City of Edmonton
Solar Photovoltaic Program

Site Selection Guideline

Volume 1

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Prepared for

INTEGRATED INFRASTRUCTURE SERVICES
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INTENT OF USE

This guideline publication was developed for establishing guidelines for the City of Edmonton expectations for solar photovoltaic systems that are to be deployed on their facilities. The greatest care has been taken to confirm the accuracy of the information contained herein. The views expressed herein do not necessarily represent those of any individual contributor. Solar photovoltaic technologies continue to evolve, and deployment practices change and improve over time and it is advisable to regularly consult relevant technical standards, codes, and other publications on solar photovoltaic products and practices rather than relying on this publication exclusively. However, the City of Edmonton, authors, and members of the technical review committee, want to convey that this document does not constitute a project specific design. As such, no part of this guideline alleviates the responsibility of the professionals retained to design and construct specific solar photovoltaic projects from taking full responsibility and authenticating their designs in accordance with APEGA requirements.

Report Version History

- REV1 – September 25, 2020 –Released
- REV2 – November 12, 2020 – Authorized Final

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Acronyms & Abbreviations

AC – Alternating Current
AEP – Alberta Environment and Parks
AESO – Alberta Electricity System Operator
AHJ – Authorities Having Jurisdiction
Al – Aluminum (conductor)
A/M/E/S – Architectural / Mechanical / Electrical / Structural Consultants
ANSI – American National Standards Institute
APEGA - Association of Professional Engineers and Geoscientists of Alberta
ARCA - Alberta Roofing Contractors Association
AUC – Alberta Utilities Commission
CAPEX – Capital Expenditure
CEC - Canadian Electrical Code
CoE – City of Edmonton
CRCA - Canadian Roofing Contractors Association
CSA – Canadian Standards Association
Cu – Copper (conductor)
DC – Direct Current
DG – Distributed Generation
EMT – Electrical Metallic Tubing
EoR – Engineer-of-Record
EPC – Engineer Procure Construct
EPS – Electrical Power System
FRP - Fiber Reinforced Polymer
GFI – Ground Fault Interrupter
IEEE - Institute of Electrical and Electronics Engineers
IFC – Issued for Construction
IFR – Issued for Review
ILR – Inverter Load Ratio (a.k.a. DC:AC Ratio)
IR – Infra-red
kW – 1000 watts (unit of power)
kWh – Kilowatt Hour (unit of energy)
kWp – Peak Kilowatt Rating (see STC below)
LOTO – Lock-out Tag-Out
MPPT – Maximum Power Point Tracker
MSDS – Material Safety Data Sheet
MLPE – Module Level Power Electronics
MW – one million watts (unit of power)
MWh – one million-watt hours (or one thousand kWh)
NBC(AE) National Building Code – 2019 Alberta Edition
NBC – National Building Code
NFPA – National Fire Protection Association
NRCA - National Roofing Contractors Association
OHS – Occupational Health & Safety
OPEX – Operating Expenditure
O&M – Operations & Maintenance
PVC – Polyvinyl chloride
PV – Photovoltaic (Solar Electric)
PPA – Power Purchase Agreement
PPE – Personal Protective Equipment
SCADA –Supervisory Control and Data Acquisition
SLD – Single Line Drawings
STC – Standard Test Conditions: 1,000 Watts per square meter solar irradiance, 25 degrees C cell temperature, air mass equal to 1.5, and ASTM G173-03 standard spectrum; units in DC Watts
UL – Underwriters Laboratory
UV – Ultraviolet Light (high energy component of the solar spectrum)
WSP – Wires Service Provider

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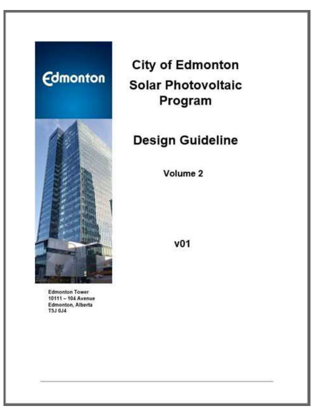
1 Overview

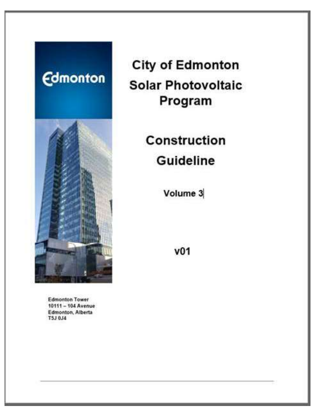
The objective of this site selection guideline is to identify the best facilities for the City of Edmonton to deploy solar photovoltaic systems on. It is understood that the factors that impact a solar photovoltaic project will vary depending on site specific conditions and constraints that impact site viability. These factors are understood to be:

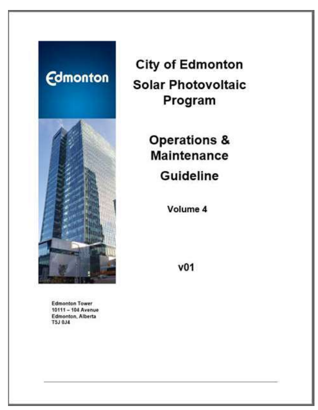
- **Technical** – this includes factors such as the architectural, structural, mechanical and electrical elements of a facility and its suitability for solar photovoltaic integration.
- **Regulatory** – this relates to specific constraints established by Authorities Having Jurisdiction (AHJ) relating to viability of the deployment, interconnection, or scale of system (e.g. wires owner requirements or safety and design standards etc.).
- **Financial** – this is based on type of system being deployed, scale of system (e.g. do economies of scale or scope exist) and long-term impact of the system on operational costs both for the host facility but also costs associated with maintaining the solar system.
- **Social** – impact of the deployment on the public, occupants of the facility, and interaction with the public at large (e.g. visibility of deployment, educational and/or engagement opportunities
- **Environmental** – this is the final and a key driver for this program as the focus of the City of Edmonton solar initiative is to maximize opportunities for greenhouse gas reduction through clean renewable energy generation.

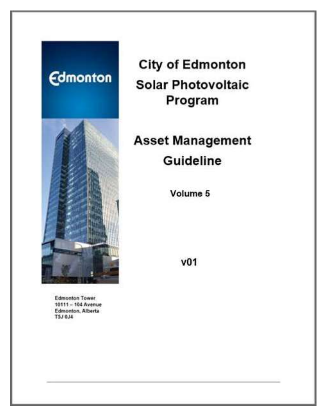
These factors are then evaluated within the context of the project, with dynamic weightings which allow opportunities to support the overall initiative to be identified efficiently and effectively. Weightings can be modified within the *CoE Site Selection Tool_v0.1*. to support knowledge (e.g., market forces, lessons learned, technological developments etc.) and/or City of Edmonton priorities. The focus of this guideline is to equip City of Edmonton staff to undertake the initial project reviews, and site assessment work in order to define a scope of services required to deploy a project. This scope of review could be am in depth professional review (for larger or more complex projects) or developing a project tender (for smaller and simpler projects).

Once a tranche of sites has been identified, and screened, the focus is to provide enough data to enable the system to be designed, procured and constructed in a way that ensures a competitive, equitable and transparent process among qualified firms.









Regardless of the path followed for procurement, this guideline is a first step in defining the project requirements. The companion documents that staff, consultants and contactors should be referring to for deployment criteria are as follows: Volume 2 – Design Guideline, Volume 3 – Construction Guideline, Volume 4 – O&M Guideline, and Volume 5 – Asset Management Guideline; in addition to all existing standards such as the Consultant Manual and Design/Construction specifications.

1.1 Purpose & Scope

This document is intended to be used for the following purposes:

- A reference for city staff who are engaged in identifying city facilities that would be suitable for a solar photovoltaic system deployment.
- Identify the methodology and process applied to screening and selecting prospective sites for solar photovoltaic deployment.
- Provide context for the ranking of City of Edmonton facilities for the deployment of solar photovoltaic systems.
- A resource for city staff to use when reviewing and framing the site evaluation work performed by contractors or engineering firms on city owned facilities as a precursor for the companion Design Guideline.
- Providing parameters for more detailed investigations that consultants would need to undertake to validate the ability for a facility to support a solar photovoltaic system.

Except where otherwise noted, the technical information contained in this document is to be used as a guide only. The consultant is expected to follow his or her professional judgment as well as all applicable codes and regulations. Building projects may have specific requirements that supersede some material presented in this document. These requirements will be communicated to the consultant at the outset of the project or during design as the need arises. When a deviation from these guidelines is either required or requested by the consultant or owner, it shall be documented in writing.

1.2 Definitions

- **Micro-generation** - electricity production, using renewable or alternative energy sources, sized to meet customer's electricity needs. These electricity needs are defined as all or a portion of the customers annual energy consumption at the customer’s site or aggregated sites.
- **Aggregated Sites** – means aggregated sites as defined in the Micro-Generation Regulation; sites can be aggregated if they are owned by the same entity (in this case the City of Edmonton), are connected on the same electrical distribution feeder that is owned and operated by the same wires owner and enrolled with the same retailer. Electrical energy consumption from multiple sites can be aggregated and assigned to a single micro-generator (provided one of those sites houses the micro-generator).
- **Large Micro-generator –** is a micro-generator that is >150 kW and does not exceed the site service transformer capacity or 5MW (whichever is the lesser of the two).
- **Photovoltaic** – solar electric technology that creates DC energy commonly inverted to AC for use within buildings.
- **Small Micro-generator–** is a micro-generator that is <150kW
- **Site Synopsis** – a high level overview of the solar PV system, including aerial image of array overlay, system size (DC and AC wattage). It can include nominal interconnection information and capacities useful for the initial field review.

1.3 Methodology

The method behind the site selection guideline is to rapidly collect, evaluate, and refine the information available on the candidate sites. It is expected that sites where information is not available, but which appear to be viable (based on information that can be assessed) would be prioritized for installations. In this way the focus will be on identifying projects that are ready to have solar PV deployed, and then organizing the specific investigations necessary to identify subsequent sites. Guiding principles of this site selection guideline include:

- **Efficiency** – identifying the quickest most efficient way to evaluate projects, screen and select candidate facilities.
- **Effectiveness** – ensuring that information collected at early stages of project investigation are organized, recorded, and accessible for subsequent stages of development to avoid rework and
- **Economy** – minimizing the costs associated with evaluating projects by using a tiered approach that minimizes City of Edmonton exposure to development costs in determining project viability.

The objective here is to maximize the available information, and focus the subsequent investigations to ensure that relevant, critical and complete information is determined through the subsequent levels of more detailed investigation. The approach for implementing this is as follows:

1.3.1 LEVEL 1: Desktop Screening Review:

This first stage leverages the information that is already available to the City for the project, including drawings, energy data (consumption and demand), prior reports (e.g. building condition assessments) to name a few. This information is used to prepare a high-level site synopsis that defines the system capacity (in terms of total quantity of modules, and DC capacity), as well as typology (e.g. flush, wall, ground etc.).

1.3.2 LEVEL 2: Initial Field Review

The second level relates to an onsite review (completed by City staff or their designated representative) to confirm basic aspects of the site. The focus is to address any missing information (previously identified in the Desktop Review) – examples are switchgear rating, type of structural system, accessibility of structural members for more detailed evaluation etc. The intent of this approach is so that field review can be completed by City staff (or contractors) with limited technical background based on a focused set of checklists with a list of specific items to review and photo documentation to collect. The information collected at this stage should be used to inform the development of a scope of work for the more detailed professional review. The approach is focused on minimizing initial costs to maximize the value of completing a project as to determine if there are any other "Go/No-Go" factors that would inhibit the project from proceeding.

1.3.3 LEVEL 3: Professional Investigations

The final level of investigation is one reserved for projects where additional onsite information is required and collecting that information is outside the purview of City staff (e.g. detailed structural assessments, building assembly sampling / investigations, etc.). In those cases, the City of Edmonton staff members tasked with developing the project would either draw on the rotating roster of pre-approved consultants (depending on the nature of the investigation) or tender out the work – in order to complete a more detailed assessment of the subject facility. The specific scope will be based on an identification of critical factors, those aspects of a project which need to be investigated to determine if a project is viable – often this will relate to structural capacity of a facility.

2 Source Data

2.1 City of Edmonton Data

Data used for the identification of sites will come from a variety of sources within the City of Edmonton departments and will include (although may not be limited to) the following sources:

Table 1 - Data Sources

Information / Data	Department Responsible
Building Information Database	Facility Management
New Building Project Documents	Facility Planning & Design
As-Built Drawings, Specifications	Facility Engineering Services
Energy Data (hourly, peak etc.)	Energy Management
Building Condition Assessments	Life Cycle Management
Building Renewal Plans	Life Cycle Management
Prior Feasibility Studies	Energy Transitions

For any given facility the specific information available can vary and so in many cases it will be necessary to collect additional information for the project.

2.2 Site Synopsis Data

The secondary information used for the site synopsis is aerial imaging of the facility accessed through a software tool such as Aurora Solar (https://www.aurorasolar.com/), Helioscope (https://www.helioscope.com), PVSyst (https://www.pvsyst.com/) or other solar assessment software package. This information is used to conceptually identify the relative system size, possible layouts, and for identifying specific areas that will require further investigation onsite (e.g. architectural element dimensions: heights, projections etc. or rooftop mounted equipment). This preliminary data is also useful in determining the relative system size and connection requirements including space requirements so that field reviewers can capture the information necessary to identify equipment locations, system interconnection, roof access requirements and deployment considerations.

2.3 Field Review Data

The final source of information is from field reviews. Field reviews will take two levels, the first completed by City Staff (or a designed representative) who have been provided an overview of the required information, how and where to locate it, and a series of checklists to complete and to guide the review. The information collected during this review would then be validated by a professional review – either pre-design, or post-design depending on the nature of the information and deployment approach for the project.

Regardless of the location of this information, the specific details required, and level of information required will be identified within the evaluation framework (as specific forms for reviewers to complete). The specifics will be augmented by site review checklists (refer to the SCHEDULES included at the back of this guideline). The forms used to input data will go through a gating and approval process by which personnel responsible for maintaining the site prioritization tool will be able to validate and confirm the integrity of the data presented.

The specific findings of the next level of field investigations (e.g. professional reviews), will be documented, and relevant parameters (e.g. structural load assumptions, presence of capacity or deficit of capacity etc.) will be included within the site prioritization tool so that it can be factored into future decision making. This information for a facility - even if it initially appears to demonstrate it is not a viable location will need to be tracked, as future capital improvements are considered, some sites that may have been initially unviable could become good candidates if there are other interventions being considered as part of a larger capital improvement program.

Field level review may include working at heights (e.g. from an elevated work platform, ladders, or on rooftops). All parties tasked with these reviews shall have the proper training (e.g. Working at Heights) and hold the appropriate certificates (e.g. Lift Operators License) to ensure all parties: Consultants, City staff and the general public are protected at all stages of the review. Please review the City of Edmonton and Provincial Occupational Health and Safety (OHS) requirements.

3 Criteria

There is a range of criteria necessary to evaluate a facility. It is understood from the outset that based on differing levels of detail, availability of information, or general age of the facility that the amount of information available will vary. To this end our overview of criteria will also indicate what is critical and what is beneficial to have in order to move forward. This range of criteria is further prioritized and filtered within the *CoE Site Selection Tool_v0.1*.

3.1 Site Parameters

This is basic information about the facility and generally is required to cross reference various sources from within the City of Edmonton records:

3.1.1 Building ID Code (Required)

This is the universal code “three-by-three” made up of three alphabetical characters, and three numbers (i.e. ABC123). All information about facilities within the City of Edmonton must include this number in order to be indexed properly across the various datasets. The master list of Building codes was provided by Life Cycle Management.

3.1.2 Address (Required)

This is the physical / street address for the property. This is important for use within correspondence and for querying mapping software for aerial imaging etc. Where a formal street address is not available refer to GPS coordinates.

3.1.3 GPS Coordinates (Decimal)

Where an address does not exist GPS coordinates can provide a proxy for referencing the parcel location and extents. This is also a format commonly used by solar photovoltaic assessment software to locate and provide input data for evaluation.

3.1.4 Record Status

This provides insight into the state of the facility and it associated records. It is a commonly used filter for retired entries etc.

3.1.5 Tenure

This provides a pre-validation of City ownership of facilities and properties. Some facilities and properties are currently leased or managed by external entities, and therefore limit the visibility as a viable deployment option. This is a consideration as some facilities require specialized access approvals (e.g. Police services) which can impact the simplicity of deploying and servicing the site.

3.1.6 Record Form

This is the actual listing of what the physical entity is (e.g. Property, Building, Structure etc.). This can be used to determine which locations are best suited for deployment.

3.1.7 Asset Classification: Class

This provides a higher-level filter to narrow down specific building typologies. This is useful for developing building type specific deployment strategies.

3.1.8 Age of Facility/Asset:

The age of the facility is key to informing building code changes (e.g. relating to structural capacity), but also for providing insight into the building condition and anticipated maintenance and renewal plans.

3.2 Energy Data

The solar photovoltaic program is based on the Micro-Generation Regulation. This means the system must be sized to offset on-site energy consumption (as opposed to being designed as an export generator). This requires that sizing is validated by both connection capacity (electrical service entrance constraints such as utility transformer size, etc.) and annual energy consumption. There is an opportunity to aggregate and group loads (more on that below) but in any event site specific energy data is required to complete a proper assessment.

3.2.1 Consumption Data

The type of billing and information available dependent on the facility size as follows:

Table 2 - Energy Data

Facility Service Size	Data Type
<150 kVA	Monthly Consumption Data
≥ 150 kVA	15-minute Interval Data

Since the evaluation must look at an annual offset (and credits can be carried month-to-month for up to 12 months) this is a sufficient level of information to determine suitability of the facility in relation to the size of the system identified in the site synopsis.

3.2.2 Demand Data

For larger facilities (≥150 kVA) it is possible to get higher resolution data (typically 15-minute). This can be helpful when determining if a solar photovoltaic system generation profiles will correlate to consumption profiles. This is helpful as it maximizes system efficiency (e.g. minimizing the amount of transformation required to export and re-import energy from the grid).

3.2.3 Generation Correlation

Where the data exists, there is a benefit to understanding the self-consumption index for the facility (i.e. the real-time consumption and use of solar generated electricity). To manage the significant amount of data associated with interval metering, this metric has been distilled into a value of time weighted demand which correlates to solar generating hours of the year.

3.2.4 Annual Energy Balance

To ensure that the PV system is “right sized” and is not creating an imbalance of energy consumption vs. generation on an annual basis to meet the requirements of the Micro-generation Regulation an effective ratio of generation to consumption will be established – this will be used to inform the Site Synopsis system sizing as a cap of 1.

3.2.5 Wires Owner Data

The meter number will be used as a reference for querying EPCOR for site specific information. This information will include:

- Electrical Site ID / Meter Number
- Connection Data: Feeder Name/Number
- Service Capacity: Transformer Size / Voltages (where info is not available onsite)
- Service Specifications: Transformer Impedance, Upstream Fault Current, Switch Clearing time
- Rate Class: Distribution and transmission tariffs

It should be noted that there are >900 electrical meters under management by the City of Edmonton, so this information will typically be requested at the detailed design stage. However, if there is an inability to determine service sizing (e.g. due to access) then this may be requested at the assessment stage.

3.3 Facility Information

The information available for each facility varies, however the starting point will be to review the Building Condition Assessments that are prepared by Life Cycle Management (it is understood these are typically no more than 5 years old).

3.3.1 Surface Condition:

The high-level information that will be collected from the desktop and subsequent site reviews is the type, age, and available surfaces (e.g. roof area, wall area, or at grade areas). The sequence of evaluation is based on the simplicity of deployment (and by extension costs) – namely roofs, then walls and finally at grade.

3.3.2 Roof Area

The roof area is the first level of review, this can often be initially determined based on a desktop aerial imaging review. Regardless of the level of detail in the imaging, this information needs to be augmented by site reviews to determine the accuracy of roof obstructions, height of relative shading features and confirmation of as-built drawing with onsite condition.

3.3.3 Wall Area

Wall area requires a more specific investigation to determine back-up structural framing and supports and evaluate options for connecting framing members (whether flush mounted or at a tilt). The opportunity associated with walls is to maximize areas and generation during lower sun angle times of year (fall / winter) and to take advantage of possible additional structural capacity (e.g. as can be found in solid masonry wall systems).

Wall mounted systems do require more attention to the visual impact of the system, and details around integration of the array into the building fabric (e.g. connection details/anchoring, wire management, flashing etc.). to ensure that the system is responsibly deployed.

3.3.4 At Grade Area

The final opportunity that is being considered is at grade area in and around the buildings (or in relatively close proximity). Despite the increased cost of foundations, structural supports and more complex racking (which can be on the range of 20% to 30% increase).

3.4 Architectural Considerations

There are a series of considerations relating to the architectural attributes of the facility which can directly impact the viability for deploying solar photovoltaic systems. The desktop review will identify areas of further investigation. These investigations may include working at heights (e.g. from an elevated work platform, ladders, or on rooftops). All parties tasked with these assessments shall have the proper training (e.g. Working at Heights) and hold the appropriate certificates (e.g. Lift Operators License) to ensure all parties: Consultants, City staff and the general public are protected at all stages of the assessment. Please review Occupational Health and Safety (OHS) requirements established by the City of Edmonton.

3.4.1 Orientation

As the relative costs of photovoltaic modules have declined (compared to overall system costs) the ability to effectively deploy systems which are outside of the conventional south orientation (e.g. defined as +/- 45 degrees from true south). This has recently been taken to the extreme by some reputable racking manufactures who have developed east-west oriented racking, which are being deployed to maximize the total deployed wattage (by reducing lost area due to inter-row spacing).

3.4.2 Slope

The roof slope can dictate the type of racking (as much as the roof type) and sloped roofs where greater density of modules can be installed using a more cost-efficient racking system such as flush mounted rail based systems should be considered as optimum opportunities for array installation. For low slope roofs (e.g. <8 degrees), almost any orientation can be effective. Flush mounted systems on a sloped roof can also significantly reduce the overall snow loading since no additional ballast is required, and there are minimal opportunities to create snow drifts.

3.4.3 Roof Size / Configuration

The array size is something that should be validated based on energy consumption (for the host facility, or other facilities owned by the City on the same feeder). Generally, it is much more cost effective to deploy larger systems where the fixed costs associated with deployment can be offset by the larger energy generation opportunity. There are a few size thresholds that should be considered to ensure systems are right sized (refer to section 3.7 Electrical Considerations).

3.4.4 Roof Type

The type of roofing system can have a major impact on the viability of a project. Specifically, in terms of the ability for the roof system to withstand the additional forces enacted on it by the construction and deployment of solar photovoltaic systems. Refer to *Table 8 – Roof Type vs Protection Requirements* included within *Volume 2 – Design Guideline* for an overview of roofing systems and relative considerations relating to solar photovoltaic system compatibility.

This is not to say that a specific roof system cannot be accommodated for within the solar racking design. It just provides a general overview of the systems and their impact on solar deployment and operation.

3.4.5 Roof Age

The age of the roof is a key consideration for a solar photovoltaic system deployment. Most systems installed need to be removed and re-installed (Re&Re) in whole or in part to facilitate roofing replacement. This can represent a significant outlay in cost in the projected system cashflows. To mitigate this cost, it is important to consider possible roofing replacement or refurbishment <u>before</u> deploying a system. Typically, this means if the roofing is going to be replaced within the next 4 to 7 years it is worth considering a re-roofing prior to deploying the system. If however the roof life is expected to exceed 10 to 15 years then a system Re&Re could be considered within the deployment evaluation.

It should be noted that the deployment of a solar photovoltaic system can extend some roofing system life expectancy (due to shading from direct UV damage) but on others, and in some configurations, it can accelerate roofing degradation (e.g. trapped heat can rapidly degrade shingles). As such it is important to consider servicing of seams, and configuration of the arrays to minimize heat build-up which can impact system performance and prematurely age the roofing system.

3.4.6 Parapet Height

The parapet height is something to note both in terms of the shading impact it will represent on the array (this is typically only a concern where the parapet exceeds 600mm in height (as measured from the top of the roofing system). The other key consideration for parapet height is the snow drifting and loading impact that it will have on the structural loading.

3.4.7 Visual Impact

The final aspect of the evaluation is to understand the visual impact of an array to the general public and users of the facility. This is hard to quantitively assess, but it is a good idea to capture images that can be used to render array concepts so that they can be evaluated. This is typically only necessary for flush mounted arrays or roofs where the parapet is quite low or nonexistent (e.g. lower than 300 mmm).

3.5 Structural Considerations

The desktop review will identify areas of further investigation and assessment. These investigations may include working at heights (e.g. from an elevated work platform, ladders, or at the ceiling level).

3.5.1 Building Age

In our Northern climate, wind and snow are major environmental loads informing the design of structures. These elements are defined and quantified in the National Building Code (NBC) and the Alberta Building Code (ABC). These Codes are re-evaluated and updated regularly as available climatic data, knowledge of materials, people's behaviors, new hazards and risks are identified, technology evolves, and environmental conditions change. Changes in construction practices, energy efficiency requirements, our understanding of snow loading, and global environmental conditions has led to refined geographical climatic data and code prescribed procedures for calculating climatic design loads.

Table 3 - ABC / NBC Code Changes over Time

CODE EDITION		SNOW		WIND				
ABC	NBC	Ss	Sr	1/10	1/50	Cb	Drift	
2019	2015	1.7	0.1	0.35	0.45	Y^^	Y+	
2014	2010	1.7	0.1	0.35	0.45	Y^	Y	
2006	2005	1.7	0.1	0.32	0.45	Y^	Y	
				1/30	1/100			
1997	1995	1.6	0.1	0.4	0.51	Y (0.8)	Y	
1991	1990	1.6	0.1	0.4	0.51	Y (0.8)	Y	Ss(CbCwCsCa)+Sr
		Snow (So)						
1990	1985	1.5		0.4	0.51	Y (0.8)	Y	SoCbCwCsCa
1985	1980	1.5		0.4	0.51	N	Y	
1981	1977	1.5		0.4	0.51	N	Y	
1977/78	1975	1.29		0.41	0.51	N	Y	
1974	1970	1.29		0.41	0.51	N	Y	
				Gust	Pres			
	1965	1.29		~	~	N	Y*	
	1960	1.05		~	~	N	Y*	SCs

LEGEND
*No projections/obstructions
~ Old Wind proceedure based on velocity and pressure
^ Large roof factor adopted
^^ Large roof factor modified
+ Drift modified

NBC/ABC publications define the load associated with the maximum snow depth load (Ss). In NBC 1941 code this value is 1.0 kPa compared with current NBC 2015/ABC 2019, value of 1.7 kPa, this value has increased significantly. Incorporating the coefficients that take into consideration snow pack, saturation due to rain, snow drifting, the effects of adjacent structures, and building geometry, the base design snow load (S) is determined. Figure 1 shows the design snow load (S) for a representative site in Edmonton based on NBC Code requirements from 1960 to current day. A plot of the data shows distinct steps that informed the determination of 2 site selection filters as noted in Table 4:

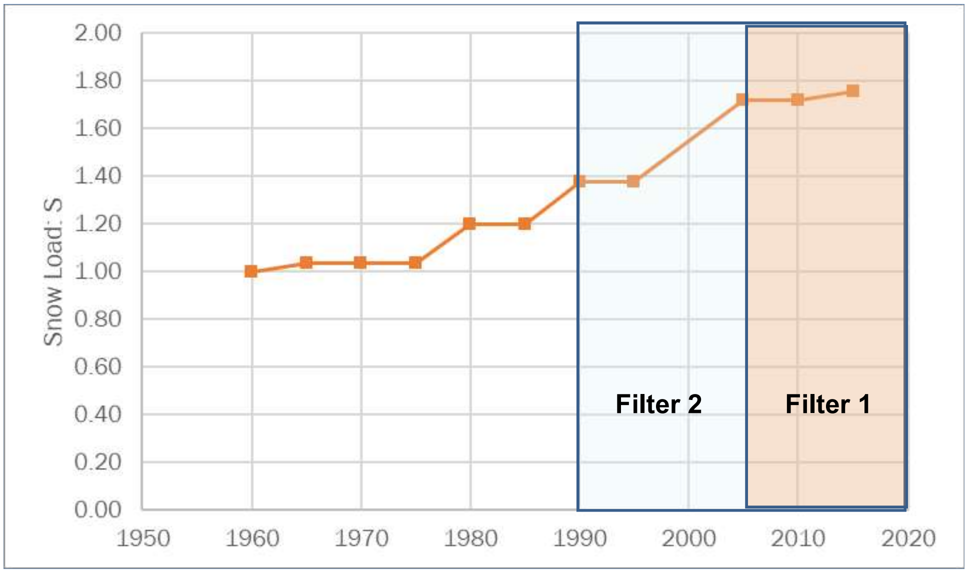


Figure 1 - Snow Load (S) NBC Code Changes over Time

The net result is that NBC 2015 (2019 ABC) edition base design snow load (S) is 1.76kPa, an approximate increase of 42% over the pre-NBC 1980 values.

Wind load is another driver for solar project deployment. A similar methodology was applied to the NBC/ABC published climatic wind load (q) to determine its impact on the screening methodology. Figure 2 shows the change in (q) in Edmonton over time. The value of (q) is adjusted by coefficients greatly dependent of the building exposure, elevation, building geometry, and specific "zones" within rooftops and walls to determine the design wind load value (p). The previous identified factors typically result in an uplift and horizontal load which increases at higher elevations, rooftop edges, building corners, and unsheltered elements.

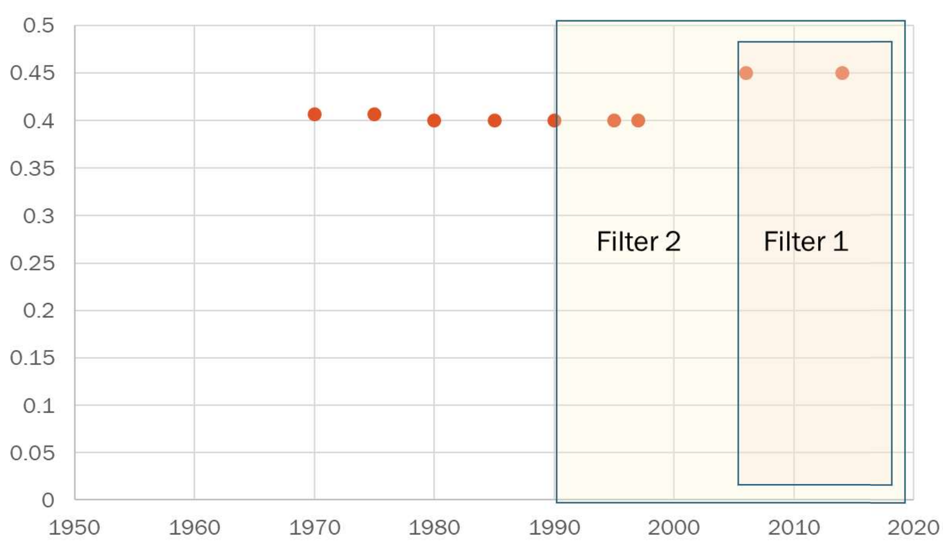


Figure 2 - Wind Load (q) NBC Code Changes over Time

The net result is that buildings with lower roof heights (typically defined as below 5 stories) are good candidates for ballasted system (i.e. thus minimizing the number of structural penetrations). Taller buildings require a more specific review of wind loading, and typically requires partially or fully anchored solutions which increases cost and complexity – so low-rise buildings are considered better candidates.

Based on the combined impact of snow load and wind load changes we have established the following filters for screening down the existing city facilities as follows:

Table 4 - Facility Screening

Filter	Date Range	Building Count
Filter 1	2006 to Present	60 facilities
Filter 2	1990 to Present	82 facilities

It should be noted that this isn't to say that older facilities could not be good candidates for solar. If those facilities are scheduled for major redevelopment then it would be worth reviewing the viability of entertaining larger scale reinforcement (as part of other work) to create an opportunity for solar. This type of major redevelopment would be governed by the Solar PV Ready requirements for New Construction or Major Renovation.

3.5.2 Importance Factor:

What type of facility, how is it currently used, what is the exposure factor to the general public (e.g., library rated differently than works garage etc.). The key aspect of this is if it is a designated post-disaster facility, or its use has been changed since initial design to a post-disaster facility, that will stipulate the structural load safety factors that should be applied to both the base building review and assessment and the solar photovoltaic system design.

3.5.3 Structural System

The increase in structural demand from solar photovoltaic equipment loading will have varying effects on different structural systems. In general, heavier systems such as concrete will see a smaller percentage increase in demand, in comparison with a lightweight system such as steel deck on steel framing or pre-engineered structures. The age, expected service life, and ease of reinforcing also impacts the feasibility of placing solar voltaic arrays on existing structures. The specifics of each case must be reviewed on a project-by-project basis to determine if residual capacity exists. Refer to *Table 1 – Structural System Investigation Methods* included within *Volume 2 – Design Guideline* for an overview of existing structural systems and recommended investigation methods.

That said, depending on the original design loads, system and configuration it may be possible to account for part or all of the solar photovoltaic equipment dead load within pre-existing design load allowances if it can be demonstrated that using those allowances will not detrimentally affect future operations – or create unnecessary hurdles for the Facilities / Life Cycle Management department in future minor renovation projects.

3.5.4 Condition & Remaining Service Life

The current condition of the facility and the anticipated remaining service life will affect the suitability for solar array installation. Previous building condition assessments will be reviewed.

3.5.5 Load Evaluation

At the Level 1 Desktop Screening phase, the current loads for a given facility will be informed by the as-built drawings if available and age of the building. If drawings are not available, field verification of the roof loading and structural assembly will be required. While onsite for the initial review there should be some consideration given to archive hardcopy drawings that may be located and photos taken.

As noted above, Code required environmental loading, as well as the code prescribed load coefficients have changed significantly over the last 50 years. As such, buildings older than 1990 will have a greater increase in demand due to environmental loading and are not ideal candidates for the addition of solar photovoltaic equipment from a structural perspective.

Environmental loading including base snow, associated snow accumulation and wind loads on the roof will be determined per the National Building Code, 2019 Alberta Edition. The increase in demand on the structure shall be determined based on a comparison of factored loads at initial design to current loads per current Code requirements. If the increase is greater than five percent, further assessment will be required.

At the Level 3 Professional Review phase, it will be necessary to carry out field level review, including detailed as-built verification and load verification to further refine the desktop review phase assumptions. Serviceability will also be addressed at this stage based on Code requirements including potential changes in drainage patterns and the effect on ponding, as well as deflections and impact on interior finishes. Section 3.5.3 within *Volume 2 – Design Guideline* should be referenced for more information relating to design load considerations.

3.5.6 Facility Exposure

The exposure class of the facility may have changed over its life. A facility that was installed in an open field 50 years ago may have additional structures and obstructions encroaching which would change the wind load expectations. This should be reviewed to validate the design assumptions. It is relatively straightforward to get a sense of this by taking photographs in each direction while conducting the site review.

3.5.7 As-Built Assessment

Where as-built drawings are available, it is prudent for the initial field reviewer (Level 2) to perform a high-level review of the structural system type and assembly, layout, spacing, and any possible changes or conditions that are not be represented in the drawings. The loading on the current structure shall also be reviewed, including roof assembly type, equipment, and finishes (including drywall or fire spray), etc. It is important to differentiate this initial review with a more detailed assessment by a professional that will take place at the Level 3 stage of review. The objective here is to validate (to some extent) the information available, and provide scope and context suitable for retaining an engineer (i.e. how many structural systems are there, is a lift or ladder required to review, does access need to be afforded by removing ceiling or wall systems etc.). Refer to Schedule 3 for the Structural Infrastructure Checklist template developed for the Level 2 Field Review.

3.5.8 Site Specific Sampling

At the Level 3 stage of review, site specific sampling and testing may be required in circumstances where accurate information is difficult to ascertain, or material specifics (e.g. location, properties etc.) included in the documents are not representative. This may include cutting and patching to remove coupons for testing structural steel, localized concrete chipping to expose reinforcing or x-ray/scan imaging concrete slabs to determine the extent of rebar. In any of these cases the scope of the sampling is to be reviewed with the Facilities Infrastructure group to ensure proper provisions are in place to safely sample and remediate the sampled areas.

3.6 Mechanical Considerations

The accessibility of the system to safely maintain it, and ability to prevent unauthorized access and risks associated with exposure is to be refined per site. There are some general guidelines that should be considered when reviewing a site to ensure that these factors are taken into consideration at subsequent stages of project development:

3.6.1 Roof Obstructions

As part of the Desktop Screening review, a review of the existing rooftop equipment will be assessed to validate “Keep-Out” areas for pre-existing equipment locations. This includes measuring the heights of roof obstructions (e.g. rooftop mounted equipment, flues, and roof drains). Further investigation into their specific function and characteristics (i.e. Rooftop unit, Exhaust fans etc.) will dictate their minimum setback for shading considerations.

3.6.2 Servicing Locations

Site specific validation of existing equipment is to be completed to ensure minimum maintenance clearances are established for servicing of existing mechanical equipment. *Table 3 – Setback Provisions Details* included within *Volume 2 – Design Guidelines*, references the specific setbacks and configurations for rooftop equipment. However, it is important that site reviews include getting photos from all sides of rooftop mounted equipment so that those clearances' can be identified (i.e., filter section, fan housing etc.).

3.6.3 Access Control

This should be reviewed in terms of the physical location of the array and determining how accessible the proposed location may be to the public. This is specifically a factor when considering wall mounted, ground mounted, or facilities that are accessible at-grade. Considerations such as mechanical protection (e.g. fencing, flashing, etc.) should be reviewed to ensure it is not creating a possible path to permit unauthorized access to elevated roof surface.

3.7 Electrical Considerations

3.7.1 Safety & Access

The initial assessment activities will be focused on a visual review of non-energized parts of equipment (e.g., nameplate etc.). A more focused field reviews of overcurrent protection or fusing shall only be conducted in accordance with CSA Z462 Standard for Workplace Electrical Safety. This means relying on photo documentation from servicing events (i.e. during bi-annual shutdown events) or using viewing windows. Should investigation of fusing (typically the case for enclosed disconnect switches) be required a site-specific safety plan needs to be developed to determine the lowest risk method to acquire that information.

3.7.2 Service Transformer Rating / Windings / Condition or Age

Assessing the "As-Recorded" electrical drawings, along with confirming with the Wires Owner (EPCOR) to determine the kVA rating of the service transformer for the existing electrical service and comparing to the manufactured date of the equipment will identify maximum system sizing without the technical considerations associated with upgrading the existing service. The configuration of the existing transformer will need to be identified to determine what the additional technical design considerations associated with deployment are.

3.7.3 Switchgear Rating

Assessing the "As-Recorded" electrical drawings to determine the electrical details (buss ampacity, main breaker rating, utility meter location, etc.) of the service Switchgear will further identify the maximum system sizing potential, along with interconnection strategies (i.e. Line vs Load side). Further site evaluation will be required to validate the desktop review, with the consideration of accessing the inside of the switchgear to determine main breaker or available branch breaker ratings/space depending on the age of the equipment.

3.7.4 Space Allocation

Determining the approximate system size will dictate the approximate PV specific space requirements for either centralized (i.e. single wall) or distributed equipment deployment options. Site evaluation of available wall and roof space with field measurements will be used to establish this equipment deployment strategy and space availability.

3.7.5 Electrical Interconnection Capacity

Following the guidelines of the Canadian Electrical code (CEC) 64-112 will establish PV system size capacity limitations based on the existing electrical service. At the site assessment stage, attention should be paid to the age and condition of the switchgear as older infrastructure may need to be upgraded and that cost would typically be attributed to the solar PV system if that were to trigger the upgrade. The specific connection methodology should be identified as early as practicable (i.e. use of spare breaker, addition of a breaker, or bus taps) to ensure that connection method can be properly costed and vetted by the switchgear manufacturer and/or servicing company. Where possible identify locations for interconnection that are at the opposite end of the bus from the main service disconnect. Also identify a location for the DG#1 Disconnect which is to be located within 7.5m of the point of connection as per the Canadian Electrical code (CEC).

3.7.6 Electrical Distribution System Feeder

The Wires Owner (EPCOR) will be engaged early in the design stage to establish any potential capacity limitations or restrictions on the distribution network. It should be noted that there are restrictions in the Edmonton downtown core which restrict the ability for systems to back feed the EPCOR grid in those locations. Any projects being considered in the downtown core should be pre-reviewed with EPCOR to determine if a zero export Solar PV system with back feed relay protection would be a possibility.

4 Site Synopsis Modeling

The approach utilizes early modeling of system layout, and configuration to inform detailed onsite investigations. This site synopsis modeling also creates a baseline for generation expectations for a given system. To ensure that a consistent evaluation methodology is applied we have defined the basics that should be included.

Table 5 - Preliminary Modeling Parameters

<table>
<tr><th>Basis of Simulation Assumptions</th><th>Parameter</th><th>Modeling Notes</th></tr>
<tr><td>3-D Shading</td><td>Site specific</td><td>Early stage simulations should include some degree of shading/3D geometry for rooftop equipment and differing roof elevations. These initial simulations should be limited to estimations (i.e. obstruction heights) from satellite imagery</td></tr>
<tr><td>Site Details (Orientation)</td><td>Azimuth: Aligned with building
Module Tilt: 10° / Flush</td><td>Flat roof systems should utilize a standard module tilt of 10^0 with the modules aligned with the building azimuth.
Flush mounted systems should match the roof slope (both tilt & azimuth).</td></tr>
<tr><td>Annual Soiling</td><td>1.0%</td><td>Base assumption of 1%.</td></tr>
<tr><td>Snow Soiling</td><td>Monthly values for snow months</td><td>Preliminary snow soiling values for all initial models:
<table>
<tr><th>Month</th><th>% Soiling</th></tr>
<tr><td>Oct</td><td>5</td></tr>
<tr><td>Nov</td><td>10</td></tr>
<tr><td>Dec</td><td>20</td></tr>
<tr><td>Jan</td><td>45</td></tr>
<tr><td>Feb</td><td>35</td></tr>
<tr><td>Mar</td><td>15</td></tr>
<tr><td>Apr</td><td>5</td></tr>
</table></td></tr>
<tr><td>Field Thermal Loss Factor</td><td>15 - 29.0W/m^2k</td><td>Value is based on the nature of the racking system, how much excess heat can escape, with wind loss factor built into the overall thermal parameter.
1. Ground mount 29 W/m^2 K
2. Standard flat rooftop: 20 W/m^2 K
3. Flush mount: 15 W/m^2 K</td></tr>
</table>

Module Quality Loss	-0.5%	Placeholder value represents a positive value. The available tolerance for PV modules ranges from 0~+5W.
Module Mismatch Losses	1.0%	Placeholder value for standard module mismatch loss without detailed information concerning Module flash test data. Where DC-DC optimizers are used, this value is set to 0% for optimizer level MLPE sections of the system.
String Mismatch Losses	1.0%	Placeholder value for standard stringing mismatch loss due to strings being run between different sections of arrays. Where DC-DC optimizers are used, this value is set to 0% for optimizer level MLPE sections of the system.
Light Induced Degradation	2%	This is a standard value for Tier 1 module suppliers.
Ohmic Wire Losses (DC)	0.5%	These values are used as placeholder values for worse case loss profile (see maximum upset limits in the Design Guideline).
AC Ohmic Loss	1.5%	
Inverter (CEC) Efficiency	Manufacturer Specific Curves	Inverter Efficiency curves included in the software modeling should be included.
Transformer	2%	Transformer losses are to be included as a placeholder.
System Downtime / Availability	0.5%	Downtime for initial system commissioning and future O&M maintenance to be estimated to be 2.0 days per year.

These generation modeling parameters should be used in any site assessment modeling to ensure that the projected generation opportunity is reasonably framed. It is expected that these values will evolve and become more refined (*Refer to City of Edmonton Solar Program – Volume 2: Design Guideline - Table 14)* as the project detailed design and construction (e.g. shop drawings) proceeds.

5 Secondary Evaluation Metrics

There are several metrics which are considered as a secondary dataset – essentially developed as part of the site synopsis and investigation process. These metrics are factors which can be used to organize and prioritize sites as the various profiles are developed for selected sites.

These metrics will also be expanded (in terms of resolution of content) as the projects move forward to help inform the future iterations of site selection. The goal will be to use these actual values and populate them into the Site Prioritization Tool to provide a benchmark for future projects and influence future metrics.

5.1 System Size (DC/AC) [kW]

The system size of a facility is a key metric – commonly the DC (direct current) nameplate rating – which is the sum of all the module nameplate ratings (e.g. module Standard Test Conditions (STC) wattage multiplied by the total number of modules). The AC nameplate value relates to the inverter (grid connected nameplate). The AC rating is typically an important consideration for authorities having jurisdiction (e.g. Wires Owner approval methodology is based on AC rating).

5.2 AC/DC Ratio – [x]

The ratio of DC nameplate wattage to AC nameplate wattage is commonly considered in evaluating solar PV systems. Most microgeneration systems range from 1.1x to 1.6x – but higher or lower values are possible depending on equipment performance. It is typically recommended to keep AC to DC ratios of 1.2x to 1.4x.

5.3 Annual Unit Generation – [kWhr/kWpDC-yr]

Total energy generation is an important value for evaluating the GHG reduction potential of a system. However when evaluating systems against one another a consideration of how much energy generation (in this case expressed as kWhr) per peak DC kW installed is a useful metric. It should be noted that due to module degradation any projection of annual energy generation into future years should be discounted appropriately (depending on manufacturer degradation ranges from between 0.5% to 1% per year).

5.4 Capital Expense (CAPEX) – [$/WpDC]

The unitized capital cost based on Watt of DC capacity that is installed is a common metric in the industry. Projects are typically tendered with absolute numbers – but it is relatively straightforward to translate into a $/W basis. This number allows systems with similar typologies to be compared and considered irrespective of system size.

5.5 Operating Expense (OPEX) – [$/kWpDC-yr]

Operating expenses are not commonly known at the outset, but as projects come online, and benchmark tenders are completed for existing operating systems these values can be refined. This metric is based on peak kilowatt of installed equipment which has evolved into a common metric in the industry.

5.6 Avoided Energy Cost – [$/yr]

This value is a blended variable based on the annual generation expected from the system correlated to the energy tariff rate (or rate structure) to create a model of what a system would “pay back” in terms of taking avoided energy cost savings.

5.7 Simple Payback – [yrs]

This is a common metric that takes into account the capital expenditures, divided by the avoided energy cost (on a declining basis due to degradation) less the annual operating (OPEX) costs for a facility. This is a metric that can be used to quickly compare between projects – but does not take into account anticipated market changes.

5.8 Levelized Cost of Energy (LCOE) – [$/kWhr]

Levelized Cost of Energy (LOCE) is a proven approach, when looking at an investment in a renewable energy source (and, increasingly, at conventional sources as well), to consider a period of time and reflect back to the present. In all our assumptions, we have taken into account inflation and the time value of money, and how it affects any future costs. The results of this analysis can then be compared to the cost of grid electricity to see what the cost impact of the project would be. It is helpful as a metric for evaluation as it provides a value that is independent of fluctuations in market conditions.

5.9 Greenhouse Gas Reduction – [tonnes CO_{2e} / yr]

Understanding the GHG reduction potential of a solar photovoltaic system requires an understanding of the energy sources that supply electricity to the electric grid that the PV system is connected too. For example, Energy Star Canada publishes data for the Alberta electrical grid which indicates Base Load indirect GHG emission factor for electricity in the province is ~860 g/kWhr while the marginal indirect generation rate which corresponds more closely to solar generation window is ~469 g/kWhr.

SCHEDULE 1 –General Site Survey Checklist

Facility Name:	Site Address:	Date of Review	Reviewer Name
Facility Number:		**System Size (kWdc)**	**Racking Type**

Orientation of Building
Available Facility Information ☐ Electrical Data ☐ Structural Drawings ☐ Electrical Drawings ☐ BCA Report ☐ Architectural Drawings ☐ Rooftop HVAC Drawings
General Comments:

Photos: ☐ Gable End ☐ Isometric Perspective ☐ N / S / E / W Elevations

SCHEDULE 2 –Architectural Infrastructure Checklist

Roof	
Roof Access	☐ Temporary ☐ Hatch ☐ Interior Staircase
Roofing System	
Condition of Roof	
Parapet Height	
Rooftop Unit Height	
Re-Roofing Considerations	
Additional Notes:	

Photos: ☐ General Roof Overview ☐ Close-up of Roof Membrane ☐ HVAC Units
☐ Roof Access ☐ Close-up of Parapet

SCHEDULE 3 –Structural Infrastructure Checklist

Structural Systems		
Type / Condition of Structural System	☐ Cast-in-Place Concrete ☐ Mass Timber ☐ Structural Steel ☐ Pre-Engineered Building ☐ Pre-Cast Concrete ☐ Stramit structural deck ☐ Other _____________	Visual Condition of System:
Accessibility for Measurements (e.g. Working at Heights)	Equipment required to reach structural components ☐ Ladder – height / type: _____________ (extension, step etc.) ☐ Rented lift – reach / type: ___________ (lift, articulating boom etc.) ☐ Onsite equipment (explain) ______________________________ NOTES:	
Removal / Relocation of Covering Assemblies	☐ Exposed Structure ☐ Relocatable coverings (e.g. ceiling tiles) ☐ Interior Attic / inter-floor access ________________ ☐ Demolition Required (e.g. removal of drywall/firespray etc):_________ NOTES:	
Structural System Verification	Does the structural system onsite correlate to the drawings on file? ☐ Confirm Type/Layout ☐ Selective Geometry Check ☐ Yes ☐ No ☐ Partially (explain):____________________ NOTES:	

Photos: ☐ Structural Deck System ☐ Structural Joist System ☐ Walls/Foundations
☐ Floor Systems ☐ Surface Condition (all components)

SCHEDULE 4 –Mechanical Infrastructure Checklist

Mounting System	
System Type - Ballasted vs. Structural Mounting - Flexibility	
Location of Penetrations	
Access (Install/Ongoing) - Maintenance Personnel - Crane Access (staging)	
Vandalism Access	
Extreme Weather Exposure Risks Hail Lightning High Winds	
Additional Notes:	

Photos:
- ☐ Site Access
- ☐ Rooftop Equipment (E / W/ S/ N) Elevation
- ☐ Roof Access
- ☐ Equipment Handling

SCHEDULE 5 –Electrical Infrastructure Checklist

Electrical Room	
Configuration (sketch)	
Location **(e.g. room number)**	
Wall Space (Dimensions)	
Anticipated Loads (Wattage, Run-Time, etc.)	
Connection Voltage & Configuration	☐ 120/240 Single Phase ☐ 120/208 Three Phase ☐ 347/600 Three Phase ☐ Other: ___________

Photos:
- ☐ Switchgear Bus Rating
- ☐ Main Breaker Rating/Setting
- ☐ E-Room
- ☐ Switchgear Make/Model
- ☐ Switchgear Age (if available)
- ☐ Spare Breakers (if applicable).