Resilience and Solar Assessment
Stamford 2030 & City of Stamford

Stamford High School

55 Strawberry Hill Avenue
Stamford, CT 06902

Submitted To:
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Introduction

Climate change is increasing the frequency and severity of extreme storms, exacerbating droughts, shifting precipitation patterns, and causing more extreme heat waves. Facilities with a critical role in the community, such as schools, police and fire stations, emergency operations centers, city halls, and emergency shelters can realize long-term operating and avoided impact cost savings, increased durability, and improved emergency operations through resilience planning. The objective of this assessment is to identify resilience and solar opportunities to improve the resilience and sustainability of the assessed property.

New Ecology, Inc. ("NEI") conducted a resilience and solar opportunity assessment of the Stamford High School building located at 55 Strawberry Hill Avenue, Stamford, CT. For this assessment, NEI conducted an onsite walkthrough of the property to visually identify critical risks; review the building's historical impact from extreme wind and hurricanes, flooding, ice and snow, and extreme heat and cold events and identify solar and storage potential. The hazards assessed align with those identified by the April, 2015 City of Stamford Hazards and Community Resilience Workshop. The walkthrough took place on April 20, 2018. The assessment team consisted of Tom Chase, Senior Project Manager and Tom Ziobron, Project Manager. Dan DiBlasio and John Varamo from the City of Stamford and Emily Gordon from Stamford 2030 were onsite for the walkthrough. This assessment was supported by a CIRCA Municipal Resilience grant to Stamford 2030 and the City of Stamford.

Building Overview

The original Stamford High School building was constructed in 1928 but has been expanded several times and now accommodates 1,719 students in grades 9-12. The main building is masonry construction and later buildings are a mix of masonry, concrete, and steel construction. Recent major renovations include replacement heating boilers and new roofs in 1997 and the 2006 addition of 62,000 sf of classrooms, labs, computer room, multi-purpose gymnasium, and locker rooms.

Entry to the main building is via stairs or a ramp to an entrance vestibule, approximately three feet above grade. Primary interior circulation is by elevator and stairways. In addition to classrooms and offices, the main gymnasium, kitchen, and locker rooms are used as an emergency shelter for the City of Stamford. The last time the building was used as a shelter was during Hurricane Sandy in 2012. There have been no recent examples of neighborhood flooding. The property is located in the FEMA Zone X, an area of minimal flood hazard.

Ongoing maintenance and capital repairs have been performed as needed. The main gymnasium, kitchen, and locker rooms as well as building-wide life safety functions are supported by a 250 kW natural gas generator, the electrical panel for which has been upgraded recently.

Resilience Opportunities

The primary hazards to the Stamford High School building are extreme heat, extreme cold, and electric outage. Based on the results below, NEI concludes that several low- to moderate-cost measures will improve the building's resilience to extreme temperatures and electric outage. Additional measures will to improve the resilience of the building in the event long term electric outages during extreme heat or cold would likely require substantial investments in upgrading the building envelope and providing additional sources of backup power, such as commercial-scale batteries. Our recommendations, in order of priority, are shown in Table 1.

Table 1: Resilience Opportunities

#	Opportunity	Hazards	Description	Quantity	Unit	Unit Cost	Estimated Cost	Implementation Timing
1	Develop Emergency Management Manual	All	A disaster can come at any time or can progress more slowly, but one of the most crucial factors in providing continuity of service is the coordination of facility and management staff in responding to the event. Provide a plan and contact list for staff, leadership, and other building occupants to communicate effectively throughout a disaster. Follow the Enterprise Disaster Staffing Toolkit guide to creating an organization-level emergency plan.	1	each	-	-	Immediate
2	Building Energy and Water Utility Tracking	N/A	Ongoing utility tracking and benchmarking will improve routine operations by providing easy access to billing and usage information and indicators of potential problems shown through spikes or declines in expected usage. Utility data will also help in identifying critical loads in planning for disasters. ENERGY STAR Portfolio Manager is a free tool for utility tracking and benchmarking.	1	each	-	-	Immediate
3	Energy Audit	N/A	Routine, in-depth, energy audits are key in ensuring that buildings operate efficiently. An efficient building is one that is much easier to protect and back up during an extreme event. The audit will likely identify the existing central mechanical equipment and	1	each	$15,000	$15,000	Immediate

#	Opportunity	Hazards	Description	Quantity	Unit	Unit Cost	Estimated Cost	Implementation Timing
			envelope improvements, as well as other potential energy conservation measures. The CT Greenbank offers third-party audit services through a cost-sharing program.					
4	Solar Feasibility and Backup Battery Analysis	Power Outage	In addition to the preliminary solar feasibility analysis below, a battery backup analysis will indicate the potential financial and resilience benefit of installing large-scale batteries in addition to a solar PV system. Contact NEI to find out more about a pilot CT Green Bank solar+storage analysis opportunity.	1	each	-	-	Immediate
5	Access to Potable Water	Power Outage, Water Outage	Given the emergency shelter function of the site, storing bottled water for use during emergencies is a low cost, high-impact resilience measure. Provide potable water storage in a central system or portable potable water storage containers: 1 gal/person/day for 1 day in stored bottled water, plus 1 gal/person/day for 6 days in collapsible storage capacity.	1,000	each	$1	$1,000	Ongoing Maintenance
6	Properly Vent Combustion Appliances	N/A	Combustion appliances must all be properly vented to the exterior to prevent combustion byproducts from entering the indoor air. Atmospheric domestic hot water boilers should be replaced with direct-venting condensing boilers. Consider replacing heating boilers as well pending energy audit recommendations.	2	each	$30,000	$60,000	Medium Term

#	Opportunity	Hazards	Description	Quantity	Unit	Unit Cost	Estimated Cost	Implementation Timing
7	Cool Roof	Extreme Heat, Power Outage	A cool roof is a reflective, light colored roof that reduces the amount of solar energy a building absorbs by reflecting the solar energy back into the atmosphere. Cool roofs can be a painted-on or membrane product, reduce the building's cooling load, and allow the interior to remain comfortable longer in the event of a power outage on a hot day. Cool roofs also reduce local heat island effects.	102,000 (estimated)	sf	$17.50	$1,785,000	Medium Term (or prior to solar PV installation)
8	Critical Loads Evaluation	Power Outage	Engage an electrical engineer to produce an evaluation of the critical loads associated with emergency shelter functions, identify any loads not currently covered by the emergency generator or without circuits tied to the emergency electrical panel, and add those circuits to the emergency electrical panel if possible.	1	Each	$5,000	$5,000	Medium Term
9	Quick Connects for Mobile Heating, Cooling, and Electricity	Power Outage	Quick connects are connection points on the exterior of the building for connecting temporary backup heating, cooling, or electrical equipment. Quick connects to hot water piping, chilled water piping, or electrical panels allow temporary mobile heating, cooling, and power equipment to connect to the building and provide services during system outages.	3	each	$2,500	$7,500	Long Term

#	Opportunity	Hazards	Description	Quantity	Unit	Unit Cost	Estimated Cost	Implementation Timing
10	Surface Stormwater Management	Flood	Surface stormwater management is a suite of infrastructure strategies that capture, store, direct, and infiltrate water into the ground or delay stormwater from entering the storm sewer rapidly and potentially backing up. Strategies may include low impact development strategies such as rainwater catchment basins that capture and store stormwater and then slowly release it into the stormwater system. The Stamford High School building and landscaping is primarily impervious, capturing and infiltrating or slowing rainwater will primarily benefit downstream sites and may provide an educational opportunity. Engage a civil engineer to design a stormwater management plan and to help determine the best strategy options.	1	each	$5,000	$5,000	Long Term

Solar Opportunity

The Stamford High School building is a good candidate for a solar PV system and may be a good candidate for backup battery storage. To evaluate the solar PV potential at the site, NEI created a preliminary solar system layout, estimated annual electricity production, and performed a cost savings estimate.

NEI used HelioScope to model solar generation for the potential solar PV systems on the Stamford High School roofs. HelioScope is a web-based solar PV system modeling and electricity production estimation tool. It estimates potential solar generation per year, accounting for building location, local weather data, shading, solar system type, size, and capacity, as well as solar panel direction and tilt.

Table 2 provides an overview of the preliminary solar PV system details, and Figure 2 shows the preliminary system layout used for this analysis. NEI estimates that a solar system of approximately 551.7 kW DC can be accommodated on the existing High School roofs. The system would produce approximately 710,900 kWh of electricity per year.

Solar system assumptions include the following:

ROOF

- Minimum setbacks, pathways, and clearance around equipment, penetrations, and roof curbs are assumed.
- The calculated system sizes include five-foot perimeter setbacks and 1.5-foot intra-row spacing on the flat roof sections, along with clearance around all penetrations that impact panel shading.
- Systems are otherwise maximized for available unshaded roof area.

STRUCTURAL

- The structural integrity of the roofs will need to be assessed to confirm the additional dead load and uplift from the arrays can be accommodated.
- Typical dead load requirements are between 3 and 5 lbs./sf.

ELECTRICAL

- An outdoor disconnect and solar meter will need to be added close to the existing electric meter.
- Arrays on all roof locations will tie back to the main electrical room.
- Additional wall space will be needed in the electrical room to allow space for inverters.
- Interconnection, solar meter, and disconnects shall be in accordance with utility requirements.

SHADING

- The roof areas described do not appear to have any significant shading from neighboring buildings or trees. Shading from adjacent roofs has been accounted for in sizing the system. On site shading analysis will be required for final system design.

The financial assumptions used in this analysis appear below in Table 3. Table 4 provides a summary of the financial impact of a solar PV system for this location under a direct purchase model.

Table 2: Preliminary Solar PV System Details

Field Segment	Estimated System Size (kW)	System Type
1	144.6	Ballasted, 10° Tilt, 180° Azimuth
2	13.8	Ballasted, 10° Tilt, 180° Azimuth
3	66.3	Ballasted, 10° Tilt, 180° Azimuth
4	22.8	Ballasted, 10° Tilt, 180° Azimuth
5	13.2	Ballasted, 10° Tilt, 180° Azimuth
6	63.9	Ballasted, 10° Tilt, 180° Azimuth
7	12.9	Ballasted, 10° Tilt, 180° Azimuth
8	182.7	Ballasted, 10° Tilt, 180° Azimuth
9	16.2	Ballasted, 10° Tilt, 180° Azimuth
10	15.3	Ballasted, 10° Tilt, 180° Azimuth

Figure 2: Preliminary Solar PV System Layout

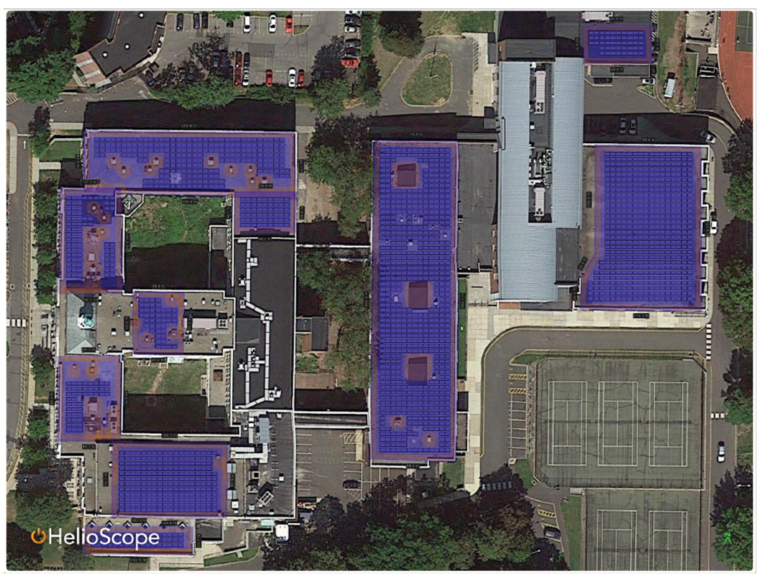


Table 3: Solar PV Analysis Assumptions

Metric	Assumption
Lifecycle Term (years)	25
Inflation Rate	2.0%
Discount Rate	4.0%

Escalation Rate for Utility Costs (per year)	3.0%
Degradation Rate for Solar PV Performance (per year)	-0.5%
ZREC Value (per kWh)	$0.10

Table 4: Summary of Solar PV Financial Impact – Direct Purchase

Net Investment without Federal ITC	$1,930,950
Net Investment with Federal ITC	$1,351,665
Net Saving (NPV) with Incentives	$1,682,763
Annual Average Utility Saving (NPV)	$141,469

	Without Incentives	*With Incentives*
Savings-to-Investment Ratio	1.87	2.24
Simple Payback (years)	14	10

If the City of Stamford can take advantage of the federal investment tax credit for renewable energy generating systems through a third party, the estimated savings to investment ratio of the system analyzed would be 2.24 and the simple payback would be 10 years. Without the federal investment tax credit, the estimated savings to investment ratio would be 1.87 and the simple payback would be 14 years. Both scenarios show a payback well within the lifetime of the projected system.

NEI assumes that direct purchase and ownership would be supported by the sale of zero-energy renewable energy credits (ZRECs). The CT ZREC plan is currently in year 6, and the year 7 RFP is scheduled to be announced in August, 2018. ZREC values for medium sized systems, including those in the 100-250 kW capacity, are determined by the bids submitted during the RFP opening. NEI assumed the average ZREC value from the list of all accepted bids for the year 6 medium size category. If a bid is accepted, ZRECs are sold to Eversource over 15 years.

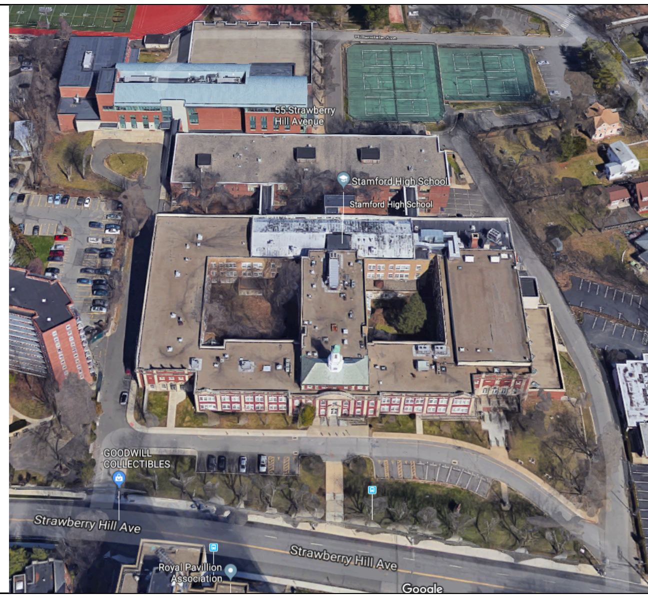
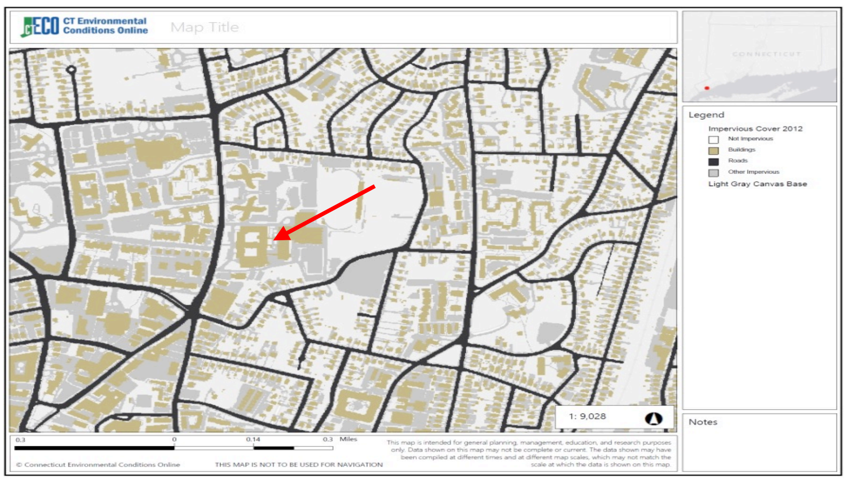
NEI recommends that the City engage a solar PV system designer and installer and investigate direct purchase and ownership options. NEI also suggests that the City investigate third-party power purchase agreement options, such as those available through the CT Green Bank. A third-party power purchase agreement would enable the installation of a solar PV system and monthly electricity cost savings without upfront investment cost. However, NEI recommends that should the City of Stamford procure a solar PV system for the building, that the cool roof upgrade recommended in the resilience measures above be implemented in advance of the solar PV installation.

Opportunities Summary

In summary, NEI identified the following opportunities to improve resilience at the Stamford High School Building:

- Engage a solar installer to provide a rooftop solar PV system either through direct purchase or through a power purchase agreement. Given the large electricity use of the building and the ample open flat roof space, a solar PV system could provide significant cost savings and enable future battery backup capacity. A critical loads evaluation will reveal any systems that are not currently backed up and will help to size a future commercial-scale battery for additional shelter functions not currently covered by the existing generator.
- As part of routine building management and staff protocol, create an Emergency Preparedness Plan to specify roles and responsibilities during emergencies including extreme weather events, building operations or shutdown procedures, and to support recovery after an extreme event.
- Implement ongoing utility tracking and benchmarking. In addition to improving ongoing operations by helping to identify issues early, tracking and benchmarking utility data will provide a more complete picture of what would be required to provide critical functions beyond life safety in the event of an extended utility outage. Engaging a firm to complete a full energy audit as well as investigating battery backup feasibility are also recommended.
- As part of the emergency shelter function preparedness, storing bottled water on site will improve the capacity of the building to respond to an emergency.
- The existing domestic hot water boilers are atmospherically vented and may be releasing combustion byproducts back into the occupied areas of the building. Upgrade boilers to direct-vented condensing type to improve indoor air quality and realize energy efficiency savings.
- A cool roof coating and thermal window shades will lower the cost of cooling the building and allow the building to remain habitable longer during an electric outage during the summer.
- Should the existing generator or future battery backup systems fail during an emergency or equipment failure, utility quick connects will facilitate rapid deployment of temporary equipment to provide heating, cooling, and/or electricity to the building.
- Improved surface stormwater management as through bio swales and other green and low impact development best practices will benefit downstream sites and may provide an educational opportunity on site.

Appendix 1: Photos

Aerial image of Stamford High School	
Impervious surface coverage map, High School indicated by arrow.	
250kW natural gas-fired standby generator to supply main gym, locker rooms, cafeteria, kitchen, and auxiliary gym.	

Atmospherically vented boilers and domestic hot water equipment.	
Significant water infiltration and/or leaking mechanical equipment. Source and potential solutions should be evaluated as part of more comprehensive energy audit.	
Recently updated electrical equipment.	

Recently updated electrical equipment.