United States
Environmental Protection
Agency

Preliminary Assessment of Renewable Energy Opportunities

SOMERSWORTH LANDFILL,
SOMERSWORTH, NEW HAMPSHIRE

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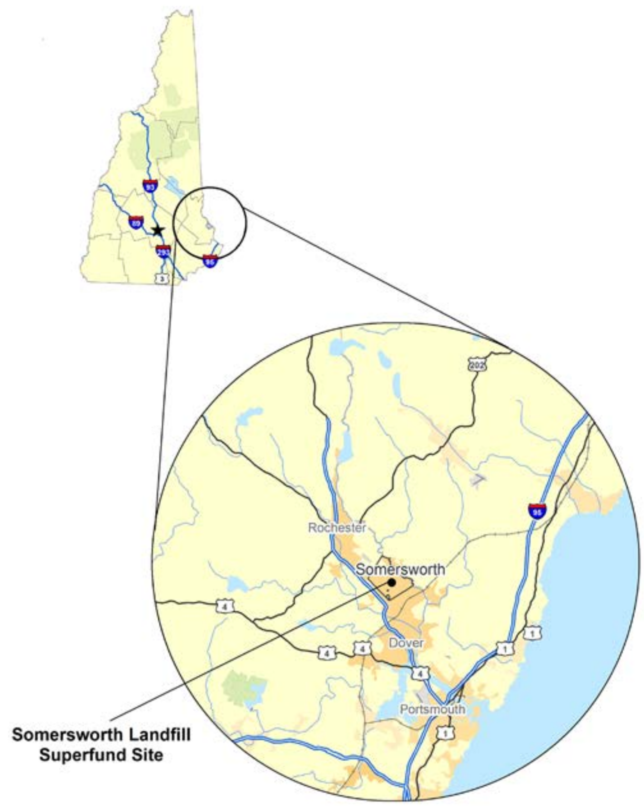
Contents

Purpose

The U.S. Environmental Protection Agency (EPA) places a high priority on the development of renewable energy (RE) and green remediation projects as part of addressing formerly contaminated properties. Through efforts such as the Superfund Redevelopment and RE-Powering America's Land initiatives, EPA works to identify Superfund, Brownfield and mining sites with RE development potential. EPA provides technical resources for site managers, developers, energy managers and other stakeholders interested in using RE at these sites.

The purpose of this pre-feasibility study, prepared by EPA New England in cooperation with the City of Somersworth, is to evaluate the opportunity for a large-scale solar photovoltaic (PV) project at the Somersworth Sanitary Landfill site in New Hampshire.



Introduction

EPA initiated this study to explore opportunities for developing a large-scale solar project at the Somersworth Sanitary Landfill site. Through EPA New England, the City of Somersworth received technical assistance to conduct a pre-feasibility assessment of the opportunities to use renewable energy technologies at the landfill site.

As part of EPA's interest in encouraging renewable energy development on current and formerly contaminated land, this pre-feasibility assessment identifies potential opportunities for developing a large scale solar energy projects on top of the Somersworth Landfill site. Solar PV systems can work well on landfill sites where there are often large, flat, un-shaded areas on top of which to build. Because of development restrictions placed on landfills due to the cap protection considerations, solar projects can represent feasible reuse options for such sites, with the potential to generate revenue streams for the City on a site that might otherwise have limited redevelopment options.

There are some inherent challenges in evaluating solar technologies: projects occur at locations with different resource quality and availability; they displace different energy types with different competing costs of energy; projects can qualify for different incentives based on project ownership; and they meet different objectives. As such, this study is a first-level screening to help the City further evaluate and prioritize potential solar project opportunities at the site. A more detailed technical engineering and economic feasibility study is needed prior to final project decision-making at the Site.

Site Background

The Somersworth Sanitary Landfill Superfund site (the Site) is a 26-acre landfill located approximately one mile southwest of downtown Somersworth, New Hampshire. The Site includes the waste disposal area and adjacent wetlands northwest of the former landfill. The City owns the entire landfill area and much of the adjacent wetland area. Numerous residential properties exist to the south, east and west of the Site, including two apartment buildings located adjacent to the northeast corner of the Site. A fire station and a National Guard Armory are located just east of the Site. Approximately 10 acres of the eastern portion of the Site were reclaimed and covered by the City in 1978 for use as recreational facilities, tennis and basketball courts, ball fields and a playground (see Figure 1).

Figure 1: Former tennis court area on Somersworth Sanitary Landfill.

The Somersworth Sanitary Landfill accepted municipal and industrial wastes from the 1930s until 1981, when the City began using a regional incinerator. Upon completion of landfill operations, the City installed four ground water monitoring wells near the northern and western boundaries of the landfill. Samples taken from these wells indicated the presence of volatile organic compound contamination in ground water.

A remedy to address contaminated ground water was finalized in 1994 and is in place at the Site. Major components of the remedy include:

- Installation of a treatment wall composed of impermeable barrier sections and permeable, chemical treatment sections to provide in-situ, flow-through treatment of contaminated ground water at the landfill waste boundary (i.e., compliance boundary).
- Placement of a permeable cover over the landfill allowing precipitation to infiltrate the landfill and flush contamination from the waste area.
- Installation of a pump in bedrock monitoring well to extract contaminated ground water migrating off site (South of the landfill area) and discharge it back onto the landfill in an infiltration gallery.
- Institutional controls in the form of a Ground Water Management Zone to ensure that affected ground water will not be used until ground water cleanup levels are met.

The permeable landfill cover system remedy is expected to remain in place until ground water cleanup goals are met at which point a permanent cap will be installed over the landfill. Final replacement of the landfill cover is expected to occur around 2049, based on the Record of Decision for the Site.

Site Suitability

The most important location-related requirements for PV solar energy projects at a site are the availability of a suitable solar energy resource, suitable local topography, available area for an array, operating status, compatible site infrastructure and location and transmission access. In addition, at formerly impaired properties, compatibility with remedy components such as landfill covers and landfill gas collection infrastructure are also important considerations.

Solar Resource

Given the Site's location, topography, excavation limitations and available renewable energy resources, solar energy is likely the most promising renewable resource for a large-scale project.

Based upon data available from the National Renewable Energy Laboratory (NREL), the state of New Hampshire has an average solar resource between 4.5 and 5 kilowatt hours per square meter per day (kWh/m^2/day), which indicates a good but not great solar resource (Figure 2) for the Site.

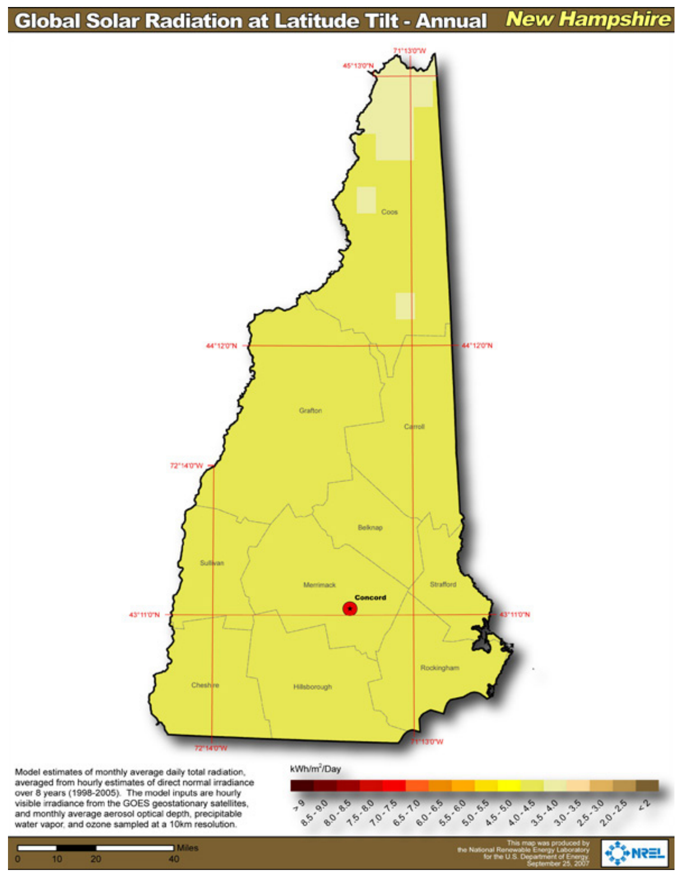


Figure 2: New Hampshire solar resource map

Infrastructure

Site-related infrastructure can be an important factor in considering the viability of a solar project.

Landfill cap area

There is a considerable amount land with minimal gradient on top of the landfill. Some obstructions are present, notably from trees near the former baseball fields and on-site drainage swales. However, the largest areas suitable for large-scale solar development have minimal obstruction.

Utilities

There is minimal electrical load at the Site; Public Service New Hampshire (PSNH) provides electrical power to the City (and the Site). There is a substation 0.5 miles north of the Site on Tates Brook Road (Tate Rd Substation 43). There is also three-phase power along Blackwater Road. An interconnection study would need to be performed through PSNH to determine the best way to interconnect a solar project to the grid.

Transportation

Blackwater Road is the main access point to the landfill area. The Site is located 3 miles from the Spaulding Turnpike.

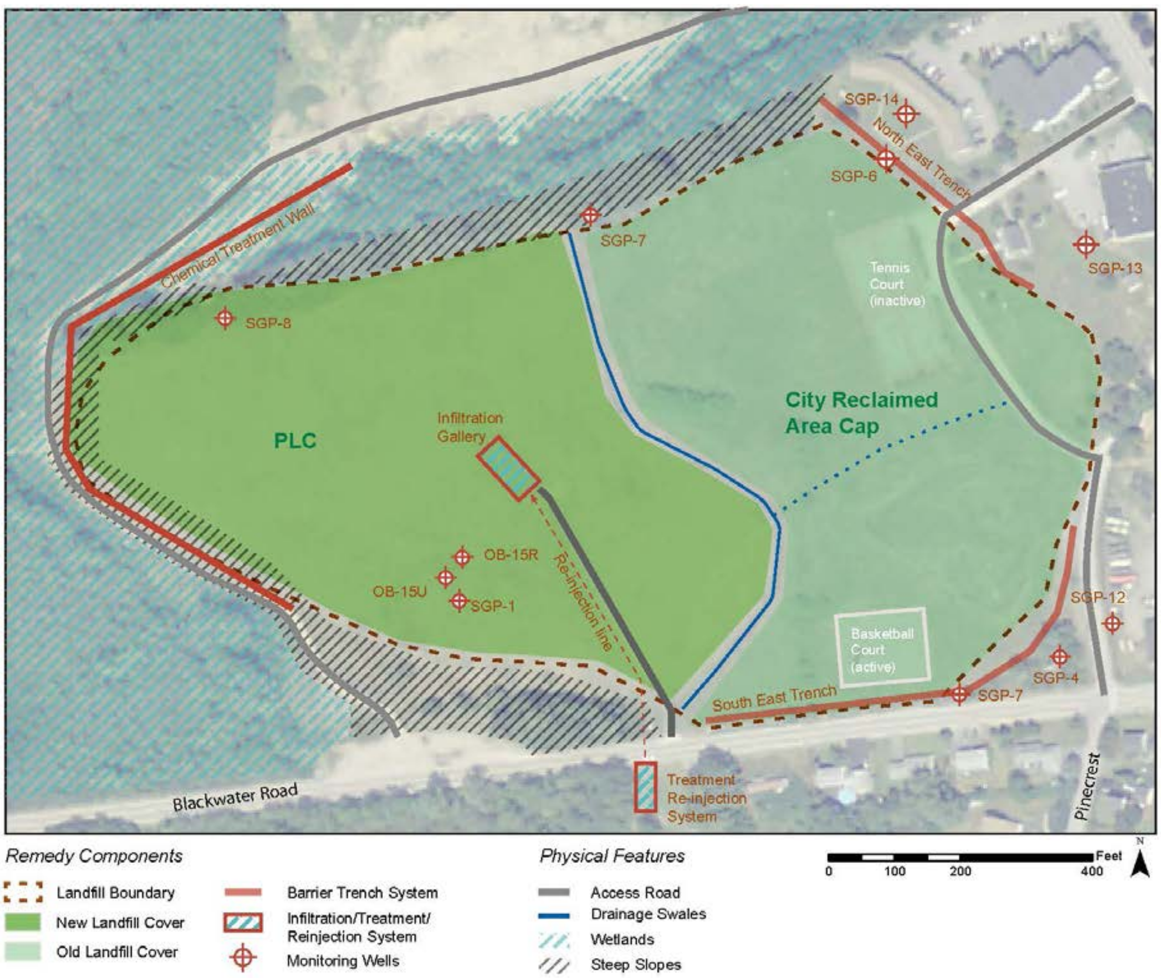
Technical Assessment

Remedy Compatibility

Figure 3 highlights major remedy components for the Site. Any potential solar renewable energy development at the Site will need to take into account the Site's existing remedy – specifically the permeable landfill cover (PLC) and the chemical treatment wall and associated components.

Any solar project on top of the landfill will need to be designed in a way to not interfere with PLC performance objectives (infiltration, stormwater management), ground water cleanup objectives and comply with the applicable Operation and Maintenance (O&M) Plan and other site-specific requirements.

Figure 3: Somersworth Landfill Major Remedy Components.



<u>Cap Characteristics</u>

The characteristics of the landfill cap (thickness, relationship to remedial goals, ongoing maintenance requirements) will affect the selection and design of foundation types, mounting systems, PV module types and the effective area for a solar project.

Completed in the summer of 2001, the PLC was placed over portions of landfill not used for recreational purposes at the time of remedy construction. The cover consists of approximately six inches of backfill material and six inches of topsoil seeded with native grass. No excavation or digging or regrading of the PLC is permitted to ensure long-term protectiveness of the cover. Any PV project design must account for these factors in a way that fully identifies the amount of land available for a project while not compromising the long-term protectiveness of the PLC and ongoing ground water cleanup.

Stormwater Management/Infiltration

Stormwater management considerations include erosion control, vegetative cover and infiltration of precipitation into the landfill. Any solar project design should consider the interaction between a solar system, stormwater management and ground water cleanup.

The purpose of the PLC is to prevent direct contact with the underlying waste material, to control soil erosion and allow for infiltration of precipitation through the landfill to flush contaminants to the CTW. A solar system will increase the impervious surface area of the landfill and may create localized changes in rainfall infiltration, erosion and runoff patterns. The extent and nature of these impacts will need to be considered early in project design to better understand overall and localized effects and how project design and construction can be engineered to accommodate the infiltration tied to the Site's remedial objectives. A final landfill cover could be designed in tandem with a solar system to ensure compatibility of both designs.

PV System Weight

The overall weight of a solar system, as determined by the aggregate weight of the anchoring system, mounting system and PV module is a key design criterion for a landfill solar project. The deadweight loading of the PV system will need to be compared to the weight bearing capacity of the landfill cover, specifically the PLC, to ensure the cover can support the anticipated deadweight loading of a solar system.

Key Landfill Solar Design Considerations for Somersworth Landfill Site

- Cover Characteristics/Weight Limitations
- No Penetrating of Landfill Cover
- Maintain Infiltration Function of PLC
- Vegetative Cover Management/Mitigating Erosion Impacts
- Anchoring System Selection and Design
- Construction and Solar System Weight Considerations
- Snow/Wind Loading Requirements
- Compatibility With Institutional Controls
- On-site Utility Requirements

Concrete footers tend to be heavier on a pounds-per-square-inch (PSI) basis than other anchoring systems (e.g., augered piles or driven piles), but they can provide more stability compared to pile systems. Concrete footers also generally require limited site changes or disturbance to vegetative cover material. Solar developers will typically have deadweight estimates or requirements for their systems (in PSI) that can be compared to the weight bearing capacity of the cover. Additional testing may be required at the Site to assess the weight bearing limitations for the PLC.

Cover Management

Site preparation, grading and construction activities could add temporary or permanent load to the cover. Construction of a solar project on a landfill can be expected to require some level of site preparation and may require new fill material to ensure a uniform project surface or to provide a layer for system infrastructure (e.g., utility trenching). Any proposed project design will need to consider the scale of site preparation required and the potential impact on the PLC and ongoing ground water cleanup activities and timeline.

Solar Development Zones

The solar reuse zones highlighted on Figure 4 identify several opportunities for solar development at the Somersworth Landfill site. Of the total acreage at the Site, approximately 15 acres are considered suitable for installation of a solar system. Development activities at the Site would need to be consistent with the Site's permeable cap remedy, O&M requirements and the City's Ground Water Management Zone ordinance. Solar development would also need to be done in coordination with EPA, the City of Somersworth and New Hampshire Department of Environmental Services (NHDES).

Figure 4: Areas suitable for solar project development

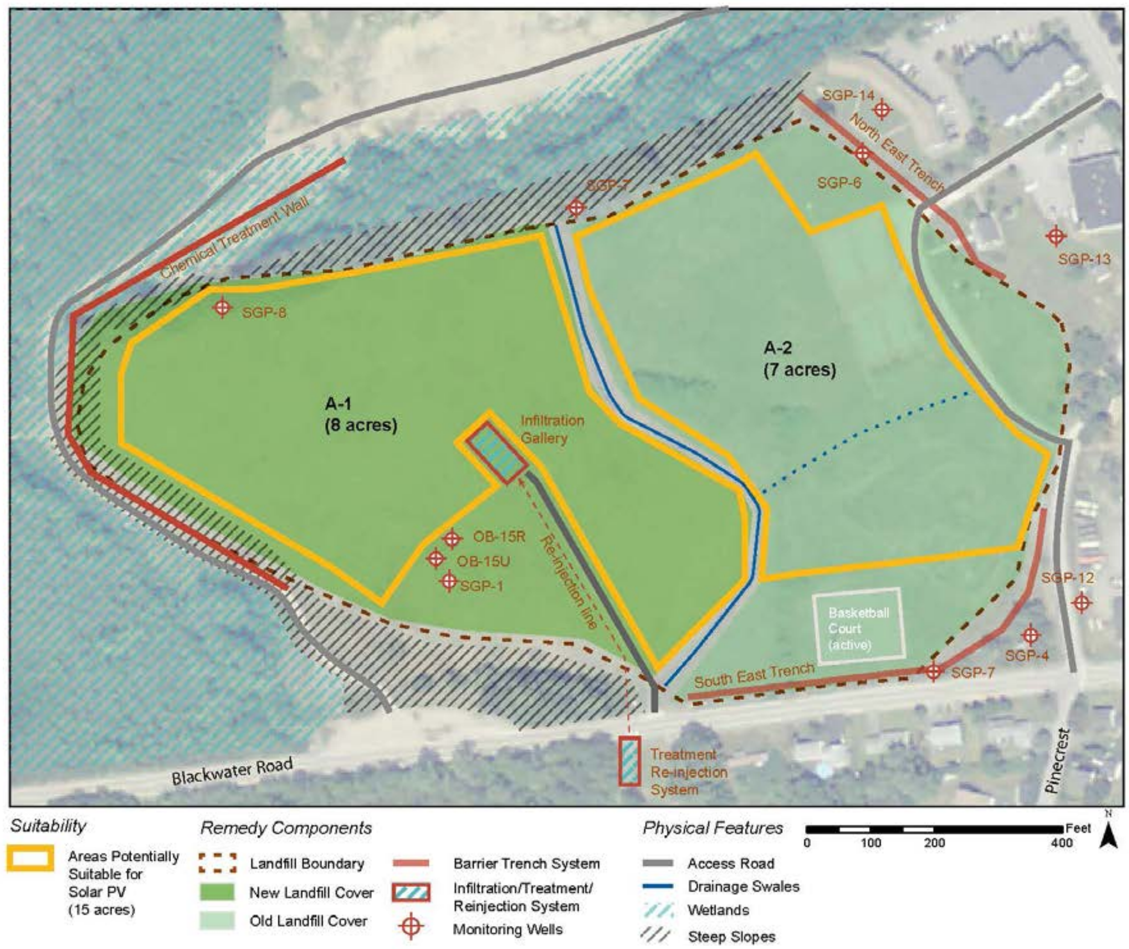


Figure 5: On-site drainage swale

Figure 6: Landfill Infiltration Gallery

PV Solar Technology Overview

A variety of technologies capture or convert sunlight into useful energy. Standard PV systems include solar PV panels (modules), inverters and balance-of-system components. The major types of commercially available solar technologies are PV, high concentrating PV (HCPV) and concentrating solar power (CSP). Because of the solar resource requirements and the amount of land needed for a cost-effective CSP plant, this study found that CSP technologies are not a viable option for the Site. HCPV technologies face a limitation as well; they cannot use diffuse light to create electricity. Diffuse light occurs in cloudy and overcast conditions. With an average of 200 sunny days per year at the Site, an HCPV system will not receive enough direct sunlight to make HCPV technologically or financially viable.

Because CSP and HCPV were not considered viable at the site, the commercially available solar-related technology evaluated as part of this study was solar PV. The most common and widely used PV module is crystalline silicon. This type of solar PV module has a 25 to 30 year lifespan. These modules convert solar energy at a rate between 12 and 18 percent.

Ground-mounted Solar System

A ground-mounted PV system can either be directly anchored into the ground (via piers or concrete footers) or ballasted on the surface without ground penetration. Ballast-weighted mounting methods (Figure 5) rely on the weight of the modules, the mounting racks and extra ballasts if necessary to meet required performance and design considerations. Because of the excavation prohibitions in place at the Site due to the PLC, ballast-weighted ground-mounted systems would be the best-suited option for any solar project developed at the Site. The size and weight of the concrete footers can be modified to meet any weight bearing limitations of the cover. Wind and snow-loading conditions – overturning, uplifting and sliding – would also need consideration when using a ballasted system on top of the landfill.

Figure 7: Ballasted anchoring system for solar PV
Source: SunDurance Energy LLC

PV Solar Generation and Cost Considerations

Based on remedy components, physical features and grade, approximately 15 acres at the Site are potentially suitable for solar PV. Potential solar PV system size, generation and cost estimates are highlighted in Table 1 below. NREL's System Advisor Model was used to estimate energy outputs for a solar project located at the Site.

The estimated installed costs do not factor in potential incentives or solar PV system ownership and financing options. They are intended to provide a baseline overview of the upfront cost associated with designing and building various size systems that may be feasible at the Site. Costs in the solar industry are changing rapidly and data below are from recent published data; therefore, the proposed system cost may be less than estimated in this report and projects could see reduced upfront costs in future years.

Table 1: Preliminary Solar PV System Size and Cost Estimates

Reuse Zone	Available Acreage	Estimated Size	Estimated Output	Installed Costs	Annual O&M Costs
Zone A1	8	1.6 – 2.1 MW	1,750 – 2,450 MWh	$5.6M – $8.4M	$32K – 42K
Zone A2	7	1.5 - 2 MW	1,650 – 2,350 MWh	$5.2M – $8M	$28K – 40K
Combined Totals	15	3.1 – 4.1 MW	3,400 – 4800 MWh	$10.8M – $16.4M	$60K – 82K

Assumptions:
System Costs: $3.30 - $4.00/Watt installed.
(assumes some additional site prep costs to accommodate project needing to be 100 percent surficial; no incentives included)
O&M Costs: $20/kW/year.
Area needed: 3.5 - 5 acres / MW of AC nameplate capacity (maximum rated output of a system).
MWh=1,000 kilowatthours (kWh).
Output estimate calculated based on average crystalline silicon PV system.

Incentives

Identifying and leveraging applicable incentives and grants is an important part of making solar systems cost effective. Incentives are available at the state and federal level and include both policy-based incentives (e.g., renewable portfolio standards) and financial incentives (e.g., tax credits and rebates). A number of policies and incentives could help facilitate the development of a larger scale solar energy project at the Site, including:

Federal Incentives

Business Energy Investment Tax Credit

- Credit equal to 30% of system expenditures, with no maximum credit
- Entities with no income tax liability (e.g., municipalities) cannot directly access this incentive if they own RE systems.

Modified Accelerated Cost-Recovery

- Current depreciation method for most property and qualifying solar energy equipment is eligible for a cost recovery period of five years.

State Policies/Incentives

Renewable Portfolio Standard (RPS)

- Utilities (excluding municipal companies) are required to generate 23.8 percent of total electricity output from renewable sources by 2025. Utilities comply with the state's RPS requirements through purchase of renewable energy certificates (RECs).
- Includes a carve out of 0.3 percent generation from solar power installed after January 1, 2006

Rebates

- Commercial & Industrial Solar Rebate Program run by State Public Utilities Commission ("PUC"). The rebate offers $0.80 per Watt for new systems, but has a maximum system size of 100 kW.

Commercial & Industrial Renewable Energy Grants (PUC)

- Applies to renewable-energy projects installed at commercial, industrial, public, non-profit, municipal or school facilities. The grant program has a minimum grant amount of $100,000, with no maximum, but a cap of $1.8 million in grants for 2013. Projects that are eligible to apply for a PUC rebate are not eligible for funding under the grant program.

Net Metering

- The state requires all utilities selling electricity in the state to offer net metering to customers who own or operate systems up to 1 Mega-Watt in capacity that generate electricity using solar. Net excess generation is either carried forward indefinitely to the customer's next bill as a kilowatt-hour credit. SB 98 (2013) allows a customer generator to become a group host for a group of customers who are not customer generators.

Utility Incentives

Public Service of New Hampshire does not offer incentives or rebates for solar projects beyond what is offered by the State of New Hampshire through the state's various programs.

Development/Ownership Scenarios

There are a range of options for the procurement, development, construction and management of a successful utility-scale renewable energy facility. The most common ownership and financing structures are described below.

Owner and Operator Financing

The owner/operator financing structure is characterized by a single entity with the financial strength to fund all of the solar project costs and, if a private entity, sufficient tax appetite to utilize all of the project's federal tax benefits.

A city owned and financed system would carry some level of financial risk. Large solar projects are capital intensive and public entities cannot directly benefit from the tax-credit based incentives available to private companies. A local government would also need to have (or hire) expertise to navigate the local utility interconnection and power purchase process.

Third-Party Developers with Power Purchase Agreements (PPA)

Because many site hosts (e.g., a municipal government) lack the financial or technical capabilities to develop a capital-intensive project like a large-scale solar project, third-party developers are often involved. In exchange for access to a site through a lease or easement arrangement, third-party developers will finance, develop, own and operate solar projects utilizing their own expertise and sources of financing. Once a system is installed, the third-party developer would sell the electricity to the site host or local utility via a purchase agreement.

A third- party PPA may provide a viable way for a system to be financed and installed at the site. A purchase agreement approach can provide cost certainty against long-term electricity prices and will generally be economically viable if a project can be developed with a PPA price that is competitive with utility electricity rates (current rates or projected rate increases).

Land Lease

Under a land lease scenario, a municipality selects a developer to design, finance, build, own, operate and maintain a system at a municipally-owned site. Under this scenario, a project developer would be responsible for all aspects of project development and maintenance and would pay an agreed to amount of rent to use the land.

A land lease approach would be expected to provide the least amount of financial risk to a public entity. A solar developer would be responsible for all aspects of project development, assume financial risk and claim project revenue. The value of the land lease will vary by developer and site, so having clear revenue goals under a land lease scenario is important during project negotiation.

Summary Findings

The development of a RE project is a complex process that requires incentives, multiple partners, favorable market conditions and other factors that need to be identified and managed throughout a project. Amidst this complexity, the Somersworth Landfill site offers a unique opportunity to accommodate a large solar energy project in a state with few large solar energy projects.

While solar is technically suitable anywhere in the United States, the economic viability of solar depends as much on local utility prices and the ability to take advantage of applicable incentives as it does on the local solar resource. Based on an assessment of these factors, the Somersworth Sanitary Landfill site could support a large-scale solar system, but a project will be challenged by modest state incentives, State policy limitations on net metering opportunities, a soft solar REC market in the northeast and the inability of the City to take advantage of federal solar tax incentives. Additionally, at present, a viable off-taker for any energy generated on-site has not been identified.

A solar project could be considered in phases at the Site. For example, the seven buildable acres of the A2 area in the eastern portion of the Site could accommodate a 1.5 to 2 MW solar project. This area would avoid the PLC and any potential remedy compatibility or protectiveness concerns in that area, and provide an initial area to gauge developer interest in a project.

Next Steps

Clarify Any Construction Limitations of PLC: The cover's vegetative layer and soil are part of the functional design of the landfill and tied to the cleanup performance goals for the Site. As a result, the soil on the cap cannot be disturbed and module foundation cannot penetrate the PLC because this will risk damaging the cover and impacting remedy protectiveness. Additional analysis is needed to better understand any weight bearing limitations for the PLC as well as whether additional fill material could be placed on the cover without adversely impacting infiltration (and thus ground water cleanup) goals. Better understanding any potential remedy-related considerations will help identify landfill areas that can accommodate a project with minimal site preparation and what areas may require additional engineering or design to accommodate a solar project.

Identify Project Development Structure: Based on the goals and interests of the City, one development approach may be more well suited to the City's financial or site-related interests. A land lease could provide low risk financial benefit if the City can find a developer looking for a location to build a project and willing to rent the landfill area. Alternatively, a third-party approach may offer a feasible way for a system to be financed and installed on this Site if the City can use or help identify end users for the power. This could potentially allow the City to utilize the benefits of the tax credits that are available to a private developer while not directly receiving them. Understanding which approach most closely fits the City's interests will help in identifying potential developers.

General Overview of Solar Project Development Process

- Site Selection
- Feasibility Analysis
- Procurement (qualification, proposal, evaluation)
- Vendor Selection
- Contract Negotiation
- Permitting
- Project Engineering Design
- Site Preparation
- Project Construction
- Interconnection
- Commissioning
- Operations & Maintenance
- Monitoring
- End of Life
- Buyout Provisions

Pursue a More Detailed Feasibility Assessment: This analysis is preliminary, with project estimates and sizes based on available area. Actual project size will be based on the availability of funds, the amount of power that can be sold or other market factors in New Hampshire. Once PLC construction limitations have been clarified, the City could consider issuing a request for information or qualifications based on the development approach of most interest to the City (i.e., land lease or third party). A developer's response to such a request will provide more refined project numbers to the City. Any solicitation should clearly articulate the type of project the City would like to pursue (lease land or purchase power) as well as any site or remedy-related conditions a project would need to accommodate moving forward.

Sources/Resources

U.S. Environmental Protection Agency. Preliminary Close Out Report, Somersworth Sanitary Landfill Superfund Site, 2005.

GeoSyntec Consultants. DRAFT Operation and Maintenance Plan, Somersworth Sanitary Landfill Superfund Site, 2004.

Superfund Redevelopment Initiative:
http://www.epa.gov/superfund/programs/recycle

Re-Powering America Best Practices for Siting Solar Photovoltaics on Municipal Solid Waste Landfills:
http://www.epa.gov/renewableenergyland/docs/best_practices_ siting_solar_photovoltaic_final.pdf

U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. Siting Clean and Renewable Energy on Contaminated Lands and Mining Sites. September 2008.

Database of State Incentives for Renewables & Efficiency (DSIRE):
http://www.dsireusa.org

DOE Solar Energy Technologies Program:
http://www1.eere.energy.gov/solar

National Renewable Energy Lab. Photovoltaic (PV) Pricing Trends: Historical, Recent, and Near-Term Projections:
http://www.nrel.gov/docs/fy13osti/56776.pdf

National Renewable Energy Lab System Advisor Model:
https://sam.nrel.gov/

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Preliminary Assessment of Renewable Energy Opportunities

SOMERSWORTH LANDFILL,
SOMERSWORTH, NEW HAMPSHIRE

EPA
United States
Environmental Protection
Agency

Prepared For:
City of Somersworth

Prepared and Funded By:
EPA New England