Solar-Ready Roof Design

Manual

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1. BACKGROUND

In alignment with the Solar-Ready Roof Engineering Instruction (EI-4), this manual provides technical guidance on designing and evaluating solar-ready roofs for Port Authority of New York and New Jersey ("Port Authority" or "Agency" or "PANYNJ") facilities. A project's eligibility and/or exemptions are outlined in EI-4, Appendix A). The manual provides tools for the Initial Solar Analysis and outlines discipline-specific guidance for designing solar ready roofs from project stage I to stage IV. The manual covers Solar Ready Roof guidance for both Existing Buildings (EB) as well as for New Construction (NC)

Note that the Guideline provides the pathway for 'Solar-Ready' design for the Engineering and Architectural Design Division (EADD). Any special inspection or Construction Management Division (CMD)/ Materials Engineering Unit (MEU) activities shall be performed as per the typical workflow. Solar photovoltaic (PV) installation (Solar-Installed') and energy storage systems are excluded and will be covered in different iterations of the Guidelines. See Table 1 for what is included in 'Solar-Ready' vs 'Solar-Installed'.

Projects located in NYC shall follow Local Law 92 and Local Law 94 of 2019 and be adopted by Chapter 15 of the NYC Building Code, which requires sustainable roofing zones in new constructions, and also when existing roofs are expanded or replaced. Additionally, cool roof standards are still required for roof areas that are not feasible for green or solar roofs, including sloped roofs.[1]

Table 1: Installation Components

	Solar-Ready	Solar-Installed
Identification/ allocation of rooftop space	x	x
Evaluation of the structural integrity of roof	x	x
Installation of forecasted wiring/ conduits	x	x
Installation of new electrical panel, disconnect switch		x
Installation of the inverter		x
Installation of the roof mounting connection		x
Installation of solar PV panels/ arrays		x

The Guideline shall not replace professional design analyses, nor is the Guideline intended to limit innovative design where equal performance in value, safety, and cost of maintenance can be demonstrated. The design team shall be responsible for producing designs that comply with the Guidelines in addition to all applicable codes, ordinances, statutes, rules, regulations, and laws. Any conflict between the Guideline and an applicable code, ordinance, statute, rule, regulation, and/or law shall be addressed with the respective functional chief. The use and inclusion of the Guidelines, specifications, or example drawing details as part of the Contract Documents does not alleviate the design professional from their responsibilities/standard of care, or legal liability for any Contract Documents they create. It is also recognized that the Guidelines are not universally applicable to every project. There may be instances where a Guideline may not be appropriate. If the design professional believes that a deviation from the Guideline is warranted, such a deviation shall be submitted in writing for approval to the respective functional chief.

[1] *LL92_94_Brief.pdf (nyc.gov)*

1.1. DEFINITIONS

CANOPY: A permanent structure or architectural projection of rigid construction over which a covering is attached that provides weather protection, identity, or decoration, which shall be structurally independent or supported by attachment to a building on one end and by not fewer than one stanchion at the outer end.

FIRE AREA: The aggregate floor area enclosed and bounded by fire walls, fire barriers, exterior walls and/or horizontal assemblies of a building. Areas of the building not provided with surrounding walls shall be included in the fire area if such areas are included within the horizontal projection of the roof or floor next above.

LEVELIZED COST OF ENERGY: Levelized cost of energy (LCOE) is a summary metric that combines the primary technology cost and performance parameters. It is useful for discussing technological advances that yield future projections because it illustrates the combined effect of the primary cost and performance parameters[2].

SOLAR PHOTOVOLTAIC (PV): Solar PV technologies result in a renewable energy source that creates electricity (voltage) through the conversion of light (photons).

SOLAR PV AGREEMENTS:

- **Direct Purchase:** The agency can purchase a solar array using agency funds through capital projects. This can be done either through various traditional or alternative project delivery processes.

- **Power Purchase Agreement (PPA):** The Agency may utilize PPAs so that a third party will design, build, finance, own, operate, and maintain solar PV systems at the Agency's facility. PPAs allow for a solar developer to finance the solar installation with no capital cost for the Agency. As the owner of the system, the solar developer can directly utilize incentives, tax credits, and third parties to finance the project. The produced electricity is purchased by the agency at a pre-determined cost. PPA agreements offer future price guarantees and reduce operational and market risk for the

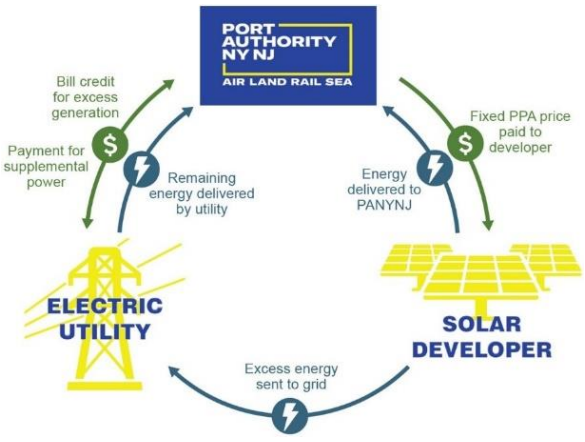


Figure 1: Power Purchase Agreement Diagram.

[2] *NREL Definitions - https://atb.nrel.gov/electricity/2021/definitions*

Agency by shifting it to the solar developer.

SOLAR PV COMPONENTS:

- **Inverters:** Converts the direct current (DC) electricity produced by PV modules into alternating current (AC) electricity that can be used on-site or exported to the grid. Inverters allow for PV system monitoring and controls by providing diagnostic information for operations and maintenance, and control functions to improve the system output.

- **PV Cell:** A PV cell is made of semiconductor material sandwiched between protective laminate materials such as plastic or glass. An individual PV cell typically produces about 1 or 2 watts of power.

- **PV Modules:** PV cells are connected in parallel to form larger units known as modules. The edges of modules are sealed for weatherproofing and held together by frames, typically made of aluminum.

- **PV Panels:** PV panels are made up of one or more PV modules assembled as a pre-wired, installable component. A PV panel framing shall be corrosion-resistant, and resistant to damage from snow, wind, hail, windblown dust and sand, and saltwater.

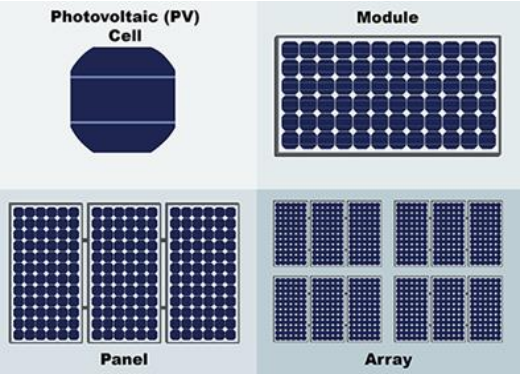


Figure 2: Components of a PV System.

- **PV Array:** A PV array consists of cells, modules, and panels. A PV array is the complete power-generating unit, consisting of any number of PV modules and panels.

SOLAR PV DESIGN:

- **Solar-Installed:** A roof with a solar photovoltaic system installed along with supporting equipment and physically interconnected to the facility and/or grid.

- **Solar-Ready:** A section of a roof designated and reserved for the future installation of a Photovoltaic Panel System, which is calculated as 100% of the horizontal or pitched roof area minus the area covered by:
  - Access or setbacks required by codes or zoning laws,
  - Rooftop structures, equipment, or appurtenances necessary for mechanical, fire protection, or other essential building systems,
  - Stormwater management systems,
  - Solar thermal installations, and/or
  - Patron or publicly accessible terraces and recreational space[3].

[3] *Engineering Instruction 4 (EI-4) Solar-ready roof initiative*

SOLAR PV MOUNTING/ CONNECTIONS:

- **Ballasted PV Panels:** Ballast-mounted panels use heavy weights, like concrete blocks, to resist uplift and sliding due to lateral forces (wind, earthquake, etc.) acting upon the solar array. This mounting rests on top of the roofing assembly without penetration. For ballasted systems, resistance to lateral loads, such as wind, is provided solely by weight and friction.

- **Canopy Mounted PV Panels:** Solar canopies are elevated structures that host solar panels and provide shade. They are typically installed over parking lots or other paved areas.

- **Mechanically Fastened PV Panels:** Solar panels are attached to a mounting structure using physical hardware such as bolts, screws, clamps, or other mechanical fasteners, includes direct-mounted (attached directly to the roof without the use of an intermediary rack-mounted system), rack-mounted (attached to a framework that is itself secured to the roof), or standoff-mounted configurations (attached to a framework that elevates the panels above the mounting surface).

  Reference Appendix C for more information on 3.1 Primary Technology for PV modules, 3.2 Types of Inverters, 3.3 Energy Storage Systems, 3.4 Interconnections, and 3.5 Typical Electrical Details.

2. Design Requirements for Solar-Ready Roof

2.1. General Project Considerations

The EOP shall hold conversations with the line department, project management, Office of Sustainability, and facility teams to ensure that the future solar PV system aligns with the Port Authority's net-zero goals

The Project teams shall consult the project managers for means of capturing standard specification language on design documents, depending on the project delivery mechanism.

Note that projects where contract books are not issued, such as project delivery using facility forces, may request information typically included in written specifications to be included in design drawings.

Refer to Appendix B – 2.2 Language for RPW/Attachment A section for language to be included in Solar RPWs

2.1.1. Applicable Codes, guidelines, and Standards

The Engineer shall use the current version of all the applicable discipline-specific codes, guidelines, and standards referenced in the manual. The following table outlines a non-exhaustive list of applicable codes, guidelines, and standards, as of the publishing of this document:

Table 2: Applicable Codes, Guidelines, and Standards

Applicable Codes, Guidelines, and Standards	Disciplines				
	RSE	Architecture	Structural	Electrical	Mechanical
Construction Code: NYC/NYS/Uniform Construction Code of the State of New Jersey (NJUCC)		x			
Building Code: NYC/NYS/International Building Code, NJ Edition, Local Codes and Ordinances		x	x	x	x
Energy Code: NYC/NYS/International Energy Conservation Code (IECC)/Energy Conservation Code of New Jersey /ASHRAE 90.1 as adopted by the International Building Code, NJ Edition		x			x
Fire Code: NYC/NYS/NJ		x		x	x
Electrical Code: NYC/NYS/NJ				x	
Occupational Safety and Health Administration (OSHA) 1910.28 - Duty to have fall protection and falling object protection.		x		x	
ASCE 7 – Minimum Design Loads and Associated Criteria for Buildings and Other Structures, AISC Code of Standard Practice, ACI Design Guidelines			x		
National Electric Code - NEC Articles 690 and 705				x	
Port Authority Technical Specifications for Electrical - Division 26				x	
ANSI/IEEE 519				x	

Applicable Codes, Guidelines, and Standards	Disciplines				
	RSE	Architecture	Structural	Electrical	Mechanical
IEEE 1584				x	
Plumbing Code: NYC/NYS/NJ					x
Fuel Gas Code: NY/NYS/NJ					x
Port Authority of New York and New Jersey Mechanical and Electrical Design Guidelines				x	x
PANYNJ Climate Resilience Design Guidelines	x	x	x	x	x
Sustainable Building Guidelines - LEED and/or Sustainable Infrastructure Guidelines - Envision	x	x	x	x	x

3. EXISTING BUILDINGS (EB)

Refer to the Building Workflow figure below for the recommended EB workflow.
The diagram below outlines the collaboration process between the Line Department, Engineering, and the Office of Sustainability

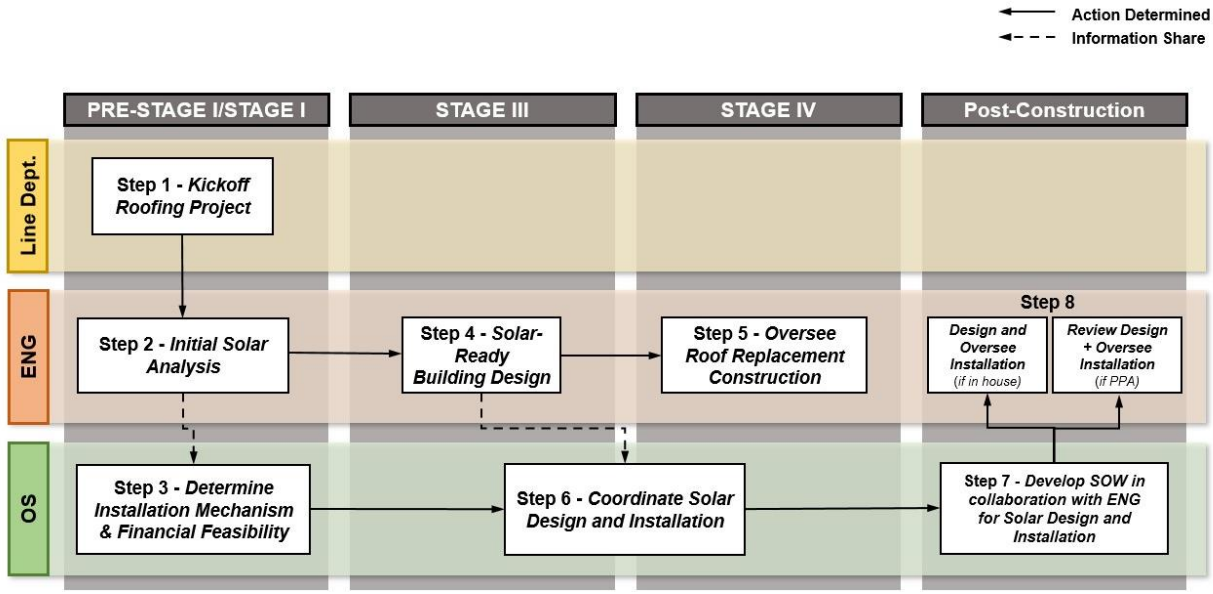


Figure 3: Workflow diagram for Existing Buildings.

3.1. INITIAL SOLAR ANALYSIS

The decision-making outlined in EI-4 is supported by the Initial Solar Analysis tools: Solar Ready Roof Analysis Checklist, and the Levelized Cost of Energy calculator

RSE Task Lead will coordinate the Initial Solar Analysis results, completed by the Engineering Disciplines with the Office of Sustainability

Solar Ready Roof Analysis Checklist

The EOP shall complete the Solar-Ready Roof Analysis checklist as per the project stage and type. The checklist is available in Appendix A and can also be accessed here – Solar-Ready Roof Worksheet - Existing Buildings.xlsx

The EOP will mark ‘X’ in the ‘Y” column if they have conducted the analysis, mark ‘X’ in the ‘N’ column if they have NOT conducted the analysis, and mark ‘N/A’ in both ‘Y and “N’ Column if the analysis does not apply to the project.

Table 3: Solar-Ready Roof Analysis Checklist for Existing Buildings

Project Stage	Analysis Checklist - Existing Building	Y	N
Pre-Stage 1	Architecture - Confirmed that the Solar PV systems are not definitively prohibited by the State Historic Preservation Office (SHPO).		
	Architecture - Confirmed that the collective gross rooftop area is greater than or equal to 1000 sq ft.		
	Architecture - confirmed that at least one contiguous Solar-Ready Zone greater than or equal to 200 sqft.		
Stage 1	Architecture - Conducted a preliminary shade study of the Solar-Ready Zone.		
	RSE - Facilitated a shade study that determined that shading does not reduce annual generation by more than 25%.		
	Structural - Conducted the loading analysis for the roof		
	RSE - Calculated the Tentative cost of structural enhancements and the Levelized cost of energy (LCOE) using the LCOE calculator and input provided by the structural		
	Architecture - Confirmed that the building rooftop slope is lower than 2:12		
	Project type - Aviation		
	EOP - Identified that the glare analysis is required in Stage III		

LEVELIZED COST OF ENERGY (LCOE) CALCULATOR

The Structural Engineer working on existing buildings shall provide the required inputs to RSE for completing the Levelized Cost of Energy (LCOE) calculator in Stage I. Refer to section 1.1 Definitions for explanation on the LCOE. RSE and OS will provide recommendations on the viability of the cost of roof reinforcement based on the LCOE calculator results. RSE and OS will collaborate to provide project-specific recommendations via email to the EOP. The EOP is responsible for conveying these recommendations to the line department.

The calculator is available in Appendix A and is also available in the *Solar-Ready Roof Worksheet*. Inputs are required for the 'Solar-Ready Roof Area,' 'Solar-Ready Roof Area in sq. ft.,' and 'Cost of Structural Enhancements' columns. The output is in cent/kilowatt-hour (c/kWh).

Table 4: Sample LCOE Calculator

The outcome of this calculator will determine if the project can move forward with including the Solar Ready Roof Design in the design and construction of the project. **Levelized Cost of Energy (c/kWh)**								
A – Solar-Ready Roof Area		**B - Total kWh over 20 years**			**C - Total Cost of Solar PV**			**D = C/B**
Solar-Ready Roof Area	**Solar-Ready Roof Area in sqft.**	**Solar Project Capacity (kW)** (Assumption - 0.01kW/sf)	**Annual Average Energy output (kWh)** (Assumption - 1200kWh/kW)	**Energy output over 20 yrs. (kWh)**	**Total Cost of Solar PV (Assumption $8.5/W and 40% incentive)**	**Cost of Structural Enhancements**	**Total Cost**	**LCOE - Cost of the system/ solar energy produced ($/kWh)**
						Average LCOE (c/kWh)		

3.2. ARCHITECTURE

3.2.1. STAGE I

3.2.1.1. GENERAL CONSIDERATIONS:

- It is best practice to orient the roof to maximize the roof area facing south.
- Solar PV panels shall be mounted at a 30-degree tilt to maximize output unless the orientation is not feasible due to site conditions.
- EADD can provide additional program support to identify appropriate orientation and tilt for the basis of design.
- Coordination with Electrical on PV panel and equipment locations, conduit routing zones, and fire-resistive construction requirements.
- Coordination with the Structural on Solar PV mounting options.
- Coordination with Mechanical for roof clear path and PV mounting options.

3.2.1.1.1. SITING ON THE ROOF:

- The extensive rooftop equipment, skylights, vegetative roof areas, or other obstructions are designed to ensure that the minimum requirements of Solar-Ready roof (a collective gross rooftop area greater than or equal to 1,000 ft and with at least one contiguous Solar-Ready zone greater than or equal to 200 ft) are met.

3.2.1.1.2. CONFIGURATION OF PANELS:

- **Layout**: Maximize available open area for PV panel placement by avoiding rooftop equipment and complying with applicable clearance requirements, roof access, and appurtenances.
- **Solar Panel Orientation** (alignment/angle of the panels for maximum exposure): Solar panels shall complement site orientation and roof pitch/slope to maximize solar radiation potential.

3.2.1.1.3. SHADING:

- Locate PV panels to limit shading. If multiple cells of a PV panel are shaded, specifically during peak hours of operation (10 AM – 2 PM), the voltage production will decrease. When production drops below a lower voltage limit, the entire panel will stop producing energy. To calculate shading, the Architect of record (AOR) shall map the sun path for the site on a mapping data source such as Helioscope4. The shading shall be assessed for 24-hour windows each month of the year. Shading models shall address the expected elevation and the location of current and expected permanent structures.

3.2.1.1.4. ROOFING SYSTEM:

- Roof membrane material shall primarily provide a weathertight enclosure as part of the building envelope and be durable enough to accommodate PV installation.

3.2.1.2. **WARRANTY:**

- Identify the existing roof system assembly.
- Determine if the roof is still under a Contractor and/or Roofing Manufacturer warranty, enabling the project team to determine if the warranty will continue even after installation.

3.2.2. STAGE III

3.2.2.1. GENERAL CONSIDERATIONS

- Where no Stage I was performed, complete all evaluations and analysis required in the Stage I section above.

3.2.2.1.1. ROOF DESIGN:

- **Roof Obstructions:** The AOR shall coordinate with discipline leads to relocate rooftop obstructions including but not limited to HVAC equipment, standpipes, electrical conduits, and antennae. Where obstructions cannot be relocated off the rooftop, they shall be grouped to maximize available area for PV installation.
- **Roof Plan(s):** The AOR shall submit a roof plan that shows a future solar PV system layout for solar-ready in coordination with other disciplines.
- **Floor Plan(s):** The AOR shall coordinate with Engineering disciplines to determine the need for and interdependencies of additional rooms to house electrical equipment. Access consideration shall be included in the design as the solar developer is required to complete maintenance/ monitoring of equipment. Coordinate with the facility to determine if access shall be provided to Operations staff.

3.2.2.1.2. CONDUITS:

- All conduits shall be consolidated and concealed. Exterior conduits are not authorized, except at roof level. Other exceptions can only be made by PANYNJ on a case-by-case basis.

3.2.2.1.3. ROOF WARRANTY:

- For existing buildings that are currently under active manufacturer and/or contractor warranty, the AOR shall engage the Roof Manufacturer and/or Contractor to coordinate with discipline, which leads to determining an approved installation by the roof warrantor of a solar PV system with associated structure and equipment as to maintain the existing warranty.

[4] *https://helioscope.aurorasolar.com/*

3.3. STRUCTURAL

3.3.1. STAGE I

3.3.1.1. GENERAL CONSIDERATIONS:

- The roofing system designer shall confirm the load that a solar panel installation may put on a roof, such as a ballasted load limit.
- Existing roof structures shall be investigated during Stage I to determine if the existing roof structure can support the loading requirements of solar panels.
- Determine the existing roof's live load capacity either through reviewing. documentation/original calculations (if available), reviewing design/as-built roof construction plans and calculating roof capacity (if drawings are available and legible), or through field inspection and material testing (concrete core/steel coupon testing).
- If the existing structure is deficient, determine if reinforcement of the existing structure could be reasonably undertaken.
- Ballasted systems are only permitted on roof structures of buildings that are Risk Categories[5] I, II, or III and six stories or fewer in height, as defined by the International Building Code (IBC). If the building is in Risk Category IV, a ballasted system is not allowed along with other restrictions/requirements.

3.3.2. STAGE III

3.3.2.1. GENERAL CONSIDERATIONS:

- Where no Stage I was performed, complete all evaluation and analysis required in the Stage I section above.
- Coordinate with Architectural on Solar PV mounting options.
- Perform any analysis that was required and not performed in Stage 1.
- If required, design reinforcement of roof structure.
- Final selection of solar PV system/layout shall consider requirements based on the type of building (i.e., Risk Category, Seismic Design Category, and number of stories of the structure).
- For existing structures, installation of structural attachment support system would penetrate existing waterproofing membrane systems, possibly causing leak issues or invalidating warrantees.
- Ballast attachments are only permitted on roof structures of Risk Categories I, II, or III and six stories or fewer in height.

3.3.2.2. CONSIDERATIONS FOR MECHANICALLY FASTENED OR STRUCTURALLY CONNECTED ATTACHMENTS

- Structural attachment may introduce additional wind/seismic loads that shall be resisted by the roof support structure.

3.3.2.3. CONSIDERATIONS FOR BALLASTED ATTACHMENTS

- Ballast-mounted systems have the advantage of not requiring roof penetrations that impact the roof waterproofing membrane.
- Ballast-mounted systems will have a higher dead load, due to the ballast weight.

[5] *As per the ASCE 7-22, section 13.6.12*

- They are only permitted on roofs with a slope equal to or less than 1 in 20.
- Limit on height of center of mass of panels based on spacing of panel supports, and no greater than 3 feet.
- Shall be designed to accommodate seismic displacements without impact/instability/loss of support relative to roof edge or curb.
- Panels shall be interconnected and form a continuous load path to resist horizontal loads.
- Shall be designed for seismic force path from center of each component to locations of friction resistance.
- Ballasted systems may only be installed on a roof that is bounded by a curb or parapet, with a minimum height of 12 inches, capable of resisting a concentrated load at the probable points of impact of the panels. Alternatively, a panel may be placed so that all parts of the panel are a minimum of twice the calculated seismic deflection of the panel system, but not less than 4 feet, from any roof edge or offset.

3.3.2.4. LOADING REQUIREMENTS

- Superimposed Dead load (SDL) shall be the weight of the solar panel, support system, and ballast (if to be used). If a specific model of solar panel cannot be chosen at the time of initial design, a placeholder of 15 psf may be used for the weight of the solar panel.
- Roof Live load shall be determined based on ASCE 7 Table 4.3-1 (minimum uniformly distributed live loads and minimum concentrated live loads).
- In addition to standard load combinations, the roof system shall be expected to resist the following conditions:
    - Uniform and concentrated roof live loads as required by ASCE 7 without solar panel system dead loads.
    - Uniform and concentrated roof live loads as required by ASCE 7 **with** solar panel system dead loads, though the live load need not be applied to an area covered by solar panels where the clear space between the panels and the roof surface is 24 inches or less.
    - Wind loading per ASCE 7.
    - Seismic loading per ASCE 7.
- No concentrated loads are to be placed directly on metal deck roofs and shall instead be placed on the supporting structure.

3.4. ELECTRICAL/ELECTRONICS

3.4.1. STAGE I

3.4.1.1. GENERAL CONSIDERATIONS

- The electrical/electronics scope of work includes, but is not limited to, performing conceptual design drawings for a study of equipment sizing, voltage drop calculation for electrical system, conduit/duct bank wires, switches, breakers, one-line diagrams, panel schedules, cable and conduit schedules, details, power panels, solar PV systems, junction boxes, SCADA (Supervisory Control and Data Acquisition) integration, lighting, lightning and grounding systems, electrical power systems studies, solar power generation calculation, etc., and electromagnetic compatibility and electromagnetic interference (EMC/EMI) tests for installation of future solar PV systems.

- Solar PV system assembly, including electrical and electronics components shall not present harmful interference to the existing Port Authority radio systems operating in VHF, UHF, 800 MHz, and Microwave frequency bands.
- Comply with requirements of the FCC Title 47 CFR Part 15, Subpart B on Conducted and Radiated Emission Limits.
- Components of the solar PV panel system such as switching power inverters and power optimizers, and other components as applicable shall be FCC certified for compliance with FCC Part 15 Subpart B, Class B electromagnetic emissions limits.
- Solar panel system shall be installed at a minimum 10-foot distance from PA's radio frequency (RF) antenna(s) and antenna cables in exterior and interior locations.
- Apply best industry practices for controlling conducted emissions, including using cable with twisted wires, proper grounding, and ferrite cores as necessary.
- Identify electrical/electronic power sources and loads that will be affected by the interruption of power during future solar PV system installation.
- Identify, on framing plans, all locations where electrical/ electronics equipment (including boxes and raceways, and their supports) interfere with the installation of a future solar PV system and note whether removal or temporary/permanent relocation is required.
- Identify conduits of systems that need to remain in operation without interrupting service during the installation of a future solar PV system and provide details for rerouting of the conduits and associated junction boxes, including the method of attachment.
- Identify lighting or any electrical/electronics equipment that will interfere with the installation of the future solar PV system.
- Assess the potential PV system size and corresponding energy production output.
- Identify where the PV electrical equipment (including the inverter, system components, and safety equipment) will be located and configured, and how this integration can be incorporated into the roof design process.
- Provide Staging and Phasing requirements for the installation of future solar PV system works.
- Identify the electrical conduit's route from the solar PV system to the building's electrical panel. All conduit pathways from the above rooftop to inside the building are internally run only to maintain the appearance of public-facing buildings. Only conduit on the rooftop shall be exterior conduit; all other conduits running through the building shall be internal conduits. Exceptions can only be made by the Port Authority on a case-by-case basis.
- The existing electrical system network and associated distribution equipment shall be evaluated and identified for interconnection voltage level and capacity to support future solar PV systems per the guidance of the latest codes and standards (NFPA 70 – NEC Articles 690 and 705[6]) and meet the utility net metering and interconnection requirements.
- Identify options for tie-in to the existing electrical system, including vertical pathways for wiring.
- Provide spare breakers/spaces in switchgear/switchboards for convenient solar PV system interconnection. Spares or spaces in electrical distribution equipment shall be labeled as for future solar PV connection.

[6] *Latest version as of May 2025*

- Identify a strategy for integrating solar PV into facility metering and monitoring equipment. Provide sufficient contact and monitoring points for future solar PV metering and monitoring by base building systems.
- Cross-reference the latest local and national codes for disconnecting means, and ensure all rapid shutdown switches are clearly labeled, accessible, and easy to reach for maintenance personnel.
- Ensure that reserved spaces are not only labeled but easily accessible and free from potential conflicts with other building systems. Maintain clearance for future installations and expansions.
- Space shall also be reserved for solar PV electrical equipment in exterior and interior locations such as:
    - Electrical distribution equipment
    - Inverters and combiner boxes
    - Monitoring and communications equipment
    - Utility-required disconnection equipment (at grade)
- Identify routing zones for future wiring and conduit pathways on the roof and within the building, to/from electrical rooms to solar PV locations and infrastructure.
- Identify future grounding pathways for future rooftop electrical equipment. Coordinate lightning protection system design with future solar PV system installation, or coordinate the PV system's grounding with the building's existing lightning protection system.
- Perform short circuit analysis to coordinate building electrical equipment short circuit current interrupting ratings accordingly. It is also recommended to perform a power quality assessment for future large solar PV systems to identify power quality mitigation measures needed for interconnection equipment.

3.4.1.2. WIRE TYPES AND SIZING, AND RACEWAYS AND DUCT BANKS

- Cables for outdoor distribution shall be triple-rated type USE-RHH-RHW.
- All low-voltage underground ground conduits shall be a minimum of 2”, and medium voltage shall be a minimum of 5”.
- For indoor general-purpose distribution, use 75° cable type XLP high heat-resistant, water-resistant (XHHW-2) for wet and dry locations. Use 90° cable type THHW in boiler and mechanical rooms.
- For vertical risers, use 75° cable type XHHW and support it as required by NEC or use special cable, which can be supported at longer vertical distances.
- Wire splices shall be compression-type.
- The use of multiwire branch circuits with a common neutral is not permitted.
- All exposed conduits shall be ¾” diameter minimum.
- Exposed outdoor conduits and supports shall be PVC-coated threaded rigid galvanized metal.
- Expansion fittings shall be installed in conduits crossing expansion joints.
- Direct buried conduits are not permitted.
- Ducts under vehicular roadways or other areas (parking lots, garages, etc.) where trucks or other heavy equipment travel shall be rigid steel or heavy wall FRE.
- System shall be designed to include any thermal management required to operate as intended for the life of the Project.
- Electrical equipment shall be adequately protected from pedestrians and vehicular traffic.

- All underground medium voltage conduits shall follow the utilities standards as required.
- Any and all switchgear required for interconnection with the medium voltage shall be compatible with the existing PA installation type.

3.4.1.3. Solar PV Array

- A group of PV module strings connected in series shall be designed in accordance with the inverter manufacturer's maximum DC voltage input specifications and applicable code requirements for maximum system voltage. The PV system shall operate with a maximum voltage of either 600 Vdc or 1000 Vdc, unless otherwise approved by the Authority Having Jurisdiction (AHJ). The maximum system voltage shall be consistent across all installations. All equipment shall be rated to handle the maximum system voltage as required. A group of PV module arrays electrically connected in parallel shall be designed in accordance with the inverter manufacturer's maximum DC current and power input specifications and applicable code requirements for maximum operating DC current and power.
- The PV system shall be connected to the facility's electrical distribution system in compliance with the applicable sections of the NEC, including Articles 690 and 705, as well as all other applicable codes and standards, including those of the PANYNJ and the utility company. The designer shall be responsible for modifying the facility's electrical distribution system as needed to accommodate the PV system. Any modifications to the facility's electrical distribution system shall be reviewed and approved by the Port Authority. The solar PV system shall be metered separately and connected in parallel with utility and facilities.

3.4.1.4. Inverters

- Inverters shall be listed in Underwriters Laboratories (UL) and shall include the necessary equipment, including suitable cable/bus connectors, controls, and accessories for the inverter to meet all code requirements and function properly as part of a power generation facility.
- Inverter shall comply with applicable Institute of Electrical and Electronics Engineers (IEEE) requirements for harmonics.
- Inverter output shall be protected by a suitable rated AC output circuit breaker. Disconnect switch/isolation device shall be provided for rooftop installed microinverter with each PV panel.
- Inverters shall communicate with the SCADA and DAS (Data Acquisition System) systems using a common, non-proprietary protocol.
- Inverters shall be capable of operating at rated capacity at the expected ambient temperatures and environmental conditions at the site and at the altitude of the site.

3.4.1.5. Lighting

- A lighting system shall be provided for the equipment installed on the roof for general maintenance purposes. Lighting shall be able to function independently from the solar PV system. Lighting design shall be as per the PA Electrical Design Guidelines Manual.

3.4.1.6. Lightning Protection

- New and/or modifications to any existing lightning protection systems necessitated by the installation of future solar PV systems or equipment shall meet all applicable codes and standards including and not limited to:
  - NFPA 780 Standard for the Installation of Lightning Protec on Systems
  - NEC Article 250
  - The Lightning Protection Institute LPI 175
  - UL Standard

3.4.1.7. SCADA

- The newly installed PV system shall be able to communicate with the facility's existing SCADA/BMS/DAS system to be monitored from the Central System.

3.4.1.8. FIRE ALARM DESIGN

- The solar PV system shall be installed in accordance with current safety codes, fire codes, and standards. Any new fire alarm systems shall have the ability to be fully integrated with the facility's central fire alarm monitoring system.

3.4.2. STAGE III

3.4.2.1. GENERAL CONSIDERATIONS

- Perform all tasks necessary to provide a complete set of contract drawings, construction cost estimate, and specifications for Stage IV Construction according to the Stage I Report approved by the Authority.
- Where no Stage I was performed, complete all evaluations and analysis required in the Stage I section above. All required provisions shall be included in the design document.
- Submit Data Sheets of all solar panel system components as applicable to demonstrate FCC Part 15 certification on EMC/EMI.

3.4.3. STAGE IV

3.4.3.1. GENERAL CONSIDERATIONS

- Confirm that all equipment and space are labeled.
- The installation of equipment and associated wiring and interconnection shall be performed only by a qualified person and shall meet the latest version of NFPA 70E, Standard for Electrical Safety in the Workplace, for electrical safety training requirements.
- Confirm and ensure all electrical equipment are tested and approved per the latest codes and standards, per Port Authority technical specifications and design guidelines, and meet the Utility Company Interconnection Requirements.
- Ensure documentation for facility planning and usage is collected when available.
- Develop and submit EMC/EMI Interference Test Procedures.
- Conduct a test to rule out the presence of harmful RF interference with Port Authority radio systems in the presence of Port Authority personnel.
- Submit test report signed by the Engineer of Record.
- Coordinate electrical/electronic work with all other disciplines on selecting equipment locations, routing zones, fire-resistive construction requirements, and minimization of impacts to facility operations.
    - PV system inverters shall be located at least 150 feet away from navigational and communications equipment that may be sensitive to electromagnetic interference (EMI).
    - A minimum setback distance of 250 feet shall be imposed between an airfield’s radar system and the leading edge of a PV array or any of its ancillary support equipment.
    - Inductor-capacitor (LCI) filters shall be installed to attenuate RF emissions at specific frequencies that could cause potential undesired interaction. In addition, grounding of PV conductors directly or indirectly via the inverter shall also attenuate undesired RF

emissions. An RF analysis shall be conducted to establish the frequencies in question.

3.4.3.1.1. ELECTRICAL ANALYSIS

- The electrical power system studies, including but not limited to, short circuit analysis, protection coordination, arc flash, voltage drop, and grounding system shall be performed and certified by a licensed engineer, in conjunction with the future solar PV system design and existing electrical distribution system integration.

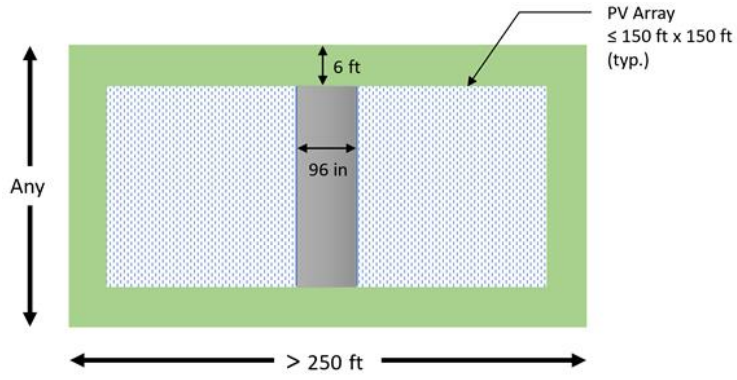
3.5. MECHANICAL / PLUMBING FIRE PROTECTION

3.5.1. STAGE I

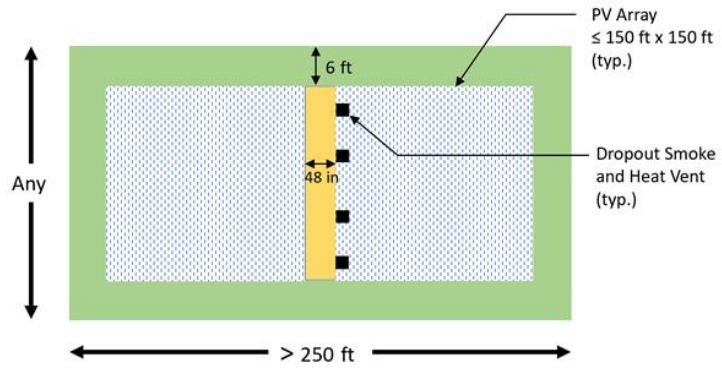
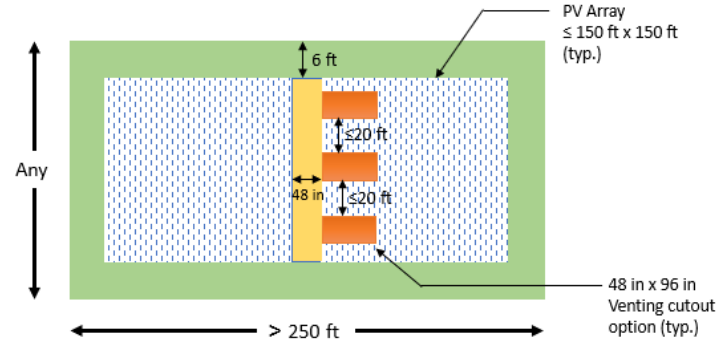
3.5.1.1. GENERAL CONSIDERATIONS

- Provide a clear physical separation between solar PV equipment and all rooftop mechanical equipment, accounting for code-required and equipment manufacturer's recommended clearances around mechanical equipment and equipment removal pathways.
- Provide a minimum 4-foot wide pathway bordering all sides of non-gravity-operated smoke and heat vents and bordering at least one side of gravity-operated smoke and heat vents.
- Ventilation options between array sections shall be one of the following options[7]:

Table 5: Ventilation options between array sections

A pathway 8 feet or greater in width	

[7] Providing Access to Roofs with a PV System | NFPA

A pathway 4 feet or greater in width bordering on roof skylights/smoke and heat vent at intervals no greater than 150 feet	
A pathway 4 feet or greater in width and bordering 4-foot by 8-foot with venting cutout options every 20 feet	

- Make provisions for heating, ventilation, and air-conditioning (HVAC) equipment to accommodate solar PV electrical equipment heat output.
- Minimize and consolidate rooftop mechanical equipment, preferably on the north side of the roof or in any shaded areas not viable for solar PV installation to maximize solar-ready roof area.
- PV panels shall not obstruct storm drainage flow to roof drains.
- The proposed solar PV panels installation shall have no impact on the roof drainage system.
- Retrofit roof drains shall not be permitted.
- Where existing fuel/gas piping is installed on the roof, perform an analysis to determine a safe separation distance between the fuel/gas piping and proposed solar PV installation that minimizes the risk of ignition from the solar panels and associated electrical components.
- Where fuel/gas piping is installed on the roof, a minimum safe separation distance of 15 feet shall be maintained to minimize the risk of ignition from the solar panel and associated electrical components.
- Where storage is proposed beneath canopied solar PV panels, an automatic fire suppression system shall be designed and installed to meet life safety and property protection fire safety requirements.
    - Submit signed and sealed copies of the permitted storage evaluation by the Engineer of Record.
- Where storage is proposed beneath the canopied solar PV panels, an automatic fire suppression system shall be designed and installed to meet life safety and property

protection fire safety goals. The storage type and the pertinent sprinkler density requirements as per NFPA 13.

- A minimum height of 18 inches shall be maintained below the canopy and the top of the storage.
- Storage height shall be based on an analysis submitted by an Engineer of Record. The analysis shall consider storage type and applicable sprinkler density requirements.

- The building's fire and emergency preparedness plan concept shall be provided to include information regarding the solar PV panel layout and roof clear path layout for fire fighter access where required.
- Coordinate and locate the roof drain in relation to the layout of the proposed solar PV panels and their associated components.
- Coordinate proposed solar PV panel design with roof drains/roof pitch requirements.
- Roof structures shall be evaluated to confirm that the roof mechanical, plumbing, and fire protection equipment are not affected by the installation of the proposed solar PV panels and their associated components.
- Coordinate proposed mechanical, plumbing, and fire protection equipment design with the installation of proposed solar PV panels and their associated components.

Table 6: Fire Protection Summary Condition for Canopied Roof Solar Panel

Canopied Roof Solar Panel – Fire Protection Summary Conditions					
Canopy Installation Conditions	**Occupancy**	**Size (sf)**	**Fire Protection Type**	**Referenced**	**Remarks**
General	Where solar panels are located on the canopy roof area; the roofing materials shall be of a non-combustible type and provide suitable passive fire protection where required to satisfy the minimum fire and life safety requirements.				
NYC - 1; NJBC -1	Miscellaneous	Below 500sf	Passive	NYCBC: 312.1- NJBC: 312.1	Roofing shall be non-combustible material, and support members shall be fireproofed or protected with a minimum 1-hour intumescent paint.
NYC - 2	Group S-1 fire areas	500 sf or Greater	Active	NYCBC: 903.2.9.1	An automatic sprinkler system shall be provided throughout any Group S-1 occupancy fire area where the fire area exceeds 500 square feet
NYC - 3	Group S-1 fire areas	5000 sf or Greater	Active	NYCBC: 903.2.9.(5)	A Group S-1 fire area used for the storage of commercial motor vehicles where the fire area exceeds 5,000 square feet
NYC - 4	Group S-2	5000 sf or Greater	Active	NYCBC: 903.2.10.1	Commercial parking garages. An automatic sprinkler system shall be provided throughout buildings used for the storage of commercial trucks, buses, or other commercial motor vehicles where the fire area exceeds 5,000 square feet.
NJBC-2	Group S-1 fire areas	12000 sf or Greater	Active	NJBC: 903.2.9(1)	A Group S-1 fire area exceeds 12,000 square feet
NJBC-3	Group S-1 fire areas	5000 sf or Greater	Active	NJBC: 903.2.9(4)	A Group S-1 fire area used for the storage of commercial motor vehicles where the fire area exceeds 5,000 square feet

- Seismic requirements for mechanical, plumbing, and fire protection systems shall be based on the structure risk and seismic design category.
- All mechanically fastened or structurally connected installations shall be constructed of noncombustible materials per ASTM E136.
- Roof structures shall be investigated to determine if existing roof mechanical, plumbing, and fire protection equipment is affected by the installation of proposed solar PV panels and their associated components.
- Identify mitigation measures if existing mechanical, plumbing, and fire protection equipment is affected by the installation of proposed solar PV panels and their associated components.
- Determine and evaluate existing roof drain capacity, considering proposed solar PV panels installation.
- Review the building's existing fire and emergency preparedness plan to determine the impact of proposed solar PV panel installation on the existing roof and identify mitigation measures if required.

3.5.2. STAGE III

3.5.2.1. GENERAL CONSIDERATIONS

- Where no Stage I was performed, complete all evaluations and analysis required in the Stage I section above. All required provisions shall be included in the design document.
- Update the building's fire and emergency preparedness plan with the proposed solar PV panel layout on the existing roof and the fire department access and egress pathway.
- Coordinate with Architecture for roof clear path and solar PV mounting options.

3.6. RESILIENT AND SUSTAINABLE ENGINEERING

3.6.1. STAGE I

3.6.1.1. GENERAL CONSIDERATIONS

- Coordinate with the Architecture and Quality Assurance Division for the applicability of NYCBC for Sustainable Roof Zones (as applicable).
- Identify how the use of these guidelines overlaps with the applicability of other RSE guidelines and manuals, such as the Sustainable Building Guidelines (SBG), and/or Sustainable Infrastructure Guidelines, and/or Climate Resilience Design Guidelines (CRG) and/or Green Infrastructure Design Manual (GIDM).
- RSE will notify the Office of Sustainability (OS) of the impending roof replacement project and coordinate with other disciplines to provide necessary planning documentation.
- RSE Task Lead will coordinate the Initial Solar Analysis results, completed by the Engineering Disciplines, with the Office of Sustainability.

3.6.2. STAGE III

- Develop necessary documentation in coordination with the design disciplines.
- Where no Stage I was performed, complete all evaluations and analysis required in the Stage
- I section above.

3.6.3. STAGE IV

- Coordinate on submittals for new construction projects.

- Transfer project information (i.e., drawings, warranties, documentation) to the Office of Sustainability as required.

3.7. ENVIRONMENTAL

3.7.1. STAGE III

3.7.1.1. GENERAL CONSIDERATIONS:

- There are no General Considerations in the Environmental section. The projects shall follow project-specific Environmental requirements outlined below.
- Environmental Engineering and Environmental Field Operations shall be engaged to identify any potential hazardous materials such as lead, asbestos, PCBs, or other materials that may be disturbed as part of the work.

4. NEW CONSTRUCTION (NC)

Refer to the Building Workflow diagram below for the recommended NC workflow.
The diagram below outlines the collaboration process between the Line Department, Engineering, and the Office of Sustainability

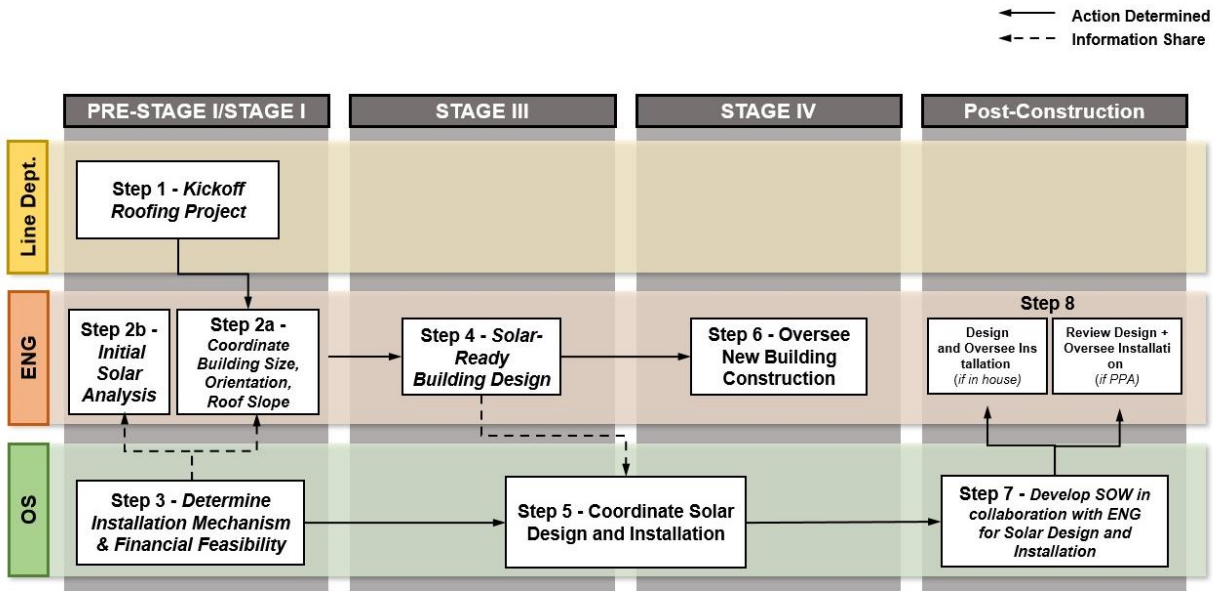


Figure4: Workflow diagram for New Construction

4.1. INITIAL SOLAR ANALYSIS

The decision-making outlined in EI-4 is supported by the Initial Solar Analysis tool: Solar Ready Roof Analysis Checklist

RSE Task Lead will coordinate the Initial Solar Analysis results, conducted by the Engineering Disciplines, with the Office of Sustainability

SOLAR READY ROOF ANALYSIS CHECKLIST

The EOP shall complete the Solar-Ready Roof Analysis checklist as per the project stage and type. The checklist is available in Appendix A and can also be accessed here – Solar-Ready Roof Worksheet - New Construction.xlsx

The EOP will mark ‘X’ in the ‘Y” column if they have conducted the analysis, mark ‘X’ in the ‘N’ column if they have NOT conducted the analysis, and mark ‘N/A’ in both ‘Y and “N’ Column if the analysis does not apply to the project.

Table 7: Solar-Ready Roof Analysis Checklist for new Construction

Project Stage	Analysis Checklist - New Construction	Y	N
Pre-Stage 1	Architecture - Confirmed that the collective gross rooftop area is greater than or equal to 1000 sq ft.		
	Architecture - Confirmed that at least one contiguous Solar-Ready Zone is greater than or equal to 200 sqft.		
Stage 1	Architecture - Conducted a preliminary shade study of the Solar-Ready Zone.		
	RSE - Facilitated a shade study that determined that shading does not reduce annual generation by more than 25%.		
	Project type - Aviation		
	EOP - Identified that the glare analysis is required in Stage III.		

4.2. ARCHITECTURE

4.2.1. STAGE I

4.2.1.1. GENERAL CONSIDERATIONS:

- It is best practice to orient the roof to maximize the roof area facing south.
- Solar PV panels shall be mounted at a 30-degree tilt to maximize output unless the orientation is not feasible due to site conditions.
- EADD can provide additional program support to identify appropriate orientation and tilt for the basis of design.
- Coordination with Electrical on PV panel and equipment locations, conduit routing zones, and fire-resistive construction requirements.
- Coordination with the Structural on Solar PV mounting options.
- Coordination with Mechanical for roof clear path and PV mounting options.

4.2.1.1.1. SITING ON THE ROOF:

- The extensive rooftop equipment, skylights, vegetative roof areas, or other obstructions are designed to ensure that the minimum requirements of Solar-Ready roof (a collective gross rooftop area greater than or equal to 1,000 ft and with at least one contiguous Solar-Ready zone greater than or equal to 200 ft) are met.

4.2.1.1.2. CONFIGURATION OF PANELS:

- **Layout**: Maximize available open area for PV panel placement by avoiding rooftop equipment and complying with applicable clearance requirements, roof access, and appurtenances.
- **Solar Panel Orientation** (alignment/angle of the panels for maximum exposure): Solar panels shall complement site orientation and roof pitch/slope to maximize solar radiation potential.

4.2.1.1.3. SHADING:

- Locate PV panels to limit shading. If multiple cells of a PV panel are shaded, specifically during peak hours of operation (10 AM – 2 PM), the voltage production will decrease. When production drops below a lower voltage limit, the entire panel will stop producing energy. To calculate shading, the Architect of record (AOR) shall map the sun path for the site on a mapping data source such as Helioscope[8]. The shading shall be assessed for 24-hour windows each month of the year. Shading models shall address the expected elevation and the location of current and expected permanent structures.

4.2.1.1.4. ROOFING SYSTEM:

- Roof membrane material shall primarily provide a weathertight enclosure as part of the building envelope and be durable enough to accommodate PV installation.

SITE SELECTION AND ROOF DESIGN:

- When selecting a building site and locating a building on a plot of land, the AOR shall work with the design team to orient the roof to maximize potential energy generation.
- Site the rooftop to avoid shading from trees, buildings, and other obstructions, especially during peak sunlight. Orient and angle the roof to maximize solar potential.

4.2.2. STAGE III

4.2.2.1.1. GENERAL CONSIDERATIONS

- Where no Stage I was performed, complete all evaluations and analysis required in the Stage I section above.

4.2.2.1.2. ROOF DESIGN:

- **Roof Obstructions:** The AOR shall coordinate with discipline leads to relocate rooftop obstructions including but not limited to HVAC equipment, standpipes, electrical conduits, and antennae. Where obstructions cannot be relocated off the rooftop, they shall be grouped to maximize available area for PV installation.
- **Roof Plan(s):** The AOR shall submit a roof plan that shows a future solar PV system layout for solar-ready in coordination with other disciplines.
- **Floor Plan(s):** The AOR shall coordinate with Engineering disciplines to determine the need for and interdependencies of additional rooms to house electrical equipment. Access consideration shall be included in the design as the solar developer is required to complete maintenance/ monitoring of equipment. Coordinate with the facility to determine if access shall be provided to Operations staff.

4.2.2.1.3. CONDUITS:

- All conduits shall be consolidated and concealed. Exterior conduits are not authorized, except at roof level. Other exceptions can only be made by PANYNJ on a case-by-case basis.

[8] *https://helioscope.aurorasolar.com/*

4.2.3. STAGE IV

4.2.3.1. GENERAL CONSIDERATIONS

- No Stage IV Architecture General considerations. The Engineer shall follow the applicable sub-sections below.

4.2.3.1.1. ROOF WARRANTY:

- For new buildings, secure fully executed Appendix "B" Contractor's Guarantee and Appendix "C" Roof System Manufacturer's Guarantee as required by PA standard technical specifications for the record.

4.3. STRUCTURAL

4.3.1. STAGE I

4.3.1.1. GENERAL CONSIDERATIONS:

- The roofing system designer shall confirm the load that a solar panel installation may put on a roof, such as a ballasted load limit.
- New construction shall be designed with loading requirements of solar panels included as design criteria; Stage I of new construction confirms the structural capacity to support a solar installation.
- Preliminary selection of solar panel systems (structural vs ballasted systems) shall consider limitations based on the type of structure (i.e., Risk Category, Seismic Design Category, and number of stories of the structure).

4.3.2. STAGE III

4.3.2.1. GENERAL CONSIDERATIONS:

- Where no Stage I was performed, complete all evaluation and analysis required in the Stage I section above.
- Coordinate with Architectural on Solar PV mounting options.

4.3.2.1.1. CONSIDERATIONS FOR MECHANICALLY FASTENED OR STRUCTURALLY CONNECTED ATTACHMENTS

- Structural attachment may introduce additional wind/seismic loads that shall be resisted by the roof support structure.

4.3.2.1.2. CONSIDERATIONS FOR BALLASTED ATTACHMENTS

- Ballast-mounted systems have the advantage of not requiring roof penetrations that impact the roof waterproofing membrane.
- Ballast-mounted systems will have a higher dead load, due to the ballast weight.
- They are only permitted on roofs with a slope equal to or less than 1 in 20.
- Limit on height of center of mass of panels based on spacing of panel supports, and no greater than 3 feet.
- Shall be designed to accommodate seismic displacements without impact/instability/loss of support relative to roof edge or curb.
- Panels shall be interconnected and form a continuous load path to resist horizontal loads.
- Shall be designed for seismic force path from center of each component to locations of friction resistance.
- Ballasted systems may only be installed on a roof that is bounded by a curb or parapet, with a minimum height of 12 inches, capable of resisting a concentrated load at the probable

points of impact of the panels. Alternatively, a panel may be placed so that all parts of the panel are a minimum of twice the calculated seismic deflection of the panel system, but not less than 4 feet, from any roof edge or offset.

4.3.2.1.3. Loading Requirements

- Superimposed Dead load (SDL) shall be the weight of the solar panel, support system, and ballast (if to be used). If a specific model of solar panel cannot be chosen at the time of initial design, a placeholder of 15 psf may be used for the weight of the solar panel.
- Roof Live load shall be determined based on ASCE 7 Table 4.3-1 (minimum uniformly distributed live loads and minimum concentrated live loads).
- In addition to standard load combinations, the roof system shall be expected to resist the following conditions:
    - Uniform and concentrated roof live loads as required by ASCE 7 without solar panel system dead loads.
    - Uniform and concentrated roof live loads as required by ASCE 7 **with** solar panel system dead loads, though the live load need not be applied to an area covered by solar panels where the clear space between the panels and the roof surface is 24 inches or less.
    - Wind loading per ASCE 7.
    - Seismic loading per ASCE 7.
- No concentrated loads are to be placed directly on metal deck roofs and shall instead be placed on the supporting structure.
- Ensure requirements for loading are included as design criteria for the roof structure.
- Final selection of solar PV panel system/layout shall consider requirements based on the type of building (i.e., Risk Category, Seismic Design Category, and number of stories of the structure) and shall be designed for load combinations, including wind and seismic.
- New construction projects may consider the ballast-mounted panel option, but shall include provisions for mechanically fastened connections.

4.4. Electrical/Electronics

4.4.1. Stage I

4.4.1.1. General Considerations

- The electrical/electronics scope of work includes, but is not limited to, performing conceptual design drawings for a study of equipment sizing, voltage drop calculation for electrical system, conduit/duct bank wires, switches, breakers, one-line diagrams, panel schedules, cable and conduit schedules, details, power panels, solar PV systems, junction boxes, SCADA (Supervisory Control and Data Acquisition) integration, lighting, lightning and grounding systems, electrical power systems studies, solar power generation calculation, etc., and electromagnetic compatibility and electromagnetic interference (EMC/EMI) tests for installation of future solar PV systems.
- Solar PV system assembly, including electrical and electronics components, shall not present harmful interference to the existing Port Authority radio systems operating in VHF, UHF, 800 MHz, and Microwave frequency bands.
- Comply with requirements of the FCC Title 47 CFR Part 15, Subpart B on Conducted and Radiated Emission Limits.

- Components of the solar PV panel system such as switching power inverters and power optimizers, and other components as applicable shall be FCC certified for compliance with FCC Part 15 Subpart B, Class B electromagnetic emissions limits.
- Solar panel system shall be installed at a minimum 10-foot distance from PA's radio frequency (RF) antenna(s) and antenna cables in exterior and interior locations.
- Apply best industry practices for controlling conducted emissions, including using cable with twisted wires, proper grounding, and ferrite cores as necessary.
- Identify electrical/electronic power sources and loads that will be affected by the interruption of power during future solar PV system installation.
- Identify, on framing plans, all locations where electrical/ electronics equipment (including boxes and raceways, and their supports) interfere with the installation of a future solar PV system and note whether removal or temporary/permanent relocation is required.
- Identify conduits of systems that need to remain in operation without interrupting service during the installation of a future solar PV system and provide details for rerouting of the conduits and associated junction boxes, including the method of attachment.
- Identify lighting or any electrical/electronics equipment that will interfere with the installation of the future solar PV system.
- Assess the potential PV system size and corresponding energy production output.
- Identify where the PV electrical equipment (including the inverter, system components, and safety equipment) will be located and configured, and how this integration can be incorporated into the roof design process.
- Provide Staging and Phasing requirements for the installation of future solar PV system works.
- Identify the electrical conduit's route from the solar PV system to the building's electrical panel. All conduit pathways from the above rooftop to inside the building are internally run only to maintain the appearance of public-facing buildings. Only conduit on the rooftop shall be exterior conduit; all other conduits running through the building shall be internal conduits. Exceptions can only be made by the Port Authority on a case-by-case basis.
- The existing electrical system network and associated distribution equipment shall be evaluated and identified for interconnection voltage level and capacity to support future solar PV systems per the guidance of the latest codes and standards (NFPA 70 – NEC Articles 690 and 705[9]) and meet the utility net metering and interconnection requirements.
- Identify options for tie-in to the existing electrical system, including vertical pathways for wiring.
- Provide spare breakers/spaces in switchgear/switchboards for convenient solar PV system interconnection. Spares or spaces in electrical distribution equipment shall be labeled as for future solar PV connection.
- Identify a strategy for integrating solar PV into facility metering and monitoring equipment. Provide sufficient contact and monitoring points for future solar PV metering and monitoring by base building systems.
- Cross-reference the latest local and national codes for disconnecting means, and ensure all rapid shutdown switches are clearly labeled, accessible, and easy to reach for maintenance personnel.

[9] *Latest version as of May 2025*

- Ensure that reserved spaces are not only labeled but easily accessible and free from potential conflicts with other building systems. Maintain clearance for future installations and expansions.
- Space shall also be reserved for solar PV electrical equipment in exterior and interior locations such as:
    - Electrical distribution equipment
    - Inverters and combiner boxes
    - Monitoring and communications equipment
    - Utility-required disconnection equipment (at grade)
- Identify routing zones for future wiring and conduit pathways on the roof and within the building, to/from electrical rooms to solar PV locations and infrastructure.
- Identify future grounding pathways for future rooftop electrical equipment. Coordinate lightning protection system design with future solar PV system installation, or coordinate the PV system's grounding with the building's existing lightning protection system.
- Perform short circuit analysis to coordinate building electrical equipment short circuit current interrupting ratings accordingly. It is also recommended to perform a power quality assessment for future large solar PV systems to identify power quality mitigation measures needed for interconnection equipment.

4.4.1.1.1. WIRE TYPES AND SIZING, AND RACEWAYS AND DUCT BANKS SHALL BE DESIGNED PER THE FOLLOWING:

- Cables for outdoor distribution shall be triple-rated type USE-RHH-RHW.
- All low-voltage underground ground conduits shall be a minimum of 2”, and medium voltage shall be a minimum of 5”.
- For indoor general-purpose distribution, use 75° cable type XLP high heat-resistant, water-resistant (XHHW-2) for wet and dry locations. Use 90° cable type THHW in boiler and mechanical rooms.
- For vertical risers, use 75° cable type XHHW and support it as required by NEC or use special cable, which can be supported at longer vertical distances.
- Wire splices shall be compression-type.
- The use of multiwire branch circuits with a common neutral is not permitted.
- All exposed conduits shall be ¾” diameter minimum.
- Exposed outdoor conduits and supports shall be PVC-coated threaded rigid galvanized metal.
- Expansion fittings shall be installed in conduits crossing expansion joints.
- Direct buried conduits are not permitted.
- Ducts under vehicular roadways or other areas (parking lots, garages, etc.) where trucks or other heavy equipment travel shall be rigid steel or heavy wall FRE.
- System shall be designed to include any thermal management required to operate as intended for the life of the Project.
- Electrical equipment shall be adequately protected from pedestrians and vehicular traffic.
- All underground medium voltage conduits shall follow the utilities standards as required.
- Any and all switchgear required for interconnection with the medium voltage shall be compatible with the existing PA installation type.

4.4.1.1.2. *Solar PV Array*

- A group of PV module strings connected in series shall be designed in accordance with the inverter manufacturer's maximum DC voltage input specifications and applicable code requirements for maximum system voltage. The PV system shall operate with a maximum voltage of either 600 Vdc or 1000 Vdc, unless otherwise approved by the Authority Having Jurisdiction (AHJ). The maximum system voltage shall be consistent across all installations. All equipment shall be rated to handle the maximum system voltage as required. A group of PV module arrays electrically connected in parallel shall be designed in accordance with the inverter manufacturer's maximum DC current and power input specifications and applicable code requirements for maximum operating DC current and power.
- The PV system shall be connected to the facility's electrical distribution system in compliance with the applicable sections of the NEC, including Articles 690 and 705, as well as all other applicable codes and standards, including those of the PANYNJ and the utility company. The designer shall be responsible for modifying the facility's electrical distribution system as needed to accommodate the PV system. Any modifications to the facility's electrical distribution system shall be reviewed and approved by the Port Authority. The solar PV system shall be metered separately and connected in parallel with utility and facilities.

4.4.1.1.3. *Inverters*

- Inverters shall be listed in Underwriters Laboratories (UL) and shall include the necessary equipment, including suitable cable/bus connectors, controls, and accessories for the inverter to meet all code requirements and function properly as part of a power generation facility.
- Inverter shall comply with applicable Institute of Electrical and Electronics Engineers (IEEE) requirements for harmonics.
- Inverter output shall be protected by a suitable rated AC output circuit breaker. Disconnect switch/isolation device shall be provided for rooftop installed microinverter with each PV panel.
- Inverters shall communicate with the SCADA and DAS (Data Acquisition System) systems using a common, non-proprietary protocol.
- Inverters shall be capable of operating at rated capacity at the expected ambient temperatures and environmental conditions at the site and at the altitude of the site.

4.4.1.1.4. *Lighting*

- A lighting system shall be provided for the equipment installed on the roof for general maintenance purposes. Lighting shall be able to function independently from the solar PV system. Lighting design shall be as per the PA Electrical Design Guidelines Manual.

4.4.1.1.5. *Lightning Protection*

- New and/or modifications to any existing lightning protection systems necessitated by the installation of future solar PV systems or equipment shall meet all applicable codes and standards including and not limited to:
  - NFPA 780 Standard for the Installation of Lightning Protec on Systems
  - NEC Article 250
  - The Lightning Protection Institute LPI 175
  - UL Standard

4.4.1.1.6. *SCADA*

- The newly installed PV system shall be able to communicate with the facility's existing SCADA/BMS/DAS system to be monitored from the Central System.

4.4.1.1.7. Fire Alarm Design

- The solar PV system shall be installed in accordance with current safety codes, fire codes, and standards. Any new fire alarm systems shall have the ability to be fully integrated with the facility's central fire alarm monitoring system.

4.4.2. Stage III

4.4.2.1. General Considerations

- Perform all tasks necessary to provide a complete set of contract drawings, construction cost estimate, and specifications for Stage IV Construction according to the Stage I Report approved by the Authority.
- Where no Stage I was performed, complete all evaluations and analysis required in the Stage I section above. All required provisions shall be included in the design document.
- Submit Data Sheets of all solar panel system components as applicable to demonstrate FCC Part 15 certification on EMC/EMI.
- Coordinate electrical design with all other disciplines on selecting equipment locations, routing zones, fire-resistive construction requirements, and minimization of impacts to facility operations.

4.4.3. Stage IV

4.4.3.1. General considerations

- Confirm that all equipment and space are labeled.
- The installation of equipment and associated wiring and interconnection shall be performed only by a qualified person and shall meet the latest version of NFPA 70E, Standard for Electrical Safety in the Workplace, for electrical safety training requirements.
- Confirm and ensure all electrical equipment are tested and approved per the latest codes and standards, per Port Authority technical specifications and design guidelines, and meet the Utility Company Interconnection Requirements.
- Ensure documentation for facility planning and usage is collected when available.
- Develop and submit EMC/EMI Interference Test Procedures.
- Conduct a test to rule out the presence of harmful RF interference with Port Authority radio systems in the presence of Port Authority personnel.
- Submit test report signed by the Engineer of Record.
- Coordinate electrical/electronic work with all other disciplines on selecting equipment locations, routing zones, fire-resistive construction requirements, and minimization of impacts to facility operations.
    - PV system inverters shall be located at least 150 feet away from navigational and communications equipment that may be sensitive to electromagnetic interference (EMI).
    - A minimum setback distance of 250 feet shall be imposed between an airfield’s radar system and the leading edge of a PV array or any of its ancillary support equipment.

Inductor-capacitor (LCI) filters shall be installed to attenuate RF emissions at specific frequencies that could cause potential undesired interaction. In addition, grounding of PV conductors directly or indirectly via the inverter shall also attenuate undesired RF emissions. An RF analysis shall be conducted to establish the frequencies in question.

4.4.3.1.1. *Electrical Analysis*

- The electrical power system studies, including but not limited to, short circuit analysis, protection coordination, arc flash, voltage drop, and grounding system shall be performed and certified by a licensed engineer, in conjunction with the future solar PV system design and existing electrical distribution system integration.

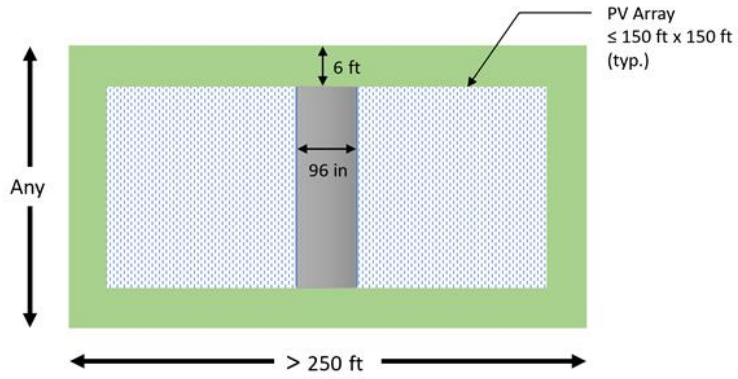
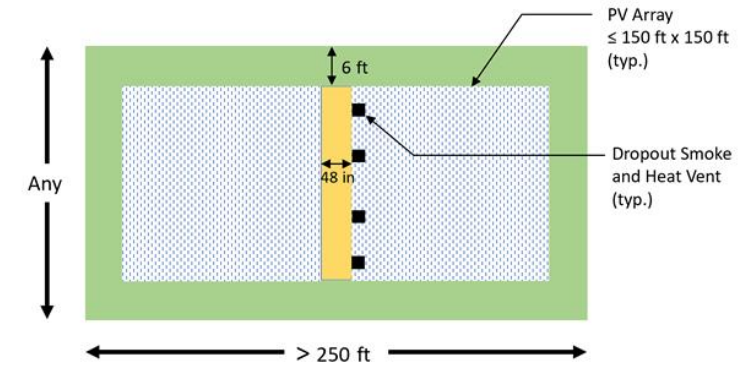
4.5. Mechanical / Plumbing Fire Protection

4.5.1. Stage I

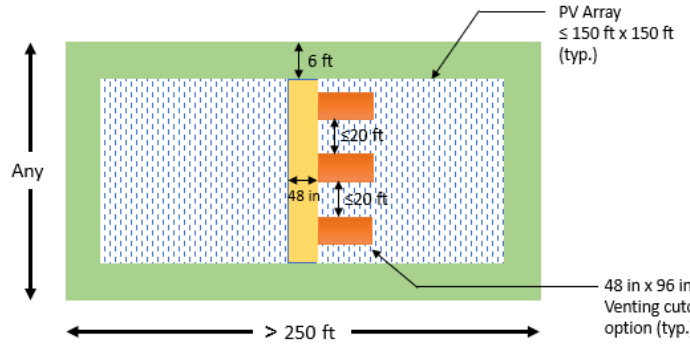
4.5.1.1. General Considerations

- Provide a clear physical separation between solar PV equipment and all rooftop mechanical equipment, accounting for code-required and equipment manufacturer's recommended clearances around mechanical equipment and equipment removal pathways.
- Provide a minimum 4-foot wide pathway bordering all sides of non-gravity-operated smoke and heat vents and bordering at least one side of gravity-operated smoke and heat vents.
- Ventilation options between array sections shall be one of the following options[10]:

Table 8: Ventilation options between array sections

A pathway 8 feet or greater in width	
A pathway 4 feet or greater in width bordering on roof skylights at intervals no greater than 150 feet	

[10] Providing Access to Roofs with a PV System | NFPA

A pathway 4 feet or greater in width and bordering 4-foot by 8-foot with venting cutout options every 20 feet	

- Make provisions for heating, ventilation, and air-conditioning (HVAC) equipment to accommodate solar PV electrical equipment heat output.
- Minimize and consolidate rooftop mechanical equipment, preferably on the north side of the roof or in any shaded areas not viable for solar PV installation to maximize solar-ready roof area.
- PV panels shall not obstruct storm drainage flow to roof drains.
- The proposed solar PV panels installation shall have no impact on the roof drainage system.
- Retrofit roof drains shall not be permitted.
- Where existing fuel/gas piping is installed on the roof, perform an analysis to determine a safe separation distance between the fuel/gas piping and proposed solar PV installation that minimizes the risk of ignition from the solar panels and associated electrical components.
- Where fuel/gas piping is installed on the roof, a minimum safe separation distance of 15 feet shall be maintained to minimize the risk of ignition from the solar panel and associated electrical components.
- Where storage is proposed beneath canopied solar PV panels, an automatic fire suppression system shall be designed and installed to meet life safety and property protection fire safety requirements.
    - Submit signed and sealed copies of the permitted storage evaluation by the Engineer of Record.
- Where storage is proposed beneath the canopied solar PV panels, an automatic fire suppression system shall be designed and installed to meet life safety and property protection fire safety goals. The storage type and the pertinent sprinkler density requirements as per NFPA 13.
    - A minimum height of 18 inches shall be maintained below the canopy and the top of the storage.
    - Storage height shall be based on an analysis submitted by an Engineer of Record. The analysis shall consider storage type and applicable sprinkler density requirements.
- The building's fire and emergency preparedness plan concept shall be provided to include information regarding the solar PV panel layout and roof clear path layout for fire fighter access where required.
- Coordinate and locate the roof drain in relation to the layout of the proposed solar PV panels and their associated components.
- Coordinate proposed solar PV panel design with roof drains/roof pitch requirements.

- Roof structures shall be evaluated to confirm that the roof mechanical, plumbing, and fire protection equipment are not affected by the installation of the proposed solar PV panels and their associated components.
- Coordinate proposed mechanical, plumbing, and fire protection equipment design with the installation of proposed solar PV panels and their associated components.

Table 9: Fire Protection Summary Condition for Canopied Roof Solar Panel

Canopied Roof Solar Panel – Fire Protection Summary Conditions					
Canopy Installation Conditions	**Occupancy**	**Size (sf)**	**Fire Protection Type**	**Referenced**	**Remarks**
General	Solar panels are located on the canopy roof area; the roofing materials shall be of a non-combustible type and provide suitable passive fire protection where required to satisfy the minimum fire and life safety requirements.				
NYC: NJBC - 1	Miscellaneous	Below 500sf	Passive	NYCBC: 312.1- NJBC: 312.1	Roofing shall be non-combustible material, and support members shall be fireproofed or protected with a minimum 1-hour intumescent paint.
NYC - 2	Group S-1 fire areas	500 sf or Greater	Active	NYCBC: 903.2.9.1	An automatic sprinkler system shall be provided throughout any Group S-1 occupancy fire area where the fire area exceeds 500 square feet
NYC - 3	Group S-1 fire areas	5000 sf or Greater	Active	NYCBC: 903.2.9.(5)	A Group S-1 fire area used for the storage of commercial motor vehicles where the fire area exceeds 5,000 square feet
NYC - 4	Group S-2	5000 sf or Greater	Active	NYCBC: 903.2.10.1	Commercial parking garages. An automatic sprinkler system shall be provided throughout buildings used for the storage of commercial trucks, buses, or other commercial motor vehicles where the fire area exceeds 5,000 square feet.
NJBC-2	Group S-1 fire areas	12000 sf or Greater	Active	NJBC: 903.2.9(1)	A Group S-1 fire area exceeds 12,000 square feet
NJBC-3	Group S-1 fire areas	5000 sf or Greater	Active	NJBC: 903.2.9(4)	A Group S-1 fire area used for the storage of commercial motor vehicles where the fire area exceeds 5,000 square feet

- Seismic requirements for mechanical, plumbing, and fire protection systems shall be based on the structure risk and seismic design category.
- All mechanically fastened or structurally connected installations shall be constructed of noncombustible materials per ASTM E136.

4.5.2. STAGE III

4.5.2.1. GENERAL CONSIDERATIONS

- Where no Stage I was performed, complete all evaluations and analysis required in the Stage I section above. All required provisions shall be included in the design document.

- Update the building's fire and emergency preparedness plan with the proposed solar PV panel layout on the existing roof and the fire department access and egress pathway.
- Coordinate with Architecture for roof clear path and solar PV mounting options.

4.6. RESILIENT AND SUSTAINABLE ENGINEERING

4.6.1. STAGE I

4.6.1.1. GENERAL CONSIDERATIONS

- Coordinate with the Architecture and Quality Assurance Division for the applicability of NYCBC for Sustainable Roof Zones (as applicable).
- Identify how the use of these guidelines overlaps with the applicability of other RSE guidelines and manuals, such as the Sustainable Building Guidelines (SBG), and/or Sustainable Infrastructure Guidelines, and/or Climate Resilience Design Guidelines (CRG) and/or Green Infrastructure Design Manual (GIDM).
- RSE will notify the Office of Sustainability (OS) of the impending roof replacement project and coordinate with other disciplines to provide necessary planning documentation.
- RSE Task Lead will coordinate the Initial Solar Analysis results, completed by the Engineering Disciplines, with the Office of Sustainability.

4.6.2. STAGE III

- Develop necessary documentation in coordination with the design disciplines.
- Where no Stage I was performed, complete all evaluations and analysis required in the Stage I section above.

4.6.3. STAGE IV

- Coordinate on submittals for new construction projects.
- Transfer project information (i.e., drawings, warranties, documentation) to the Office of Sustainability as required.

4.7. ENVIRONMENTAL

4.7.1. STAGE III

4.7.1.1. GENERAL CONSIDERATIONS:

- There are no General Considerations in the Environmental section. The projects shall follow project-specific Environmental requirements outlined below.
- Evaluate the following items prior to Stage III:
    - PA/Tenant spills (historic, open, consent order, etc.)
    - Active remediation sites
    - Wetlands (initial review of Wetland Mapper)
- Identify relevant permitting requirements for the site.
- Evaluate the impact on the following items prior to Stage III as applicable:
    - Soil Erosion and Sediment Control plans.
    - Stormwater
    - Groundwater/dewatering management
    - Excavation and soil handling, and disposal

- Quantify the area of disturbance (greater than 5,000 sq feet for NJ and/or greater than 1 acre for NY/NJ) and new impervious surfaces (as applicable).

DOCUMENT CHANGE CONTROL

N	Update Date	Version	Author	Update Description
1	06/26/2025	1	EADD	First version of the document published