test Program at a Closed Landfill Site. The Goal: Derive Design Criteria

Goal: The collection of power generation performance data as well as information on any impacts the solar racking system may have on the landfill cap's functions regarding gas collection and infiltration minimization.

Figure shows a small scale, PV solar rack pilot system, located on a landfill cap. The purpose of the pilot unit is to measure and monitor the systems power generation operating performance on a landfill site where prior desk-top calculations have shown the installation of a 1 to 10 MW PV solar facility may be technically and economically viable.

The pilot facility would typically be operated from 1 to 2 years, thereby permitting any effects of the solar system on the cap (e.g. in the form of increased load and altered storm water management) to be evaluated.

1. WiFi/telemetric system data collection/transmission
2. Reference settlement monument
3. Landfill lateral gas collection system (which may or may not exist for the selected landfill)
4. Landfill waste
5. Engineered landfill cap/cover. This can be an ET monofill or a multilayer RCRA equivalent cap
6. Weather station
7. Wireless strain gauge monitoring system, or associated system to measure strain changes in the solar panel racking system
8. Tilt gauge
9. System orientation monitoring
10. Power generation capacity over entire annual cycle
11. Storm water run off management
12. Monitor growth of cap's vegetative layer under array
13. Panel washing and associated water use; methods and frequency



1. Project Navigator, Ltd.'s solar company, PV Navigator, LLC, was awarded a grant from the California Energy Commission (CEC) to pilot test the performance of racked, PV solar modules, on a closed California landfill site. The business and scale-up premise is that 1,000's of acres of closed and capped landfill space, close to urban load, make ideal siting locations for MW-scale distributed PV power installations.

Courtesy of New Cure, Inc. (NCI) and U.S. EPA, the pilot system has now been installed and is operational on the top deck of the south parcel of the Operating Industries, Inc. (OII) landfill in Monterey Park, CA.

A CEC representative visited the project site on March 7, 2012.



2. The entire pilot installation is comprised of three (3), 10 ft X 20 ft, PV racks, each weighing about 3000lbs. The racks are self-ballasting, with no need for tie down, and thereby cap penetration (which is a major consideration in any post-closure, landfill-located development.)

At OII, two (2) racks are positioned adjacent to each other (with only one having the PV modules for power generation.) The relative positioning of the racks will be monitored during the test.

The performance of the PV-module rack will be closely monitored, as described in illustration 4.



3. A third rack is located approximately 200 ft from the 2-rack system. This 3rd rack's location has been accurately surveyed relative to the 2-rack system, with the objective of trying to evaluate the effects of any differential landfill settlement on the performance of a more extensive, larger MW-scale system.



Lessons Learned After 5 Years of PV Navigator's Solar Project Development Efforts

- The challenges are in (1) **permitting**, and (2) finding a **power off taker** who'll pay enough (cents/kW-hr) to make the economics work
 - Technology and construction challenges are secondary
- Have a good (probabilistic?) **economic model**
- Define and negotiate with the potential offtaker(s) early
 - Perform **power interconnect / feasibility** study early in the process
- Bid the forecasted power from the development into utility RPS RFOs
- Regarding landfill post closure use:
 - If considering a closed landfill, **evaluate the quality/quantity of existing site characterization data, esp. "geotech."** Keep costs down by leveraging past technical info.
- Develop a project fact sheet, early, and discuss with all possible stakeholders
- **Enter into a Letter of Intent (LOI) with Municipality** to investigate the project's technical and economic feasibility

PV Navigator, LLC At-a-Glance.

We Plan, Permit, Design and Develop MW-Scale PV Solar Power Facilities on Landfills and Brownfield Sites.

Landfill Sites are Excellent Platforms for PV Solar Facilities. Flat Acreage, Close to Load and Interconnect, Putting Otherwise Unusable Acreage Back to Use.

PV Solar on Landfills Focus

PVN's Solar Development Projects

CA and NJ Sites in Permitting

PV Solar Facilities on Brownfields and Landfill Sites: Value Creation by PV Navigator, LLC

300 MW Development Pipeline

Key Design Criteria are Minimal Settlement & The Continued Need for Cap Functionality.

Design considerations include eliminating cap penetration, continued functionality of the cap, storm water management, wind design and ensuring protectiveness during an earthquake event.

Technical Expertise

1 – 10 MW, Small-Scale, Distributed, PV Solar Facilities Can Rapidly Deliver Power to Meet Utilities' RPS Standards or Generate Renewable Energy Credits (SRECs)

PV Navigator, LLC's solar development business is centered around the following drivers:

- Spaced to maximize amount of larger acreage
- Availability of urban landfills or brownfield sites which can host the panels
- Availability of funding for small plants
- Location of sites by existing infrastructure or local road
- Proven cost avoidance via use of brownfield sites and the need for new transmission lines
- Minimizing permitting requirements via development on State or Federal land/landfill sites
- 20% renewable power by 2010 and 33% by 2020

Distributed Generation's Growing Importance

Conceptual Layout of Solar Modules for the Southern Ocean Landfill PV Power Development.

CONCEPTUAL PLAN

- 2,300 SunPods solar units (each unit 10'x20')
- Total system would be capable of 5.86 MW, generating about 6 MM kW-hrs per year
- 30 year operating lifetime (planned)

6 MW Southern Ocean Landfill Project (NJ)

Use of Simple, Fixed Tilt, PV Systems

Conceptual Plan for a 2MW PV Solar Installation on Top Deck of Capped, Closed Anguilla Landfill, St. Croix, USVI

CONCEPTUAL PLAN

- Top deck development only
- PVN solar team would work with landfill closure design team to formulate an integrated environmental closure/PV design
- Conceptually install 800 fixed tilt, polycrystalline solar racks on the landfill's capped top-deck
- System capacity would be approximately 2.1 MW for Anguilla
- Total landfill generation capacity could be augmented with a TFG to power system
- Facility would operate continuously for 25-30 years

Caribbean Growth Initiative

The Economic Viability of PV Power is Increasing.

High electricity prices, combined with... State-specific renewable portfolio standards (RPS) and... the gradual annual increases in power prices... will make PV generation competitive

Competitive PV Economics (\$1/Watt by 2017)

The Anguilla Landfill as a PV Installation Location: PVN will Formulate a Site Conceptual Model, with Associated Design Calculations, to Verify PV System Feasibility

Planning and Permitting Using Existing Data

According to U.S. EPA, There is No Shortage of Brownfield and Landfill Site Acreage Which Could be Suitable for Renewable Energy

- Over 400,000 identified Brownfield sites in the United States
- 16 million acres are available for development of renewable energy
- That's enough land to generate approximately 3,175,000 MW
- (For reference, the Hoover Dam generates about 2,000 MW)

100,000's of Candidate Sites Nationwide

PV Navigator, LLC Leads a Multi-talented Solar Development Team

Established Teaming Partners

PVNavigator, LLC (PVN)

PERFIL DE LA EMPRESA

Qué Hacemos

- PVN desarrolla una escala de megavatios (MW), instalaciones de energía fotovoltaica en los vertederos y zonas industriales abandonadas
- Fija la inclinación, auto-montado, instalaciones con balasto
- Aproximadamente 50 MW de capacidad del sitio en Los Terminos de Acuerdo
- Mas de 300 MW en proyectos general de PVN

Quiénes Somos

- PVN es una subsidiaria de propiedad total de Project Navigator, Ltd. (www.ProjectNavigator.com)
 - Financiación interna (hasta la fecha)
- Formados por ingenieros, expertos en desarrollo de la tierra y energía
- Cuatro años de crecimiento y esfuerzo de marca
- Relaciones con Enel, Gestamp y Chevron Energy Solutions

Proyectos Representativos



Vertedero de Barstow, CA

20MW



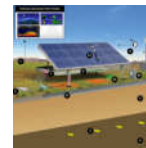
Vertedero de Milliken, CA

5MW



Vertedero de Big Bear, CA

2MW



La Comisión de Energía de California

Beca de estudios



Ocean Township, NJ

10MW



Vertedero de Owens Corning, NJ

3MW



Buena Vista Township, NJ

1MW

En Donde Trabajamos

- Proyectos principalmente en California y Nueva Jersey
- Metas de expansión en el Caribe

Cómo Lo Hacemos

- Sitios detallados y conocimiento de vertederos
- Conocimiento de las hectareas de empresas en la lista Fortune 500"
- Excelente relaciones con las agencias reguladoras
- Experiencia obteniendo permisos de fotovoltaica para los vertederos cerrados
- Aprovechar las tecnologías probadas de fotovoltaica y aplicar a los vertederos
 - (ejemplo PVN's Beca de La Comisión de Energía de California)
- Reconocimiento de marca esta creciendo

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