Feasibility Study of Economics and Performance of Solar Photovoltaics In Puerto Rico

A Study Prepared in Partnership with the Environmental Protection Agency
For the RE-Powering America’s Land Initiative: Siting Renewable Energy on Potentially Contaminated Land and Mine Sites &
For the Department of Energy’s Technical Assistance Program

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Jimmy Salasovich, NREL

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Background

• Gail Mosey – NREL’s project lead
• Jimmy Salasovich – NREL’s technical lead
• NREL’s effort was funded through: EPA’s RE-Powering America’s Lands Initiative and DOE’s Technical Assistance Program (TAP)
• NREL held three site visits
• Two feasibility study reports of solar on landfills in Puerto Rico now available for download at NREL.gov
First Site Visit

- Toa Alta: 2.2 Acres
- Toa Baja: 5.2 Acres
- Cataño: 5.6 Acres
- San Juan: 48.2 Acres
- Santa Isabel: 4.1 Acres
- Salinas: 3.0 Acres
- Guaynabo: 1.9 Acres

- PV areas in orange
- Images at same scale
- Salinas not feasible
- Images from Google Earth
Second Site Visit

- Aguadilla
  - 5.3 Acres
  - Images at same scale
  - Images from Google Earth

- Isabela
  - 5.4 Acres

- Puerto Rico

- Mayagüez
  - 19.8 Acres

- Añasco
  - 6.0 Acres

- Moça
  - 8.3 Acres

- PV areas in orange
- Images at same scale
- Images from Google Earth
Third Site Visit

- Vega Baja: 3.8 Acres
- Carolina: 4.4 Acres
- Fajardo: 1.3 Acres
- Cayey: 2.3 Acres
- Juncos: 3.6 Acres
- Humacao: 23.7 Acres

- PV areas in orange
- Images at same scale
- Images from Google Earth
‘Desktop’ Analysis for Vieques

Old Vieques Municipal Landfill
6.6 Acres

Old Camp Garcia Landfill
63.7 Acres

Former Vieques Landing Strip
57.6 Acres

Former Naval Training Range

Puerto Rico

Vieques

- PV areas in orange
- Images at same scale
- Images from Google Earth

National Renewable Energy Laboratory
Innovation for Our Energy Future
Photovoltaics

• Photovoltaics (PV) are semiconductor devices
• PV panels convert sunlight directly into electricity
  • No moving parts
  • No noise
  • No pollution
Ground Mounted PV Suitable for Landfills

Amorphous (Thin Film)
Ballasted Fixed Tilt
- Lower first cost
- Lower O&M cost
- 6-8% efficient
- Lower energy output
- Panels can be flexible

Crystalline-Silicon
Ballasted Single-Axis Tracking
- Higher first cost
- Higher O&M cost
- 17% efficient
- Higher energy output
PV Integrated into the Landfill Cap

Composite system that integrates both flexible photovoltaic laminates with an enhanced geomembrane liner system to create a dual-purpose closure system.

*Not investigated for this study*
Grid Tied PV System Components

PV

Inverter

Main Panel

Electric Grid

Electric Meter
Considerations for Siting PV on Landfills

- Closure status
- Cap characteristics
  - Type
  - Age
  - Institutional controls
  - Long-term maintenance requirements
- Slope
- Settlement
- Erosion control and vegetative cover
- Control of leachate and gas
- Stormwater management
- Solar resource availability
- Acreage of the site
- Distance to graded roads
- Distance to transmission lines
- Interconnection
- Environmental review and permitting
- Economic factors
Representative Landfill for PV - Aguadilla

View to the South

View to the North

View to the West

View to the East
## Aguadilla PV System – Crystalline Fixed Tilt

<table>
<thead>
<tr>
<th>Description</th>
<th>Potential System Size (kW)</th>
<th>Annual Energy Output (kWh)</th>
<th>Number of Households Powered*</th>
<th>Annual Cost Savings ($)</th>
<th>Annual O&amp;M ($) Assumptions</th>
<th>System Cost Estimates with Incentives ($) Assumptions</th>
<th>Simple Payback Estimates (years) Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aguadilla Landfill</td>
<td>800</td>
<td>1,281,600</td>
<td>134</td>
<td>$166,608</td>
<td>$4,760</td>
<td>$1,860,000 $3.50/Watt $1,860,000 $7.00/Watt</td>
<td>11</td>
</tr>
</tbody>
</table>

*Assume the average household in Puerto Rico uses 800 kWh/month as per Ruth Dones from PREPA.
Success Stories
Solar PV on Former Landfill in Fort Carson

PROJECT OVERVIEW
Location: Colorado
Completed: December 2007
Site type: Former landfill
Installation Type: Ground mounted, fixed system
System Size: ~2 MW, about 2% of Ft Carson load
Covered Area: 12 acres
Project Cost: $13 million
First Solar Thin Film, 25 year warranty
Homes Powered: 540

Governor Ritter at Fort Carson, CO Landfill Project
Solar PV on Former Landfill on Nellis AFB, NV

PROJECT OVERVIEW
Location: Nevada
Completed: December 2007
Property Type: Former landfill
Installation Type: Ground mounted, single axis
System Size: ~15 MW
Covered Area: 140 acres including former landfill
Number of Panels: 70,000
SunPower® T20 Tracker
Geomembrane Solar PV Hickory Ridge Landfill

PROJECT OVERVIEW
Location: Georgia
Completed: December 2011
Property Type: Former landfill
Installation Type: Geomembrane with PV laminate
System Size: ~1 MW
Covered Area: 48 acres
Uni-Solar thin film laminate
Largest PV system in Georgia
Largest geomembrane solar cap in the world

Photos courtesy of Carlisle Energy