EXCELLENCE IN ENGINEERING

Solar Energy Potential Report
City Of Providence

Prepared For
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MONDRE ENERGY, INC.

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1.0 EXECUTIVE SUMMARY

Northeast Engineers & Consultants, Inc. (NE&C) has conducted a feasibility study of designated city-owned properties to evaluate the technical and financial viability of solar photovoltaic (PV) projects. The City's Office of Sustainability identified a list of 20 "Target Sites" as potential project sites for the implementation of rooftop solar energy projects.

The project included a desktop review, preliminary Energy Production Potential calculations, site visits, preliminary economic calculations, site ranking, and a review of available funding sources and ownership models.

After evaluating each Target Site, they were plotted to illustrate how the Sites compare with relation to both qualitative and quantitative factors (Refer to Appendix B). The Sites were then grouped by Tier based on their plotted location, with Tier I the most likely candidate for a successful solar PV project and Tier IV the least likely. A summary of the target sites along with the potential PV system size, the estimated Energy Production Potential (EPP), qualitative score, and resulting tier classification is provided in the following table.

Tier	Name	PV Size*, kW	EPP*, MWh/yr	Qual. Score
I	Dr. Jorge Alvarez High School	460	574	1.7
	Public Safety Complex	250	316	1.7
	Providence Career and Technical Academy	530	662	2.2
II	Mt. Pleasant High School	180	226	2.2
	Nathaniel Greene Middle	70	88	2.2
	Nathan Bishop Middle School	130	163	2.2
	Pleasant View Elementary	190	198	1.9
	George J. West Elementary	180	226	2.2
	Carl G. Lauro Elementary School	180	225	2.2
	Providence Schools Administration	90	113	2.2
	Providence Emergency Management Agency	5	6	2.2
	Public Safety Complex Garage	140	175	1.9
III	Classical High School	560	702	0.7
	Department of Public Works	370	422	1.4
	DPW Traffic Engineering	410	514	0.7
IV	Hope High School	150	188	1.5
	Roger Williams Middle School	70	88	1.2
	Esek Hopkins Middle School	30	38	1.2
	Gilbert Stuart Middle School	80	100	1.2
	Providence City Hall	10	13	1.2

Note: *Estimated PV size and EPP were calculated for relative ranking purposes only. Actual figures based on detailed design calculations will vary.

Generic installed PV system costs in $/kW DC as a function of system PV capacity were estimated by Mondre Energy, Inc. (MEI). The approximate costs of installed systems are expected to range from approximately $21,000 for a small 5 kW system to over $2 million dollars for a large 600 kW system. Allowing for uncertainty in the preliminary estimates, PV projects of 100 kW or more and which can take advantage of the 30% Investment Tax Credit (ITC) could potentially compete with utility supplied power. Smaller projects, or projects that can not take advantage of the 30% ITC will likely require additional financial incentives to be economically advantageous.

Based on the findings of this evaluation, the six sites most likely to be feasible are:

- Providence Career and Technical Academy (Tier I)
- Dr. Jorge Alvarez High School (Tier I),
- Public Safety Complex (Tier I),
- Mt. Pleasant High School (Tier II),
- George J. West Elementary School (Tier II)
- Carl G. Lauro Elementary School (Tier II)

The next recommended step is for the City to select one or more of these six sites for further evaluation and issue a Request for Proposals. Requested proposals should include, in part, the following:

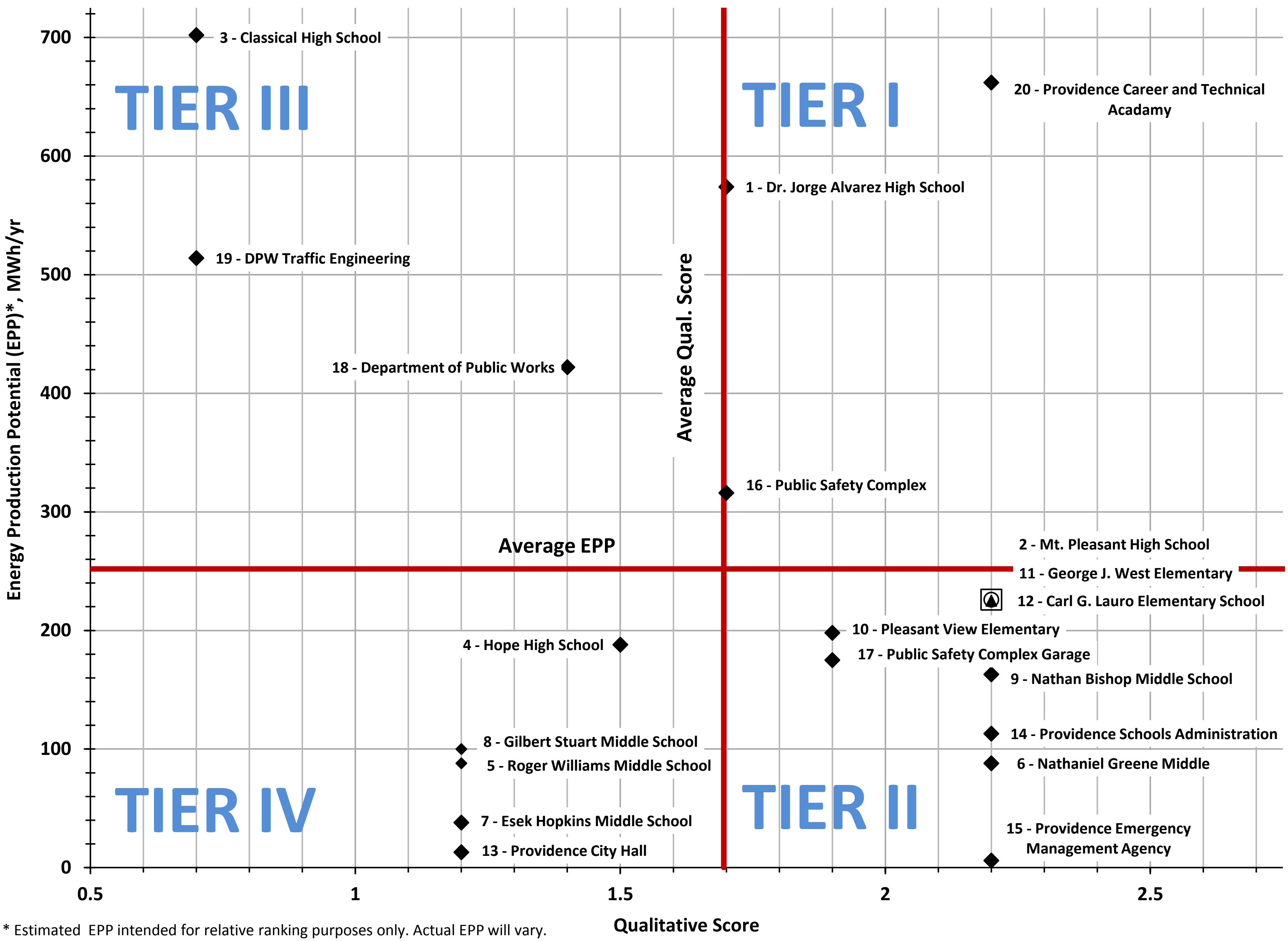
- A detailed evaluation of each site including shading, obstacles, array layout, electrical connections, required improvements, system size, and construction logistics.
- A detailed description of the proposed ownership model including assumptions, limitations, and guarantees.
- A preliminary pro-forma evaluation of the proposed project including a description of all assumptions, margin of error, tax incentives, grants, and loans.
- A description of proposed mounting methods and roof warranty implications.

Criteria for evaluating potential PV sites should include, in part, the following:

- Return on Investment
- Upfront costs to the City, if any.
- Operation and Maintenance costs to the City, if any.
- Site accessibility, disturbance during construction.
- Educational value (to students and/or the public.)

The schools listed above as well as the Nathanial Greene Middle School, the Nathan Bishop Middle School, and the Pleasant View Elementary school may also be viable candidates for the Renewable Energy at RI Schools Grant. This grant could provide up to 75% of the total project cost for up to a 50 kW system (or the 50 kW portion of a larger system). *Applications are due by April 17, 2015*. It appears feasible that a 50 kW PV system benefitting from the RI Schools Grant could be economically advantageous. A Distributed Generation Contract would further increase the return on investment. The Nathanial Greene Middle School appears to be well suited for a 50 kW system and therefore is most likely to take full advantage of this grant. The larger schools may also be well suited for this grant if combined with supplemental financial incentives and/or the size of the system is limited.

Figure B-1: Relative Site Ranking



* Estimated EPP intended for relative ranking purposes only. Actual EPP will vary.

2.0 INTRODUCTION

NE&C has conducted a feasibility study of designated city-owned properties to determine the technical and financial viability of solar photovoltaic (PV) projects. The City's Office of Sustainability identified the following list of 20 "Target Sites" as potential project sites for the implementation of rooftop solar energy projects.

Table 1: Target Sites

Site ID	Name	Address	Use
1	Dr. Jorge Alvarez High School	375 Adelaide Ave.	High school
2	Mt. Pleasant High School	434 Mt. Pleasant Ave.	High School
3	Classical High School	770 Westminster St.	High school
4	Hope High School	324 Hope St.	High school
5	Roger Williams Middle School	278 Thurbers Ave.	Middle school
6	Nathaniel Greene Middle	721 Chalkstone Ave.	Middle school
7	Esek Hopkins Middle School	480 Charles St.	Middle school
8	Gilbert Stuart Middle School	188 Princeton Ave.	Middle school
9	Nathan Bishop Middle School	101 Sessions St.	Middle school
10	Pleasant View Elementary	50 Obediah Brown Rd.	Elementary
11	George J. West Elementary	145 Beaufort St.	Elementary
12	Carl G. Lauro Elementary School	99 Kenyon St.	Elementary
13	Providence City Hall	25 Dorrance St.	Administrative
14	Providence Schools Administration	797 Westminster St.	Administrative
15	Providence Emergency Management Agency	591 Charles Street	Admin/Garage
16	Public Safety Complex	325 Washington Street	Public safety
17	Public Safety Complex Garage	349 West Fountain St.	Garage
18	Department of Public Works	20 Ernest Street	Garage
19	DPW Traffic Engineering	40 Ernest St.	Maintenance garage
20	Providence Career and Technical Academy	41 Fricker Street	School

2.1 OBJECTIVES

The objectives of this study were:

- To complete a solar PV feasibility study of designated City owned properties including technical characteristics of the properties, an estimation of the electricity generating potential and cost of PV systems, and outline financing options.
- Rank and prioritize sites to assist the City in determining priority candidates for future PV projects and maximize the financial viability of these projects.
- Assess the viability of the sustainability action plan's renewable energy targets.

- Recommend actions that will help the City achieve renewable energy targets in the most cost effective and impactful way.

- Develop a set of criteria for the Office of Sustainability to use when evaluating potential PV sites.

2.2 SCOPE OF SERVICES

To accomplish the objectives of this study, NE&C and Mondre Energy, Inc. performed the following:

1. Completed an initial desktop evaluation of each of the 20 Target Sites identified by the City based on aerial photographs, GIS data, and Tax Assessor's data.

2. Estimated the annual Energy Production Potential of each Target Site using NREL's PVWatts calculator.

3. Observed physical site characteristics of the rooftop condition of each Target Site.

4. Completed an initial financial evaluation (Mondre Energy, Inc.)

5. Evaluated and categorized the target Sites based on both qualitative and quantitative characteristics.

6. Evaluated various ownership and financing models (Mondre Energy, Inc.)

3.0 SUSTAINABLE PROVIDENCE

In September 2014 the City of Providence issued *Sustainable Providence*, a comprehensive plan to "…usher Rhode Island's capital city into a resilient and sustainable future."[1] The plan includes five sustainability goals; Zero Waste, Food, Transportation, Water, Energy, and Land Use and Development. The City's sustainable energy goals are detailed in the report's Energy Plan, which includes reducing energy use by 2030 in all City-owned properties, expanding renewable and clean energy projects, and promoting energy reduction policies and practices. To increase the number of renewable energy projects on City-owned properties, the City has received a grant from the Rhode Island Renewable Energy Fund to evaluate the feasibility of implementing hydropower on City-owned properties and solar energy projects on existing rooftops.

The goal of the Sustainable Providence Energy Plan includes a goal to expand renewable energy projects. The listed strategy to achieve this goal is to "identify and implement renewable energy opportunities on City properties, as well as citywide." The metric by which to measure progress is given as the "number of renewable energy projects in Providence."

Based on the findings of this Solar Energy Potential Report, it is not unrealistic for the City to set a more specific numeric goal of approximately one to two MW of solar capacity on City owned

[1] Sustainable Providence, September 2014, p.7, Letter From the Mayor.

buildings. A metric based on the kWh of solar energy generated may be more useful than the number of projects alone. This metric would recognize several large projects over many small projects, which is more likely to be economically beneficial.

4.0 TARGET SITE EVALUATION

4.1 DESKTOP EVALUATION

NE&C evaluated the twenty Target Sites based on multiple qualitative factors. The qualitative evaluation began with a desktop review based on aerial photographs, GIS data, and Tax Assessor's data. This initial evaluation included the following parameters:

- Number of Stories
- Roof Structure
- Building Foot Print
- Lot Size
- Zoning
- Roof Orientation
- Potential Shading
- Estimated Available Roof Area
- Estimated potential size of PV system
- Surrounding Use
- Permitting Obstacles

Findings are tabulated in Table A-1 included in Appendix A.

The approximate available roof area was estimated from 2011 aerial photographs based on visible roof obstructions, roof configuration, and shaded areas. This roof area was used to estimate the potential PV system size assuming a 16% efficiency.

PVWatts is a solar calculator developed by the National Renewable Energy Laboratory (NREL) that estimates the electricity production of a grid-connected photovoltaic system based on a few select inputs. This tool was used to estimate the annual Energy Production Potential (EPP) of each Site. The estimated EPP ranges from 6 to 702 megawatt-hours per year (MWh/year) as shown in the following table.

Table 2: Estimated PV Size and EPP

Site ID	Name	PV Size*, kW	EPP*, MWh/yr
3	Classical High School	560	702
20	Providence Career and Technical Academy	530	662
1	Dr. Jorge Alvarez High School	460	574
19	DPW Traffic Engineering	410	514
18	Department of Public Works	370	422
16	Public Safety Complex	250	316
2	Mt. Pleasant High School	180	226
11	George J. West Elementary	180	226
12	Carl G. Lauro Elementary School	180	225
10	Pleasant View Elementary	190	198
4	Hope High School	150	188
17	Public Safety Complex Garage	140	175
9	Nathan Bishop Middle School	130	163
14	Providence Schools Administration	90	113
8	Gilbert Stuart Middle School	80	100
5	Roger Williams Middle School	70	88
6	Nathaniel Greene Middle	70	88
7	Esek Hopkins Middle School	30	38
13	Providence City Hall	10	13
15	Providence Emergency Management Agency	5	6

Note: * Estimated PV size and EPP were calculated for relative ranking purposes only. Actual figures based on detailed design calculations will vary.

These estimates were derived using similar assumptions and simplifications for each site and are useful for comparing on project to another. Actual energy production values will differ from those presented in this report. More accurate energy production estimates for selected sites should be calculated during later phases of the project. These detailed calculations should include design specific factors such as "on the ground" measurements of available roof area and shading and product specific efficiency factors and should be conducted using a more complex model.

4.2 PRELIMINARY STRUCTURAL OBSERVATIONS

None of the Target Sites were ruled out based on obvious fatal flaws during the initial evaluation. Therefore, all twenty Sites were visited by NE&C. The Site visits included observations of the general condition of the roofs to evaluate their likely suitability for a PV system.

Most roof structures were found to be in good or excellent condition, a few were found to be in fair condition, and only one was found to be in poor condition. Observations are tabulated in Table A-2 included in Appendix A and described in individual Roof Inspection Reports included in Appendix C. A summary of the roof structure and system conditions as well as the estimated remaining life is provided in the table below. No significant structural repairs necessary to support a PV system were readily observable.

Table 3: Summary of Roof Observations

Site ID	Site Name	Roof Structure	Roofing System	Remaining Life, yrs
1	Dr. Jorge Alvarez High School	Excellent	Excellent	12-17
2	Mount Pleasant High School	Fair	Fair	17-22
3	Classical High School	Good	Fair	4 to 9
4	Hope High School	Good	Good	membrane: 15-20 ballasted: 5-10
5	Roger Williams Middle School	Good	Good	5 - 10
6	Nathaniel Greene Middle School	Good	Good	17 - 22
7	Esek Hopkins Middle School	Good	Poor	5-10
8	Gilbert Stuart Middle School	Good	Good	5-10
9	Nathan Bishop Middle School	Good	Excellent	15-20
10	Pleasant View Elementary	Good	Good	15-20
11	George J. West Elementary	Good	Excellent	17-22
12	Carl G. Lauro Elementary	Fair	Excellent	17-22
13	Providence City Hall	Fair	Good	5-10
14	Providence Schools Administration Bldg.	Good	Excellent	17-22
15	Providence Emergency Management Agency	Excellent	Excellent	19-24
16	Providence Public Safety Complex	Excellent	Excellent	8-13
17	Providence Public Safety Complex Parking Garage	Good	NA	NA
18	Providence Department of Public Works	Good	Good	10 - 15
19	Providence DPW Traffic Engineering Bldg	Poor	Poor	0
20	Providence Career & Technical Academy	Excellent	Excellent	15-20

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

These ratings were derived using similar assumptions for each site and are useful for comparing one project to another. A more detailed structural evaluation of selected sites should be conducted during later phases of the project.

4.3 QUALITATIVE RANKING

The qualitative factors were evaluated in an attempt to rank the Target Sites. As the Sites were found to have much in common, the three most distinguishing factors were selected to generate qualitative scores. The three factors selected are: zoning, estimated remaining useful roof life, and security from vandalism. These factors were weighted based on the subjective importance of each. The scoring system is illustrated in the following table.

Table 4: Qualitative Scoring Key

Category	Score	Description	Weight
Zoning			20%
	1	Historic District - special permitting required	
	2	All others - permitted as accessory structure	
Estimated Remaining Roof Life			50%
	0	< 5 yrs	
	1	5 - 10 yrs	
	2	10 - 15 yrs	
	3	15 - 20 yrs	
Security			30%
	0	Relatively unsecure	
	1	Relatively secure	
Total Weight			**100%**
Max possible weighted score	**2.2**		

The estimated remaining roof life was weighted the highest. The cost of replacing a roofing system is significantly increased once a solar array is installed. Therefore, roofs with the most life remaining were scored the highest. The scores are summarized in the table below. Refer to Table B-1 included in Appendix B for detailed scoring.

Table 5: Qualitative Scoring Key

ID	Name	Zoning (wt = 0.2)	Rem. Life (wt = 0.5)	Security (wt = 0.3)	Total Score
2	Mt. Pleasant High School	2	3	1	2.2
6	Nathaniel Greene Middle	2	3	1	2.2
9	Nathan Bishop Middle School	2	3	1	2.2
11	George J. West Elementary	2	3	1	2.2
12	Carl G. Lauro Elementary School	2	3	1	2.2
14	Providence Schools Administration	2	3	1	2.2
15	Providence Emergency Management Agency	2	3	1	2.2
20	Providence Career and Technical Academy	2	3	1	2.2
10	Pleasant View Elementary	2	3	0	1.9
17	Public Safety Complex Garage	2	3	0	1.9
1	Dr. Jorge Alvarez High School	2	2	1	1.7
4	Hope High School	1	2	1	1.5
18	Department of Public Works	2	2	0	1.4
5	Roger Williams Middle School	2	1	1	1.2
7	Esek Hopkins Middle School	2	1	1	1.2
8	Gilbert Stuart Middle School	2	1	1	1.2
13	Providence City Hall	2	1	1	1.2
16	Public Safety Complex	2	2	1	1.7
3	Classical High School	2	0	1	0.7
19	DPW Traffic Engineering	2	0	1	0.7

4.4 Site Ranking

Each Target Site was plotted according the qualitative score and the quantitative EPP. The chart was divided into four quadrants divide by the average EPP and the average qualitative Score. Each quadrant was assigned a Tier number. This chart, included in Appendix B, illustrates how the Sites compare with relation to both qualitative and quantitative factors.

The chart was used to group and rank the Sites by Tier.

- Tier I sites have the most potential for a successful solar PV project and warrant a more detailed evaluation. They have above average EPP and qualitative scores.
- Tier II sites are not top ranked, however, they still have a reasonable potential for a successful solar PV project and warrant a more detailed evaluation. They have below average EPP and above average qualitative scores.
- Tier III sites have low potential for a successful solar PV project as-is. They have above average EPP and below average qualitative scores. However, additional improvements to the building would increase the qualitative score, potentially increasing its ranking to Tier I.
- Tier IV sites have the least potential for a successful solar PV project. They have below average EPP and qualitative scores.

The sites, grouped by Tier are summarized in the following table.

Table 6: Target Site Tier Ranking

Tier	ID	Name	EPP, MWh/yr	Qual. Score
I	1	Dr. Jorge Alvarez High School	574	1.7
	16	Public Safety Complex	316	1.7
	20	Providence Career and Technical Academy	662	2.2
II	2	Mt. Pleasant High School	226	2.2
	6	Nathaniel Greene Middle	88	2.2
	9	Nathan Bishop Middle School	163	2.2
	10	Pleasant View Elementary	198	1.9
	11	George J. West Elementary	226	2.2
	12	Carl G. Lauro Elementary School	225	2.2
	14	Providence Schools Administration	113	2.2
	15	Providence Emergency Management Agency	6	2.2
	17	Public Safety Complex Garage	175	1.9
III	3	Classical High School	702	0.7
	18	Department of Public Works	422	1.4
	19	DPW Traffic Engineering	514	0.7
IV	4	Hope High School	188	1.5
	5	Roger Williams Middle School	88	1.2
	7	Esek Hopkins Middle School	38	1.2
	8	Gilbert Stuart Middle School	100	1.2
	13	Providence City Hall	13	1.2

It should be noted that with improvements a Tier III Site could be re-classified as Tier I. For example, a roof with very few years remaining would be scored much higher if it were reevaluated after the roof was replaced. Similar improvements to Tier IV Sites are less likely to be feasible due to the relatively low quantitative score. Potential improvements for Tier III Sites are summarized in the following table.

Table 7: Potential Improvements for Tier III Sites

ID	Name	Potential Improvements
3	Classical High School	The estimated remaining roof life is 4 to 9 years for all but the new wing. Installing solar arrays on a roof that will need to be replaced in as soon as 4 years is not desirable. However, this Site has one of the highest Energy Production Potentials of the 20 evaluated. A detailed analysis may be warranted to determine if it is economical to replace the roofs early, prior to installing a solar array or if it is economically feasible to replace the roof during the lifetime of the PV array. Alternatively, the Site could be reevaluated at a later date once the existing roof has reached the end of its life and is replaced as scheduled.
18	Department of Public Works	Trees growing along the southern edge of the building as well as an adjacent building that rises above the Site is likely to be a shading concern for a portion of the roof. The trees also provide roof access to animals and vandals. Removing or trimming the trees and modeling the shade effect of the adjacent building could improve the qualitative score.
19	DPW Traffic Engineering	It does not appear that the existing roof has any useful life remaining. It is estimated to be older than 30 years and is in poor condition. Replacing this roof would increase the qualitative score and elevate the building to Tier I. However, the overall condition of the building was observed to be in poor condition. It appears that significant work would be required prior to replacing the roof and installing PV modules on the roof.

5.0 FINANCIAL VIABILITY

NE&C's subconsultant, Mondre Energy, Inc. (MEI) provided a preliminary evaluation of the potential financial viability of solar PV projects at the Target Sites. The preliminary evaluation is intended for initial planning and comparative ranking purposes. A more detailed pro-forma evaluation should be conducted prior to proceeding with any project.

5.1 Levelized Cost of Energy

Figure 1 presents a current, standard cost curve (before tax benefits) that illustrates generic installed PV system costs in $/kW DC as a function of system PV capacity, without taking into account site-specific conditions. As shown, standard installed costs range from more than $4,250/kW for a 5kW system to approximately $3,600/kW for a 600 kW system. Installed costs were developed by MEI based on previous project experience.

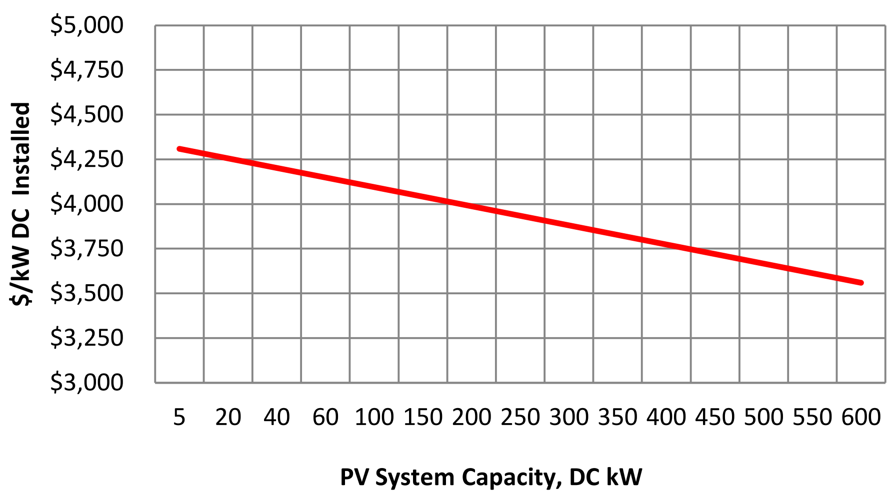


Figure 1: Installed Cost vs. PV System Capacity

Figure 2 presents a comparison of the life cycle costs of rooftop solar projects compared to the life cycle cost of purchasing power from the utility at current retail prices in $/kWh. Shown as the levelized cost of electricity (LCOE), these curves represent the present value of the total costs of installing, operating, and maintaining a rooftop solar project divided by the total kWh's generated over the life of the project. The LCOE as shown in Figure 2 provides a comparison of the LCOE of three different scenarios;

1. Third party ownership with 30% Investment Tax Credit (ITC – See Section 5.3.2.)
2. Third party ownership with 10% ITC
3. City-owned, 0% ITC

The third party ownership scenarios assume that a third party would own, finance, build and operate the system, based on the installed capital cost shown in Figure 1. The third party would sell the generated power to the City at a price that recovers all of the financing and O&M costs of the system pursuant to a 25 year power purchase agreement (PPA) with the City. The LCOE curves shown in Figure 2 assume that the PV system owner would realize either a 30% or 10% tax credit respectively, and accelerated depreciation, and would pass these benefits through to the City. The City-owned scenario assumes the City would own, finance, build and operate the system, based on the installed capital cost shown in Figure 1 and would use the generated power itself over a 25 year term. Figure 2 does not include incentives such as potential grants and distributed generation contracts.

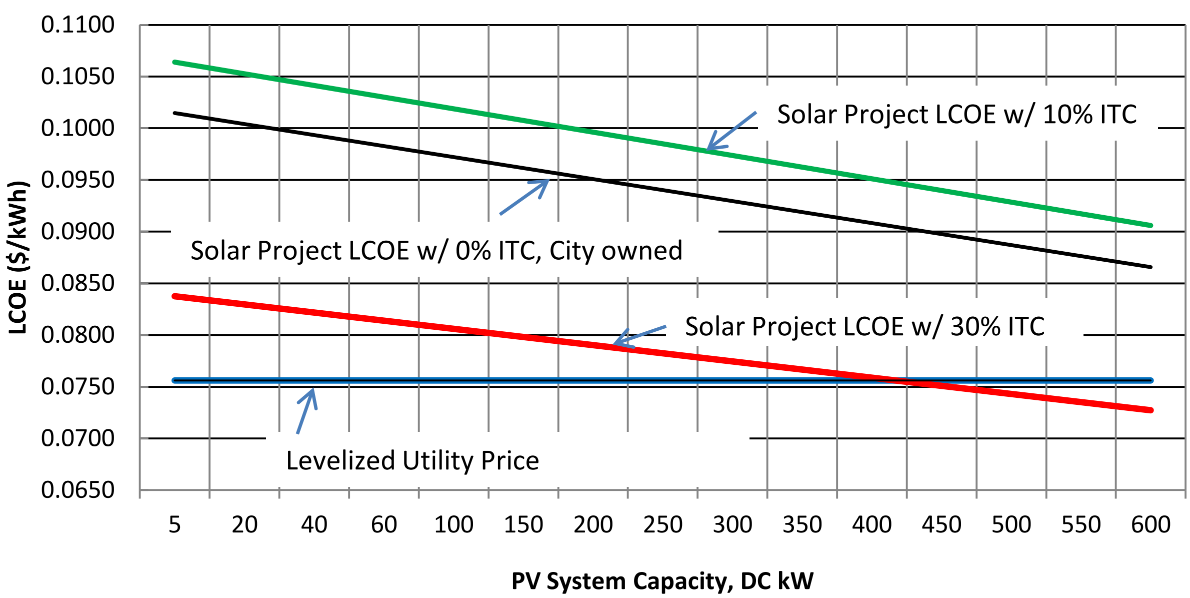


Figure 2: LCOE vs. System Capacity

As shown by the red "*Solar Project LCOE w/ 30% ITC*" trend line, the LCOE for a solar PV project that realizes a 30% ITC might be expected to range from 8.5 c/kWh for a 5 kW system to 7.4 c/kWh for a 600 kW system. Similarly, the LCOE for a PV project that realizes a 10% ITC might be expected to range from 10.8 c/kWh for a 5kW to 9.2 c/kWh for a 600 kW system. The

LCOE for a City-owned system, which is unable to take advantage of the ITC benefit, but which can be expected to have lower borrowing rates, might be expected to range from 10.3 c/kWh for a 5 kW system to 8.8 c/kWh for a 600 kW system. Estimated power production costs shown in Figure 2 are based on the following financial and PV system assumptions that have been modeled for the City's rooftop projects:

Table 8: LCOE Assumptions

Assumption	Value	Reference
Loan term	25 years	NREL
Interest rate, PPA (3rd party owned)	5%	Assumed
Interest rate, City owned project	3.5%	Assumed
Discount rate	7%	Assumed
Current Energy price paid by City	14 c/kWh	City
Capacity Factor	16 %	NREL
O&M costs	20 $/kW-yr	NREL/PV Watts

The LCOE curves are based on generalized data and assumptions; actual PV system costs will vary and should be determined if the City decides to pursue vendor quotes for project implementation.

The current LCOE for City-purchased electricity from the utility is estimated to be 7.6 c/kWh and is illustrated by the blue "*Levelized Utility Price*" line shown in Figure 2. According to EIA data, average commercial electric rates in Rhode Island increased from approximately 13 c/kWh to 16 c/kWh over the past year.[2] Thus, a PV project with a 25 year term would need to be able to produce power with a LCOE below the 7.6 c/kWh threshold to be competitive with power purchased from the utility.

Allowing for uncertainty in the preliminary estimates, PV projects of 100 kW or more and which can take advantage of the 30% ITC could potentially compete with utility supplied power. Smaller projects, or projects that can not take advantage of the 30% ITC will likely require additional financial incentives to be economically advantageous.

[2] U.S. Energy Information Administration, Electric Power Monthly, September, 2014 Report.

Table 9: Target Site LCOE, $/kWh with 30% ITC

Site ID	Name	PV Size, kW	EPP, MWh/yr	LCOE
3	Classical High School	560	702	0.073
20	Providence Career and Technical Academy	530	662	0.074
1	Dr. Jorge Alvarez High School	460	574	0.075
	Levelized Utility Price			0.076
18	Department of Public Works	370	422	0.076
19	DPW Traffic Engineering	410	514	0.076
16	Public Safety Complex	250	316	0.078
2	Mt. Pleasant High School	180	226	0.080
4	Hope High School	150	188	0.080
10	Pleasant View Elementary	190	198	0.080
11	George J. West Elementary	180	226	0.080
12	Carl G. Lauro Elementary School	180	225	0.080
17	Public Safety Complex Garage	140	175	0.080
8	Gilbert Stuart Middle School	80	100	0.081
9	Nathan Bishop Middle School	130	163	0.081
14	Providence Schools Administration	90	113	0.081
5	Roger Williams Middle School	70	88	0.082
6	Nathaniel Greene Middle	70	88	0.082
7	Esek Hopkins Middle School	30	38	0.082
13	Providence City Hall	10	13	0.083
15	Providence Emergency Management Agency	5	6	0.083

Note: LCOE estimated for comparison purposes only. Actual LCOE developed with detailed analysis will differ.

5.2 Potential Ownership Structures and Financing Arrangements

There are a variety of methods which can be used to finance municipal solar energy projects. According to the National Renewable Energy Laboratory (NREL) Renewable Energy Finance Tracking Initiative (REFTI), which has surveyed financing of renewable energy projects since 2009, the most common methods of financing solar PV energy projects under 1 MW are:[3]

1. Balance sheet financing, 38% (City would own and finance the solar energy project)

2. Tax equity financing, 15% (City would partner with a developer and tax equity partner)

3. Lease, 7% (City would lease the system from a solar developer, either as a sale leaseback or as a standard capital lease)

4. Other, 40% (This category includes Investment Bank participation, Congressionally appropriated projects, institutional fixed rate notes; commercial bank debt, and tax equity partner financing with no flip)

Looking at overall financing trends, the REFTI reported that, for PV projects under 1 MW, balance sheet financing has declined significantly since 2009 and that tax equity and other types of financing are continuing to grow. This is most likely a direct reflection of the desire to take advantage of the federal Investment Tax Credit (ITC).

[3] https://financere.nrel.gov/finance/REFTI, Project Status and Information, 2H 2011.

5.2.1 Power Purchase Agreement Model

Because the ITC is only of value to tax paying entities and the City is tax-exempt, it would need a project counterparty with a tax liability large enough to take advantage of the ITC and accelerated depreciation. The City would enter into a PPA with this entity and benefit by paying a lower energy price than if the tax benefits were not monetized. In a municipal solar project structured with a PPA there are typically three major project participants:

1. City (power purchaser)
2. Developer (system constructor and operator/power provider)
3. Tax equity partner (beneficial owner)

As between the developer and tax equity partner, there are typically three contractual arrangements used to finance the solar project:

1. Sale leaseback
2. Partnership flip
3. Inverted lease

Under the sale and leaseback arrangement, the City would enter into the PPA with the developer, who would construct and operate the project. The City would grant a site easement (which could be in the form of site lease) to the developer. The developer would then purchase the solar panels and simultaneously sell them to a tax equity partner, and then lease them back from the tax equity partner, thus becoming the lessee of the solar equipment. The tax equity partner (owner and lessor of the solar equipment) would then have right to the ITC and the accelerated depreciation on the equipment. The developer would then enter into a power purchase agreement (PPA) with the City for the sale of power from the solar project.

A power purchase agreement (PPA) between the energy user (City) and energy provider is a popular contracting vehicle for installing municipal solar energy projects. The PPA takes advantage of the federal ITC by having a tax paying third party be responsible for owning and operating the solar energy system, typically installed on the end user's property. The PPA term is long-term, typically 15 to 25 years, and provides that the end user purchases all of the output of the system at an agreed upon price. The price over the term may have an initial price ($/kWh), which is escalated annually. Another pricing method is to provide a discount compared to the local utility's otherwise applicable retail cost.

Other advantages of the PPA model to the City (as the end user) are as follows:

1. There are no capital requirements imposed on the City.
2. The City is hedged against energy price fluctuations by providing the City with long-term energy pricing.

3. A private developer/owner can take advantage of the tax benefits (ITC and depreciation), resulting in lower system costs than if the City owned and operated the system.

4. The developer/owner is responsible for operations and maintenance of the system.

During project operation, the tax partner/lessor would receive lease payments from the developer/lessee, and the City would pay the developer for power generated by the solar system.

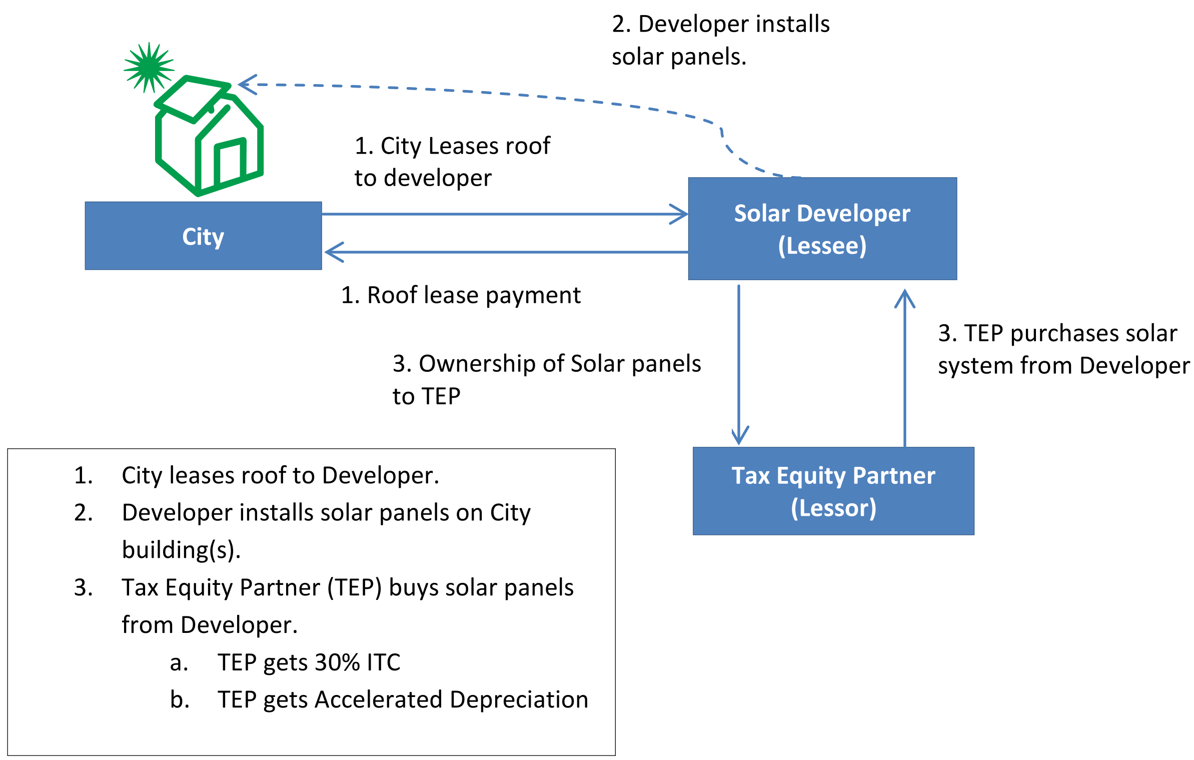


Figure 3: Sale Lease Back - Development/Construction Phase

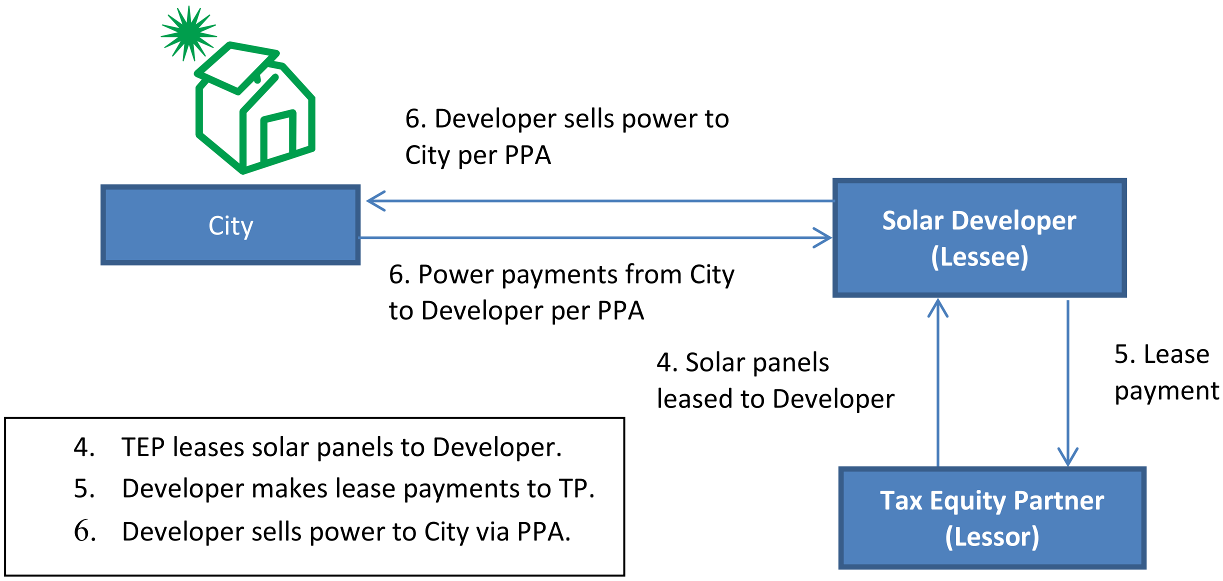


Figure 4: Sale Lease Back - Operations

The following chart summarizes the advantages and disadvantages of the sale leaseback option:

Advantages	**Disadvantages**
Simplest of all tax equity financing structures	Cost of capital from Tax Equity Partner higher than from other sources
Allows transfer of 100% of tax benefits to Tax Equity Partner	Developer must meet lease payments to Tax Investor
No financing capital required from Developer	If Developer wants to own system at end of term, must purchase it from Tax Equity Partner
Can be put in place 90 days after in-service date	Lease must be structured so that Fair Market Value (FMV) at end of lease is at least 20% of initial value.
Basis for ITC is transaction price between Developer and Tax Equity Partner	

In the partnership flip financing structure, the developer and tax equity partner form a joint venture, and both provide up-front capital to purchase system components. This allows the developer to retain an ownership interest in the project, which it will be able to monetize at a later date. The tax equity partner benefits from by obtaining the ITC and accelerated depreciation on its solar system assets. After the tax equity partner achieves its required financial returns (IRR target) system ownership "flips" to the developer. This usually occurs between years 5 and 9 of operation.

As the power purchaser, the City is not impacted by the behind the scene flip, and its power price is contractually guaranteed by the PPA, just as it is in the sale leaseback structure. Therefore, the decision of whether or not to structure the deal as a partnership flip is one primarily between the developer and tax equity partner.

The following chart summarizes the advantages and disadvantages of the partnership flip structure:

Advantages	**Disadvantages**
Well understood structure	Developer invests own capital in project
Developer can regain project ownership	Less than 100% of tax benefits flow to Tax Equity Partner
Can be structured so that Developer does not have to make a fixed payment to Tax Equity Partner, reducing risk to Developer if project underperforms. Flip date can be delayed until economic is achieved.	Joint Venture between Developer and Tax Equity Partner must be in place prior to time solar assets are placed in service.
	Cost basis (for Tax purposes) may be Developers installation cost, which may be lower than Fair Market Value. This risk influences the value of ITC and therefore power price paid by City.

An inverted lease is the most complicated of the structures used to finance renewable energy projects. The developer and the tax equity partner create and fund two partnership entities; the developer partnership (lessor) and the master tenant partnership (lessee). The tax equity partner owns 99% of the master tenant partnership and 51% of the developer partnership, allowing the developer to keep 49% of the depreciation benefits. There are issues with this structure regarding asset valuation in a non-arm's length transaction, which raised IRS concerns, and in practice a limited number of tax equity partners are willing to enter into this financing structure.

5.2.2 Balance Sheet Financing

Under this scenario the City would finance PV projects through its own capital budgeting efforts and would not seek third party participation. As previously discussed, City ownership would preclude utilization of the ITC and result in a project LCOE that is higher than the cost of utility supplied power. As an alternative, the City could consider bidding for a Distributed Generation contract with the local utility which would pay an above market/premium price for power or a grant from the Commerce RI Renewable Energy Fund. (See Section 5.4.)

5.3 Federal Incentives

5.3.1 Modified Accelerated Cost-Recovery System (MACRS)

Corporate Tax Depreciation using the 5-year MACRS schedule may be applied to the installed cost of a solar PV project. Under the federal Modified Accelerated Cost Recovery System (MACRS), businesses may recover investments in certain property through depreciation deductions. The MACRS establishes a set of class lives for various types of property, ranging from three to fifty years, over which the property may be depreciated. Solar facilities are classified as five-year property.

Bonus depreciation allowing between 50% to 100% first year deductions have been in place since 2008, and most recently was extended to systems placed in service during 2014. The future applicability of the bonus depreciation is not known at this time.

5.3.2 Investment Tax Credit (ITC)

The ITC is equal to 30% of expenditures, with no maximum credit and is recognized as a key component in making solar energy projects economically feasible. The system must be placed in service before December 31, 2016. After that date the 30% ITC is currently set to expire, at which time it will revert to a 10% ITC.

5.4 State Incentives

In order to promote the development and installation of renewable energy projects there are a variety of state and federal incentives that are available to project owners, developers and operators. Programs applicable to the City of Providence are described below.

5.4.1 The Commerce RI Renewable Energy Fund (REF)

Grants from the REF are available for renewable energy projects on municipal property which are greater than 10 kW in size. These grants can provide project funding up to a maximum of $350,000 per project. Incentives proposed for 2015 (as of February 2015) are as follows:

- $1.15/W for the first 10-50kW
- $1.00/W for the 2nd 50kW (up to 100kW)
- $0.85/W for the 3rd 50kW (up to 150kW)
- $.070/W for the 4th 50kW (up to 200kW)
- $.055/W for the 5th 50kW (up to 250kW)
- $.040/W for all installed capacity over the first 250kW

Note that the REF grant cannot be combined with a Distributed Generation Standard Long Term Contract (described below).

Application Blocks 4, 5 and 6 are scheduled for 2015 per the following schedule:

Block	Solicitation Open	Application Due
Block 4	December 4, 2014	January 8, 2015
Block 5	February 2, 2015	March 10, 2015
Block 6	April 7, 2015	June 2, 2015

Applicants are required to provide the following information:

1. Energy audit

2. A signed turnkey contract with installer/developer
3. PPA (if utilized)
4. Electrical drawing
5. ROI/simple payback
6. Proof of project funds for construction
7. Copy of electric bill
8. Layout drawing showing major system components
9. Aerial image
10. A minimum 3 year workmanship warranty on labor associated with the installation.
11. Final Inspection: Commerce RI reserves the right to inspect all projects before final funding is released.
12. Projects must be completed within eighteen (18) months of contract signing.

Small-scale solar grants are allocated to projects smaller than 10 kW in size and are capped at $10,000 per project. However, projects can be "bundled" in groups of between 3 and 20 individual projects for a maximum of $350,000 in grant funds per solicitation period. Applicants are required to provide the following information:

1. Energy audit
2. A signed turnkey contract
3. ROI/simple payback
4. Copy of electric bill
5. A layout drawing
6. Aerial image
7. One (1) photo of the project location taken from the south looking northward toward the building or site
8. Shade-analysis
9. Manufacturer's specifications for panels to be installed
10. Manufacturer's specifications for inverter(s) to be installed
11. Electrical drawing
12. Final Inspection: Commerce RI reserves the right to inspect all projects before final funding is released.
13. Projects must be completed within twelve (12) months of contract signing.

Application Blocks 4, 5 and 6 are scheduled for 2015 per the following schedule:

Block	Solicitation Open	Application Due
Block 4	December 8, 2014	January 28, 2015
Block 5	March 4, 2015	April 17, 2015
Block 6	May 21, 2015	July 1, 2015

The Rhode Island Renewable Energy Fund will also fund predevelopment feasibility studies for solar projects being developed on brownfield sites. (The scope of work of this evaluation does not include investigation of potential brownfield sites.) As defined by the US Environmental Protection Agency a brownfield site is *"… real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant."* The REF will award loans up to $200,000 with a 20% cost share from the applicant for this work. Applicants are required to have conducted initial feasibility work and understand the technical and economic issues associated with the project. Applicants are also required to submit the following information:

1. Detailed scope of work
2. Detailed project budget with assumptions
3. Contracts with all major subcontractors working on the Study
4. Clear evidence of cost-sharing specific to the Study, including proof of funds
5. The municipality must have a clear path in place to allow the development of the proposed project.
6. For municipal projects:
    a. Any municipality applying for a pre-development feasibility study must include evidence of a Town/City Council vote in favor of the proposed project. The vote must also include approval to borrow money on behalf of the municipality.
7. Specific desired outcomes of the Pre-development Feasibility Study needed to catalyze project development. This list should include at a minimum:
    a. ROI/Simple Payback
    b. interconnection cost
    c. a financial plan with assumptions
    d. stakeholder feedback
    e. any physical opportunities or barriers
    f. all other items that could affect a projects ability to go forward

5.4.2 Renewable Energy at RI Schools Grant

The Rhode Island Office of Energy Resources has issued a Request for Proposals for funding renewable energy projects at schools (K-12) that also include an educational component as part of the project (http://www.energy.ri.gov/rfp/index.php). Grant awards are limited to 75% of total project costs up to a 50 kW system (or the 50 kW portion of a larger system). Applications were due by April 17, 2015. Over one million dollars is available for the program. Eligibility requirements include the following:

1. Eligible projects shall be renewable energy projects, including solar PV, installed on the school or on school grounds, and shall directly provide energy to the school, or produce energy savings for the school.
2. There are no restrictions against combining these funds with other Rhode Island energy funding programs, such as the Renewable Energy Fund (REF).
3. Eligible projects shall also include an educational program designed to support the understanding of the renewable energy project.
4. Grant awards may be used for the costs of the eligible project, including materials, labor, regulatory permitting, engineering, design, construction, and the cost of developing and implementing the educational component.

The solicitation explains that:

- Priority will be given to schools that have had an energy audit performed at their facility; have benchmarked their facility energy usage; and/or have implemented significant energy efficiency measures at their facilities.
- Eligible projects shall also include an educational program designed to support the understanding of the renewable energy project. For example, educational solar PV projects may include innovative classroom and extracurricular programs/projects that explore the science of solar energy and the generation of electricity from the sun. The project should include use of scientific data gathered from the actual project that can be analyzed by students to better understand how renewable projects generate energy and energy cost savings. It is recommended that the educational component be incorporated into the future educational curriculum at the school.
- In addition, the school must commit to send at least one (1) teacher to a National Energy Education Development (NEED) Rhode Island workshop.

Proposals will be competitively evaluated based on the following:

- Energy output of the installed system (kWh). Integration with other renewable or energy efficiency/energy conservation programs. Evidence that the school has benchmarked energy usage at the school (30%)

- Cost-effectiveness of the installed price per watt of the installation (30%)
- Current annual cost of electricity at the school (applicant must submit most recent electric bill) compared with the proposed annual cost of electricity at the school after the solar system is installed (10%)
- Educational component. Commitment to send one or more teachers to a NEED Project workshop in Rhode Island (20%)
- State or federal funds or tax credits leveraged (10%)

5.4.3 DISTRIBUTED GENERATION STANDARD CONTRACT (DGC)

Distributed Generation Standard Contracts (DGC), also referred to as a Feed-In Tariff, were enacted in 2011 by the State for renewable energy projects up to 3 MW in capacity. Rhode Island's Distributed Generation law requires that the state's electric distribution companies enter into standard 15 year contracts with eligible renewable energy generators. The DGC provides eligible generators with a fixed energy production payment that historically has been above the retail rate of utility power. As a result, a DGC is an attractive vehicle for ensuring the financial competitiveness of a PV project.

In 2014, Act H 7727 created the Renewable Energy Growth (REG) program (RIGL § 39-26.6.) with the goal of financing the development, construction, and operation of renewable-energy distributed-generation projects. Solar projects are grouped into four categories based on capacity:

- Small scale solar projects: up to 25kW
- Medium scale solar projects: 25kW to 250 kW
- Commercial scale solar projects: 250 kW to 1 MW
- Large scale solar projects: 1 MW to 5 MW

The goal of this program is to promote the installation of 160 MW of distributed renewable energy projects over 5 years beginning in 2015 by providing performance based payments to eligible projects for a 15 -20 year term. Based on the initial project sizes for rooftop solar in the City, it is anticipated that the City's solar projects would fall within the small, medium, and commercial classification.

Applicants interested in the DGC must bid directly to National Grid. Projects are awarded power contracts based on their comparison to other bidders and ceiling prices set by the State. As of February 2015, the 2015 schedule and price ceilings are yet to be finalized and published. Recommendations made by the Distributed Generation Board indicate that successfully bid solar projects will be required to have prices below the following ceiling prices:

Table 10: DGC Proposed Ceiling Prices

Eligible Technology	System Size	Contract Term	Recommended Ceiling Prices ($/kWh)
Small Solar - Host Financed	1 to 10 kW	15 years	.4135
Small Solar - Host Financed	1 to 10 kW	20 years	.3775
Small Solar I 3rd Party Financed	1 to 10 kW	20 years	.3295
Small Solar II	11 to 25 kW	20 years	.2980
Medium Solar	26 to 250 kW	20 years	.2440
Commercial Solar	251 to 999 kW	20 years	.2095
Large Solar	1 to 5 MW	20 years	.1670

Under the DGC, electricity generated by the eligible renewable energy project is sold directly to National Grid. Thus, the City would need to either finance and own the system and receive payments for power generated, or lease the rooftop to a developer who would own the project and receive the payments. Estimating LCOE based on the DGC ceiling prices suggests that a DGC could potentially provide a return on investment for any of the target sites.

5.4.4 Other State Incentives

Rhode Island allows cities and towns to exempt, by ordinance, renewable energy systems from property taxation. In addition, certain renewable energy systems and equipment sold in Rhode Island are exempt from the State's sales and use tax. Eligible products include solar electric systems, DC-to-AC inverters that interconnect with utility power lines, solar thermal systems, manufactured mounting racks and ballast pans for solar collectors. These tax incentives provide an additional benefit to the project owner, which helps support a competitive price for power to the City under a PPA.

6.0 STRATEGIC ADVICE FOR IMPLEMENTING SOLAR PROJECTS

The implementation of rooftop solar projects on City owned properties hinges on three key elements:

- Site applicability
- Power sales (kWh) and power price $/kWh (a function of solar efficiency, site characteristics and power contract)
- Project ownership, financing and construction costs

As discussed earlier in this report, the relative cost of producing solar energy falls as system size and energy production potential increases. This in turn is generally a function of a site's physical characteristics (i.e. rooftop area suitable for solar panel installation, shading, and solar panel orientation) and the size of the completed solar array. In addition to these project elements the power price paid will determine the overall economic efficiency of implementing rooftop solar projects.

In order to take advantage of the federal ITC, the City would need to enter into a Power Purchase Agreement, which typically includes a tax equity partner and a developer as counterparties. Typically, the developer and the tax equity partner would form a special purpose entity to implement the project.

After identifying potentially viable sites for solar projects, the City can issue a competitive solicitation to select a developer/contractor for the project. A simplified project implementation schedule is shown below:

- Select Site(s) RFP Process
    - Include pro-forma evaluation to compare ROI of various ownership models proposed.
    - Select Developer/Tax Partner
- Power Purchase Agreement
    - Enter into PPA with Developer/Tax Equity Partner
- Design/Permitting
- Construction
- Begin operations

The City can consider participating directly or indirectly in National Grid's Distributed Generation Standard Contract program. Direct participation involves City financing and ownership of the project; indirect participation would involve leasing the rooftop to a developer who would sell the power to National Grid. This alternative, which requires a competitive award of projects, may be preferable for smaller PV projects, as the economics of such projects under a PPA structure are not favorable in comparison to utility power prices.

An RFP should initially be issued for one or more selected Tier I and II sites. Based on the findings of this preliminary evaluation, the six sites most likely to be feasible are:

- Providence Career and Technical Academy (Tier I)
- Dr. Jorge Alvarez High School (Tier I),
- Public Safety Complex (Tier I),
- Mt. Pleasant High School (Tier II),
- George J. West Elementary School (Tier II)
- Carl G. Lauro Elementary School (Tier II)

Requested proposals should include, in part, the following:

- A detailed evaluation of each site including shading, obstacles, array layout, electrical connections, required improvements, system size, and construction logistics.
- A detailed description of the proposed ownership model including assumptions, limitations, and guarantees.

- A preliminary pro-forma evaluation of the proposed project including a description of all assumptions, margin of error, tax incentives, grants, and loans.
- A description of proposed mounting methods and roof warranty implications.

Criteria for evaluating potential PV sites should include, in part, the following:

- Return on Investment
- Upfront costs to the City, if any.
- Operation and Maintenance costs to the City, if any.
- Site accessibility, disturbance during construction.
- Educational value (to students and/or the public.)

If the City and School Department are in a position to do so it may be worthwhile to submit a proposal for the Renewable Energy at RI Schools Grant (See Section 5.4.2) as the grant could provide up to 75% of the total project cost up to a 50 kW system (or the 50 kW portion of a larger system). It appears feasible that a 50 kW PV system benefitting from this grant could be economically advantageous. A Distributed Generation Contract and a 30% ITC would further increase the return on investment. (The ITC is only applicable if the City partners with a tax paying entity.)

The schools listed above as well as the Nathanial Greene Middle School, the Nathan Bishop Middle School, and the Pleasant View Elementary school may all be viable candidates for the Renewable Energy at RI Schools Grant. The Nathanial Greene Middle School appears to be well suited for a 50 kW system and therefore is most likely to take full advantage of this grant. The larger schools may also be well suited for this grant if combined with supplemental financial incentives and/or the size of the system is limited.

7.0 LIMITATIONS AND CONDITIONS

1. Energy Production Potentials were estimated using NREL's PVWatts calculator. Photovoltaic system performance predictions calculated by PVWatts include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor many site-specific characteristics. More precise and complex modeling should be conducted prior to investing in any solar project.

2. All observations, calculations, estimates, opinions, and recommendations were made exclusively for use in a relative ranking of the Target Sites. The information presented herein may not be used for any other purpose. All information should be validated prior to design and construction.

3. The purpose of the structural inspections was to evaluate the relative condition and general suitability of the Target Sites. A more detailed structural evaluation should be conducted prior to design, permitting, and construction.

4. This report was prepared within the budgetary and time constraints imposed in the contract between Northeast Engineers & Consultants, Inc. (NE&C), and the Client.

5. Partial findings of this report are based on data provided by others. NE&C cannot guarantee the accuracy or completeness of this information.

8.0 APPENDICES

APPENDIX A TARGET SITE DATABASE

Table A-1: Target Site Database

Site ID	Name	Address	Use	Longitude	Latitude	Tax Assessor's Data: Plat	Lot	Built	Stories	Roof Structure	Bldg Footprint, sf	Lot Size, Acres	Zoning
1	Dr. Jorge Alvarez High School	375 Adelaide Ave.	High school	-71.430321	41.795117	51	323	2006	2	Flat	57621	4	M1
2	Mt. Pleasant High School	434 Mt. Pleasant Ave.	High School	-71.452782	41.839546	128	2	1920	4	Average	154363	28.92	R1
3	Classical High School	770 Westminster St.	High school	-71.420778	41.817593	29	491	1960	3	Average	75820	2.9	PS - WSOD/CCOD overlay
4	Hope High School	324 Hope St.	High school	-71.402078	41.834845	9	215	1938	4	Gable	101959	18.51	PS - HD
5	Roger Williams Middle School	278 Thurbers Ave.	Middle school	-71.410736	41.798504	54	325	1905	3	Average	63680	3.46	R3
6	Nathaniel Greene Middle	721 Chalkstone Ave.	Middle school	-71.431721	41.834494	82	92	1920	4	Average	90036	5.24	PS
7	Esek Hopkins Middle School	480 Charles St.	Middle school	-71.419947	41.848428	76	14	1920	3	Average	45226	0.75	PS
8	Gilbert Stuart Middle School	188 Princeton Ave. (160 Bucklin St.)	Middle school	-71.427054	41.804854	44	552	1930	3	Average	86934	3.22	R3
9	Nathan Bishop Middle School	101 Sessions St. (360 Elmgrove Ave.)	Middle school	-71.393505	41.840801	86	319	1910	3	Average	93846	5.37	R1
10	Pleasant View Elementary	50 Obediah Brown Rd.	Elementary	-71.462191	41.834607	129	1	1983	2	Average	600	63.33	OS
11	George J. West Elementary	145 Beaufort St.	Elementary	-71.450336	41.830829	64	508	1906	3	Average	45860	2.23	PS
12	Carl G. Lauro Elementary School	99 Kenyon St.	Elementary	-71.425864	41.821431	28	827	1927	3	Average	62494	1.56	PS
13	Providence City Hall	25 Dorrance St.	Administrative	-71.412914	41.824173	20	38	1847	5	Average	79484	0.74	D1-100, DD Overlay
14	Providence Schools Administration	797 Westminster St.	Administrative	-71.421411	41.818029	29	134	1945	4	Average	28050	0.99	C4 - WSOD overlay
15	Providence Emergency Management Agency	591 Charles Street	Admin/Garage	-71.420097	41.85237	71	611	1930	2	Gable	2808	0.66	C2
16	Public Safety Complex	325 Washington Street	Public safety	-71.420735	41.820103	25	456	2002	3	Average	78824	2.79	C2
17	Public Safety Complex Garage	349 West Fountain St.	Garage	-71.421282	41.819733	29	533	2001	6	Average	25408	0.77	C4
18	Department of Public Works	20 Ernest Street	Garage	-71.395318	41.79426	101	4	1930	1	Average	41618	5.85	R2
19	DPW Traffic Engineering	40 Ernest St.	Maintenance garage	-71.396606	41.794544	101	4	1930	2	Average	41618	5.85	R2
20	Providence Career and Technical Academy	41 Fricker Street	School	-71.422049	41.816425	29	546	2009	3	Average	84345	8.93	C2, CCOD Overlay

Table A-1: Target Site Database

Site ID	Name	2011 Aerial Photograph Roof Orientation	Potential Shading	Useful Roof Area, M^2	Surrounding Use	PVWatts PV Size, kW	EPP, MWh/yr	Notes
1	Dr. Jorge Alvarez High School	Flat	Little-none	2860	Residential	458	574	
2	Mt. Pleasant High School	Flat	Little-none	1150	Residential	180	226	
3	Classical High School	Flat	Little-none	3500	Municipal	560	702	Building covers Lots 491, 492, and 493. Lot 491 in WSOD Lot 493 in CCOD
4	Hope High School	Gable E/W	Little-none	970	Residential	150	188	Roof area excludes gable roof
5	Roger Williams Middle School	Flat	Little-none	450	Resid. and Commercial	70	88	
6	Nathaniel Greene Middle	Flat	Little-none	430	Residential	70	88	
7	Esek Hopkins Middle School	Flat	Little-none	220	Residential	30	38	
8	Gilbert Stuart Middle School	Flat	Little-none	550	Residential	80	100	
9	Nathan Bishop Middle School	Flat	Little-none	830	Residential	130	163	
10	Pleasant View Elementary	Circular	Med-Heavy	1227	Residential	190	198	3 buildings total/2nd building: 67176sf - built 1950/3rd building: 6000sf - built 2010
11	George J. West Elementary	Flat	Little-none	1180	Residential	180	226	
12	Carl G. Lauro Elementary School	Flat	Little-none	1120	Residential	180	225	
13	Providence City Hall	Flat	Little-none	110	Commercial	10	13	
14	Providence Schools Administration	Flat	Little-none	550	Commercial	90	113	
15	Providence Emergency Management Agency	South	Little-none	40	Resid. and Commercial	5	6	
16	Public Safety Complex	Flat	Little-none	1560	Commercial	250	316	
17	Public Safety Complex Garage	Flat	Little-none	900	Commercial	140	175	Building is garage. PV units would replace parking spaces.
18	Department of Public Works	Flat	Little-Med.	2340	Commercial	370	422	Trees and adjacent building to south, area includes southern side of rounded roof
19	DPW Traffic Engineering	Flat	Little-none	2570	Commercial	410	514	Very few roof obstructions
20	Providence Career and Technical Academy	Flat	Little-none	3300	Commercial	528	662	2nd building: 20646sf - built 1950

Table A-2: Roof Inspection Summary Tabulation

Site ID	Name	Stories	1. Roof Structure & Deck Type	Fair. Roof Structure Condition	3. Roofing System Type	Excellent. Roofing System Condition	5. Roof Surface Durability	6. Estimated / Reported Age of Roofing System
1	**Dr. Jorge Alvarez High School**	2	Based on age, assume steel joists with steel deck and rigid insulation	Excellent	Black Membrane, EPDM, fully adhered	Excellent	firm (possibly OSB or plywood substrate over rigid insulation)	8 years
2	**Mount Pleasant High School**	4	possibly concrete	Fair	White membrane (EPDM), fully adhered	Fair	soft (rigid insulation substrate, probably no plywood or OSB)	Based on 2011 aerial photo, roof was replaced in 2011, therefore roof is 3 years old.
3	**Classical High School**	3	concrete deck (assumed)	Good	black membrane with stone ballast. Typical of all roofs except west wing which has a newer white membrane,EPDM, fully adhered.	Fair	medium soft	new wing is 3 years old, the other roofs are reportedly approx. 16 years old.
4	**Hope High School**	4	unknown	Good	New Science wing; white membrane, EPDM, fully adhered. Main Bldg; asphalt shingled gabled roof. Auditorium & Gymnasium; black membrane with gravel ballast.	Good	firm/hard	white membrane- 3-5 years ballasted roof- 10-15 years
5	**Roger Williams Middle School**	3	Building is similar to Nathaniel Greene Middle School, assume concrete roof	Good	Black membrane with gravel ballast.	Good	hard/firm	based on similarity to Classical HS, assume approx. 15 years old
6	**Nathaniel Greene Middle School**	4	Concrete based on observations made from Auditorium attic	Good	White membrane, EPDM, fully adhered	Good	firm/hard with some soft spots	approx. 3 years based on 2011 aerial showing a black roofing
7	**Exek Hopkins Middle School**	3	unknown	Good	Black membrane, EPDM, adhered (some areas do not appear to be adhered based on apparent wrinkles (see photos).	Poor	hard, possibly plywood or OSB substrate. Many places felt like cracking and giving way under footsteps.	approx. 5-10 years
8	**Gilbert Stuart Middle School**	3	Building is similar to Nathaniel Greene Middle School, assume concrete roof	Good	Black membrane with gravel ballast	Good	Hard/firm	similar to Classical, approx. 15 years
9	**Nathan Bishop Middle School**	3	unknown	Good	White membrane, EPDM, fully adhered	Excellent	hard/firm	Installed in 2009 renovations, approx. 5 years
10	**Pleasant View Elementary**	2	Gymnasium is steel joist with steel deck, assume rest of building is similar construction. Pool wing is glulam beams and wood deck.	Good	White membrane, EPDM, fully adhered.	Good	hard/firm	Estimated 8-10 years
11	**George J. West Elementary**	3	Concrete, underside of roof could be observed from attic space.	Good	white membrane, EPDM, fully adhered	Excellent	hard/firm	<3 years based on 2011 aerial showing black roofing.
12	**Carl G. Lauro Elementary**	3	From attic, it appears to be wood framed.	Fair	White membrane, EPDM, fully adhered.	Excellent	firm/hard	Estimate <3 years based on 2011 aerial showing black roofing
13	**Providence City Hall**	5	Steel beams and girders with steel grillage with concrete infill deck.	Fair	textured membrane fully adhered. Painted coating.	Good	hard/firm	10-15 years (estimated)
14	**Providence Schools Administration Bldg.**	4	Possibly steel joists and steel deck based on visible roof in mechanical penthouse.	Good	Black membrane, EPDM, fully adhered.	Excellent	medium soft	estimated < 3 years
15	**Providence Emergency Management Agency**	2	New addition built 2013, assume to be steel joists with steel deck.	Excellent	Black membrane, EPDM, fully adhered.	Excellent	hard/firm	1 year
16	**Providence Public Safety Complex**	3	Steel Joists with Steel decking	Excellent	Black membrane, EPDM, fully adhered, over rigid insulation	Excellent	firm/hard	12 years (assuming original)
17	**Providence Public Safety Complex Parking Garage**	6	Precast Concrete Parking Deck	Good	No roof, just the concrete parking deck.	NA	NA	NA
18	**Providence Department of Public Works**	1	Steel Beams and Steel deck	Good	Black membrane, EPDM, fully adhered. Stone ballast only on the west end approx. 30 feet.	Good	firm with some soft spots. In one area, membrane is draped from parapet to create a cant, but nothing solid under membrane.	Estimate 5-10 years
19	**Providence DPW Traffic Engineering Bldg**	2	unknown	Poor	Builtup-Tar & Gravel	Poor	Soft	estimated >30years
20	**Providence Career & Technical Academy**	3	Old part of bldg, south wing appears to be concrete waffle slab. New part assumed to be steel joists and metal deck. Field House was observed from below to be steel girders and metal deck.	Excellent	White membrane, EPDM, fully adhered.	Excellent	firm/hard	5 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

Table A-2: Roof Inspection Summary Tabulation

SiteID	Name	7. Estimated Remaining Useful Life	8. Observable Required Repairs	9. Roof Access	10. Security against Vandalism	11. Roof Pitch and Orientation
1	**Dr. Jorge Alvarez High School**	12-17 years	none	walk-out full size door from 2nd floor northwest hall to lower roof. Fixed wall mounted ladder to upper roofs.	Locked door from 2nd floor hall, fixed ladder to upper roof	low pitch towards interior drains on Main Bldg. scuppers on gymnasium
2	**Mount Pleasant High School**	17 to 22 years	Leaks appear to be related to clogged roof drains over library. Other leaks may require membrane repairs.	ladders from old greenhouse to door leading directly onto roof. Various fixed wall mounted ladders to various roofs	access doors to greenhouse floor is locked.	low pitch towards interior drains.
3	**Classical High School**	4 to 9 years	reported leaks exist. Seams show signs of opening up.	Doors at top of stair towers lead directly onto roofs.	Doors are lockable but one would not open, others were observed to be propped open.	low pitch towards interior drains.
4	**Hope High School**	white membrane- 15-20 years ballasted roof- 5-10 years	None	fixed wall mounted ladder from upper hallway in science wing to penthouse, then door directly onto roof.	fixed ladder has a lockable gate over it.	low pitch towards interior drains.
5	**Roger Williams Middle School**	Approx. 5 - 10 years	Seams are opening up in various locations, possible leaks.	climbed through window onto lower roof, then up fixed wall mounted ladders to upper roofs.	only (2) windows provide access, both located in teachers offices with locked doors.	low pitch towards interior drains
6	**Nathaniel Greene Middle School**	17 - 22 years	None	climbed through window onto lower roof, then up fixed wall mounted ladders to upper roofs.	only (2) windows provide access, both located in teachers offices with locked doors.	low pitch towards interior drains
7	**Exek Hopkins Middle School**	5-10 years based on comments above.	Reported leaks, refer to above comments.	fixed ladder in Boys restroom on 4th floor. Ladder leads to small door which opens directly onto lower roof. Fixed wall ladders provide access to upper roof.	Boys Room is kept locked and ladder has locked cage.	Low pitch towards interior drains.
8	**Gilbert Stuart Middle School**	5-10 years	None	climbed through window onto lower roof, then up fixed wall mounted ladders to upper roofs.	only (2) windows provide access, both located in teachers offices with locked doors.	low pitch towards interior drains
9	**Nathan Bishop Middle School**	15-20 years	None, some drains are clogged.	Short fixed ladder in closet, through door directly onto lower roof, fixed wall mounted ladders to upper main roof.	Closet door kept locked.	Low pitch towards interior drains.
10	**Pleasant View Elementary**	15-20 years	Standing water due to improper pitch. Clogged drain grates.	No access, used 10 foot step ladder.	No direct access but roof is only single story high.	Each wing has a sloped roof (2:12+) pitching towards outer edges. Interior drains located at wing intersections with center hub.
11	**George J. West Elementary**	17-22 years	None	(2) interior fixed ladders located in the upper floor hallways lead to old hatches that have been roofed over. The only roof hatch does not have a ladder. Had to use a tall step ladder to reach.	No direct or easy access.	Low pitch towards interior drains.
12	**Carl G. Lauro Elementary**	17-22 years	None to roof, did observe large vertical crack in chimney.	Fixed interior ladder in custodian closet, through roof hatch. Typical each wing. Fixed exterior ladders to lower roofs.	Custodial closet is kept locked.	Low pitch towards interior drains.
13	**Providence City Hall**	5-10 years	None	Stairs to roof hatch.	Gate to stairs that lead to attic is locked.	Roof slopes to edge parapet and is drained with interior drains.
14	**Providence Schools Administration Bldg.**	17-22 years	None	Walk-out door from Mechanical Penthouse	Building is secure, must be buzzed in and sign in at front desk.	low pitch to interior drains.
15	**Providence Emergency Management Agency**	19-24 years	None	Ladder Stair to walk-out door onto roof	Facility is gated and secure.	low pitch to edge gutters.
16	**Providence Public Safety Complex**	8-13 years	Clogged drain grates	Each wing is accessed via at ship ladder at the top landing of the stair towers. Roof hatches provide direct access to roof.	Access into building is secure.	Low pitch towards interior drains.
17	**Providence Public Safety Complex Parking Garage**	NA	None	Parking garage deadends at roof level. Must turn around to exit.	Garage was open and free to public at time of inspection.	deck pitches towards interior drains
18	**Providence Department of Public Works**	10 - 15 years	Standing water due to poor drainage, clogged drain grates	No direct access, used a ladder up against the rear of the building.	Embankment and trees up against the south side of the building appear to provide access for vandals and animals (fresh raccoon tracks were observed). Graffiti was found on the arched roof.	Low pitch towards interior drains. Some areas are not draining and vegetation was observed in at least one area.
19	**Providence DPW Traffic Engineering Bldg**	0 years	Clogged drains, standing water, vegetation, failed flashing,	direct walk-out access from old map room.	building is locked.	Low pitch towards interior drains.
20	**Providence Career & Technical Academy**	15-20 years	None	Stairs to door, walk-out directly on roof. Ladder to Field House roof.	Stairway has locked gate.	Low pitch to interior drains. Field House has low pitch from center ridge to east and west eave gutters.

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

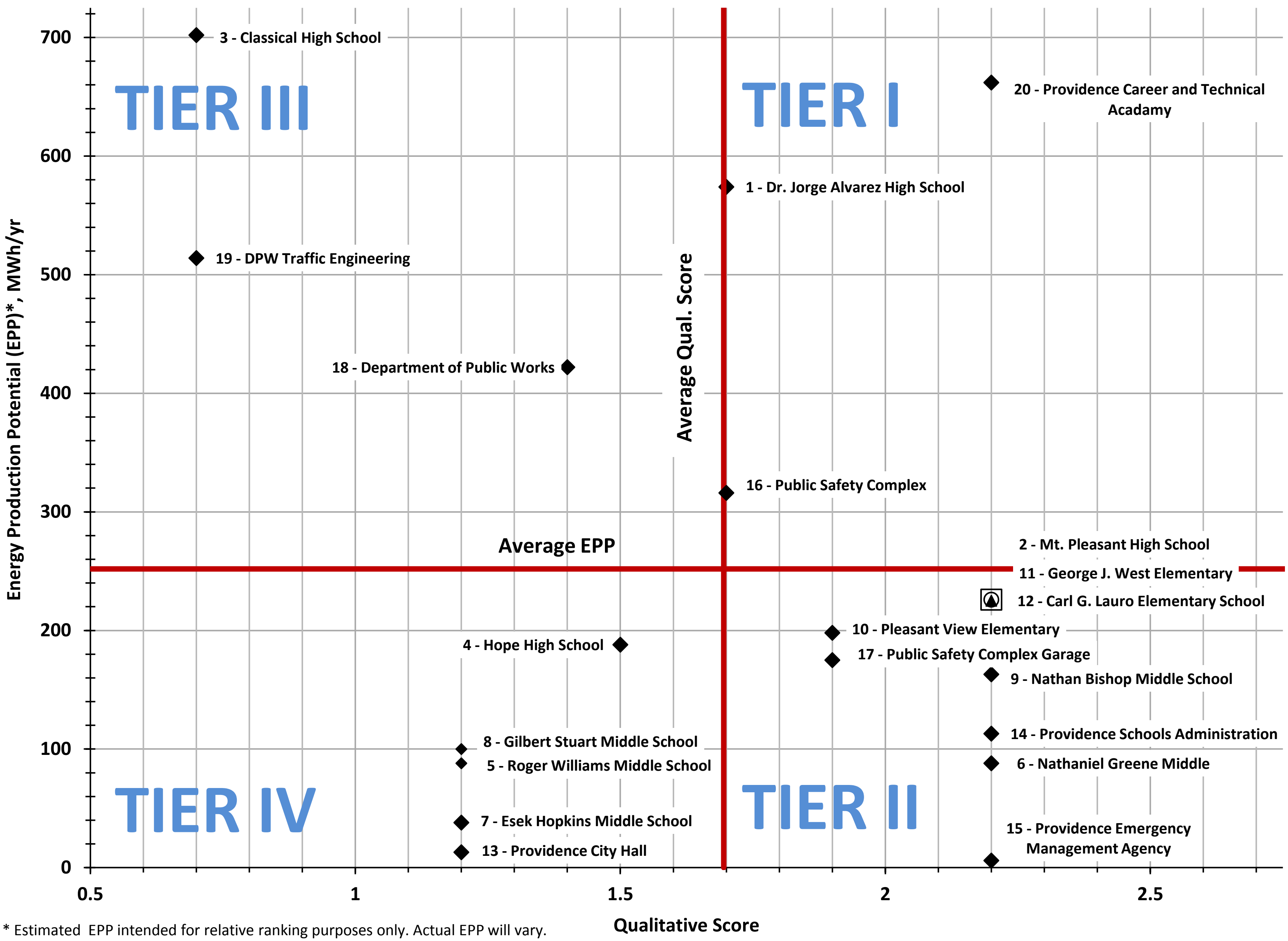
Table A-2: Roof Inspection Summary Tabulation

SiteID	Name	12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)	13. Existing Parapet	14. Potential Shading	Notes:
1	**Dr. Jorge Alvarez High School**	vents, drains, HVACs on gymnasium	Y	None	
2	**Mount Pleasant High School**	none on gymnasium, main building has various skylights, vents, conduits, wiring troughs. Existing PV & H/W solar panels located on the north end of the north wing.	N	none	
3	**Classical High School**	stair towers, skylights, HVAC and vents on new roof. Existing PV & H/W solar panels on new roof.	Y	Stair towers	Campus has (3) buildings: Main School; Auditorium (very little useable space); Gymnasium (couldn't open door to get on roof)
4	**Hope High School**	Vents, HVAC, skylights. Existing PV & H/W solar on science wing roof.	N	None	
5	**Roger Williams Middle School**	Vents, drains, and what may be old vent and/or skylight structures.	Y	None on upper roofs, auditorium has tall projection to the south.	Charlotte Woods Elementary School is located to the south. Building appears to have a flat roof clear of obstructions and may be a potential site.
6	**Nathaniel Greene Middle School**	Vents, drains, and what may be old vent and/or skylight structures.	Y	None	
7	**Exek Hopkins Middle School**	Skylights, drains, vents.	Y	None	
8	**Gilbert Stuart Middle School**	Vents, skylights and drains	Y	None on upper roofs, auditorium has tall projection to the south.	
9	**Nathan Bishop Middle School**	Vents, drains, skylights, HVAC units. Existing tube solar panel system (assume hot water)	Y	None	Major renovations occurred in 2009 ($33M). School is like new interior and exterior.
10	**Pleasant View Elementary**	each wing has a center raised flat roof (4 foot high), various vents, conduits, cables and chimneys.	N	Building is one story and has tall tress to the south, east, and west.	
11	**George J. West Elementary**	Skylights, chimney, and vents.	N	None	Did not have access to gymnasium roof.
12	**Carl G. Lauro Elementary**	Old roof vent structures,skylights, vent stacks.	N	None	
13	**Providence City Hall**	Large monitor runs the length of the building, chimneys, vents, and skylights.	Y	Biltmore Hotel is located to the northwest.	
14	**Providence Schools Administration Bldg.**	HVAC unit, vents, and roof drains	Y	none	
15	**Providence Emergency Management Agency**	None on lower roof. Upper roof has HVAC units	N	Upper roof and original building taller than lower roof.	
16	**Providence Public Safety Complex**	Vents, conduits, cables, HVAC units, exhaust fans.	Y	None	
17	**Providence Public Safety Complex Parking Garage**	None	Y	Elevator/Stair Tower with large communication tower is located on the south end of the building.	Parking spaces would need to be given up if solar were to be installed on the upper roof level.
18	**Providence Department of Public Works**	Skylights, vents, exhaust fans, pipes, and conduits	N	Large trees along the south side of the building.	
19	**Providence DPW Traffic Engineering Bldg**	Drains grates only	N	None	Roof is open and spacious however in very poor condition. In addition, building is in overall poor condition and several structural defiencies were observed. - Face brick on the Ernest Street side has fallen off the building. - Apparent significant settlement has occurred at the garage overhead door of the VIN station. Slab is cracked and settled, and significant cracking in the walls around the door were observed.
20	**Providence Career & Technical Academy**	vents, piping, conduits, HVAC units. Existing H/W solar panels located on southern end of new wing. Field House roof is open with only lightening rods.	Y	None	

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

APPENDIX B TARGET SITE RANKING

Figure B-1: Relative Site Ranking



* Estimated EPP intended for relative ranking purposes only. Actual EPP will vary.

Table B-1: PV Solar Target Site Ranking Matrix (Qualitative Factors)

Site ID	Name	Zoning	Zoning Score (weight = 0.2)	Remaining Roof Life*	Rem. Life Score* (weight = 0.5)	Security against Vandalism	Security Score (weight = 0.3)	Total Score
2	Mt. Pleasant High School	R1	2	17	3	Access doors to greenhouse floor is locked.	1	2.2
6	Nathaniel Greene Middle	PS	2	17	3	Only (2) windows provide access, both located in teachers offices with locked doors.	1	2.2
9	Nathan Bishop Middle School	R1	2	15	3	Closet door kept locked.	1	2.2
11	George J. West Elementary	PS	2	17	3	No direct or easy access.	1	2.2
12	Carl G. Lauro Elementary School	PS	2	17	3	Custodial closet is kept locked.	1	2.2
14	Providence Schools Administration	C4 - WSOD overlay	2	17	3	Building is secure, must be buzzed in and sign in at front desk.	1	2.2
15	Providence Emergency Management Agency	C2	2	19	3	Facility is gated and secure.	1	2.2
20	Providence Career and Technical Acadamy	C2, CCOD Overlay	2	15	3	Stairway has locked gate.	1	2.2
10	Pleasant View Elementary	OS	2	15	3	No direct access but roof is only single story high.	0	1.9
17	Public Safety Complex Garage	C4	2		3	Garage was open and free to public at time of inspection.	0	1.9
1	Dr. Jorge Alvarez High School	M1	2	12	2	Locked door from 2nd floor hall, fixed ladder to upper roof	1	1.7
4	Hope High School	PS - HD	1	10	2	Fixed ladder has a lockable gate over it.	1	1.5
18	Department of Public Works	R2	2	10	2	Embankment and trees up against the south side of the building appear to provide access for vandals and animals (fresh raccoon tracks were observed). Graffiti was found on the arched roof.	0	1.4
5	Roger Williams Middle School	R3	2	5	1	Only (2) windows provide access, both located in teachers offices with locked doors.	1	1.2
7	Esek Hopkins Middle School	PS	2	5	1	Boys Room is kept locked and ladder has locked cage.	1	1.2
8	Gilbert Stuart Middle School	R3	2	5	1	Only (2) windows provide access, both located in teachers offices with locked doors.	1	1.2
13	Providence City Hall	D1-100, DD Overlay	2	5	1	Gate to stairs that lead to attic is locked.	1	1.2
16	Public Safety Complex	C2	2	10	2	Access into building is secure.	1	1.7
3	Classical High School	PS - WSOD/CCOD overlay	2	4	0	Doors are lockable but one would not open, others were observed to be propped open.	1	0.7
19	DPW Traffic Engineering	R2	2	0	0	Building is locked.	1	0.7

Note: Estimated remaining roof life is intended for comparitive ranking purposes only.

Table B-2: Qualitative Scoring Key

Category	Score	Description	Weight
Zoning			20%
	1	Historic District - special permitting required	
	2	All others - permitted as accessory structure	
Estimated Remaining Roof Life			50%
	0	< 5 yrs	
	1	5 - 10 yrs	
	2	10 - 15 yrs	
	3	15 - 20 yrs	
Security			30%
	0	Relatively unsecure	
	1	Relatively secure	
Total Weight			**100%**
Max possible weighted score	**2.2**		

APPENDIX C INDIVIDUAL SITE REPORTS

Solar Feasibility Site Evaluation Summary

Site ID:	1
Name:	Dr. Jorge Alvarez High School
Address:	375 Adelaide Avenue
Tier Ranking:	I
Building Use:	High School
Approx. Potential PV system size, kw	460
Approx. EPP, MWh/yr:	574
Site Qualitative Score:	1.7
LCOE with 30% ITC, $/kWh:	0.075

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site and the approximate Energy Production Potential (EPP) are both above average resulting in a Tier I ranking. Tier I sites have the most potential for a successful solar PV project and warrant a more detailed evaluation.

Rooftop observations are reported in the attached Roof Inspection Report.

2011 Orthophoto

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

RESULTS

574,005 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	32,223	2,610
February	3.67	38,634	3,129
March	4.58	51,905	4,204
April	5.35	57,152	4,629
May	5.78	61,629	4,992
June	6.15	61,609	4,990
July	6.39	64,721	5,242
August	5.95	60,586	4,907
September	4.55	45,910	3,719
October	4.00	43,430	3,518
November	2.74	29,813	2,415
December	2.28	26,394	2,138
Annual	**4.51**	**574,006**	**$ 46,493**

User Comments

Dr. Jorge Alvarez High School

Location and Station Identification

Requested Location	375 Adelaide Ave. providence ri
Weather Data Source	(TMY2) PROVIDENCE, RI 5.4 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	458 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

Northeast Engineers & Consultants, Inc.
"A Knowledge Corporation"®

Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study	Project No.:	14132.0
Inspector:	S. Otten	Temperature	43 ºF
Weather:	Sunny		
Date:	12/4/2014	Arrival Time	11:50AM
Departure Time:	12:15PM		

Site ID	1		
Name	Dr. Jorge Alvarez High School		
Address	375 Adelaide Avenue		
Use	High School	Stories	2
Year Built	2006		

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

Based on age, assume steel joists with steel deck and rigid insulation

2. Roof Structure Condition

	Poor	Comments:
	Fair	
	Good	
X	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

Black Membrane, EPDM, fully adhered

4. Roofing System Condition

	Poor	Comments:
	Fair	
	Good	
X	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

firm (possibly OSB or plywood substrate over rigid insulation)

6. Estimated/Reported Age of Roofing System

8 years

7. Estimated Remaining Useful Life

12-17 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

none

9. Roof Access (i.e. hatch, stairs, ladder)

walk-out full size door from 2nd floor northwest hall to lower roof. Fixed wall mounted ladder to upper roofs.

10. Security against Vandalism

Locked door from 2nd floor hall, fixed ladder to upper roof

11. Roof Pitch and Orientation

low pitch towards interior drains on Main Bldg. scuppers on gymnasium

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

vents, drains, HVACs on gymnasium

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

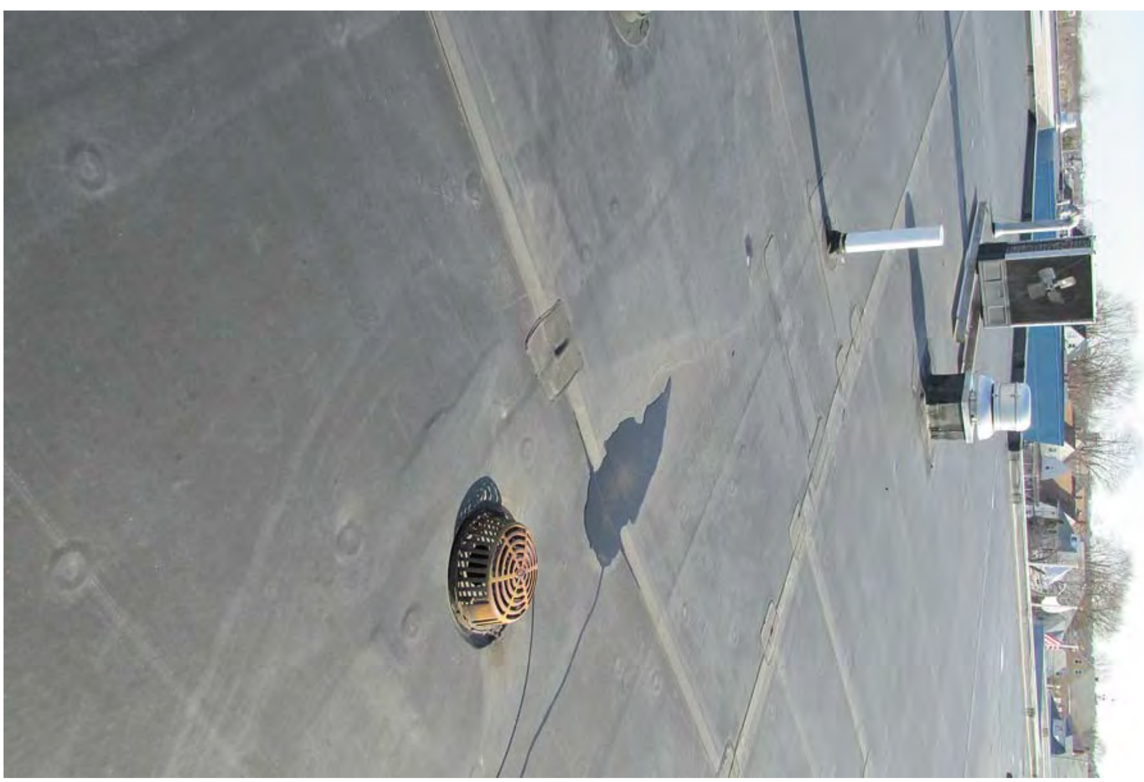
X	Yes	Height	8 inches
	No		

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

None

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.



Solar Feasibility Site Evaluation Summary

Site ID:	2
Name:	Mt. Pleasant High School
Address:	434 Mt. Pleasant Ave.
Tier Ranking:	II
Building Use:	High School
Approx. Potential PV system size, kw	180
Approx. EPP, MWh/yr:	226
Site Qualitative Score:	2.2
LCOE with 30% ITC, $/kWh:	0.080

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site is above average and the approximate Energy Production Potential (EPP) is slightly below average resulting in a Tier II ranking. Tier II sites are not top ranked however, they still have a reasonable potential for a successful solar PV project and warrant a more detailed evaluation.

Rooftop observations are reported in the attached Roof Inspection Report.

2011 Orthophoto

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Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

RESULTS

225,591 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	12,664	1,026
February	3.67	15,184	1,230
March	4.58	20,399	1,652
April	5.35	22,462	1,819
May	5.78	24,221	1,962
June	6.15	24,213	1,961
July	6.39	25,436	2,060
August	5.95	23,811	1,929
September	4.55	18,043	1,461
October	4.00	17,068	1,383
November	2.74	11,717	949
December	2.28	10,373	840
Annual	**4.51**	**225,591**	**$ 18,272**

Location and Station Identification

Requested Location	434 Mt. Pleasant Ave. Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 8.5 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	180 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

Northeast Engineers & Consultants, Inc.
"A Knowledge Corporation"®

Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study			Project No.:	14132.0
Inspector:	S. Otten	Temperature	42ºF	Weather:	Rain/Cloudy
Date:	12/10/2014	Arrival Time	9:00AM	Departure Time:	10:40AM

Site ID	2				
Name	Mount Pleasant High School				
Address	434 Mt. Pleasant Avenue				
Use	High School	Stories	4	Year Built	1920

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

possibly concrete

2. Roof Structure Condition

	Poor	Comments:
X	Fair	
	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

White membrane (EPDM), fully adhered

4. Roofing System Condition

	Poor	Comments: visually observed active leaks in library
X	Fair	
	Good	
	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

soft (rigid insulation substrate, probably no plywood or OSB)

6. Estimated/Reported Age of Roofing System

Based on 2011 aerial photo, roof was replaced in 2011, therefore roof is 3 years old.

7. Estimated Remaining Useful Life

17 to 22 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

Leaks appear to be related to clogged roof drains over library. Other leaks may require membrane repairs.

9. Roof Access (i.e. hatch, stairs, ladder)

ladders from old greenhouse to door leading directly onto roof. Various fixed wall mounted ladders to various roofs

10. Security against Vandalism

access doors to greenhouse floor is locked.

11. Roof Pitch and Orientation

low pitch towards interior drains.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

none on gymnasium, main building has various skylights, vents, conduits, wiring troughs. Existing PV & H/W solar panels located on the north end of the north wing.

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

	Yes	Height	____________
X	No		

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

none

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.


GENERAC

Solar Feasibility Site Evaluation Summary

Site ID:	3
Name:	Classical High School
Address:	770 Westminster St.
Tier Ranking:	III
Building Use:	High School
Approx. Potential PV system size, kw	560
Approx. EPP, MWh/yr:	702
Site Qualitative Score:	0.7
LCOE with 30% ITC, $/kWh:	0.073

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site is below average and the approximate Energy Production Potential (EPP) is above average resulting in a Tier III ranking. Tier III sites have low potential for a successful solar PV project as-is. However, additional improvements to the building would increase the qualitative score making the site a good candidate.

The Classical High School site received a low qualitative score because the estimated remaining roof life is 4 to 9 years for all but the new wing. Installing solar arrays on a roof that will need to be replaced in as soon as 4 years is not desirable. However, this Site has one of the highest Energy Production Potentials of the 20 evaluated. A detailed analysis may be warranted to determine if it is economical to replace the roofs early, prior to installing a solar array or if it is economically feasible to replace the roof during the lifetime of the PV array. Alternatively, the Site could be reevaluated at a later date once the existing roof has reached the end of its life and is replaced as scheduled.

This Site is located in a Historic District. Proposed solar PV systems will require the approval of the Historic District Commission.

Rooftop observations are reported in the attached Roof Inspection Report.

2011 Orthophoto

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RESULTS

701,840 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	39,400	3,191
February	3.67	47,238	3,826
March	4.58	63,464	5,141
April	5.35	69,880	5,660
May	5.78	75,354	6,104
June	6.15	75,330	6,102
July	6.39	79,134	6,410
August	5.95	74,078	6,000
September	4.55	56,134	4,547
October	4.00	53,102	4,301
November	2.74	36,453	2,953
December	2.28	32,272	2,614
Annual	**4.51**	**701,839**	**$ 56,849**

User Comments

Classical High School

Location and Station Identification

Requested Location	770 Westminster St. Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 7.0 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	560 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study			Project No.:	14132.0
Inspector:	S. Otten	Temperature	40 ºF	Weather:	Sunny
Date:	12/4/2014	Arrival Time	9:00AM	Departure Time:	10:30AM

Site ID	3				
Name	Classical High School				
Address	770 Westminster Street				
Use	High School	Stories	3	Year Built	1960

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

concrete deck (assumed)

2. Roof Structure Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

black membrane with stone ballast. Typical of all roofs except west wing which has a newer white membrane,EPDM, fully adhered.

4. Roofing System Condition

	Poor	Comments:
X	Fair	West wing roof is in excellent condition
	Good	
	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

medium soft

6. Estimated/Reported Age of Roofing System

new wing is 3 years old, the other roofs are reportedly approx. 16 years old.

7. Estimated Remaining Useful Life

4 to 9 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

reported leaks exist. Seams show signs of opening up.

9. Roof Access (i.e. hatch, stairs, ladder)

Doors at top of stair towers lead directly onto roofs.

10. Security against Vandalism

Doors are lockable but one would not open, others were observed to be propped open.

11. Roof Pitch and Orientation

low pitch towards interior drains.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

stair towers, skylights, HVAC and vents on new roof. Existing PV & H/W solar panels on new roof.

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

X	Yes	Height	20 in.
	No		

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

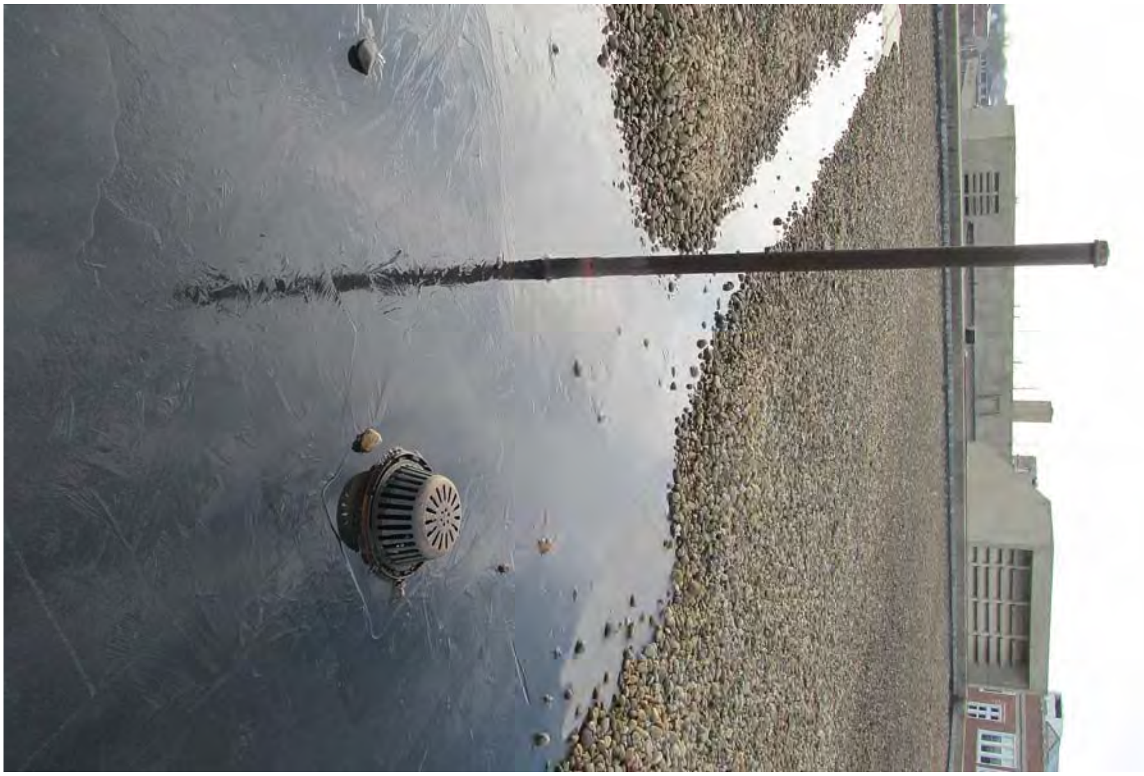
Stair towers

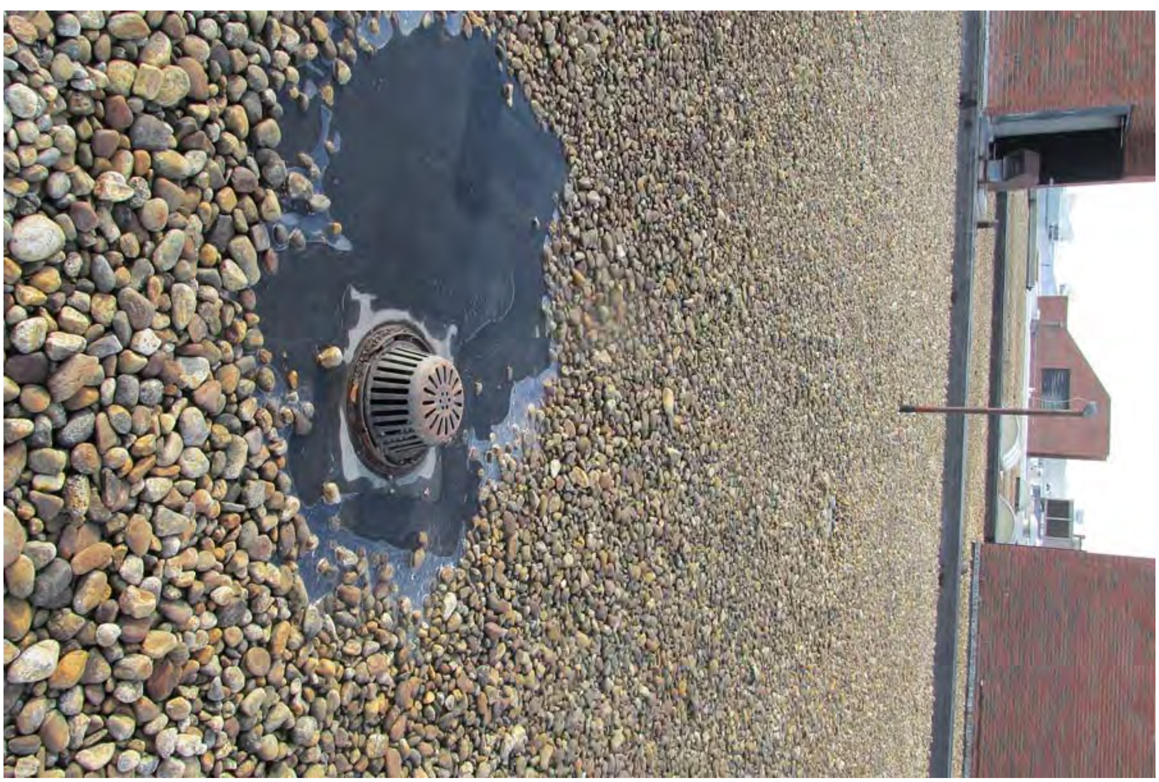
Notes:

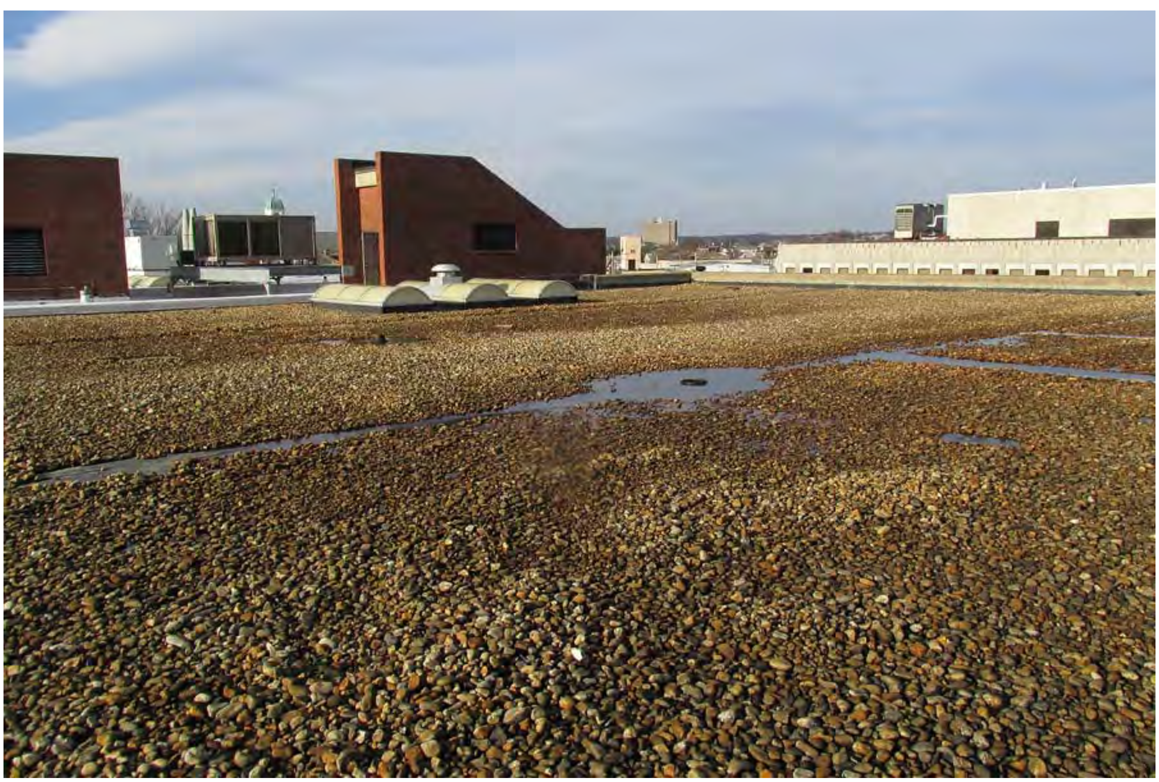
Campus has (3) buildings:

- Main School
- Auditorium (very little useable space)
- Gymnasium (couldn't open door to get on roof)

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.








2013

Solar Feasibility Site Evaluation Summary

Site ID:	4
Name:	Hope High School
Address:	324 Hope St.
Tier Ranking:	IV
Building Use:	High School
Approx. Potential PV system size, kw	150
Approx. EPP, MWh/yr:	188
Site Qualitative Score:	1.5
LCOE with 30% ITC, $/kWh:	0.080

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

Both the qualitative score of this Site and the approximate Energy Production Potential (EPP) are below average resulting in a Tier IV ranking. Tier IV sites have the least potential for a successful solar PV project.

Rooftop observations are reported in the attached Roof Inspection Report. Note that the science wing roof has an estimated 15 – 20 year remaining life while the auditorium and gymnasium roofs have 5 – 10 years of remaining life. A 10 year life was assumed for scoring purposes. Existing PV and solar hot water systems are already installed on the newer roof.

The gable roof and lower level roofs were not considered in the roof area estimate. The gable roof is oriented east-west, which is not ideal for solar PV, and the lower roofs are likely to be shaded by the upper roofs.

2011 Orthophoto

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RESULTS

187,993 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	10,553	855
February	3.67	12,653	1,025
March	4.58	16,999	1,377
April	5.35	18,718	1,516
May	5.78	20,184	1,635
June	6.15	20,178	1,634
July	6.39	21,197	1,717
August	5.95	19,842	1,607
September	4.55	15,036	1,218
October	4.00	14,224	1,152
November	2.74	9,764	791
December	2.28	8,644	700
Annual	**4.51**	**187,992**	**$ 15,227**

User Comments

Hope High School

Location and Station Identification

Requested Location	324 Hope St. Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 8.3 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	150 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study	Project No.:	14132.0
Inspector:	S. Otten	Temperature	34ºF
Weather:	Ptly Cloudy		
Date:	12/12/2014	Arrival Time	12:50 PM
Departure Time:	1:30 PM		

Site ID	4				
Name	Hope High School				
Address	324 Hope Street				
Use	High School	Stories	4	Year Built	1938

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

unknown

2. Roof Structure Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

New Science wing; white membrane, EPDM, fully adhered.
Main Bldg; asphalt shingled gabled roof.
Auditorium & Gymnasium; black membrane with gravel ballast.

4. Roofing System Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

firm/hard

6. Estimated/Reported Age of Roofing System

white membrane- 3-5 years
ballasted roof- 10-15 years

7. Estimated Remaining Useful Life

white membrane- 15-20 years
ballasted roof- 5-10 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

None

9. Roof Access (i.e. hatch, stairs, ladder)

fixed wall mounted ladder from upper hallway in science wing to penthouse, then door directly onto roof.

10. Security against Vandalism

fixed ladder has a lockable gate over it.

11. Roof Pitch and Orientation

low pitch towards interior drains.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

Vents, HVAC, skylights. Existing PV & H/W solar on science wing roof.

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

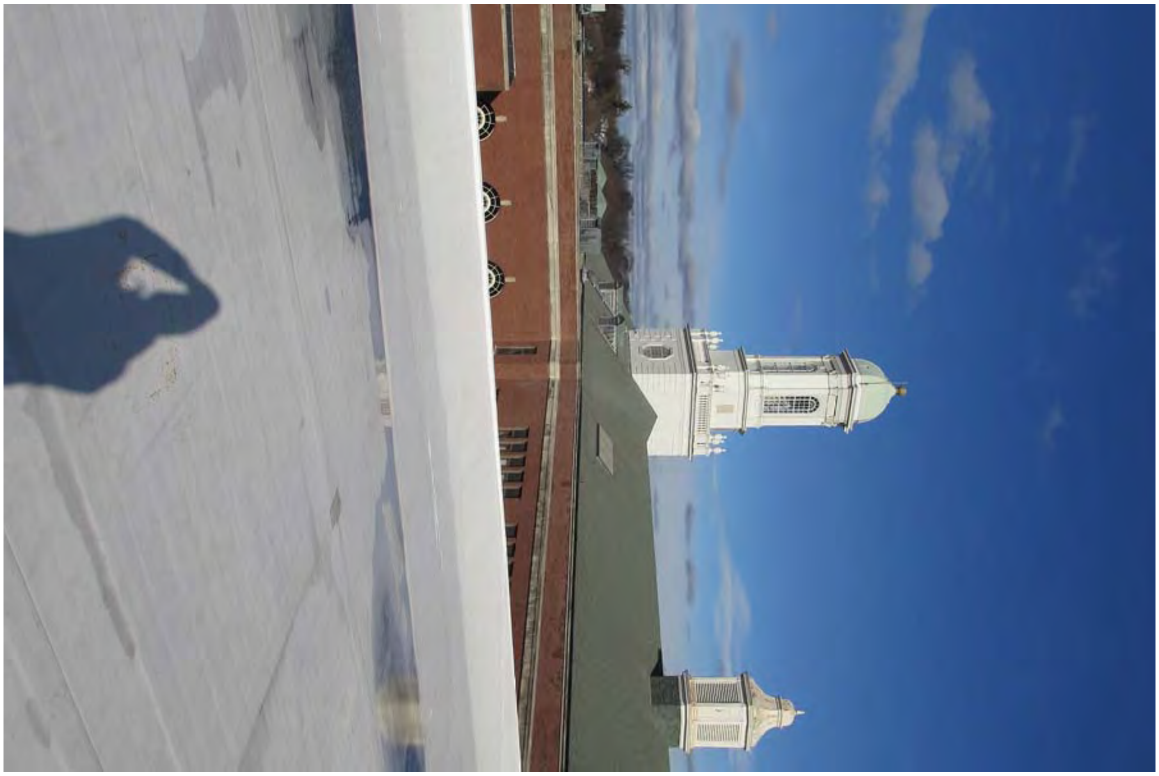
	Yes	Height	____________
X	No		

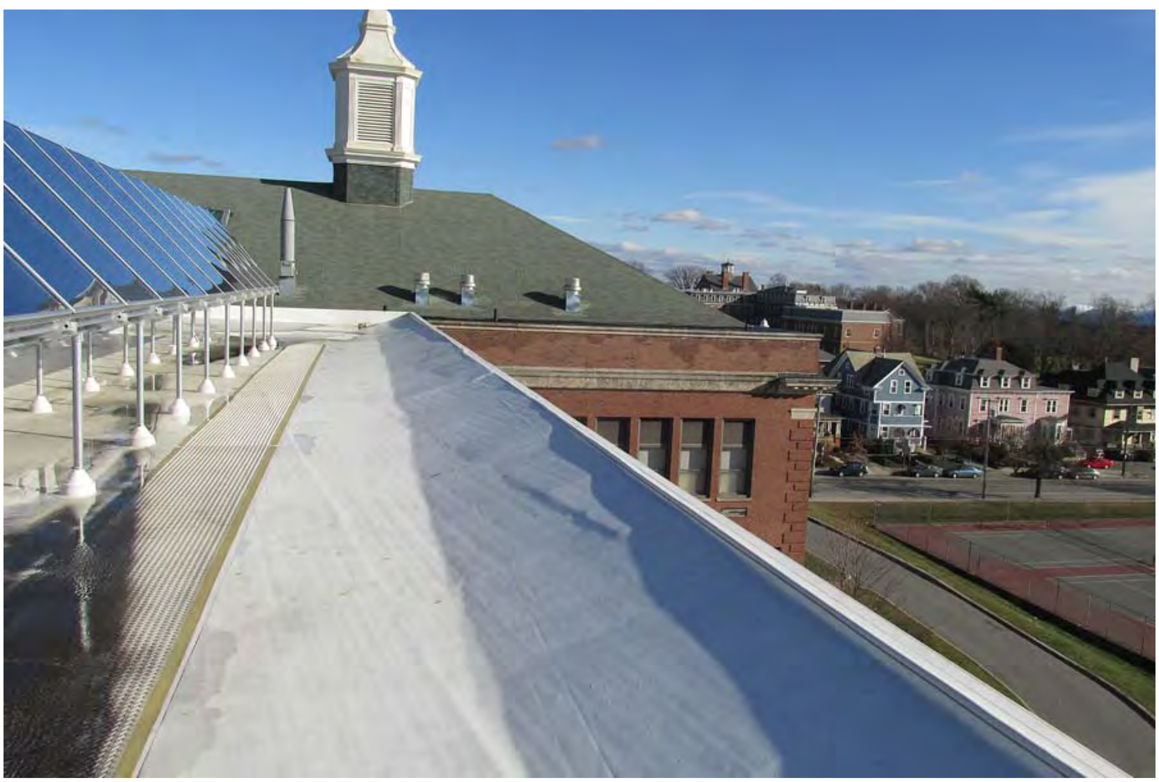
14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

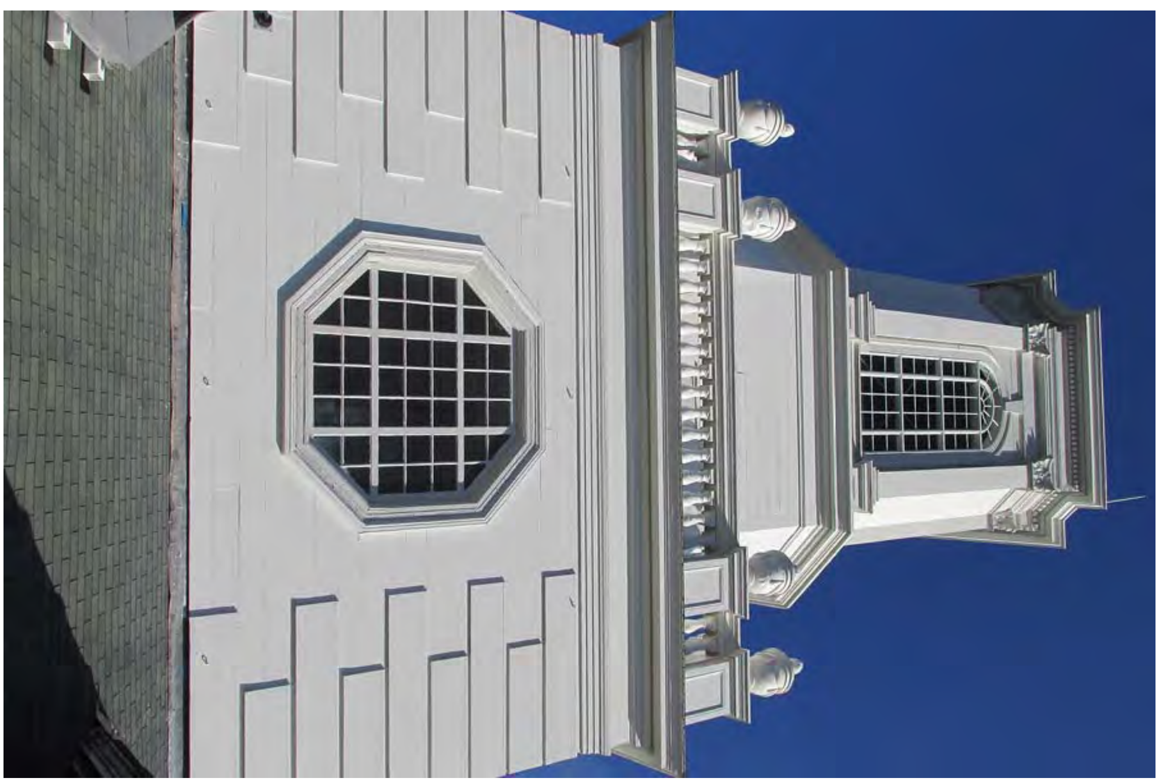
None

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.







Solar Feasibility Site Evaluation Summary

Site ID:	5
Name:	Roger Williams Middle School
Address:	278 Thurbers Ave.
Tier Ranking:	IV
Building Use:	Middle School
Approx. Potential PV system size, kw	70
Approx. EPP, MWh/yr:	88
Site Qualitative Score:	1.2
LCOE with 30% ITC, $/kWh:	0.082

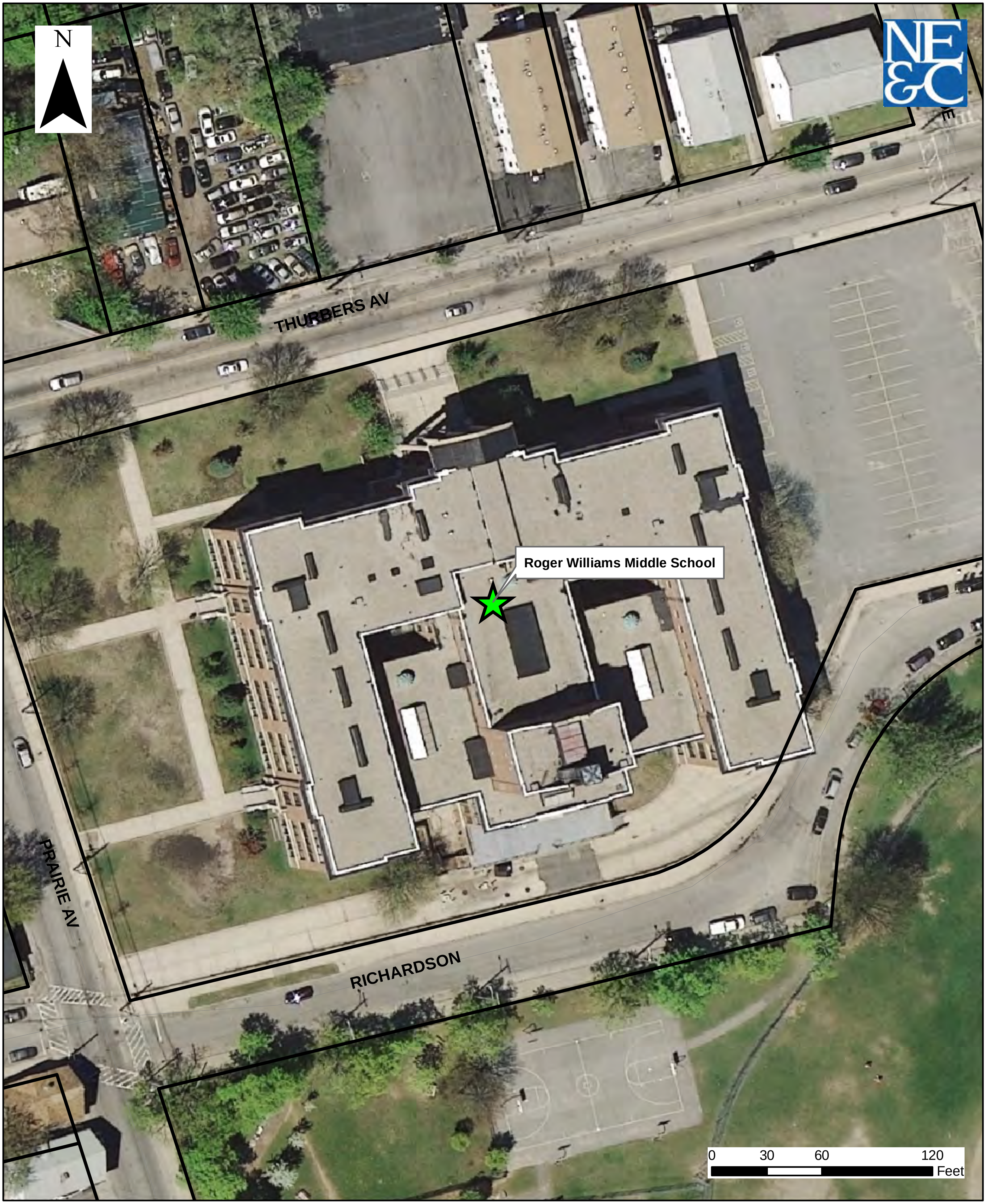
Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

Both the qualitative score of this Site and the approximate Energy Production Potential (EPP) are below average resulting in a Tier IV ranking. Tier IV sites have the least potential for a successful solar PV project.

Rooftop observations are reported in the attached Roof Inspection Report.

The gabel roof and lower level roofs were not considered in the roof area estimate. The gable roof is oriented east-west, which is not ideal for solar PV, and the lower roofs are likely to be shaded by the upper roofs.



2011 Orthophoto

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RESULTS

87,730 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	4,925	399
February	3.67	5,905	478
March	4.58	7,933	643
April	5.35	8,735	708
May	5.78	9,419	763
June	6.15	9,416	763
July	6.39	9,892	801
August	5.95	9,260	750
September	4.55	7,017	568
October	4.00	6,638	538
November	2.74	4,557	369
December	2.28	4,034	327
Annual	**4.51**	**87,731**	**$ 7,107**

User Comments

Roger Williams Middle School

Location and Station Identification

Requested Location	278 Thurbers Ave. Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 5.7 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	70 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study	Project No.:	14132.0
Inspector:	S. Otten	Temperature	41ºF
Weather:	Sunny		
Date:	12/4/2014	Arrival Time	12:15 PM
Departure Time:	12:35 PM		

Site ID	5				
Name	Roger Williams Middle School				
Address	278 Thurbers Avenue				
Use	Middle School	Stories	3	Year Built	1905

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

Building is similar to Nathaniel Greene Middle School, assume concrete roof

2. Roof Structure Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

Black membrane with gravel ballast.

4. Roofing System Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

hard/firm

6. Estimated/Reported Age of Roofing System

based on similarity to Classical HS, assume approx. 15 years old

7. Estimated Remaining Useful Life

Approx. 5 - 10 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

Seams are opening up in various locations, possible leaks.

9. Roof Access (i.e. hatch, stairs, ladder)

climbed through window onto lower roof, then up fixed wall mounted ladders to upper roofs.

10. Security against Vandalism

only (2) windows provide access, both located in teachers offices with locked doors.

11. Roof Pitch and Orientation

low pitch towards interior drains

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

Vents, drains, and what may be old vent and/or skylight structures.

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

X	Yes	Height 16 in.
	No	

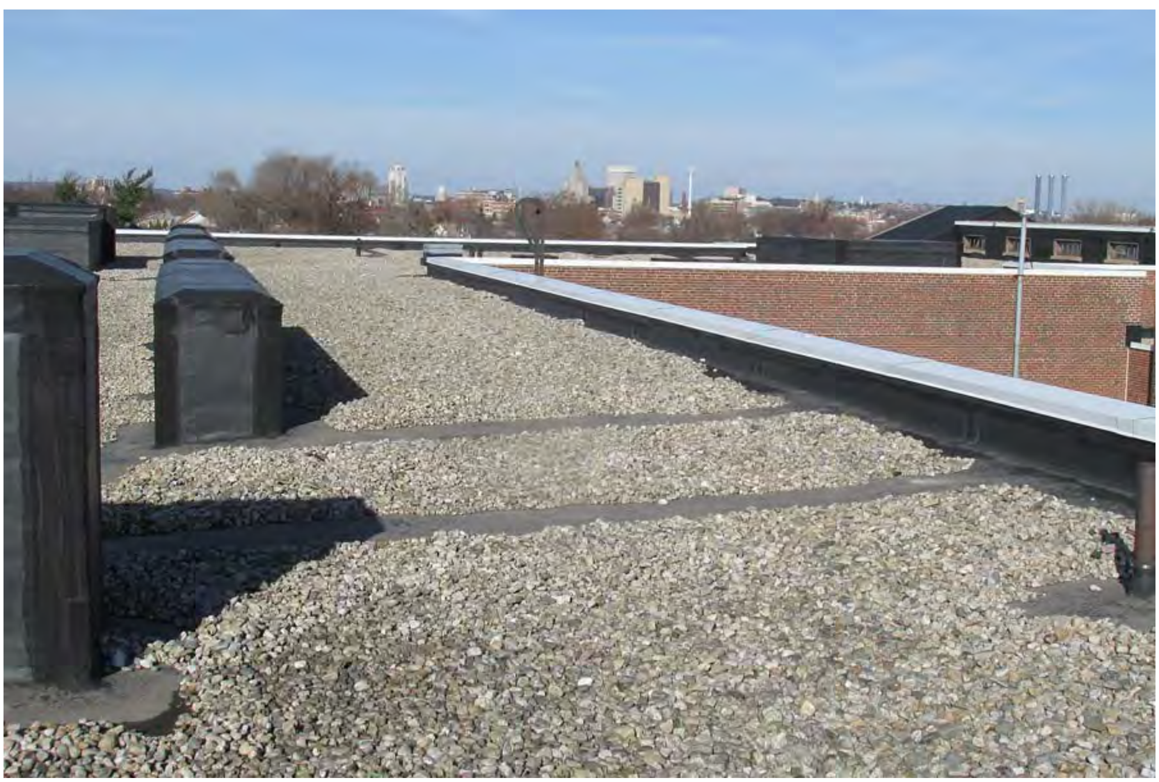
14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

None on upper roofs, auditorium has tall projection to the south.

Notes:

Charlotte Woods Elementary School is located to the south. Building appears to have a flat roof clear of obstructions and may be a potential site.

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.



Solar Feasibility Site Evaluation Summary

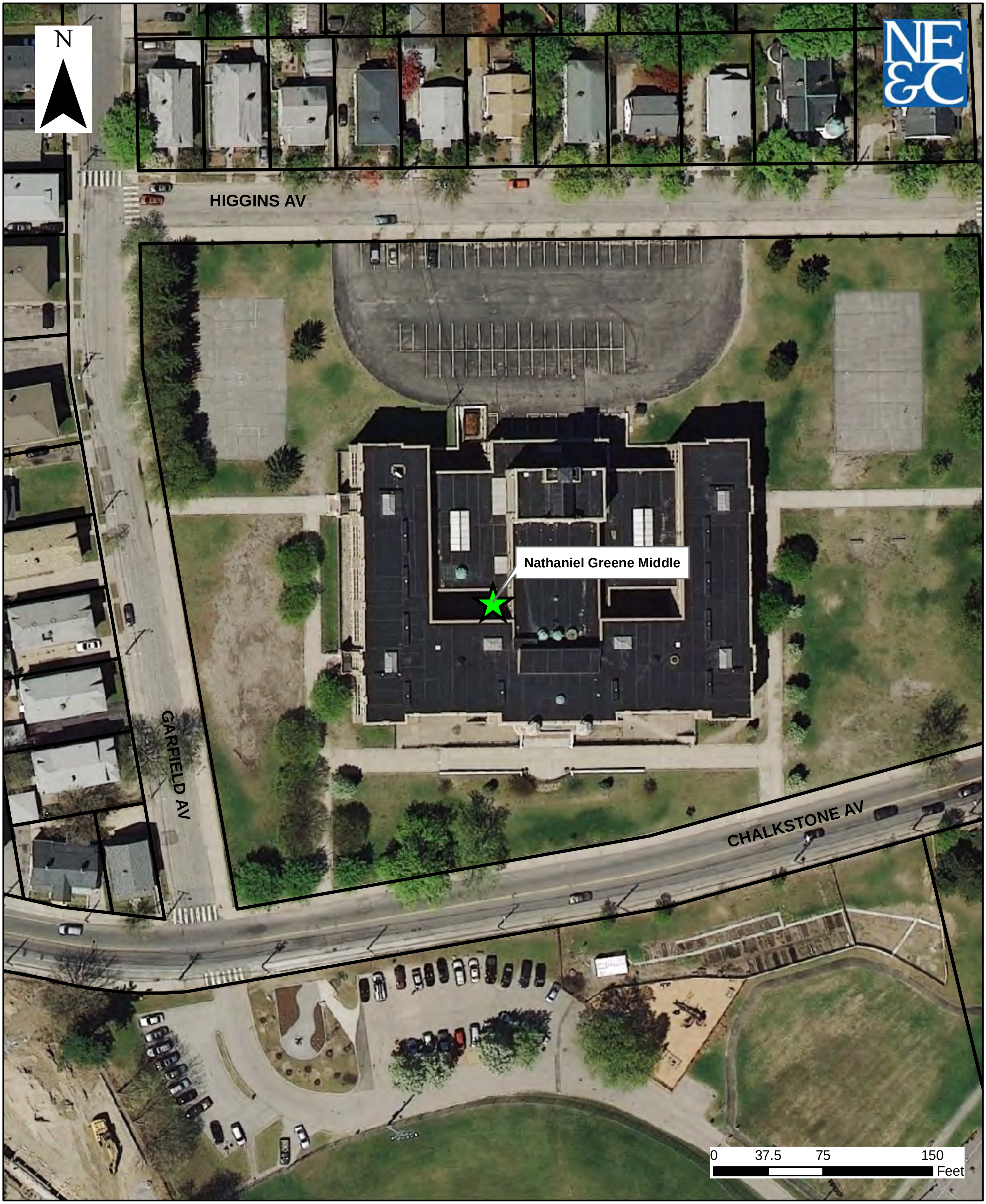
Site ID:	6
Name:	Nathaniel Greene Middle
Address:	721 Chalkstone Ave.
Tier Ranking:	II
Building Use:	Middle School
Approx. Potential PV system size, kw	70
Approx. EPP, MWh/yr:	88
Site Qualitative Score:	2.2
LCOE with 30% ITC, $/kWh:	0.082

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site is above average and the approximate Energy Production Potential (EPP) is below average resulting in a Tier II ranking. Tier II sites are not top ranked however, they still have a reasonable potential for a successful solar PV project and warrant a more detailed evaluation.

Rooftop observations are reported in the attached Roof Inspection Report.



2011 Orthophoto

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RESULTS

87,730 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	4,925	399
February	3.67	5,905	478
March	4.58	7,933	643
April	5.35	8,735	708
May	5.78	9,419	763
June	6.15	9,416	763
July	6.39	9,892	801
August	5.95	9,260	750
September	4.55	7,017	568
October	4.00	6,638	538
November	2.74	4,557	369
December	2.28	4,034	327
Annual	**4.51**	**87,731**	**$ 7,107**

User Comments

Nathaniel Greene Middle

Location and Station Identification

Requested Location	721 Chalkstone Ave. Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 8.1 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	70 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study			Project No.:	14132.0
Inspector:	S. Otten	Temperature	40 ºF	Weather:	Rainy/Cldy
Date:	12/10/2014	Arrival Time	12:00 PM	Departure Time:	12:40 PM

Site ID	6				
Name	Nathaniel Greene Middle School				
Address	721 Chalkstone Avenue				
Use	Middle School	Stories	4	Year Built	1920

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

Concrete based on observations made from Auditorium attic

2. Roof Structure Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

White membrane, EPDM, fully adhered

4. Roofing System Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

firm/hard with some soft spots

6. Estimated/Reported Age of Roofing System

approx. 3 years based on 2011 aerial showing a black roofing

7. Estimated Remaining Useful Life

17 - 22 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

None

9. Roof Access (i.e. hatch, stairs, ladder)

climbed through window onto lower roof, then up fixed wall mounted ladders to upper roofs.

10. Security against Vandalism

only (2) windows provide access, both located in teachers offices with locked doors.

11. Roof Pitch and Orientation

low pitch towards interior drains

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

Vents, drains, and what may be old vent and/or skylight structures.

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

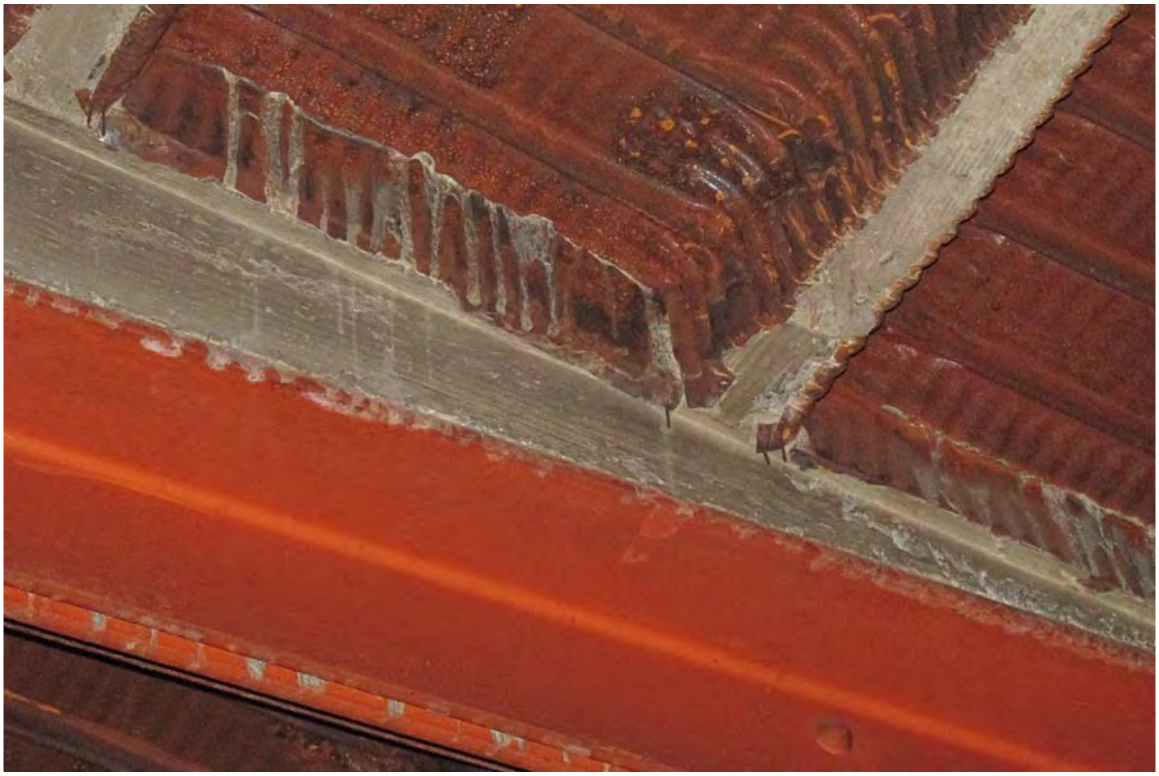
X	Yes	Height	24 in.
	No		

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

None

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.



Solar Feasibility Site Evaluation Summary

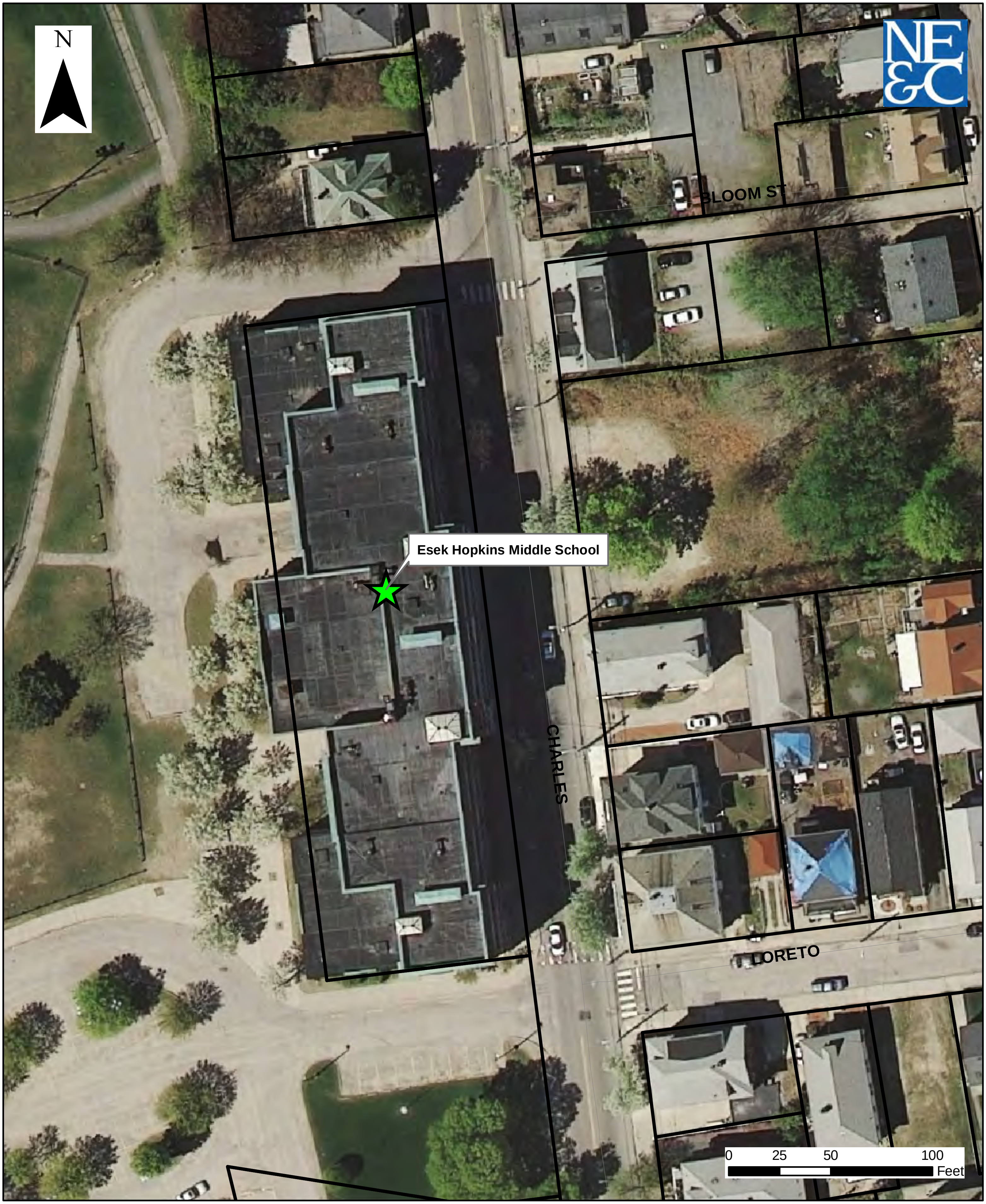
Site ID:	7
Name:	Esek Hopkins Middle School
Address:	480 Charles St.
Tier Ranking:	IV
Building Use:	Middle School
Approx. Potential PV system size, kw	30
Approx. EPP, MWh/yr:	38
Site Qualitative Score:	1.2
LCOE with 30% ITC, $/kWh:	0.082

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

Both the qualitative score of this Site and the approximate Energy Production Potential (EPP) are below average resulting in a Tier IV ranking. Tier IV sites have the least potential for a successful solar PV project.

Rooftop observations are reported in the attached Roof Inspection Report.



2011 Orthophoto

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RESULTS

37,599 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	2,111	171
February	3.67	2,531	205
March	4.58	3,400	275
April	5.35	3,744	303
May	5.78	4,037	327
June	6.15	4,036	327
July	6.39	4,239	343
August	5.95	3,968	321
September	4.55	3,007	244
October	4.00	2,845	230
November	2.74	1,953	158
December	2.28	1,729	140
Annual	**4.51**	**37,600**	**$ 3,044**

User Comments

Esek Hopkins Middle School

Location and Station Identification

Requested Location	480 Charles St. Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 9.1 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	30 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study			Project No.:	14132.0
Inspector:	S. Otten	Temperature	40 ºF	Weather:	Cldy/Rainy
Date:	12/10/2014	Arrival Time	12:54 PM	Departure Time:	1:15 PM

Site ID	7				
Name	Exek Hopkins Middle School				
Address	480 Charles Street				
Use	Middle School	Stories	3	Year Built	1920

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

unknown

2. Roof Structure Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

Black membrane, EPDM, adhered (some areas do not appear to be adhered based on apparent wrinkles (see photos).

4. Roofing System Condition

X	Poor	Comments: Many wrinkles may be an indication of membrane moving from wind. Many seams are showing signs of failure.
	Fair	
	Good	
	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

hard, possibly plywood or OSB substrate. Many places felt like cracking and giving way under footsteps.

6. Estimated/Reported Age of Roofing System

approx. 5-10 years

7. Estimated Remaining Useful Life

5-10 years based on comments above.

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

Reported leaks, refer to above comments.

9. Roof Access (i.e. hatch, stairs, ladder)

fixed ladder in Boys restroom on 4th floor. Ladder leads to small door which opens directly onto lower roof. Fixed wall ladders provide access to upper roof.

10. Security against Vandalism

Boys Room is kept locked and ladder has locked cage.

11. Roof Pitch and Orientation

Low pitch towards interior drains.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

Skylights, drains, vents.

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

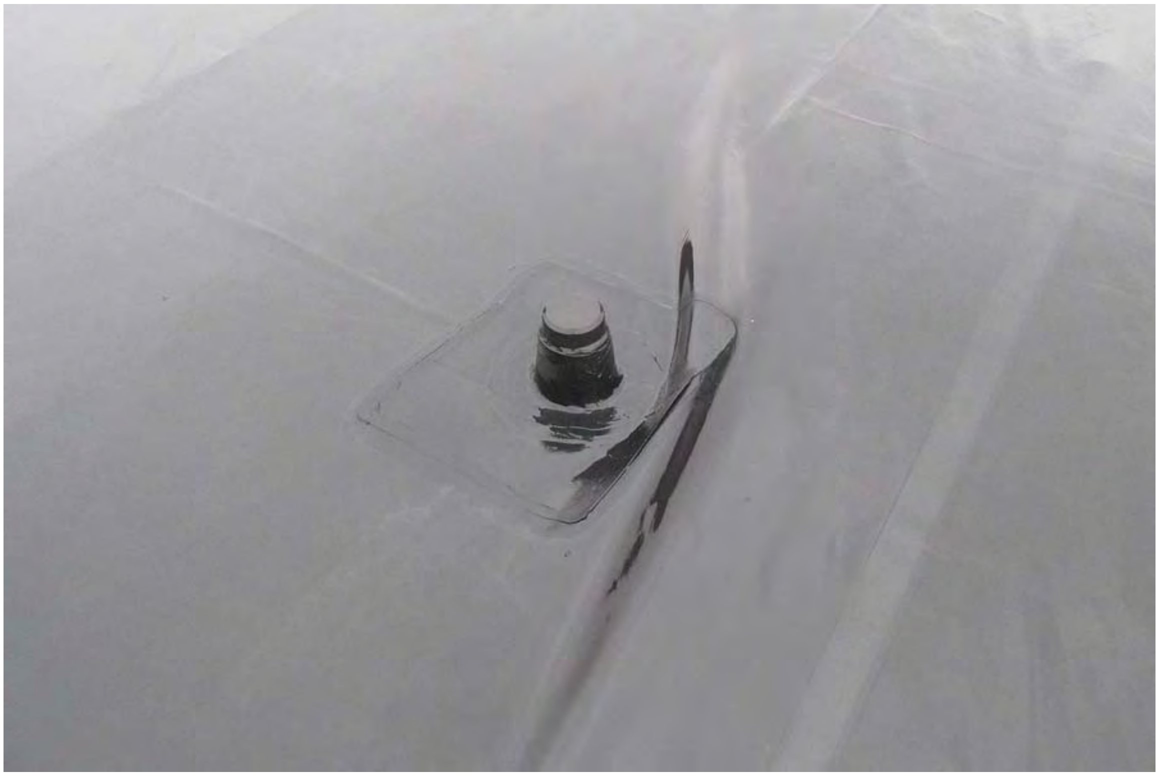
X	Yes	Height	36 in.
	No		

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

None

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.



Solar Feasibility Site Evaluation Summary

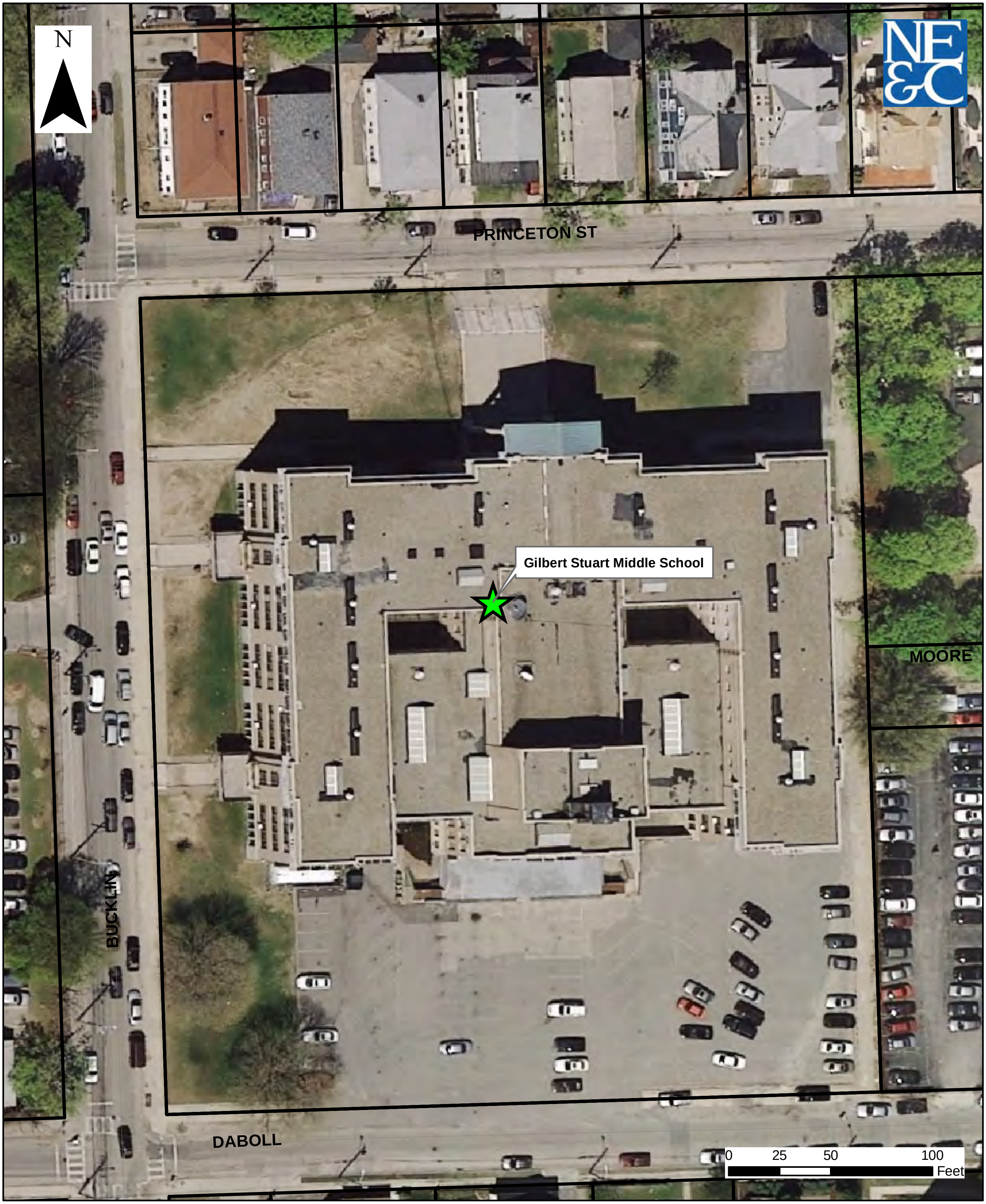
Site ID:	8
Name:	Gilbert Stuart Middle School
Address:	188 Princeton Ave. (160 Bucklin St.)
Tier Ranking:	IV
Building Use:	Middle School
Approx. Potential PV system size, kw	80
Approx. EPP, MWh/yr:	100
Site Qualitative Score:	1.2
LCOE with 30% ITC, $/kWh:	0.081

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

Both the qualitative score of this Site and the approximate Energy Production Potential (EPP) are below average resulting in a Tier IV ranking. Tier IV sites have the least potential for a successful solar PV project.

Rooftop observations are reported in the attached Roof Inspection Report.



2011 Orthophoto

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

RESULTS

100,263 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	5,629	456
February	3.67	6,748	547
March	4.58	9,066	734
April	5.35	9,983	809
May	5.78	10,765	872
June	6.15	10,761	872
July	6.39	11,305	916
August	5.95	10,583	857
September	4.55	8,019	650
October	4.00	7,586	614
November	2.74	5,208	422
December	2.28	4,610	373
Annual	**4.51**	**100,263**	**$ 8,122**

User Comments

Gilbert Stuart Middle School

Location and Station Identification

Requested Location	188 Princeton Ave Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 6.1 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	80 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study	Project No.:	14132.0
Inspector:	S. Otten	Temperature	40 ºF
Weather:	Sunny		
Date:	12/4/2014	Arrival Time	12:15PM
Departure Time:	12:40PM		

Site ID	8		
Name	Gilbert Stuart Middle School		
Address	188 Princeton Avenue (160 Bucklin Street)		
Use	Middle School	Stories	3
Year Built	1930		

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

Building is similar to Nathaniel Greene Middle School, assume concrete roof

2. Roof Structure Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

Black membrane with gravel ballast

4. Roofing System Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

Hard/firm

6. Estimated/Reported Age of Roofing System

similar to Classical, approx. 15 years

7. Estimated Remaining Useful Life

5-10 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

None

9. Roof Access (i.e. hatch, stairs, ladder)

climbed through window onto lower roof, then up fixed wall mounted ladders to upper roofs.

10. Security against Vandalism

only (2) windows provide access, both located in teachers offices with locked doors.

11. Roof Pitch and Orientation

low pitch towards interior drains

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

Vents, skylights and drains

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

X	Yes	Height	20 in.
	No		

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

None on upper roofs, auditorium has tall projection to the south.

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

Solar Feasibility Site Evaluation Summary

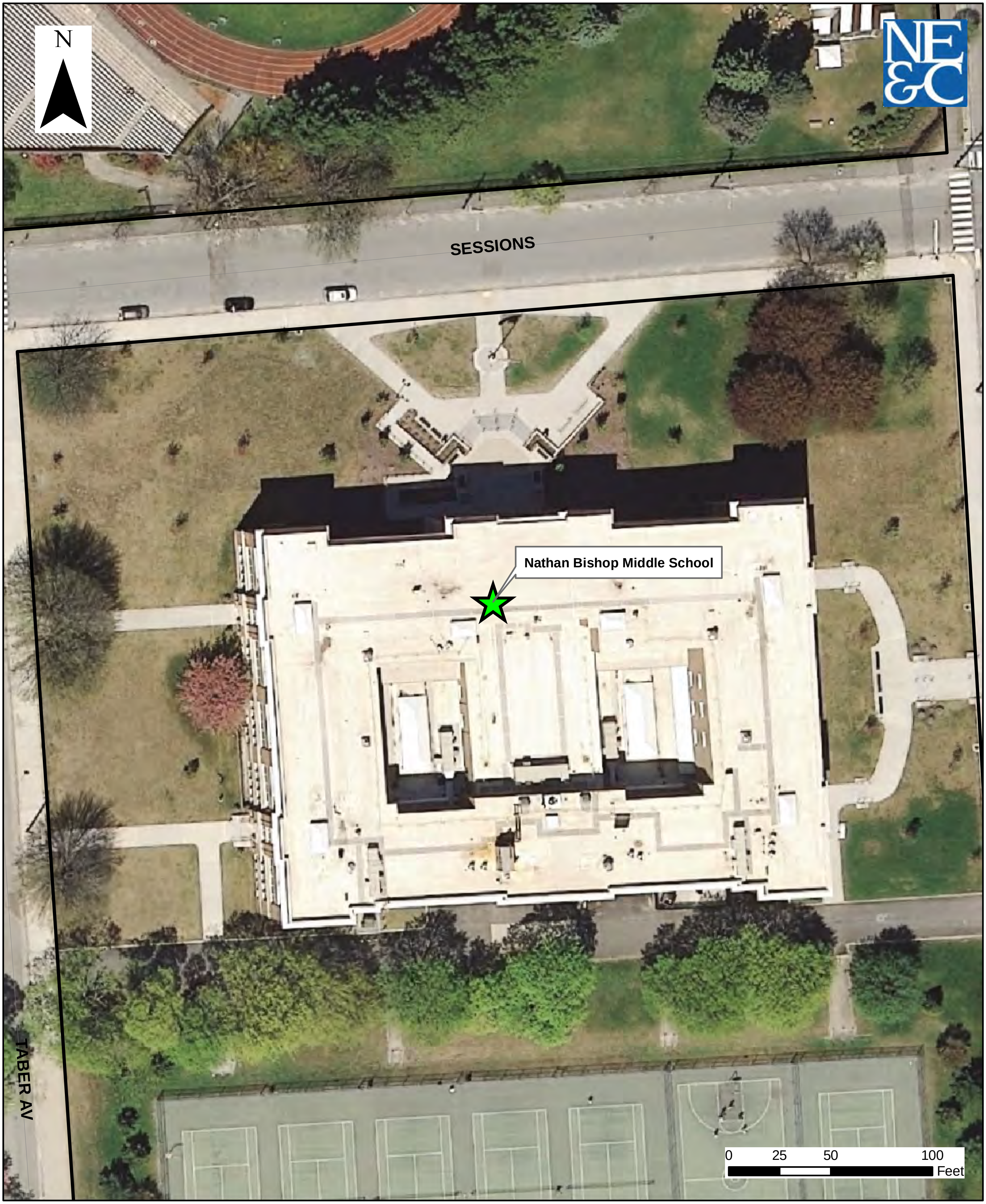
Site ID:	9
Name:	Nathan Bishop Middle School
Address:	101 Sessions St. (360 Elmgrove Ave.)
Tier Ranking:	II
Building Use:	Middle School
Approx. Potential PV system size, kw	130
Approx. EPP, MWh/yr:	163
Site Qualitative Score:	2.2
LCOE with 30% ITC, $/kWh:	0.081

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site is above average and the approximate Energy Production Potential (EPP) is below average resulting in a Tier II ranking. Tier II sites are not top ranked, however, they still have a reasonable potential for a successful solar PV project and warrant a more detailed evaluation.

Rooftop observations are reported in the attached Roof Inspection Report.



2011 Orthophoto

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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RESULTS

162,927 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	9,146	741
February	3.67	10,966	888
March	4.58	14,733	1,193
April	5.35	16,222	1,314
May	5.78	17,493	1,417
June	6.15	17,487	1,416
July	6.39	18,370	1,488
August	5.95	17,197	1,393
September	4.55	13,031	1,056
October	4.00	12,327	999
November	2.74	8,462	685
December	2.28	7,492	607
Annual	**4.51**	**162,926**	**$ 13,197**

User Comments

Nathan Bishop Middle School

Location and Station Identification

Requested Location	101 Sessions St Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 8.8 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	130 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

Northeast Engineers & Consultants, Inc.
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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study	Project No.:	14132.0
Inspector:	S. Otten	Temperature	42 ºF
Weather:	Cldy		
Date:	12/12/2014	Arrival Time	2:10 PM
Departure Time:	2:30PM		

Site ID	9				
Name	Nathan Bishop Middle School				
Address	101 Sessions Street (360 Elmgrove Ave.)				
Use	Middle School	Stories	3	Year Built	1910

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

unknown

2. Roof Structure Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

White membrane, EPDM, fully adhered

4. Roofing System Condition

	Poor	Comments:
	Fair	
	Good	
X	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

hard/firm

6. Estimated/Reported Age of Roofing System

Installed in 2009 renovations, approx. 5 years

7. Estimated Remaining Useful Life

15-20 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

None, some drains are clogged.

9. Roof Access (i.e. hatch, stairs, ladder)

Short fixed ladder in closet, through door directly onto lower roof, fixed wall mounted ladders to upper main roof.

10. Security against Vandalism

Closet door kept locked.

11. Roof Pitch and Orientation

Low pitch towards interior drains.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

Vents, drains, skylights, HVAC units. Existing tube solar panel system (assume hot water)

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

X	Yes	Height	3'-6" ±
	No		

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

None

Notes:

Major renovations occurred in 2009 ($33M). School is like new interior and exterior.

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

Solar Feasibility Site Evaluation Summary

Site ID:	10
Name:	Pleasant View Elementary
Address:	50 Obediah Brown Rd.
Tier Ranking:	II
Building Use:	Elementary School
Approx. Potential PV system size, kw	190
Approx. EPP, MWh/yr:	198
Site Qualitative Score:	1.9
LCOE with 30% ITC, $/kWh:	0.080

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site is above average and the approximate Energy Production Potential (EPP) is below average resulting in a Tier II ranking. Tier II sites are not top ranked, however, they still have a reasonable potential for a successful solar PV project and warrant a more detailed evaluation.

This building is comprised of multiple slanted roofs in a shaded location. Shading has been accounted for in the EPP estimate.

Because the building is one story tall the zoning ordinance requires the construction of a parapet wall to screen the PV system.

Rooftop observations are reported in the attached Roof Inspection Report.

2011 Orthophoto

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

RESULTS

197,565 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	11,037	894
February	3.67	13,271	1,075
March	4.58	17,854	1,446
April	5.35	19,676	1,594
May	5.78	21,233	1,720
June	6.15	21,244	1,721
July	6.39	22,340	1,810
August	5.95	20,917	1,694
September	4.55	15,805	1,280
October	4.00	14,936	1,210
November	2.74	10,218	828
December	2.28	9,034	732
Annual	**4.51**	**197,565**	**$ 16,004**

User Comments

Pleasant View Elementary

Location and Station Identification

Requested Location	50 Obediah Brown Rd. Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 8.3 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	190 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	32.68%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.16 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

Northeast Engineers & Consultants, Inc.
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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study			Project No.:	14132.0
Inspector:	S. Otten	Temperature	38 ºF	Weather:	
Date:	12/10/2014	Arrival Time	10:00 AM	Departure Time:	10:40AM

Site ID	10				
Name	Pleasant View Elementary				
Address	50 Obediah Brown Road				
Use	Elementary School	Stories	2	Year Built	1983

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

Gymnasium is steel joist with steel deck, assume rest of building is similar construction.
Pool wing is glulam beams and wood deck.

2. Roof Structure Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

White membrane, EPDM, fully adhered.

4. Roofing System Condition

	Poor	Comments: some areas that don't drain, standing water
	Fair	
X	Good	
	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

hard/firm

6. Estimated/Reported Age of Roofing System

Estimated 8-10 years

7. Estimated Remaining Useful Life

15-20 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

Standing water due to improper pitch. Clogged drain grates.

9. Roof Access (i.e. hatch, stairs, ladder)

No access, used 10 foot step ladder.

10. Security against Vandalism

No direct access but roof is only single story high.

11. Roof Pitch and Orientation

Each wing has a sloped roof (2:12$\pm$) pitching towards outer edges. Interior drains located at wing intersections with center hub.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

each wing has a center raised flat roof (4 foot high), various vents, conduits, cables and chimneys.

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

	Yes	Height	____________
X	No		

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

Building is one story and has tall tress to the south, east, and west.

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.


ARAMARK


29

Solar Feasibility Site Evaluation Summary

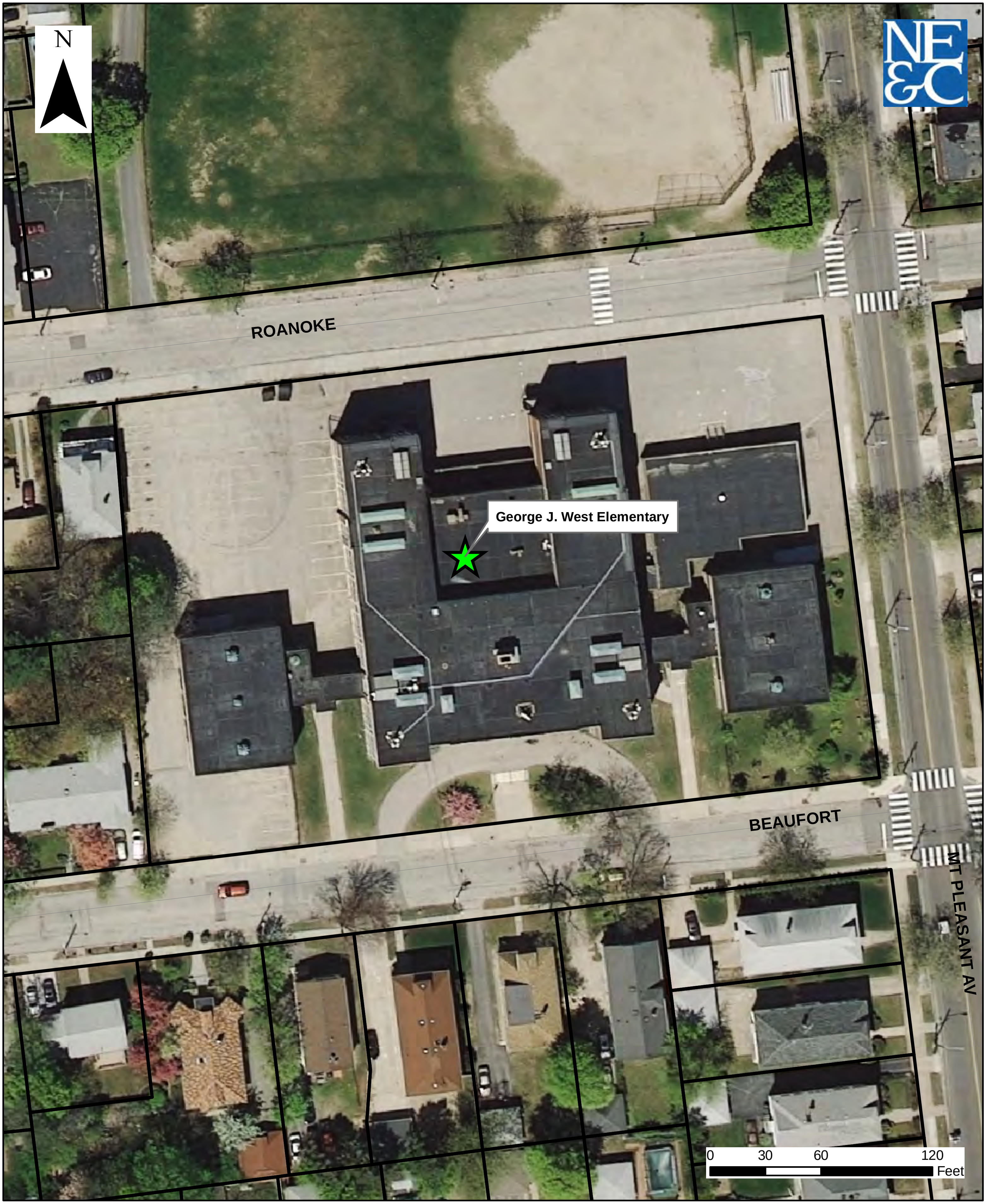
Site ID:	11
Name:	George J. West Elementary
Address:	145 Beaufort St.
Tier Ranking:	II
Building Use:	Elementary School
Approx. Potential PV system size, kw	180
Approx. EPP, MWh/yr:	226
Site Qualitative Score:	2.2
LCOE with 30% ITC, $/kWh:	0.080

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site is above average and the approximate Energy Production Potential (EPP) is below average resulting in a Tier II ranking. Tier II sites are not top ranked, however, they still have a reasonable potential for a successful solar PV project and warrant a more detailed evaluation.

Rooftop observations are reported in the attached Roof Inspection Report.



2011 Orthophoto

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

RESULTS

225,591 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	12,664	1,026
February	3.67	15,184	1,230
March	4.58	20,399	1,652
April	5.35	22,462	1,819
May	5.78	24,221	1,962
June	6.15	24,213	1,961
July	6.39	25,436	2,060
August	5.95	23,811	1,929
September	4.55	18,043	1,461
October	4.00	17,068	1,383
November	2.74	11,717	949
December	2.28	10,373	840
Annual	**4.51**	**225,591**	**$ 18,272**

User Comments

George J. West Elementary

Location and Station Identification

Requested Location	145 Beaufort St. Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 7.9 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	180 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

Northeast Engineers & Consultants, Inc.
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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study	Project No.:	14132.0
Inspector:	S. Otten	Temperature	43ºF
Weather:	Rainy/Cldy		
Date:	12/10/2014	Arrival Time	10:40AM
Departure Time:	11:10AM		

Site ID	11				
Name	George J. West Elementary				
Address	145 Beaufort Street				
Use	Elementary School	Stories	3	Year Built	1906

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

Concrete, underside of roof could be observed from attic space.

2. Roof Structure Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

white membrane, EPDM, fully adhered

4. Roofing System Condition

	Poor	Comments:
	Fair	
	Good	
X	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

hard/firm

6. Estimated/Reported Age of Roofing System

<3 years based on 2011 aerial showing black roofing.

7. Estimated Remaining Useful Life

17-22 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

None

9. Roof Access (i.e. hatch, stairs, ladder)

(2) interior fixed ladders located in the upper floor hallways lead to old hatches that have been roofed over. The only roof hatch does not have a ladder. Had to use a tall step ladder to reach.

10. Security against Vandalism

No direct or easy access.

11. Roof Pitch and Orientation

Low pitch towards interior drains.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

Skylights, chimney, and vents.

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

	Yes	Height ____________
X	No	

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

None

Notes:

Did not have access to gymnasium roof.

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

Solar Feasibility Site Evaluation Summary

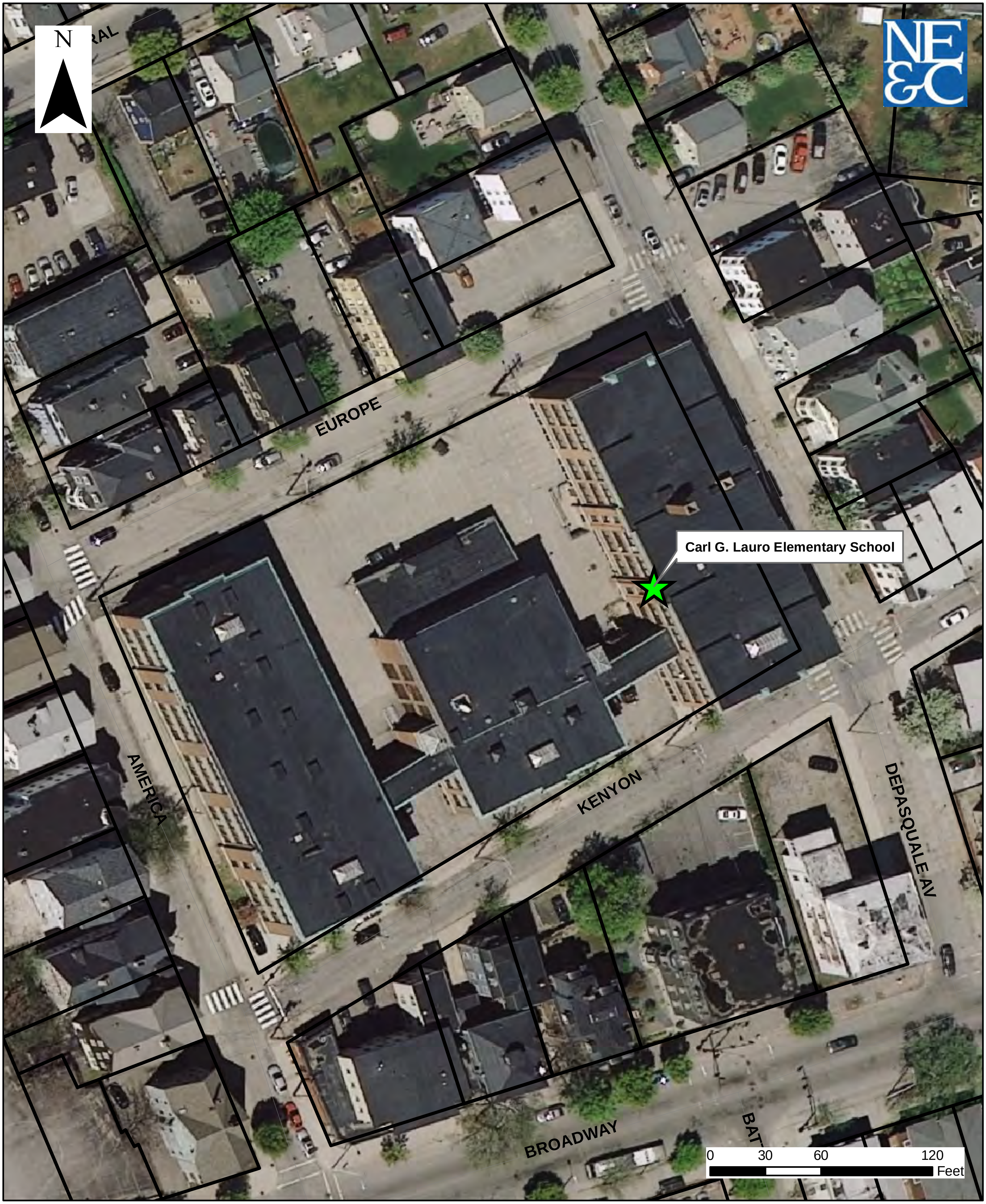
Site ID:	12
Name:	Carl G. Lauro Elementary School
Address:	99 Kenyon St.
Tier Ranking:	II
Building Use:	Elementary
Approx. Potential PV system size, kw	180
Approx. EPP, MWh/yr:	225
Site Qualitative Score:	2.2
LCOE with 30% ITC, $/kWh:	0.080

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site is above average and the approximate Energy Production Potential (EPP) is below average resulting in a Tier II ranking. Tier II sites are not top ranked, however, they still have a reasonable potential for a successful solar PV project and warrant a more detailed evaluation.

Rooftop observations are reported in the attached Roof Inspection Report.



2011 Orthophoto

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RESULTS

225,591 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	12,664	1,026
February	3.67	15,184	1,230
March	4.58	20,399	1,652
April	5.35	22,462	1,819
May	5.78	24,221	1,962
June	6.15	24,213	1,961
July	6.39	25,436	2,060
August	5.95	23,811	1,929
September	4.55	18,043	1,461
October	4.00	17,068	1,383
November	2.74	11,717	949
December	2.28	10,373	840
Annual	**4.51**	**225,591**	**$ 18,272**

User Comments

Carl G. Lauro Elementary School

Location and Station Identification

Requested Location	99 Kenyon St. Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 7.2 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	180 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

Northeast Engineers & Consultants, Inc.
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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study			Project No.:	14132.0
Inspector:	S. Otten	Temperature	42 °F	Weather:	Sunny
Date:	12/4/2014	Arrival Time	2:00 PM	Departure Time:	2:20PM

Site ID	12				
Name	Carl G. Lauro Elementary				
Address	99 Kenyon Street				
Use	Elementary School	Stories	3	Year Built	1927

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

From attic, it appears to be wood framed.

2. Roof Structure Condition

	Poor	Comments:
X	Fair	
	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

White membrane, EPDM, fully adhered.

4. Roofing System Condition

	Poor	Comments:
	Fair	
	Good	
X	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

firm/hard

6. Estimated/Reported Age of Roofing System

Estimate <3 years based on 2011 aerial showing black roofing

7. Estimated Remaining Useful Life

17-22 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

None to roof, did observe large vertical crack in chimney.

9. Roof Access (i.e. hatch, stairs, ladder)

Fixed interior ladder in custodian closet, through roof hatch. Typical each wing. Fixed exterior ladders to lower roofs.

10. Security against Vandalism

Custodial closet is kept locked.

11. Roof Pitch and Orientation

Low pitch towards interior drains.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

Old roof vent structures,skylights, vent stacks.

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

	Yes	Height	________
X	No		

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

None

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

Solar Feasibility Site Evaluation Summary

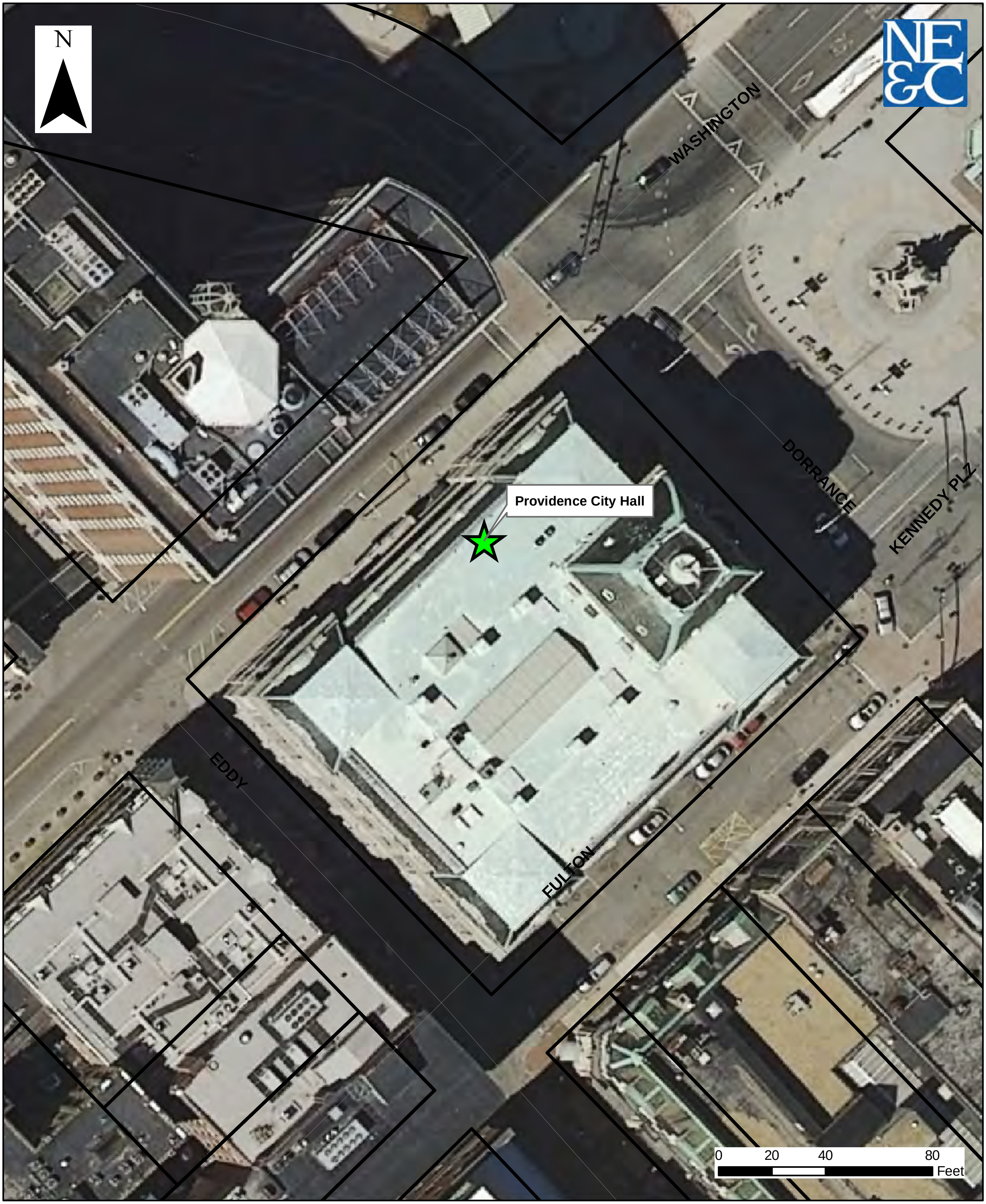
Site ID:	13
Name:	Providence City Hall
Address:	25 Dorrance St.
Tier Ranking:	IV
Building Use:	Administrative
Approx. Potential PV system size, kw	10
Approx. EPP, MWh/yr:	13
Site Qualitative Score:	1.2
LCOE with 30% ITC, $/kWh:	0.083

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

Both the qualitative score of this Site and the approximate Energy Production Potential (EPP) are below average resulting in a Tier IV ranking. Tier IV sites have the least potential for a successful solar PV project.

Rooftop observations are reported in the attached Roof Inspection Report.



2011 Orthophoto

NREL
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Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

RESULTS

12,533 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	704	57
February	3.67	844	68
March	4.58	1,133	92
April	5.35	1,248	101
May	5.78	1,346	109
June	6.15	1,345	109
July	6.39	1,413	114
August	5.95	1,323	107
September	4.55	1,002	81
October	4.00	948	77
November	2.74	651	53
December	2.28	576	47
Annual	**4.51**	**12,533**	**$ 1,015**

User Comments

Providence City Hall

Location and Station Identification

Requested Location	25 Dorrance St Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 7.5 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	10 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

Northeast Engineers & Consultants, Inc.
"A Knowledge Corporation"®

Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study	Project No.:	14132.0
Inspector:	S. Otten	Temperature	33 ºF
Weather:	Prtly Cdly		
Date:	12/12/2014	Arrival Time	9:00AM
Departure Time:	10:10AM		

Site ID	13
Name	Providence City Hall
Address	25 Dorrance Street
Use	Administrative
Stories	5
Year Built	1847

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

Steel beams and girders with steel grillage with concrete infill deck.

2. Roof Structure Condition

	Poor
X	Fair
	Good
	Excellent

Comments:
For age roof structure looks good.

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

textured membrane fully adhered. Painted coating.

4. Roofing System Condition

	Poor
	Fair
X	Good
	Excellent

Comments:

5. Roof Surface Durability (i.e. soft or hard)

hard/firm

6. Estimated/Reported Age of Roofing System

10-15 years (estimated)

7. Estimated Remaining Useful Life

5-10 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

None

9. Roof Access (i.e. hatch, stairs, ladder)

Stairs to roof hatch.

10. Security against Vandalism

Gate to stairs that lead to attic is locked.

11. Roof Pitch and Orientation

Roof slopes to edge parapet and is drained with interior drains.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

Large monitor runs the length of the building, chimneys, vents, and skylights.

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

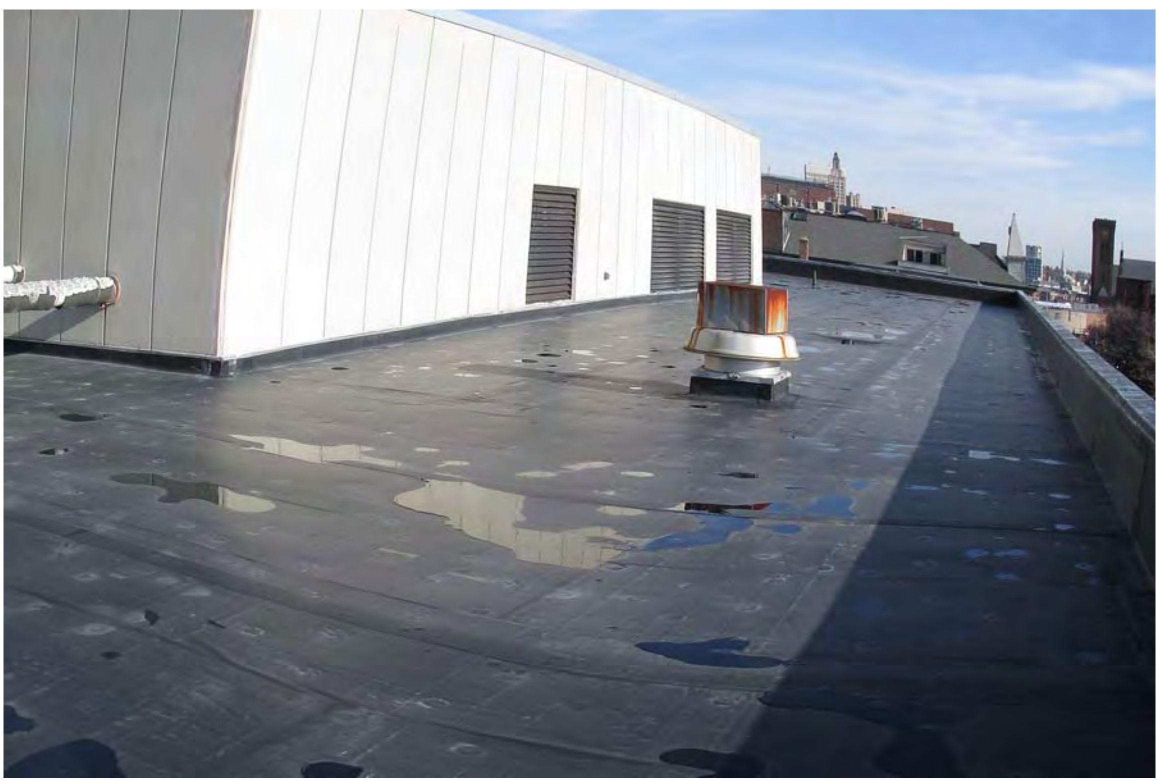
X	Yes	Height 1-2 feet
	No	

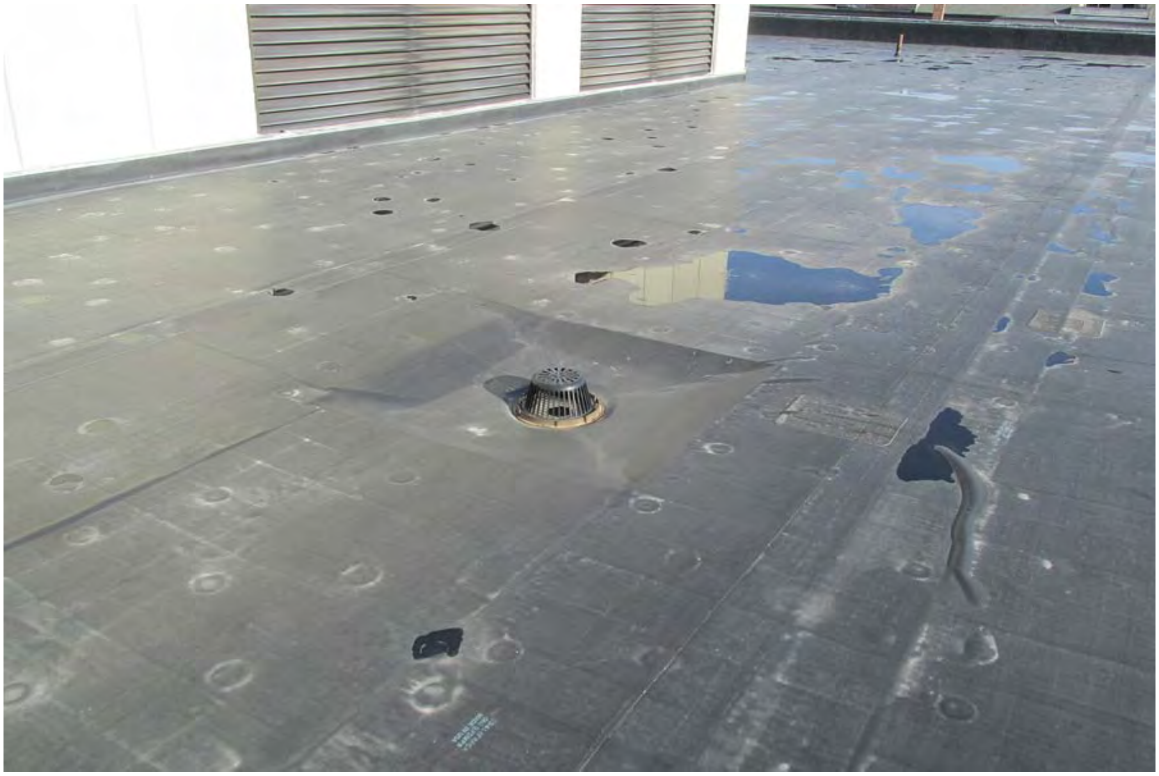
14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

Biltmore Hotel is located to the northwest.

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.





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Solar Feasibility Site Evaluation Summary

Site ID:	14
Name:	Providence Schools Administration
Address:	797 Westminster St.
Tier Ranking:	II
Building Use:	Administrative
Approx. Potential PV system size, kw	90
Approx. EPP, MWh/yr:	113
Site Qualitative Score:	2.2
LCOE with 30% ITC, $/kWh:	0.081

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site is above average and the approximate Energy Production Potential (EPP) is below average resulting in a Tier II ranking. Tier II sites are not top ranked, however, they still have a reasonable potential for a successful solar PV project and warrant a more detailed evaluation.

Rooftop observations are reported in the attached Roof Inspection Report.

2011 Orthophoto

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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RESULTS

112,796 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	6,332	513
February	3.67	7,592	615
March	4.58	10,200	826
April	5.35	11,231	910
May	5.78	12,110	981
June	6.15	12,107	981
July	6.39	12,718	1,030
August	5.95	11,905	964
September	4.55	9,022	731
October	4.00	8,534	691
November	2.74	5,858	475
December	2.28	5,187	420
Annual	**4.51**	**112,796**	**$ 9,137**

User Comments

Providence Schools Administration

Location and Station Identification

Requested Location	797 Westminster St. Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 7.0 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	90 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

Northeast Engineers & Consultants, Inc.
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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study			Project No.:	14132.0
Inspector:	S.Otten	Temperature	42ºF	Weather:	Sunny
Date:	12/4/2014	Arrival Time	10:45AM	Departure Time:	11:00AM

Site ID	14				
Name	Providence Schools Administration Bldg.				
Address	797 Westminster Street				
Use	Administrative	Stories	4	Year Built	1945

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

Possibly steel joists and steel deck based on visible roof in mechanical penthouse.

2. Roof Structure Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

Black membrane, EPDM, fully adhered.

4. Roofing System Condition

	Poor	Comments:
	Fair	
	Good	
X	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

medium soft

6. Estimated/Reported Age of Roofing System

estimated < 3 years

7. Estimated Remaining Useful Life

17-22 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

None

9. Roof Access (i.e. hatch, stairs, ladder)

Walk-out door from Mechanical Penthouse

10. Security against Vandalism

Building is secure, must be buzzed in and sign in at front desk.

11. Roof Pitch and Orientation

low pitch to interior drains.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

HVAC unit, vents, and roof drains

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

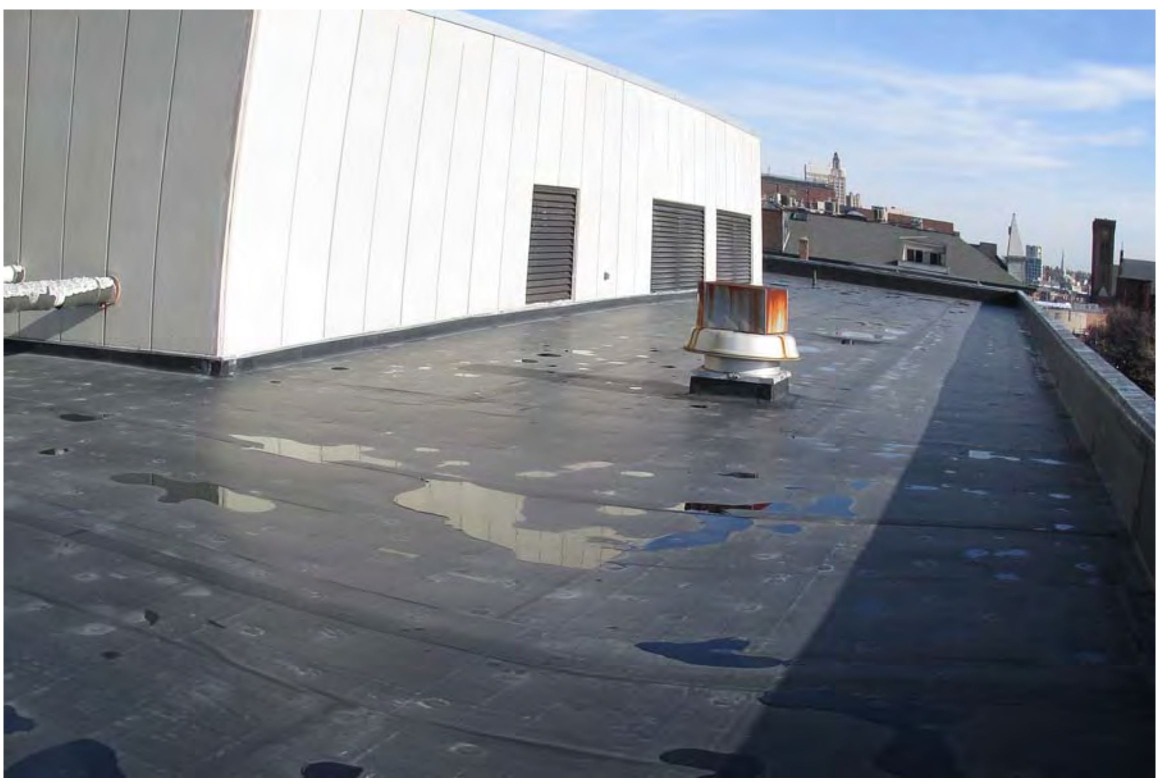
X	Yes	Height	28 in.
	No		

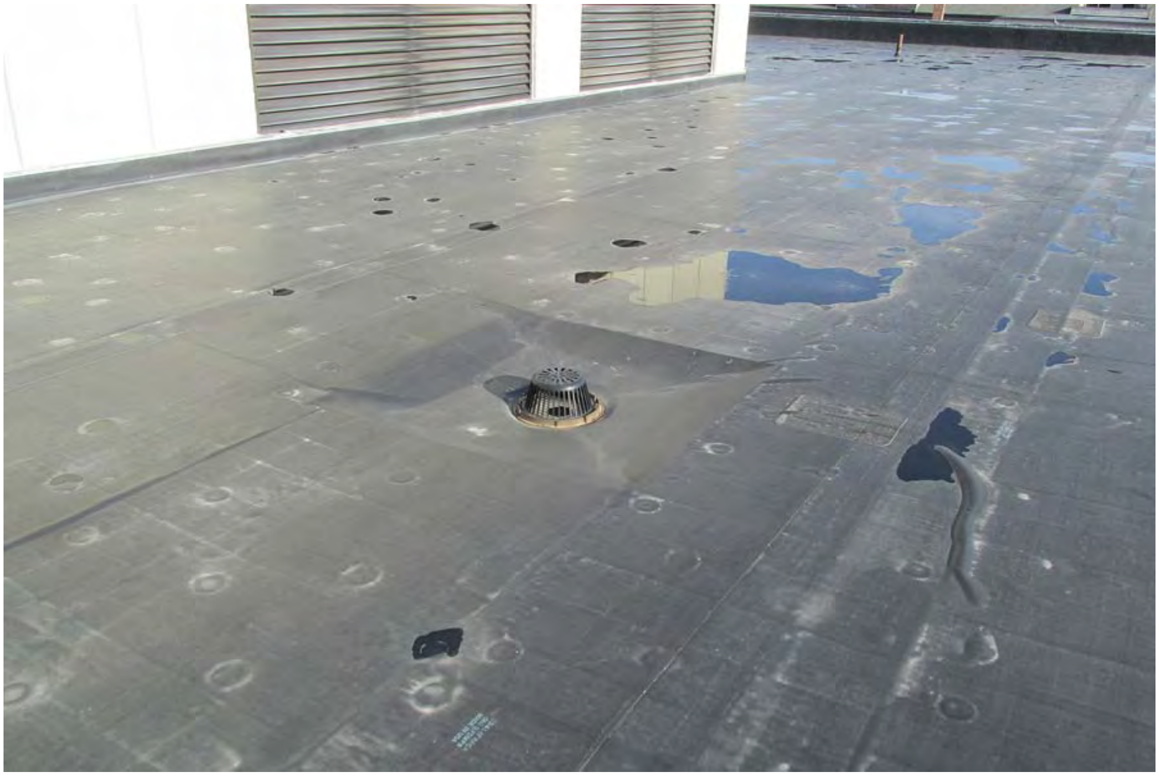
14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

none

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.





Solar Feasibility Site Evaluation Summary

Site ID:	15
Name:	Providence Emergency Management Agency
Address:	591 Charles Street
Tier Ranking:	II
Building Use:	Admin/Garage
Approx. Potential PV system size, kw	5
Approx. EPP, MWh/yr:	6
Site Qualitative Score:	2.2
LCOE with 30% ITC, $/kWh:	0.083

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site is above average and the approximate Energy Production Potential (EPP) is below average resulting in a Tier II ranking. Tier II sites are not top ranked, however, they still have a reasonable potential for a successful solar PV project and warrant a more detailed evaluation.

While this Site scored well qualitatively, it has the lowest estimated Energy Production Potential of all of the sites evaluated. Obstructions, a slanted roof, and shading from adjacent roofs limit the area available for a PV system.

Because the building is two stories tall the zoning ordinance requires the construction of a parapet wall to screen the PV system.

Rooftop observations are reported in the attached Roof Inspection Report.

2011 Orthophoto

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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RESULTS

6,266 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	352	28
February	3.67	422	34
March	4.58	567	46
April	5.35	624	51
May	5.78	673	54
June	6.15	673	54
July	6.39	707	57
August	5.95	661	54
September	4.55	501	41
October	4.00	474	38
November	2.74	325	26
December	2.28	288	23
Annual	**4.51**	**6,267**	**$ 506**

User Comments

Providence Emergency Management Agency

Location and Station Identification

Requested Location	591 Charles Street Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 9.4 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	5 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

Northeast Engineers & Consultants, Inc.
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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study			Project No.:	14132.0
Inspector:	S. Otten	Temperature	42 ºF	Weather:	Rainy
Date:	12/10/2014	Arrival Time	1:30PM	Departure Time:	2:00PM

Site ID	15				
Name	Providence Emergency Management Agency				
Address	591 Charles Street				
Use	Administrative	Stories	2	Year Built	1930

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

New addition built 2013, assume to be steel joists with steel deck.

2. Roof Structure Condition

	Poor	Comments:
	Fair	
	Good	
X	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

Black membrane, EPDM, fully adhered.

4. Roofing System Condition

	Poor	Comments:
	Fair	
	Good	
X	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

hard/firm

6. Estimated/Reported Age of Roofing System

1 year

7. Estimated Remaining Useful Life

19-24 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

None

9. Roof Access (i.e. hatch, stairs, ladder)

Ladder Stair to walk-out door onto roof

10. Security against Vandalism

Facility is gated and secure.

11. Roof Pitch and Orientation

low pitch to edge gutters.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

None on lower roof. Upper roof has HVAC units

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

	Yes	Height	____________
X	No		

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

Upper roof and original building taller than lower roof.

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

Northeast Engineers & Consultants, Inc.
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Solar Feasibility Site Evaluation Summary

Site ID:	16
Name:	Public Safety Complex
Address:	325 Washington Street
Tier Ranking:	IV
Building Use:	Public safety
Approx. Potential PV system size, kw	250
Approx. EPP, MWh/yr:	316
Site Qualitative Score:	1.7
LCOE with 30% ITC, $/kWh:	0.078

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site and the approximate Energy Production Potential (EPP) are both above average resulting in a Tier I ranking. Tier I sites have the most potential for a successful solar PV project and warrant a more detailed evaluation.

Rooftop observations are reported in the attached Roof Inspection Report.

2011 Orthophoto

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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RESULTS

316,076 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	17,678	1,432
February	3.67	21,231	1,720
March	4.58	28,551	2,313
April	5.35	31,461	2,548
May	5.78	33,960	2,751
June	6.15	33,975	2,752
July	6.39	35,723	2,894
August	5.95	33,449	2,709
September	4.55	25,294	2,049
October	4.00	23,898	1,936
November	2.74	16,373	1,326
December	2.28	14,482	1,173
Annual	**4.51**	**316,075**	**$ 25,603**

User Comments

Public Safety Complex

Location and Station Identification

Requested Location	325 Washington St, Providence, RI
Weather Data Source	(TMY2) PROVIDENCE, RI 7.2 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	250 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

Northeast Engineers & Consultants, Inc.
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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study			Project No.:	14132.0
Inspector:	S. Otten	Temperature	44 ºF	Weather:	Rainy/Cdly
Date:	12/10/2014	Arrival Time	2:15PM	Departure Time:	2:35PM

Site ID	16				
Name	Providence Public Safety Complex				
Address	325 Washington Street				
Use	Public Safety	Stories	3	Year Built	2002

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

Steel Joists with Steel decking

2. Roof Structure Condition

	Poor	Comments:
	Fair	
	Good	
X	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

Black membrane, EPDM, fully adhered, over rigid insulation

4. Roofing System Condition

	Poor	Comments:
	Fair	
	Good	
X	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

firm/hard

6. Estimated/Reported Age of Roofing System

12 years (assuming original)

7. Estimated Remaining Useful Life

8-13 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

Clogged drain grates

9. Roof Access (i.e. hatch, stairs, ladder)

Each wing is accessed via at ship ladder at the top landing of the stair towers. Roof hatches provide direct access to roof.

10. Security against Vandalism

Access into building is secure.

11. Roof Pitch and Orientation

Low pitch towards interior drains.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

Vents, conduits, cables, HVAC units, exhaust fans.

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

X	Yes	Height	22 in.
	No		

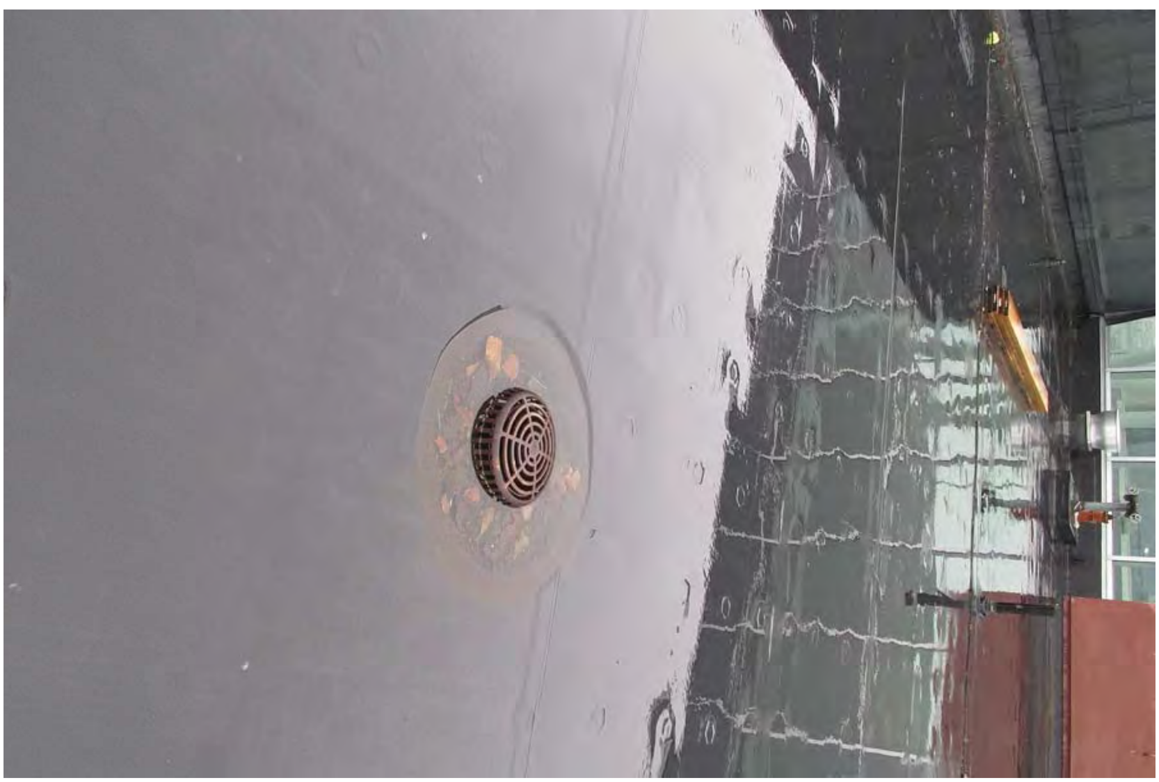
14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

None

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.


APARTMENTS




APARTMENTS


APARTMENTS


DAIKIN

Solar Feasibility Site Evaluation Summary

Site ID:	17
Name:	Public Safety Complex Garage
Address:	349 West Fountain St.
Tier Ranking:	II
Building Use:	Garage
Approx. Potential PV system size, kw	140
Approx. EPP, MWh/yr:	175
Site Qualitative Score:	1.9
LCOE with 30% ITC, $/kWh:	0.080

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site is above average and the approximate Energy Production Potential (EPP) is below average resulting in a Tier II ranking. Tier II sites are not top ranked, however, they still have a reasonable potential for a successful solar PV project and warrant a more detailed evaluation.

This facility is a garage. Installing PV modules would require the elimination of parking spaces.

A communication tower located on the southern end of the building will partially shade any PV modules installed. An elevator/stairway tower also located on the southern end of the building will shade modules installed in the vicinity.

Rooftop observations are reported in the attached Roof Inspection Report.

2011 Orthophoto

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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RESULTS

175,460 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	9,850	798
February	3.67	11,810	957
March	4.58	15,866	1,285
April	5.35	17,470	1,415
May	5.78	18,839	1,526
June	6.15	18,832	1,525
July	6.39	19,784	1,602
August	5.95	18,520	1,500
September	4.55	14,034	1,137
October	4.00	13,275	1,075
November	2.74	9,113	738
December	2.28	8,068	654
Annual	**4.51**	**175,461**	**$ 14,212**

User Comments

Public Safety Complex Garage

Location and Station Identification

Requested Location	349 West Fountain St. Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 7.1 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	140 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

Northeast Engineers & Consultants, Inc.
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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study			Project No.:	14132.0
Inspector:	S. Otten	Temperature	43 ºF	Weather:	Rainy/Cldy
Date:	12/10/2014	Arrival Time	2:10PM	Departure Time:	2:15PM

Site ID	17				
Name	Providence Public Safety Complex Parking Garage				
Address	349 West Fountain Street				
Use	Parking Garage	Stories	6	Year Built	2001

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

Precast Concrete Parking Deck

2. Roof Structure Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

No roof, just the concrete parking deck.

4. Roofing System Condition

	Poor	Comments:
	Fair	
	Good	
	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

NA

6. Estimated/Reported Age of Roofing System

NA

7. Estimated Remaining Useful Life

NA

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

None

9. Roof Access (i.e. hatch, stairs, ladder)

Parking garage deadends at roof level. Must turn around to exit.

10. Security against Vandalism

Garage was open and free to public at time of inspection.

11. Roof Pitch and Orientation

deck pitches towards interior drains

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

None

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

X	Yes	Height	36 in.
	No		

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

Elevator/Stair Tower with large communication tower is located on the south end of the building.

Notes:

Parking spaces would need to be given up if solar were to be installed on the upper roof level.

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.


Ford


PROVIDENCE


7
POLICE

Solar Feasibility Site Evaluation Summary

Site ID:	18
Name:	Department of Public Works
Address:	20 Ernest Street
Tier Ranking:	III
Building Use:	Garage
Approx. Potential PV system size, kw	370
Approx. EPP, MWh/yr:	422
Site Qualitative Score:	1.4
LCOE with 30% ITC, $/kWh:	0.076

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

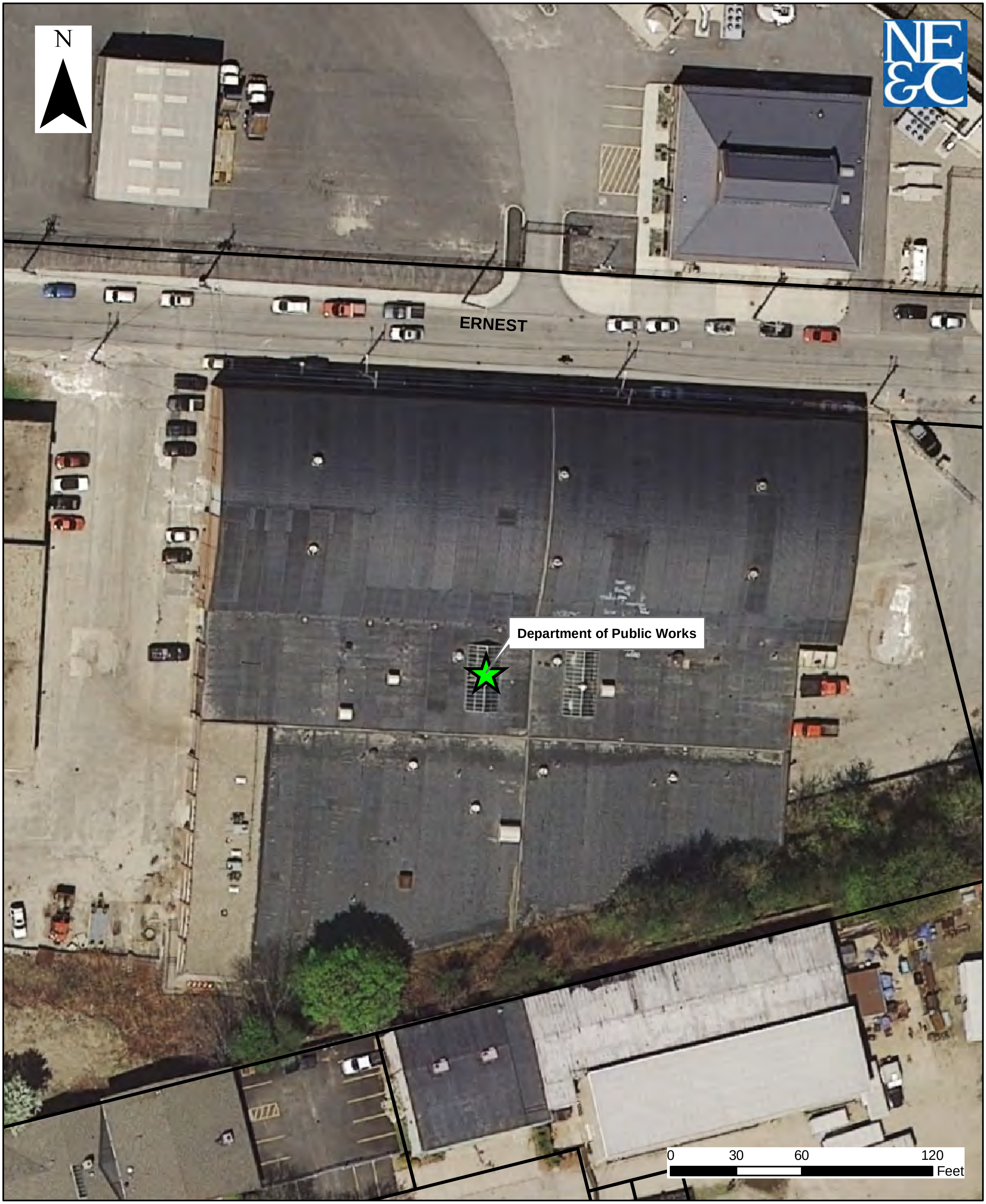
Comments:

The qualitative score of this Site is below average and the approximate Energy Production Potential (EPP) is above average resulting in a Tier III ranking. Tier III sites have low potential for a successful solar PV project as-is. However, additional improvements to the building would increase the qualitative score.

Trees growing along the southern edge of the building as well as an adjacent building that rises above the Site is likely to be a shading concern for a portion of the roof. The trees also provide roof access to animals and vandals. Removing or trimming the trees and modeling the shade effect of the adjacent building could improve the qualitative score.

Because the building is one story tall the zoning ordinance requires the construction of a parapet wall to screen the PV system.

Rooftop observations are reported in the attached Roof Inspection Report.



2011 Orthophoto

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Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

RESULTS

422,709 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	23,718	1,921
February	3.67	28,451	2,305
March	4.58	38,232	3,097
April	5.35	42,099	3,410
May	5.78	45,391	3,677
June	6.15	45,378	3,676
July	6.39	47,673	3,861
August	5.95	44,626	3,615
September	4.55	33,803	2,738
October	4.00	31,981	2,590
November	2.74	21,939	1,777
December	2.28	19,419	1,573
Annual	**4.51**	**422,710**	**$ 34,240**

Location and Station Identification

Requested Location	20 Ernest Street, Providence, RI
Weather Data Source	(TMY2) PROVIDENCE, RI 5.7 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	370 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	25.5%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.14 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

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Northeast Engineers & Consultants, Inc.
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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study			Project No.:	14132.0
Inspector:	S. Otten	Temperature	38 ºF	Weather:	Sunny
Date:	12/12/2014	Arrival Time	12:30PM	Departure Time:	1:20PM

Site ID	18				
Name	Providence Department of Public Works				
Address	20 Ernest Street				
Use	Garage	Stories	1	Year Built	1930

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

Steel Beams and Steel deck

2. Roof Structure Condition

	Poor	Comments:
	Fair	
X	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

Black membrane, EPDM, fully adhered. Stone ballast only on the west end approx. 30 feet.

4. Roofing System Condition

	Poor	Comments:
	Fair	some recent repair patches were observed.
X	Good	
	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

firm with some soft spots. In one area, membrane is draped from parapet to create a cant, but nothing solid under membrane.

6. Estimated/Reported Age of Roofing System

Estimate 5-10 years

7. Estimated Remaining Useful Life

10 - 15 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

Standing water due to poor drainage, clogged drain grates

9. Roof Access (i.e. hatch, stairs, ladder)

No direct access, used a ladder up against the rear of the building.

10. Security against Vandalism

Embankment and trees up against the south side of the building appear to provide access for vandals and animals (fresh raccoon tracks were observed). Graffiti was found on the arched roof.

11. Roof Pitch and Orientation

Low pitch towards interior drains. Some areas are not draining and vegetation was observed in at least one area.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

Skylights, vents, exhaust fans, pipes, and conduits

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

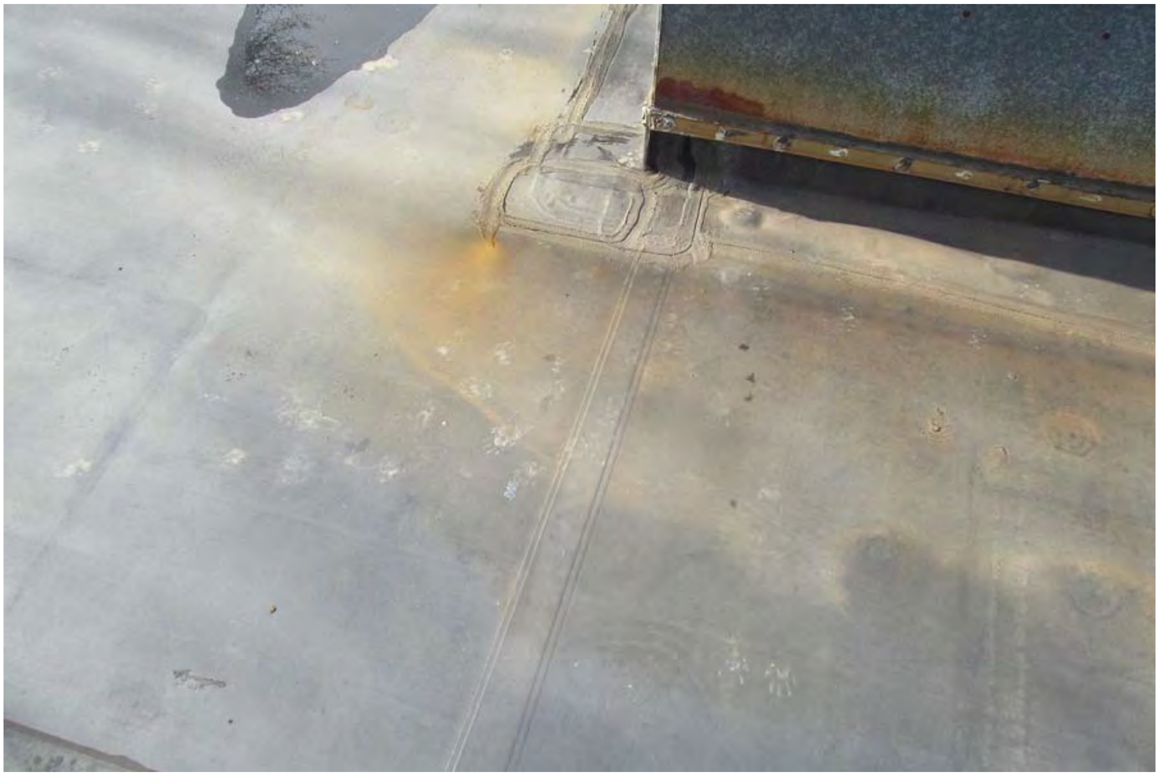
	Yes	Height	____________
X	No		

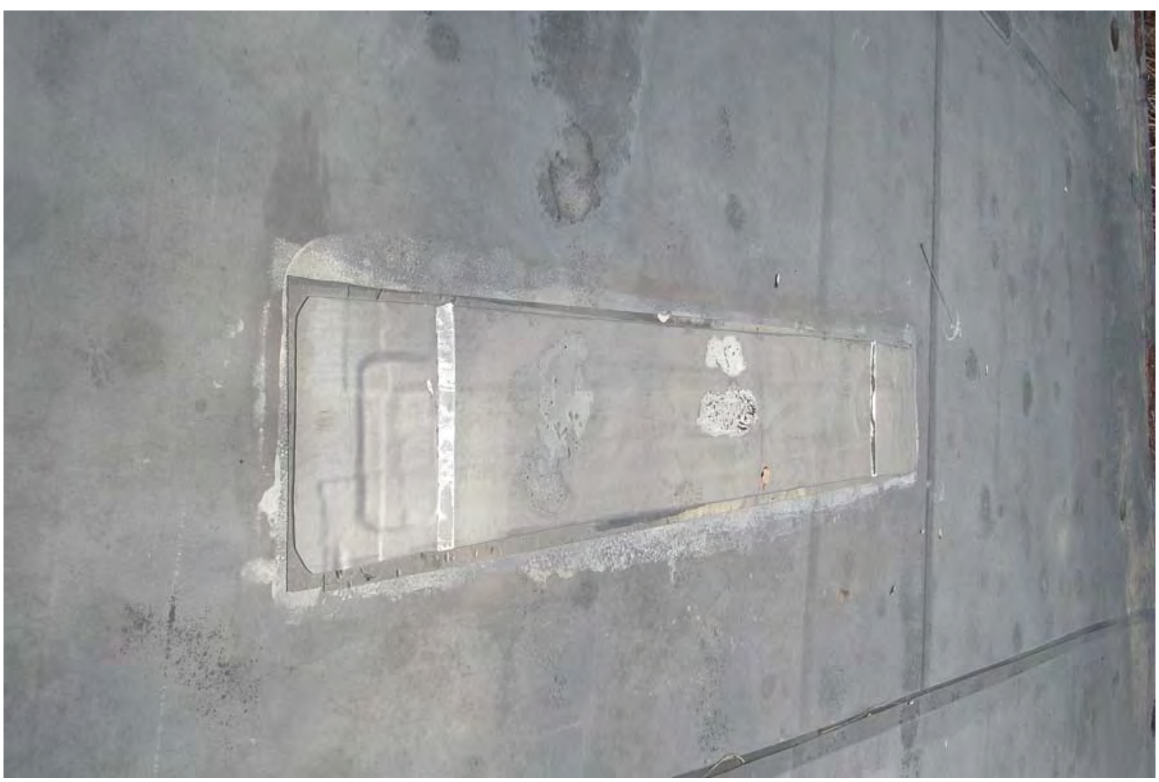
14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

Large trees along the south side of the building.

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.





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Solar Feasibility Site Evaluation Summary

Site ID:	19
Name:	DPW Traffic Engineering
Address:	40 Ernest St.
Tier Ranking:	III
Building Use:	Maintenance garage
Approx. Potential PV system size, kw	410
Approx. EPP, MWh/yr:	514
Site Qualitative Score:	0.7
LCOE with 30% ITC, $/kWh:	0.076

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site is below average and the approximate Energy Production Potential (EPP) is above average resulting in a Tier III ranking. Tier III sites have low potential for a successful solar PV project as-is. However, additional improvements to the building would increase the qualitative score making the site a good candidate.

It does not appear that the existing roof has any useful life remaining. It is estimated to be older than 30 years and is in poor condition. Replacing this roof would increase the qualitative score and elevate the building to Tier I. However, the overall condition of the building was observed to be in poor condition. It appears that significant work would be required prior to replacing the roof and installing PV modules on the roof.

Because the building is one story tall the zoning ordinance requires the construction of a parapet wall to screen the PV system.

Rooftop observations are reported in the attached Roof Inspection Report.

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RESULTS

513,847 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	28,846	2,337
February	3.67	34,585	2,801
March	4.58	46,465	3,764
April	5.35	51,162	4,144
May	5.78	55,170	4,469
June	6.15	55,152	4,467
July	6.39	57,938	4,693
August	5.95	54,236	4,393
September	4.55	41,098	3,329
October	4.00	38,878	3,149
November	2.74	26,689	2,162
December	2.28	23,628	1,914
Annual	**4.51**	**513,847**	**$ 41,622**

User Comments

DPW Traffic Engineering

Location and Station Identification

Requested Location	40 Ernest st Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 5.7 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	410 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study			Project No.:	14132.0
Inspector:	S. Otten	Temperature	34ºF	Weather:	Sunny
Date:	12/12/2014	Arrival Time	11:07AM	Departure Time:	12:15PM

Site ID	19				
Name	Providence DPW Traffic Engineering Bldg				
Address	20-60 Ernest Street (40 Ernest Street)				
Use	Garage	Stories	2	Year Built	1930

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

unknown

2. Roof Structure Condition

X	Poor	Comments:
	Fair	
	Good	
	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

Builtup-Tar & Gravel

4. Roofing System Condition

X	Poor	Comments:
	Fair	
	Good	
	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

Soft

6. Estimated/Reported Age of Roofing System

estimated >30years

7. Estimated Remaining Useful Life

0 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

Clogged drains, standing water, vegetation, failed flashing,

9. Roof Access (i.e. hatch, stairs, ladder)

direct walk-out access from old map room.

10. Security against Vandalism

building is locked.

11. Roof Pitch and Orientation

Low pitch towards interior drains.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

Drains grates only

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

	Yes	Height	________
X	No		

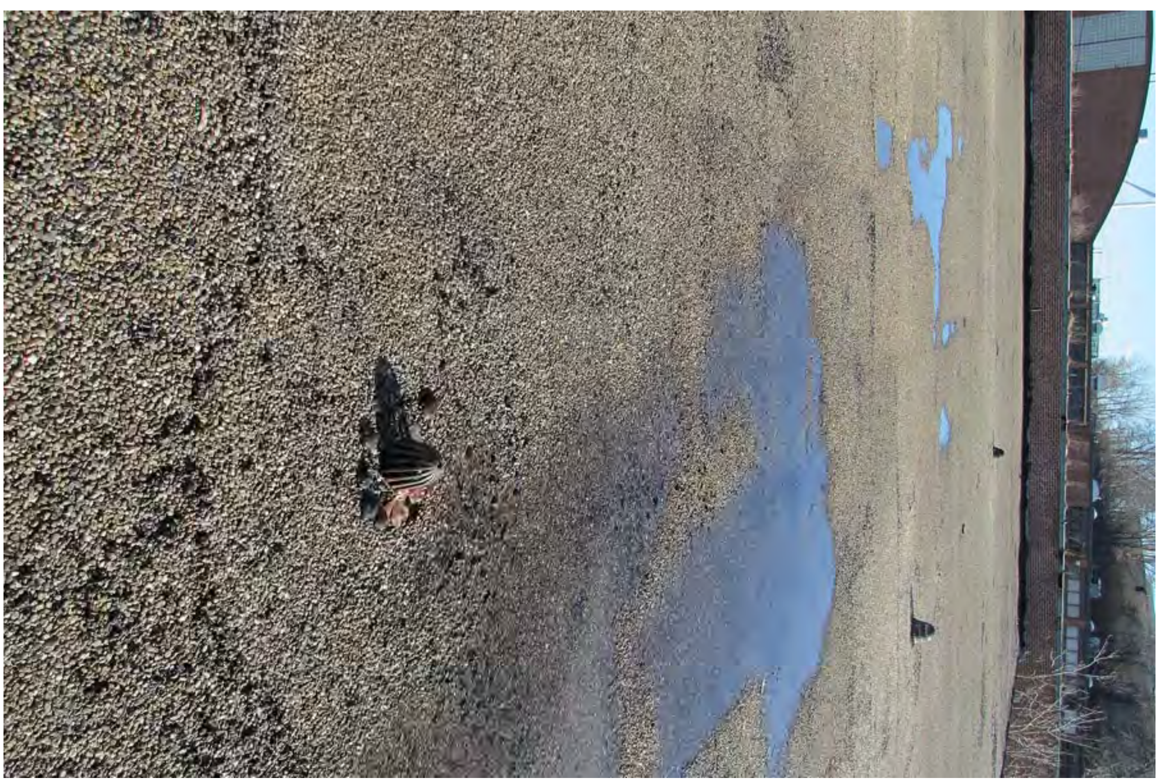
14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

None

Notes:

Roof is open and spacious however in very poor condition. In addition, building is in overall poor condition and several structural defiencies were observed. - Face brick on the Ernest Street side has fallen off the building. - Apparent significant settlement has occurred at the garage overhead door of the VIN station. Slab is cracked and settled, and significant cracking in the walls around the door were observed.

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.



Solar Feasibility Site Evaluation Summary

Site ID:	20
Name:	Providence Career and Technical Academy
Address:	41 Fricker Street
Tier Ranking:	I
Building Use:	School
Approx. Potential PV system size, kw	530
Approx. EPP, MWh/yr:	662
Site Qualitative Score:	2.2
LCOE with 30% ITC, $/kWh:	0.074

Notes: 1) All values are approximate and intended for comparative purposes only. 2) Refer to complete report and tables for additional details.

Comments:

The qualitative score of this Site and the approximate Energy Production Potential (EPP) are both above average resulting in a Tier I ranking. Tier I sites have the most potential for a successful solar PV project and warrant a more detailed evaluation.

This site is the highest ranked site with the highest qualitative score and the second highest Estimated Power Production Potential.

Rooftop observations are reported in the attached Roof Inspection Report.

2011 Orthophoto

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RESULTS

661,735 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	37,148	3,009
February	3.67	44,539	3,608
March	4.58	59,838	4,847
April	5.35	65,887	5,337
May	5.78	71,048	5,755
June	6.15	71,025	5,753
July	6.39	74,612	6,044
August	5.95	69,845	5,657
September	4.55	52,926	4,287
October	4.00	50,067	4,055
November	2.74	34,370	2,784
December	2.28	30,428	2,465
Annual	**4.51**	**661,733**	**$ 53,601**

User Comments

Providence Career and Technical Acadamy

Location and Station Identification

Requested Location	41 Fricker Street Providence RI
Weather Data Source	(TMY2) PROVIDENCE, RI 6.9 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	528 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	18.37%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.08 $/kWh
Initial Cost	2.60 $/Wdc
Cost of Electricity Generated by System	0.13 $/kWh

These values can be compared to get an idea of the cost-effectiveness of this system. However, system costs, system financing options (including 3rd party ownership) and complex utility rates can significantly change the relative value of the PV system.

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Roof Inspection Report

Project:	Providence Solar Energy Feasibility Study	Project No.:	14132.0
Inspector:	S. Otten	Temperature 40 °F	Weather: Sunny
Date:	12/4/2014	Arrival Time 11:10AM	Departure Time: 11:45AM

Site ID	20				
Name	Providence Career & Technical Academy				
Address	41 Fricker Street				
Use	School	Stories	3	Year Built	2009

1. Roof Structure & Deck Type (i.e., steel, wood, concrete)

Old part of bldg, south wing appears to be concrete waffle slab.
New part assumed to be steel joists and metal deck.
Field House was observed from below to be steel girders and metal deck.

2. Roof Structure Condition

	Poor	Comments:
	Fair	
	Good	
X	Excellent	

3. Roofing System Type (i.e. membrane, built-up, gravel ballast)

White membrane, EPDM, fully adhered.

4. Roofing System Condition

	Poor	Comments:
	Fair	
	Good	
X	Excellent	

5. Roof Surface Durability (i.e. soft or hard)

firm/hard

6. Estimated/Reported Age of Roofing System

5 years

7. Estimated Remaining Useful Life

15-20 years

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.

8. Observable Required Repairs

None

9. Roof Access (i.e. hatch, stairs, ladder)

Stairs to door, walk-out directly on roof. Ladder to Field House roof.

10. Security against Vandalism

Stairway has locked gate.

11. Roof Pitch and Orientation

Low pitch to interior drains. Field House has low pitch from center ridge to east and west eave gutters.

12. Obstructions (i.e., piping, conduits, HVAC Units, Skylights)

vents, piping, conduits, HVAC units. Existing H/W solar panels located on southern end of new wing. Field House roof is open with only lightening rods.

13. Existing Parapet (Req'd by zoning for bldgs 2 stories or less)

X	Yes	Height	24 in. min.
	No		None on eaves of Field Hse.

14. Potential Shading (i.e., trees, roof obstructions taller than PV system, adjacent buildings)

None

Notes:

Note: All observations, ratings, and estimated remaining roof life are intended for comparative ranking purposes only.