13 – PV Systems

Version	Date	Authors	Reviewer	Summary of Changes
1.0	05 July 2023	Inga Doemland		New Section

Preamble

07.01. This document contains requirements for photovoltaic systems, a section of the Campus and Building Requirements Manual (the CBRM, the Requirements or the Manual). The document describes the design objectives and performance requirements for PV systems designed and installed at the Australian National University (the ANU or the University).

07.02. The ANU is committed to energy efficient design and long-term, low maintenance costs. Consultants shall familiarise themselves with the existing services and systems on the campus' on which they may be involved with prior to the commencement of feasibility and planning.

Introduction

07.03. The CBRM documents the minimum design and construction requirements for new, refurbishment or repurposed building works, landscapes and engineering/infrastructure projects on buildings, facilities and campuses of the ANU. The Requirements are prepared for the direction of a Consultant, Designer or Project Manager in the preparation of project specific documentation and in the delivery of project works.

07.04. Notwithstanding any Consultant's particular discipline or area of responsibility, each Consultant and/or designer shall consider the document in its entirety. The complete CBRM consists of the following Sections which may be referred to within this Section:

Campus and Building Requirements Manual	
Section 01	General Requirements
Section 02	Architectural Requirements
Section 03	Roads, Car Parking & Civil Works
Section 04	Soft Landscaping
Section 05	Roofing, Roof Fabric & Roof Safety
Section 06	Building Management Systems
Section 07	Electrical Services
Section 08	Fire Protection Systems
Section 09	Hydraulic Systems
Section 10	Mechanical Services
Section 11	Lifts, Cranes & Vertical Transportation Systems
Section 12	Security, CCTV & Access Control
Section 13	PV Systems

Scope

07.05. This section of the CBRM addresses the requirements associated with (non-concentrating) photovoltaic systems, predominantly rooftop mounted. Photovoltaic systems in the context of this document consist of one or multiple inverter(s), which are electrically connected to one or multiple array(s) of solar electricity generating silicon based panels.

07.06. Inclusions:

- PV systems with grid integration
- Metering requirements

07.07. Exclusions:

- Battery systems
- Tracking PV system
- HV grid integration
- Standalone PV systems

Accreditation

07.08. Solar retailers must be accredited by Clean Energy Council and since 2023 be New Energy Tech Consumer Code (NETCC) approved. Provide accreditation and/or approval with tender submission.

07.09. At least one installer must be fully accredited by the Clean Energy Council.

07.010. Inverters and PV panels must be approved by the Clean Energy Council.

07.011. All low voltage works must be carried out by a fully licensed electrician and/or apprentice.

07.012. For completion of the Building Approval (BA) application, the solar retailer must have an accredited builder as part of the project team.

07.013. A structural engineer registered on National Engineering Register (NER) is required for structural roof assessment.

System Requirements

General

07.014. The Facilities and Services Division (F&S or the Division) is required to maintain an overview of the electrical services installed on all campuses, buildings, structures and facilities owned and managed by the ANU in the various states and localities of Australia.

07.015. Consultants, Designers or Project Managers who are engaged by the ANU to produce project design documentation may use this guide if appropriate or alternatively provide a project

specific electrical specification incorporating all the ANU's requirements as identified in the CBRM.

07.016. All PV systems shall be designed and constructed as a fully functional, safe and compliant solar photovoltaic installation, including PV modules, mounting structures, inverters, cabling, earthing, switchgear and electrical distribution boards, system protection and energy metering.

07.017. The design shall be based site inspections, assessing suitability of roofs for the PV panels, suitable locations for inverters, verification of electrical switchboard locations and existing single line diagrams and identification of cable routes.

Applicable Standards and Guidelines

AS/NZS 1170.2: 2021	Structural Design Actions – Wind Actions
AS/NZS 3000:2018	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 61439 series	Low-voltage switchgear and control gear assemblies
AS/NZS 5033:2021	Installation and safety requirements for photovoltaic (PV) arrays
AS/NZS 4777.1:2016	Grid connection of energy systems via inverters – Installation Requirements
AS/NZS 4777.2:2020	Grid connection of energy systems via inverters – Inverter Requirements
AS/NZS 3008.1.1:2017	Electrical installations – Selection of cables – Cables for alternating voltages up to and including 0.6/1 kV – Typical Australian installation conditions
AS 1768:2021	Lightning protection

07.018. ACT specific requirements: Installation in accordance with Electricity network service and installation rules, in particular the section on Embedded generation:

- Evoenergy embedded generation connection requirements
- Technical requirements for Embedded Generators (micro, low voltage and high voltage)

07.019. Refer to the ANU's Campus and Buildings Requirements Manuals (CBRMs) for ANU specific requirements, in particular the following:

- Section 6 Building Management Systems
- Section 7 Electrical Services
- General Electrical Specification
- ANU electrical meter specification
- Section 5 Roofing, Roof Fabric & Roof Safety

PV system requirements

07.020. When developing panel layouts, assess optimal orientation of panels for maximum yield. Consider self-shading and shading from adjacent structures or vegetation. Ensure no part of the

array is shaded between 9am and 4pm throughout the year, either through self-shading or by adjacent objects such as rooftop mechanical equipment, structures or trees.

07.021. Allow in PV panel layout space for maintenance access and ensure PV arrays to leave 3 m clearance from roof's edge.

07.022. Allow small gaps in between panels for thermal expansion and allow for at least 50 mm air gap at the back of the panels for ventilation when mounted flush with the roof.

07.023. Consider pitch angle to facilitate self-cleaning preference for a minimum pitch of 7-10° but consideration to be given to impact on roof space utilisation.

07.024. Design mounting structures (rails) to clamp on the individual modules. Do not drill in the roof sheets and do not compromise the integrity of the roof including water tightness. Refer to ANU specific requirements on mounting and access (section *Solar modules*

07.025. *Efficiency according* to IEC 60904-3 measurements >20%.

07.026. Product certification as per IEC 61215 (Part 1 and 2, Terrestrial photovoltaic (PV) modules - Design qualification and type approval) and IEC 61730 (Part 1 and 2, Photovoltaic (PV) module safety qualification). This is a requirement for the modules to be accredited by the Clean Energy council.

07.027. Product warranty: 15 years

07.028. Performance warranty as a minimum >= 92% after 10 years, >=85% after 25 years.

Inverters

07.029. Make: Fronius, SMA, Solar Edge or approved equal.

07.030. Size inverter appropriately for maximum PV array power output at the location of installation. Ensure inverter operates at all times within its rated current and voltage limits, under all weather conditions expected at the location of installation.

07.031. IP rating of 65 or higher for outdoor inverters. IP rating of 45 permitted for indoor installations.

07.032. Inverter to conform to IEC 62109-2 (Safety of power converters for use in photovoltaic power systems, Part 2: Particular requirements for inverters) for grid connected systems (as per requirement of AS/NZS 5033 and AS/NZS 4777.2 and AS/NZS 3000).

07.033. Inverters to meet requirements under AS/NZS 4777.2 including anti-islanding protection, under/over voltage protection and under/over frequency protection.

07.034. Provide earth fault detection and alarm systems as per requirements of AS/NZS 5033.

07.035. Do not exceed limit of AC voltage total harmonic distortion (THD) as per AS/NZS 4777.2 (5%).

07.036. Install inverter in well-ventilated location to prevent heat build-up. Shield inverter from direct sun light for example by installing galvanized sheet metal covers. Meet manufacturer's clearance requirements.

07.037. Transformerless (TL) inverters to be provided for all new systems.

07.038. Inverter efficiencies as per weighted "European Efficiency": >97%

07.039. Optional: BMS via HLI to communicate array performance and fault monitoring.

07.040. Provide balanced, three-phase feed-in to the electricity network.

07.041. Inverters and installation to meet the manufacturer's recommendations with regards to Electro Magnetic Compatibility (EMC).

07.042. Product warranty minimum 10 years.

Cabling

07.043. DC cabling requirements in accordance with AS/NZS 5033.

07.044. Protect internal DC cabling in heavy-duty conduit.

07.045. Protect external DC wiring from UV light through UV-resistant cabling or heavy-duty (UV resistant) conduit. Do not lay on roof unprotected.

07.046. AC cabling shall be rated to greater than the inverter output and the main switch rating.

07.047. DC and AC components in the same enclosure shall be segregated. DC cabling shall be installed in a separate conduit. Provide cable tray for AC cabling. Refer to General Electrical Specification for requirements for cable tray.

07.048. Any roof penetrations shall be suitably sealed and waterproofed.

System protection

07.049. Install at least one bypass diode for each module connected in series in an array, unless bypass diode for module is already provided as part of the module by manufacturer.

07.050. Supply and install overcurrent protection devices and disconnection devices on DC and AC side in accordance with AS/NZS 5033, AS/NZS 4777 and AS/NZS 3000. Label accordingly.

07.051. External equipment to be IP65 rated UV resistant.

07.052. Provide protective earthing in accordance with AS/NZS 3000.

07.053. Adhere to requirements outlined in AS/NAZS 3000 and AS/NZS 5033 for requirements for protection against electric shock, in particular section 4.6 of AS/NZS 5033 stipulating requirements of earthing arrangements.

Lightning Protection

07.054. Consultants shall seek confirmation from the ANU Project Manager if their commission extends to providing lightning protection risk assessment advice and subsequent lightning protection design.

07.055. For buildings with lightning protection system (LPS) installed: PV array must be bonded to existing LPS as per AS/NZS 5033 and AS 1768. Also provide Surge Protection Devices (Novaris

or approved equal) in each new Solar AC Distribution Board or on the AC circuit connecting new inverters to the existing switchboard.

07.056. Roof mounting and access).

07.057. Carry out structural assessment for array mounting. On rooftop PV systems check integrity of supporting roof structure by an accredited structural engineer and undertake calculation to verify weight of installation (including modules, frames and other balance of system equipment) is within maximum load allowance of roof.

07.058. Identify best location for inverters taking into consideration their weight and the integrity of the structure the inverters are mounted against/on. Location of inverters and DBs must be indoors, ensuring adequate ventilation to prevent overheating and loss of efficiency. All alternate proposed locations for inverters must be subject to approval by the ANU. Where located outside, inverters are to be located such that they are not exposed to direct solar radiation, e.g. direct sun light between 9am and 3pm at the equinox, contractor to be responsible for adequate shade and weatherproofing of the inverter.

07.059. Match PV strings to inverters considering number of maximum power point (MPP) trackers, maximum and minimum input currents and voltages (including for MPPs).

07.060. Provide a suitably IP rated Solar AC Distribution Board to aggregate the supply from the individual inverters, prior to feeding into the building's electrical switchboard. Provide AC isolators for each inverter and AC isolator for all inverters within board. The Solar AC Distribution Board is to house the solar electricity meter. Assess availability of space for Solar AC DBs.

07.061. For all new buildings the PV system and Solar AC Distribution board shall be connected to the Main Switchboard (MSB) on site. For existing buildings connection to the MSB is preferred, however, connections to MSSBs are at ANU's discretion if adequate justification is provided (including voltage drop and voltage rise calculations and assessment of cables and switchboards). Typically, this will only be considered where there is an extensive cable run from roof to MSB and the MSSB has suitable demand and a dedicated submain from the MSB.

07.062. Assess switchboard rating, upstream cable current carrying capacities and breaker rating. Include system protection and signage. Undertake voltage drop and voltage rise calculations, and cable sizing calculations for DC and AC side. In addition to the voltage drop requirements outlined in AS/NZS 3000, adhere to the voltage rise requirements of AS/NZS 4777.1. Size DC. cables such that the voltage drop from the furthermost PV module to inverter is < 3%. Limit the voltage rise between inverter and main switchboard and between main switchboard and consumer main to 1%.

07.063. Identify all upgrades to existing electrical infrastructure required to accommodate the PV system. These may include constraints identified through voltage rise calculations, review of existing drawings, site inspections or regulatory requirements. If the installation of the PV system requires substantial refurbishment of the existing electrical infrastructure, obtain approval from ANU project manager prior to proceeding with the design activities.

07.064. Select and protect all cables in accordance with relevant standards and from damaging climatic effects such as exposure to UV radiation.

07.065. Identify if electrical network is supplied by other embedded generation, for example diesel generators, UPS, PFC or other. Assess if PV system requires a switch to disconnect it from feeding into this network should back up system start. PV system should be installed to feed into non-essential services. PV systems shall not interfere with functions of the existing back-up systems (unless otherwise specified).

07.066. Signage to be provided to all PV components (except for individual modules) as per relevant standards.

07.067. Test and commission the system in accordance with AS/NZS 5033.

Solar modules

07.068. Efficiency according to IEC 60904-3 measurements >20%.

07.069. Product certification as per IEC 61215 (Part 1 and 2, Terrestrial photovoltaic (PV) modules - Design qualification and type approval) and IEC 61730 (Part 1 and 2, Photovoltaic (PV) module safety qualification). This is a requirement for the modules to be accredited by the Clean Energy council.

07.070. Product warranty: 15 years

07.071. Performance warranty as a minimum >= 92% after 10 years, >=85% after 25 years.

Inverters

07.072. Make: Fronius, SMA, Solar Edge or approved equal.

07.073. Size inverter appropriately for maximum PV array power output at the location of installation. Ensure inverter operates at all times within its rated current and voltage limits, under all weather conditions expected at the location of installation.

07.074. IP rating of 65 or higher for outdoor inverters. IP rating of 45 permitted for indoor installations.

07.075. Inverter to conform to IEC 62109-2 (Safety of power converters for use in photovoltaic power systems, Part 2: Particular requirements for inverters) for grid connected systems (as per requirement of AS/NZS 5033 and AS/NZS 4777.2 and AS/NZS 3000).

07.076. Inverters to meet requirements under AS/NZS 4777.2 including anti-islanding protection, under/over voltage protection and under/over frequency protection.

07.077. Provide earth fault detection and alarm systems as per requirements of AS/NZS 5033.

07.078. Do not exceed limit of AC voltage total harmonic distortion (THD) as per AS/NZS 4777.2 (5%).

07.079. Install inverter in well-ventilated location to prevent heat build-up. Shield inverter from direct sun light for example by installing galvanized sheet metal covers. Meet manufacturer's clearance requirements.

07.080. Transformerless (TL) inverters to be provided for all new systems.

07.081. Inverter efficiencies as per weighted “European Efficiency”: >97%

07.082. Optional: BMS via HLI to communicate array performance and fault monitoring.

07.083. Provide balanced, three-phase feed-in to the electricity network.

07.084. Inverters and installation to meet the manufacturer’s recommendations with regards to Electro Magnetic Compatibility (EMC).

07.085. Product warranty minimum 10 years.

Cabling

07.086. DC cabling requirements in accordance with AS/NZS 5033.

07.087. Protect internal DC cabling in heavy-duty conduit.

07.088. Protect external DC wiring from UV light through UV-resistant cabling or heavy-duty (UV resistant) conduit. Do not lay on roof unprotected.

07.089. AC cabling shall be rated to greater than the inverter output and the main switch rating.

07.090. DC and AC components in the same enclosure shall be segregated. DC cabling shall be installed in a separate conduit. Provide cable tray for AC cabling. Refer to General Electrical Specification for requirements for cable tray.

07.091. Any roof penetrations shall be suitably sealed and waterproofed.

System protection

07.092. Install at least one bypass diode for each module connected in series in an array, unless bypass diode for module is already provided as part of the module by manufacturer.

07.093. Supply and install overcurrent protection devices and disconnection devices on DC and AC side in accordance with AS/NZS 5033, AS/NZS 4777 and AS/NZS 3000. Label accordingly.

07.094. External equipment to be IP65 rated UV resistant.

07.095. Provide protective earthing in accordance with AS/NZS 3000.

07.096. Adhere to requirements outlined in AS/NAZS 3000 and AS/NZS 5033 for requirements for protection against electric shock, in particular section 4.6 of AS/NZS 5033 stipulating requirements of earthing arrangements.

Lightning Protection

07.097. Consultants shall seek confirmation from the ANU Project Manager if their commission extends to providing lightning protection risk assessment advice and subsequent lightning protection design.

07.098. For buildings with lightning protection system (LPS) installed: PV array must be bonded to existing LPS as per AS/NZS 5033 and AS 1768. Also provide Surge Protection Devices (Novaris or approved equal) in each new Solar AC Distribution Board or on the AC circuit connecting new inverters to the existing switchboard.

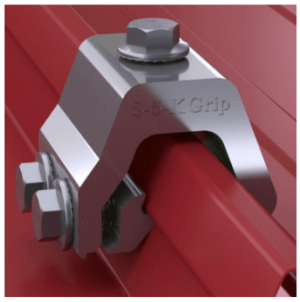
Roof mounting and access

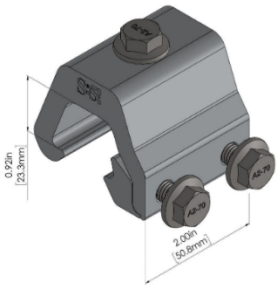
07.099. Carry out wind loading assessment for PV system and install mounting structure and array to the requirements of the wind load assessment outcome.

07.0100. Install PV arrays on rails and provide frame if desired pitch angle is higher than roof pitch. Ensure mounting is of structurally sound installation rated to the expected wind loading at the site of installation and as per zones classification on roof based on wind load assessment. Certify racking and mounting system by chartered structural engineer on National Engineering Register (NER).

07.0101. Ensure that mounting allows for reasonable clearance above the roof (>50 mm) to provide sufficient air flow and space for roof hosing underneath the panels.

07.0102. Do not drill in the roof to attach the frame to the roof. For Klip-Lok roofs use clip fixings such as TrakTite Mounting Clips (On-Trak) or S-5-K Grip (Gripperfix) to attach structures to the roof.





S-5-K Grip

The S-5-K Grip clamp was specifically developed to fit concealed fix roof profiles.
The clamp utilises one of two inserts in order to accommodate a variety of bulb snap-together profiles;
1. GX50 Insert; LYSAGHT KLIP-LOK 700®, Stramit Speed Deck Ultra®, Fielders KingKlip, Metroll Metlok 700, Revolution Roofing Rev-Klip 700
2. GX10 Insert; LYSAGHT KLIP-LOK 406®

07.0103. Allow for all PV modules to be accessible for inspection and cleaning, without stepping on adjacent modules.

07.0104. Install walkways made from FRP Fiberglass Reinforced Polymer (ON-TRAK Yellow, 600mm wide) to safely access all panels. For example, four rows of panels can be installed with walkways on either side. The walkway will facilitate cleaning of panels and of the roof and prevent slipping and falling when the roof is wet. Use the clip fixing technology to attach walkways to roof (do not drill in roof sheeting).

07.0105. Provide warranty for mounting system workmanship and equipment for at least 15 years.

Ground-mounting requirements

07.0106. The feasibility of ground-mounted systems must be assessed prior to design and construction.

07.0107. Carry out site survey to identify existing in-ground infrastructure, geotechnical investigation to inform the design of the ground-mounting structure, flood-levels and current use of the area.

07.0108. Assess existing electrical infrastructure for suitability for solar array feed in and identify upgrades to existing electrical infrastructure required. Before progressing to detailed design, seek ANU approval.

07.0109. Aim to achieve solar array pitch angle of latitude +/-10° due north, for deviation from this requirement seek advice from ANU Project Manager.

07.0110. A structural engineer registered on National Engineering Register (NER) is required for structural assessment and certification of ground-mounting structure.

Evoenergy requirements (ACT specific)

07.0111. Undertake voltage rise calculation as required by the Evoenergy regulations.

07.0112. Contractors are to prepare and submit the Special Connection Request (SCR) form to Evoenergy on behalf of ANU for the individual PV systems and buildings. The ANU project manager shall be included in all official correspondence with Evoenergy. Information to be provided as part of the application is stipulated by Evoenergy embedded generation connection requirements:

- Location of the proposed installation (address and suburb or block and section)
- Details of embedded generating unit(s)
- Site specific single line diagram showing proposed connection arrangement.
- Details of protection
- Typical generation/ load profile over a 24 – hour period at point of connection
- Site plan
- Voltage rise calculations.
- Any specific requirements for supply services levels and connection arrangement
- Additional information specific to the proposed installation as requested by Evoenergy to complete the assessment.
- Anticipated dates for connection

07.0113. A copy of the Evoenergy network application approval is to be issued to the ANU's Project Manager.

Electrical Metering & Communication Infrastructure

07.0114. Supply and install solar electricity meter within IP rated Solar AC Distribution Board to measure electricity generated by the solar array.

07.0115. The electricity meter must be bi-directional and be NMI approved. Refer to *ANU Metering Specification* for additional meter requirements such as class and accuracy.

07.0116. Provide data point for the connection of the solar generation electricity meter to the ANU's Energy Management System TCP/IP LAN network. Patch to switch in nearest communication room and allow to reticulate communication cabling from closest communication room to new data port for each meter. Install one spare data port. If meter is installed in suitably IP rated outdoor Solar AC DB, provide data point within DB. If DB is inside plant room, data point can be located adjacent to Solar AC DB. Coordinate all works with ANU's Project Manager. Communication infrastructure must be installed by one of ANU ITS approved communications sub-contractor (Stowe, Pathway, MPR, Programmed).

07.0117. The ANU will engage the BMS contractor to enable access to the information on the electricity meter to the EMS.

07.0118. For Building Management System refer to *CBRM Section 6 Building Management Systems*.

Submissions and Deliverables

07.0119. Provide specification and design drawings as part of the design documentation. Post construction documents shall include Operation & Maintenance Manuals, technical data sheets and a set of As-Built drawings.

07.0120. Prepare drawings and submit for review. As a minimum the following information shall be provided:

- Site and roof layout drawings including PV modules, arrays, sub-arrays, string arrangement, inverter location and connection to switchboards.
- Single Line diagram showing modules, junctions, strings, sub-arrays and arrays connected to each inverter, Solar AC Distribution Board including electricity meter, and connection to switchboard and connection to building's electrical network, cables and cable sizes, system protection, location of energy meter etc.
- Sections and elevations to clarify installation requirements
- Solar AC Distribution Boards including layouts and single line diagram
- Updated modified existing switchboard drawings (layouts and single line diagrams) including new switchgear, signage, and connection details.
- Network drawing for energy meter to be connected to the EMS for monitoring

07.0121. Submit certification of structural assessment (for each PV system on each building) by accredited structural engineer registered on National Engineering Register (NER) and append to O&M.

07.0122. Submit for review wind load assessment.

07.0123. Submit for ANU approval design calculations, drawings and equipment selection. Do not order equipment or commence work without ANU approval:

07.0124. Submit for approval equipment schedules, selections and equipment data sheets showing how array and inverter match, prior to ordering equipment and installation.

07.0125. Submit for approval schedule of all labels to be prepared prior to manufacture.

07.0126. Submit Testing & Commissioning Plan including commissioning checklist in line with AS/NZS 5033 Appendix E for every system and building. Submit testing and commissioning results for review. Append results to O&M.

07.0127. Complete and lodge the Building Approval (BA) application for new PV systems under the Building Act 2004. This will include the completion of the "Appointment of Builder & Application for commencement Notice" form and the "Appointment of a Certifier Application for Building

Approval" form. Seek authorization and approval from ANU where input from building owner is required.

07.0128. Submit connection request to local electricity network service provider (Evoenergy).

07.0129. Operational and Maintenance (O&M) manuals – submission for review and final. The content shall include as a minimum:

- Contact details of the contractors and subcontractors and equipment suppliers
- Description of works
- System shut down procedure.
- Basis of design for every PV/Inverter system summarizing design assumption such minimum and maximum ambient temperatures, wind conditions, orientation of system, shading, impacts of site topography and adjacent buildings and PV-module and string configuration matching to each inverter.
- Equipment schedules and selection criteria
- Manufacturer literature
- As-built drawings
- Commissioning and testing results
- Distribution Network Service Provider (DNSP) connection approval
- Approved Certificate of Electrical Safety (by ACT Government Electrical Inspectorate).
- Certification of installation to NCC 2022.
- Detailed maintenance checklist
- Operational safety plans

07.0130. Provide defects liability period (DLP) for 12 months, including installation warranty and defects liability. Provide comprehensive service and maintenance of all systems during the defects liability period in accordance with AS/NZS 5033 Appendix D Maintenance recommendations. At the end of DLP, provide final cleaning of all PV systems.

07.0131. Provide product warranties, workmanship warranties and PV module performance warranties.

07.0132. Provide handover documentation including training on how the system is safely operated and maintained.

National Capital Authority (Acton campus only)

07.0133. The ANU must submit an application to the National Capital Authority for the installation of new PV systems on roofs at the Acton campus. The application consists of a locality plan of the site showing the panel layout on the roof(s) and any external features changing the looks and feel of the building. The design documentation provided must be developed in such a manner that the NCA application can be prepared and submitted by ANU's Project Manager, showing the panel layout on the roof and any externally visual implications to the building.