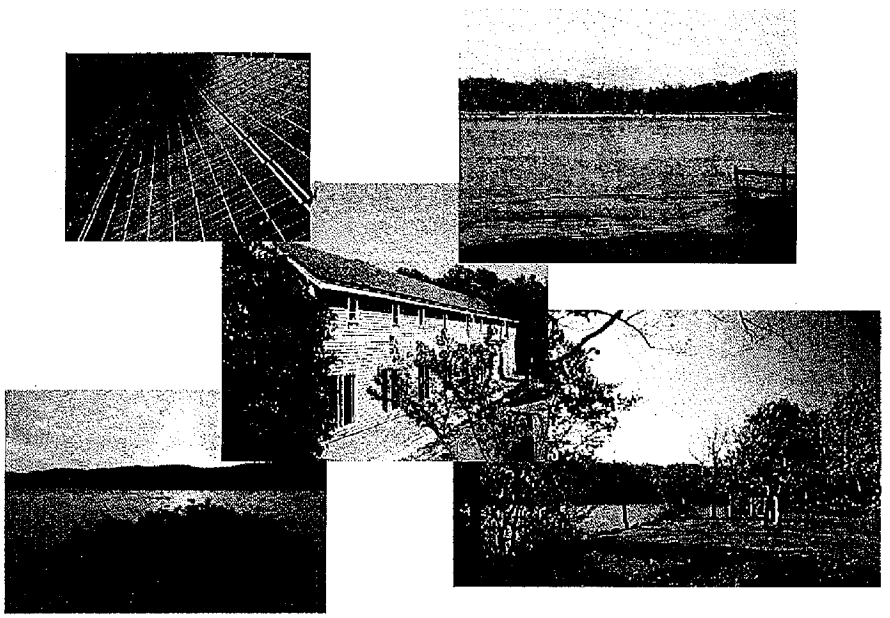
ATTACHMENT C

Argo Consulting

Eastham Solar Photovoltaic Options Feasibility Study

Town Hall, Recreation Building, Police Station, and Fire Station

12/02/09



Solar Photovoltaic Options Feasibility Study

Prepared for the Town of Eastham
By Liz Argo

12/2/09

Introduction

Renewable Energy for Eastham Municipal Buildings; Town Hall, Recreation Building, Fire Station, and Police Station

Renewable Energy installations are a desirable element to overall Town Municipal Building Maintenance Plans for long-range economic benefit, reduction of carbon footprint, and inspiration to local citizens. Concern is mounting about the Cape's vulnerability to the effects of global warming on its fragile coastline. Renewable energy at the municipal level is one step available to the community to act responsibly to mitigate climate change while securing long-term financial benefits.

The following study will examine the feasibility of Renewable Energy in the form of photovoltaic installation at the Eastham Municipal buildings located between 2500 and 2550 State Highway in Eastham, respectively the Eastham Town Hall, the Eastham Recreation Building, the Eastham Fire Station, and the Eastham Police Station.

Technical Feasibility Analysis

Municipal Building Evaluation

An evaluation of four Eastham municipal buildings located at the corner of State Highway and Samoset Road was made to leverage a Massachusetts Energy and Efficiency Block Grant of $150,000. The current market cost of a conventional, moderately sized photovoltaic installation at this time is estimated at less than $6.50 per watt. A conservative price of $6.40 per watt was used to calculate an installation of approximately 23.43 kilowatts to match the grant financing opportunity.

The criteria leading to the recommendation of the most promising roof, or roofs, at the Municipal Buildings site for a 23.43kW installation were:

- Roof orientation to south and freedom from shading
- Square footage available on the southern facing roof
- Pitch, age, and composition of roof
- Surety of roof permanence without demolition or renovation for 20 years

Figure 1. Eastham Municipal Buildings Site at Route 6 and Samoset Road

Site Evaluations

Eastham Town Hall

The illustration below is a view of the southern roof face at the Eastham Town Hall.

Figure 2. Eastham Town Hall – southern roof face

While the opportunity for solar collection does exist on the Eastham Town Hall building with a reasonable expanse of southern facing roof, electric tie-in viability, and the necessary rafter support, shading from a very old and "historic" tree is a strong determiner against a Town Hall installation at this time. The tree in question is visible in

the photo above. The shortened collection period due to shading argues in favor of choosing an alternate roof installation at any of the other three municipal buildings.

Eastham Police Station

There are two southern roof faces on the Eastham Police Station available for solar collection. The roof in the illustration below is the larger of the two. A second smaller southern roof face on the Police Station is illustrated in Figure 3.

Figure 2. Eastham Police Station – largest southern roof face

Figure 3. Eastham Police Station – smaller southern roof face

Both southern facing roofs of the Eastham Police Station are favorable for solar photovoltaic installation. Their magnetic solar orientations are both 189°. Maximum solar orientation at the Eastham latitude is 194° magnetic.

The pitch of the larger roof is the more favorable of the two roofs at 30°, but the smaller roof is still perfectly acceptable at 28°. See Figure 4 below for the chart identifying ideal roof pitch.

Optimal Pitch for Fixed Tilt Solar Installation Arrays
in the Eastern, MA Environs

RReDC

Source: PVWatts

Sample System Size ~ 10 kW @ 180° Azimuth

Pitch	Annual AC Energy (kW/h)	Incremental Difference in kW/h annually from Optimal pitch of 35°
40°	12,112	130
35°	12,242	Optimal
30°	12,180	62
25°	12,044	136
20°	11,833	211
15°	11,546	287
10°	11,183	363
5°	10,748	435
0°	10,236	512

Figure 4. Determination of Solar Efficiency at Pitch Angles

Neither roof has shading issues, either from trees or from neighboring buildings.

Wooden rafter construction with varying spans but mostly at about 24" on center was identified at both roofs. This construction is acceptable for the rack mounting and support of the proposed solar installations.

Electrical tie-in with the three-phase power at the Eastham Police Station can be accommodated. The emergency generator should be noted. The exact location of

the inverter(s) would be determined by the installer working in conjunction with the Police Department.

A single difficulty was identified in proposing a photovoltaic installation for the Eastham Police Station roofs. This is in the age of the asphalt shingle roofing installed during the building's original construction in 1989. These shingles are due for replacement with replacement currently scheduled for 2011.

Eastham Fire Station

There is one southern roof face on the Eastham Fire Station and an alternative flat "rubber" roof available for solar collection. The roof in the illustration below is two views of the largest southern roof face. The top view is from the front of the building and the bottom, from the rear. The flat roof is in Figure 7.

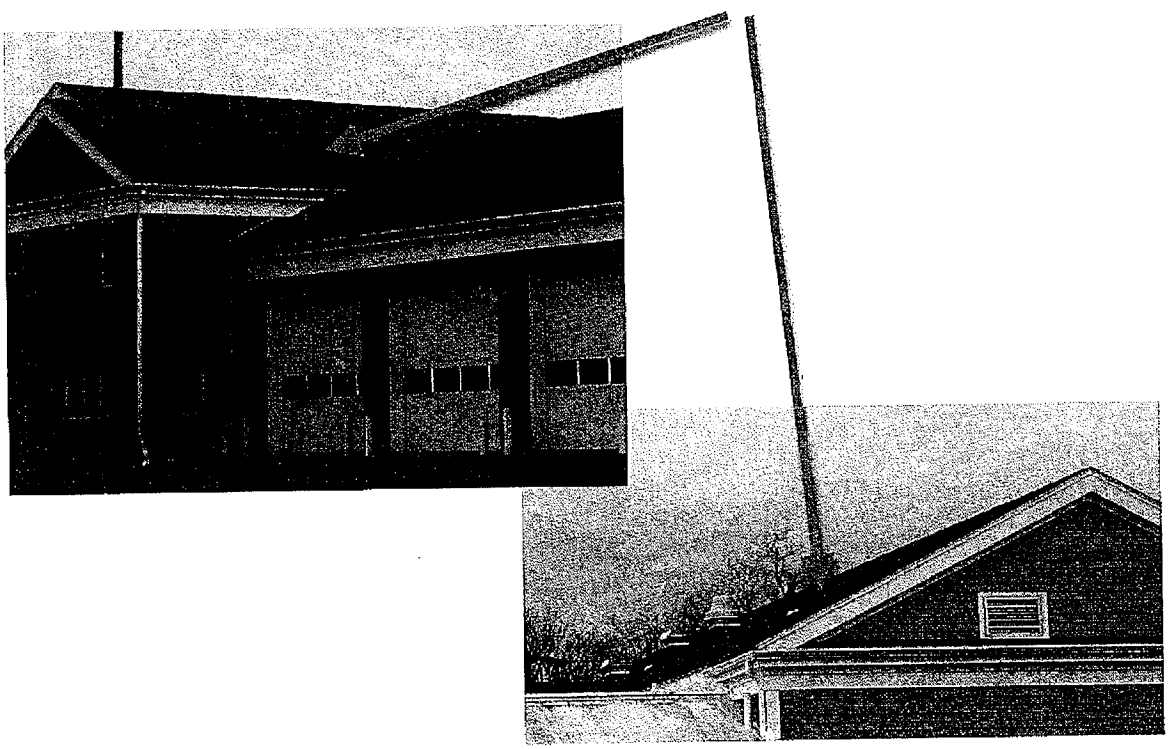


Figure 5. Eastham Fire Station – largest southern roof face

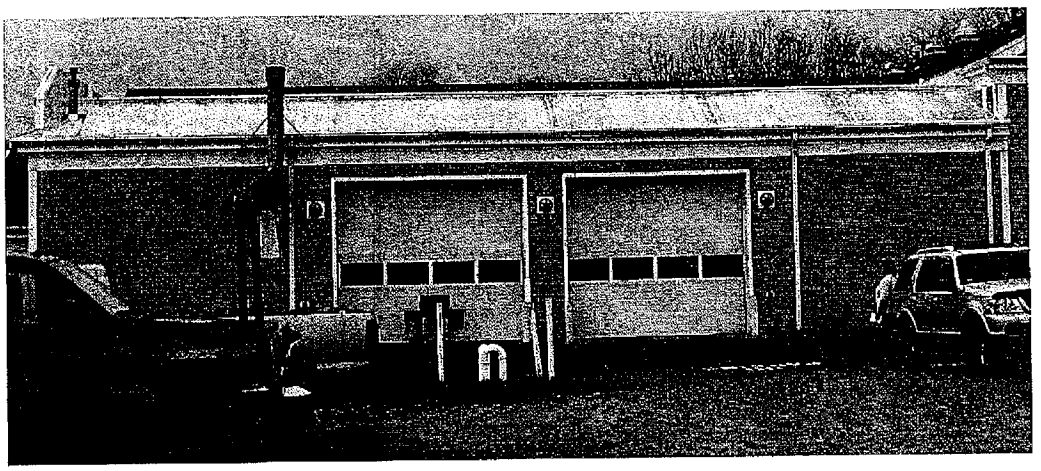


Figure 7. Eastham Fire Station – Sarnafil "rubber" roof face

The Eastham Fire Station is also suitable to accommodate photovoltaic installation. Again, the magnetic solar orientations the pitched roof is189°. The angle of the southern-pitched roof is favorable at 25°.

The flat roof, with no pitch to the southern sky, would be less productive as per the chart in Figure 4.

Neither roof has shading issues, either from trees or from neighboring buildings.

Construction using prefabricated wooden trusses at 24" on center was identified at both roof locations. This construction is acceptable for rack mounting and support of the proposed solar installations.

Electrical tie-in with three-phase power at the Eastham Fire Station can be accommodated. An emergency generator is on-line for the Fire Station although it is

housed in the adjacent Town Hall. The exact location of the inverter(s) would be determined by the installer working in conjunction with the Fire Department.

Eastham Recreation Building

There is one southern roof face on the Eastham Recreation Building as illustrated in Figure 8.

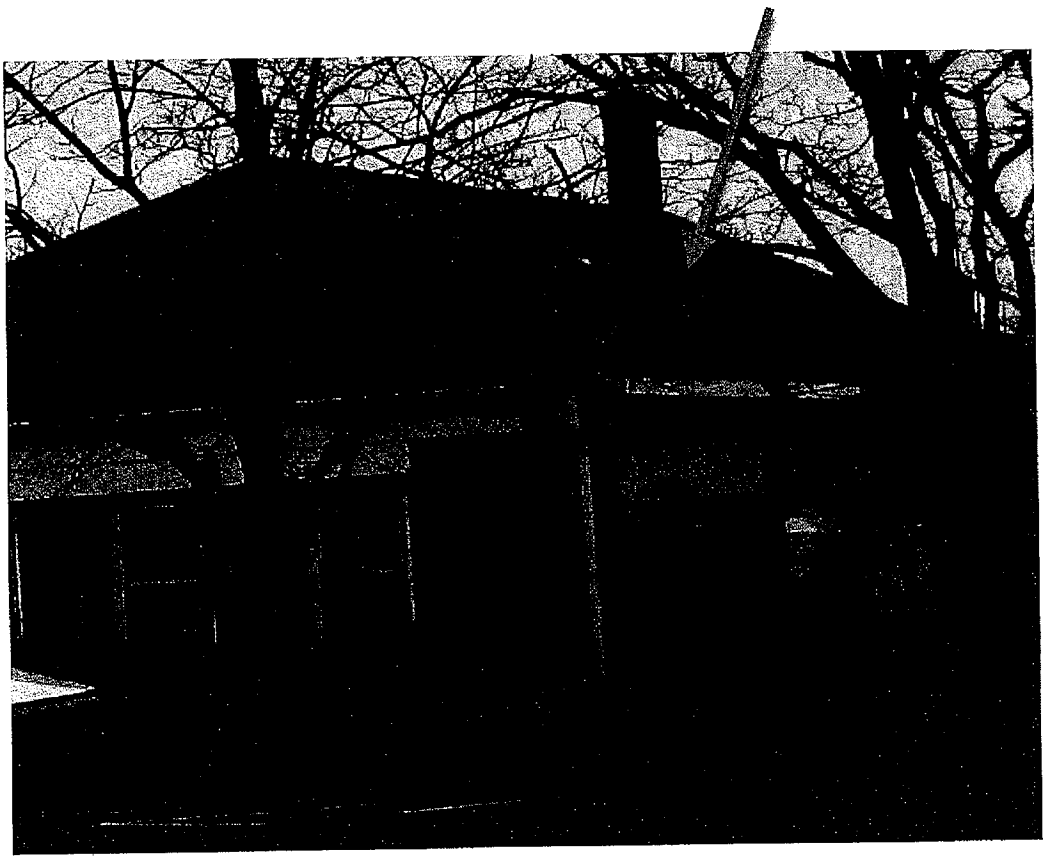


Figure 8. Eastham Recreation Building – southern roof face

The Eastham Recreation southern facing roof was dismissed as a candidate for a photovoltaic solution at this time due to both its shading by the adjacent Town Hall building, and its diminutive size.

Photovoltaic Installation Options

Photovoltaic Modeling and Design Evaluations

Eastham Police Station

The Evergreen ESA-210 is an exemplary, moderately priced solar module made in America. The made-in-America requirement is an element of the EECBG offering. The Evergreen 210 watt module (ESA – 210) was used in the design of a variety of photovoltaic systems to determine the best of the potentials at the Eastham municipal site. The resulting designs were used to determine the best combination of roof installations at the Eastham site to fulfill a total of 23.43 kilowatts of photovoltaics and maximize the EECBG grant opportunity of $150,000.

Figure 9 below illustrates a design filling the largest roof of the southern facing roofs at the Eastham municipal buildings site with Evergreen ESA-210 modules. The roof illustrated below is the larger southern roof of the Eastham Police Station.

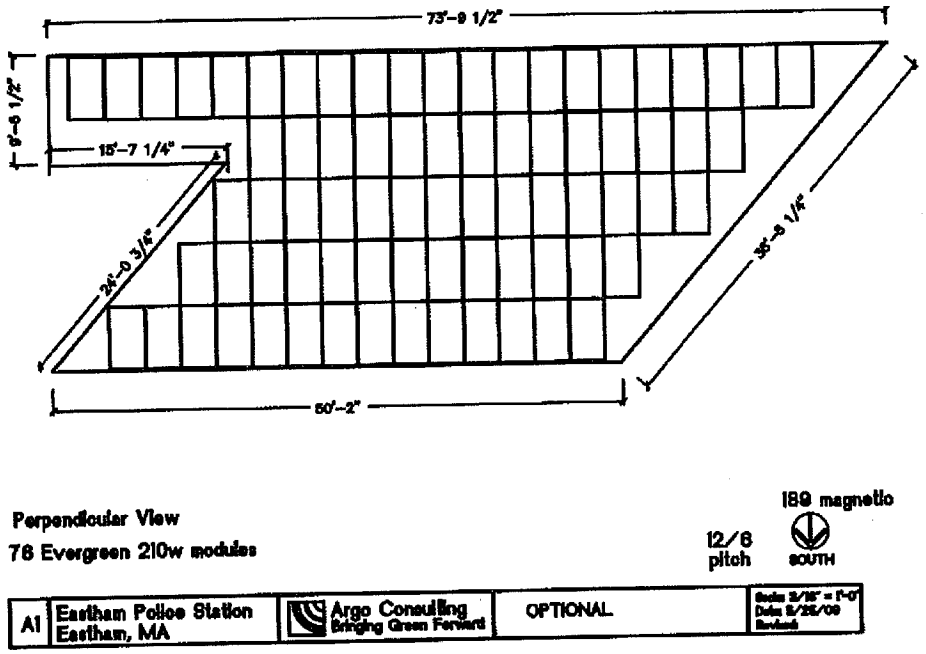


Figure 9. Largest Roof - Eastham Police Station

In Figure 9, 76 Evergreen 210-watt modules are demonstrated to fill the roof utilizing the Direct Power and Water racking system. Review of inverter combinations identifies string sizing needs, based on inverter thresholds, may limit the installation to 75 modules.

The 75-module installation of 210-watt modules will result in an installation of 15,750 watts or 15.75kW. With a target of 23.43kW set by the EECBG grant, an array of 7.68 remains to be located.

The second, smaller roof of the Police Station is the next logical installation opportunity to fill out the grant offering. However, as Figure 10 illustrates below, the roof is too small

to hold more than 24 210-watt modules for an installation of only 5.04kW, 2.64kW short of the 7.68kW goal.

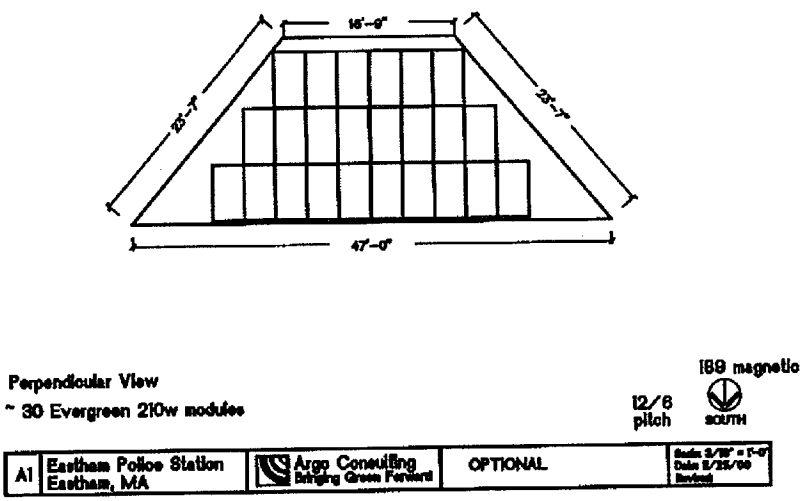


Figure 10. Smaller Police Station Roof

Next for design review is the largest pitched roof on the Fire Station for its potential to fill out the remaining photovoltaic total of 7.68kW. Figure 11 illustrates a design using the Evergreen ESA-210 to fill the larger Fire Station roof to capacity.

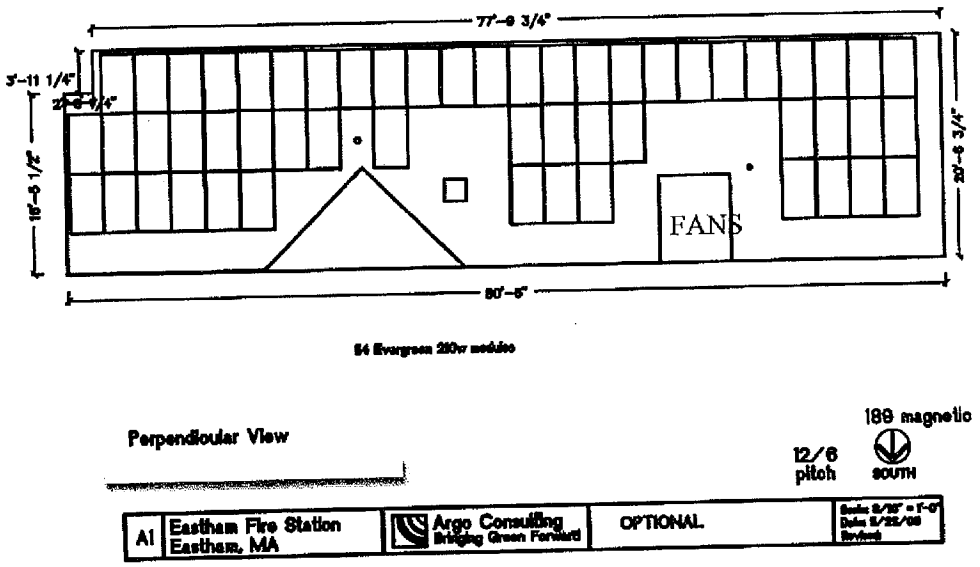


Figure 11. Largest Pitched Fire Station Roof

An installation of 54 Evergreen ESA-210 modules was found to fit the largest pitched Fire Station roof while leaving the necessary room for three venting fans. One vent pipe's relocation is called for according to the design above.

54 210-watt modules would deliver 11.34kW, more than enough to meet the remaining 7.68kW of photovoltaic power sought to fill out the EECBG opportunity.

The Fire Station is a good candidate for a solar thermal solution, as well as for photovoltaics for electricity. A solar thermal solution would provide hot water to the staff that inhabits the premises for showering, cooking, and cleaning. The above design can be modified as depicted below in Figure 12 to allow for future solar thermal collection. Reducing the size of the installation by the19 modules as

illustrated in Figure 12 will maximize the EEGBC grant offering and still leave room for an adequate solar thermal system at a later date.

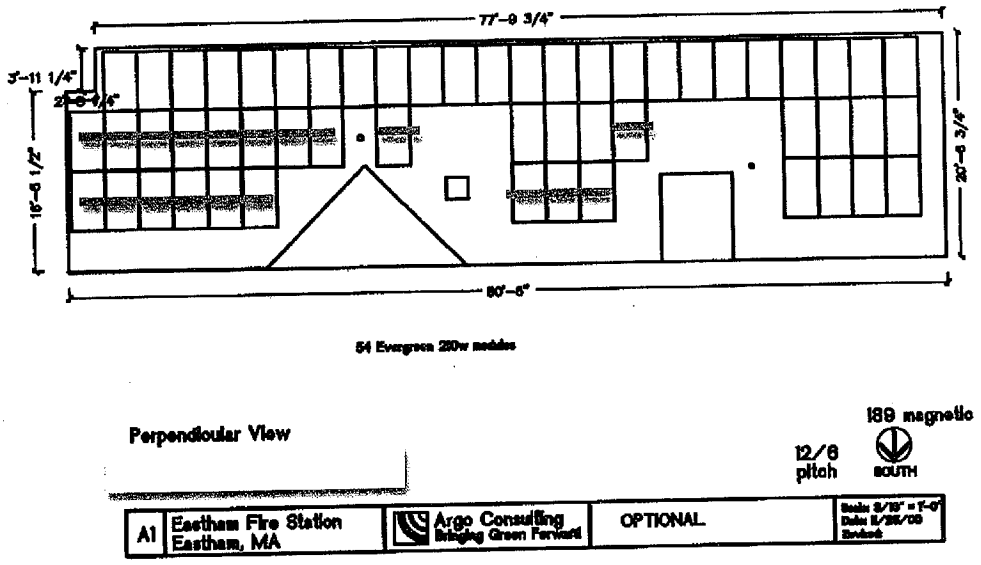


Figure 12. Largest Pitched Roof at Eastham Fire Station - (reduced installation by 19 modules to meet EECBG offer and still leave room for future solar thermal collectors in the 4' X10' portrait installation.) The 19 modules covered by the blue lines would be eliminated.

String sizing applicability to fit an inverter to the above 35 210-watt module array is confirmed.

An alternative installation opportunity presents itself on the Sarnafil (rubber) roof at rear of the Fire Station. Figure 13 represents a design of Evergreen ESA-210 modules in racked mounting flat to the roof.

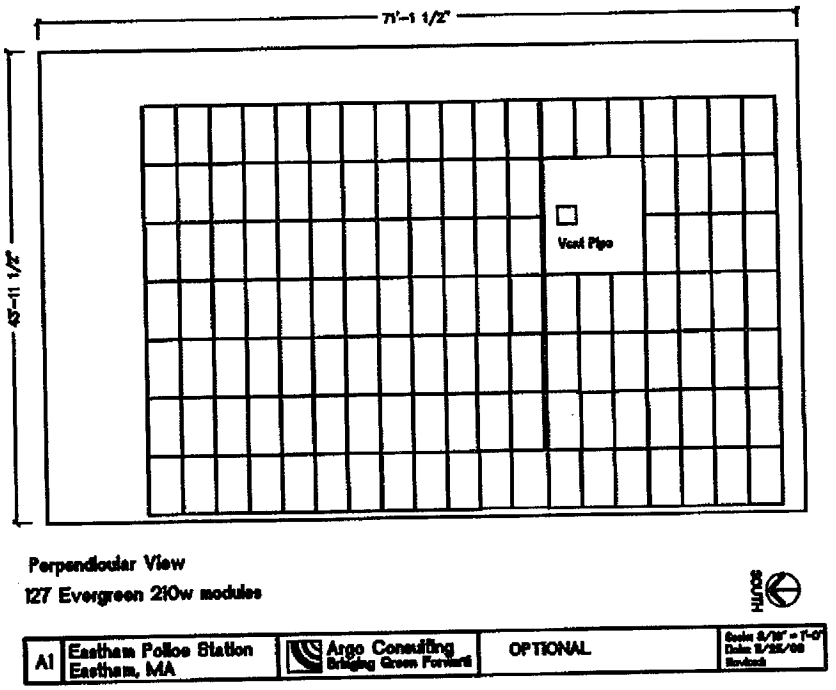


Figure 13. "Flat" (2 degree pitch) Sarnafil Rubber Fire Station Roof

An installation of 127 Evergreen ESA-210 modules was found to fit the flat rubber roof of the Fire Station with room left for the existing vent pipe. The decorative false roof face at the southern end of the roof to hide the rubber roof will be a shading consideration. The design in Figure 13 illustrates the backing off from the southern end of the roof to avoid the shade from this false roof extension.

Two Solectria 13kW inverters would accommodate the installation, one taking 48 modules and one taking 64 modules. The extra two modules bring the total installation to 112 modules, which could potentially be afforded by the $150,000 grant. The total at $6.40 for a 112-module installation costs out at $150,528.

It should be noted that the option to install photovoltaics on the flat rubber roof of the Fire Station has its pros and cons. On the pro side, the single wire run would have its cost advantages. However, it presents a less preferable installation opportunity due to the added construction requirements involved with the Sarnafil roofing materials (sleeper installation with additional Sarnafil sealing), lack of pitch equating to less efficient solar collection, and lack of visibility to the general public.

Summary

Photovoltaic Production

Photovoltaic Production Capacity

To calculate the actual electrical production that can be anticipated from the model arrays created, consideration of roof pitch, roof angle to solar south and historic weather patterns are made. The Renewable Resource Data Center of the National Renewable Energy Laboratory (NREL) is the accepted resource for computing these variables. According to the analysis provided through PVWatts, a total of 28,921 kilowatt hours per year can be projected as potential electrical production from the total of 23.10kW installed on the pitched roofs. A 23.52kW installation on the flat roof can be projected to provide 24,288 kilowatt hours annually.

Recommendation

To meet the opportunity presented by the Energy Efficiency and Conservation Block Grant of $150,000, it's recommended that a photovoltaic installation for the Police Station consisting of 75 210-watt modules be developed for solicitation along with a solicitation for a system on the Fire Station consisting of 35 210-watt modules. The total of 110 210-watt modules on both stations' roofs will meet the opportunity

presented by the EECBG grant with a larger end production of electricity and better public visibility.

End Notes

The proposed photovoltaic installations at the Eastham Municipal Building Complex are net-metering enabled systems, which means that any time the systems are producing more energy than is being consumed, the excess energy will be sent back to the grid for a credit, and energy will be drawn from the grid when consumption exceeds the system's production.

These systems have no batteries and do not provide emergency backup power.