SOLAR PHOTOVOLTAICS FEASIBILITY STUDY

for the
CITY OF EASTHAMPTON
MASSACHUSETTS

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RENWEABLE ENERGY & CONSERVATION UPGRADES

TABLE OF CONTENTS

SECTION **PAGE**

1.0 INTRODUCTION

The city of Easthampton, Massachusetts is considering installing a solar photovoltaics system on one or more of its municipal buildings. During the fall of 2007 Precision Decisions LLC was contacted to perform a feasibility study. This report details the results of the feasibility study.

The study focused on six potential sites:

- City Office Building - 50 Payson Avenue
- Public Safety - 32 Payson Avenue
- Senior Center - 19 Union Street
- Highway Garage - 1 Northampton Street
- Water Treatment Plant - 109 Hendrick Street
- Waste Water Treatment Plant - 95 Ferry Street

Each of the sites was evaluated for their solar potential and the electrical and structural feasibility of each facility to be configured to accept a system.

2.0 BACKGROUND

The city of Easthampton, Massachusetts has made efforts to reduce energy consumption through audits and energy conservation measures (ECMs). The city has discussed the potential of installing solar photovoltaics (systems that produce solar electricity from the sunlight). It is the intention of the City that this project would be partially funded through one of the Massachusetts Technology Collaborative's (MTC) Renewable Energy Rebate Programs.

In June of 2007 the City produced a request for proposal (RFP) for a consultant to perform design and implementation of a solar photovoltaic system. Precision Decisions LLC was the selected consultant from those that responded to the RFP. The project has been separated into three phases:

I. The first phase will be to determine the feasibility of solar photovoltaics at six different facilities. This information will be reviewed by the city to determine which projects will move forward.

II. The second phase will be to develop detailed plans and specifications for the selected site(s). These will be sent out for public bids. The rebate application(s) will then be submitted to the MTC.

III. Once approved, the project will move into the third phase of construction and commissioning.

This report summarized the results of 'Phase I'.

The initial indications were that the system(s) would have total combined capacity of up to 40 KW. The site specifics, total amount of funding available and potential project payback will ultimately determine the final system size(s).

3.0 FEASIBILITY STUDY DELIVERABLES

A similar evaluation process was used for each of the six sites. This process was only fully assessed for the more promising sites as some of the sites had one or more attributes that eliminated them from solar system potential.

The screening process for each site was as follows:

- Solar site analysis: This would include shading analysis, orientation, and tilt of the potential solar array. *(1)
- Overview of the electrical systems for ability to integrate the electrical output of the PV system and available space for the related appurtenances.
- Structural observations to determine if there are limitations that may prohibit the additional load capacity of the solar array. *(2)

*(1) The combined factors of shading, orientation and tilt are put into a rating matrix and given a 'score'. Note: the commonwealth solar program now requires a score of 80!!!

*(2) This structural review is only performed if the supporting members are accessible and/or easily identified. This task is limited to a review of existing structural drawings and specifications of each roof. If structural drawings are not available, a visual inspection is made of the exposed structural members.

For the sites that score above 70 and did not appear to have electrical or structural limitations, the following was determined:

- Projection for the system's annual electrical production
- Estimated total installed cost for each site/system
- The maximum system size that could be accommodated at that site.

There are three considerations that limit the size of a solar photovoltaic system: 1) electrical usage at that site, on that meter 2) the ability size (ampacity) that can be fed into the existing electrical service 3) the amount of available unshaded south facing roof space.

The electrical usage at the site can put a practical limit on the solar PV system size because of the way that excess power generated onsite is treated in Massachusetts. Usually a PV system is sized so that the site will not generate a monthly excess of electricity.

$$\text{Monthly PV Generation} - \text{Monthly Usage} \leq 0$$

Recent changes in the 'green communities' bill has changed the way net metering will work. The net excess generated will be credited to the account.

**** A note on solar siting / shading ****

The performance of Solar Photovoltaics is very dependant on good access to sunlight. There are 3 factors considered: orientation, tilt and shading.

Orientation: The orientation to true south affects the amount of sunlight that will hit the solar panels. The further the panels are oriented from true south the worst they will perform. The impact is not linear and higher tilt systems are more impacted by deviations on southern orientation.

Tilt: The tilt of a system also has an impact on system performance. Panels are typically mounted flat onto the roof for roofs with some pitch (> 4:12). For flat roof installation, panels are put on 'tilt up' mounting kits that hold the panels at anywhere from 5-25+ degrees; the amount of tilt depend on several mounting and structural variables.

Shading: Solar Photovoltaics are particularly sensitive to shading. This is due in part to the way they are wired in series to boost the voltage to achieve acceptable performance in a normal electrical service. An array that covers an entire roof could have only 10% of the its area blocked by a chimney or exhaust vent and result in an 80% reduction in output for the entire period that the shadow passes across the array. Siting away from elements that cast shadows is extremely important.

4.0 CITY OFFICE BUILDING -ASSESSMENT

The city office building, located at 50 Payson Avenue, is a commercial style office building with a rectangular footprint and a flat roof.

Portions of the roof are shaded by roof mounted HVAC units and an existing tree off of the southwest corner of the building. The usable unshaded/unoccupied roof is approximately 50-60% of the roof area, which would allow for a sizable array of 20 – 25 KW.

The electrical system was inspected and there are currently locations to tie back into one of the existing service panels.

Several of the structural roof members were measured. A few of these members were analyzed. Based on the analysis the members were at or slightly below code. Adding the additional load of a solar system would require additional structural support. The ability to perform structural upgrades is complicated by the mechanical and electrical systems that are installed under the structural members. **This structural limitation makes the City Office Building an unfeasible site for solar photovoltaics.**

Roof Structure

5.0 PUBLIC SAFETY – ASSESSMENT

The public safety building, located at 32 Payson Avenue, is constructed on an irregular footprint. There are many dormers that run perpendicular to the length of the building. The highest ridge runs from the southwest to the northeast. The ends of nearly all of the roofs and dormers are constructed with hip (triangular) ends. These architectural features results in shadows that are cast on adjacent portions of the roof at various points throughout the day, reducing the solar performance below the required score of 70 for the majority of the roof surfaces. Many of the remaining surfaces are shaded by the communications tower (located adjacent to the south of the building), two brick chimneys and several roof exhausters. A relatively small array (< 4 KW) could be placed on one of two potential portions of the roof. This small an array is not recommended for a facility of this size (unless it was done as a 'demonstration project'), as it would contribute only a small fraction of the building's electrical supply.

The roof structure was not assessed as the solar potential is lackluster.

This roof configuration and shading limit the Public Safety Building to a very small solar array for demonstration purposes only.

6.0 SENIOR CENTER - ASSESSMENT

The senior center, located at 19 Union Street, is a brick building that was originally constructed as a post office. There are two distinct roof surfaces: the front of the building (facing the street) has a pitched roof with the ridge running southeast to northwest; the rear of the building has a larger, relatively flat, roof with a parapet wall.

The orientation (to south) of the front roof is less than ideal given its steeper pitch. The roof construction and the vintage building aesthetics further diminish the development of this roof for solar photovoltaics. The flat rear portion of the roof has a chimney and HVAC roof exhausts over a portion of the roof. There is also a tree to the right of the front of the building that currently shades the portion of the roof that is unshaded by the other fixed obstructions. This section of the roof would fit a modestly sized solar array of 3.5 KW (roughly 27' x 12'). If a solar system is pursued for this roof area, the tree will require substantial pruning (or removal) for the system to reach an acceptable level of performance.

The electrical system was inspected and there are currently locations to tie back into one of the existing service panels.

The roof structural members are inaccessible. The ceiling of the second (main) floor is plastered. Inquiries were made as to the availability of plans; however, based on the construction date of the building none were available.

Based on the solid construction techniques of the US Postal Service during the time of construction and the apparent condition (and lack of deflection) in the existing ceiling, there is a chance that the roof construction exceeds the current code and would be able to accept the additional load of the solar array. Obtaining documentation on the structure may provide to be a futile effort; a search of the library, historical society, building inspector archives and US Postal Service archives could all be considered in a records research effort. Alternatively, inspection holes can be made in the ceiling (through the plaster) and then repaired. Given the modest size of the potential array, this may not be worth the effort.

If structural documentation becomes available and the structure is found to be adequate, the Senior Center may be a feasible site for a modest-sized solar array; the tree would also have to be pruned or removed.
Note: This site will likely fall below the minimum score of 80 and not qualify for the commonwealth solar program

7.0 HIGHWAY GARAGE - ASSESSMENT

The Highway Garage, located at 1 Northampton Street, is a long rectangular, block walled, metal flat roofed building.

There is a row of trees to the east of the building that shades the roof. Some of the trees are reportedly on the city's property and the potential exists that they might be pruned or removed to improve overall solar access.

The roof construction is relatively flat with a membrane. There are a few exhaust vents and stacks, most of which are on the eastern portion of the roof.

The resulting usable space is dependent on the amount of tree clearing. With only a few trees removed, a large section on the southwestern third of the roof could be used for solar arrays.
This is a considerable area (approximately 120' x 21') that could accommodate an array of 28-30 KW. *Note: this size system would far exceed the usage at the site (the usage is modest for a building this size, on a square foot basis, but is expected given the use of the building)*.

Note: this appears to no longer be an issue with the in the 'green communities' bill as several city sites could be combined and the excess from the garage would be 'shared' with another building such as public safety. So a large system could be pursued.

The electrical system was inspected. The system currently has only a 150A main service panel, which is small given the usage at the site (welders/ air compressors, etc). Furthermore, all of the circuits are in use for the various functions at the garage. For this reason, the installation of a photovoltaic system will likely require a moderate upgrade to the electrical service. This does not have too substantial an impact to the overall project economics. The electrical upgrade would be further developed during the detailed design phase of the project.

The Highway Garage, with moderate tree clearing, has the potential for 28-30 KW of solar photovoltaics. A smaller system, at 8-10 KW, would be a good match given the current electrical consumption.

Closest trees need removal for larger array

Note: this site scored a 78, and needs an 80 under the new program, so the tree clearing is needed.

8.0 WATER TREATMENT PLANT - ASSESSMENT

The water treatment plant, located at 109 Hendrick Street, is a brick building with prefabricated wooden trusses.

The rectangular building is oriented in a north to south direction making most of the roof (facing east and west) inappropriate for solar. The southern side of the building has a hip roof facing south. There is a line of trees along the horizon. The trees cause minor shading in the early morning and late afternoon, and will result in modest shading in December when the sun is low in the sky.

The hip roof construction is a 7 in 12 pitch with asphalt shingles. There are no obstructions (vents, etc) on the south roof. This entire small roof could be developed for solar. The trapezoidal roof area measures a 50' base, 16' top and 16' tall. This will accommodate an array of 5.5-6.5 KW. The usage at this site is significant given that it is a water treatment facility. This size system would contribute a portion of the electrical usage.

Some drawings were available for this facility. The information on these drawing gave some indications that there is enough load bearing capacity in the current roof design to accommodate a solar array. However, definitive information will need to be gathered and analyzed during detailed design to confirm the adequacy of the roof trusses.

The electrical system was inspected and there are currently locations to tie back into one of the existing service panels.

The Water Treatment Plant has the potential for 5.5 – 6.5 KW of solar photovoltaics.

9.0 WASTE WATER TREATMENT PLANT - ASSESSMENT

The wastewater treatment plant, located at 95 Ferry Street, has several buildings at the site.

The **main waste treatment building** has several exhaust stacks on the roof. There is also high-pressure blower ductwork running much of the length of the main roof. This equipment causes enough shading that the roof is considered unusable for solar photovoltaics.

The **headworks building** was also considered for solar. This building has several skylights across the roof surface rendering it unusable for solar.

The **Sewer Department Maintenance Garage** at the wastewater treatment facility was also reviewed. This rectangular building was constructed in two portions:

- A northern section consisting of 3 bays, with a roof construction of wood beams and plank decking. In the southernmost bay of this section the roof support beams have been replaced by steel beams.
- A southern section, more recently constructed, is a double bay, prefabricated metal building.

Select beams from the northern section were measured and analyzed. The southern bay, with the steel beams, appears to be adequate for the additional solar load. The thickness of the decking still needs to be confirmed. The two northern bays, with the original wood beams, are not adequate for the additnioal loading of a solar array. An upgrade similar to that of the southern bay might be performed to allow for solar usage of the entire northern portion of the roof. A more comprehensive analysis of the upgrades would be incorporated into the detailed design of the system.

No drawings were available for the southern section of the building. Shop drawings for this style of prefabricated building are needed to perform an adequate analysis. This would be performed as part of the detailed design if the potential of this structure were pursued.

There are two trees that would need to be removed to provide for solar access.

There is an exhaust chimney located in the center of the roof (between the northern and southern portions of the building). This results in shading for about 30% of the southern roof. The boiler using this chimney is quite old. If it were replaced in the near future a ‘direct vent’ unit could be installed and the chimney eliminated (resulting in more usable roof space). The existing space on the northern unshaded portion of the roof will accommodate an array of 9-11 KW. (The area over the one upgraded bay with steel beams will accommodate only 2 KW of panels by itself). If the southern prefabricated roof were found structurally adequate, an additional 5-6 KW could be added. The electrical usage at this site is significant given that it is a wastewater treatment facility. This size system would contribute only a fraction of the electrical usage.

The electrical system at the Sewer Department maintenance garage is inadequate to accept a PV system of this size. It also is on a separate meter from the main wastewater plant and the usage would be more than offset by the solar production. For this reason, the installation of a photovoltaic system will likely require a moderate upgrade to the electrical service. This would either feed the power back to the main waste treatment building electrical service; or tie the garage electrical service so that it is feed off of the service of the main building. The electrical upgrade does not have too substantial an impact to the overall project economics and would be further developed during the detailed design phase of the project.

The Waste Water Treatment Plant has the potential for 9 – 11 KW of solar photovoltaics on the northern roof, if upgraded to support the additional load. An additional 5-6 KW can be installed on the southern roof, if found to be adequate. For this project, two trees would need to be removed and upgrades to the electrical service feeder performed.

Sewer Department Maintenance Garage Main WWTP Building (not usable)

10.0 PROJECT ECONOMICS

The project economics are based on the initial investment, which is partially offset by a rebate. The remaining investment is paid off over time by the reductions of the electric utility bill based on the amount of electricity that the solar system generates.

> It is important to note that all of the electric utility accounts are comprised of three components:
>
> 1. A *customer services charge*, that is essentially a flat fee based on the type of account and magnitude of the maximum annual demand
> 2. A *demand charge*, based on the monthly peak demand, measured in KW
> 3. A *usage charge*, based on the energy used, measured in KWh
>
> The usage charge makes up much, if not most of the bill. The demand charge will vary considerably based on the peak demand that a service uses during that month. For a facility like a wastewater treatment plant that has a lot of large motors that may all be on at the same time (such as during a peak flow period) the demand may be very high and represent a larger demand charge and hence a larger portion of the bill for that service.
>
> These differ from residential accounts, most of which do not have the ‘demand charge’. Conventional wisdom might suggest that if you install a solar PV system and it makes 80% of your electricity it should reduce you bill by 80%. However, with a demand-metered account, solar PV does not usually affect the demand component of the bill and its impact may only drop the bill 60-70% (depending on the magnitude of the demand).
>
> This was taken in into account for each of the municipal buildings, each of which has a different demand component for electrical service. The result is that the unit savings varies somewhat from site to site.

The initial cost of photovoltaics is based on, at a minimum, the following components/tasks:

- Solar array (the panels themselves)
- Mounting hardware
- Inverter & associated disconnects
- Conduit & wiring
- Panel installation & electrical labor
- Metering

Currently the total installed cost of supplying and installing this equipment is in the range of $10-$12 per watt, or $10,000 - $12,000 per kilowatt (KW). This cost range is for municipal installations that have been bid according to the Massachusetts Procurement Guidelines. The private market enjoys a lower range of $8-$9 per watt. There is a modest (3-7%) reduction in unit cost for much larger installations (20-100 KW). Since all of the proposed installation here are less than 10 KW, the range of $10-$12 per watt will be used.

The exact figure used will vary depending on the site conditions and mounting configuration.

For some of the projects, additional work is required on either the roof structure or the electrical service. In these cases a budget estimate has been projected for the upgrades.

The Commonwealth Solar program has no limits at 10 KW that affect program applications requirements.

Currently the Commonwealth Solar program funds projects at a base level of $3.25 per watt up to 25 KW, with a variety of other 'adders'. The following adders can apply to the City of Easthampton:, Public Building - $1.00, Massachusetts Manufactured Components - $0.25. The adders plus the base level total $4.50 per watt (or roughly half of the total system costs).

There are other federal and state tax incentives for solar; however, none of these apply for a municipality, which is tax-exempt.

There are now provisions that allow for third party ownership of municipal systems. This allows for some additional tax benefits. The general conceprt is for the city to 'lease' the roof space to a third party. The third part furnishes and installs a PV system on the roof. They collect all the rebates, and take all the tac credits and depreciation since they are a 'for-profit' taxable enitities. They sell the power made back to the site (the city). After some period of time, generally thought to be 10 to 20 years, the project is 'paid off' and the system is turned over to the city. Several variables can be negotiated, such as the contract term, the rate charged for power (i.e. fixed, discounted or market rate). More information can be obtained at www.masstech.org. Sample RPF's and other legal documents are available. The Mayor of Easthampton was invited, and attended an informational session for third party ownership of PV systems.

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Table A shows a summary of the various project financials including: project cost, projected production, internal rate of return (IRR) and net present value. A 'simple payback' is not shown as it can often be misleading for a project with longer payback, as it does not incorporate future cost increases or the 'time value of money'.

For the four recommended projects, the IRR is above what would be expected as a 'loan' (in this case a city bond is expected at less than 4%). These projects also have positive net present values with a discount rate of 3.8%. Both these financial metrics indicate that the City of Easthampton should proceed with these projects.

One additional attribute that can add to the investment is the selling of the RECs (renewable energy credits). At this time these can be sold for approximately $.06/KWh yielding another $1817 per year (assuming all 30 KW is developed). One issue with selling the RECs it that you are selling the city's right to claim that the facility is running (in part) off of green energy (you can actually still claim that you have solar panels, but at the same time you have to indicate that you have sold the credits). This is not to be confused with the electricity that is generated – that is still used at the site, it is only the renewable attribute (aka the 'greenness') that is sold. This is usually a community decision and the opinions can vary widely. Many, if not most, communities do decide to sell the RECs.

More information on buying and selling REC's can be found at:
http://www.eere.energy.gov/greenpower/markets/certificates.shtml?page=2

11.0 CONCLUSIONS

Of the six municipal sites assessed for solar photovoltaics potential, three demonstrate enough promise to warrant further consideration by the City of Easthampton: the Highway Garage, Water Treatment Plant and Waste Water Treatment Plant.

Highway Garage: This site has the potential for the largest system, but does not have the usage to match the maximum system size. Therefore, a 10 KW system is proposed to match electrical consumption and to also qualify for the MTC's simplest rebate program. An electrical serivce upgrade is also needed for this site. This site should be considered for a 25 KW installation based on changes to the net meteirng law.

Water Treatment Plant: A 6.5 KW system is proposed.

Wastewater Treatment Plant: A 10 KW system is proposed on the Sewer Department Maintenance Garage. This will require upgrades to some of the structural roof members over two of the bays. An additional 5-6 KW may be installed on the prefabricated portion of the building if it is found to be structurally adequate during detailed analysis.

The initial assessments were based on a site review and preliminary computations. A more detailed analysis of the structures and electrical system is needed during detailed design to confirm the viability of each site.

City of Easthampton
Solar Photovoltaics Feasibility Study
Summary of Financials

Site Name	Address	PV Recommended	System Size (KW)	Base System Cost	Cost of upgrade (*1)	Total System Cost	MTC SRI Rebate	Net Initial Cost	Site Score	Annual Output kWh	Value of Energy -kWh	Value of Demand KW (*2)	1st year savings	IRR (*3)	Net Present Value (*3) (at 3.8%)
Town Office Building	50 Payson Ave	N	n/a												
Public Safety	32 Payson Ave	N	n/a												
Senior Center	19 Union St	Y	3.5	$40,250	$2,500	$42,750	**$15,750**	$27,000	70	3062	$428	$270	$698	4.54%	$4,343
Highway Garage	1 Northampton St	Y	25	$245,000	$4,000	$249,000	**$112,500**	$136,500	77	23915	$3,339	$1,287	$4,626	6.01%	$71,631
Water Treatment Plant	109 Hendrick St	Y	6.5	$74,750	$0	$74,750	**$29,250**	$45,500	82	6601	$920	$291	$1,211	4.69%	$8,813
Waste Water Treatment Plant	95 Ferry St	Y	10	$108,000	$12,000	$120,000	**$45,000**	$75,000	89	11059	$1,541	$448	$1,989	4.68%	$14,367
			45	$468,000	$18,500	$486,500	**$202,500**	$284,000		44637	$6,227	$2,296	$8,524		
Assumed annual electric increase			5%												
Maintenance Cost (each 20 yr, % of total system cost)			12%												

(*1) - Upgrade costs need to be confirmed based on confirmed plans developed during detailed design
(*2) - To determine a 'value of demand' it is assumed a portion of solar production occurs during peak demand - the estimated portion varies by site based on type of use
(*3) - IRR & Net Present Value based 40 year class life, annual electric increase, and one 20 year major repair (likely inverter)

All cost figures are estimated (opinion of cost); all production figures are based on projected generation/utility costs.

TABLE A