

# The Guide to Developing **Solar Photovoltaics** at Massachusetts Landfills



Commonwealth of Massachusetts

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# Introduction

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There has never been a more opportune time for municipalities to develop solar photovoltaic (PV) systems on landfill sites.

- » Municipalities are seeking additional, creative ways to leverage underperforming assets to save money or generate new revenues.
- » Massachusetts has a robust market for Solar Renewable Energy Certificates (SRECs) generated by solar PV production.
- » Investor-owned utilities in Massachusetts allow net metering, which allows projects to capture retail rates for electricity produced by qualifying renewable energy projects.
- » Electricity produced by an onsite solar PV system can provide a hedge against volatile energy prices.

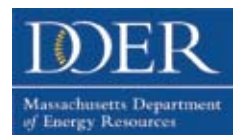
This guidebook has been published to help municipal officials identify, evaluate, and pursue opportunities to harness the sun's power to generate electricity and revenue from undeveloped landfill space. Topics covered include: physical requirements of PV systems; PV system economics; landfill considerations; public procurement; and PV system development, design, and installation.

This guidebook was prepared by Nexamp, Inc. on behalf of the Massachusetts Department of Energy Resources (DOER).

## About DOER

DOER's mission is to create a cleaner energy future for the Commonwealth, economically and environmentally, including:

- » achieving all cost-effective energy efficiencies;
- » maximizing development of cleaner energy resources;
- » creating and leading implementation of energy strategies to assure reliable supplies and improve relative cost; and
- » supporting clean tech companies and spurring clean energy employment.



DOER is an agency of the Massachusetts Executive Office of Energy and Environmental Affairs (EEA).

## About Nexamp

As a leading solar independent power producer, Nexamp develops, builds, owns, and operates distributed and utility-scale solar projects for private and public sector clients and partners.

Nexamp delivers integrated solutions—from project development and financing through construction and asset management—to ensure that our clients and partners maximize the value of their solar energy investments.



# Module #1: How Does Solar Electricity Work?

## The Basics

Solar photovoltaic (PV) systems convert sunlight directly into electricity. When sunlight strikes the semiconductor material in a solar cell electrons are freed and begin to flow. This flow of electrons creates an electric current, or electricity. The more intense the sunlight striking the panel, the greater the amount of electricity produced.

The solar cell is the basic block of PV technology. Solar cells are aggregated to form a PV module or panel. One or more modules are wired together into strings, or groups of panels. Strings are connected to an inverter, which converts the direct current (DC) produced by panels into the alternating current (AC) used by electrical devices in the United States. Figures 1, 2, and 3 show some typical solar cells, panels, and inverters.

Electricity production from PV systems is primarily a function of PV panel orientation, tilt, and DC to AC conversion losses. These factors are described in greater detail below. The capacity of a system is described in terms of the instantaneous amount of power it can produce, expressed in watts, or kilowatts (kW). In Massachusetts, 1 kW (DC) of PV capacity, at the optimal orientation and tilt for maximum annual production, can produce between 1,000 and 1,500 kilowatt-hours (kWh) of electricity annually. These production estimates account for the fact that the sun shines more in the summer than in the winter, and not at all at night. As a point of comparison, a residential

customer might see an average monthly use of 500-750 kWh, and the average residential system of 3 kW produces 3,000-4,500 kWh per year.

A good rule of thumb when sizing systems is that 1 kilowatt of PV requires 100 square feet of unobstructed area for a pitch roof, and up to 130 square feet for open land. For ground-mount systems, each megawatt (MW) of installed capacity typically needs 4-5 acres. Larger systems are somewhat more cost effective than smaller systems due to economies of scale associated with system design, installation, and interconnection.

## How Is Electricity Production from a PV System Maximized?

### Shading

The amount of sunlight, measured as insolation, that a PV system experiences impacts overall system performance. PV system design should avoid placing solar panels in areas that are shaded at any point during the day in order to maximize insolation. In particular, it is important to maximize solar access from May-September, when production is highest. The only exceptions are up to ninety minutes after sunrise in the morning and ninety minutes before sunset in the afternoon. The most common features that cause shading are trees, buildings, telecommunications structure, or rooftop HVAC systems. Ground-mount systems risk shading from grasses and other vegetation.

Figure 1: Solar Cell (photo: US Department of Energy / NREL)



Figure 2: Solar Module (photo: US Department of Energy / NREL)

Figure 3: 500-kilowatt Inverter (photo: Solectria Renewables)





Figure 4: Massachusetts-manufactured Panel Claw Mounting System (photo: Nexamp)

Well-designed PV systems avoid panel-to-panel shading except near sunrise or sunset. The modules will also face seasonal snow coverage, which will vary depending on the height and tilt of modules, depth of snow coverage and other weather conditions (e.g., a slight thaw can create icing conditions that prevent snow from sliding off the modules). While snow typically melts and slides off tilted modules, there may be short periods when the array is covered and the array does not produce electricity.

### Orientation

PV systems are oriented in a south-facing direction in order to maximize power production. For roof-mounted projects, it may be possible to get up to 95 percent of optimal production even if the roof faces Southeast or Southwest. For ground-mounted arrays, system design should optimize the orientation to be facing as close to true south as possible. Note: True south differs from magnetic south in Massachusetts.

Solar PV arrays must be designed to meet site-specific conditions and to optimize production.

### Tilt

The tilt angle of a PV system is another key variable that impacts power production. Maximizing generation based on tilt angle can be a very site-specific and project-specific exercise. PV layout and tilt angles can be optimized to achieve different goals, so understanding project objectives at an early stage can help guide the design process. For example, at Massachusetts latitudes, a tilt angle of 36 degrees will typically maximize annual generation. However, installing a



Figure 5: High-density Pre-cast Concrete System (photo: Solar FlexRack)

system at a 5-degree tilt can maximize summer production, and still achieve more than 80 percent of the production achieved by a 36 degree tilt angle. Optimizing tilt and production may provide benefits to customers that for example pay higher electricity rates in the summer months or at certain periods of the day.

Similarly, there may be opposing design considerations for a maximum tilt angle (36 degrees) and a tilt angle closer to 10 or 20 degrees. Systems with a higher tilt angle require more spacing between rows to prevent

panel to inter-panel shading, and may have higher structural engineering requirements in order to comply with state wind load requirements. While a 36-degree tilt maximizes annual production per kW of

installed capacity, a lesser tilt of 20 degrees would provide an annual production of nearly 95 percent of that maximum, and would allow for the installation of more modules in the same area. Therefore, pursuing a larger project with a smaller tilt angle may be more cost advantageous for some projects.

### Trackers

Most New England PV installations rely on a “stationary” design, meaning the systems do not track the movement of the sun. However, systems do exist that track the path of the sun to increase production, but the added cost of installing and maintaining a tracking system often outweighs the net increase in system production realized by a tracking system in New England. To maximize the production of electricity, the

design of individual PV installations must consider (and optimize) the factors of shading, orientation, and module tilt.

## What Hardware Is Included?

A typical solar PV system consists of three primary components: solar panels; inverters; and a mounting system. Different options are available for each of these components, and it is important to choose the options that best fit the site conditions.

### Modules

Solar modules vary in size (dimensions), DC capacity (amount of instantaneous DC energy produced in Watts), efficiency (amount of energy produced per square unit area, typically listed as Watts/square meter), and location of manufacture. Panels typically come with a 5-year minimum workmanship warranty, and a production guarantee of 90% of maximum rated capacity after 10 years, and 80% of maximum rated capacity after 25 years.

### Inverters

Inverters are the heart of a well-built PV array. Inverters convert DC electricity produced by the solar panels into AC electricity to be transmitted to the grid. Typical inverters come with a minimum 5 year warranty, although 10 years is quickly becoming the industry standard.

### Mounting System

Ground mounted PV arrays typically use one of three common mounting structures, a low density concrete block ballasted system (see Figure 4 for a system that sits on top of the ground without penetrating the soil),

a high density pre-cast concrete system (see Figure 5 for a system that uses pre-cast concrete blocks to hold modules and the racking in place), and a driven pile mounting structure (see Figure 6). The mounting system must be optimized for specific site concerns, including lift, snow shedding, wetlands, water table, and permitting issues, in addition to subsurface issues such as landfill, stone, or other potential impediments. For typical landfill sites, the ideal mounting system is more likely to be a non-penetrating system than a system with ground penetrations.

Roof mounted PV arrays can be developed to meet a range of site-specific conditions. Common mounting types include non-roof penetrating systems for standing seam metal roofs and rubber membrane roofs, while other mounting solutions may rely on roof penetrations. The solar industry has developed solutions to address most scenarios, including flat and pitched roofs, and metal, rubber, and other roof material types.

Qualified integrators and developers should be able to provide guidance on appropriate mounting solutions for a diversity of sites.

### Additional System Components

In addition to the three primary components highlighted above, a PV array will require additional hardware including DC wiring, combiner boxes, disconnects, meters, transformers, and AC wire. The placement of additional equipment must be optimized based on soil conditions, footprint, and other site-specific concerns. Many municipalities will also choose to install a data acquisition system with a web-based interface so that municipal officials, citizens, schools, and other stakeholders can view information about the solar array and the power it is generating.



Figure 6: Driven Pile Mounting Structure  
(photo: Solar FlexRack)

## Module #2: What Incentives Are Available for Solar?

Various state and federal policies are available to improve the economics of installing and owning large-scale solar PV arrays. This module outlines some of these key incentives and policy mechanisms, some of which apply to municipal projects, while others apply only to systems owned by for-profit entities. The incentives available for projects owned by for-profits are indirectly available to municipalities through a third-party ownership model, explained in more detail in Module #4.

The list of incentives that follows is not meant to be comprehensive, but instead to highlight the key considerations for embarking on a solar PV project in Massachusetts.

**Note:** The information provided here is for general information only, and should not be relied upon with regard to a specific project without consultation with town counsel.

### Solar Renewable Energy Certificates

In 2010, as outlined by the Massachusetts Green Communities Act of 2008 and in support of Governor Deval Patrick's goal of installing 250 MW of solar generation capacity by 2017, the Massachusetts Department of Energy Resources established regulations that promote solar installation and generation in Massachusetts, within the Commonwealth's existing Renewable Portfolio Standard. Under the "Solar Carve-out," Massachusetts's retail electric suppliers are required to buy Solar Renewable Energy Certificates (SRECs) for an increasing portion of the electricity they deliver each year. SRECs are created as qualifying solar installations generate electricity. One SREC is created for every 1,000 kWh (1 MWh) of electricity generated by a qualifying Massachusetts PV array.

In support of Governor Patrick's goal of installing 250 MW of solar PV by 2017, the Solar Renewable Energy Certificate, or environmental attribute of the energy produced by the solar array, can be sold at a premium.

The Solar Carve-out creates a market demand for SRECs. The advent of SRECs creates an additional potential revenue stream for qualified solar projects. SRECs have a minimum value of \$285/MWh and a price ceiling of up to \$550/MWh, depending on market conditions.

The owner of a solar PV array can sell SRECs generated by the project directly to the retail electric suppliers or work with a broker who will help them identify buyers of those SRECs. SRECs can be sold each quarter at spot market prices, or projects can enter into long-term purchase agreements that provide assurance for long-term system revenue. More detail is included in Appendix B.

### Net Metering

Customers of Massachusetts' investor-owned utilities, National Grid, NSTAR, Western Massachusetts Electric Company, and Unitil, have the option of selling net excess electricity generation from a qualifying solar project via net metering. Net metering allows a project host to offset its electricity usage with electricity generated on-site, reducing the amount of electricity the customer must buy from the distribution company. For customers that produce more electricity than they consume in any given month, credits accrue and can be carried forward and applied to future months' bills. Credits also may be transferred to another customer of the same distribution utility as long as they are within the same service territory and ISO-NE (the regional electricity grid operator) load zone. The value of each kilowatt-hour is worth more as a net-metered credit under this policy than if the kWh was sold to the utility grid at the clearing price. Additional detail on transaction types for selling net metering credits is included in Module #4.

In Massachusetts, there are several categories of net metering facilities. "Class I" facilities are generally defined as systems up to 60 kW in capacity. "Class II" facilities are generally defined as systems greater than 60 kW and up to 1 megawatt (MW) in capacity that generate electricity from agricultural products, solar energy, or wind energy. "Class III" facilities are generally defined as systems greater than 1 MW and up to 2 MW in capacity and that generate electricity from agricultural products, solar energy or wind energy.



Under current net metering rules, net metered facilities must be located behind a customer's meter, but only a minimal amount of onsite electricity load is required. A legislative amendment enacted in late 2010 established a new definition for "a net metering facility of a municipality or other governmental entity." As provided for in the legislation, this category of net metered facility must be either Class II or Class III and must be owned by a municipality or governmental entity, or the entity must use all of the facility's output. The legislation also capped the aggregate amount of capacity a municipality or other governmental entity may net meter at 10 MW.

Customers of Municipal Light Plant Departments (MLPs) may be eligible for net metering and are encouraged to contact their local MLP to learn more about what options are available to them.

## Federal Investment Tax Credit

Qualified solar PV projects are eligible for a federal investment tax credit of up to 30% of eligible system costs, if installed by December 31, 2016. The tax credit can be taken and applied against the federal tax obligation of a for-profit entity. The 30% tax credit will sunset at the end of 2016 and revert to a 10% tax credit which has no expiration date.

For more information, please visit:  
<http://www.dsireusa.org/documents/Incentives/US02F.htm>

## Accelerated Depreciation / Bonus Depreciation

Under the federal Modified Accelerated Cost Recovery System (MACRS), businesses are able to recover investments in eligible property through depreciation reductions. Solar PV is specifically eligible for a 6-year accelerated depreciation schedule if the system is installed by 2016. Moreover, for systems installed in 2012, bonus depreciation is available. For systems installed in 2012, businesses can depreciate 50% of the value of the system in the 2012 tax year, with the remaining value depreciated over years 2-5 of the project lifetime based on the MACRS schedule.

For more information, please visit  
[http://www.irs.gov/irb/2011-16\\_IRB/ar10.html](http://www.irs.gov/irb/2011-16_IRB/ar10.html)

**Note:** Massachusetts does not allow the deduction at IRC § 168(k) for bonus depreciation. A Massachusetts taxpayer that claims bonus depreciation under IRC 168(k) for federal purposes must calculate a separate depreciation schedule for purposes of claiming depreciation on the Massachusetts tax return. See *Technical Information Release 03-25, Depreciable Business Assets; Modifications for Decoupling from Federal Bonus Depreciation*.

Link to Massachusetts Business Related Credits:  
<http://www.mass.gov/dor/individuals/filing-and-payment-information/guide-to-personal-income-tax/credits/business-related-credits.html>

## Summary

More information about these incentives can be found online at: <http://www.dsireusa.org>. The site is periodically updated to include new information and changes in incentives. For example, there are federal tax credit bond offerings that are available when authorized by Congress, such as Clean Renewable Energy Bonds and Qualified Energy Conservation Bonds.

## Module #3: Considerations for Designing and Developing Solar on a Landfill

Solar PV development on landfills offers a significant opportunity for municipalities in Massachusetts. The Commonwealth has more than 490 landfills, 466 of which are now inactive or closed. More than 40 have received post-closure use permit approvals from MassDEP, including 20 projects with solar PV specific uses totaling more than 42.8 MW.

Although not every landfill is suitable to host a solar PV system, municipal landfills with advantageous site characteristics may provide an opportunity for cities and towns to generate revenue from otherwise undevelopable land. Table 1 (left) outlines some of the key advantages and challenges associated with siting solar PV projects on landfills.

Module #3 will address each of the primary challenges listed in Table 1 in greater detail.

### Getting Started: Feasibility Assessment

As a first step, municipalities seeking to evaluate the potential for pursuing solar on a landfill should determine whether any existing permit or site limitations preclude, prevent, or limit post-closure activity at the landfill. Limitations may be a result of:

- » a landfill's site assignment, issued by the local Board of Health
- » a landfill's approved closure plan, and closure certification approval from the Massachusetts Department of Environmental Protection (MassDEP) which applies only to landfills closed after 1990
- » incomplete landfill assessment or capping
- » release of hazardous materials or oil, resulting in either a compliance issue or an Activity and Use Limitation
- » zoning issues, given that the site's existing zoning may not be a permitted use

If a landfill was not closed and capped in accordance with a MassDEP approval, or if a landfill was closed and capped before 1990, an environmental assessment (required by 310 CMR 19.150) and MassDEP closure permit (pursuant to 310 CMR 19.151) may be required prior to developing a solar PV array as a post closure activity. These assessment and corrective action requirements may be done concurrently with the post closure development of the site, provided that the site development is done in accordance with a MassDEP approval. Information about a landfill's cap status, permits obtained, and Board of Health determinations should be available at your MassDEP Regional Office, and local Board of health, respectively.

The environmental permits that may be required in order to develop a solar PV array on a properly closed and capped landfill are listed below:

- » Solid Waste Post-Closure Use Permit (MassDEP)
- » Wetland Notice of Intent (NOI) and Order of Conditions (Local Conservation Commission)
- » Wetlands Protection Act Request for Determination (Local Conservation Commission)
- » Massachusetts Environmental Policy Act (MEPA) filing may be required if the project exceeds certain thresholds (regulated by the Executive Office of Energy and Environmental Affairs, MEPA Unit). More details about what might trigger a MEPA review are included in 301 CMR 11.00 MEPA Regulations.

Table 1: Landfill Siting Advantages and Challenges	
Advantages	Challenges
Large, open space	Permitting restrictions
Access for construction	Settlement issues
Remote location	Cap Restrictions
Limited shading	Weight/Load limits
Inexpensive open space	System design
New use for otherwise unusable land	Distance to interconnection
Increased site monitoring	Topography and slope

- » EPA Stormwater Permit may be required for construction activities for storm water management and erosion control.
- » National Pollution Discharge Elimination System (NPDES) permit for storm water run off due to construction activity may be required when more than one acre of land is disturbed.
- » Massachusetts Endangered Species Act (MESA) protects rare species and their habitats. The MA Natural Heritage and Endangered Species program provides maps that can be used to determine whether a project falls in a priority habitat or estimated habitat.

See Appendix C for additional information on these permits.

Potential applicants for a Solid Waste Post-Closure Use Permit are strongly encouraged to schedule a “pre-application” meeting with the MassDEP prior to preparing the post-closure use permit application. The MassDEP has experience working with municipalities on solar projects at landfill sites, and can help guide a municipality’s early development efforts. Contact information for the MassDEP Regional Offices is included in Appendix C.

## Existing Site Conditions

As part of any feasibility assessment, the host municipality will need to inspect the landfill to evaluate a number of potential issues that may impact site development, including management of storm water, landfill gas, and settlement. Storm water and landfill gas management issues can be mitigated by system design, but settlement should be evaluated early in the feasibility process. Inspectors will need to carefully evaluate past settlement as a potential obstacle to the project. If a landfill has recently ceased accepting waste primary settlement may pose a fatal flaw for the project. If a landfill has been closed for a significant period of time, typically on the order of 10 to 15 years, much of the primary settlement may have already occurred. The extent and timing of settlement will vary from landfill to landfill depending on the depth of waste, type of waste, and operational history.

Pittsfield Wastewater Treatment Plant:  
1.58-MW Solar PV Array (photo: Nexamp)



## How Does Construction & Operation of Solar PV Affect Landfill Management?

In preparation for its review of proposed solar projects on landfills, the MassDEP will request a variety of documentation describing existing conditions and proposed PV design (the post-closure use). Documentation will include site plans, closure plans, and a summary of previous environmental assessment findings. The post-closure use design plans will need to include a site plan, detailed solar PV designs (stamped by a Professional Engineer), a narrative report that outlines the technical analysis of the PV system, and a review of any anticipated impacts to the site resulting from the proposed changes. MassDEP is looking for projects that: coordinate the designs of multiple experts; integrate well with the function of the existing landfill cap/cover system; do not increase the potential for erosion; do not create new exposures to landfill gas; and provide access for site maintenance.

Applicants to the MassDEP for post-closure use permits can be either the host municipality itself, or a third-party on behalf of the municipality. It may be difficult to issue an RFP and negotiate a land lease, CPA, or other arrangement with a third-party entity without having first addressed the outstanding permit(s).

If the landfill was previously assessed and properly closed, agency review typically takes 2-6 months. If the site has not been assessed and properly closed, agency review may take longer.

The MassDEP will evaluate a PV system post-closure use permit application with a focus on two primary criteria:

- » maintaining the integrity of landfill's final cover system, and
- » no adverse impact to public health, safety and the environment.

The post-closure use permit application will be approved only if the proposed PV system meets

MassDEP's criteria for post-closure use of landfills (310 CMR 19.143). In order for MassDEP to determine if the proposed project meets the post-closure use criteria, the MassDEP will scrutinize four major aspects of the PV system design:

- » Settlement & stability
- » Storm water controls
- » Landfill gas management
- » Monitoring and maintenance

### Settlement: PV System Foundation

Solid waste engineers often characterize landfill settlement into two categories: existing settlement and projected settlement. An engineer should be able to identify existing settlement through a site inspection process. Similarly, a solid waste engineer should be able to estimate predicted settlement using a number of important variables, such as compression, biodegradation, and creep. Finally, the impact due to predicted settlement from the designed solar PV array can be assessed and reviewed with the MassDEP. The PV system foundation will need to prevent ponding and generally keep water out of the landfill while maintaining the integrity of the final cover system to control gas emissions.

The foundation design must be stable, capable of accommodating the loading of the system itself, and flexible enough to adjust for potential site settlement.

### Storm Water

Storm water needs to be controlled in order to maintain and prevent erosion of the landfill final cover system; and to prevent adverse impacts to abutters and the surrounding environment. The post-closure use permit application needs to contain a depiction of all existing storm water erosion control systems as well as any alterations to that system associated with the post-closure use activity. The type and complexity of additional storm water controls, to facilitate the post-closure use will vary widely depending on the existing storm water system design, proposed foundations,

Existing and projected ground settlement are a key concern for technical design, and needs to be evaluated early in the development process in order to assess potential impacts to the project.

increase in impervious areas, proposed changes to topography (i.e. construction roads), and adjacent receptors (i.e. wetlands). The MassDEP has indicated that modules should not be considered impervious surfaces. In addition, MassDEP currently requires that landfill storm water controls manage the peak discharge of a 24-hour, 25 year storm event and evaluate for the 24-hour, 100 year storm event for flooding. If storm water discharges to surface water wetlands, additional permitting and or standards may apply. Vegetative cover is often used for stormwater management so there may be restrictions on the area of the landfill that can be covered by the PV system foundation.

### Landfill Gas Management

MassDEP also reviews the impact of the PV array on the landfill gas management plan. MassDEP evaluates the site's existing gas control system, gas characteristics, and gas migration pathways. The MassDEP team considers the impact of the proposed PV system design on that landfill gas management system, to ensure: protection of public health (by preventing the release of toxic compounds into ambient air); public safety (by preventing explosion, fire, or asphyxiation); and the welfare of the community (by preventing nuisance odors).

Typically all post-closure uses incorporate a combination of engineering controls, management controls and monitoring to ensure landfill gas does not pose an unacceptable safety or health risk.

**Engineering Controls:** Every building, inverter, transformer, and every subsurface utility conduit located on or in close proximity to a landfill becomes a new "landfill gas receptor." The construction of buildings on a landfill is strictly controlled. All building shall be above grade structures and be designed to prevent the accumulation of gas within the structure. Buildings may require: gas monitoring and warning devices; vapor barriers; and/or venting systems. To the extent feasible utility lines should be located above ground when located on or in close proximity to landfills. Subsurface utilities need to be designed to minimize the potential for landfill gas to enter the conduit and create a safety (explosion, fire) or health hazard.

**Management Controls and Monitoring:** The owner and their contractors need to ensure all necessary precautions are taken to protect health and safety of workers and the general public during both construction and maintenance of the PV system. In some cases, when there is limited landfill assessment data, landfill gas sampling and/or a risk assessment may be required to evaluate post-closure use exposure pathways. However, in many cases, a site-specific OSHA health and safety plan that includes worker training, management controls and landfill monitoring will be sufficient. Most landfills will have pre-existing monitoring wells, and the design and construction of the PV array will have to ensure there is no disturbance or obstruction of monitoring wells.

PV system designers and builders should be well versed in the challenges associated with developing and building projects on landfills. Designers and builders will have to work closely with the landfill's solid waste engineer to ensure seamless system operation.

### Post-Closure Use Operations, Monitoring and Maintenance

Finally, the MassDEP will review the proposed PV array design to confirm that long-term maintenance can be performed as required after the PV array is constructed. The PV array designer will need to ensure that water cannot penetrate and landfill gas cannot escape from the landfill. A poorly designed system may incur future costs due to instability, erosion, cap breakdown, or vegetation overgrowth.

Additional details about the tasks associated with pursuing and obtaining a post-closure use permit from the MassDEP are included in Appendix C.

## PV Design Considerations at Landfills

Installing solar PV projects on landfill sites gives rise to additional solar-specific design and construction issues. Consultants, designers, and builders should all be well-versed in the technical issues associated with developing a solar project on a landfill. Solar-specific technical concerns include the following:

- » Topography and Usable Area: Often, only the flat surface of a landfill is appropriate for usage for solar. While it may be technically feasible in certain cases to develop mounting structures for the sloped sides, usually the cost of engineering and custom mounting structures is too high to be economically feasible. Ideally, the landfill will have a large flat area or if there is a moderate slope, a large south facing orientation.
- » Location of Wiring: DC and high voltage wiring, which may be installed in below ground conduit in typical ground-mounted projects, may need to be run above ground to avoid penetrating the landfill cap. There may be a limit on depth of excavation allowed.
- » Load Limits: The weight of the PV array will likely be affected by the load limit of the cap. This weight load limit will likely also affect construction, and could prevent high weight trucks, cranes, and related equipment from accessing portions of a site, creating additional logistics considerations.
- » Settlement: Concrete pads for inverters, transformers, and other transmission equipment may need to be placed off of the landfill cap itself because of settlement issues, weight, and a concern about electrical equipment over the landfill. MassDEP has reviewed and approved solar project designs that incorporate adjustable supports to account for landfill settlement. Inspection operations need to include assessment of landfill settlement due to the stresses that could be induced in the array support system. However, if settlement causes ponding, settled areas must be repaired.
- » Storm Water Management and Erosion Control: a vegetative cap is often used for storm water management and erosion control. There may be restrictions on how much area the PV system foundation can cover without either requiring a remedial measure or storm water analysis by a professional engineer.

## Construction Considerations

The construction of the PV array must take into account unique considerations of building on a landfill. Maintaining the integrity of the landfill cap and the gas management system are primary concerns. The construction considerations include:

- » limiting the depth of excavation, depending on the depth of the cover
- » avoiding the usage of heavy equipment on certain areas of the landfill
- » restrictions on laydown areas
- » maintaining erosion controls
- » maintaining stormwater controls
- » soil and/or groundwater testing if hazardous materials or petroleum products have been released on the site
- » robust health and safety plans
- » cap repair plans
- » monitoring of on-landfill construction

## Post-Closure Use Maintenance Considerations

If the PV array design does not call for replacement of the existing vegetative cover system (typically grass), there is a risk that shading from PV array will have deleterious effects on the underlying vegetation. During PV array operations and maintenance, reseeding and/or additional erosion control measures may be necessary depending on the response of the vegetation to reduced sunlight. The extent of the problem will depend largely on the design of the PV array and the ability of the existing vegetation to handle reduced sunlight. Potential negative impacts associated with shading from solar array components can be mitigated by implementing erosion controls, planting vegetation on undeveloped portions of the property, or planting low-growth, low light flora beneath the solar modules.

Installing a PV system will make some of these maintenance issues more difficult, and planning for that process will need to occur as part of the post-closure use permit process. Maintenance tasks like grass mowing, gas system repair, landfill gas management hardware upkeep, and site inspections require access to certain onsite equipment. The PV array will need to be designed to allow access to existing infrastructure, and to allow for certain upkeep requirements to occur unimpeded.

One advantage for municipalities developing solar on their landfill is the increased site monitoring that comes with the secondary use. PV array inspectors can be trained to look for landfill final cover damage and can identify necessary repairs before they become major problems. Landfill final cover system inspection and maintenance could also be rolled into an agreement with a third-party vendor responsible with PV system upkeep. This vendor would have an increased interest in ensuring site security and management, and would want to actively address any settlement issues.

Cathartes Private Investments:  
Construction of 4.5-MW Solar PV Array (photo: Nexamp)



Cathartes Private Investments:  
4.5-MW Solar PV Array (photo: Les Vants Aerial Photo Service)



# Module #4: What Ownership Structures and Strategies Can We Use to Develop a Landfill Solar PV Array?

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There are multiple development and ownership structures that can be used to develop solar energy projects on municipal property. In addition, new strategies are continually evolving. The following module summarizes some of the more traditional approaches that are used by municipalities. It is intended to provide general background for municipalities seeking to understand the range of options available for developing PV projects on municipal property.

## Typical Development Tasks

Today, an average MW-scale solar project may take between twelve and twenty-four months to develop and build. Some of the first large-scale solar projects in Massachusetts, built in the mid-2000s, took as many as five years to develop, but the industry has gained significant experience since then. Whereas the Brockton Brightfields solar project, built in 2006 on a former brownfield site (see Case Study #1 for more details) took more than six years to develop, the Easthampton landfill project (see Case Study #2) took closer to two years.

Some of the major tasks included in developing solar projects include:

- » Site selection
- » Feasibility assessment
- » Conceptual design
- » Energy and attribute (e.g., SRECs) offtake agreements
- » Permitting and Interconnection Application
- » Engineering
- » Equipment Procurement
- » Project finance
- » Construction
- » Interconnection
- » Long-term system operations and management

Whether a municipality wants to own a renewable energy project or simply host a project, it needs to understand and assess which of these tasks it has the expertise to perform/manage on its own, and which need to be subcontracted.

## Municipal Ownership

One common development structure for solar projects at municipal sites is the standard municipal ownership model. In this approach, the municipality serves as the developer, financier, builder, and owner of the PV system. As owner, the municipality enjoys all of the direct benefits resulting from the project, including electricity savings and revenues from SREC sales. Subcontractors are generally used for most or all of the project tasks, but the subs need to be managed by municipal officials or volunteers, and the quality of their work product needs to be verified at each step. An owner's engineer can help the municipality with the subcontractor selection and management.

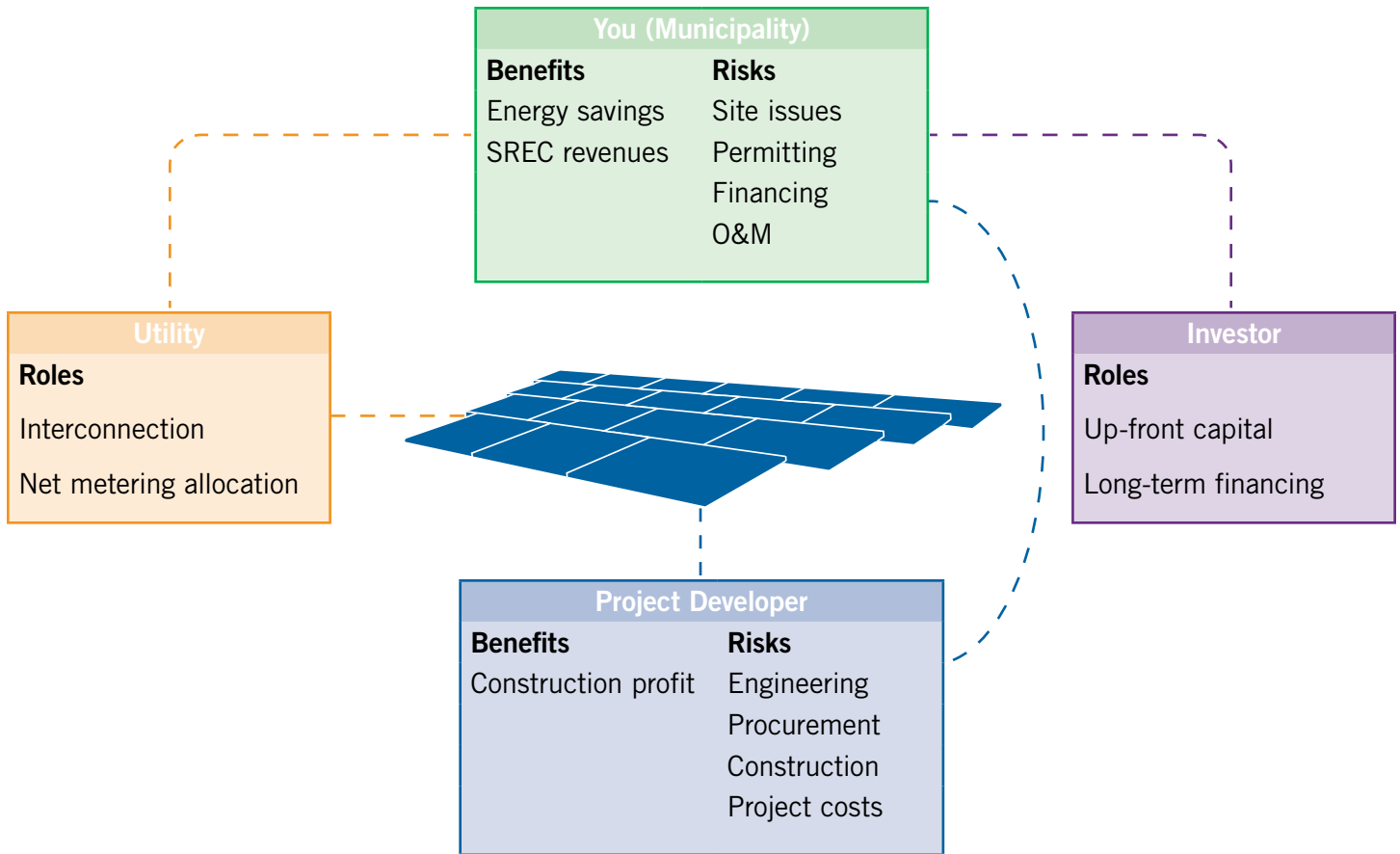
The structure of a municipally developed and owned project typically follows one of two paths: design-build or design-bid-build. In the design-build framework, the municipality issues a single request for proposals (RFP) or request for qualifications (RFQ) for a firm that can engineer, design, build, and manage all aspects of system implementation. In the design-bid-build framework, a separate design firm is hired to provide upfront project analysis, a conceptual design, and other engineering services. Based on the findings of the design firm, a second procurement is then issued to hire a traditional Engineering, Procurement, and Construction (EPC) firm that will manage the balance of the project design and construction tasks.

Both approaches have advantages and disadvantages. The design-build framework requires that a certain level of due diligence be completed by the municipality prior to issuing the RFP. This enables potential bidders to have sufficient information on topics related to site characteristics, interconnection, landfill considerations, permitting requirements, and other project details. In practice, sometimes design-build RFPs are issued with information that is insufficient for potential bidders to prepare comprehensive, accurate bids. This places upward pressure on bid prices. In some cases, an incomplete or unrealistic RFP will result in low/no response from experienced bidders. In contrast to the design-build approach, the design-bid-build development style may provide bidding EPC firms with helpful upfront information about the project that can guide the estimating and scheduling process.



The risks and benefits of developing a municipally owned project are outlined in Figure 7, below:

Figure 7: Municipal Ownership Model



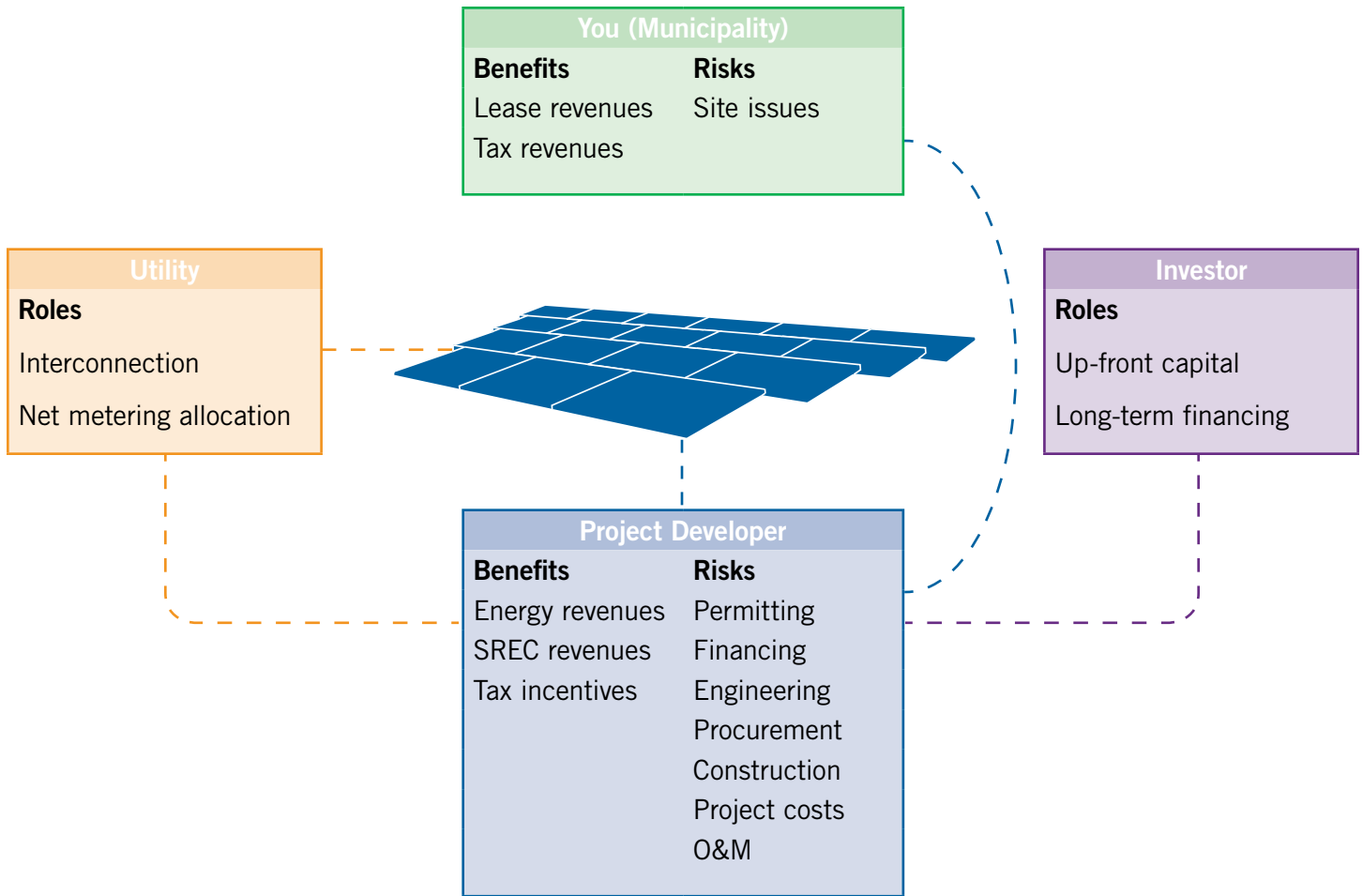
## Land Lease

The land lease scenario is significantly different from the municipal ownership scenario, in that much of the risk and responsibility is shifted away from the municipality to the project developer/owner. In a land lease scenario, the municipality selects a vendor to design, finance, build, own, operate and maintain a system at a municipally owned site. The vendor is responsible for all aspects of project development, assumes all risks, and claims much of the project revenue. In exchange, the project developer/owner negotiates a land lease with the host municipality.

The value of the land lease may vary by developer and project site, so municipalities should expect this to be an important point of negotiation in the vendor RFP/selection phase. In some cases, a power purchase agreement may also be negotiated with the host municipality, separate from the lease payment, or the lease payment may be included as part of the PPA. If included as part of the PPA, then the negotiation over the price for electricity should contemplate the inclusion of that payment

The risks and benefits of developing a land lease project are shown in Figure 8 on the following page.

Figure 8: Land Lease Model Benefits and Risks



Greater Lawrence Sanitary District: 441-kW Solar PV Array  
(photo: Gregg Shupe)



## Power Purchase Agreement and Credit Purchase Agreement

Power purchase agreements, or PPAs, are common contract instruments used in energy project development, and valid PPAs are typically critical to project financing. In this case, the solar PPA is a contract between a project owner and project host through which the project host, the municipality, buys the electricity generated by the PV array from the owner at a predetermined rate. From the perspective of the municipality, traditional PPAs provide a known and predictable price of power, with the goal of long-term savings. From the standpoint of the project owner, the PPA provides a fixed revenue stream to finance project development, installation, and operation. PPAs in Massachusetts can be used in both investor-owned utility and may be used in some municipal light territories.

The precise terms of a PPA are subject to negotiation. As an electricity end user, the municipality signs an agreement with the project developer to pay a specific rate for every kWh produced by the system. PPAs may incorporate a fixed price a fixed price with an agreed upon escalator, or a price that is indexed to the actual retail cost of electricity (from the utility) for a fixed period of time. Key variables impacting the PPA include the site's potential for energy production and the credit-worthiness of the off-taker.

The second type of structure, the net-metering Credit Purchase Agreement (CPA), is similar to a PPA but is newer to the Massachusetts market. CPA transactions are enabled by the Green Communities Act of 2008. As previously outlined, solar energy systems located

in investor owned utility territories are allowed to transfer the value of their energy production (on a per kWh basis, as determined by the utility rate) to certain other customers via net-metering credits. These CPA transactions can take a number of different forms. In some cases, they may resemble more conventional PPA structures (e.g., fixed price/fixed period), but they may also incorporate strategies such as a fixed discount for a fixed period of time (i.e., the generator transfers 100% of the value of net-metering credits to the end user, and the end user pays the generator 95% of that value, for a guaranteed savings of 5%). From the standpoint of the municipality, there can be significant advantages to pursuing a Credit Purchase

Agreement, including reduced public procurement burden (discussed in greater detail in Module #7), reduced risk (fixed discount with no downside risk), and higher flexibility.

## Performance Based Revenue Via Power Purchase/Net Metering Credit Purchase Agreements

Solar PV revenue models based on PPAs or CPAs share a similar risk and benefit profile as the land lease structure outlined previously, but it is important to understand where they differ. A fixed lease payment provides no risk to the host municipality: the payment is made from the project owner to the host municipality whether the system operates or not. By contrast, revenue-based payment may fluctuate if the system produces more or less power in a given year. However, a revenue-based structure (PPA or CPA) provides additional financial incentive to the developer to maximize system production, which helps to increase savings for the host customer.

Power Purchase Agreements (PPAs) and Net Metering Credit Purchase Agreements (CPAs) are two structures used to capture revenue from energy projects.

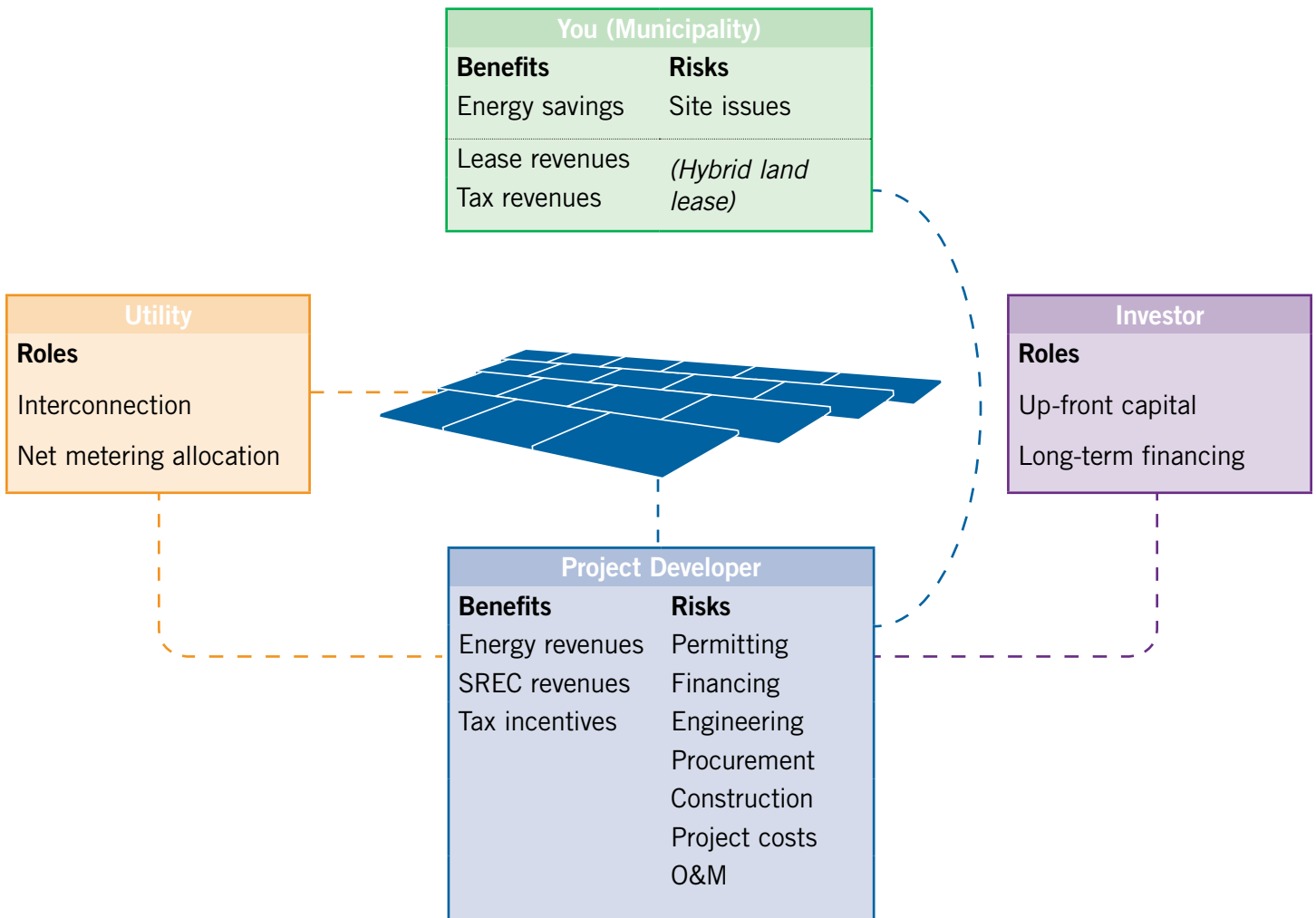
## Hybrid Land Lease and CPA/PPA Revenue Structure

It is also important to note that a municipality may choose to negotiate a hybrid land lease and PPA/CPA structure. This type of project provides both guaranteed, low-risk revenue by way of a long-term land lease, and a performance based revenue stream that provides a hedge against long-term electricity prices.

This arrangement encourages the developer to design the system for long-term operation and adds value in the event of a system ownership change to the host municipality.

The risks and benefits of developing a power purchase / credit purchase style project are shown in Figure 9, below.

Figure 9: Power Purchase Agreement / Credit Purchase Agreement Model



## Module #5: Development and Design Considerations

Careful consideration of site development and system design, from the initial planning phase straight through to the anticipated end-of-life for the project, is a prerequisite for the successful development and operation of large-scale solar PV projects. Failure to adequately address development and design concerns early in the project life cycle can result in unexpected costs, delays, underperformance, and lost revenue over the lifetime of the project.

### What Else Do I Need to Know about Permitting?

The permitting process for any landfill construction project is inherently complex, due to the unique environmental concerns associated with such projects. A detailed list of the required permits, reviews and approvals, including estimated due dates, review periods, and expiration timeframes, should be developed and tracked throughout the project development process. This section summarizes the typical permits and approvals that are required for landfill-based solar PV projects in Massachusetts. Note that many of these permits and approvals have been highlighted in greater detail in Module #3.

### Permitting Fees

In general, the permitting fees associated with landfill PV projects depend upon the size of the project. For example, building permit fees are often between 1.0% and 3.0% of the total costs of a project's eligible materials (i.e., permanent structures). Electrical permit fees are typically closer to 0.5% to 1.5% of the total cost of eligible materials (i.e., electrical components, including modules, inverters, and wiring). One exception is the MassDEP Post-Closure Use permit, which is subject to a fixed fee ("Minor": \$1,085; "Major": \$2,790) regardless of the project size. Fees for Requests for Determination of Applicability and Notices of Intent are determined by the local conservation commissions in the municipality where the site is located, and do vary. The costs in Table 2 are for illustrative purposes.

Table 2 highlights typical permitting costs for a sample 1-megawatt (MW) solar PV landfill project. The total installed project cost is assumed to be \$5,000,000, of which 5% of the total cost (\$250,000) is attributable to permanent structures, and 50% of the total cost (\$2,500,000) is attributable to electrical components.

### Additional Permitting Details

MassDEP provides detailed guidelines for navigating the Post-Closure Use permitting process. The guidelines include an extensive list of required documentation, including: site plans, construction plans, storm water and erosion plans, stability analyses, utility infrastructure plans, monitoring and maintenance plans, and more. Complete requirements are available online at <http://www.mass.gov/dep/recycle/laws/lfpccguid.pdf>.

### Massachusetts Environmental Policy Act (MEPA)

MEPA provides an opportunity for public review of potential environmental impacts from proposed projects that receive state financial support, or require one or more state permits or approvals and exceed specific regulatory thresholds.

If your community has received any state financial assistance for its renewable energy installation on a closed landfill, or the project is large enough to trigger one or more MEPA thresholds, you will need to file an Environmental Notification Form (ENF) with the MEPA Office. The thresholds most likely to apply are:

- » Direct alteration of 25 or more acres of land for anything other than accepted agricultural or forestry practices.
- » Creation of five or more acres of impervious area.
- » Alteration or disturbance of Priority Habitat or Estimated Habitat for one or more state-listed rare species of animals or plants. (See the separate discussion of the Natural Heritage and Endangered Species Program below.)
- » Location within a state-designated Area of Critical Environmental Concern (ACEC).

**Table 2: Permitting Costs for Sample 1 MW Project (Total Cost: \$5,000,000)**

<b>MassDEP Post-Closure Use Permit (Major)</b>	\$2,790
<b>MEPA Environmental Notification Form</b>	No charge
<b>MassDEP Request for Determination of Applicability</b>	\$300
<b>MassDEP Notice of Intent</b>	\$2,500
<b>Building Permit (at 1.5%)</b>	\$3,750
<b>Electrical Permit (at 1%)</b>	\$25,000
<b>Total Permitting Fees</b>	<b>\$34,340+</b>

- » Construction of a new electric generating facility with a capacity of 25 megawatts (MW) or more, or expansion of an existing facility by more than 25 MW.

The ENF will undergo public review and based on any comments received, the Secretary of Energy and Environmental Affairs may require avoidance, minimization or mitigation measures, or more in-depth study in the form of an Environmental Impact Report (EIR).

Even if your project does not trigger any of the thresholds above, there are other MEPA requirements that may apply, including:

- » If construction or expansion of the landfill was reviewed through the MEPA process and the facility was closed within five years of its most recent MEPA review, then you will need to file a Notice of Project Change with the MEPA Office for your post-closure use. If construction or expansion of the landfill was reviewed through the MEPA process and your project involves closing the landfill, then you may need to file a Notice of Project Change with the MEPA office for the closure and post-closure use.
- » Projects that affect nearby wetlands or require road construction or alteration exceeding specific thresholds also require MEPA review.

To learn more about the MEPA process or consult with state staff about how MEPA requirements or thresholds might apply to your project, visit: <http://www.env.state.ma.us/mepa/>

## Massachusetts Natural Heritage & Endangered Species Program (NHESP)

Under the Massachusetts Endangered Species Act (MESA) and its implementing regulations, NHESP protects rare animal and plant species and their habitats. Specifically, NHESP reviews projects proposed within:

- » **Priority Habitats.** These are areas known to be populated by state-listed animal and/or plant species. Any project within a Priority Habitat is subject to NHESP regulatory review unless specifically exempt or “grandfathered.” You will need to file a MESA Project review Checklist, a project plan and description, a U.S. Geological Service (USGS) topographical map of the site, an assessor’s map, proof of ownership or authorization

for filing, photographs of the site, and a review fee based on acreage. NHESP will let you know within 30 days if your filing is complete, then will determine within the next 60 days – and often sooner – whether your project, as proposed, would result in a “take” of state-listed species. The vast majority of projects are allowed to proceed as proposed, while NHESP may require conditions

- » **Estimated Habitats.** These are a sub-set of Priority Habitats and are based on the geographical range of state-listed rare wetlands wildlife (not including plants). If your project is proposed within an Estimated Habitat and the local Conservation Commission requires you to file a Notice of Intent (NOI) under the Wetlands Protection Act, you will need to submit a copy of the NOI to NHESP. At the same time, you will also need to file for MESA review. You can do both concurrently through a streamlines NOI filing process. Within 30 days, NHESP will send its comments to the Conservation Commission, with copies to you, your consultants, and the Department of Environmental Protection (MassDEP).

Each atlas that NHESP develops to delineate Priority and/or Estimated Habitats is based on local observations of rare animals and plants within the last 25 years. To ensure adequate protection of rare species, NHESP does not disclose their exact locations.

Priority and/or Estimated Habitat maps are available through an interactive web viewer (see link below). In addition, NHESP provides maps of communities containing Priority and/or Estimated Habitats to local conservation commissions, building inspectors and planning boards.

NHESP encourages you to schedule a pre-filing consultation with its staff. You may also submit a MESA Information Request Form to learn more about rare species known to occur in and around your site. Communication early in the project development phase will help you avoid potential project changes and delays later on, and most likely will save you time and money in the long run.

Learn more about the NHESP review process and download a MESA Information Request Form:  
[http://www.mass.gov/dfwele/dfw/nhosp/regulatory\\_review/ mesa/ mesa\\_home.htm](http://www.mass.gov/dfwele/dfw/nhosp/regulatory_review/ mesa/ mesa_home.htm)

Use the Priority and Estimated Habitat Interactive Web Viewer:  
[http://www.mass.gov/dfwele/dfw/nhosp/regulatory\\_review/ priority\\_habitat/online\\_viewer.htm](http://www.mass.gov/dfwele/dfw/nhosp/regulatory_review/ priority_habitat/online_viewer.htm)

Review lists of rare animal and plant species in Massachusetts:  
[http://www.mass.gov/dfwele/dfw/nhosp/species\\_info/ mesa\\_list/ mesa\\_list.htm](http://www.mass.gov/dfwele/dfw/nhosp/species_info/ mesa_list/ mesa_list.htm)

## Wetlands

As with the Environmental Notification Form, a Wetlands Protection Act Request for Determination of Applicability requires that site plans, project plans and project descriptions be submitted to the local conservation commission where the project is located. The applicant is responsible for publishing a public notification of the Request in newspaper(s) circulated in the municipality(ies) affected by the project. Instructions and forms are available online at <http://www.mass.gov/dep/water/approvals/wpaform1.pdf> with fee schedules available from the local conservation commissions.

## Local Permits

Requirements for building and electrical permits vary by municipality. Municipal officials are encouraged to consult with the local building department and any other relevant departments to review these requirements prior to issuing construction RFP bid documents.

## Is Zoning an Issue?

The municipality in which the project site resides will have a Table of Use Regulations that specifies approved land uses by zoning district. Depending upon the uses approved for a landfill's zoning district, a large-scale solar PV project may or may not be deemed an acceptable use of the land parcel. If the project does not qualify under the range of permissible uses, a special permit may be required, adding a review by the local Zoning Board of Appeals or Planning Board. Solar PV projects may also be permissible under the Chapter 40A Section 3 zoning exemption for solar energy facilities. Municipalities that have been designated as "Green Communities" may have as-of-right siting for solar PV projects. For a list of Green Communities, see

<http://www.mass.gov/energy/greencommunities>.

A copy of the Commonwealth's Model As-of-Right Zoning Bylaw is online at: <http://www.mass.gov/eea/docs/doer/green-communities/grant-program/solar-model-bylaw-mar-2012.pdf>.

## Interconnection

The ability to connect a solar PV system to the electric grid and the associated cost of doing so can have a significant impact on project economics. Distributed generation projects, such as solar and wind systems located on landfills, must be reviewed by the local distribution utility to determine the technical viability of connecting the project to the grid. Key considerations of the utility include:

- » Voltage of nearby electric distribution lines
- » Presence of single phase vs. three phase power
- » Electricity usage of nearby end-users connected to the distribution grid
- » Nearby electricity generators that are connected to the distribution grid
- » Proximity to substations and other utility-owned hardware
- » Distance to and cost of upgrading distribution lines to handle proposed project

All of the costs associated with interconnecting a renewable energy facility to the distribution grid will be borne by the project itself. As such, it is important to understand at an early project stage the technical feasibility of interconnecting to the grid and the costs associated with that interconnection.

Separately, the voltage rating for a distribution line may dictate the maximum project size that can cost-effectively be installed in a given location. In Massachusetts, a rule of thumb is that a 5 kV transmission line can support only a few hundred kW of intermittent renewable generation capacity. The next step up, a 13 kV line, can typically only support up to 3 MW of renewable generation capacity. A 23 kV line may be able to support up to 6 MW of renewable generation capacity, depending on other variables. Determining the voltage of the power lines near the site will be important to understanding a potential limiting factor to system size – the line voltage. The carrying capacity of a line also includes other generators that may be using the line. For instance, if another nearby

Proximity to adequate transmission and distribution infrastructure is a primary consideration for project success, and needs to be evaluated early in the development process.

project has already applied to the utility for interconnection, they are given first rights to that carrying capacity, further limiting the maximum system size at a project site. Finally, it is worth noting that the interconnection of

a large scale solar array will require three-phase power.

In most cases, distribution lines can be upgraded and improved, but it is important to emphasize that those costs would be incurred by the project, and not the utility.

All investor-owned utilities in Massachusetts (which include: National Grid, NSTAR, Western Massachusetts Electric, and Unitil) are required to adhere to the Department of Public Utilities' (DPU) Utility Interconnection Tariff, which outlines a uniform process for seeking approval to connect DG facilities (e.g. solar PV) to the utility grid. The Massachusetts Department of Energy Resources (DOER) maintains a centralized resource for information on DG and interconnection, available online at <http://sites.google.com/site/masssdgic/>.

Municipal Light Departments (MLPs) are not required to participate under the DPU tariff, but they may have their own interconnection process in place. If the project site resides in MLP territory, consult with the utility to determine if an interconnection process exists, or, if not, if one is under development.

## What Should I Be Looking for in System Design?

Finding suitable project sites represents just a portion of what is required to successfully develop and build large-scale solar PV projects. Of equal importance is the solar PV system itself, which must be carefully designed to provide reliable power output year after year for the entire life of the project—typically 30 years or more. This is of particular importance to the entity that will be relying upon revenues from system electricity and SREC production in the initial years, and it will also be important in the event of an ownership change in the project's later years.

Forecasting system production is of critical importance to solar PV system economics. Due to the long design life of a solar PV system, year-to-year performance estimates should be calculated to address long-term variables that may impact production, such as solar module power degradation and vegetation growth, so that you can understand system performance in both the short-term and long-term, and understand the value of the system's production in future years.

A qualified solar designer should be able to provide a performance estimate at the  $P_{50}$  level and the  $P_{90}$  level, which will be important to potential project financiers.  $P_{50}$  indicates an estimated level of power production that the system should exceed at least 50% of the time on an annual basis.  $P_{90}$  indicates an annual power production estimate that the system should exceed 90% of the time.



## Module #6: What Is the Project Cost Profile?

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When deciding to pursue a large-scale solar energy project, it is important to understand the nature of the costs involved, independent of the project development structure. The following section outlines the typical costs incurred during the development, installation, and operation phases of a large-scale solar PV project. These costs are current through 2011, and may change over time.

### Design and Engineering

Design and engineering is a term used broadly to represent a host of project-related tasks. Some of the work performed during the design and engineering phase includes:

- » Site feasibility
- » Conceptual design
- » Interconnection management
- » Wetlands delineation
- » Permitting support
- » Buildable design
- » High voltage design
- » System cost estimating
- » System performance estimating
- » System optimization
- » Equipment selection

Design and engineering costs can vary significantly depending on site-specific conditions and system size, but is generally in the \$0.05/Watt to \$0.15/Watt range.

### Permitting

As highlighted in Module #5, permitting requirements and expectations vary by municipality, and may or may not include a requirement to pursue a MassDEP capped landfill permit. Outside of the scope of design document preparation, permitting costs are often incurred on a time and materials basis. The permitting expenditures for a particular project are impacted by the size of the project, proximity to wetlands and floodplains, the required permits, the number of meetings attended in support of permit applications, and related tasks. The labor costs associated with permitting can represent a wide range, but developers typically plan for a range

of costs between \$0.05/Watt to \$0.15/Watt. This cost range does not include the cost of permitting fees, outlined in greater detail in Module #5.

### Interconnection

Interconnection costs are typically incurred at three points in the project development process:

- » Application submission
- » System impact study (SIS)
- » System installation

For large-scale PV projects, utilities typically request an application fee of \$2,500 per meter at the time an initial interconnection application is filed.

Assuming that the utility identifies no major fatal flaws, the next step is a system impact study (SIS), to be performed by the utility and its consultants. The SIS may have a cost of \$25,000-\$100,000, depending on project size. The system impact study allows the utility to determine the feasibility of installing the proposed solar PV system on its distribution network. Included within the scope of the SIS is an assessment of the infrastructure upgrades potentially required to interconnect the system and the construction costs associated with those upgrades. Interconnection costs are borne by the project developer in the PPA model and by the municipality in the municipal ownership model.

The final cost of interconnection will depend on the equipment needed to interconnect the project. The cost of line upgrades (e.g. single phase to three phase power), reclosers, transfer trips, and other hardware needed to ensure the safety of the grid and of the project, will be borne by the project. The final cost of these upgrades may be between \$100,000 and \$2M (or more). A reasonable estimate of these costs is provided after the system impact study is performed to assess the ability of the transmission infrastructure to support the project.

## Construction and Equipment

Construction costs are critical to the financial viability of a project. Some key construction costs include:

- » Modules
- » Inverters
- » Mounting
- » Installation labor
- » Site work
- » Road construction
- » Low voltage equipment
- » High voltage equipment
- » Conduit and conductors
- » Equipment rentals/storage/etc.
- » Security fence
- » Monitoring hardware

Construction costs can vary for a number of reasons. Decisions about technology and manufacturer selection, which take variables like quality and location into account, can often have significant impacts upon pricing. This is particularly true for major system components, such as panels, inverters, and mounting system. In addition, Massachusetts prevailing wage provisions may need to be considered.

The construction costs for a typical project will vary based on site-specific conditions. Excluding design, engineering, interconnection, permitting, and other items listed above, typical pricing is between \$3.25/Watt and \$4.50/Watt for a MW-scale PV project built in Massachusetts.

## Operations & Maintenance

After a project has been constructed, an O&M agreement provides long-term assurance that the solar PV system will perform at an acceptable level over time. Typical pricing for an O&M agreement on a MW scale array is likely to fall between \$0.0125/Watt and \$0.025/Watt per year in the first 1-10 years of system operation. The cost of an O&M agreement may increase in years 10-25 of system operation. The higher end of the O&M range is likely to include features like system monitoring, as discussed below. Operations and Maintenance will be highlighted in greater detail in Module #8. These costs are borne by the developer in the PPA/CPA model and by the municipality in the self-ownership model.

## System Monitoring

System monitoring provides assurance that the solar PV system is performing in accordance with its design specifications. System monitoring relies on a Data Acquisition System, or DAS. A DAS is a computer that monitors system production and notifies appropriate users when the system is not performing as expected so that a technical team can be dispatched. The long-term cost of monitoring varies by system, but is typically \$0.01/Watt to \$0.013/Watt per year. System monitoring will be described more fully in Module #8.

## Insurance

For projects in the MW scale size range, system insurance is mandated by the utility, and is typically required by most financiers. Municipalities are allowed to self-insure, which removes this obligation. However, in the event that the system is to be built, owned, and maintained by a third-party, there may be insurance costs. Typical insurance premiums are between \$0.0075/Watt to \$0.0125/Watt per year.

## Local Taxation

The following section on local property taxation applies only to development models in which the municipality is not the sole system owner.

## General Property Tax

Most large-scale solar projects installed on governmentally owned landfills by third-party, for-profit entities, are subject to local property taxes. Property taxes in those cases are assessed by the municipality directly to the lessee, under M.G.L. c. 59, §2B. The solar property will either be assessed as personal property or as part of the real estate upon which it is sited, depending on the particular configuration of the array. If the array is specifically designed for the parcel, likely to remain on the parcel for its useful life, or significantly attached to the real estate it will be assessed as part of the realty. If the array is easily movable and panels may be swapped out periodically or transferred to a different site, it may be taxable as personal property. Concrete slabs or other foundations and structures would still be taxed as part of the real estate to the user, occupant or lessee of the real estate. Whether assessed as personal property or as part of the real estate, the tax rate for the property would be the same; i.e. at the municipality's single tax rate, or at

the commercial tax rate if the municipality has a split rate, since the property would be used commercially to produce electricity. Tax rates will vary by municipality. In any event, the local board of assessors should be consulted during the project development phase.

Although M.G.L. ch. 59 §5 (45) provides a property tax exemption for solar and wind energy systems, this exemption applies only to projects that are “being utilized as a primary or auxiliary power system for the purpose of heating or otherwise supplying the energy needs of property taxable” under chapter 59. The Department of Revenue’s Division of Local Services has interpreted this provision as requiring the use of the energy produced at or near the site of the taxable property and the exemption does not apply if energy is sold to the grid. For most landfill projects, there is limited onsite load for a solar energy project to serve, likely negating the property tax exemption.

### Payment in Lieu of Taxes

According to M.G.L. c. 59, §38H(b), a Payment in Lieu of Tax, or PILOT, may be negotiated as a reasonable alternative to the property tax outlined above, if the owner is a generation company or wholesale generation company. See M.G.L. c. 164, §1 Definitions. A PILOT is a formal agreement between the municipality and a developer based on good faith negotiations, in which both sides agree to a valuation or tax payment structure and PILOT term which reasonably approximates what the taxes would be over the term of the agreement. PILOT payments are treated as property taxes for Proposition 2 ½ and tax classification purposes. They are subject to the municipality’s levy limit, and the values on which the payments are based are used to calculate its levy ceiling and minimum residential factor. PILOT agreements can be advantageous, providing the project developer/owner with a known and predictable payment stream (not subject to changing real estate or commodities pricing) and the host municipality with a similarly predictable revenue stream. Well-structured PILOT payments may allow both parties to achieve their own project-related goals over the project lifetime.

### Tax Increment Financing

For municipalities that designate an area as having potential for the development of a Class I Renewable Portfolio Standard-eligible energy generating source, and have the area approved as an Economic

Opportunity Area and an Economic Target Area by the Economic Assistance Coordinating Council, the developer and the municipality may be able to negotiate a Tax Increment Finance (TIF) agreement. See MGL c. 40, Section 59, MGL c. 23A, Section 3D(a)(ii)(K) & MGL c. 25A, Section 11F, and 402 CMR 2.00 for more information. TIF agreements can reduce taxation of the system up to the full amount of the personal property located at the site and the incremental added value to the real estate for up to 20 years (5 years is the minimum) in exchange for providing specific benefits to the community. If a municipality is not already located in an Economic Target Area or cannot qualify to become one, the Undersecretary of Business Development would need to approve the project as being an “Exceptional Opportunity” for increased economic development in order for the company to pursue a TIF from the municipality. All TIFs must be approved by the Economic Assistance Coordinating Council. In addition, the municipality will need to formally approve the TIF by town meeting or other municipal legislative body. A TIF can be used in tandem with a PILOT to help offset the property tax burden on a project while providing alternative benefits to the municipality.

For further questions on local taxation and PILOTS contact the Massachusetts Department of Revenue at 617-626-2400 (Local Officials Only). For questions on TIFs, contact the Massachusetts Office of Business Development at 617-973-8534.

## Module #7: How Do We Manage the Procurement Process?

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Hosting a renewable energy project can provide real and tangible financial benefits to a municipality. Depending on the desired project structure and intended revenue sources, a municipality may need to use one or more specific sections of Massachusetts General Laws (M.G.L.) to manage the procurement. This section highlights the major procurement types and their applicable uses for a solar PV project. The following section provides the authors' interpretation of Massachusetts General Laws at the time of drafting, and should not be considered legal advice. Please consult your municipality's attorney to identify the proper methodology for your procurement situation.

### What Does a Complete and Thorough Solicitation Include?

An advertised, competitive solicitation should be used for each phase of procurement as required by law and otherwise as a best practice. The solicitation should be carefully written to articulate the goals of the host municipality. Whether the goal of procurement is to select an owner's engineer, a designer, a designer and builder, or to enter into a Power Purchase Agreement (PPA)/ Credit Purchase Agreement (CPA), a well-written solicitation will help support project success. Thorough solicitations should include, as a minimum, the following:

- » Clearly articulated project goals
- » Realistic timeframes and development expectations
- » Evaluation and selection criteria
- » Available project details, including site analysis (size, space, location of interconnection, etc.) and site plan with boundaries and ownership information
- » Indication of how the proposed project complies with Massachusetts procurement law
- » Clearly articulated expectations on property tax and other costs to a developer
- » Inclusions and exclusions

- » Methodology by which proposal prices/revenues will be evaluated
- » Performance guarantees, if applicable
- » Draft Power Purchase Agreement, if applicable; caution should be used with any draft agreement provided by a potential developer
- » Time of performance and liquidated damages provisions
- » Transfer of ownership provisions, if applicable
- » Decommissioning provisions, if applicable

### How Do I Select the Right Vendor for My Project?

Selecting the right vendor is a key element of project success. A qualified vendor should be experienced with solar energy and understand the key elements of the Massachusetts market. Important considerations during the solicitation review and follow-up interview phase include the vendor's:

- » Qualifications and experience, including certifications
- » Available personnel / capacity
- » Performance of record on similar projects
- » Installed capacity
- » Understanding of and experience with landfill specific design and construction issues
- » Customer references
- » Division of Capital Asset Management (DCAM) certification and score, if applicable
- » Project understanding
- » Thoroughness of proposal
- » Price proposal and/or analysis of costs and revenues
- » Massachusetts market knowledge
- » Technical capability
- » Ability to secure financing required to complete the project

Municipalities should carefully consider these and other criteria in reviewing solicitation responses. Multiple projects in Massachusetts have failed to move from the development phase to construction because municipalities were not convinced of a firm’s ability to offer a realistic price or complete the project within a realistic timeframe. Other projects have not come to fruition after a developer selection because the developer was unable to secure financing. Throughout the procurement process, municipalities need to be tuned in to not only the potential revenues that a project will bring to the host community, but also the ability of the proposer to fully develop, finance, install, and (if applicable) operate the proposed system for the entire life of the project.

### Which Procurement Process Is Right for My Municipality?

The public law that applies to the procurement of a solar PV system on your jurisdiction’s landfill must be determined carefully. Your legal counsel should be consulted, and you may have to seek advice from state oversight agencies, principally the Inspector General’s Office, the Attorney General’s Office, and the Department of Energy Resources (DOER). You may want to obtain professional expertise to assist with the procurement process. The procurement of a professional expert may be subject to Chapter 30B.

For many of the development structures outlined in this guidebook, municipalities may be deciding between Chapter 25A, §§11C or 11I; Chapter 30B, §16; Chapter 149A, §§14-21; or M.G.L. c.164, §143(d) of the Massachusetts General Laws. In deciding which procurement method is most appropriate, each municipality must determine the option that best fits their situation, and procurements must adhere to Massachusetts General Laws.

More than one chapter may apply. If so, In order to determine which chapter is most beneficial, it is important to:

- » Determine the goals and objectives of the solar landfill project;
- » Enlist project, procurement, legal, and finance experts;
- » Evaluate the procurement options, along with the advantages and disadvantages of each, relative to the project goals and resources;
- » Seek assistance from the appropriate state agencies; and,
- » Seek model solicitation documents and follow best practices.

Table 3 outlines the different procurement options.

Table 3: Procurement Options						
	Chapter 25A, §§11C or 11I	Chapter 30B, §16	Chapter 149A, §§14-21	Chapter 30, §39M	Chapter 164, §143(d) (allows procurement of equipment and services using Chapter 30B)	Chapter 30B §§1(b)(32) and (33)
Municipally owned solar PV system, <\$5M	✓			✓	✓ (if <10 MW)	
Municipally owned solar PV system, ≥\$5M	✓		✓	✓	✓ (if <10 MW)	
Land Lease		✓				
Land Lease w/PPA or CPA	✓	✓				
PPA / CPA only						✓

## Chapter 25A, §11C or §11I

Chapter 25A provides for procurement of energy management services and can apply to any of the development scenarios outlined in this guidebook. Section 11C and Section 11I apply both to projects to be built and owned by the municipality, and to third-party owned projects. Section 11C is a RFP process; whereas Section 11I is a RFQ process. Both Section 11C and Section 11I are one-step processes, meaning the municipality issues one single RFP or RFQ for design-build services.

Procurements under Chapter 25A have very specific requirements that are detailed in the online instructions and guidance. Many communities have issued RFPs and RFQs for renewable energy specific services. The DOER posts model documents on its website.

The primary difference between the two is that an RFP process under Section 11C includes price as an evaluation criteria. It is possible to choose a company that is not the lowest bidder, but the selection process and criteria must be explained in the RFP. Section 11I is an RFQ process that allows a municipality to review proposals through an evaluation based on bidder qualifications and experience only. It should be noted that under Section 11I, a municipality may consider the compensation to be paid under the contract only during negotiations conducted once an apparent winning bidder (determined to be most qualified) has been identified. Table 4 provides a summary of the minimum requirements for evaluating proposals under the two different sections.

Both Sections 11C and 11I require that the municipality provide DOER with documentation of the solicitation as part of DOER's review process.

There are several advantages to using Chapter 25A, several of which have already been noted. Municipalities can streamline design and installation services through a single RFP or RFQ for design-build services. In addition, Chapter 25A can be used for all ownership scenarios, municipally-owned as well as third-party owned projects as part of a PPA or CPA. Third-party owned projects may not require any upfront capital costs and the developer/owner is responsible for financing, permitting, installation, operations and maintenance easing the burden on the municipality. Finally, Chapter 25A requires a performance guarantee. This means that over the life of the solar PV system, each year the installation must provide a minimum

amount of electricity generation as specified in the contract. Although other procurement paths may provide for design-build or for multiple ownership scenarios, the performance guarantee is unique to Chapter 25A. Chapter 25A can be used for ground-mounted or roof-top projects.

## Chapter 30B, §16

Municipalities that seek to enter into a land lease with a third-party developer would likely manage procurement via Chapter 30B, §16, which is applicable to the purchase, sale, lease, or rental of landfills and other real property (including interests in real property). This chapter could also be used if a municipality wants to sell its property to a third party developer.

## Chapter 149A, §§14-21

Chapter 149A, §§14-21, is an option that allows the use of the design-build alternative construction method for projects that are expected to cost \$5 million or more. Chapter 149A, §§14-21 may be one of the procurement tools available to municipalities that plan to build and own a renewable energy project. Chapter 149A, §§14-21 is a two-step process, with an RFQ phase and RFP phase.

## Chapter 30, §39M

Chapter 30, §39M is another procurement tool available to municipalities that plan to build and own a solar PV project. Chapter 30, §39M governs all contracts for construction, reconstruction, alteration, remodeling, or repair that do not include work on a building when the estimated cost of the contract exceeds \$10,000. These contracts generally fall into the category of public works projects, or "horizontal construction" projects. Public works projects include not only the construction and repair of roads, bridges, water mains, sewers, and the like, but also work on improvements to public land such as landfills.

Although you are not legally required to conduct an advertised competition for Chapter 30, §39M public works design contracts, we recommend that you do so for construction projects estimated to cost more than \$100,000. The RFP process outlined in M.G.L. c.30B is a good model to adopt in developing competitive procurement procedures for a public works design contract.

**Table 4: Minimum Evaluation Criteria**

Chapter 25A, § 11 C	Chapter 25A, § 11I
<ol style="list-style-type: none"> <li>1. DOER Certificate of Compliance;</li> <li>2. Total project price;</li> <li>3. Estimated savings/production;</li> <li>4. Price data;</li> <li>5. Criteria on which responses will be evaluated;</li> <li>6. References of other energy savings contracts performed by the qualified providers;</li> <li>7. The certificate of eligibility and update statement provided by the qualified providers;</li> <li>8. Methodology of determining energy savings;</li> <li>9. General reputation and performance capabilities of the qualified providers;</li> <li>10. Substantial conformity with the specifications and other conditions set forth in the request for proposal;</li> <li>11. Time specified in the proposal for the performance of the contract; and any other factors the public agency considers reasonable and appropriate, which factors shall be made a matter of record.</li> </ol>	<ol style="list-style-type: none"> <li>1. DOER Certificate of Compliance;</li> <li>2. References of other energy savings contracts performed by the qualified providers;</li> <li>3. The certificate of eligibility and update statement provided by the qualified providers;</li> <li>4. Criteria on which responses will be evaluated;</li> <li>5. Quality of the products proposed;</li> <li>6. Methodology of determining energy savings;</li> <li>7. General reputation and performance capabilities of the qualified providers;</li> <li>8. Substantial conformity with the specifications and other conditions set forth in the request for qualifications;</li> <li>9. Time specified in the qualifications for the performance of the contract; and any other factors the public agency considers reasonable and appropriate, which factors shall be made a matter of record.</li> </ol>

**Chapter 164, §143(d)**

The Green Communities Act, Chapter 169 of the Acts of 2008, also amended M.G.L Chapter 164 by inserting Section 143(d) which allows municipalities to design, install, own, and operate a “small municipal renewable energy generating facility”, which could include a solar landfill project of up to 10 megawatts, and to procure design and installation services using Chapter 30B. Section 143(d) provides as follows:

*A municipality shall procure services required for the design, installation, improvement, repair and operation of small municipal renewable energy generating facilities authorized under this section, and acquire any equipment necessary in connection therewith, in accordance with the procurement requirements of Chapter 30B as applicable. A municipality may procure any such services and equipment together as one procurement or as separate procurements thereunder.*

For contracts of \$25,000 or more, M.G.L. c 30B requires a formal advertised competition by issuing an invitation for bids (IFB) or an RFP. In a bid process pursuant to M.G.L. c 30B, §5, the contract is awarded to the qualified bidder who meets the specifications and offers the best price. In a proposal process pursuant to M.G.L. c30B, §6, the contract is awarded to the offeror submitting the most advantageous proposal, taking into consideration specified evaluation criteria as well as price.

The advantage of using M.G.L. c 30B, §6 is that it allows a municipality to weigh evaluation criteria before looking at the prices. First, since installation of solar on a landfill is a complex process, the proposers’ experience, qualifications, and if required, a proposed plan for providing the supplies and services can be evaluated on their relative merits. The most advantageous proposal is selected after price proposals are considered. The RFP process may not always result in the selection of the proposer offering the lowest price.

To assist you in selecting the applicable procurement law for your project, Table 5 is provided for your reference.

## Chapter 30B, §§1(b)(32) and (33)

A municipality may also be purchasing electricity from a vendor that builds a solar PV system on your landfill.<sup>1</sup> Chapter 30B, §§1(b)(32) and 1(b)(33), exemptions allow municipalities to enter into agreements for energy without using the 30B procurement process. Chapter 30B §1(b)(32) exempts energy aggregation contracts entered into by municipalities for energy and energy-related services. Chapter 30B §1(b)(33) exempts energy contracts entered into by municipalities for energy and energy related services, provided that certain reporting requirements are met. Specifically, within 15 days of contract execution, a municipality must forward a copy of any electricity or natural gas contract to which it is a party and a report of the process used to execute the contract to the Department of Public Utilities, the Department of Energy Resources, and the Office of the Inspector General.

The Office of the Inspector General interprets the term “energy,” which is not defined in any applicable statute, to apply only to electricity and natural gas commodity contracts. Contracts for fuel sources other than natural gas, such as gasoline, fuel oil and propane, are all supply contracts that must be competitively procured.

It is important to add that when pursuing a rooftop mounted system (as opposed to ground-mounted on a landfill) using a third party developer, various aspects of the public construction laws, including items like prevailing wage, may be implicated and your counsel as well as the Attorney General’s office should be consulted.

## Prevailing Wage

Some of the project types defined in this guidebook may trigger prevailing wage requirements. In Massachusetts, the Department of Labor Standards (DLS) oversees the Prevailing Wage Program through its Division of Occupational Safety. The Division issues prevailing wage schedules to cities, towns, counties, districts, authorities, and agencies of the Commonwealth for construction projects and several other types of public work.

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1. Although the focus of this Guide is solar PV systems on landfills, the Chapter 30B energy exemptions also apply to the purchase of electricity from a vendor that builds a solar PV system on your building.

These prevailing wage schedules contain hourly wage rates that workers must receive when working on a public project.

Developers would need to meet obligations of the prevailing wage program for projects to be owned by a municipality, and for projects that are paying a land lease to the municipality. This requirement should be included in the procurement as appropriate.

As noted in Table 5, different agencies provide guidance and oversight for different procurement laws. The Chapter 30B Manual published by the Office of the Inspector General is available at <http://www.mass.gov/ig/publ/30bmanl.pdf>. Questions regarding Chapter 30B should be directed to the Inspector General’s Office which oversees procurement under that chapter. For additional questions on Chapter 30B, please call the Attorney-of-the-day at 617-722-8838. The Inspector General’s manual on Designing and Constructing Public Facilities is available at <http://www.mass.gov/ig/publ/dcmanual.pdf>.

DOER oversees the Chapter 25A procurement process. Guidance is available at [http://www.mass.gov/green/energy-management-services\\_public-procurement](http://www.mass.gov/green/energy-management-services_public-procurement). Questions regarding Chapter 25A should be directed to DOER. For more questions on procurement under Chapter 25A, please contact Eileen McHugh, [eileen.mchugh@state.ma.us](mailto:eileen.mchugh@state.ma.us) or at 617-626-7305.

The Attorney General’s Office provides oversight for M.G.L. c. 30, §39M, and Chapter 149A. For further question on these procurements, please contact the Attorney General’s Office, Deborah Anderson, Esq. at 617-727-2200 ext 2371 or Brian O’Donnell, Esq. at 617-727-2200 ext 2340.

For further questions on prevailing wage, contact Patricia DeAngelis, Esq. at the Department of Labor Standards at [Patricia.DeAngelis@state.ma.us](mailto:Patricia.DeAngelis@state.ma.us), (617) 626-6976.



**Table 5: Procurement of Solar Photovoltaic Panels on Landfills – Laws**

Law	Comments	Procurement Oversight
M.G.L. c.25A, §§11C or 11I	Chapter 25A is an alternative method of construction delivery that contains provisions for procuring contracts for energy management services, a program of services that includes energy conservation projects, defined as “projects to promote energy conservation.” Chapter 25A, §§11C or 11I may be used for energy conservation projects involving on-site electrical generation equipment using new renewable generating systems. These sections of the law provide for a public owner to conduct one procurement process for design and construction, and if the awarding authority is seeking a third-party developer the sections provide for one procurement process for leasing the land and obtaining the design and construction.	Department of Energy Resources
M.G.L. c.30B, §16	Chapter 30B §16 applies to the purchase, sale, lease, or rental of real property (including interests in real property). It establishes an advertised proposal process that you must follow in acquiring real property by purchase or rental with a cost greater than \$25,000, and in disposing real property by sale or rental with a value greater than \$25,000. Chapter 30B has additional requirements for the disposition of real property, regardless of its value.	Inspector General’s Office
M.G.L. c.149A, §§14-21	An option that applies to the construction, reconstruction, alteration, remodeling or repair of a public works project estimated to cost not less than \$5,000,000. The law provides for a public jurisdiction to conduct a two-phase procurement to obtain a design build firm.	Inspector General’s Office and Attorney General’s Office
M.G.L. c.30, §39M	Chapter 30, §39M governs contracts for the construction, reconstruction, alteration, remodeling, or repair of a public work estimated to cost more than \$10,000 that does not include work on a building. This can be used when a public entity is seeking to have a renewable energy facility built for its use.	Attorney General’s Office
M.G.L. c.164 §143(d)	Requires that a local governmental body procure any services required for the design, installation, improvement, repair and operation of small municipal renewable energy generating facilities (<10MW), and acquire any equipment necessary in connection therewith, in accordance with the procurement requirements of Chapter 30B §§5 and 6. A municipality may procure any such services and equipment together as one procurement or as separate procurements. This law provides the flexibility of Chapter 30B with regard to the procurement process and would allow for one procurement process for both design and construction of a project. Please consult with the Office of the Inspector General to see if other procurement rules apply.	Inspector General’s Office

## Module #8: What About Long-term System Management?

Revenue streams from a solar PV project are accrued over a project lifetime that may span 30 years or more, monitoring and maintaining system performance is a vital function over the lifetime of the system. The following module outlines some of the key considerations for ensuring long-term system operation, and highlights some planning considerations for municipalities that may take ownership of the system at some point.

### Operations & Maintenance

A system's operations and maintenance (O&M) plan will depend on the development structure utilized for project installation. If a system was built and is owned by a municipality, the municipality should enter into an O&M agreement with the project developer or a qualified solar system maintenance company. The O&M agreement should include items like regular site/hardware inspections, warranty management, ongoing system monitoring, and on-call service/repairs. Optional items may include site clearing/mowing, panel cleaning, and tree-trimming, as needed. A typical O&M agreement will not include a production/performance guarantee.

In a land lease, PPA or similar structure, the municipality will not need O&M agreement, as risk associated with system performance is borne by the project owner. The project owner is incentivized to ensure that the systems is performing and being maintained at an optimal level and will perform O&M accordingly.

Boston Properties: 110-kW Solar PV Array  
(photo: Nexamp)



### Equipment Warranty

Equipment selection is a key element of long-term system management. When selecting system components you will want to select quality materials with a strong warranty. As outlined in Module #1, each of the primary components (modules, inverters, and mounting) has its own warranty. Typical warranties for major system components span 5-25 years. A workmanship warranty from the installer should be for at least 5 years. Extended warranties are often available at an additional cost, particularly for inverters. If there is an O&M agreement, it should require both that the O&M provider is trained in maintaining those warranties, and that the provider is responsible for equipment repairs and as well as the installation of replacement hardware.

### Monitoring

Monitoring equipment enables developers, owners, and O&M providers to ensure system functionality over time. A Data Acquisition System, or DAS, is a computer-based hardware system that can be used to monitor system production at the project level, the inverter level, or at the string (PV module grouping) level. A string is an individual group of modules wired in series to achieve a certain voltage threshold. Each deeper level of monitoring comes with a higher cost, but provides greater assurance that systems are functioning as expected. Many monitoring systems also allow for real-time alerts when systems stop working. Systems larger than 10 kW are required to include a DAS so that it can automatically report production data to the Production Tracking System as a requirement for generation SRECs.

In practice, a monitoring system may respond to a system fault in the following manner. A DAS that is monitoring production for an inverter for a large-scale array finds that the system is not producing power as expected. The DAS will automatically send an alert email to the system owner and the O&M provider. The O&M provider is then able to dispatch a team to the site within 24 hours to identify the cause of the malfunction and to remedy the problem.

## End of Life

Large-scale energy project developers and owners need to consider what happens at the end of system life. A typical solar array has a design life of at least 25 years, although it will likely retain useful functionality beyond its design lifetime. As outlined in Module #5, many project owners create a reserve fund to account for the cost of system removal at the end of its lifetime. A host municipality and any third-party owner should determine up front who will bear the responsibility and cost liability associated with system removal, known as decommissioning. If the municipality intends to take ownership of the system and intends to maintain its operation after the end of a transaction, it should be aware of potential removal costs.

## Buyout Provisions

For third-party developed and owned systems, transfer of ownership after a certain number of years is a common contract element. Under this arrangement, the project developer agrees to sell the project back to the host customer at fair market value at a certain point in time. This model allows the developer to capture value from the project through tax credits, SRECs, and other short-term incentives, and allows the municipality to own the asset in the later years and capture revenue from system production. At the time of a buyout the municipality assumes ownership liability and risk, including O&M costs and associated performance risk. If an ownership transfer model is desirable, it should be considered during the RFP development phase. If a

municipality is considering owning the system after the end of the PPA period instead of decommissioning the system, proper system design and the quality of the products used should be outlined in the RFP.

In order to comply with many of the various procurement rules outlined in Module #7 the price for transfer cannot be predetermined, but must be based on the fair-market value of the system. The fair-market value of the system may depend on the quality of materials used, design strategy, and other issues that affect system longevity.

The timeframe for transfer can be pre-determined, but will likely be no less than five years. Provisions of the federal cash grant preclude transfer of ownership within the first five years without triggering certain grant recapture provisions. Typically, the timeframe for transfer will be in years 10-25, after the value of the SRECs has been fully maximized. This can be a point of review and negotiation.

If a municipality does intend to exercise its option in a buyout provision, it may consider setting up a reserve account that sets aside revenue from the land lease or credit purchase agreement each year and places it in escrow. That reserve account could then provide the funds necessary to purchase the project.

Barnstable Wastewater Treatment Facility:  
819-kW Solar PV Array (photo: Nexamp)



## What Are My Next Steps?

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Below are some initial steps that we recommend to get started with the development process. Additionally, Appendix A provides a checklist that municipalities can use to navigate the development process.

- » Form an energy committee, comprised of informed and active volunteers.
- » Educate all potential PV project team members.
  - Take some time to learn more about solar.
  - Consider complementary options, such as solar on schools and other municipal buildings.
- » Consult with your DOER Regional Coordinator and solid waste official at the DEP regional office.
- » Identify the technical capacity of your landfill or other municipal site to host a renewable energy project.
  - Look for flat, open, and unshaded space.
  - Identify proximity to transmission.
  - Characterize construction access.
- » Determine your permitting requirements.
  - Do you need a post-closure use permit?
  - Will you have to file with MEPA?
- » Meet with your community and ask yourselves about the goals of the project.
- » Do you want to own the project from the beginning? If so, how will the community pay for the project?
  - Who will be responsible for each phase of the project – development, financing, construction, operations and maintenance?
  - Are you comfortable with a third-party developed project, and if so, do you want to own the project in the future?
  - What is your risk profile?
- » Set realistic expectations around timelines, financial goals, and volunteer effort.
- » Talk to other municipalities that have worked through many of the same issues.
- » Identify the project structure that is best for your situation.

Municipalities are encouraged to access resources and start conversations with one or more potential service providers.

The Solar Energy Business Association of New England (SEBANE) lists a Solar Energy Yellow Pages on its website, <http://www.sebane.org>. Listings include designers, installers, manufacturers, consultants, and other professionals and suppliers in the solar energy field.

The North American Board of Certified Energy Practitioners (NABCEP) awards PV installers a professional credential based on their experience and knowledge. Installers who have received this voluntary certification are listed, by state, at <http://www.nabcep.org>.

The National Renewable Energy Laboratory (NREL) of the U.S. Department of Energy hosts an excellent website with information on all renewable energy technologies: <http://www.nrel.gov>. Information on photovoltaic systems with many links to specific information can be found at: <http://www.nrel.gov/solar>.

NREL also offers a cost estimator for PV grid connected systems at a site maintained by its Renewable Resource Data Center: <http://rredc.nrel.gov/solar/calculators/PVWATTS>.

DOER Solar Carve-out SREC program website: <http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar/rps-solar-carve-out>.

Please note: webpage addresses change periodically; these sites also have search functions to help find pages if the links provided no longer function.

# Case Study #1: Brockton Brightfields

In the late 1990s, the City of Brockton faced a dilemma over how the City should handle the Bay State Gas brownfield site located on Grove Street. The site, a Brockton Gas Works manufactured gas plant from 1898-1963, abuts a number of residential areas and it was contaminated. The site had been designated a Coal Gasification and Related Materials (CGRM) landfill, which significantly limits its uses. The site owner, Bay State Gas, had started remediating the site but nobody had any idea what to do once the site was remediated. Brockton was sure of only one thing: the City did not want to see the site turn into a dumping ground.

Then, the idea! What if the City could use the site to host a clean, quiet, and environmentally sound solar array? A solar array could create revenue for the City while giving the site a purpose. In 2000, the concept of the Brockton Brightfields was born.

Using funding from the Department of Energy and the Massachusetts Technology Collaborative’s Renewable Energy Trust (the Trust is now part of the Massachusetts Clean Energy Center), Brockton studied the feasibility of hosting a solar array in 2001 and 2002, and developed a conceptual plan. By 2003, Brockton was ready to issue and RFP to select a vendor to build the system, but solar energy at the scale that Brockton was proposing was new to the Commonwealth, and the procurement process needed to be updated. In 2004 and 2005, Brockton worked with City Councilors and then with the State Legislature to create a legal pathway for the project. Countless hours were spent educating local and state legislatures on the benefits of solar and the ways to use Massachusetts General Law to allow Brockton to proceed with its plan. Finally, in 2006, the pathway was unveiled.

Brockton reissued its procurement, selected a vendor, and managed construction of its 460-kW solar array all in one year. The project’s financing uses a mix of state and federal funding, along with a long-term Renewable Energy Certificate (REC) purchase agreement.

Many of the lessons learned by Brockton were incorporated into the Green Communities Act of 2008, which has made the procurement process much easier for municipalities today. Many of the policies and opportunities described in this guidebook are the results of the hard work invested into the Brockton Brightfields solar PV project.

## Quick Facts:

System Size:	468 kW
Project cost:	\$4.2 mm
Land Size:	3.7 acres
Procurement Method:	Chapter 30B, Mass. General Law
Ownership Style:	Municipal
# of Modules:	1,512 SCHOTT Solar ASE 300s
Inverters:	SatCon Inverters
Azimuth:	180 degrees
Tilt:	42 degrees
Installation Service Provider:	Landerholm Electric Company
Estimated Annual Production:	580 MWh
Estimated Production Equivalent:	81 homes
Annual CO2 Reduction:	677,000 lbs
Design life:	30 year minimum



Brockton, the “City of Champions” was the first City in Massachusetts to successfully develop, build, and own a brightfield project. A drive down Grove Street today shows the final result of the City’s perseverance and hard work, a 460-kW solar PV array that creates no pollution, no noise, and no increased traffic, save the occasional local school field trip.

Figure 10: Brockton Brightfields Solar PV Array  
Photo: City of Brockton

## Case Study #2: Easthampton Landfill Solar PV Array

### Quick Facts:

System Size:	2.26 MW
Project cost:	PPA: \$0.06 per kWh for 10 years
Land Size:	16 acres
Procurement Method:	Chapter 25A, Mass. General Law
# of Modules:	9,620 Yingli 235-watt
Inverters:	4 SMA 500-kW
Azimuth:	180 degrees
Tilt:	30 degrees
Installer/Financier:	Borrego Solar
Estimated Annual Production:	2,828,000 kWh
Estimated Production Equivalent:	392 homes
Annual CO <sub>2</sub> Reduction:	108,184,380 lbs
Design life:	30 years

Michael Tautznik, Mayor of Easthampton, summed it up best: “This is an exciting day for Easthampton.”

That was the general sentiment in December of 2010, when the city of Easthampton officially signed a contract with Borrego Solar to construct a 2.3-megawatt (DC) solar array on the city’s landfill. The landfill has long been closed, and was providing no appreciable benefit to the city. As one of the Department of Energy Resources (DOER) designated Green Communities, Easthampton is taking great strides towards becoming a clean energy leader in the state, and taking advantage of the otherwise unused landfill resource to add revenue to the city.

The solar PV project broke ground in September of 2011 and will generate electricity to offset a significant portion of the municipal buildings in Easthampton. Under a Power Purchase Agreement (PPA) and lease, the City will recognize benefits through the purchase of discounted energy and taxes.

Mayor Tautznik attributes Easthampton’s success in developing a solar PV project on the landfill to the citizens who voiced it as an important project during the Master Plan process. Before getting started, the City participated in an initial feasibility analysis led by Paul Tangredi from Environmental Compliance Service. The site was considered good; it was large, relatively flat, and had little shading. Prior to issuing the RFP, the city vetted the idea internally, then gathered detailed site drawings for the landfill and obtained clear documentation on the permits that were required, both important steps to the due diligence process. Armed with this information, the City then issued what Borrego Solar and others saw as a straightforward and thorough RFP under Chapter 25A. Easthampton says that the proposals were highly detailed and easy to compare against one another, and attributes the depth of the responses to the quality of the RFP. The City evaluated each proposal and selected the vendor that would provide Easthampton the greatest benefit—with the smallest amount of risk.

Thanks to Easthampton’s thorough approach, Borrego Solar has been on schedule. The MassDEP issued its Post-Closure Use Permit within three months of application submission, and Western Massachusetts Electric Co. approved the project for interconnection within nine months of submission of the Interconnection Application. Construction of the project is complete and Easthampton’s landfill is scheduled to start generating clean solar power in early 2012—a little over one year after the contract award.



Figure 11: Easthampton Landfill Solar PV Array  
Photo: Borrego Solar Systems, Inc.

# Appendix A: Project Checklist

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## Site

- Flat, unobstructed
- Access for construction
- Proximity to transmission

## Permitting

- Conservation Commission Wetlands Notice of Intent
- MassDEP Wetlands Protection Act
- Request for Determination of Applicability
- MassDEP Post-Closure Use
- Mass Environmental Protection Act
- Building permit
- Electrical permit

## System Design

- Settlement concerns mitigated
- Production optimized for tilt, shading, and orientation
- Permittable design
- System meets warranty requirements

## System Costs

- Property tax / Tax Increment Financing / Payment in Lieu of Taxes
- Construction and installation costs
- Insurance
- Operations and maintenance
- System monitoring

## Revenues Optimized

- SRECs purchase agreement executed
- Power Purchase or Credit Purchase Agreement executed
- Investment Tax Credit (if applicable)
- Accelerated depreciation (if applicable)
- State tax deduction (if applicable)

## Procurement

- Project phasing
- Procurement method
- Request for proposals
- Long-term system operation
- Operations and maintenance
- System monitoring

## Appendix B: Additional Detail on Solar Renewable Energy Certificates

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Massachusetts' Renewables Portfolio Standard (RPS) requires each regulated electricity supplier/provider serving retail customers in the state to include in the electricity it sells 15% qualifying renewables by December 31, 2020. In January 2011, final rules were implemented for the state's Solar Carve-Out program, which states that a portion of the required renewable energy under the Class I Standard that must come from qualified, in-state, interconnected solar PV facilities.

Solar Renewable Energy Certificates (SRECs) represent the renewable attributes of solar photovoltaic generation, bundled in minimum denominations of one megawatt-hour (MWh) of production. Massachusetts' Solar Carve-Out provides a means for SRECs to be created and verified, and allows electric suppliers to buy these certificates in order to meet their RPS solar carve-out requirements. Only solar electric facilities built after January 1, 2008, may be qualified to generate SRECs. Generators must apply and receive a statement of qualification (SQ) from the DOER and must establish an account with NEPOOL GIS in order to participate in this program. Projects can get qualified through an aggregator which represents a number of PV systems and owners, provides qualification from DOER, establishes an account on the NEPOOL GIS, and markets and sells its members' SRECs. DOER encourages PV Systems owners of all sizes to take advantage of aggregations; however, each owner must be aware of and carefully consider the aggregation's contract terms and fees for the disposal of its members' SRECs. Facilities that received funding prior to the effective date of the Solar Carve-Out from the Massachusetts Renewable Energy Trust or the Massachusetts Clean Energy Center, or received more than 67% of project funding from the American Recovery and Reinvestment Act of 2009, are ineligible.

To support solar facilities and market prices, the DOER has created the Solar Credit Clearinghouse Auction. In the solar facility's SQ, the DOER specifies the "opt-in" term, which grants the facility the right to participate in the Solar Credit Clearinghouse Auction for a certain number of years. Through July 2012, the opt-in term is set at 10 years. The term can be adjusted down in future compliance years, depending on market conditions (the first seven years of the program will provide at least a five-year opt-in term, and the term will not drop by more than two years in any annual adjustment). Solar facilities may deposit unsold SRECs into the Solar Credit Clearinghouse and participate in

an annual auction. SRECs sold through this mechanism are re-minted and have a shelf-life of two years (initially). The annual auction is held by the end of July (30 days after utility compliance reports are received), but only if solar facilities have deposited SRECs into the Solar Credit Clearinghouse account. Any SRECs sold in this way are sold for \$300/MWh the depositor will receive \$285 because there is a 5% administrative fee for use of the auction account. The price of SRECs is determined primarily by market availability, although the DOER has created a certain amount of market stability through the fixed price Auction as well as by setting the Alternative Compliance Payment (ACP) with a 10 year rolling ACP schedule. Solar facilities generally sell their SRECs on the market (either spot market or through long-term contracts). Retail Electric Suppliers may use SRECs for compliance under the state RPS for the year in which they are generated. Retail Electric Suppliers may purchase up to 10% more SRECs than they require for compliance and "bank" those surplus SRECs for compliance during the following two years.

The Solar Carve-Out program is intended to support approximately 400 MW of solar facilities in Massachusetts. Once the state reaches that goal, and the opt-in terms for all solar facilities have expired, SRECs will no longer be generated. Solar facilities will at that time generate renewable energy credits (RECs) and will be able to sell those for compliance under the Class I standard.

For more information see: <http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar/rps-solar-carve-out/> .



## Appendix C: Additional Details on MassDEP Permit Requirements

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If the landfill was not closed and capped in accordance with a MassDEP approval, or was closed and capped before 1990, an environmental assessment (Required by 310 CMR 19.050) and other closure activities (Required by 210 CMR 19.140) may be required. These activities may be done concurrently with the post closure development of the site, provided that development is done in accordance with a MassDEP approval to proceed. This information should be available at the appropriate MassDEP Regional Office, and local Board of health, as needed.

The following is a list of state environmental permits that may be required:

### **Solid Waste Post-Closure Use permit (MassDEP)**

A Major Post-Closure Use permit is required if the planned renewable energy facility would involve construction of a structure or installation of equipment on or into the landfill's capping system. This includes any activity that would alter or impact the cap, such as constructing a footing or foundation. Otherwise, a Minor Post-Closure Use permit is likely required. Complete, detailed guidelines and requirements, including an extensive list of required documentation such as: site plans, construction plans, storm water and erosion plans, stability analyses, utility infrastructure plans, monitoring and maintenance plans, and more, are available online at

<http://www.mass.gov/dep/recycle/laws/lfpccguid.pdf>.

Applicants will need to prepare:

- » A description of all features, equipment, and activity associated with the proposed renewable energy development project.
- » Storm water erosion control plan for the construction and operation of the project.
- » A description of the existing waste mass (i.e. type, depth, etc...) and the potential for differential settlement, and potential impacts of the post-closure use as well as an analysis of the stability of all structures and reinforcement necessary to build on the landfill cap and side slopes.
- » A description of any proposed alterations to the landfill gas control system and safeguards employed to prevent landfill gas build-up.

- » A description of any modifications that will be needed for the landfill's environmental monitoring system, focusing on the landfill gas monitoring system.
- » A description of the development's interface with the landfill's capping system, particularly where the installation will lie upon or penetrate the landfill cap.
- » A description of utilities proposed to be installed (including proposed connections to the utility grid for renewable energy projects).
- » A qualitative (and, if needed, quantitative) assessment of the public health risks that may be posed by the construction, installation, and operation and maintenance of the development, for site workers, neighbors, and other people who may be affected by the project.
- » A description of the activities that the owner/operator of the post-closure development will undertake to maintain the integrity of the landfill capping system.
- » A description of the financial assurance instrument that will provide for care and maintenance of the landfill capping system in the future.

MassDEP has prepared additional resources for project planning, including:

- » Fact Sheet: Developing Renewable Energy Facilities on Closed Landfills: <http://www.mass.gov/dep/energy/landfill.htm>
- » How MassDEP Permitting Works
- » Post Closure Use Instructions & Application Form
- » Landfill Technical Guidance Manual: <http://www.mass.gov/dep/recycle/laws/policies.htm#swmf>
- » Control of Odorous Gas at MA Landfills: <http://www.mass.gov/dep/recycle/laws/policies.htm#swmf>
- » Regulations:
  - Solid Waste (310 CMR 19.000): <http://www.mass.gov/dep/recycle/laws/regulati.htm#sw>
  - MEPA (301 CMR 11.00): <http://www.env.state.ma.us/mepa/meparegulations.aspx>

### **Wetland Notice of Intent (NOI) and Order of Conditions (Local Conservation Commission)**

At a minimum, a project should file a Request for Determination of Applicability to determine if the project will come under the Wetlands Protection Act. If so, a Wetlands NOI and Order of Conditions would be required if construction and/or operation of the proposed renewable energy installation will alter land within a fresh or coastal wetland, marsh, swamp, or riverfront area; is located on land subject to flooding; or is located within the 100 foot buffer zone of a wetland. The Request for Determination of Applicability requires that site plans, project plans and project descriptions be submitted to the MassDEP. The applicant is responsible for publishing a public notification of the Request in newspaper(s) circulated in the municipality(ies) affected by the project. Instructions and forms are available online at <http://www.mass.gov/dep/water/approvals/wpaform1.pdf>. More information can be found in 310 CMR 10.00 and MGL 131 §40.

### **Massachusetts Environmental Policy Act (MEPA) Filing**

May be required if the project exceeds certain thresholds (regulated by the Executive Office of Energy and Environmental Affairs, MEPA Unit).

For example, MEPA requires filing an Environmental Notification Form (ENF) if a proposed renewable energy installation will generate 25 or more megawatts of electricity, or construction will require alteration of one or more acres of bordering vegetated wetland, ten or more acres of any other wetland area (including land altered to install roads and utilities), or disturbance of designated priority habitat for state-listed endangered or threatened species. The ENF requires a site plan, construction plan, and a US Geological Survey (USGS) map of the location. As part of the ENF process, the applicant is responsible for publishing a Public Notice of Environmental Review in newspaper(s) circulated in the municipality(ies) affected by the project. A brief checklist of requirements is available online at <http://www.env.state.ma.us/mepa/enfchecklist.aspx>. More information is available at 301 CMR 11.03.

A list of contacts for additional information is as follows:

- » Northeast Region:
  - MassDEP: John Carrigan, (978) 694-3299, [John.Carrigan@state.ma.us](mailto:John.Carrigan@state.ma.us)
  - DOER: Joanne Bissetta, (617) 823-4029, [Joanne.Bissetta@state.ma.us](mailto:Joanne.Bissetta@state.ma.us)
- » Southeast Region:
  - MassDEP: David Ellis, (508) 946-2833, [Dave.Ellis@state.ma.us](mailto:Dave.Ellis@state.ma.us)
  - DOER: Seth Pickering, (617) 780-7156, [Seth.Pickering@state.ma.us](mailto:Seth.Pickering@state.ma.us)
- » Central Region:
  - MassDEP: Lynne Welsh, (508) 849-4007, [Lynne.Welsh@state.ma.us](mailto:Lynne.Welsh@state.ma.us)
  - DOER: Kelly Brown, (617) 780-8144, [Kelly.Brown@state.ma.us](mailto:Kelly.Brown@state.ma.us)
- » Western Region:
  - MassDEP: Dan Hall, (413) 755-2212, [Daniel.Hall@state.ma.us](mailto:Daniel.Hall@state.ma.us)
  - DOER: Jim Barry, (617) 823-4588, [Jim.Barry@state.ma.us](mailto:Jim.Barry@state.ma.us)

**Please note:** requirements for building and electrical permits vary by municipality. Municipal officials are encouraged to consult with the local building department and any other relevant departments to review these requirements prior to issuing construction RFP bid documents.



Cathartes Private Investments:  
4.5-MW Solar PV Array (photo: Tara Morris Images)





