ECO360

GLOBAL SUSTAINABILITY

LVSC SUSTAINABLE DEVELOPMENT STANDARDS

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SDS MODULE QUICK REFERENCE TABLE

The following table is meant to provide a quick reference to project teams regarding which Las Vegas Sands Corp. Sustainable Development Standards (SDS) modules are generally applicable to different project types. If any questions regarding applicability consult the local or corporate sustainability team.

Quick Reference Table Module Applicability Matrix

Project Type	**Lighting Systems**	**HVAC Systems**	**BMS, Controls & Integration**	**Commissioning**	**Water Systems**	**Submetering**	**Energy Performance**	**Building Façade & Envelope**	**Construction Pollution Prevention**	**Waste Management and Recycling**	**Material Selection**	**Indoor Environmental Quality**
New Property, Building Additions	√	√	√	√	√	√	√	√	√	√	√	√
General Building Renovations	√	√	√	√	√	√	√		√	√	√	√
Tenant Fit-Out With LVSC Business Involvement **(Retail, F&B, Theater)**	√	√	√	√	√	√	√		√	√	√	√
Tenant Fit-Out No LVSC Business Involvement **(Retail, F&B, Theater)**						√						
Hotel Guest Room Renovations	√	√	√	√	√		√		√	√	√	√
HVAC System Upgrade or Retrofits		√	√	√			√		√	√	√	√
Central Plant and Central Systems Retrofits		√	√	√	√	√	√		√	√	√	
Plumbing Fixture Upgrades or Retrofits				√	√	√			√	√	√	
Commercial Kitchen Upgrades or Retrofits		√	√	√	√	√	√		√	√	√	√
Landscape and Irrigation Upgrades			√	√	√	√			√	√	√	
FF&E	√				√				√	√	√	√

SDS MODULE: LIGHTING SYSTEMS

The following module is one component of the Las Vegas Sands Corporation Sustainable Development Standards (SDS). The module outlines the owner's requirements for design, performance, execution, and submittal requirements for projects implemented in existing or new build facilities across the Las Vegas Sands Corporation portfolio. Refer to Table 1 to confirm which sections of the Lighting Systems module are applicable to your project.

Table 1. Lighting Systems Module Applicability Matrix

Project Type Code	Project Type	Project Sample Description	Applicable Module Subsections
*The project code below is referenced throughout this module to help identify the sections relevant to your specific project type. Project Code "U" represents that the module universally applies to all applicable project types. ** New builds, additions, and major renovations must adhere to all components of the module.			
New Construction, Tenants, & Central Systems			
New Build Construction Code: N-B or U		Ground up construction or major renovation of a facility	Must adhere to all sections
Major Building Renovation Code: M-B or U		Extensive renovation including replacement of major systems and reconfiguration of spaces for a large portion of an existing facility	Must adhere to all sections
Central Plant & Central Systems Retrofit Code: C-P or U		Major central plant upgrade or retrofits	Must adhere to all sections
HVAC System Upgrade or Retrofits Code: HVAC or U		Replacement of major equipment or retrofit of broader system, such as air handling unit, terminal units (VAV, fan coil, FPB's)	Must adhere to all sections
Hotel Guest Rooms Code: Htl or U		New build or retrofit of guest room, guest room controls, or guest room equipment	Must adhere to all sections
Tenant Fit-Out with Owner Involvement Code: T-I or U		Full fit-out of systems, equipment, space configuration, and finishes for a tenant space with Owner involved retail, theater and/or F&B	Must adhere to all sections
Non-Applicable Projects			
Tenant Fit-Out without Owner Involvement Code: T-NI		Full fit-out of systems, equipment, space configuration, and finishes for a tenant space without Owner involved retail, theater and/or F&B	Not Applicable
All Other Project Types			Not Applicable

1.0 Lighting System Performance Standards

LEEDv4.1 & GREEN MARK HIGHLIGHTS
Minimum and Optimize Energy Performance This section requires conformance with high performance energy code requirements. Adhering to the section, will support meeting whole building energy performance requirements and sustainability goals. LEEDv4.1 projects: It may be necessary to exceed the IECC 2018 requirements to reach the required overall building energy performance. **Green Mark (for Singapore projects)**

This section requires conformance with three sections of Green Mark: Part 2 - Building Energy Performance criteria, including Lighting Efficiency and Controls, Lighting System Efficiency, Carpark System Efficiency (lighting requirements), Lighting (section ii).

<table>
<tr><th colspan="2">1.1 IECC 2018</th></tr>
<tr><td colspan="2">The baseline required performance criteria for the building lighting systems shall be the International Energy Conservation Code (IECC) 2018. To the extent that local applicable building code is stricter or further energy performance is desired or required by this standard, the lighting systems may exceed IECC 2018. See specific elements of lighting system performance covered by IECC 2018 below.</td></tr>
<tr><td>U</td><td>1.1.1 Lighting systems shall be provided with controls as specified in Sections C405.2.1, C405.2.2, C405.2.3, C405.2.4, C405.2.5, and C405.2.6. Note stated exceptions in section C405.2 of the standard.
IECC 2018 C405.2</td></tr>
<tr><td>U</td><td>1.1.2 Area-specific lighting controls shall be designed per the following guidance. Where overlap or conflict exists between IECC 2018 requirements and guidance in this sub-section, IECC 2018 will take priority unless otherwise directed by the owner
1.1.2.1 Back of House Areas: install occupancy sensors in private and open offices, conference rooms, facility rooms (such as mechanical rooms), housekeeping closets and other areas which are occupied sporadically
1.1.2.1.1 For applicable spaces, such as mechanical spaces, lighting control will be designed such that the occupancy sensor can be bypassed to prevent the lights from turning off during critical maintenance activities
1.1.2.2 Stairwell: based on local code requirement, while maintaining minimum required lighting level, install occupancy sensor to limit lighting energy consumption during non-occupied times
1.1.2.3 Public space with natural daylight: applying daylight sensors to control lighting during daytime while abundant natural daylight is available. Sensors shall incorporate dimming setbacks and overrides to compensate for insufficient daylight.
1.1.2.4 Parking garage: for covered parking garages with natural daylight exposure, lighting sensors shall be installed at the perimeter of the parking garage to control the lighting in areas with abundant natural daylight. Sensors shall incorporate dimming setbacks and overrides to compensate for insufficient daylight. Interior areas lacking daylighting shall be separately zoned and do not need daylight sensors
1.1.2.5 Meeting room space: Evaluate the feasibility of installing occupancy sensors in restrooms and individual meeting rooms to turn off the lights when unoccupied. Make sure sensors cover the entire area as not to disturb guest experience. Meeting rooms require several features: downlighting, cove lighting and chandeliers/sconces shall all be on separate dimmable circuits controlled by local interface; If meeting room becomes vacant for up to twenty minutes (adjustable), when occupants re-enter the last dimmer control settings shall be restored. When occupants re-enter after more than twenty minutes of consecutive unoccupied time (adjustable), and daily at midnight, the room lighting shall automatically revert to default settings. Divisible ballrooms/meeting rooms with airwalls shall have the ability to gang together multiple rooms with the same dimmer settings and occupancy sensing when airwalls are retracted
1.1.2.6 Exterior lighting: evaluate installing daylight sensors for exterior lighting
1.1.2.7 Atriums: Apply daylight sensors to control lighting during daytime while abundant natural daylight is available. Sensors shall incorporate dimming setbacks and overrides to compensate for insufficient daylight.</td></tr>
<tr><td>U</td><td>1.1.3 The facility shall meet the interior lighting power requirements as indicated in Table C405.3.2(1) or C405.3.2(2). See Table 1 for Building Area Method Lighting Power Allowance summary of Table C405.3.2(1).
1.1.3.1 The facility lighting power shall be calculated per sections C405.3.1 and C405.3.2 Refer 2018 IECC Interior lighting power excerpts at end of module.</td></tr>
</table>

	1.1.3.2 Public circulation areas shall be considered as Hotel/Motel area types for the purposes of interior lighting power, with an allowance of 0.75 Watts/Sq. Foot (8.07 Watts/Sq. Meter) IECC 2018 C405.3
U	1.1.4 The facility shall meet the exterior lighting power requirements as indicated in section C405.4 IECC 2018 C405.4

Table 1: Interior Lighting Power Allowances for Building Area Method

Building Area Type	Lighting Power Allowance Watts/ Sq. Foot (Watts/ Sq. Meter)
Convention Center	0.76 (8.18)
Dining: Bar Lounge/Leisure	0.90 (9.68)
Dining: Cafeteria/Fast Food	0.79 (8.50)
Dining: Family	0.78 (8.39)
Exercise center	0.65 (6.99)
Hotel/Motel	0.75 (8.07)
Office	0.79 (8.50)
Parking Garage	0.15 (1.61)
Performing Arts Theater	1.18 (12.70)
Retail	1.06 (11.41)
Sports Arena	0.87 (9.36)
Warehouse	0.48 (5.16)
Workshop	0.90 (9.68)

1.2 Green Mark	
In addition to meeting IECC 2018, projects located in Singapore must assess compliance with the following sections of the Green Mark Non-Residential Buildings 2015 Standard. For Green Mark strategies requiring capital investment, lifecycle cost analysis must be utilized to determine incremental additional investment cost and estimated long term energy cost savings.	
U	1.2.1 Energy Performance, sections P.05 Lighting Efficiency and Controls, 2.01b Lighting System Efficiency, 2.01c Carpark System Efficiency (lighting requirements), 4.02a Lighting (subsection ii)

1.3 Lighting Performance	
Lighting systems must meet the following guidance as well as the performance criteria listed in Table 2 below.	
U	1.3.1 All lamps and luminaires must use LED technology.
U	1.3.2 Evaluate implementing color tunable LED lighting to reinforce human circadian rhythm within the BOH areas. This allows for changes in color temperature of white LED lighting throughout the day to match the spectrum of sunlight outside
U	1.3.3 Conduct study on upward facing exterior lighting to evaluate light pollution risk.
U	1.3.4 Hotel room lighting requirements 1.3.4.1 Lamp shade to accommodate lamps with the following dimensions: A-19: Length (MOL) minimum - 125mm; Diameter (DIA) - 70mm; Candelabra base: Length (MOL) minimum - 110 mm; Diameter (DIA) - 36mm 1.3.4.2 Lamp shade to allow lighting to penetrate to maximize light output. Avoid dark color lamp shades 1.3.4.3 Avoid fully enclosed light fixtures that inhibit heat dispersion where not required by code

U	1.3.4.4 Wall sconces: Use 2 or fewer lamps in each sconce when possible 1.3.4.5 Toilet room: Avoid candelabra lamps and prefer A-19 when possible to achieve the same light output 1.3.4.6 Ceiling light: Avoid candelabra lamps and prefer A-19 when possible to achieve the same light output 1.3.4.7 Placement of wall sconces to complement the placement of ceiling lights to create balanced and sufficient lighting in the room 1.3.4.8 Use attached Lighting Project Template to determine feasibility and calculate ROI/payback
Lighting Controls	
U	1.3.5 All luminaires must include dimmable drivers with smooth, flicker-free, and uniform dimming down to minimum 1% setting. Front of house spaces shall employ control technologies that can reduce light output to no more than 1% of maximum value for LED luminaires using drivers and dedicated modules. Luminaires using socket-based LED lamps are exempt from this requirement
U	1.3.6 Lighting to be controlled via master lighting control system with general scene presets for all areas and local control overrides in individual spaces. Refer to "Table 2" for specific recommendations by space type
U	1.3.7 Lighting system to integrate with building automation system over centralized network system infrastructure to allow for building-wide control and monitoring.

Table 2. Lighting Performance Recommendations

Lighting design to meet light level requirements set by LVSC marketing and guest experience standards. Adjust preset dimming levels in individual spaces during the commissioning process to match lighting design intent. For detailed design guidelines and light level recommendations by space type/application, refer to the most recent edition of the IES Lighting Handbook.

Application	**CCT (Kelvin)**	**Design Guidelines**	**Lighting Control**	**Maintenance Requirements**
Front of House Lobby Lighting	3000K (subject to local preference)	▪ Downlights for general ambient lighting ▪ Cove lights/wall wash/wall graze for perimeter illumination ▪ Accent lighting for highlighting artwork and reception desk ▪ Decorative pendant chandelier as feature element in space	▪ Local zone control keypad or touchscreen at reception desk ▪ Lobby controls must include ability to store and recall scene presets as well as schedule active presets based on time of day.	▪ For high-ceiling spaces, use remote fixture drivers and locate in accessible space
Front of House Entertainment / Casino	3000K (subject to local preference)	▪ Downlights for general ambient lighting ▪ Cove lights/wall wash / wall graze for perimeter illumination ▪ Accent lighting for highlighting artwork, event areas, game tables	▪ Master controller in operations room, with local override keypads / touchscreens in staff-accessible spaces	▪ For high-ceiling spaces, use remote fixture drivers and locate in accessible space

Front of House Meeting / Convention Room Lighting	3000K (subject to local preference)	▪ Downlights for general ambient lighting ▪ Cove lights/wall wash / wall graze for perimeter illumination	▪ Local keypad or touchscreen control station ▪ Large meeting spaces must include ability to store and recall presets as well as ability to manually dim room to guest taste. Consideration should be given to including interfaces to AV equipment, shade control, and partition sensors. When airwalls retracted shall be possible to combine multiple spaces into one controller with occupancy sensors.	▪ For high-ceiling spaces, use remote fixture drivers and locate in accessible space
Front of House Guest Room Lighting	2700K (subject to local preference)	▪ Recessed/surface downlights and/or floor lamps for general ambient lighting ▪ Table lamps for task lighting at desks ▪ Wall sconces at nightstands ▪ Illuminated mirrors or sconce at vanities	▪ Local scene keypad or wall switch / dimmer	▪ N/A
Front of House Retail Lighting	3000K (subject to local preference)	▪ Downlights for general ambient lighting ▪ Point source or linear accent lighting for small product ▪ Track accent lighting for general product	▪ Local keypad or touchscreen control station	▪ Use of track should be considered for future flexibility in changing retail displays.
Front of House Interior Landscape Lighting	3000K (subject to local preference)	▪ In-grade or stake-mounted flood/accent lights for illuminating trees / flowers	▪ Master controller in operations room	▪ Locate remote fixture drivers in a dry, accessible location
Front of House Exterior Façade Lighting	4000K-5000K / RBG to match exterior	▪ Flood lights or wall wash / wall graze to highlight façade elements.	▪ Timeclock and daylight sensor	▪ Locate fixture drivers in a dry, accessible location

Front of House Exterior Area Lighting	4000K / RBG (subject to local preference)	▪ Bollards or pedestrian-scale poles for pathway illumination	▪ Timeclock and daylight sensor	▪ Locate fixture drivers in a dry, accessible location
Front of House Exterior Accent and Landscape Lighting	4000K / RGB (subject to local preference)	▪ In-grade or stake-mounted flood/accent lights for up-lighting trees/flowers	▪ Timeclock and daylight sensor	▪ Locate fixture drivers in a dry, accessible location
Back of House Corridor / Shop / MEP Room / Storage Lighting	4000K (subject to local preference)	▪ Recessed 2x4 troffers or pendant 1x4 strip lights	▪ Occupancy sensor and timeclock	▪ N/A
Back of House Office Lighting	3500K (subject to local preference)	▪ Linear pendant direct / indirect lighting ▪ Cove lights/wall wash / wall graze for perimeter illumination	▪ Local keypad control stations throughout space, vacancy and daylight sensors as applicable	▪ N/A

1.4 Lighting Quality (New Build Construction and Major Building Renovation)	
Lamp Quality	
U	1.4.1 Lamp Testing (LM-79): All fixtures specified shall include LM-79 report from laboratory accredited by the National Voluntary Lab Accreditation Program (NVLAP) or one of its Mutual Recognition Arrangement (MRA) signatories 1.4.2 Color Temperature (CCT): Color temperature to remain consistent across all spaces within a project. Refer to “Table 1” for specific recommendations by space type. See list below for general project recommendations: 1.4.2.1 Entertainment/Casino: 3000K 1.4.2.2 Guest Rooms: 2700K 1.4.2.3 Hotel Lobby/FOH Areas: 3000K 1.4.2.4 Meeting/Convention: 3000K 1.4.2.5 Retail: 3000K 1.4.2.6 BOH Office: 3500K unless color tunable lighting, see section 1.3.2. 1.4.2.7 BOH: 4000K unless color tunable lighting, see section 1.3.2. 1.4.3 Color Rendering (CRI): All fixtures specified on a project to have a minimum CRI rating of 80. For high-end spaces/artwork applications, all fixtures to have a minimum CRI of 90 1.4.4 Chromaticity: Color consistency and stability shall be limited to a maximum change in chromaticity of a 3-step MacAdam ellipse 1.4.5 Lamp Life (LM-80 & TM-21): All fixtures specified on a project shall deliver at least 70% of initial lumens for a minimum of 50,000 hours. All submitted fixtures to include lumen maintenance data measured using IESNA LM-80-08 standard for IES approved method of measuring lumen maintenance of LED light sources. Projected long term lumen maintenance shall be per IESNA TM-21. Exceptions include decorative light fixtures for which a suitable LED lamp cannot be found or fixtures requiring non-LED light sources
Luminaire Quality	
U	1.4.6 Certifications: All luminaires and assembled components shall be new, of good quality, and approved by and bear the label of UL or other approved testing agencies (i.e., CSA, ETL) unless otherwise specified in writing. Documentation of such testing shall be provided upon request

U	1.4.7 Warranty: all fixtures specified to have a minimum manufacturer warranty of (5) years. Exceptions include decorative light fixtures and special applications for which a suitable product with required warranty cannot be found 1.4.8 Efficiency: all fixtures must have a minimum efficacy (defined as "delivered fixture lumens per watt of power draw") by application as designated: 1.4.8.1 General purpose lighting: 90 lumens per watt 1.4.8.2 General purpose indirect lighting: 110 lumens per watt 1.4.8.3 Accent lighting: 80 lumens per watt 1.4.8.4 BOH office lighting: 100 lumens per watt 1.4.8.5 BOH lighting: 120 lumens per watt 1.4.8.6 Garage Lighting: 150 lumens per watt 1.4.8.7 Retrofit lamps: 70 lumens per watt 1.4.8.8 Decorative lighting: 70 lumens per watt 1.4.8.9 Landscape lighting: 70 lumens per watt 1.4.8.10 Color changing (RGB) lighting: 60 lumens per watt RGB+W Global Efficiency
Design Quality Assurance and Maintenance	
U	1.4.9 Upon project completion, Commissioning Agent to verify initial light levels meet original design intents 1.4.10 Facility Manager to perform visual inspection walk-through of all spaces a minimum of twice annually to identify dysfunctional light fixtures and repair/replace as necessary 1.4.11 Facility Manager to perform annual light level measurements in typical space types and adjust dimming levels to match operational intent 1.4.12 Cleaning staff to dust off decorative fixtures, floor/table lamps, and upward-facing fixtures a minimum of once monthly 1.4.13 Facility to maintain stock of fixtures and components for all luminaires on project

2.0 Submittals

2.1 Design Development:	
U	2.1.1 Electrical Engineer and/or Lighting Designer Responsibility: Provide documentation demonstrating the building lighting systems design meets the requirements as indicated in Section 1.1, 1.3 and 1.4 of this module 2.1.2 Electrical Engineer and/or Lighting Designer Responsibility: Provide a summary describing the high-performance lighting system technologies and strategies that are incorporated into the building design 2.1.3 Electrical Engineer and/or Lighting Designer Responsibility: For projects in Singapore, provide documentation demonstrating that the building meets the Green Mark requirements for Lighting Efficiency and Controls, Lighting System Efficiency, Carpark System Efficiency (lighting requirements), and Lighting (subsection ii)

2.2 Construction Documents (100%):	
U	2.2.1 Electrical Engineer and/or Lighting Designer Responsibility: Provide updated documentation demonstrating the building lighting systems design meets the requirements as indicated in Section 1.1 and 1.3 of this module 2.2.2 Electrical Engineer and/or Lighting Designer Responsibility: Provide an updated summary describing the high-performance lighting system technologies and strategies that are incorporated into the building design 2.2.3 Electrical Engineer and/or Lighting Designer Responsibility: For projects in Singapore, provide updated documentation demonstrating that the building meets the Green Mark requirements for Lighting Efficiency and Controls, Lighting System Efficiency, Carpark System Efficiency (lighting requirements), and Lighting (subsection ii) 2.2.4 Electrical Engineer and/or Lighting Designer Responsibility: Review all fixture submittals and substitutions to assure quality of design intent is maintained

SDS MODULE: HVAC SYSTEMS

The following module is one component of the Las Vegas Sands Corporation Sustainable Development Standards (SDS). The module outlines the owner's requirements for design, performance, execution, and submittal requirements for projects implemented in existing or new build facilities across the Las Vegas Sands Corporation portfolio. Refer to Table 1 to confirm which sections of the HVAC Systems module are applicable to your project.

Table 1. HVAC Systems Module Applicability Matrix

<table>
<tr><th>Project Type Code</th><th>Project Type</th><th>Project Sample Description</th><th>Applicable Module Subsections</th></tr>
<tr><td colspan="4">*The project code below is referenced throughout this module to help you identify the sections relevant to your specific project type. Project Code "U" represents that the module universally applies to all applicable project types.
** New builds, additions, and major renovations must adhere to all components of the module.</td></tr>
<tr><td colspan="4">New Construction, Tenants, & Central Systems</td></tr>
<tr><td colspan="2">New Build Construction
Code: N-B or U</td><td>Ground up construction or major renovation of a facility</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="2">Major Building Renovation
Code: M-B or U</td><td>Extensive renovation including replacement of major systems and reconfiguration of spaces for a large portion of an existing facility</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="2">Central Plant & Central Systems Retrofit
Code: C-P or U</td><td>Major central plant upgrade or retrofits</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="2">HVAC System Upgrade or Retrofits
Code: HVAC or U</td><td>Replacement of major equipment or retrofit of broader system, such as air handling unit, terminal units (VAV, fan coil, FPB's)</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="2">Hotel Guest Rooms
Code: Htl or U</td><td>New build or retrofit of guest room, guest room controls, or guest room equipment</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="2">Tenant Fit-Out with Owner Involvement
Code: T-I or U</td><td>Full fit-out of systems, equipment, space configuration, and finishes for a tenant space with Owner involved retail, theater and/or F&B</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="4">Non-Applicable Projects</td></tr>
<tr><td colspan="2">Tenant Fit-Out without Owner Involvement
Code: T-NI</td><td>Full fit-out of systems, equipment, space configuration, and finishes for a tenant space without Owner involved retail, theater and/or F&B</td><td>Not Applicable</td></tr>
<tr><td colspan="2">All Other Project Types</td><td></td><td>Not Applicable</td></tr>
</table>

Other Related Sections: Energy Performance

1.0 HVAC System Performance Standards

LEEDv4.1 & GREEN MARK HIGHLIGHTS
Minimum and Optimize Energy Performance This section requires conformance with high performance energy code requirements. Adhering to the section, as well as Energy Performance and BMS Controls modules will support meeting whole building energy performance requirements and sustainability goals. LEEDv4.1 projects: It may be necessary to exceed IECC 2018 requirements to reach the required overall building energy performance. **Green Mark (for Singapore projects)** This section requires conformance with three sections of Green Mark: Part 2 - Building Energy Performance including Envelope and Roof Thermal Transfer, Air Tightness and Leakage, Tropical Façade Performance.

1.1 IECC 2018	
The baseline required performance criteria for the building HVAC systems shall be the International Energy Conservation Code (IECC) 2018. To the extent that local applicable building code is stricter or further energy performance is desired or required, the HVAC systems may exceed IECC 2018. See specific elements of HVAC system performance covered by IECC 2018 below.	
U	1.1.1 Mechanical systems and equipment serving the building heating, cooling or ventilating needs shall comply with Section C403.2 and shall comply with Sections C403.3 and C403.4 based on the equipment and systems provided 1.1.1.1 HVAC equipment shall meet the minimum efficiency requirements of Tables C403.3.2(1), C403.3.2(2), C403.3.2(3), C403.3.2(4), C403.3.2(5), C403.3.2(6), C403.3.2(7), C403.3.2(8) and C403.3.2(9) IECC 2018 C403.2-C403.4
U	1.1.2 Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.10.2, C403.10.3, and C403.10.4 1.1.2.1 Commercial refrigeration equipment shall have an energy use in kWh/day not greater than the values of Tables C403.10.1 (1) and C403.10.1(2) IECC 2018 C403.10
U	1.1.3 The following high energy performance strategies should be incorporated into the HVAC systems design, per the IECC 2018 requirements, as appropriate given the project location, HVAC configuration, building programming requirements, and energy targets outline in the LVSC Sustainable Development Standards section for Energy Performance 1.1.3.1 HVAC systems controls (section C403.4) 1.1.3.2 Hot water boiler outdoor temperature setback control (section C403.4.1.5) 1.1.3.3 Demand controlled ventilation (section C403.7.1) 1.1.3.4 Energy recovery ventilation systems (section C403.7.4) (i.e. enthalpy wheels) 1.1.3.5 Fan efficiency (section C403.8.1(2)) 1.1.3.6 Economizers (section C403.5.3) 1.1.3.7 Supply-air temperature reset controls (section C403.6.5) 1.1.3.8 Heat recovery for service water heating (section C403.9.5) IECC 2018 C403

U	1.1.4 Service water heating systems shall meet the requirements of section C404 [IECC 2018 C404]

1.2 Green Mark	
In addition to meeting IECC 2018, projects located in Singapore must assess compliance with the following sections of the Green Mark Non-Residential Buildings 2015 Standard. For Green Mark strategies requiring capital investment, lifecycle cost analysis must be utilized to determine incremental additional investment cost and estimated long term energy cost savings.	
U	1.2.1 Energy Performance, sections P.04 Air Conditioning Total System and Component Efficiency, 2.01a Air Conditioning Total System and Component Efficiency, 2.01d Receptacle Load Efficiency

1.3 HVAC System Technologies	
High performance HVAC technologies should be integrated into the HVAC systems design per the following owner goals. For strategies that exceed the minimum building code requirements to comply with IECC or other stricter performance criteria requiring capital investment, lifecycle cost analysis must be utilized to determine incremental additional investment cost, estimated operation and maintenance burden and estimated long term energy cost savings. Long term energy cost savings for larger/complex building systems and equipment will be demonstrated as part of the energy simulation executed to meet the Energy Performance section of the LVSC Sustainable Development Standards. To the extent practicable, the impact of individual upgrades shall be evaluated as well as composite building performance with all upgrades.	
U	1.3.1 Duct sizing and fittings shall be designed to have appropriate velocities to prevent noise and excess pressure drop. Pressure drop shall not exceed 0.15 in/100ft or 1140 pa/m of duct. Peak supply velocities of 800 ft/min (4 m/s) to 1000 ft/min (5 m/s) should typically be designed. Straight exhaust ducting may have peak velocities up to 1500 ft/min (7.62 m/s) if able to maintain pressure drop standards. 1.3.2 Electronically commutated (EC) type fan motors shall be specified for all fan systems. Any fans and pumps not available with EC motors are to be provided with premium efficiency induction motors. 1.3.3 Variable frequency drives shall be installed on all induction motor fans and pumps except backup systems that do not normally operate or should only operate at fixed constant speed (EC motors do not require separate variable speed drives as they accomplish variable speed with internal electronic controls). 1.3.4 Limited variable volume and variable temperature air handling systems shall be specified for air handling units serving large spaces such as pre-function corridors, hotel lobbies, retail corridors, and other spaces not equipped with variable volume terminal devices (i.e. no VAV boxes). The design objective will be to vary supply and return airflow with actual cooling or heating load to achieve significant fan energy savings. Owner routinely allows low-load fan speeds down to 50% or less with no problems related to inconsistent temperatures or high CO2 problems. 1.3.5 Cooking activity sensors such as Melink, Halton, MARVEL (or similar), shall be integrated with variable volume kitchen makeup and hood exhaust systems to control exhaust operation. Kitchens must be carefully designed to zone similar activities/schedules into dedicated makeup fans and hood exhausts to allow greatest amount of equipment to shut down when certain types of kitchen activities not occurring for greatest overall performance. For example, segregate 24-hour activities from intermittent activities such as pastry preparation. Cooking activity sensors must be commissioned to ensure proper operation. 1.3.6 Applicable plug loads including computers, copiers and scanners, plug-in lamps, guest room refrigerators, and air-cooled hotel icemakers shall be at minimum ENERGY STAR certified. Consider addressable plug strips to monitor power usage and allow remote shut down to minimize phantom power consumption. 1.3.7 The HVAC design must investigate the inclusion of advanced energy efficiency technologies and system designs to ensure high performance throughout the facility life. Examples include variable refrigerant flow systems, heat recovery chillers and/or 70°C+ high temperature heat pumps to provide simultaneous sterilized domestic hot water heating and simultaneous chilled water generation for properties with high boiler fuel costs, condensing boilers, UFAD or displacement ventilation (especially in smoking areas or areas with atriums), heat recovery for interior pool dehumidification units, and

U	advanced HVAC controls integration such as occupancy sensors and automatic setback for unoccupied spaces. 1.3.8 In regions with cooling and heating loads perform detailed evaluation of four pipe FCU coils (chilled water and space heating hot water) versus two pipe FCU coils (chilled water and electric resistance heating). Evaluation must include consideration of total capital cost of each system, annual operating cost of each system per Energy Performance Module's Energy Simulation Requirements and expected long term maintenance burden. Hot water space heating must be evaluated in conjunction with high temperature heat pumps/ energy recovery chillers, renewable hot water generation systems and/or combined heat and power systems in addition to conventional fuel burning boilers. 1.3.9 Evaluate total capital cost and operating cost of dehumidification in relevant climates. Emphasis upon incremental capital cost of heat recovery (i.e. enthalpy wheels, DX "run-around coils, heat recovery chillers) vs. annual operating cost benefit compared to simple dehumidification such as boiler hot water reheat and electric resistance reheat. 1.3.10 ADD ALT Scope: UVC disinfection technologies integrated for air sanitation on all air handling units not utilizing 100% outside air (no air recirculated) or smoking areas utilizing HEPA filters by default. UVC fixture's intensity shall be designed and modeled to achieve minimum COVID19 log 2 reduction dosage of 2,800 uW/cm2 after one year of operation. UV sanitation airflow residence time determined by expected maximum air flow velocity divided by HVAC compartment illuminated length. Minimum required intensity then determined by minimum dosage divided by minimum residence time. If necessary multiple UV emitter arrays can be utilized with cumulative dosage when too difficult to achieve required intensity in one compartment with only one compartment residence time. Preference to utilize 254 nm output low-mercury bulbs, but 222 nm output bulbs are also acceptable if intensity meets above dosage standard.

2.0 Submittals

2.1 Design Development:	
U	2.1.1 MEP Engineer Responsibility: Provide documentation demonstrating the building HVAC systems design meets the requirements as indicated in section 1.1 of this module. Utilizing reliable estimated capex information from Owner's cost consultant, develop estimated lifecycle cost analysis of all upgrades to present to Owner for approval and adjust for construction project scope accordingly 2.1.2 MEP Engineer Responsibility: Provide a summary describing the high-performance HVAC system technologies and strategies that are incorporated into the building design 2.1.3 MEP Engineer Responsibility: For projects in Singapore, provide documentation demonstrating that the building meets the Green Mark requirements for Air Conditioning Total System and Component Efficiency and Receptacle Load Efficiency

2.2 Construction Documents (100%):	
U	2.2.1 MEP Engineer Responsibility: Provide updated documentation demonstrating the building HVAC systems design meets or exceeds the requirements as indicated in section 1.1 of this module 2.2.2 MEP Engineer Responsibility: Provide an updated summary describing the high-performance HVAC system technologies and strategies that are incorporated into the building design 2.2.3 MEP Engineer Responsibility: For projects in Singapore, provide updated documentation demonstrating that the building meets the Green Mark requirements for Air Conditioning Total System and Component Efficiency and Receptacle Load Efficiency

SDS MODULE: BMS, CONTROLS, & INTEGRATION

The following module is one component of the Las Vegas Sands Corporation Sustainable Development Standards (SDS). The module outlines the owner's requirements for design, performance, execution, and submittal requirements for projects implemented in existing or new build facilities across the Las Vegas Sands Corporation portfolio. Refer to Table 1 below to confirm which sections of the Controls Integration & Energy Management module are applicable to your project.

Table 1. Controls & Integration Module Applicability Matrix

Project Type Code	Project Type	Project Sample Description	Applicable Module Subsections
*The project code below is referenced throughout this module to help you identify the sections relevant to your specific project type. Project Code "U" represents that the module universally applies to all applicable project types. ** New builds, additions, and major renovations must adhere to all components of the module.			
New Construction, Tenants, & Central Systems			
New Builds, Additions, & Major Renovations		- Ground up construction or major renovation of a facility	Must adhere to all sections
U	All projects	- This code is used for requirements that are universal for all applicable project types - Includes tenant fit-out projects	1,1,1; 1.1.2; 1.2; 1.3; 1.5; 1.6; 1.7; 1.8; 4.1.1; 4.1.2; 4.1.3; 4.2; 4.3; 4.4
Space Level Retrofits			
HVAC and Ltng	HVAC & Lighting Systems Upgrade or Retrofit	- Replacement of major equipment or retrofit of broader system, such as air handling unit, terminal units (VAV, fan coil, FPB's) - Lighting fixture and controls retrofits	1.1.3; 1.4.1
Htl	Hotel	New build or retrofit of guest room, guest room controls, or guest room equipment	3.1; 4.1.4
C	Casino	New build or retrofit of casino controls, or equipment	3.2
M	MICE	New build or retrofit of MICE controls, or equipment	3.3
Rtl	Retail	New build or retrofit of Retail controls, or equipment	3.4
K	Kitchen	New build or retrofit of Kitchen controls, or equipment	3.5
Thtr	Theater	New build or retrofit of Theater controls, or equipment	3.6
Non-Applicable Projects			
	Façade Improvements	Installation or improvement of major façade element, such as glazing.	Not Applicable
	Interior Finish Improvement	New carpet installation, painting, etc. No building systems adjustments.	Not Applicable
	FF&E Replacement	Installation or replacement of furniture, fixtures, and equipment. No building systems adjustments	Not Applicable

Other Related Sections: Commissioning; Submetering

1.0 Building Management System (BMS) Design Requirements

LEEDv4.1 & GREEN MARK HIGHLIGHTS
LEED v4.1 **The BMS, associated network, and controls are not directly addressed by LEED prerequisites or credits. However, the BAS is a critical component to a high-performance facility.** **Green Mark** **This section aligns with Green Mark: Part 4 – Smart & Healthy Building, Section 4.3a (ii), which requires that the BAS and contollers be built upon open non-proprietary protocols.**

1.1 BMS Scope	
The BMS shall be the default SCADA system for the property unless a more compelling case can be made that the electrical system power monitoring and control system (PMCS) should be configured as overall "data acquisition" system	
U	1.1.1 The following systems and spaces must be networked to the BMS with noted features: HVAC – full control and monitoring; Electrical – monitoring and non-revenue energy consumption; Lighting – on/off exterior control, separate dimmer and lighting effect controller system, faults and electrical consumption; Plumbing – DHW – full control and monitoring; Potable water – pumping and consumption; Water Features (fountains) – full control and monitoring; Irrigation – monitoring of independent control system; Elevators / Escalators / moving walkways – faults and electrical consumption; Pools / Spas – full control and monitoring; Guest room control units as noted; BOH – full control and monitoring (standalone controllers avoided); Data centers – full control and monitoring of CRACs with distributed controllers; Garage – full control (unless fire alarm control) and monitoring.
U	1.1.2 The BMS must provide network interfaces with the site electrical control system, life safety system, mission critical IT equipment, irrigation control equipment, tenant utility billing system, all utility meters via high level interface, water features, and optional equipment such as combined heat & power (CHP), thermal energy storage (TES), renewable energy and similar systems if implemented.
U	1.1.3 The BMS shall have data trending & analytics capability for all equipment and submetered. It must also have capability to export raw time series csv type files for analysis by team members. It must also have the capability to export data to SQL servers automatically.
HVAC and Ltng	1.1.4 Variable speed drives, thermal energy meters, flow meters, airflow stations, kitchen exhaust and makeup demand control system, pressure booster pump skids, garage parking management systems and similar must have a high-level network interface.
HVAC and Ltng	1.1.5 Local HVAC and lighting remote control such as distributed Crestron systems for ballrooms/ meeting spaces and VIP (Paiza) rooms must be directly linked to BMS with remote monitoring, alarm monitoring, override capability, automatic scheduling, and time synchronization via separate Delphi (or similar event sales platform) interface.

1.2 Open Protocol
The installed building management system must provide a peer-to-peer networked, standalone, distributed control system utilizing ANSI/ASHRAE Standard 135-2001 BACnet™ or other widely utilized open communication protocols accepted by owner into one open, interoperable system. Avoid proprietary systems/vendors not locally supported by robust independent system integrators. For projects in SCL BACnet is the preferred protocol to ensure successful integration with Niagara.

U	1.2.1 Avoid "Single loop" or standalone equipment controllers that have no external monitoring by BMS or supervisory control. Exceptions must be approved by the owner. 1.2.2 The BMS shall have the capabilities to read and monitor, or write and control to each of the building sub-systems using open communications protocol standards. 1.2.3 The vendor shall provide a system communications driver for building sub-systems integration to the BMS.

1.3 Haystack Nomenclature	
U	1.3.1 All equipment and instruments shall be consistently labeled per Project Haystack naming conventions. Requirement applies to all devices and equipment property wide even if not networked into BMS and PMCS.

1.4 Auto Fault Detection	
Auto Fault Detection systems must be integrated with the BMS (if possible) to provide the operations team with a single SCADA platform program to monitor. The Fault Detection and Diagnostics shall be based on rules and data developed by the National Institute of Science and Technology (NIST) or other validated formula based on rules as well as rules developed by the manufacturer's engineering resources.	
U	Features must include: 1.4.1 On-Premise fault detection (no 'cloud interface' unless expressly pre-approved by LVSC Cyber Security Department). 1.4.2 Configuration of custom rules to detect faults must be reasonably possible by local Facilities Team. 1.4.3 Fault detection shall cover all points of directly connected BMS equipment/sensors and integrated systems through network interfaces (aka 'high level interface'). 1.4.4 Standard fault detection capabilities for sensors/instruments/meters/equipment must include: Failure detection; Increasing deviation of controlled variable from setpoint as % trend and threshold deviation fault; Worsening loop tuning/stability; Inconsistent reading with system operation (e.g. SAT does not decrease with increasing CHW valve opening); Suspected sensor calibration problem; Increasing response time suggesting clogged or dirty coils; Failure to achieve setpoint after reasonable delay. 1.4.5 Detected faults shall be automatically prioritized based upon Owner adjustable criteria. Prioritized faults shall be logged and generate Maximo work orders for Facilities team. Facilities team shall be notified of critical alarms per owner criteria via alarm messages. A Fault database shall be created with Owner searchable criteria including, but not limited to: Total historical faults by piece of equipment/device by date/time/type. Data analytics shall track failure frequency of similar equipment/ device and provide warnings upon increasing failure frequency.

1.5 Graphics	
U	1.5.1 BMS/BAS User workstation graphics must have actual property architectural background renderings and overall system process diagrams with active visual status indication of all controlled and monitored equipment. 1.5.2 Overall building areas shall also have consolidated graphic page sets for: Hotel; Casino; Meeting Rooms; Exhibition Halls; Retail; Theaters; Garages; and Back-of-House offices. 1.5.3 All graphics pages must have embedded navigation tools to directly move from process view to individual equipment drill down graphics and further into component information and control point settings. 1.5.4 The user must be able to navigate from system and equipment views directly to architectural backgrounds of areas served and current space sensor information. 1.5.5 The graphics interface must indicate the area served by major equipment such as AHUs. Similarly, terminal units must be tagged or otherwise identify which units serve them.

U	1.5.6 The location of control devices such as CO2, temperature, and building static pressure sensors must be identified on building floor plans included in the graphics package. All sensors must be labelled and indicate the equipment to which they are associated. 1.5.7 Simple point-and-click user interfaces that document the as-built condition of all interdependent equipment must be provided. Interdependent system equipment shall have navigation buttons to move directly between equipment screens with system process diagram visible at all times. 1.5.8 Overall system process flow diagrams with active visual status and current operating setpoint information with drill down capability to component equipment detailed operating information must be provided. 1.5.9 Equipment feedback units must align with the control signal units to improve ease of use for facility engineering teams. For example, if the control signal to a fan array is %, the equipment feedback unit should be adjusted to match as %. 1.5.10 A complete library of building sub-system equipment graphics shall be included. The Facilities team shall have the capability to edit system graphics, create graphics, and integrate graphics into the system. 1.5.11 Dashboards for analytics and reporting shall be customizable with content defined by the owner. 1.5.12 Users shall have administrator-defined access privileges. Authorized operators with administrator rights shall be able to add and deny individual operator's accessible functions based on equipment or geographic location.

1.6 Network Performance	
U	1.6.1 Network performance regarding system scan and update time periods must be conservatively established to allow 40% future expansion of connected I/O points combined with 20% of I/O points in data trending (at five second interval frequency) over one month period with acceptable resulting performance. 1.6.2 Change of Value (COV) settings must be appropriately set by type of point and criticality of system (i.e. tenant metering need only be updated at consumption increment yielding no more than once per hour COV increment whereas critical chilled water supply temp should be updated every 0.2 degree deviation for tight control). The change of value report for individual points must be set to facilitate proper operation by the end user, but also to minimize unnecessary consumption of network bandwidth. 1.6.3 Virtualization of point servers on robust industrial grade servers in central data center environment strongly preferred over distributed, less robust PC type point servers. 1.6.4 Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.

1.7 Execution Requirements	
U	1.7.1 An independent commissioning agent or qualified members of the project team must verify functionality of the BMS systems and satisfaction of performance requirements. See the Commissioning section of the Las Vegas Sands Development Standards for more information on when an independent commissioning agent is required. 1.7.1.1 Verify the proper operation, placement, calibration and installation of all sensors and actuators associated with all major systems and equipment such as central plant equipment, PAU, and AHU. 1.7.1.2 Verify the proper operation, placement, calibration and installation of all sensors and actuators associated with a sample of terminal units such as VAV boxes and Fan Coil Units. 1.7.1.3 Verify proper PID and other control loop response and stability in driving toward setpoints with improving precision without overshooting or never reaching setpoints. Verify and record actual: Deadband in controlled setpoints; Deviation from Setpoint trends confirming proper loop response; Alarms programmed for every analog input, analog output, digital input and digital output. Alarms must include, but not be limited to: detect operation outside allowed parameters, instrument/device failure and loss of signal.

U	1.7.1.4 Verify proper set up and functionality of the user interface and graphics. Identify deficiencies that impact the facility team to properly view and control building systems during operations. 1.7.2 The contractor must provide comprehensive operator training to the facilities maintenance team to facilitate ongoing maintenance and operations of the controls system. This training shall include unlimited telephone technical support to answer user questions, within warranty period, and formal, on-site and off-site training program for technical and administrative operating personal.

2.0 Power Management Control System (PMCS)

2.1 PMCS Requirements	
U	2.1.1 PMCS to utilize distributed PLCs at substations/ switchgear of 400V or higher voltages interconnected with central monitoring and control workstation on a dedicated, UPS backed fiber backbone. 2.1.2 PMCS workstation shall have overall, one-line, and discrete substation graphical representations including the status of all breakers, current kW demand, totalized kWh, etc. 2.1.3 All interconnected substation/ switchgear breakers must act as submeters for demand kW and totalized kWh consumption and populate a searchable database interconnected with BMS with password protected, read only network interface. BMS shall retrieve all consumption information from PMCS. Monthly total kWh consumption shall be automatically trended and written into BMS for all breakers on both a 'per breaker' amount and aggregate of breakers serving distinct areas such as hotel tower. 2.1.4 Distributed PLCs shall be interconnected with relays and breakers, configured and programmed to detect electrical faults and automatically refeed loads when possible in dual fed "main" – "tie" – "main configuration. 2.1.5 PMCS shall provide priority alarms upon: Loss of any feeder, undervoltage, overvoltage, underfrequency, over-frequency, or tripped breaker; Automatic transfer switch operation; UPS operation after power loss or fault; and Emergency generator operation with status of paralleled generators.

3.0 Program Area Controls Requirements

3.1 Hotel	
Hotel Guest Rooms: Install controls that reduce energy consumption for HVAC, lighting, plug loads, and curtain controls in the hotel rooms when guests are not present	
Htl	3.1.1 Controls: 3.1.1.1 Thermostats utilized in room control units must be compatible with preferred fan coil units with multiple speed ECM fan motors and fully modulating water coil control valves. 3.1.1.2 Room control unit should be part of an overall suite technology system which allows for maximum energy conservation by switching off lighting and unnecessary plug loads, closing curtains to reduce solar heat gain and thermal losses through glazing, and resetting thermostat setpoint when rooms are unoccupied. 3.1.1.3 These controls must be capable of interfacing with multiple software programs within specific room environment and should utilize the occupancy and door sensors. To minimize extent of a network security breach, every room must operate as an island such that a hostile compromise of a specific room's controls could not extend to any other rooms. Such a configuration may prevent automatic communication of room equipment fault information to Facilities and/or Front Desk staff. Control system interfaces for lighting, temperature and drapery are limited to fixed control panels within individual rooms – wireless interfaces for guest control are not allowed.

Htl	3.1.1.4 Each guest room should have an individual digital thermostat control with three fan settings for guest's comfort. 3.1.1.5 Thermostats should have an ECO mode for easy selection of more environmentally preferable (deeper reset) temperature settings. 3.1.1.6 Thermostats should be capable of being programmed for multiple modes such as occupied, unoccupied, occupied-vacant, unoccupied-vacant. 3.1.1.7 All FCUs and AHUs shall have multiple speed ECM fan motors and fully modulating water coil control valves.
Htl	3.1.2 Occupancy Sensor: 3.1.2.1 Sensors need to be reliable, have proper room coverage (maximum of 10 feet spacing), have programmable timers, and coordinated with single room control unit system (preferred) or ability to work with multiple systems such as HVAC and lighting to maximize energy savings. 3.1.2.2 Consider compatibility with the door lock system so that all systems can work together. 3.1.2.3 Sensors should be equipped with switchable LED light to assist with verifying normal sensor operation. When in normal operation mode, LED light deactivated to not attract guest attention.
Htl	3.1.3 Balcony door sensors: In hotel rooms with balconies, install sensors to shut down the HVAC after the balcony door stays open for longer than 2 minutes. 3.1.3.1 The energy management system should be designed so that the room fan coil will shut down the cooling or heating once a door sensor is activated by the opening of the balcony door. 3.1.3.2 If the room is using a compressor HVAC system, the entire unit should shut down upon opening of a balcony door. 3.1.3.3 Once the system detects the door has been closed the energy management system will return to normal operation and settings.
Htl	3.1.4 Master Switch or Key Card Repository: 3.1.4.1 All rooms should have a key card repository switch (preferred) or master light switch located just inside the entry door. 3.1.4.2 Devices controlled by the key card repository/master switch should include all hardwired lighting fixtures, including but not limited to: Entry light; Bathroom ceiling lights; Bathroom wall sconces; Bedroom ceiling lights; Bedroom wall sconces; Wardrobe and closet lights; Living room ceiling lights; Living room wall sconces. 3.1.4.3 Electrical devices that should not be controlled by the key card repository/master switch include: The HVAC system; Room Control Unit, minibar monitoring and other technology; Any life safety or emergency devices such as smoke detectors; All electrical outlets for clock radio, minibar refrigerator and adjacent to bed(s). Exception is special ADA rooms where no plugs should be switched; Step lights.
Htl	3.1.5 Execution: 3.1.5.1 Perform a detailed evaluation of potential energy cost savings with energy simulation program if required under the Energy Performance module. 3.1.5.2 Evaluate potential Room Control Units and their ability to provide features and network interfaces. 3.1.5.3 Ensure new or existing devices are compatible with selected Room Control Unit. Perform due diligence evaluation of proposed product(s). Ensure required communication drivers are provided by vendor. 3.1.5.4 Develop estimated energy savings and associated costs to implement with various options such as switched electrical outlets, switched lighting, automatic curtain closure, etc.

3.2 Casino	
C	3.2.1 The ventilation and exhaust systems serving casino smoking areas must be balanced with adjacent spaces such that smoking areas are at negative pressure to induce transfer air from adjacent spaces into the smoking area with ambient smoke containment and exhaust. 3.2.1.1 Due to 24-hour occupancy and typical enthalpy wheel heat recovery, ensure all applicable sequences such as airside optimization/ wheel operation and wheel bypass/ limited variable volume in constant volume type equipment maintain negative pressure for the casino smoking areas and efficiently maximize ventilation with wheels and economizer operation without increasing energy use. When in full mechanical cooling and when space heating or reheating required the ventilation shall satisfy applicable ASHRAE 62.1 demand ventilation criteria. 3.2.2 Systems must be configured with: 3.2.2.1 Fully modulating control dampers, temperature sensors within center one third of duct/pipe cross-sectional area, fully modulating coil valves with independent positioner valve feedback (display setpoint vs. command), off-coil temp sensors in-between pre-heat, cooling and reheat coils (if present). 3.2.2.2 When enthalpy wheel equipped: variable speed wheel and temp/humidity sensors upstream and downstream of wheel to calculate benefit or penalty of wheel operation and control accordingly. 3.2.2.3 CO2 sensors shall be placed in served spaces and ventilation air volumes controlled to adjustable max. CO2 ppm setpoint. 3.2.2.4 Supply and return air volumes and fan speeds shall modulate in direct relation to cooling or heating load from operator adjustable minimum fan speed % to maximum. Terminal devices such as VAV boxes are not required for mass gaming floor areas for variable volume operation. 3.2.3 All FCUs and AHUs shall have multiple speed ECM fan motors and fully modulating water coil control valves.

3.3 MICE	
M	3.3.1 Meeting rooms must be served ventilation/makeup air from a DOAS type PAU unit 3.3.2 VAV boxes shall control ventilation flow rates based on local breathing zone CO2 levels measured by local sensors in the meeting room space and per ASHRAE 62.1 – 2010. 3.3.2 Meeting rooms will be served by FCUs for local temperature and maximum humidity control with multiple speed ECM fan motors and fully modulating water coil control valves. 3.3.3 When meeting room CO2 levels fall below the setpoint, ventilation flows will be adjusted to the minimum flow per ASHRAE 62.1 – 2010. 3.3.4 VAV boxes to close 100% when the meeting space is unoccupied. 3.3.5 Pre-Function areas to monitor CO2 during occupied periods and reset to ASHRAE 62.1 or other applicable building code minimum DCV ventilation. 3.3.6 All FCUs and AHUs shall have multiple speed ECM fan motors and fully modulating water coil control valves.

3.4 Retail	
Rtl	3.4.1 Provide ventilation air to each retail tenant via VAV box based upon CO2 or fixed flowrate when occupied. 3.4.1.1 If ventilation is adjusted based on measured CO2 levels, VAV boxes shall reference CO2 levels measured by local sensors in the retail space and per ASHRAE 62.1 – 2010. 3.4.2 When retail space CO2 levels fall below the setpoint, ventilation flows will be adjusted to the minimum flow per ASHRAE 62.1 – 2010. 3.4.3 All FCUs and AHUs shall have multiple speed ECM fan motors and fully modulating water coil control valves.

3.5 Kitchen	
K	3.5.1 Provide ventilation air to each retail tenant based upon CO2 or fixed flowrate when occupied. 3.4.1.1 If ventilation is adjusted based on measured CO2 levels, VAV boxes shall reference CO2 levels measured by local sensors in the space per ASHRAE 62.1 – 2010. 3.5.2 When space CO2 levels fall below the setpoint, ventilation flows will be adjusted to the minimum flow per ASHRAE 62.1 – 2010. 3.5.3 All FCUs and AHUs shall have multiple speed ECM fan motors and fully modulating water coil control valves.

3.6 Theater	
Thtr	3.6.1 Theaters must be served ventilation/makeup air based on local breathing zone CO2 levels measured by local sensors in the space per ASHRAE 62.1 – 2010. 3.6.2 Theater spaces served by FCUs for local temperature and maximum humidity control will have multiple speed ECM fan motors and fully modulating water coil control valves. 3.6.3 When space CO2 levels fall below the setpoint, ventilation flows will be adjusted to the minimum flow per ASHRAE 62.1 – 2010. 3.6.4 VAV boxes to close 100% when the space is unoccupied. 3.6.5 Pre-Function areas to monitor CO2 during occupied periods and reset to ASHRAE 62.1 or other applicable building code minimum DCV ventilation. 3.6.6 All FCUs and AHUs shall have multiple speed ECM fan motors and fully modulating water coil control valves.

4.0 Submittal Requirements

4.1 Design Development: Architect / Engineer of Record Responsibility	
U	4.1.1 Submit a preliminary inventory of all equipment and systems to be directly controlled by BMS and additional equipment and systems to be monitored via network interface. Identify any equipment/system proposed to NOT be monitored by BMS or networked interface system.
U	4.1.2 Provide documentation demonstrating that the proposed systems comply with the Open Protocol and Integration Requirements.
U	4.1.3 Demonstrate BMS compatibility with Las Vegas Sands' central property utility monitoring dashboard system.
Htl	4.1.4 Submit estimated energy savings Hotel Guest Unit control system, if applicable.

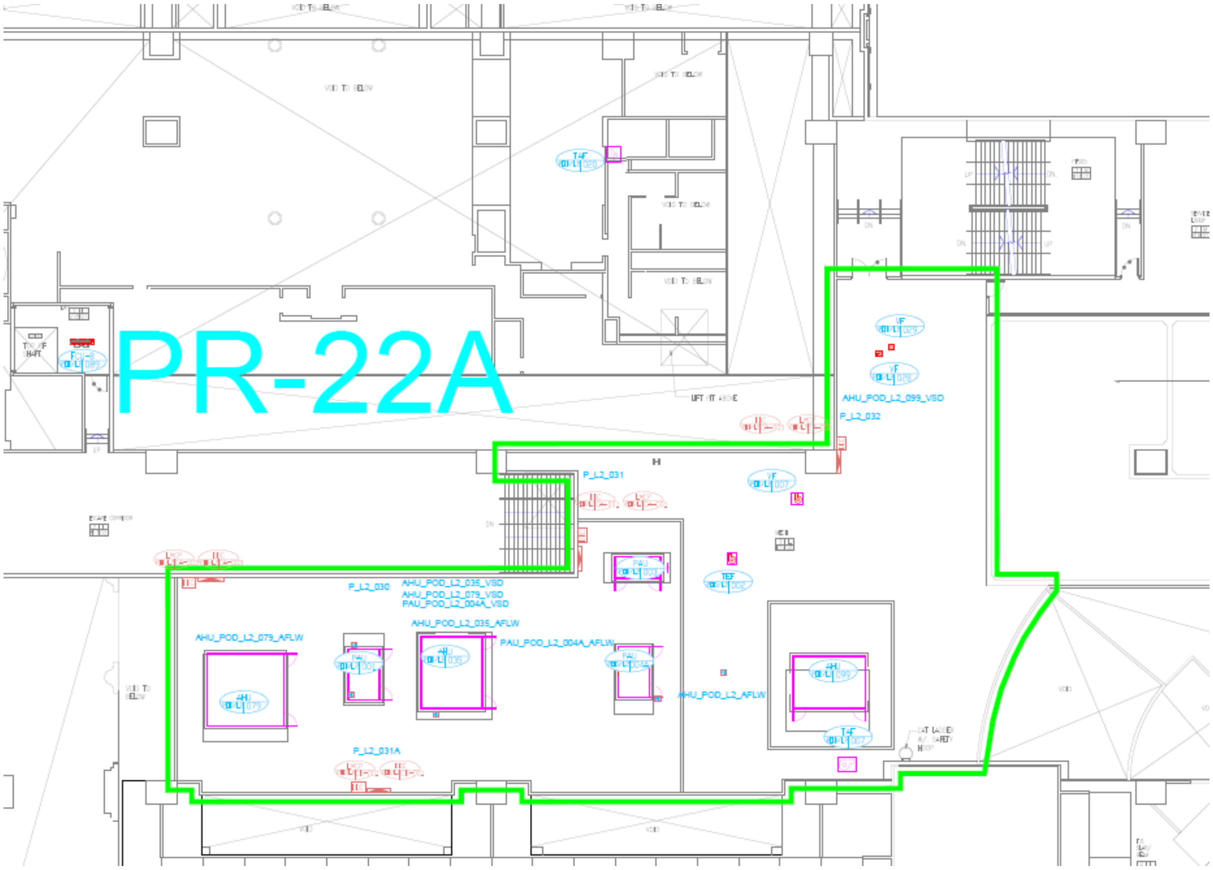
4.2 Construction Documents 60% Design Progress:	
U	4.2.1 Architect / Engineer of Record Responsibility: Submit a final inventory of all equipment and systems to be directly controlled by BMS and additional equipment and systems to be monitored via network interface. Identify any equipment/system proposed to NOT be monitored by BMS or networked interface system. 4.2.2 Controls Contractor Responsibility: Provide a comprehensive controls submittal package that includes the following details for all panels, devices, systems, equipment, etc., included on the project. 4.2.2.1 Controls Legend & Abbreviation sheet applicable to all included submitted drawings 4.2.2.2 Control System Architecture / Topology Diagrams 4.2.2.3 Control Panel and Device wiring and termination details, specifications, etc. 4.2.2.4 Control Valve schedules (incl. part #'s, tags, settings, etc.) 4.2.2.5 Automatic Damper schedules (incl. part #'s, tags, settings, etc.) 4.2.2.6 Air Flow Measuring Station schedules (incl. part #'s, tags, settings, etc.) 4.2.2.7 VAV Box schedules (incl. part #'s, tags, settings, etc.) 4.2.2.8 Equipment cut sheets for all field control system devices and components 4.2.2.9 For ALL HVAC Systems (Airside & Waterside), and Equipment: 4.2.2.9.1 Control System Diagram layout (incl. related systems, eg: AHU w/ VAV should include the VAV terminal devices on the same diagram) 4.2.2.9.2 Control Wiring diagram 4.2.2.9.3 System Sequence of Operation 4.2.2.9.4 Component Control Diagrams (eg: valve actuator, VAV box controller) 4.2.2.10 Product Bill of Materials 4.2.2.11 Manufacturer Control System Component/Equipment product submittal data cut sheets (can be copy of what would be in O&M)

4.3 Construction Documents 100% Design for Construction: Contractor Responsibility (shop drawings and/or as-built)	
U	4.3.1 Submit the sequence of operations and coordinated equipment/system capabilities for all energy and water efficiency features implemented through the BMS.
U	4.3.2 Submit sample cut sheets of proposed control and instrumentation devices.
U	4.3.3 Provide sample BMS workstation graphics, workstation trending capabilities, and sample reports.

4.4 Construction: Contractor As-Built Responsibility	
U	4.4.1 Submit documentation confirming proper installation, function, and communication of networked systems. 4.4.2 At end of commissioning provide to owner: Electronic file copies of all controller final programming; Necessary software and licenses to view and modify controller programming at DDC controller and SCADA levels; Electronic copies of any SCADA programming and graphics files; As-built bus topology; Documentation of current firmware versions and where installed; Change Control Document for DDC and SCADA programming and graphics files. Refer attached samples. 4.4.3 Complete documentation of the as-built controls system must be provided to the owner. The content must include the system hardware and network configurations as well as electronic copies of actual software and sequence programming. In addition, the documentation must include sensor cut sheets, calibration requirements, wiring diagrams, and the updated sequences of operations associated with the controls system and equipment. The documentation must be clearly indexed and easy to navigate. 4.4.4 Provide floor plans highlighting installed space temperature sensors, CO2 sensors and CO sensors to facilitate ongoing maintenance of these devices during operations.

Appendix A: Sample As-Built Submittal Documentation

Appendix A includes sample documentation to be included in the submittal package to the owner. The following samples provide an indication of the type of information and level of detail required. The samples are not comprehensive of all information required. Refer to Section 4.0 Submittal Requirements for the full list of required documentation.



Appendix B: Recommended Control Devices

Appendix B outlines recommended control sensors and devices for typical building applications. Design and construction teams may select alternative devices and sensors if the alternatives are shown to meet the performance specifications of the recommended equipment below.

Central Plants & Major Systems				
Device Type	Description	Typical Location	Recommended Manufacturer	Recommended Model Number
Air Side Humidity & Temp Combined Sensor	Outside (ambient) Temp Sensor [24Vdc]	Weather Station	VAISALA	HMD60YO
	Outside (ambient) Humid Sensor [24Vdc]	Weather Station	VAISALA	HMD60YO
	Duct Temperature and Humidity Sensor Combined Weatherproof [24VAC]	Supply/return air ducts	HONEYWELL	HRH200W02K
(Air Side) Temp Sensor	Duct Insertion Temp. Sensor [STANDARD]	Supply/return air ducts	HONEYWELL	HTE200B20E2
	Duct Insertion Temp. Sensor [WEATHERPROOF]	Supply/return air ducts	HONEYWELL	HTE200BW20E2
(Air Side) Humid Sensor	Duct Type Humidity Sensor [STANDARD] [24Vdc]	Supply/return air ducts	HONEYWELL	HRH200A02
	Duct Type Humidity Sensor [WEATHERPROOF] [24Vdc]	Supply/return air ducts	HONEYWELL	HRH200W02
CO2 / CO Sensor	Duct Insertion CO2 Sensor [24Vac]		VAISALA	GMD20
Smoke Detector	Duct Smoke Detector	Return Air Ducts	HONEYWELL	D4240 + DST10
(Air or Water Side) Switch	Differential Pressure Switch [IF PRE-FILTER(G4)+MAIM FILTER (F9)] FOR BOTH	Main Filters / All Fan run status	HONEYWELL	DPS Series
	Water Flow Switch		SETRA	FS580
	Differential Pressure Switch [Fire situations] DPS IN METAL CASE FOR FIRE RELATED SYSTEM	Stair case FANs status and Fire protection.	HONEYWELL	AP5017-30
Air Flow Devices	Thermal Dispersion Air Flow Device [FAN INLET] [24Vac]	Where pitot array not feasible (plug fan inlet)	EBTRON	GTC116F
	Pitot Array Air Flow Devices [DCUTS] [NOT USED NOW]	Supply/Return Air Ducts	EBTRON	GTC116PC
Actuator	Modulating Spring Return Damper Motor [24Vac]	General as required	HONEYWELL	CS7520A2007
	Open/Close Spring Return Damper Motor [230Vac]	General as required	HONEYWELL	CS4120A1029

	Open/Close Spring Return Fire Smoke Damper Motor [24Vac]	Duct Mounted Zone/Riser Shafts.	HONEYWELL	S2024-F-SW2
(Water Side) Temp Sensor	Pipe Insertion Temp Sensor [STANDARD] (4")	Chilled/Heating & Domestic Hot Water Systems	HONEYWELL	HTE200C20B2A
	Pipe Insertion Temp Sensor [WEATHER PROOF] (4")	Chilled/Heating & Domestic Hot Water Systems	HONEYWELL	HTE200CW20B2A
	Pipe Insertion Temp Sensor [WEATHERPROOF] (2")		HONEYWELL	HTE200CW20A2A
(Water Side) Differential Pressure Sensor or Pressure Sensor	Water Systems Differential Pressure Sensor/Transmitter [24Vdc]	Heating & Cooling System Flow Control	SETRA	2301-100PD-2F-11-B-C
	Water Systems Pressure Sensor/Transmitter [24Vdc]	Domestic Hot & Cold Water System Control	SETRA	2091-250PG-2M-11-02-P
Controller	Direct Digital Controller for Larger Systems [24Vac]	PLANT ROOMS	HONEYWELL	CPO-PC-6A
General Commercial Areas				
Device Type	Description	Typical Location	Recommended Manufacturer	Recommended Model Number
(Air Side) Humid&Temp Combined Sensor	Ceiling or Wall Mounted Humid&Temp Sensor Combined [24Vac]	General	HONEYWELL	HRH100B02K
	Room Temperature and Humidity Sensor Combined [24Vac]	GENERAL	HONEYWELL	HRH100B02K
(Air Side) Temp Sensor	Capillary Averaging Temp Sensor	AHU/PAU with cooling/heating	HONEYWELL	HTE200FDC20D
	Wall Mounted Temp Sensor	General	HONEYWELL	HTE200AD20
	Ceiling Mounted Temp Sensor	Areas with fold back partitions	HONEYWELL	HTE200AD20
(Air Side) Humid Sensor	Ceiling or Wall Mounted Humid Sensor [24Vdc]	Areas with fold back partitions	HONEYWELL	HRH100B02
CO2 / CO Sensor	Wall Mounted CO2 Sensor [24Vac]	General	VAISALA	GMW21
	Wall Mounted CO Sensor [24Vac]	Casino	Honeywell	GD250W4NB
(Air Side) Differential Pressure Sensor or Pressure Sensor	Duct Static Pressure Sensor/Transmit [range: 0 to 250pa] [24Vac]	VAV & CAV Air Systems	SETRA	2671-250-LD-11-G1-H-D
	Duct Static Pressure Sensor/Transmit [range: 0 to 1000pa] [24Vac]	VAV & CAV Air Systems	SETRA	2671-10C-LD-11-G1-H-D
	Duct Static Pressure Sensor/Transmit [range: 0 to 500pa] [24Vac]	AHU/PAU Pre Filters	SETRA	2671-500-LD-11-G1-H-D
	Low Pressure Differential Press	Paiza/Casino to Corridor	SETRA	2671-025-LD-11-G1-H-D

	Sensor/Transmitter (0-10Pasc?) [range: 0 to 25pa] [24Vac]			
	Staircase Differential Pressure Sensor/Transmitter (50Pasc set point) [range: 0 to 50pa] [24Vac]	Stairwell Pressurization	SETRA	2671-050-LD-11-G1-H-D
	Staircase Differential Pressure Sensor/Transmitter (50Pasc set point) [range: 0 to 100pa] [24Vac]	Paiza/Casino to Corridor	SETRA	2671-100-LD-11-G1-H-D
	Pre-Filter Differential Pressure Sensor [IF PRE-FILTER(F9)+MAIM FILTER (H13 HEPA)] FOR PRE-FILTER [range: 0 to 500pa] [24Vac]	AHU/PAU Pre-filters	SETRA	2671-500-LD-11-G1-H-D
Wall Mounted Thermostats	Room Wall Thermostat / LCD Controller- For FCU and VAV control- Wall Mounted [24Vac]	Common office/area FCU Control and VAV units.	HONEYWELL	CP-WM
	Wall Thermostat with Display [24Vac]	FCU single / group control	HONEYWELL	CP-WM-FCU
	Wall Thermostat with Display [24Vac]	FCU single / group control	Crestron	CHV-TSTAT-FCU-PIR-10
	VAV control- Wall Mounted [24Vac]		HONEYWELL	CP-WM-VAV
Controller	Fan Coil DDC Controller [24Vac]	FCU DDC	HONEYWELL	CP-SPC
	Direct Digital Controller for Smaller Point [24Vac]		HONEYWELL	CP-IPC
	Direct Digital Controller for VAV [24Vac]		HONEYWELL	CP-VAV
Motion Sensor	Motion Sensor		HONEYWELL	DT-7550C

End of BMS, Controls & Integration Module

SDS MODULE: COMMISSIONING

The following module is one component of the Las Vegas Sands Corporation Sustainable Development Standards (SDS). The module outlines the owner's requirements for design, performance, execution, and submittal requirements for building systems projects implemented in existing or new build facilities across the Las Vegas Sands Corporation portfolio.

The intent of the module is to support the design, construction, and operation of a project and verify that it meets the owner's project requirements for precise operation, minimal energy and water use, indoor environmental quality, and durability. Commissioning is standard practice for Las Vegas Sands Corporation properties and can significantly reduce repairs, change orders, energy costs, and maintenance and operation costs. Commissioning requirements for various types of projects are detailed in the sections below.

Table 1. Commissioning Module Applicability Matrix

Project Type Tag	Project Type	Sample Scope	Commissioning Level
*Determine the level of commissioning required for your project based on the project's type and complexity. The project code below is referenced throughout this module to help you identify all the sections relevant to your specific project type. L1 = Level 1, L2 = Level 2, L3 = Level 3			
New Construction, Major Renovations, Tenants, & Central Systems			
L3	Sophisticated Façade Improvements	Installation or improvement of sophisticated façade elements, such as electrochromic windows and active curtain walls	Level 3
	Controls System Retrofit	Controls systems updates, retrofits, and newly added systems	
	F&B Tenant Fit-Out	Full fit-out of systems, equipment, space configuration, and finishes for a tenant space with Owner involved retail, theater and/or F&B	
	Central Plant Retrofit	Major central plant upgrade or retrofit	
	Major Building Renovation	Extensive renovation including replacement of major systems and reconfiguration of spaces for a large portion of an existing facility	
	New Build Construction	Ground up construction of a new facility	
Space Level Retrofits			
L2	Space Renovation	Complete retrofit of a meeting room, hotel guest room, etc., and building system infrastructure changes associated with the retrofit	Level 2
	HVAC Systems Upgrade or Retrofit	Replacement of major equipment or retrofit of broader system, such as air handling unit, terminal units (VAV, fan coil, FPB's)	
	Lighting Systems Upgrade or Retrofit	Comprehensive lighting fixture and controls retrofits	
Minor Equipment & System Component Upgrades			
L1	Equipment Replacement	Installation of non-critical basic equipment with standalone controls	Level 1
	Equipment Controller Upgrade	Installation or upgrade of control device for standalone equipment	

L1	System Component Upgrade	Replacement of components within a broader system, such as dampers, valves and instruments.	
Non-Applicable Projects			
	F&B Tenant Fit-Out	Full fit-out of systems, equipment, space configuration, and finishes for a tenant space without Owner involved retail, theater and/or F&B	Not Applicable
	Interior Finish Improvement	New carpet installation, painting, etc. No building systems adjustments.	Not Applicable
	FF&E Replacement	Installation or replacement of furniture, fixtures, and equipment. No building systems adjustments.	Not Applicable
	Miscellaneous	No material modifications or adjustments made to building energy or water consuming systems.	Not Applicable

1.0 Commissioning Process Requirements

LEEDv4.1 & GREEN MARK HIGHLIGHTS
LEED v4.1 **The requirements outlined in this module for Commissioning Level 3 align with the LEED-BD+C v4.1 prerequisite for Fundamental Commissioning & Verification** **Green Mark** **The technical guidelines for Green Mark Non-Residential Buildings 2015 do not directly address commissioning.**

1.1 Commissioning (Cx) Lead		
The commissioning lead must be selected per the commissioning level of the project as established in Table 1.		
Commissioning Level & Project Type Tag	*Commissioning (Cx) Lead Requirement*	*Commissioning Team Requirement*
L1	May be a qualified member of the LVSC Facilities Team familiar with the design and installation of the system(s) included in the project scope.	▪ Project Owner ▪ Commissioning Lead ▪ Sustainability/Development Team ▪ Building Engineering/Operations Team ▪ Contractor(s)
L2	Should be an individual certified to lead the commissioning process; may be an employee of the design or construction teams.	▪ Project Owner ▪ Commissioning Lead ▪ Sustainability/Development Team ▪ Building Engineering/Operations Team ▪ A/E Designers ▪ Contractors
L3	Should be an individual certified to lead the commissioning process, with documented experience on at least two projects of similar scope; shall be independent of the design or construction teams	▪ Project Owner ▪ Commissioning Lead ▪ Sustainability/Development Team ▪ Building Engineering/Operations Team ▪ A/E Designers ▪ General Contractor ▪ MEP and Controls Subcontractors

*On any project pursuing the LEED Enhanced Commissioning credit, the Cx Lead may not be an employee of the design or construction firm nor a subcontractor of the construction firm.

1.2 Required Commissioning Tasks

Required commissioning tasks must be performed per the commissioning level of the project as established in Table 1

Phase	L1 Commissioning	Responsible Party	L2 Commissioning	Responsible Party	L3 Commissioning	Responsible Party
Predesign	'	-	-	-	Designate Cx Lead	Owner
	'	-	-	-	Develop OPR	Owner
	'	-	-	-	Develop BOD	Design Team
	-	-	-	-	Review OPR and BOD	Cx Lead
Design Development	-	-	Designate Cx Lead	Owner	Develop and implement Cx Plan	Cx Lead
	-	-	Develop and implement Cx Plan	Cx Lead	Incorporate Cx requirements into Construction Documents	Cx Lead, Design Team
	-	-	Conduct Cx design reviews	Cx Lead	Conduct Cx design reviews	Cx Lead
Construction / Installation	Review equipment submittals and O&M manuals	Cx Lead	Conduct Cx submittal reviews	Cx Lead	Conduct Cx submittal reviews	Cx Lead
	Develop/update installation checklists and functional tests	Cx Lead	Site visits to assess installation progress.	Cx Lead	Site visits to assess installation progress.	Cx Lead
	Verify equipment installation and performance	Cx Lead, Operations Team	Develop/update installation checklists and functional testing	Cx Lead	Develop/update installation checklists and functional testing	Cx Lead
	Verify operator and occupant training	Cx Lead, Manufacturer Rep	Verify equipment installation and performance	Cx Lead, Operations Team	Verify equipment installation and performance with detailed trended performance Confirm adequate alarms with proper thresholds for expected operating ranges	Cx Lead, Construction Team
	Update CFR and O&M Plan, System Manual	Cx Lead	Verify operator and occupant training	Cx Lead, Manufacturer Rep	Verify operator and occupant training delivery and effectiveness. Prepare CFR and O&M Plan	Cx Lead
	-	-	Update CFR and O&M Plan, System Manual	Cx Lead	Develop Systems Manual	Cx Lead
	-	-	Prepare Cx Final Report	Cx Lead	Develop Ongoing Commissioning Plan and Fault Detection setup.	Cx Lead
	-	-	-	-	Prepare Cx Final Report with As-Built documentation and TAB	Cx Lead
Turnover / Occupancy	-	-	-	-	Review Fault Detection reports monthly with Operations Team for first 12 months. Review detailed system operations within 10 months of substantial completion	Cx Lead, Operations Team
	-	-	-	-	Perform Fault Detection and ongoing commissioning	Operations Team

1.3 Commissioning Level 3 Detailed Scope of Work	
The scope of work for Level 3 commissioning must comply with LEED-BD+C v4.1 prerequisite Fundamental Commissioning and Verification	
L3	1.3.1 The project Owner will designate an individual as the Commissioning Authority (CxA) to lead, review, and oversee the execution of commissioning process activities 1.3.1.1 The CxA must be involved in the project prior to the completion of the design phase 1.3.1.2 To maximize value to the project, the CxA should be involved as early as possible, preferably during predesign
L3	1.3.2 The project Owner will document the Owner's Project Requirements (OPR) 1.3.2.2 The CxA may provide input and assist in the development of the OPR
L3	1.3.3 The Design Team will develop the Basis of Design (BOD)
L3	1.3.4 The CxA will review the OPR for completeness and the BOD to verify that the project design will achieve the owner's expectations 1.3.4.1 The Owner and Design Team shall be responsible for updating their respective documents should the project requirements and/or design change
L3	1.3.5 The CxA shall develop Commissioning Requirements for the project and the Design Team shall incorporate these requirements into the construction documents
L3	1.3.6 The CxA shall develop a Commissioning Plan and identify the Commissioning Team; the Commissioning Team shall implement the Commissioning Plan
L3	1.3.7 The CxA shall conduct one commissioning design review of design documents at end of Design Development, at 50% Contract Documents stage and 90% Contract Documents stage plus a review and backcheck of comments in the for bid and for construction submissions. CxA focus includes, but not limited to: sequences of operation, sensors/ instruments/ meters/ devices/ SCADA and PMCS architecture, etc.
L3	1.3.8 The CxA shall review contractor submittals applicable to systems being commissioned for compliance with the OPR, BOD and for bid/construction documents. Submittal reviews shall be concurrent with Architect and Engineer reviews. Submittal reviews shall be submitted to the Design Team and Owner.
L3	1.3.9 The CxA shall develop prefunctional checklists and functional performance tests based on approved submittals,
L3	1.3.10 The CxA shall verify equipment installation by reviewing completed prefunctional checklists and conducting periodic site visits during construction
L3	1.3.11 The CxA shall verify system performance by directing the execution of functional performance tests. Trended performance for minimum 24 hour period shall be reviewed by CxA to verify proper and efficient operation. Systems such as chiller and boiler plants subject to 7 day trending to be reviewed by CxA. Confirm adequate alarms set up with proper thresholds for expected operating ranges.
L3	1.3.12 The CxA shall develop a Systems Manual including summaries of as programmed sequences of operation to provide the Operations Team with information necessary to understand and optimally operate the commissioned systems
L3	1.3.13 The CxA shall verify the delivery and effectiveness of operator and occupant training 1.3.13.1 The requirements shall be outlined in the OPR 1.3.13.2 The shall be provided by qualified members of the Construction Team and/or equipment manufacturer representatives
L3	1.3.14 The CxA shall develop an Ongoing Commissioning Plan and Fault Detection setup (if utilized) tightly coordinated with as programmed sequences to provide the Operations Team with protocols and automatic defect feedback (if utilized) to continually verify the performance of the commissioned systems
L3	1.3.15 The CxA shall compile a summary Commissioning Report with as-built information and TAB and submit to the Owner and Operations Team.
L3	1.3.16 The CxA shall be involved in reviewing Fault Detection reports monthly with the Operations Team and the detailed operation of the commissioned systems with the Operations Team within 10 months of substantial completion 1.3.16.1 The review shall include a plan for resolving any outstanding commissioning-related issues

2.0 Commissioning Submittal Requirements

2.1 Submittal Requirements	
Required submittals must be provided per the commissioning level of the project as established in Table 1. Projects pursuing LEED Certification shall adhere to the same required submittals list outlined for Level 3 Commissioning.	
Commissioning Level and Project Type Tag	*Required Submittals*
Level 1	▪ Statement of approval signed by Project Owner confirming Level 1 Commissioning is appropriate for the project ▪ Verification that replacement equipment complies with system specifications ▪ Documentation confirming proper installation, calibration, and performance of installed equipment ▪ Verification of operator training delivery and effectiveness ▪ Updated documentation for CFR, O&M Plan, Systems Manual
Level 2	▪ Statement of approval signed by Project Owner confirming Level 2 Commissioning is appropriate for the project ▪ Detailed Commissioning Plan defining project scope, roles and responsibilities, system/equipment list, project schedule ▪ Verification of commissioning design and submittal reviews ▪ Documentation confirming proper installation, calibration, and performance of installed systems and equipment ▪ Verification of operator training delivery and effectiveness ▪ Updated documentation for CFR, O&M Plan, Systems Manual ▪ Commissioning Final Report
Level 3	▪ Verification of Commissioning Lead's previous experience ▪ Owner's Project Requirements document ▪ Basis of Design document ▪ Commissioning specifications for systems in the project scope ▪ Detailed Commissioning Plan defining project scope, roles and responsibilities, system/equipment list, project schedule ▪ Verification of commissioning design and submittal reviews ▪ Documentation confirming proper installation, calibration, performance, alarm thresholds and Fault Detection settings of installed systems and equipment ▪ Verification of operator training delivery and effectiveness ▪ Detailed CFR and O&M Plan ▪ Comprehensive Systems Manual including summaries of as programmed sequences of operation ▪ Ongoing Commissioning Plan and Fault Detection setup ▪ Commissioning Final Report

APPENDIX A

Applicable Guidelines and References

- ASHRAE Guideline 0-2005, *The Commissioning Process*
- ASHRAE Guideline 1.1-2007, *HVAC&R Technical Requirements for the Commissioning Process*
- NIBS Guideline 3-2012, *Building Enclosure Commissioning Process*

  Commissioning process activities for mechanical, electrical, plumbing, renewable energy systems and assemblies, and building enclosure systems and assemblies shall be completed in accordance with the above guidelines.

- LEED v4.1, *Fundamental Commissioning and Verification; Enhanced Commissioning*

  Projects pursuing LEED Certification shall meet the requirements prescribed by the LEED v4.1 Fundamental Commissioning and Verification prerequisite and the Enhanced Commissioning credit

- Building and Construction Authority, *Green Mark for Non-Residential Building NRB: 2015 Assessment Criteria*

SDS MODULE: WATER SYSTEMS

The following module is one component of the Las Vegas Sands Corporation Sustainable Development Standards (SDS). The module outlines the owner's requirements for design, performance, execution, and submittal requirements for projects implemented in existing or new build facilities across the Las Vegas Sands Corporation portfolio. Refer to Table 1 to confirm which sections of the Water Systems module are applicable to your project.

Table 1. Water Systems Module Applicability Matrix

<table>
<tr><th>Project Type Code</th><th>Project Type</th><th>Project Sample Description</th><th>Applicable Module Subsections</th></tr>
<tr><td colspan="4">*The project code below is referenced throughout this module to help you identify the sections relevant to your specific project type. Project Code "U" represents that the module universally applies to all applicable project types that include "U" in the code description.
** New builds, additions, and major renovations must adhere to all components of the module.</td></tr>
<tr><td colspan="4">New Construction, Tenants, & Central Systems</td></tr>
<tr><td colspan="2">New Build Construction
Code: N-B or U</td><td>Ground up construction or major renovation of a facility</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="2">Major Building Renovation
Code: M-B or U</td><td>Extensive renovation including replacement of major systems and reconfiguration of spaces for a large portion of an existing facility</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="2">Tenant Fit-Out with Owner Involvement
Code: T-I or U</td><td>Full fit-out of systems, equipment, space configuration, and finishes for a tenant space with Owner involved retail, theater and/or F&B</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="2">Plumbing Fixture Upgrade or Retrofits
Code: P-F</td><td>Replacement of major plumbing distribution equipment or retrofit of broader plumbing system, such as fixture replacements</td><td>1.2</td></tr>
<tr><td colspan="2">Commercial Kitchen Upgrades or Retrofit
Code: K</td><td>New build or retrofit of F&B or Owner kitchens such as installation or replacement of dishwashers</td><td>1.2</td></tr>
<tr><td colspan="2">Landscape and Irrigation Upgrades
Code: L&I</td><td>New landscape installations or upgrades to existing systems and equipment</td><td>1.3</td></tr>
<tr><td colspan="4">Non-Applicable Projects</td></tr>
<tr><td colspan="2">Tenant Fit-Out without Owner Involvement
Code: T-NI</td><td>Full fit-out of systems, equipment, space configuration, and finishes for a tenant space without Owner involved retail, theater and/or F&B</td><td>Not Applicable</td></tr>
<tr><td colspan="2">All Other Project Types</td><td></td><td>Not Applicable</td></tr>
</table>

Other Related Sections: Submetering, Commissioning

1.0 Water System Performance Standards

LEEDv4.1 & GREEN MARK HIGHLIGHTS
LEEDv4.1 This section requires conformance with high performance water requirements. Adhering to the section will support meeting LEED credits for Indoor and Outdoor Water Use as well as the LEED for Existing Buildings O&M credit for Cooling Tower Water Use. **Green Mark** This section requires conformance with two sections of Green Mark: Part 3 - Resource Stewardship including Water Efficient Fittings and Water.

1.1 Green Mark	
In addition to meeting other performance requirements in this module, projects located in Singapore must assess compliance with the following sections of the Green Mark Non-Residential Buildings 2015 Standard. For Green Mark strategies requiring capital investment, lifecycle cost analysis must be utilized to determine incremental additional investment cost and estimated long term energy and water cost savings.	
U	1.1.1 Resource Stewardship, sections P.07 Water Efficient Fittings and 3.01 Water

1.2 Plumbing Fixture and Appliance Performance	
P-F	1.2.1 The building plumbing fixtures will meet the performance requirements outlined in Table 2 below
	1.2.2 Fixture Labeling: To ensure that the performance of low-flow fixtures is not compromised, it is recommended that U.S. EPA WaterSense labeled and/or Singapore PUB WELS fixtures are selected. WaterSense-labeled products are certified to use at least 20 percent less water, while performing as well as or better than regular models. Singapore PUB WELS fixtures, documented in the PUB WELS Guidebook, are rated in ticks and may be mandatory or voluntary, depending on fixture and desired Green Mark rating.

Table 2. Plumbing Fixture and Appliance Performance Requirements

	Fixture	Performance Requirement
P-F	Water closet – Dual flush	0.8 & 1.0 gpf (3.0 & 3.8 lpf)
	Water closet – Single flush	1.0 gpf (3.8 lpf)
	Urinal	0.125 gpf (0.47 lpf)
	Showerhead – guest room	1.75 gpm (6.62 lpm)
	Showerhead – back of house and pool	1.5 gpm (5.67 lpm)
	Sink faucet – guest room	1.0 gpm (3.7 lpm)
	Faucet – front of house	1.0 gpm (3.7 lpm)
	Bathtub Faucet – front of house	No flow restrictions provided adequate drainage
	Faucet – back of house bathroom	0.75 gpm (2.8 lpm)
	Faucet – kitchen hand wash sink	1.0 gpm (3.7 lpm)
	Housekeeping janitorial closet sink	1.75 gpm (6.62 lpm)
	Metering faucets	0.2 gpc (0.75 lpc)
	Replacement faucets	Match flow rate to corresponding faucet type above
	Residential dishwashers (standard and compact)	ENERGY STAR or performance equivalent
	Residential clothes washers	ENERGY STAR or performance equivalent
	Commercial (family sized) clothes washers	CEE Tier 3A
	Automatic commercial ice makers	ENERGY STAR or performance equivalent and use either air-cooled or closed-loop cooling, such as chilled or condenser water system
	Commercial Kitchen Systems	
K	Pre-rinse spray valves	1.3 gpm (4.9 lpm)
	Dipper well	Install in-line flow restrictor to reduce dipper well flow rate to 0.3 gpm (1.13 lpm)
	Combination oven	Connectionless model that uses no more than 15 gallons of water per hour or 3.5 gallons per pan per hour
	Steam cooker	ENERGY STAR or performance equivalent
	Wok stove	Specify waterless, air-cooled, or recirculated chilled water models. Evaluate opportunity for pedal faucets, occupancy sensors, induction woks, etc.
	Food disposal systems	Assess food pulper, food pulper/strainer combination, and food strainer systems as alternatives to conventional disposal systems
	Commercial dishwasher	ENERGY STAR or performance equivalent
	Hot Water Boilers	ENERGY STAR or performance equivalent
	Food Warmer	ENERGY STAR or performance equivalent

1.3 Landscape and Irrigation Performance	
The landscape and irrigation design must reduce the facility's landscape water requirement by at least 50% from the calculated baseline for the site's peak watering month. At least 30% of the water requirement reductions must be achieved through plant species selection and irrigation system efficiency, as calculated by the Environmental Protection Agency (EPA) WaterSense Water Budget Tool. Additional, reductions beyond 30% may be achieved using any combination of efficiency, alternative water sources, and smart scheduling technologies.	
L&I	1.3.1 Alternative water sources for consideration in the design include captured rainwater or stormwater, recycled wastewater, and water treated and conveyed by a public agency specifically for non-potable uses
	1.3.2 Design teams must perform a soil/climate analysis to determine appropriate plant material and design the landscape with native or adapted plants to reduce or eliminate irrigation requirements. Where irrigation is required, use high-efficiency equipment and/or climate-based controllers

1.4 Blackwater/Graywater Recycling	
The facility design must include an assessment of backwater/graywater recycling opportunities. For strategies that require capital investment, lifecycle cost analysis must be utilized to determine incremental additional investment cost and estimated long term energy, water, or infrastructure cost savings.	
U	1.4.1 Governmental agencies must be consulted prior to determining approved water usage. The use of reclaimed water is also subject to local health department and building regulations: 1.4.1.1 Typical uses for treated reclaimed water include: Toilet flushing; Irrigation; Cooling tower makeup; Limited water features; Emergency fire suppression water source 1.4.1.2 Plumbing and civil engineers estimate magnitude of recovered water sources and the associated potable water load types to be reduced / replaced with blackwater and graywater recycling 1.4.1.3 Plumbing and civil engineers to then meet with authority having jurisdiction (e.g. health department) to confirm permissible types of water recycling and required design features, develop special CAPEX and OPEX lifecycle costs with system, and perform evaluation
U	1.4.2 Reclaimed water sources vary geographically but may include the following: 1.4.2.1 Storm / rainwater retained onsite in protected tanks, preferably from roofs and/or pool decks (versus contaminated locations such as surface parking areas); 1.4.2.2 Cooling coil condensate from large air handling units in humid areas 1.4.2.3 Groundwater recovered from under the property that poses a flood risk if not removed 1.4.2.4 Well water from a continuous source such as an aquifer 1.4.2.5 Cooling tower blow-down (for toilet flushing only)
U	1.4.3 Water storage and treatment is typically necessary to ensure adequate water quality: 1.4.3.1 Reclaimed water systems should be designed such that residence time in storage does not exceed three days 1.4.3.2 Water storage capacity should be equal to one and a half days of consumption 1.4.3.3 Storm Manual daily testing is required to ensure proper system operation and water quality. 1.4.3.4 The treatment system should be connected to the Building Management System to monitor flow, total dissolved solids, and PH, as well as gallons per day produced and used 1.4.3.5 The source of the reclaimed water in conjunction with its intended use will determine the specific treatment system requirements and the equipment needed
U	1.4.4 Utility water supply back-up: 1.4.4.1 Potable utility water supplies must automatically backup reclaimed water sources via an appropriate open connection and/or reduced pressure backflow prevention device to reduce the risk of contamination 1.4.4.2 Detailed life cycle costing is the most appropriate means to evaluate total benefits and cost of reclaimed water infrastructure, including special maintenance and testing costs which are not otherwise present with potable utility water sources 1.4.4.3 Water conserving fixtures and practices must always be utilized regardless of the water source

1.5 Process Water Use	
U	1.5.1 Refrigeration equipment may not use once-through cooling with potable water
U	1.5.2 Cooling tower systems must evaluate the LEED for Existing Buildings O&M credit for Cooling Tower Water Use 1.2.2.1 The design team must conduct a potable water analysis, measuring five control parameters including Ca (as $CaCO_3$), total alkalinity, SiO_2, Cl^-, and Conductivity per the LEED for Existing Building O&M v4.1 requirement 1.2.2.2 Based on the potable water analysis, the design team will prepare a cooling tower operations plan to maximize the cooling tower cycles up to a maximum of 10
U	1.5.3 Minimize flushing water of reverse osmosis/water softener systems and ensure backwashing/flushing based upon actual requirement versus simple timer operation

1.6 Water Bottling Plant and Guestroom Water Stations	
U	1.6.1 A reusable water bottling plant shall be incorporated in the hotel BOH space to provide guestrooms with reusable water bottles. Appropriate infrastructure shall also be allocated for the plant to dump, sanitize, and refill bottles.
U	1.6.2 Suites shall be outfitted with plumbing infrastructure to easily install water filtration and filling stations.
U	1.6.3 BOH offices shall consider plumbing infrastructure to easily install water filtration and filling stations.

2.0 Water Systems Design

2.1 Water Systems Monitoring	
U	2.1.1 Submetering: See applicable sections of the SDS Submetering Module related to submetering of water-using systems and water end uses
U	2.1.2 Domestic water leak detection systems will be assessed for incorporation into the facility plumbing systems. The goals of the leak detection system will be to minimize water waste and to protect property from water damage resulting from leaks. The following areas must be included in the leak detection assessment 2.1.2.1 Hotel guest rooms (floor level) 2.1.2.2 Commercial kitchen and restaurant areas 2.1.2.3 Front of house restrooms 2.1.2.4 Pool and spa areas 2.1.2.5 Irrigation system (zone level) 2.1.2.6 Retail tenant spaces
U	2.1.3 Isolation valves must be installed at all branches of the water systems service lines.
U	2.1.4 Water systems designated for human contact will be designed to meet the following requirements 2.1.4.1 The turbidity of the delivered water must be less than 1.0 NTU 2.1.4.2 Total coliforms (including E. coli) must not detected in delivered water 2.1.4.3 Secondary sterilization (chlorine injection) must be incorporated into hotel cold water and hot water lines for legionella prevention. Chlorine levels must fall within the range of 0.3 to 2 ppm free chlorine at guest contact outlets such as sinks and showers
U	2.1.5 Water systems shall be designed in accordance with local codes and ASHRAE Standard 188-2018 to manage operational risks related to legionellosis.
U	2.1.6 Water piping shall be designed to have a peak pressure drop between 3ft/100 ft length to 4 ft/100 ft (0.03 meter/ meter length to 0.04 meter/ meter length). Water velocity is a primary design constraint and proper precautions to eliminate air and turbulence.

3.0 Water System Startup

3.1 Water Systems Startup	
U	3.1.1 Commissioning: Proper function of complex water systems including water treatment, water features, leak detection technologies, and submeters must be verified during the commissioning process 3.1.1.1 The commissioning process for water related systems must align with the requirements of the Commissioning module of the LVSC Sustainable Development Standards
U	3.1.2 Contaminant Controls: 3.1.2.1 The commissioning process must verify acceptable water quality delivery to all systems designated for human contact as indicated in section 2.1.4 3.1.2.2 The commissioning process must verify that the water system design and installation aligns with ASHRAE Standard 188-2018

4.0 Submittals

4.1 Design Development:	
U	4.1.1 Landscape Architect: Provide a narrative summarizing high level results of the soil and climate analysis. Include proposed landscape design elements and plant material that are appropriate for the site 4.1.2 Plumbing Engineer: Provide a narrative summarizing proposed black/graywater systems. Include design assumptions regarding storage volume, treatment, and life cycle cost analysis in the narrative for owner review and approval 4.1.2.1 Schematic diagrams, plan drawings with space requirements of plumbing modifications 4.1.3 Plumbing Engineer: Provide a summary of results and findings from the leak detection assessment. Include proposed leak detection strategies and the system level

4.2 Construction Documents (100%):	
U	4.2.1 Plumbing Engineer: Manufacturers' data showing the water consumption rates, manufacturer, and model of each type of fixture and fitting specified in the facility 4.2.2 Commercial Kitchen Consultant: Manufacturer data demonstrating compliance with the performance criteria of this module 4.2.3 Landscape Architect Responsibility: Provide calculations demonstrating the required irrigation water use reduction using the Environmental Protection Agency (EPA) WaterSense Water Budget Tool 4.2.4 Plumbing Engineer: Recommended treatment systems with system cut sheets operation and maintenance requirements, due diligence findings and reference contacts 4.2.4.1 Letter or memo from authority having jurisdiction outlining acceptable recovery systems 4.2.5 Plumbing Engineer: Provide drawings and/or specifications for designed facility domestic water leak detection systems

4.3 Construction:	
U	4.3.1 Commissioning Agent (water systems): Provide a commissioning report highlighting functional performance tests completed, deficiency log and resolution, and verifying proper function of complex water systems 4.3.1.1 Provide a copy of all policies and procedures to the owner, that were developed during the design and construction processes to meet the requirements of ASHRAE Standard 188-2018

SDS MODULE: SUBMETERING

The following module is one component of the Las Vegas Sands Corporation Sustainable Development Standards (SDS). The module outlines the owner's requirements for design, performance, execution, and submittal requirements for projects implemented in existing or new build facilities across the Las Vegas Sands Corporation portfolio. Refer to Table 1 to confirm which sections of the Submetering module are applicable to your project.

Table 1. Submetering Module Applicability Matrix

Project Type Tag	Project Type	Project Sample Description	Applicable Module Subsections
*The project code below is referenced throughout this module to help you identify all of the sections relevant to your specific project type. Project Code "U" represents that the module universally applies to all applicable project types. ** New builds, additions, and major renovations must adhere to all components of the module			
New Construction, Tenants, & Central Systems			
New Builds, Additions, & Major Renovations		- Ground up construction or major renovation of a facility	Must adhere to all sections
U	All projects	- This code is used for requirements that are universal for all project types	1.1.9; 1.6; 2.0; 4.0
C-P	Central Plant & Central Systems Retrofit	- Major central plant upgrade or retrofits - Controls systems updates, retrofits, and newly added systems	1.1.3; 1.5.1; 2.0; 4.0
T	Tenant Fit-Out	- Full fit-out of systems, equipment, space configuration, and finishes for a tenant space	1.1.7; 1.2.4; 1.3.4; 1.4.4; 1.5.6; 1.6; 2.0; 3.5; 4.0
Space Level Retrofits			
M	MICE	- Complete retrofit of a meeting room, hotel guest room, theater, etc. - Replacement of major equipment or retrofit of broader system, such as air handling unit, terminal units (VAV, fan coil, FPB's) - Lighting fixture and controls retrofits	1.1.6; 1.2.3; 1.3.3; 1.4.3; 1.5.4; 1.6; 2.0; 3.3; 4.0
C	Casino		1.1.4; 1.2.1; 1.3.1; 1.4.1; 1.5.2; 1.6; 2.0; 3.1; 4.0
Htl	Hotel		1.1.5; 1.2.2; 1.3.2; 1.4.2; 1.5.3; 1.6; 2.0; 3.2; 4.0
Thtr	Theater		1.1.8; 1.2.5; 1.3.5; 1.4.5; 1.6; 2.0; 4.0
K	Kitchen		1.5.6; 1.6; 2.0; 3.4; 4.0
Attrn	Attractions		1.1.10; 1.1.11; 1.3.6; 1.6; 2.0; 4.0
Non-Applicable Projects			
	Façade Improvements	- Installation or improvement of major façade element, such as glazing.	Not Applicable
	Interior Finish Improvement	- New carpet installation, painting, etc. No building systems adjustments.	Not Applicable
	FF&E Replacement	- Installation or replacement of furniture, fixtures, and equipment. No building systems adjustments	Not Applicable

Other Related Sections: BMS, Controls, & Integration

Table 2. Submeter Requirements by Program Area

Submeter	Space Type							
	Hotel	Casino	MICE	Retail	Kitchens	Theater	Attractions	Exterior Lighting
Electric	√	√	√	√	√	√	√	√
Heating/Cooking Fuel	√	√	√	√	√			
Chilled Water	√	√	√	√	√	√	√	
Space Heating Hot Water	√	√	√	√	√	√	√	
Domestic Hot Water	√	√	√	√	√	√	√	
Potable Water	√	√	√	√	√	√	√	

1.0 Metering Design Requirements

LEEDv4.1 HIGHLIGHTS

Building Level Metering

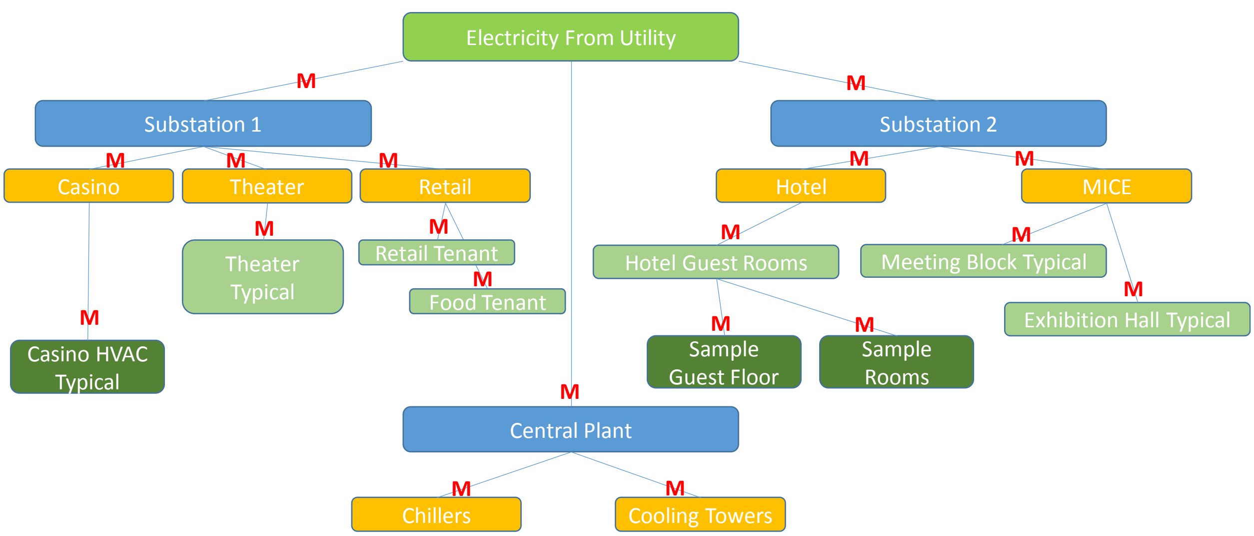
The requirements of this section align with and exceed the LEED BD+C v4.1 prerequisite for Building Level Energy Metering.

Advanced Energy Metering

In addition, the requirements of this section support the Advanced Energy Metering credit associated with the LEED BD+C v4.1 credit for advanced energy metering credit, which requires installing advanced metering for any system that constitutes more than 10% of the annual building energy use.

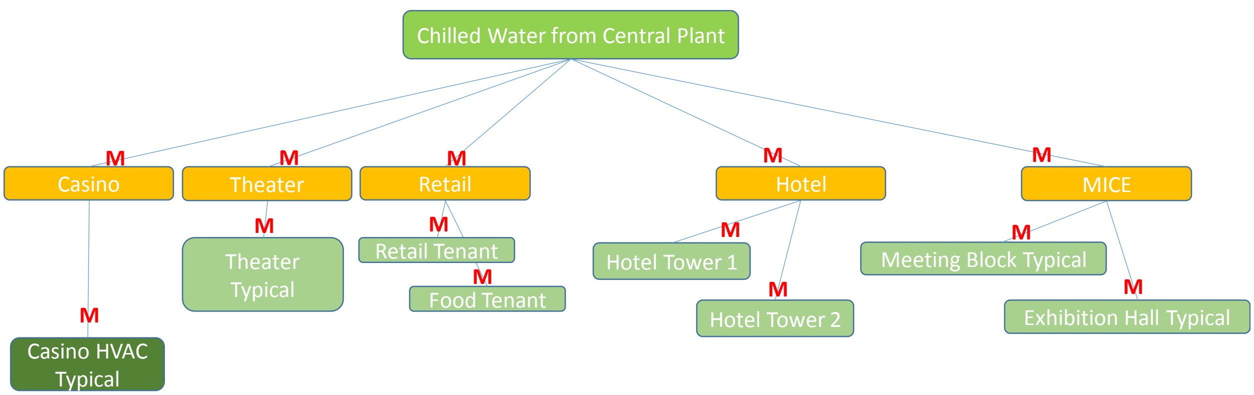
1.1 Electricity		
The electric utility distribution and metering scheme must be designed such that the entire facility, distinct program areas, major equipment, and individual tenant spaces are metered separately. The requirements below detail specific areas to be separately metered.		
U	1.1.1	Whole campus electricity
U	1.1.2	Every major electrical substation via the PMCS system
C-P	1.1.3	The entire central plant 1.1.3.1 Major equipment within the central plant (e.g. chillers)
C	1.1.4	The entire Casino area
Htl	1.1.5	The entire Hotel area 1.1.5.1 Hotel tower guest rooms 1.1.5.2 One sample guest room floor 1.1.5.3 One sample guest room for each building exposure
M	1.1.6	The entire MICE area 1.1.6.1 MICE distinct areas (e.g. each group of 12 meeting rooms/pre-function space by floor)
Rtl	1.1.7	The entire Retail area 1.1.7.1 Retail area tenants [meters must be revenue grade] 1.1.7.2 Food and beverage tenants [meters must be revenue grade]
Thtr	1.1.8	The entire Theater area 1.1.8.1 Individual theaters
U	1.1.9	Major HVAC equipment serving distinct zones (e.g. car park exhaust fans)
Attrn	1.1.10	Exterior lighting systems
Attrn	1.1.11	All attraction areas

Figure 1. Electric Meter Scope Diagram



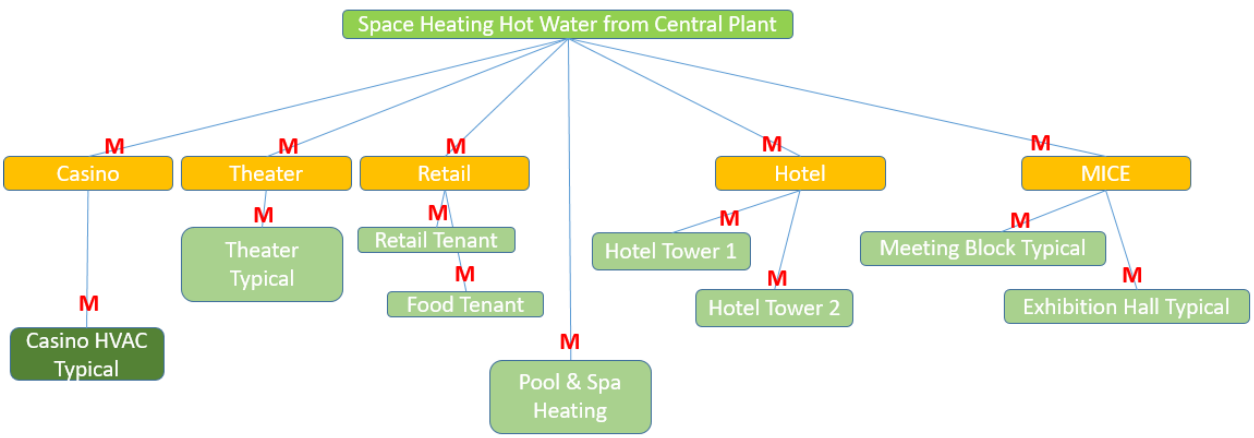
1.2 Chilled Water		
The following areas will be metered for chilled water. The chilled water distribution and metering scheme must be designed such that the distinct program areas, major equipment, and individual tenant spaces are metered separately. The requirements below detail specific areas to be separately metered.		
C-P	1.2.1	The entire Central Plant area 1.2.1.1 Major equipment within the chiller plant (e.g. chillers)
C	1.2.2	The entire Casino area
Htl	1.2.3	The entire Hotel area 1.2.2.1 Each hotel tower
M	1.2.4	The entire MICE area 1.2.3.1 MICE distinct areas (e.g. each group of 12 meeting rooms/pre-function corridor by floor) Each MICE floor should at minimum be broken into quadrants.
Rtl	1.2.5	The entire Retail area 1.2.4.1 Retail area tenants 1.2.4.2 Food and beverage tenants
Thtr	1.2.6	The entire Theater area 1.2.5.1 Individual theaters

Figure 2. Chilled Water Meter Scope Diagram



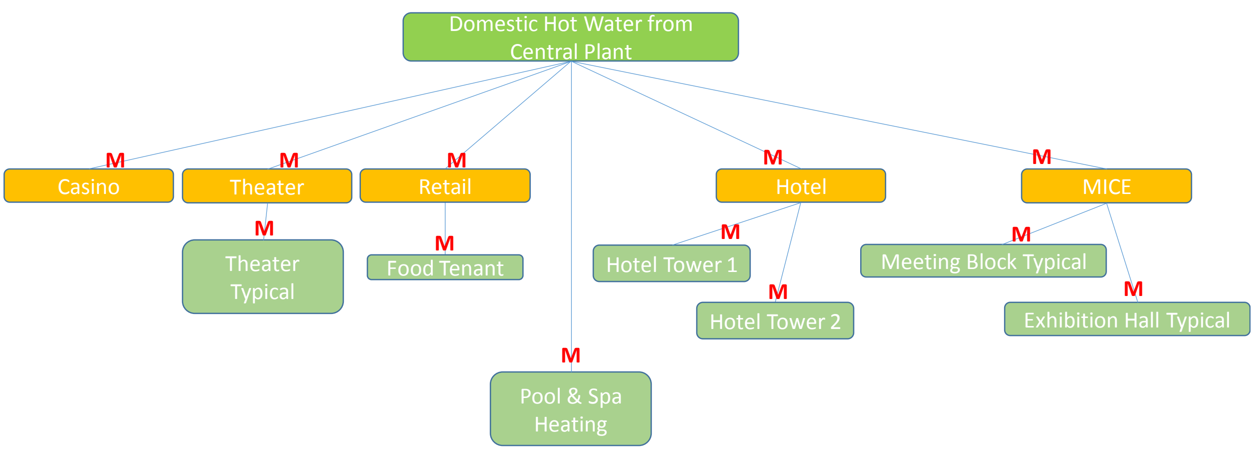
1.3 Space Heating Hot Water		
The following areas will be metered for space heating hot water. The space heating hot water distribution and metering scheme must be designed such that the distinct program areas and individual tenant spaces are metered separately. The requirements below detail specific areas to be separately metered.		
C-P	1.3.1	The entire Central Plant area
C	1.3.2	The entire Casino area
Htl	1.3.3	The entire Hotel area 1.3.2.1 Each hotel tower
M	1.3.4	The entire MICE area 1.3.3.1 MICE distinct areas (e.g. each group of 12 meeting rooms/pre-function space by floor)
Rtl	1.3.5	The entire Retail area 1.3.4.1 Retail area tenants 1.3.4.2 Food and beverage tenants
Thtr	1.3.6	The entire Theater area 1.3.5.1 Individual theaters
Attrn	1.3.7	Pool and spa heating (if supplied from space heating hot water system)

Figure 3. Space Heating Hot Water Meter Scope Diagram



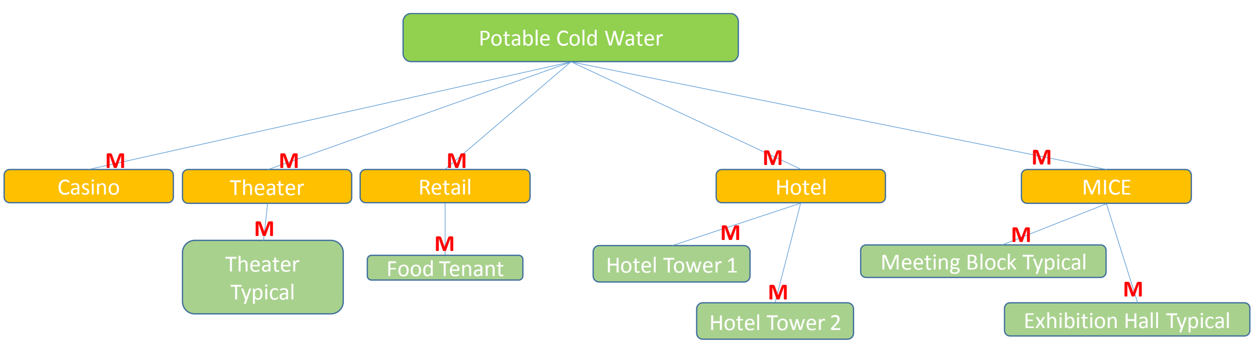
1.4 Domestic Hot Water	
The following areas will be metered for domestic hot water. The domestic hot water distribution and metering scheme must be designed such that the distinct program areas and individual tenant spaces are metered separately. The requirements below detail specific areas to be separately metered.	
C-P	1.4.1 The entire Central Plant area
C	1.4.2 The entire Casino area
Htl	1.4.3 The entire Hotel area 1.3.2.1 Each hotel tower
M	1.4.4 The entire MICE area 1.3.3.1 MICE distinct areas (e.g. each group of 12 meeting rooms/pre-function space by floor)
Rtl	1.4.5 The entire Retail area 1.3.4.1 Retail area tenants 1.3.4.2 Food and beverage tenants
Thtr	1.4.6 The entire Theater area 1.3.5.1 Individual theaters
Attrn	1.4.7 Pool and spa heating (if supplied from domestic hot water heating system)
K	1.4.8 Kitchens

Figure 4. Domestic Hot Water Meter Scope Diagram



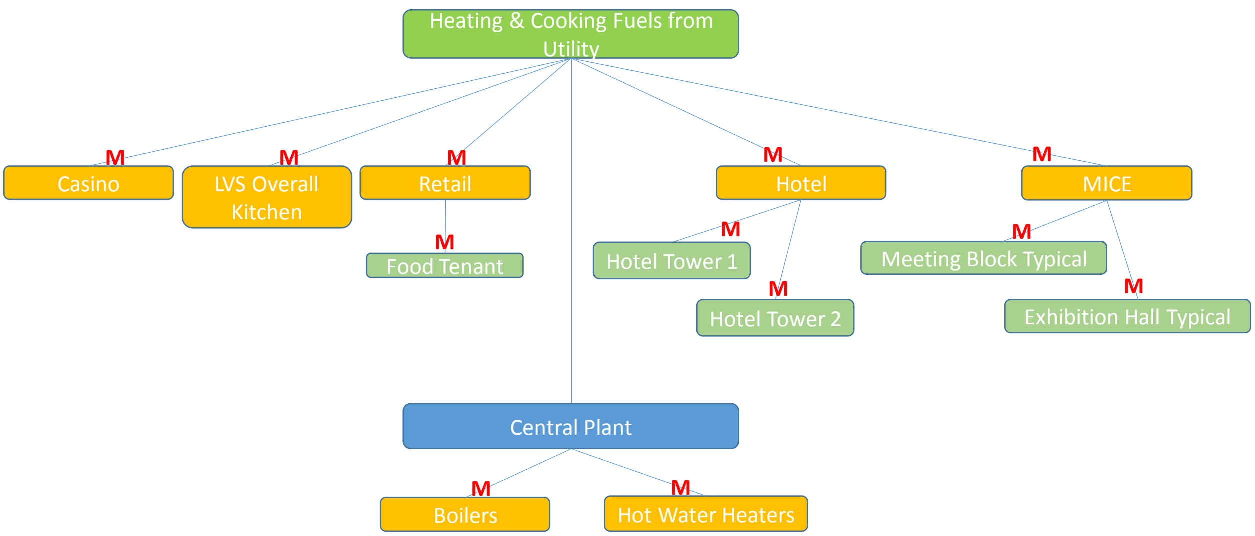
1.5 Potable Cold Water		
The following areas will be metered for potable cold water. The potable cold water distribution and metering scheme must be designed such that the distinct program areas and individual tenant spaces are metered separately. The requirements below detail specific areas to be separately metered.		
U	1.5.1	Whole campus (may utilize utility meter if direct access to compatible consumption data)
C	1.5.2	The entire Casino area
Htl	1.5.3	The entire Hotel area 1.5.3.1 Each hotel tower
M	1.5.4	The entire MICE area 1.5.4.1 MICE distinct areas (e.g. each group of 12 meeting rooms/pre-function space by floor)
Rtl	1.5.5	The entire Retail area 1.5.5.1 Retail area tenants 1.5.5.2 Food and beverage tenants
Thtr	1.5.6	The entire Theater area 1.5.6.1 Individual theaters
Attrn	1.5.7	Pool, spa and water feature makeup
Attrn	1.5.8	Cooling tower makeup and blowdown
Attrn	1.5.9	Irrigation makeup (also include any graywater/ recovered water sources)
K	1.5.10	Kitchens

Figure 5. Potable Cold Water Meter Scope Diagram



1.6 Heating/Cooking Fuel	
Heating and cooking fuel must be metered for the following areas. The heating and cooking fuel distribution and metering scheme must be designed such that the central plant, distinct program areas, kitchen areas, and individual food and beverage tenant spaces are metered separately. The requirements below detail specific areas to be separately metered.	
U	1.6.1 Whole campus (may utilize utility meter if direct access to compatible consumption data)
C-P	1.6.2 The central plant 1.5.1.1 Boilers 1.5.1.2 Hot water heaters
C	1.6.3 The entire Casino area
Htl	1.6.4 The entire Hotel area 1.5.3.1 Each hotel tower
M	1.6.5 The entire MICE area 1.5.4.1 MICE distinct areas (e.g. each group of 12 meeting rooms/pre-function space by floor)
Rtl	1.6.6 The entire Retail area 1.6.5.1 Food and beverage tenants
K	1.6.7 Kitchens

Figure 6. Heating/Cooking Fuel Meter Scope Diagram



1.6 Coordinated Utility Distribution Configurations for Base Metering Scope	
U	1.6.1 The electricity distribution, thermal energy piping distribution, and water piping distribution must be configured to allow single point, single meter installation for all base metering scope to properly and cost effectively meter entire load. For example, food and beverage tenants often have local AHUs/FCUs serving dining area and remote MAUs and KEFs serving kitchen areas. Utility distribution must be configured for one set of meters to measure all AHUs/FCUs/MAUs/KEFs
U	1.6.2 Hardwired meter interface required with electrical system PMCS, building management system and tenant billing system. Such a configuration requires special design and construction coordination for proper execution
U	1.6.3 Utility distribution must be designed to accommodate the metering requirements above and to allow the facility to derive the energy and water consumption for distinct program areas. In particular, the utility distribution must allow for metering and thereby measuring of ongoing energy and water consumption for tenant areas

2.0 Meter Performance & Accuracy Requirements

2.1 General Meter Performance Requirements	
All energy and water meters installed in the facility, including building owned and tenant meters, shall meet the following performance requirements.	
U	2.1.1 Integrate "smart breaker" or "smart panel" technology into the BMS and PMCS systems to facilitate streamlined data collection and communication of electricity consumption and demand. Sample product: Schneider Electric Smart Panels. Breakers & panels dedicated measure and invoice tenant and building level energy consumption must also have revenue grade submeters.
U	2.1.2 Energy and water meters must be capable of communicating with building wide data management and controls systems, such as the Intelligent Building Management System (IBMS) or Building Management System (BMS), via BACnet IP, BACnet gateway, or other Open Protocol Communication (OPC) data exchange format approved by the Owner

2.2 Electricity Meter Requirements	
U	2.2.1 Type and Measured Units: Fully electronic meter to measure demand (kWh), consumption (kWh), and consumption by utility tariff time of use 2.2.2 Required Accuracy and Installation: +/- 0.2% or less error from 0% to 100% load 2.2.3 Output: Emon-Dmon RS-485 Emon Energy EZ7 2.2.4 Recommended Meter: Emon-Dmon Class 3400 Smart Meter and Appropriate Current Sensors or similar manufactured by Schneider or ABB 2.2.5 Meters installed to measure and invoice tenant and building level energy consumption must be revenue grade. All other meters for building systems and equipment are for energy management purposes and may be non-revenue grade, as approved by the owner

2.3 Natural Gas Meter Requirements	
U	2.3.1 Type and Measured Units: Fully electronic (no moving parts) thermal mass flow; standard cubic feet or normal cubic meters 2.3.2 Required Accuracy and Installation: +/- 1.0% or less error from 500 – 7000 SFPM (2.3 – 33 NMPS), +/- 2.0% from 100 – 500 SFPM (0.47 – 2.3 NMPS); Minimum 10 straight pipe diameters upstream and 5 straight pipe diameters downstream 2.3.3 Output: Pulse Every 1,000 Standard Cubic Feet (28 normal cubic meters) consumption; 2.3.4 Recommended Meter: Onicon Class 5400 Inline Meter 1" to 3" (2.54 cm to 7.62 cm) 2.3.5 Acceptable Alternates: Fox FT1 Inline Meter 0.5" to 6" (1.27 cm to 15.24 cm) 2.3.6 Meters installed to measure and invoice tenant and building level energy consumption must be revenue grade. All other meters for building systems and equipment are for energy management purposes and may be non-revenue grade, as approved by the owner

2.4 Chilled Water Meter Requirements	
U	2.4.1 Type and Measured Units: Fully Electronic (no moving parts) Ultrasonic flow and insertion PT1000 RTDs or equivalent 2.4.2 Required Accuracy and Installation: +/- 1.0% or less error over 25:1 turndown, +/- 2.0% or less error over 100:1 turndown; Minimum 10 straight pipe diameters upstream and 5 straight pipe diameters downstream 2.4.3 Output: Pulse Every 1,000 BTU (1,000 kilojoules) consumption 2.4.4 Recommended Meter:

U	2.4.4.1 Onicon class F-4600 Ultrasonic Inline Meter 0.5” to 2.5” (1.27 cm to 6.35 cm) combined with Onicon System 10 Energy Computer and Insertion Thermowell Temperature Sensors 2.4.4.2 Onicon Class F-3100 Magnetic Inline Meter 3” to 12” (7.62 cm to 30.48 cm) combined with Onicon System 10 Energy Computer and Insertion Thermowell Temperature Sensors 2.4.5 Acceptable Alternates: Flexim Fluxus F704 Energy With Insertion Thermowell Temperature Sensors Permanent Mount 2.4.5.1 Flexim Fluxus F704 Energy With Insertion Thermowell Temperature Sensors Permanent Mount 2.4.5.2 Siemens Sitrans FUE1010 Energy With Insertion Thermowell Temperature Sensors Permanent Mount 2.4.5.3 Kamstrup Ultraflow 54 Inline Meter ¾” to 5” and Multical 602 Energy Computer and Insertion Thermowell Temperature Sensors 2.4.6 Meters installed to measure and invoice tenant and building level energy consumption must be revenue grade. All other meters for building systems and equipment are for energy management purposes and may be non-revenue grade, as approved by the owner

2.5 Space Heating Hot Water Meter Requirements	
U	2.5.1 Type and Measured Units: Fully Electronic (no moving parts) Ultrasonic flow and insertion PT1000 RTDs or equivalent 2.5.2 Required Accuracy and Installation: +/- 1.0% or less error over 25:1 turndown, +/- 2.0% or less error over 100:1 turndown; Minimum 10 straight pipe diameters upstream and 5 straight pipe diameters downstream 2.5.3 Output: Pulse Every 1,000 BTU (1,000 kilojoules) consumption 2.5.4 Recommended Meter: 2.5.4.1 Onicon class F-4600 Ultrasonic Inline Meter 0.5” to 2.5” (1.27 cm to 6.35 cm) combined with Onicon System 10 Energy Computer and Insertion Thermowell Temperature Sensors 2.5.4.2 Onicon Class F-3100 Magnetic Inline Meter 3” to 12” (7.62 cm to 30.48 cm) combined with Onicon System 10 Energy Computer and Insertion Thermowell Temperature Sensors 2.5.5 Acceptable Alternates: 2.5.5.1 Flexim Fluxus F704 Energy With Insertion Thermowell Temperature Sensors Permanent Mount 2.5.5.2 Siemens Sitrans FUE1010 Energy With Insertion Thermowell Temperature Sensors Permanent Mount 2.5.5.3 Kamstrup Ultraflow 54 Inline Meter ¾” to 5” and Multical 602 Energy Computer and Insertion Thermowell Temperature Sensors 2.5.6 Meters installed to measure tenant and building level energy consumption must be revenue grade. All other meters for building systems and equipment are for energy management purposes and may be non-revenue grade, as approved by the owner

2.6 Domestic Hot Water Meter Requirements	
U	2.6.1 Type and Measured Units: Fully electronic (no moving parts) ultrasonic flow rated for up to 150 degF (66 degC) 2.6.2 Required Accuracy and Installation: +/- 1.0% or less error over 25:1 turndown, +/- 2.0% or less error over 100:1 turndown; Minimum 10 straight pipe diameters upstream and 5 straight pipe diameters downstream 2.6.3 Output: Pulse every 1,000 gallons (3,785 liters) consumption 2.6.4 Recommended Meter: 2.6.4.1 Onicon Class F-3100 Magnetic Inline Meter 1” to 12” (2.54 cm to 30.48 cm) with PTFE liner for high temp service 2.6.5 Acceptable Alternates: 2.6.5.1 Siemens Sitrans FUS1010 Ultrasonic Inline Meter 2.6.5.2 Kamstrup Ultraflow 54 Ultrasonic Inline Meter ¾” to 5”

	2.6.6 Meters installed to measure and invoice tenant and building level energy consumption must be revenue grade. All other meters for building systems and equipment are for energy management purposes and may be non-revenue grade, as approved by the owner

2.7 Domestic Cold Water Meter Requirements	
U	2.7.1 Type and Measured Units: Fully electronic (no moving parts) ultrasonic flow rated for up to 150 degF (66 degC) 2.7.2 Required Accuracy and Installation: +/- 1.0% or less error over 25:1 turndown, +/- 2.0% or less error over 100:1 turndown; Minimum 10 straight pipe diameters upstream and 5 straight pipe diameters downstream 2.7.3 Output: Pulse every 1,000 gallons (3,785 liters) consumption 2.7.4 Recommended Meter: 2.7.4.1 Onicon class F-4600 Ultrasonic Inline Meter 0.5" to 2.5" (1.27 cm to 6.35 cm) 2.7.4.2 Onicon Class F-3100 Magnetic Inline Meter 3" to 12" (7.62 cm to 30.48 cm 2.7.5 Acceptable Alternates: 2.7.5.1 Siemens Sitrans FUS1010 Ultrasonic Inline Meter 2.7.5.2 Kamstrup Ultraflow 54 Ultrasonic Inline Meter ¾" to 5" 2.7.5.3 Flexim Fluxus ADM 5107 Ultrasonic Inline Meter 2.7.6 Meters installed to measure and invoice tenant and building level energy consumption must be revenue grade. All other meters for building systems and equipment are for energy management purposes and may be non-revenue grade, as approved by the owner.

2.8 Steam Meter Requirements	
U	2.8.1 Type and Measured Units: Engineered smart DP transmitter with integral orifice plate 2.8.2 Required Accuracy and Installation: +/- 0.95% flow rate accuracy, 14:1 flow turndown dry steam, minimum 4 pipe diameters upstream and 4 pipe diameters downstream (of conditioning orifice plate) 2.8.3 Output shall be computed "pounds of steam" (weight measurement) or MBTU (one thousand BTU): 2.8.4 Recommended Meter: 2.8.4.1 Rosemount 3051SF DP Flowmeter 2.8.5 Acceptable Alternates: 2.8.5.1 If approved by VCR, high temp condensate flowmeter 2.8.6 Meters installed to measure and invoice tenant and building level energy consumption must be revenue grade. All other meters for building systems and equipment are for energy management purposes and may be non-revenue grade, as approved by the owner

3.0 Program Area Metering Requirements

The following summary outlines requirements for separately metered energy, water, and building systems in specific program areas of the facility.

3.1 Casinos	
C	3.1.1 Electric energy consumption (equipment plug loads/ lighting)
	3.1.2 HVAC energy consumption (electricity/ chilled water/ space heating) by zone

3.2 Hotels	
Htl	3.2.1 Electric total energy consumption (lighting/ plug loads/ vertical transportation)

Htl	3.2.2 HVAC energy consumption (electricity/ chilled water/ space heating)
	3.2.3 Domestic water consumption
	3.2.4 Domestic hot water consumption
	3.2.5 Energy & water consumption metering for hotel guest rooms, one sample floor, sample rooms on each building exposure

3.3 SECC / MICE	
M	3.3.1 Lighting energy consumption within exhibition halls/ ballrooms/ meeting rooms/ pre-function corridors
	3.3.2 HVAC electricity, chilled water, space heating hot water within blocks of exhibition halls/ ballrooms/ meeting rooms/ pre-function corridors
	3.3.3 Plug loads within exhibition halls/ ballrooms/ meeting rooms/ pre-function corridors

3.4 Kitchens	
K	3.4.1 Refrigeration systems – walk-in coolers, freezers
	3.4.2 Dishwashers
	3.4.3 Total potable water
	3.4.4 Total domestic hot water
	3.4.5 Heating/ cooking fuel

3.5 Retail	
Rtl	3.5.1 Non F&B tenants (all electricity/ chilled water/ space heating/ potable water/ domestic hot water)
	3.5.2 F&B tenants (all electricity/ chilled water/ space heating/ potable water/ domestic hot water/ cooking and heating fuel)
	3.5.3 CAM by zone (HVAC electricity/ chilled water/ space heating/ lighting/ plug loads)

4.0 Submittal Requirements

4.1 Design Development: Architect / Engineer of Record Responsibility	
U	4.1.1 Submit a detailed compliance plan addressing the design, meter performance, and program area metering requirements. The plan must include, but is not limited to, a description of the separately metered program areas, metering schema for energy and water, separately metered equipment and building systems, separately metered tenant areas, and other specified metering zones. confirmation of coordinated design for single meter per zone requirement, proposed meters for each service compatible with requirements, confirmation of system compatibility for tenant bill generation, ad hoc report generation, specific network design (fiber/ structured cabling/ routers and switches) to support initial construction meters and minimum 20% spare capacity with no performance issues, and SCADA architecture diagram

4.2 Construction Documents 60%: Architect / Engineer of Record Responsibility	
U	4.2.1 Submit specifications for proposed meters to satisfy the metering requirements
	4.2.2 Demonstrate metering system capability for tenant bill generation and ad hoc report generation
	4.2.3 Submit the detailed SCADA architecture diagram for the metering system

4.3 Construction Documents 100%	
U	4.3.1 Contractor Responsibility: Deliver submittal documentation for energy and water meters to be installed in the facility. Update SCADA and tenant billing systems for metering information provided with 'high level' network interface such as electricity data from smart breakers, power consumption from VFDs, tenant billing meters with pulse consumption outputs for billing as well as BMS network interfaces for Facilities troubleshooting (i.e. Tenant C contacts Facilities with hot call. Facilities can remotely study Tenant C's chilled water meter's instantaneous flow and supply temperature to better understand potential issues). Indicate how automatic fault detection system will interface with SCADA and tenant billing systems.
U	4.3.2 Architect/Engineer of Record Responsibility: Submit an updated metering compliance plan. Update SCADA and tenant billing systems for metering information provided with 'high level' network interface such as electricity data from smart breakers, power consumption from VFDs, tenant billing meters with pulse consumption outputs for billing as well as BMS network interfaces for Facilities troubleshooting (i.e. Tenant C contacts Facilities with hot call. Facilities can remotely study Tenant C's chilled water meter's instantaneous flow and supply temperature to better understand potential issues). Indicate how automatic fault detection system will interface with SCADA and tenant billing systems.

4.4 Construction: Contractor Responsibility	
U	4.4.1 Submit documentation confirming proper installation, calibration, and communication of data for installed meters. Provide documentation of system approval by Commissioning Authority
	4.4.2 Submit O&M documentation for use by facility staff

End of Submetering Module

SDS MODULE: ENERGY PERFORMANCE

The following module is one component of the Las Vegas Sands Corporation Sustainable Development Standards (SDS). The module outlines the owner's requirements for design, performance, execution, and submittal requirements for projects implemented in existing or new build facilities across the Las Vegas Sands Corporation portfolio. Refer to Table 1 to confirm which sections of the Energy Performance module are applicable to your project.

Table 1. Energy Performance Module Applicability Matrix

Project Type Code	Project Type	Project Sample Description	Applicable Module Subsections
*The project code below is referenced throughout this module to help you identify the sections relevant to your specific project type. Project Code "U" represents that the module universally applies to all applicable project types. ** New builds, additions, and major renovations must adhere to all components of the module.			
New Construction, Tenants, & Central Systems			
U	New Builds, Additions, & Major Renovations to HVAC and/or lighting infrastructure	- Ground up construction or major renovation of a facility	Must adhere to all sections
T-I or U	Tenant Fitout with Owner Involvement	Tenant fitout (new and renovation) with Owner involved retail, theater and/or F&B	Must adhere to all sections
C-P or U	Central Plant & Central Systems Retrofit	- Major central plant upgrade or retrofits - Controls systems updates, retrofits, and newly added systems	Must adhere to all sections
Non-Applicable Projects			
	Tenant Fitout without Owner Involvement	Tenant fitout (new and renovation) without Owner involved retail, theater and/or F&B	Not Applicable
	Interior Finish Improvement	New carpet installation, painting, etc. No building systems adjustments.	Not Applicable
	FF&E Replacement	Installation or replacement of furniture, fixtures, and equipment. No building systems adjustments	Not Applicable

Other Related Sections: HVAC Systems, Lighting, BMS Controls & Integration, Building Façade & Envelope, Commissioning

1.0 Energy Performance Standards

LEEDv4.1 HIGHLIGHTS

Minimum and Optimize Energy Performance

Designs must stipulate specific improvements, estimated cost and associated estimated energy cost savings above applicable minimum building code requirements to achieve IECC 2018 and beyond from specific improvements for Owner review and acceptance.

For LEED projects: This section requires evaluation of a proposed design that exceeds the LEED prerequisite for Minimum Energy Performance. In addition, the recommended 30% total energy use improvement over the baseline building, equates to 12 points for the Optimize Energy Performance credit.

1.1 IECC 2018	
U	The baseline required performance criteria for building systems and equipment shall be the International Energy Conservation Code (IECC) 2018. To the extent that local applicable building code is stricter or that further energy performance is desired or required, the building systems and equipment may exceed IECC 2018. [IECC 2018 Chapter 4]

1.2 Green Mark	
In addition to meeting IECC 2018, projects located in Singapore must assess compliance with the following sections of the Green Mark Non-Residential Buildings 2015 Standard. For Green Mark strategies requiring capital investment, lifecycle cost analysis must be utilized to determine incremental additional investment cost and estimated long term energy cost savings.	
U	1.2.1 Climate Responsive Design, sections P.01 Envelope and Roof Thermal Transfer, P.02 Air Tightness and Leakage, and 1.01 Leadership (including all subsections)
U	1.2.2 Building Energy Performance, all sections and subsections
U	1.2.3 Smart and Healthy Building, sections P.14 Permanent Instrumentation for the M&V of Air-Conditioning Systems, 4.03 Smart Building Operations (including all subsections)

1.3 Energy Performance Goals	
In addition to the prescriptive IECC and Green Mark requirements, projects must be designed to achieve the following energy performance targets.	
U	1.3.1 New construction projects must be evaluated to achieve improved energy performance of 30% above the baseline building code requirements. Document applicable minimum building code performance, specific necessary modifications to achieve IECC 2018 performance and beyond. Energy performance shall be demonstrated per the energy simulation requirements in Section 2 Energy Simulation Requirements below
U	1.3.2 Existing building projects must also be evaluated to achieve a minimum 20% improvement in the proposed building performance over the pre-renovation performance.

2.0 Energy Simulation Requirements

LEEDv4.1 HIGHLIGHTS
Minimum and Optimize Energy Performance This section requires that the design team complete a whole-building energy simulation per the LEED methodology.

2.1 Whole Building Energy Simulation	
U	2.1.1 The project must complete a whole-building energy simulation per the requirements and guidance provide in the LEED BD+C v4.1 prerequisite Minimum Energy Performance, Option 1
U	2.1.2 The whole building simulation must be completed using sophisticated “8760 hour” energy simulation software that is capable of analyzing multiple alternative design options as well as the individual and combined energy impact of all building systems including façade, orientation, envelope, HVAC, lighting, renewable energy, CHP, thermal energy storage, and process loads. Approved software tools include EnergyPlus, IES VE, and eQUEST

U	2.1.3 The building simulation must reflect precise thermal resistance values for the enclosure considering the designed window sizes, glazing type, continuous insulation, thermal bridges, and spandrel panels. Use an energy modeling software that allows for window thermal resistance values to be entered as two values, one for the frame and one for the field of glass

3.0 Non-Renewable Energy Generation & Storage

3.1 Combined Heat & Power Plant	
New construction projects and major renovations or additions to central plant infrastructure must consider Combined Heat & Power (CHP) systems to generate electricity and meet thermal loads in the building. CHP may be appropriate in situations where simultaneous electric and thermal loads are expected, and where appropriate low emission fuel source such as natural gas are available on the property. The most conducive thermal loads for CHP are stable heating and cooling loads (CHP in conjunction with absorption or steam turbine centrifugal chiller), domestic hot water, pool/spa heating and other process hot water such as laundry or vehicle washing.	
C-P	3.1.1 Incorporate analysis of the CHP system into the whole building energy simulation completed for Section 2.0 above
C-P	3.1.2 The analysis must include an assessment of simultaneous electric and thermal loads to verify whether a CHP is appropriate for the facility. For an existing facility or central plant renovation, review submeter data to confirm simultaneous electric and thermal loads
C-P	3.1.3 The analysis will assess and compare high quality natural gas or waste to energy generated syngas fueled gas turbine, low emission reciprocating engine, and steam boiler based CHP systems
C-P	3.1.4 The analysis and comparisons of CHP systems will consider production capacity versus loading, operating flexibility and efficiency at various loading, air emissions, special electric interconnection with utility, extent standby generation can be provided by CHP equipment (reducing need for separate generators), and due diligence of equipment and service personnel. Evaluation must include base loaded system capacity (typically best payback) to increased electric and thermal capacity at lower utilization factor.
C-P	3.1.5 A lifecycle cost analysis will be performed for the best-fit CHP system and will be used to compare alternative central plant strategies considered in the design

3.2 Thermal Energy & Battery Storage	
C-P	3.2.1 If tariff structure has significant demand charges that vary by time of day and season, include an assessment of thermal energy storage and battery electricity storage to manage peak and operational energy loads. The assessment must include the following points: 3.2.1.1 Study utility tariffs to determine how peak demand and consumption costs change by time of day each season 3.2.1.2 Develop storage options from limited partial shift to full shift from peak to off peak periods 3.2.1.3 Estimate differential efficiency and operating costs from default case with no storage to partial and full shift storage options 3.2.1.4 Meet with utility representatives to determine whether rebate incentives are available 3.2.1.5 Perform due diligence evaluation of proposed storage technologies 3.2.1.6 Ensure all project impacts are considered with each option (structural, mechanical and electrical systems, construction processes, special operating expenses for maintenance/repair, etc.) 3.2.1.7 Determine rough order of magnitude space requirements for proposed storage system types and capacities
C-P	3.2.2 Perform detailed lifecycle cost evaluation of systems with a focus on incremental additional construction cost, estimated utility operating cost reduction (if any) given special operating modes and time of use utility rates, and sensitivity analysis of current utility tariff structure to estimated cost savings (if any)

4.0 Renewable Energy

LEEDv4.1 HIGHLIGHTS
Renewable Energy Production Designs must evaluate specific improvements, estimated cost and associated estimated energy cost savings for Owner review and acceptance. For LEED projects: At least 1% of the building's annual energy consumption must be produced by renewable energy to achieve a point for the LEED credit for Renewable Energy Production. Two additional points are available for achieving 5% and 10% of energy consumption produced by renewable energy.

4.1 Renewable Energy	
New construction projects and major renovations or additions must perform detailed evaluation of potential renewable energy systems capable of reasonable utilization for a new or existing property. Applicable sources of renewable energy include solar photovoltaic electric generation, solar thermal hot water generation, wind turbine electric generation, and utilization of fuels deemed partially sustainable such as waste to energy syngas generated on site or nearby and biofuel. For LEED projects: Biofuel must meet the eligibility requirements for renewable energy according to LEED-BD+C v4.1 Renewable Energy Production. Utilize the energy simulation required under this module to complete the following tasks:	
U	4.1.1 Estimate energy generation profile of proposed renewable energy systems,
U	4.1.2 Determine extent, to which energy generation matches property energy consumption with proposed system capacities
U	4.1.3 Determine whether "net metering" utility tariffs exist, and if property may become a net energy exporter
U	4.1.4 Determine estimated energy cost savings of renewable energy systems with specific tariff analyses (by time of day each season)
U	4.1.5 Perform due diligence evaluation of proposed renewable energy technologies and ensure potential nuisance conditions are evaluated and can be mitigated
U	4.1.6 Ensure all project impacts are considered with each option (structural, mechanical and electrical systems, construction processes, special opex for maintenance/repair, etc.
U	4.1.7 Perform detailed lifecycle cost evaluation of renewable energy systems with a focus on incremental additional construction cost, estimated utility operating cost reduction (if any) given special operating modes and time of use utility rates, and sensitivity analysis of current utility tariff structure to estimated cost savings (if any)

5.0 Refrigerant Management

LEEDv4.1 HIGHLIGHTS
Fundament & Enhanced Refrigerant Management All projects must meet the LEED prerequisite for fundamental refrigerant management, which prohibits the use of CFC refrigerants for Heating, Ventilation, Cooling and Refrigeration (HVAC&R).Standards apply to kitchen equipment including icemakers and walk in refrigerators or chillers. For LEED projects: Projects are required to meet Enhanced Refrigerant Management unless an exception must be made per the requirements below.

5.1 Refrigerant Management	
U	5.1.1 Design the building HVAC&R equipment and systems to meet the LEED-BD+C v4.1 rating system prerequisite for Fundamental Refrigerant Management & Enhanced Refrigerant Management 5.1.2.1 LEED Enhanced Refrigerant Management requires refrigerants with an Ozone Depletion Potential of 0 and Global Warming Potential less than 50. 5.1.2.2 Exceptions can be made for projects that are unable to meet the LEED Enhanced credit due to direct conflict with programmatic, operational, energy, or other owner requirements. A detailed summary to justify the project exception must be provided to the owner in applicable cases
U	5.1.2 Projects in Singapore shall also meet the Green Mark Platinum requirements for refrigerant management, which requires an Ozone Depletion Potential of 0 and Global Warming Potential less than 10.

6.0 Submittals

6.1 Schematic Design: Energy Simulation Provider / Consultant Responsibility	
U	6.1.1 Energy Simulation Provider / Consultant Responsibility: Provide a report with detailed findings of the energy performance simulation for base design case and all optional upgrades. Report to be closely coordinated with schematic design level documents especially regarding building areas, uses, orientation, local utility rates and weather data, building code analysis, load diversity and systems sizing, proposed equipment and systems cut sheets and reliable capex investment costs provided by Owner's cost consultant
U	6.1.2 Energy Simulation Provider / Consultant Responsibility: Lifecycle cost analysis to be provided for all optional upgrades to base building systems and process load equipment efficiency improvement. If project is pursuing a Sustainability Certification, provide additional analysis of which optional upgrades are necessary to achieve specific certification minimum performance thresholds
U	6.1.3 Energy Simulation Provider / Consultant Responsibility: Provide a summary table of the energy performance simulation input parameters and outputs. Provide electronic copies of all input and output simulation files to the Owner
U	6.1.4 Architect / Engineer of Record Responsibility: Provide a detailed report discussing relevant sections of IECC 2018 to the project and analysis demonstrating the current design satisfies applicable IECC 2018 requirements or stricter provisions of Sustainable Certification standard or applicable building code
U	6.1.5 Architect / Engineer of Record Responsibility: Stipulate the minimum required equipment and system efficiency to achieve target IECC 2018 and energy performance
U	6.1.6 Architect / Engineer of Record Responsibility: Provide a comprehensive feasibility report for CHP including potential equipment, recommended equipment for implementation (if any), due diligence evaluation of recommended equipment, extent central plant equipment benefits from

	diversity, detailed permitting analysis with relevant code provision analysis, comprehensive financial analysis, and recommended next steps
U	6.1.7 Architect / Engineer of Record Responsibility: Provide a detailed report with analysis of potential renewable systems documenting information required in Section 4.0 Renewable Energy
U	6.1.8 Architect / Engineer of Record Responsibility: Provide the financial analysis pro-forma spreadsheet utilized for CHP, thermal energy storage, and Renewable Energy. All material assumptions such as utility costs, equipment type, utilization, O&M costs, useful life, payback with WACC discount rate, etc. must be included

6.2 Design Development:	
U	6.2.1 Energy Simulation Provider / Consultant Responsibility: Provide updated energy simulation results including an assessment of the proposed design performance against the project goals and requirements
U	6.2.2 Architect / Engineer of Record Responsibility: Provide updated information for the IECC 2018, CHP, thermal energy storage, and renewable energy assessments as continued from the Schematic Design phase. Utilizing reliable estimated capex information from Owner's cost consultant develop estimated lifecycle cost analysis of all upgrades with Owner and adjust project scope accordingly
U	6.2.3 Architect / Engineer of Record Responsibility: Provide a preliminary refrigerant management plan including a summary of proposed cooling equipment and systems, the refrigerants used in the base building equipment, and the calculated refrigerant impact per the LEED credit methodology

6.3 Construction Documents (100%):	
U	6.3.1 Energy Simulation Provider / Consultant Responsibility: Provide final energy simulation results including an assessment of the proposed design performance of the designed project including all Owner selected upgrades against the original project goals and requirements
U	6.3.2 Architect / Engineer of Record Responsibility: Provide final summary of the as designed building approach to IECC 2018, CHP, thermal energy & battery storage, and renewable energy systems as continued from earlier design phases. Indicate where performance exceeds or does not comply with IECC 2018 requirements
U	6.3.3 Architect / Engineer of Record Responsibility: Provide the updated refrigerant management plan with all required details
6.4 As-Built Performance:	
U	6.4.1 Energy Simulation Provider / Consultant Responsibility: Compare actual, commissioned building performance against final energy simulation results including an assessment of the proposed design performance of the designed project. Discuss relevant findings from commissioning regarding actual operation and performance vs. design stage expected operation and performance of distinct infrastructure and systems

SDS MODULE: BUILDING FACADE & ENVELOPE

The following module is one component of the Las Vegas Sands Corporation Sustainable Development Standards (SDS). The module outlines the owner's requirements for design, performance, execution, and submittal requirements for projects implemented in existing or new build facilities across the Las Vegas Sands Corporation portfolio. Refer to Table 1 to confirm which sections of the Building Façade & Envelope module are applicable to your project.

Table 1. Building Façade & Envelope Module Applicability Matrix

<table>
<tr><th>Project Type Code</th><th>Project Type</th><th>Project Sample Description</th><th>Applicable Module Subsections</th></tr>
<tr><td colspan="4">*The project code below is referenced throughout this module to help you identify the sections relevant to your specific project type. Project Code "U" represents that the module universally applies to all applicable project types.
** New builds, additions, and major renovations must adhere to all components of the module.</td></tr>
<tr><td colspan="4">New Construction, Tenants, & Central Systems</td></tr>
<tr><td colspan="2">New Build Construction
Code: N-B or U</td><td>Ground up construction or major renovation of a facility affecting building envelope. Refer to Energy Simulation Requirements under Energy Performance Module.</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="2">Major Building Renovation
Code: M-B or U</td><td>Extensive renovation including replacement of major systems and reconfiguration of spaces for a large portion of an existing facility involving building envelope. Refer to Energy Simulation Requirements under Energy Performance Module. Non-LEED projects shall evaluate upgrades from base building code to IECC 2018 as discretionary investment on lifecycle cost basis if IECC 2018 stricter.</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="2">Façade Improvements
Code: F-I or U</td><td>Installation or improvement of major façade elements, such as glazing. Non-LEED projects shall evaluate upgrades from base building code to IECC 2018 as discretionary investment on lifecycle cost basis if IECC 2018 stricter.</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="4">Non-Applicable Projects</td></tr>
<tr><td colspan="2">All Other Project Types</td><td></td><td>Not Applicable</td></tr>
</table>

1.0 Envelope Performance Standards

LEEDv4.1 & GREEN MARK HIGHLIGHTS
LEEDv4.1 (for LEED projects) **Minimum and Optimize Energy Performance** This section requires conformance with high performance energy code requirements. Adhering to the section, will support meeting whole building energy performance requirements and sustainability goals. However, exceeding the IECC 2018 requirements may be required to reach the required energy overall building energy performance. **Fundamental and Enhanced Commissioning** This section includes requirements for building envelope commissioning that align with the LEED credit for Fundamental and Enhanced Commissioning (Option 2 Envelope Commissioning).

Green Mark (for Singapore projects)
This section requires conformance with three sections of Green Mark: Part 1 - Climate Responsive Design including Envelope and Roof Thermal Transfer, Air Tightness and Leakage, and Tropical Façade Performance.

1.1 IECC 2018	
The baseline required performance criteria for the building envelope and fenestration shall be the International Energy Conservation Code (IECC) 2018. Compare applicable local building code to IECC 2018. To the extent that local applicable building code is stricter or further energy performance is desired or required, the envelope and fenestration performance must exceed IECC 2018. See specific elements of building envelope performance covered by IECC 2018 below.	
U	1.1.1 Thermal envelope insulation requirements: See section C402.2 along with tables C402.1.3 and C402.1.4 of IECC 2018 for detailed requirements for envelope insulation. Projects teams may comply with the insulation requirements based on either the R-value or U-value basis IECC 2018 C402.1
U	1.1.2 Roof solar reflectance and thermal emittance: See section C402.3 and table C402.3 of IECC 2018 for specific roof requirements IECC 2018 C402.3
U	1.1.3 Fenestration: See section C402.4 and table C402.4 for specific fenestration performance requirements IECC 2018 C402.4
U	1.1.4 Air leakage: See section C402.5 and table C402.5.2 for specific air leakage requirements IECC 2018 C402.5

1.2 Green Mark	
In addition to meeting IECC 2018, projects located in Singapore must assess compliance with the following sections of the Green Mark Non-Residential Buildings 2015 Standard. For Green Mark strategies requiring capital investment, lifecycle cost analysis must be utilized to determine incremental additional investment cost and estimated long term energy cost savings.	
U	1.2.1 Climate Responsive Design, sections P.01 Envelope and Roof Thermal Transfer, P.02 Air Tightness and Leakage, 1.03a Tropical Façade Performance

1.3 Envelope Commissioning	
Contract with a qualified commissioning agent to complete thermal envelope commissioning per the following requirements. See the Commissioning module of the Sustainable Design Standards for a summary of commissioning team requirements	
U	1.3.1 By the end of the design development phase, engage a commissioning authority. The commissioning authority must complete the following commissioning process (CxP) activities for the building's thermal envelope in accordance with ASHRAE Guideline 0–2005 and the National Institute of Building Sciences (NIBS) Guideline 3–2012, Exterior Enclosure Technical Requirements for the Commissioning Process, as they relate to energy, water, indoor environmental quality, and durability. 1.3.1.1 Review the OPR for completeness and the BOD to verify that the project envelope design will achieve the owner's expectations 1.3.1.2 Conduct one commissioning design review of design documents related to the building envelope prior to the mid-construction documents phase plus a second review and backcheck of comments in the subsequent submission 1.3.1.3 Review contractor submittals applicable to envelope systems being commissioned for compliance with the OPR and BOD. Submittal reviews shall be concurrent with Architect and Engineer reviews. Submittal reviews shall be submitted to the Design Team and Owner

	1.3.1.4 Develop pre-functional checklists and functional performance tests for the envelope systems based on approved submittals 1.3.1.5 Verify envelope systems installation by reviewing completed pre-functional checklists and conducting periodic site visits during construction 1.3.1.6 Verify envelope system performance by directing the execution of functional performance tests. Oversee seasonal envelope tests as needed and review envelope systems operations after 10 months of operations. See required and recommended functional tests in Table 1 Required Laboratory Enclosure Tests, Table 2 Required Field Tests, and Table 3 Recommended Field Tests 1.3.1.7 Verify systems manual and operator training requirements in the construction documents 1.3.1.8 Verify systems manual updates and operator training delivery and effectiveness 1.3.1.9 Develop an Ongoing Commissioning Plan to provide the Operations Team with protocols to continually verify the performance of the commissioned systems

Table 1. Recommended Laboratory Enclosure Tests

The following list of testing standards are designed to be performed in a controlled testing environment. Typically, the product manufacturer is responsible for determining the product's performance under these testing standards.

Source	System	Test Type	Test type	Name	Title
NIBS Guideline 3-2013	Enclosure Assembly	General	Laboratory	ASTM E 2099	Standard Practices of the Specification and Evaluation of Pre-Construction Laboratory mockups or Exterior Wall Systems
NIBS Guideline 3-2013	Garage Doors	Thermal and Air	Laboratory	ANSI/DASMA 105	Test method for thermal transmittance and air infiltration of garage doors
NIBS Guideline 3-2013	Glazing	Color	Laboratory	NFRC 300	Test Method for Determining the Solar Optical Properties of Glazing Materials and Systems
NIBS Guideline 3-2013	Masonry	Water	Laboratory	ASTM E 514	Test Method for Water Penetration and Leakage Through Masonry
NIBS Guideline 3-2013	Opaque Systems	Air	Laboratory	ASTM E 2178	Standard Test Method for Air Permeance of Building Materials Not to exceed 0.004 cfm at 0.3" w.g or 1.57 psf (0.02 L/s.m at 75 PA)
NIBS Guideline 3-2013	Opaque Systems	Air	Laboratory	ASTM E 2357	Standard Test Method for Determining Air Leakage of Air Barrier Assemblies 0.06 cfm at 6.24 psf (0.3 L/s.m at 300 Pa)
NIBS Guideline 3-2013	Window	Thermal	Laboratory	NFRC 100	Procedure for Determining Fenestration Product U-factors
NIBS Guideline 3-2013	Window	Thermal	Laboratory	NFRC 200	Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence
NIBS Guideline 3-2013	Window, Door, and	Condensation	Laboratory	AAMA 1502.7	Voluntary Test Method for Condensation Resistance of

	Curtain Wall				Windows, Doors and Glazed Wall Sections
NIBS Guideline 3-2013	Window, Door, and Curtain Wall	Thermal	Laboratory	AAMA 1503.1	Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections
NIBS Guideline 3-2013	Window, Door, and Curtain Wall	Water	Laboratory	AAMA 501.1	Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure
NIBS Guideline 3-2013	Window, Door, and Curtain Wall	Air	Laboratory	ASTM E 283	Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
NIBS Guideline 3-2013	Window, Door, Skylight, and Curtain Wall	Structure	Laboratory	ASTM E 330	Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference
NIBS Guideline 3-2013	Windows	Condensation	Laboratory	NFRC 500	Procedure for Determining Fenestration Product Condensation Resistance Values

Table 2. Recommended Field Tests

The following list of required testing standards are designed to be performed in the field to verify functional performance of a Mock-Up either on the building or elsewhere. Each test listed refers to the current version of the standard. The contractor will execute the test while the commissioning agent will ensure that the test is run correctly and passed.

NIBS Guideline 3-2013	Concrete Slabs	Moisture	Field	ASTM F 2170	Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes
NIBS Guideline 3-2013	Concrete Slabs	Moisture	Field	ASTM F 1869-03	Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride
NIBS Guideline 3-2013	Curtain wall, Storefront, Skylights and Doors	Water	Field	AAMA 501.2-03	Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls and Sloped Glazing Systems
NIBS Guideline 3-2013	Curtain wall, Storefront, Skylights	Water	Field	AAMA 503-03	Voluntary Specification for Field Testing of Storefront, Curtain Walls, and Sloped Glazing
NIBS Guideline 3-2013	Masonry	Water	Field	ASTM C 1601	Standard Test Method for Field Determination of Water

					Penetration of Masonry Wall Surfaces
NIBS Guideline 3-2013	Whole Building	Structure	NA	ASCE 7-02	Minimum Design Loads for Buildings and Other Structures
NIBS Guideline 3-2013	Whole Building	Thermal	Field	ASTM C 1060-90	Infrared Imaging of Building Envelope
NIBS Guideline 3-2013	Whole Building	Thermal	Field	ASTM 799-99	Infrared Imaging with Building Pressure Manipulation
NIBS Guideline 3-2013	Windows	Air	Laboratory	NFRC 400	Procedure for Determining Fenestration Product Air Leakage
NIBS Guideline 3-2013	Whole Building	Air	Field	ASTM E 799-87	Test Method for Determining Air Leakage by Fan Pressurization (Blower Door test)
NIBS Guideline 3-2013	Window, Door, Skylight, and Curtain Wall	Water	Field	ASTM E 1105-00	Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Curtain Walls, and Wall Assemblies by Uniform or Cyclic Static Air Pressure Difference
NIBS Guideline 3-2013	Windows, and Doors	Air	Field	ASTM E 783	Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors
NIBS Guideline 3-2013	Windows, Sliding glazed doors	Water	Field	AAMA 502-02	Voluntary Specification for Field Testing of Windows and Sliding Glass Doors

Table 3. Additional Recommended Field Tests

The following list of recommended testing standards are designed to be performed in the field to verify functional performance of a Mock-Up either on the building or elsewhere. Each test listed refers to the current version of the standard. The contractor will execute the test while commissioning agent will ensure that the test is run correctly and passed.

LVSC Recommended Test	Roof	Water	Field	ASTM D 5957	Standard Guide for Flood Testing Horizontal Waterproofing Installations
LVSC Recommended Test	Concrete Slabs	Moisture	Field	ASTM D 4263-83	Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
LVSC Recommended Test	Whole Building	Air	Field	ASTM E 1827-11	Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door
LVSC Recommended Test	Whole Building	Air	Field	ASTM E 2357-11	Standard Test Method for Determining Air Leakage of Air Barrier Assemblies
LVSC Recommended Test	Whole Building	Air	Field	ASTM E 1186-03	Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

LVSC Recommended Test	Sealants	Adhesion	Field	ASTM C 794	Standard Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
LVSC Recommended Test	Sealants	Adhesion	Field	ASTM C 1193	Standard Guide for Use of Joint Sealants

1.4 Daylighting	
Vertical fenestration and skylights should meet the following daylight requirements from IECC 2018. To the extent designs do not comply provide a gap analysis to allow informed review by Owner's Project Team. Projects located in Singapore will also meet the following requirements of the Green Mark program	
U	1.4.1 Total vertical fenestration area shall be designed in accordance with IECC 2018 section C402.4.1 1.4.2 Daylight zones shall be provided in the building in accordance with IECC 2018 Section C402.4.4 1.4.3 Visible transmittance of vertical fenestration shall be provided in the building in accordance with IECC 2018 section C402.4.1.1 1.4.4 Skylight fenestration area shall be designed in accordance with IECC 2018 section C402.4.1.1 and C402.4.2 1.4.5 The design team must analyze and identify the potential impact of glare on the interior work environment and on neighboring sites. 1.4.5.1 The glare analysis may be conducted either by expert team members or through design analytic tools such as DIVA 1.4.5.2 The project team must propose design solutions to mitigate glare through strategies such as exterior and interior shading and glazing coatings 1.4.6 Projects in Singapore shall document effective daylighting per the requirements of section 4.02a(i) of Green Mark NRB 2018 1.4.7 Projects in Singapore shall meet the methodology and daylight autonomy requirements of Annex B of Green Mark NRB 2018

1.5 Climate Adapted Design & Fenestration Technologies	
In addition to compliance with most recent applicable FM Global Data Sheets, the facility design must consider incorporation of resilient enclosure systems and emerging enclosure technologies to ensure high performance throughout the facility life. The following points provide guidance as to the types of considerations and technologies that should be assessed during the enclosure design	
U	1.5.1 To foster a resilient enclosure design, consider location-specific risks when choosing building sites and developing enclosure design. Establish resiliency goals for the building structure and enclosure to withstand hurricane force winds, sandstorms, heavy snow loads, heavy rain, flooding, or fire as applicable to the building site. Consider incorporating resilient program standards into the enclosure design. Design teams may refer to FORTIFED for Safer Business standard for additional guidance on risk-specific, resilient design strategies 1.5.2 Investigate the use of emerging enclosure technologies to improve facility performance and durability. Several example technologies have been included below 1.5.2.1 ETFE Ethylene Tetrafluroethylene is a polymer plastic developed for the aeronautics industry for its resistance to corrosion and temperature variation and has been incorporating in buildings since the 1970's. At one percent the weight of glass, the material has become an alternative to long span structures while saving on structural costs. The material is up to 95% transparent to provide light to large spaces and can be applied as an alternative to skylights and light monitors. These systems are often designed at air pillows for added structural and thermal performance 1.5.2.2 Electrochromic (dynamic) glazing is an IGU that uses electricity to tint a window according to the amount of sunlight hitting it. The dynamic nature of the tint allows for visibility out while minimizing solar heat gain. The primary benefit of this technology is increased human comfort in the space due to less radiant heat hitting interior surfaces and people, as well as avoiding curtains and blinds 1.5.2.3 Dynamic enclosure systems may be included in the design to create a climate responsive enclosure. This includes simple systems such as automatic shades and vented curtain walls to complicated systems like rotating floor plates. When considering a dynamic enclosure, the focus should remain on the comfort of occupants, energy performance and lifecycle utility cost reduction with a critical lens on durability of the system

U	1.5.3 Evaluate the use of exterior shading for buildings façade. Examples include guest room downstands, balconies, shading artwork, etc.

2.0 Submittals

2.1 Schematic Design:	
U	2.1.1 Commissioning Agent Responsibility: Provide a commissioning plan for the building envelope and façade systems 2.1.2 Architect Responsibility: Provide a narrative summarizing the project team's proposed approach to resilient design. Include a summary of the assumed environmental and climate risk relevant to the facility along with any referenced FM Global Data Sheets and any other resiliency standards and/or technologies that will be investigated to mitigate those risks.

2.2 Design Development:	
U	2.2.1 Architect Responsibility: Provide documentation demonstrating the building design meets the thermal envelope insulation, roof solar reflection and thermal emittance, and fenestration requirements as indicated in section 1.1 of this module. Compare estimated lifecycle cost justification of building code minimum façade performance with comparison to discounted payback of upgraded IECC 2018 façade performance (if stricter than building code) and other potential upgrades such as dynamic glazing. 2.2.2 Architect Responsibility: Provide a summary describing how the building envelope design will meet the air leakage requirements as indicated in section 1.1 of this module 2.2.3 Architect Responsibility: For projects in Singapore, provide documentation demonstrating that the building meets the Green Mark requirements for Envelope and Roof Thermal Transfer, Air Tightness and Leakage, and Tropical Façade Performance 2.2.4 Commissioning Agent Responsibility: Provide a summary of recommendations based on the commissioning design review of the building envelope systems 2.2.5 Architect Responsibility: Provide documentation demonstrating that the building design meets the requirements for total fenestration area, daylight zones, visible light transmittance, skylight fenestration, and glare control as indicated in section 1.4 of this module 2.2.6 Architect Responsibility: For projects in Singapore, provide documentation demonstrating that the building meets the Green Mark requirements for Effective Daylighting 2.2.7 Architect Responsibility: Provide an updated narrative summarizing the project team's proposed approach to resilient design

2.3 Construction Documents (100%):	
U	2.3.1 Architect Responsibility: Provide updated documentation demonstrating the building design meets the thermal envelope insulation, roof solar reflection and thermal emittance, and fenestration requirements of minimum building code and/or section 1.1 of this module based upon Owner's acceptance of specific envelope performance criteria 2.3.2 Architect Responsibility: For projects in Singapore, provide updated documentation demonstrating that the building meets the Green Mark requirements for Envelope and Roof Thermal Transfer, Air Tightness and Leakage, and Tropical Façade Performance 2.3.3 Commissioning Agent Responsibility: Provide a copy of the proposed pre-functional and functional tests to be conducted for the building envelope and façade systems 2.3.4 Commissioning Agent Responsibility: Provide a summary of deficiencies identified during the commissioning submittal review and the associated resolution. 2.3.5 Architect Responsibility: Provide updated documentation demonstrating that the building design meets the requirements for total fenestration area, daylight zones, visible light transmittance, skylight fenestration, and glare control as indicated in section 1.4 of this module

	2.3.6 Architect Responsibility: For projects in Singapore, provide updated documentation demonstrating that the building meets the Green Mark requirements for Effective Daylighting 2.3.7 Architect Responsibility: Provide a final narrative summarizing the project team's proposed approach to compliance with applicable FM Global Data Sheets and resilient design

2.4 Substantial Completion:	
U	2.4.1 Commissioning Agent Responsibility: Provide the final commissioning report 2.4.2 Commissioning Agent Responsibility: Provide an ongoing commissioning plan to ensure proper operation of the building envelope and façade during facility operations

SDS MODULE: CONSTRUCTION POLLUTION PREVENTION

The following module is one component of the Las Vegas Sands Corporation Sustainable Development Standards (SDS). The module outlines the owner's requirements for design, performance, execution, and submittal requirements for projects implemented in existing or new build facilities across the Las Vegas Sands Corporation portfolio. Refer to Table 1 to confirm which sections of the Construction Pollution Prevention module are applicable to your project.

Table 1. Construction Pollution Prevention Module Applicability Matrix

Project Type Code	Project Type	Project Sample Description	Applicable Module Subsections
*The project code below is referenced throughout this module to help you identify the sections relevant to your specific project type. Project Code "U" represents that the module universally applies to all applicable project types. ** New builds, additions, and major renovations must adhere to all components of the module.			
New Construction, Tenants, & Central Systems			
New Build Construction Code: N-B or U		Ground up construction or major renovation of a facility	Must adhere to all sections
Major Building Renovation Code: M-B or U		Extensive renovation including replacement of major systems and reconfiguration of spaces for a large portion of an existing facility	Must adhere to sections
Non-Applicable Projects			
Tenant Fit-Out		Full fit-out of systems, equipment, space configuration, and finishes for a tenant space without Owner involved retail, theater and/or F&B	Not Required
All Other Project Types			Not Applicable

1.0 Construction Pollution Prevention Standards

LEEDv4.1 & GREEN MARK HIGHLIGHTS
LEEDv4.1 projects: Requirements of following sections in this module have bearing upon LEEDv4.1 Indoor Environmental Quality requirements: **Construction Pollution Prevention performance** This section requires conformance with construction pollution prevention provisions minimizing site construction erosion. **Green Mark (for Singapore projects)** Requirements of this module has bearing upon certain sections of Green Mark requirements.

1.1 Construction activity pollution prevention	
To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation. Erosion prevention, sediment control and storm water quality management during construction, future infrastructure repairs and new construction, and long-term post-construction site stabilization.	
U	1.1.1 DESIGN

U		1.1.1.1 Create and implement an erosion and sedimentation control plan for all construction activities associated with the project. The plan must conform to the erosion and sedimentation requirements of the 2003 EPA Construction General Permit OR local standards and codes, whichever is more stringent. The plan must describe the measures implemented to accomplish the following objectives: 1.1.1.1.1 Prevent loss of soil during construction by stormwater runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse 1.1.1.1.2 Prevent sedimentation of storm sewers or receiving streams 1.1.1.1.3 Prevent pollution of the air with dust and particulate matter 1.1.1.2 The Contractor's erosion and sedimentation control methods shall conform to local erosion and sedimentation control standards and codes. If local standards and codes are not available, then comply with U.S. Environmental Protection Agency (EPA) Document No. EPA 832/R-92-005 (1992) Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices – Chapter 3: Sedimentation and Erosion Control. Information on the EPA construction general permit is available at http://cfpub.epa.gov/npdes/stormwater/cgp.cfm
U	1.1.2	IMPLEMENTATION 1.1.2.1 Erosion and sedimentation control plan shall be incorporated into the construction drawings and specifications with clear instructions regarding responsibilities, scheduling, and inspections. Erosion prevention techniques are designed to protect soil particles from the force of rain and wind to prevent loss of soil during construction by storm water runoff and/or wind erosion. These techniques include, but are not limited to construction scheduling, ground cover and plantings, dust control measures, and installation of erosion control matting. 1.1.2.2 Sediment control measures designed to capture soil particles after they have been dislodged and attempt to retain soil particles on-site. Measures include, but not limited to silt fences, sediment barriers, and settling or sediment detention basins. Both erosion prevention techniques and sediment control measures have appropriate uses; however, it has been shown that sediment control measures are less effective in preventing soil movement and water quality impacts than erosion prevention techniques. 1.1.2.3 A listing of the Standard Erosion Control Measures to be utilized shall appear either attached to the grading plan (if one required to be submitted), or on a plot plan (if no grading plan required).
U	1.1.3	COST IMPLICATIONS/LIFECYCLE COST ANALYSIS 1.1.3.1 Measures are typically code required and insignificant cost. No lifecycle cost analysis is necessary.
U	1.1.4	CONSTRUCTION QUALITY ASSURANCE 1.1.4.1 Professional responsible for development of Detailed Erosion Control Plans/ Erosion and Sediment Control Measures shall review effectiveness of as built measures.

2.0 Submittals

2.1 Construction activity pollution prevention		
U	2.1.1 2.1.2	Design Development 2.1.1.1 Preliminary Erosion Control Plan shall be prepared by: Certified Professional Soil Erosion and Sediment Control Specialist; Licensed Civil Engineer; Licensed Landscape Architect; or Licensed Contractor Construction Documents (100%) 2.1.2.1 Final Erosion Control Plan shall be prepared by: Certified Professional Soil Erosion and Sediment Control Specialist; Licensed Civil Engineer; Licensed Landscape Architect; or Licensed Contractor

SDS MODULE: WASTE MANAGEMENT AND RECYCLING

The following module is one component of the Las Vegas Sands Corporation Sustainable Development Standards (SDS). The module outlines the owner's requirements for design, performance, execution, and submittal requirements for projects implemented in existing or new build facilities across the Las Vegas Sands Corporation portfolio. Refer to Table 1 to confirm which sections of the Waste Management and Recycling module are applicable to your project.

Table 1. Waste Management and Recycling Applicability Matrix

<table>
<tr><th>Project Type Code</th><th>Project Type</th><th>Project Sample Description</th><th>Applicable Module Subsections</th></tr>
<tr><td colspan="4">*The project code below is referenced throughout this module to help you identify the sections relevant to your specific project type. Project Code "U" represents that the module universally applies to all applicable project types.
** New builds, additions, and major renovations must adhere to all components of the module.</td></tr>
<tr><td colspan="4">New Construction, Tenants, & Central Systems</td></tr>
<tr><td colspan="2">New Build Construction
Code: N-B or U</td><td>Ground up construction or major renovation of a facility</td><td>Must adhere to all sections</td></tr>
<tr><td colspan="2">Major Building Renovation
Code: M-B or U</td><td>Extensive renovation including replacement of major systems and reconfiguration of spaces for a large portion of an existing facility</td><td>Must adhere to sections</td></tr>
<tr><td colspan="2">Hotel Guest Rooms
Code: Htl or U</td><td>New build or retrofit of guest room, guest room controls, or guest room equipment</td><td>1.2
1.4.2</td></tr>
<tr><td colspan="2">Commercial Kitchen Upgrades or Retrofit
Code: C-K or U</td><td></td><td>1.3.1; 1.3.2; 1.3.5; 1.3.7</td></tr>
<tr><td colspan="2">MICE Space
Code: M or U</td><td></td><td>1.4.3;1.4.4;1.4.5</td></tr>
<tr><td colspan="2">Tenant Fit-Out with Owner Involvement
Code: T-I or U</td><td>Full fit-out of systems, equipment, space configuration, and finishes for a tenant space with Owner involved retail, theater and/or F&B</td><td>1.3.1; 1.3.2; 1.3.5; 1.3.7 for tenant restaurant or kitchen renovation
1.4.6</td></tr>
<tr><td colspan="4">Non-Applicable Projects</td></tr>
<tr><td colspan="2">Tenant Fit-Out without Owner Involvement</td><td>Full fit-out of systems, equipment, space configuration, and finishes for a tenant space without Owner involved retail, theater and/or F&B</td><td>Not Required</td></tr>
<tr><td colspan="2">All Other Project Types</td><td></td><td>Not Applicable</td></tr>
</table>

1.0 Waste Management and Recycling

LEEDv4.1 & GREEN MARK HIGHLIGHTS
LEEDv4.1 projects: Requirements of following sections in this module have bearing upon LEEDv4.1 Indoor Environmental Quality requirements: 1.1 Storage and Collection of Recyclables 1.2 Construction Waste Management **Green Mark (for Singapore projects):** Projects must comply with Resource Sustainability Act of 2019, with strict requirements for waste diversion and recycling.

1.1 Storage and Collection of Recyclables	
Provide an easily-accessible dedicated area or areas for the collection, separation and storage of materials for recycling for the entire building. Materials must include, at a minimum: paper, corrugated cardboard, glass, plastics, aluminum, metals, food waste and cooking oil.	
U	1.1.1 Owner and designer must determine the best way to create a dedicated recycling collection and storage area that is easily accessible within the building and encourages recycling yet is accessible to the waste hauler. Design and visibly mark the central collection and storage areas. The recycling collection and storage area needs to be designed based on the recycling method and capacity of the city, and tailored to maximize the efficiency for the recycling efforts. A thorough study on applicable recycling model for the building is required before design. Seek input from local hauler who will be providing waste management service to the site. Depending on the city's recycling capacity and model, general recommendation is having collection and storage areas for the following recyclables: - Food waste - Compostables - Paper - Cardboard - Aluminum - Metal - Plastic - Glass - Cooking oil - Recovered assets (china, silver ware, glasses etc.) - Construction waste - Hazardous waste
U	1.1.2 Recyclable material collection and storage space might increase the project footprint in some instances. Design space for processing equipment (can and plastic crushers, cardboard balers etc.) which can minimize the space required for recycling activities. Also ensure sufficient space for waste tilt storage and cleaning, and ensure good traffic flow. If sorting is required, make sure proper sorting space is designed and the space meets height requirement and is equipped with proper drainage system. Ensure the space has sufficient electric capacity to operate the equipment. Scales should be provided for weighing outgoing recyclables.
U	1.1.3 Design considerations for recycling areas should include signage to discourage contamination, protection from the elements, and security for high-value materials. Design security for the recyclable collection areas to discourage illegal disposal. Consider how recycling activities might affect a building's indoor environmental quality. Activities that create odors, noise, and air contaminants should be isolated or performed during non-occupant hours

1.2 Construction Waste Management	
U	1.2.1 CONSTRUCTION WASTE MANAGEMENT PLAN Implement Construction Waste Management to: • Reduce waste generation • Reuse, salvage, or recycle waste materials • Minimize waste disposal in landfills Contractors prepare and submit a Construction Waste Management Plan (CWM) to the owner for approval. The CWM Plan shall outline the provisions to be implemented to reuse, salvage and recycle demolition and construction waste generated during the project. The end-of-project recycling rate shall equal, at minimum, 75% (by weight) of the total waste from construction, demolition, and land clearing activities. The Construction Waste Management Plan shall include, but not be limited to, the following components: 1.2.1.1 Listing of Targeted Materials: develop a list of the waste materials from the project that will be targeted for reuse, salvage, or recycling. Describe how the materials will be reused, salvaged or recycled. The following materials shall be accounted for (materials that will not be recycled shall be indicated as such): - Cardboard, paper, packaging - Clean dimensional wood, palette wood - Beverage containers - Land clearing debris - Concrete - Bricks - Concrete Masonry Units (CMU) - Asphalt - Metals from banding, stud trim, ductwork, piping, rebar, roofing, other trim, steel, iron, galvanized sheet steel, stainless steel, aluminum, copper, zinc, lead, brass, and bronze. - Drywall - Carpet and pad - Paint - Asphalt roofing shingles if applicable for any existing building demolition - Rigid Foam - Glass - Plastics - FFE 1.2.1.2 Landfill or Incineration Plant Information: provide the name of the landfill(s) or incineration plan where trash will be disposed of and the applicable fee(s). 1.2.1.3 Sorting Method: provide a description of the proposed means of sorting and transporting the recyclable materials (whether materials will be site-separated and self-hauled to designated centers, or whether mixed materials will be collected by a waste hauler and removed from the site for off-site sorting). 1.2.1.4 Packaging Waste: provide an estimate of packaging materials generated, and note whether suppliers will eliminate or take back packaging. 1.2.1.5 Field Conditions: include provisions in the Construction Waste Management Plan for addressing conditions in the field that do not adhere to the CWM Plan, including provisions to implement a stop work order, or to rectify non-compliant conditions. 1.2.1.6 Recycling/donation facilities: provide the name of the recycling/donation facilities(s) where materials will be sent for recycling/donation, how it will be recycled, and the applicable fee(s). 1.2.1.7 All the Applicable Fee(s): fee needs to include all costs, including delivery charge, pick up charge, rental of container charge, contamination fee and hookup fees etc. 1.2.1.8 Additional Information: include any additional information deemed relevant to describe the scope and intent of the CWM Plan to the owner.
U	1.2.2 SUBCTONRACTOR REQUIREMENT

		Construction Waste Management and recycling requirements shall be incorporated into all subcontractors' contracts.
U	1.2.3	IMPLEMENTATION Implement the Construction Waste Management plan, and coordinate the Plan with all affected trades. Designate one individual as the Construction Waste Management Representative, who will be responsible for communicating the progress of the plan with the owner on a regular basis, and for assembling the required documentation.
U	1.2.4	MEETINGS Conduct Construction Waste Management meetings. Meetings shall include subcontractors affected by the CWM Plan. At a minimum, waste management goals and issues shall be discussed at the following meetings: • Pre-bid meeting • Pre-construction meeting • Regular job-site meetings

1.3 Back of House Space Upstream Recycling	
Design appropriate space for collection and separation of waste for typical BOH areas:	
U	1.3.1 Kitchens: the primary waste generated in the kitchen is food waste which is also the main source of contamination. Separating food waste from general waste is the key. Design space for food waste bin and general waste bin (side by side) at food processing/preparing/cleaning stations. Allocate space for breakdown and storage of cardboard. Design space for food waste tilts and general waste tilts that transport waste to the recycling center. Design sufficient space and infrastructure for food digesters near kitchens.
U	1.3.2 Restaurants: the primary waste generated in the restaurant is food waste which is also the main source of contamination. Separating food waste from general waste is the key. Design space for food waste bin and general waste bin (side by side) at food processing/preparing/cleaning stations. Allocate space for breakdown and storage of cardboard. Design space for food waste tilts and general waste tilts that transport waste to the recycling center. If food digester is going to be used for food diversion instead, design sufficient space and infrastructure for food digesters.
U	1.3.3 Housekeeping closets/hotel tower BOH elevator landings: design space to collect bathroom amenities (soap and shampoo products), newspaper and magazines, and leftover toilet paper. If rooms have separate recycling bins, ensure proper collection space is designed for other recyclables as well. Design housekeeping carts to accommodate collection of recyclables from rooms.
U	1.3.4 Facility shops: design appropriate space for recycling bins for the following commodities: - Paper and cardboard - Plastic, cans and bottles - Metal - Hazardous waste - Trash
U	1.3.5 Offices: general waste bin and recycling bin (for plastic, bottles and cans). Paper must be separated – either place a large paper recycling bin at a centralized location or small paper bins at each desk.
U	1.3.6 Team Member dining: the primary waste generated in the Team Member dining room is food waste which is also the main source of contamination. Separating food waste from general waste is the key. Design space for food waste bin and general waste bin (side by side).
U	1.3.7 Bars and Lounges: the primary waste from bars and lounges is glass, aluminum cans and plastic bottles. Design space for bottle recycling bins and general waste bins side by side.

1.4 Front of House (FOH) Upstream Recycling	
Design appropriate space for collection and separation of waste for typical FOH areas:	
U	1.4.1 Casino floor and circulation: Design space to accommodate receptacles that include waste and recycling sections. The recycling section of the receptacle shall be clearly marked with a recycling symbol and may utilize a round opening for bottles/cans and a narrow opening for paper (if paper is separated from other recyclables).
U	1.4.2 Hotel rooms: Design space to accommodate receptacles that include waste and recycling sections. The recycling section of the receptacle shall be clearly marked with a recycling symbol. If multiple trash receptacles are placed in the room, only one recycling receptacle is sufficient for the entire area.
U	1.4.3 MICE prefunction areas: Design space to accommodate receptacles that include waste and recycling sections. The recycling section of the receptacle shall be clearly marked with a recycling symbol and may utilize a round opening for bottles/cans and a narrow opening for paper (if paper is separated from other recyclables).
U	1.4.4 MICE meeting rooms: Design space to accommodate receptacles that include waste and recycling sections. The recycling section of the receptacle shall be clearly marked with a recycling symbol and, at a minimum, include recycling for paper, plastic/cans and compostable waste.
U	1.4.5 MICE expo: Design space to accommodate receptacles that, at a minimum, include waste and recycling sections. The recycling section of the receptacle shall be clearly marked with a recycling symbol and, at a minimum, include recycling for paper, plastic/cans and compostable waste.
U	1.4.6 Retail: Design space to accommodate receptacles that include waste and recycling sections. The recycling section of the receptacle shall be clearly marked with a recycling symbol and may utilize a round opening for bottles/cans and a narrow opening for paper (if paper is separated from other recyclables).
U	1.4.7 Pool deck: Design space to accommodate receptacles that, at a minimum, include waste and recycling sections. The recycling section of the receptacle shall be clearly marked with a recycling symbol and, at a minimum, include recycling plastic bottles/cans.
U	1.4.8 Exterior: Design space to accommodate receptacles that include waste and recycling sections. The recycling section of the receptacle shall be clearly marked with a recycling symbol and may utilize a round opening for bottles/cans and a narrow opening for paper (if paper is separated from other recyclables).

1.5 Singapore Resource Sustainability Act of 2019	
Projects in Singapore must comply with Resource Sustainability Act of 2019 which sets targets for recycling and diversion of electrical/electronic waste, food waste, and packaging waste.	
U	1.5.1 Space and infrastructure must be set aside to collect, segregate, weigh, track, treat and transport waste to achieve targets. Potential solutions to reach targets include: • Waste to energy facility • Food waste sorting facility • Food waste treatment facility • Recycling facilities

2.0 Submittals

2.1 Recyclable Storage and Collection	
U	2.1.1 Design Development 2.1.1.1 Keep a record of the recycling plan's size and accessibility to occupants and facility staff; based on expected volume for the entire building (pickup frequency of commingling, etc.), consider whether the planned approach will be adequate. 2.1.1.2 Prepare documentation such as floor plans and site plans that highlight all recycling storage areas. A path of travel of waste and recyclables through the building to the on-site recycling center must be shown on floor plans. A narrative of how the on-site facilities operate is also required as backup.

2.2 Construction Waste Management	
U	2.2.1 Construction Documents (100%) 2.2.1.1 A copy of the Construction Waste Management Plan, as defined above (prior to project commencement). 2.2.1.2 A Construction and/or Demolition Methodology Report is required for Green Mark, which: a. can be a summary of the larger Construction Method Plan. b. needs to describe: i. how the demolition process is, ii. volume of demolition waste, iii. estimated tonnage of recyclable concrete waste c. includes the process and frequency of sending waste for recycling d. indicates the demolition sequence approved by QP e. includes a plan drawing showing storage of recyclable concrete waste on site f. lists approved recyclers that the recyclable waste will be sent to 2.2.1.3 Monthly recycling report to demonstrate recycling rates meeting the requirements for construction waste recycling in this policy (75% or above). Report includes weight of each type of reused, salvaged and recycled materials and note how they are reused, salvaged and recycled, the weight of waste sent to landfill and weight of total waste. 2.2.1.4 Calculations and supporting documentation to demonstrate end-of–project recycling rates meeting the requirements for Construction Waste Management in this policy (end of project). 2.2.1.5 Receipts and/or transmittals from recycler showing the amount of recycled concrete are to be submitted as part of the Waste Management Plan. 2.2.1.6 For LEED projects, the following are to be submitted: 2.2.1.6.1 LEED Construction and Demolition Waste Plan (based on the USGBC template) 2.2.1.6.2 USGBC Construction and Demolition Waste Management Calculator

2.3 Back of House Upstream Recycling	
U	2.3.1 Design Development 2.3.1.1 Drawings indicate the locations and types of the recycling and waste bins.

2.4 Front of House (FOH) Upstream Recycling	
U	2.4.1 Design Development

	2.4.1.1 Drawings indicate the locations and types of the recycling and waste bins.

2.5 Singapore Resource Sustainability Act of 2019	
U	2.5.1 Design Development 2.5.1.1 Drawings indicate the locations and types of facilities utilized to reach diversion targets. 2.5.1.2 Analysis showing projected amount of waste per type, and methodology used to treat waste and reach targets.

SDS MODULE: MATERIAL SELECTION

The following module is one component of the Las Vegas Sands Corporation Sustainable Development Standards (SDS). The module outlines the owner's requirements for design, performance, execution, and submittal requirements for projects implemented in existing or new build facilities across the Las Vegas Sands Corporation portfolio. Refer to Table 1 to confirm which sections of the Material Selection module are applicable to your project.

Table 1. Material Selection Applicability Matrix

Project Type Code	Project Type	Project Sample Description	Applicable Module Subsections
*The project code below is referenced throughout this module to help you identify the sections relevant to your specific project type. Project Code "U" represents that the module universally applies to all applicable project types. ** New builds, additions, and major renovations must adhere to all components of the module.			
New Construction, Tenants, & Central Systems			
New Build Construction Code: N-B or U		Ground up construction or major renovation of a facility	Must adhere to all sections
Major Building Renovation Code: M-B or U		Extensive renovation including replacement of major systems and reconfiguration of spaces for a large portion of an existing facility	Must adhere to all sections
Hotel Guest Rooms Code: Htl or U		New build or retrofit of guest room, guest room controls, or guest room equipment	Sections 1.1 – 1.6
Tenant Fit-Out with Owner Involvement Code: T-I or U		Full fit-out of systems, equipment, space configuration, and finishes for a tenant space with Owner involved retail, theater and/or F&B	Sections 1.1 – 1.6
Non-Applicable Projects			
Tenant Fit-Out without Owner Involvement		Full fit-out of systems, equipment, space configuration, and finishes for a tenant space without Owner involved retail, theater and/or F&B	Not Applicable
All Other Project Types			Not Applicable

1.0 Material Selection Performance Standards

LEEDv4.1 & GREEN MARK HIGHLIGHTS
LEEDv4.1 projects: Requirements of following sections in this module have bearing upon LEEDv4.1 Indoor Environmental Quality requirements: **Green Mark (for Singapore projects)** This section requires conformance with two sections of Green Mark: Part 3 - Resource Stewardship including Materials, covering the sub-sections 3.2a Sustainable Construction, 3.2b Embodied Carbon, and 3.2c Sustainable Products.

1.1 Building Materials	
Sustainable purchases shall meet one or more of the following criteria (% on cost basis):	
U	1.1.1 50% of purchases contain at least 20% postconsumer and/or 40% postindustrial material.
U	1.1.2 Purchases contain at least 70% material salvaged from off-site or outside the organization.
U	1.1.3 Purchases contain at least 70% material salvaged from on-site, through an internal organization materials and equipment reuse program.
U	1.1.4 Purchases contain at least 50% rapidly renewable material.
U	1.1.5 100% of forest products must come from legal sources with chain of custody (CoC) certification. 70% must come from certified responsible sources in accordance with LEED Certified Wood Pilot ACP. Local certifications of responsible forestry products are acceptable.
U	1.1.6 Purchases contain at least 50% material harvested and processed or extracted and processed within 500 miles (800 kilometer) radius of the project. Building materials or products shipped by rail or water have been extracted, harvested or recovered, as well as manufactured within a 500 mile (800 kilometer) total travel distance of the project site using a weighted average determined through the following formula: (Distance by rail/3) + (Distance by inland waterway/2) + (Distance by sea/15) + (Distance by all other means) ≤ 500 miles [800 kilometers].

1.2 Furniture	
Sustainable purchases shall meet one or more of the following criteria (% on cost basis):	
U	1.2.1 50% of purchases contain at least 20% postconsumer and/or 40% postindustrial material.
U	1.2.2 Purchases contain at least 70% material salvaged from off-site or outside the organization.
U	1.2.3 Purchases contain at least 70% material salvaged from on-site, through an internal organization materials and equipment reuse program.
U	1.2.4 Purchases contain at least 50% rapidly renewable material.
U	1.2.5 100% of forest products must come from legal sources with chain of custody (CoC) certification. 70% must come from certified responsible sources in accordance with LEED Certified Wood Pilot ACP. Local certifications of responsible forestry products are acceptable.
U	1.2.6 Purchases contain at least 50% material harvested and processed or extracted and processed within 500 miles (800 kilometer) radius of the project. Building materials or products shipped by rail or water have been extracted, harvested or recovered, as well as manufactured within a 500 mile (800 kilometer) total travel distance of the project site using a weighted average determined through the following formula: (Distance by rail/3) + (Distance by inland waterway/2) + (Distance by sea/15) + (Distance by all other means) ≤ 500 miles [800 kilometers] .

1.3 Low-emitting Materials – Adhesive and Sealants	
To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants. All adhesives and sealants used on the interior of the building (i.e., inside of the weatherproofing system and applied on-site) must comply with the following requirements as applicable to the project scope.	
U	1.3.1 Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168. Volatile organic compound (VOC) limits listed in the table below correspond to an effective date of July 1, 2005 and rule amendment date of January 7, 2005.

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Architectural Applications	**VOC Limit (g/L less water)**	**Specialty Applications**	**VOC Limit (g/L less water)**
Indoor carpet adhesives	50	PVC welding	510
Carpet pad adhesives	50	CPVC welding	490
Wood flooring adhesives	100	ABS welding	325
Rubber floor adhesives	60	Plastic cement welding	250
Subfloor adhesives	50	Adhesive primer for plastic	550
Ceramic tile adhesives	65	Contact adhesive	80
VCT and asphalt adhesives	50	Special purpose contact adhesive	250
Drywall and panel adhesives	50	Structural wood member adhesive	140
Cove base adhesives	50	Sheet applied rubber lining operations	850
Multipurpose construction adhesives	70	Top and trim adhesive	250
Structural glazing adhesives	100		
Substrate Specific Applications	**VOC Limit (g/L less water)**	**Sealants**	**VOC Limit (g/L less water)**
Metal to metal	30	Architectural	250
Plastic foams	50	Roadway	250
Porous material (except wood)	50	Other	420
Wood	30		
Fiberglass	80		
Sealant Primers	**VOC Limit (g/L less water)**		
Architectural, nonporous	250		
Architectural, porous	775		
Other	750		

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1.3.2 Aerosol adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000.

Aerosol Adhesives	**VOC Limit**
General purpose mist spray	65% VOCs by weight
General purpose web spray	55% VOCs by weight
Special purpose aerosol adhesives (all types)	70% VOCs by weight

This table excludes adhesives and sealants integral to the water-proofing system or that are not building related.

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1.3.3 IMPLEMENTATION

Specify low-VOC materials in construction documents. Ensure that VOC limits are clearly stated in each section of the specifications where adhesives and sealants are addressed. Common products to evaluate include general construction adhesives, flooring adhesives, fire-stopping sealants, caulking, duct sealants, plumbing adhesives and cove base adhesives. Review product cut sheets, material safety data (MSD) sheets, signed attestations or other official literature from the manufacturer clearly identifying the VOC contents or compliance with referenced standards.

1.4 Low-emitting Materials – Paints and Coatings	
To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants. Paints and coatings used on the interior of the building (i.e., inside of the weatherproofing system and applied onsite) must comply with the following criteria as applicable to the project scope.	
U	1.4.1 Architectural paints and coatings applied to interior walls and ceilings must not exceed the volatile organic compound (VOC) content limits established in Green Seal Standard GS-11, Paints, 1st Edition, May 20, 1993.
U	1.4.2 Anti-corrosive and anti-rust paints applied to interior ferrous metal substrates must not exceed the VOC content limit of 250 g/L (2 lb/gal) established in Green Seal Standard GC-03, Anti-Corrosive Paints, 2nd Edition, January 7, 1997.
U	1.4.3 Clear wood finishes, floor coatings, stains, primers, sealers, and shellacs applied to interior elements must not exceed the VOC content limits established in South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, rules in effect on January 1, 2004.
U	1.4.4 Avoid using spray paint aerosols indoors where possible. Required spray paint aerosols should be low VOC content and fast drying, and water based or latex based spray paint should be evaluated if available.
U	1.4.5 IMPLEMENTATION Specify low-VOC paints and coatings in construction documents. Ensure that VOC limits are clearly stated in each section of the specifications where paints and coatings are addressed. Track the VOC content of all interior paints and coatings during construction.

1.5 Low-emitting Materials – Flooring Systems	
OPTION 1: All flooring must comply with the following as applicable to the project scope:	
U	1.5.1 All carpet installed in the building interior must meet one of the following requirements: 1.5.1.1 Meets the testing and product requirements of the Carpet and Rug Institute Green Label Plus. 1.5.1.2 Maximum VOC concentrations are less than or equal to those specified in the California Department of Health Services Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda, using the office scenario as defined in Table 7.5 within the practice. The additional VOC concentration limits listed in Section 9.1a must also be met. 1.5.1.3 Maximum VOC concentrations meet the California requirements specified above based on the following: - California Department of Public Health (CDPH) Standard Method V1.1-2010 using test results obtained at the 14 day time point. - Projects outside the U.S. may use the German AgBB/DIBt testing method and all testing methods based on AgBB/DIBt method (GUT, EMICODE, Blue Angel) using test results obtained at the 3 day or 7 day or 14 day time point. For caprolactam, if test results obtained at the 3 day or 7 day time point is used, the emission concentration must be less than 1/2 of the concentration limit specified above because the emission may not have peaked at the measured time points. If a European testing method (AgBB/DIBt GUT, EMICODE, Blue Angel) had used parameters for calculating test results different from those specified in the

	referenced California method, then the European test results for carpets or floorings need to be converted into California air concentrations by multiplication with 0.7.
U	1.5.1.4 All carpet cushion installed in the building interior must meet the requirements of the Carpet and Rug Institute Green Label program.
	1.5.1.5 All carpet adhesive must meet the requirements of 1.3: Adhesives and Sealants, which includes a volatile organic compound (VOC) limit of 50 g/L (0.4 lb/gal).
	1.5.1.6 All hard surface flooring installed in the building interior must meet one of the following requirements: • Meet the requirements of the FloorScore standard (current as of the date of this rating system, or more stringent version) as shown with testing by an independent third-party. • Demonstrate maximum VOC concentrations less than or equal to those specified in the California Department of Health Services Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda, using the office scenario as defined in Table 7.5 within the practice. • Maximum VOC concentrations meet the California requirements specified above based on the following: - California Department of Public Health (CDPH) Standard Method V1.1-2010 using test results obtained at the 14 day time point. - Projects outside the U.S. may use the German AgBB/DIBt testing method and all testing methods based on AgBB/DIBt method (GUT, EMICODE, Blue Angel) using test results obtained at the 3 day or 7 day or 14 day time point. For caprolactam, if test results obtained at the 3 day or 7 day time point is used, the emission concentration must be less than 1/2 of the concentration limit specified above because the emission may not have peaked at the measured time points. If a European testing method (AgBB/DIBt GUT, EMICODE, Blue Angel) had used parameters for calculating test results different from those specified in the referenced California method, then the European test results for carpets or floorings need to be converted into California air concentrations by multiplication with 0.7. • Mineral-based finish flooring products such as tile, masonry, terrazzo, and cut stone without integral organic-based coatings and sealants and unfinished/untreated solid wood flooring qualify for credit without any IAQ testing requirements. However, associated site-applied adhesives, grouts, finishes and sealers must be compliant for a mineral-based or unfinished/untreated solid wood flooring system to qualify for credit
	1.5.1.7 Concrete, wood, bamboo and cork floor finishes such as sealer, stain and finish must meet the requirements of South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, rules in effect on January 1, 2004.
	1.5.1.8 Tile setting adhesives and grout must meet South Coast Air Quality Management District (SCAQMD) Rule 1168. VOC limits correspond to an effective date of July 1, 2005 and rule amendment date of January 7, 2005.
	1.5.1.9 For carpet adhesive, concrete, wood, bamboo and cork floor finishes, and tile setting adhesives, compliance can be demonstrated with test results of: • Total volatiles fraction, based on one of the following, provided that water and exempt compounds are subtracted from total volatiles test results and the mass VOC content is calculated consistent with SCAQMD Rule 1113 and Rule 1168: - ASTM D2369

U	- EPA method 24 - ISO 11890 part 1 • Total volatile organic compounds fraction, based on one of the following, provided that all VOCs with a boiling point up to 280°C (536°F) are included, and exempt compounds are subtracted from total volatiles test results and the mass VOC content is calculated consistent with SCAQMD Rule 1113 and Rule 1168: - ASTM D6886 - ISO 11890 part 2
OPTION 2	
U	1.5.2 All flooring elements installed in the building interior must meet the testing and product requirements of the California Department of Health Services Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda. Mineral-based finish flooring products such as tile, masonry, terrazzo, and cut stone without integral organic based coatings and sealants and unfinished/untreated solid wood flooring qualify for credit without any IAQ testing requirements. However, associated site-applied adhesives, grouts, finishes and sealers must be compliant for a mineral-based or unfinished/untreated solid wood flooring system to qualify for credit.

1.6 Low-emitting Materials – Composite Wood and Agrifiber Products	
U	1.6.1 Composite wood and agrifiber products used on the interior of the building (i.e., inside the weatherproofing system) must contain no added urea-formaldehyde resins. Laminating adhesives used to fabricate on-site and shop-applied composite wood and agrifiber assemblies must not contain added urea-formaldehyde resins. Composite wood and agrifiber products are defined as particleboard, medium density fiberboard (MDF), plywood, wheatboard, strawboard, panel substrates and door cores. Materials considered fixtures, furniture and equipment (FF&E) are not considered base building elements and are not included.
U	1.6.2 IMPLEMENTATION Specify wood and agrifiber products that contain no added urea-formaldehyde resins. Specify laminating adhesives for field and shop-applied assemblies that contain no added urea-formaldehyde resins. Review product cut sheets, material safety data (MSD) sheets, signed attestations or other official literature from the manufacturer.

1.7 Embodied Carbon and Carbon Footprint & Lifecycle Assessment (LCA)	
U	1.7.1 Major renovations and new builds must track embodied carbon for the project in compliance with CDP for Real Estate. Approved methods to assess embodied carbon include: • BBCA Label (Bâtiment Bas Carbone) • E+C- Label (Énergie Positive & Réduction Carbone) • Embodied Carbon in Construction Calculator (EC3) Tool • EN 15978 • EN 15804 • GHG Protocol - Product Life Cycle Accounting and Reporting Standard • ISO 14040/44 • ISO 14025 • One Click LCA • Whole life carbon assessment for the built environment (RICS)
U	1.7.2 Major renovations and new builds must asses LCA emissions for the project. Approved methods to assess LCA emissions include: • BBCA Label (Bâtiment Bas Carbone) • E+C- Label (Énergie Positive & Réduction Carbone)

U	• Embodied Carbon in Construction Calculator (EC3) Tool • EN 15978 • EN 15804 • GHG Protocol - Product Life Cycle Accounting and Reporting Standard • ISO 14040/44 • ISO 14025 • One Click LCA • Whole life carbon assessment for the built environment (RICS)

2 Submittals

2.1 Building Materials	
U	2.1.1 Design Development 2.1.1.1 Provide documentations demonstrating requirements are incorporated into specifications. 2.1.1.2 Maintain materials tracking spread sheet; Provide materials cost information for materials in compliance; Provide backup documentations to confirm compliance

2.2 Furniture:	
U	2.2.1 Design Development 2.2.1.1 Provide documentations demonstrating requirements are incorporated into specifications. 2.2.2 Construction Documents (100%) 2.2.1.2 Maintain furniture tracking spread sheet; Provide furniture cost information for materials in compliance; Provide backup documentations to confirm compliance

2.3 Adhesive and Sealants:	
U	2.3.1 Design Development 2.3.1.1 Architect of record incorporate VOC limits in specifications 2.3.2 Construction Documents (100%) 2.3.2.1 Provide a list of interior adhesives and sealants; 2.3.2.2 Provide product info sheets for interior adhesives and sealants with VOC content;

2.4 Adhesive and Sealants:	
U	2.4.1 Design Development 2.4.1.1 Architect of record incorporate VOC limits in specifications 2.4.2 Construction Documents (100%) 2.4.1.2 Provide a list of interior paints and coatings used; 2.4.1.3 Provide product info sheets for interior paints and coatings with VOC content

2.5 Flooring Systems	
U	2.5.1 Design Development 2.5.1.1 Interior designers incorporate requirement in specifications 2.5.2 Construction Documents (100%) 2.5.2.1 Maintain a list of each carpet, carpet cushion, and carpet adhesive installed in the building interior. Record the VOC content for each adhesive. 2.5.2.2 Maintain a list of each hard surface flooring product, tile setting adhesive, finishes, and grout installed in the building interior. Record the VOC content for each tile setting adhesive and grout.

2.6 Composite Wood and Agrifiber Products	
U	2.6.1 Design Development 2.6.1.1 Architect of record: Incorporate requirement in specifications 2.6.2 Construction Documents (100%) 2.6.2.1 Maintain a list of each composite wood and agrifiber product installed in the building interior. Confirm that each product does not contain any added urea-formaldehyde.

2.7 Embodied Carbon and Carbon Footprint & Lifecycle Assessment (LCA)	
U	2.7.1 Embodied Carbon 2.7.1.1 Detailed assessment of embodied carbon by material in compliance with one of various approved methods in section 1.7.1. 2.7.2 LCA Emissions 2.7.2.1 Detailed assessment of LCA by in compliance with one of various approved methods in section 1.7.2.

SDS Module: INDOOR ENVIRONMENTAL QUALITY

The following module is one component of the Las Vegas Sands Corporation Sustainable Development Standards (SDS). The module outlines the owner's requirements for design, performance, execution, and submittal requirements for projects implemented in existing or new build facilities across the Las Vegas Sands Corporation portfolio. Refer to Table 1 to confirm which sections of the Indoor Environmental Quality module are applicable to your project.

Table 1. Indoor Environmental Quality Module Applicability Matrix

Project Type Code	Project Type	Project Sample Description	Applicable Module Subsections
*The project code below is referenced throughout this module to help you identify the sections relevant to your specific project type. Project Code "U" represents that the module universally applies to all applicable project types. ** New builds, additions, and major renovations must adhere to all components of the module.			
New Construction, Tenants, & Central Systems			
New Build Construction Code: N-B or U		Ground up construction or major renovation of a facility	Must adhere to all sections
Major Building Renovation Code: M-B or U		Extensive renovation including replacement of major systems and reconfiguration of spaces for a large portion of an existing facility	Must adhere to sections
HVAC System Upgrade or Retrofits Code: HVAC or U		Replacement of major equipment or retrofit of broader system, such as air handling unit, terminal units (VAV, fan coil, FPB's)	Must adhere to sections
Hotel Guest Rooms Code: Htl or U		New build or retrofit of guest room, guest room controls, or guest room equipment	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7
Tenant Fit-Out with Owner Involvement Code: T-I or U		Full fit-out of systems, equipment, space configuration, and finishes for a tenant space with Owner involved retail, theater and/or F&B	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7
Non-Applicable Projects			
Tenant Fit-Out		Full fit-out of systems, equipment, space configuration, and finishes for a tenant space without Owner involved retail, theater and/or F&B	Not Applicable
All Other Project Types			Not Applicable

1.0 Indoor Environmental Quality Performance Standards

LEEDv4.1 & GREEN MARK HIGHLIGHTS
LEEDv4.1 projects: Requirements of following sections in this module have bearing upon LEEDv4.1 Indoor Environmental Quality requirements: **Minimum indoor air quality (IAQ) performance** This section requires conformance with minimum indoor air quality provisions contributing to the comfort and well-being of the occupants. **Environmental tobacco smoke control** This section requires conformance with features to prevent or minimize building occupants' exposure to environmental tobacco smoke.

Outdoor air delivery monitoring
This section requires conformance with features to ensure adequate quantities of ventilation air are being provided.

Construction IAQ management plan
This section reduces IAQ problems from construction or renovation for comfort and well-being of occupants and construction workers.

Indoor chemical and pollutant source control
Minimize exposure of building occupants to hazardous particulates and pollutants.

Control of lighting and temperature
Provide high level of lighting and temperature control to building occupants for comfort and well-being.

Thermal comfort
Design HVAC systems to achieve comfortable occupant conditions

Green Mark (for Singapore projects)
Requirements of this module has bearing upon certain sections of Green Mark requirements.

1.1 Minimum indoor air quality (IAQ) performance		
Establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings contributing to the comfort and well-being of occupants. To the extent that local applicable building code is stricter or further air quality performance is desired or required by this standard, the building systems may exceed these requirements. See specific elements of required air quality performance below.		
U	1.1.1	DESIGN 1.1.1.1 Mechanical ventilation systems must be designed using the ventilation rate procedure as defined by ASHRAE 62.1-2007, or the applicable local code, whichever is more stringent. OPTION 1. ASHRAE Standard 62.1-2007 or Non-U.S. Equivalent Meet the minimum requirements of Sections 4 through 7 of ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality (with errata but without addenda). Projects outside the U.S. may use a local equivalent to Sections 4 through 7 of ASHRAE Standard 62.1-2007. OR OPTION 2. CEN Standards EN 15251: 2007 and EN 13779: 2007 Projects outside the U.S. may earn this prerequisite by meeting the minimum requirements of Annex B of Comité Européen de Normalisation (CEN) Standard EN 15251: 2007, Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics; and the requirements of CEN Standard EN 13779: 2007, Ventilation for nonresidential buildings, Performance requirements for ventilation and room conditioning systems, excluding Section 7.3 – Thermal environment, 7.6 – Acoustic Environment, A.16, and A.17.
U	1.1.2	IMPLEMENTATION 1.1.2.1 Design ventilation systems to meet or exceed the minimum outdoor air ventilation rates as described in the ASHRAE standard. Balance the impacts of ventilation rates on energy use and indoor air quality to optimize for energy efficiency and occupant comfort. Use the ASHRAE Standard 62.1-2007 Users Manual (with errata but without addenda) for detailed guidance on meeting the referenced requirements. 1.1.2.2 The mechanical engineers must use the Ventilation Rate Procedure defined in this ASHRAE standard to determine minimum outside air delivery rates. This requires listed anticipated occupant densities, airflow distribution efficiencies, outdoor air intake rates, and zone-by-zone airflows. 1.1.2.3

U	1.1.3	COST IMPLICATIONS/LIFECYCLE COST ANALYSIS 1.1.3.1 None - ASHRAE 62.1 – 2007 is the required standard for ventilation design for many areas.
U	1.1.4	CONSTRUCTION QUALITY ASSURANCE 1.1.4.1 Upon project completion, Commissioning Agent to verify actual ventilation rates satisfy requirements

1.2 Environmental tobacco smoke control		
Prevent or minimize exposure of building occupants, indoor surfaces and ventilation air distribution systems to environmental tobacco smoke (ETS). Applicable to building interior areas including 25’ distance from entries, air intakes and operable windows. Projects in Singapore must comply with both SDS standards below and Singapore’s National Environmental Agency smoking regulation policies, whichever is stricter.		
U	1.2.1	DESIGN 1.2.1.1 Prohibit smoking in all common areas of the building. 1.2.1.2 Locate any exterior designated smoking areas, including balconies where smoking is permitted, at least 25 feet (8 meters) from entries, outdoor air intakes and operable windows opening to common areas. 1.2.1.3 Prohibit on-property smoking within 25 feet (8 meters) of entries, outdoor air intakes and operable windows. 1.2.1.4 Provide signage to allow smoking in designated areas, prohibit smoking in designated areas or prohibit smoking on the entire property. 1.2.1.5 Weather-strip all exterior doors and operable windows in the residential units to minimize leakage from outdoors. 1.2.1.6 Minimize uncontrolled pathways for ETS transfer between individual residential units by sealing penetrations in walls, ceilings and floors in the residential units and by sealing vertical chases adjacent to the units. 1.2.1.7 Weather-strip all doors in the residential units leading to common hallways to minimize air leakage into the hallway. 1.2.1.8 Demonstrate acceptable sealing of residential units by a blower door test conducted in accordance with ANSI/ASTM-E779-03, Standard Test Method for Determining Air Leakage Rate By Fan Pressurization. Projects outside the U.S. may use a local equivalent to ANSI/ASTM-E779-03, Standard Test Method for Determining Air Leakage Rate By Fan Pressurization. 1.2.1.9 Use the progressive sampling methodology defined in Chapter 4 (Compliance Through Quality Construction) of the Residential Manual for Compliance with California’s 2001 Energy Efficiency Standards. 1.2.1.10 Residential units (hotel rooms/ serviced apartments/ condominiums) must demonstrate less than 1.25 square inches leakage area per 100 square feet (8 square centimeters of leakage area per 10 square meters) of enclosure area (i.e., sum of all wall, ceiling and floor areas).
U	1.2.2	IMPLEMENTATION 1.2.2.1 For residential and hospitality projects, prohibit smoking in common areas and design building envelope and systems to minimize ETS transfer among dwelling units. Specifications shall include details for sealing units and supporting test procedure. 1.2.2.2 General Contractor construct residential units to specifications and details including sealing requirements
U	1.2.3	COST IMPLICATIONS/LIFECYCLE COST ANALYSIS 1.2.3.1 Additional costs are anticipated for blower door testing and tighter construction. Weather-stripping is generally included in baseline design and does not represent additional cost. Tighter building construction has reduced infiltration/leakage leading to lower operating costs.
U	1.2.4	CONSTRUCTION QUALITY ASSURANCE 1.2.4.1 Commissioning Agent conduct blower door testing of hotel rooms

1.3 Outdoor air delivery monitoring	
Provide ventilation system monitoring to promote occupant comfort and well-being as well as support energy savings to avoid overventilation. HVAC ventilation systems must meet the following requirements below.	
U	1.3.1 DESIGN 1.3.1.1 Install permanent monitoring systems to ensure that ventilation systems monitor actual ventilation airflow (systems greater than 1,000 L/s or 2,200 CFM) and served spaces larger than 100 square meters (1,076 square feet) are equipped with permanent carbon dioxide (CO_2) monitoring used to reset actual ventilation to target CO_2 concentration when occupied. CO_2 monitoring must be between 1 and 2 meters above floor.
U	1.3.2 IMPLEMENTATION 1.3.2.1 Install CO_2 and airflow measurement equipment coordinated into HVAC building automation system (BAS) to dynamically regulate ventilation based upon occupied area CO_2 levels. 1.3.2.2 Commissioning Agent must review all aspects of design and submittals to ensure variable ventilation system will precisely monitor and vary ventilation to accurately maintain target CO_2 setpoints.
U	1.3.3 COST IMPLICATIONS/ LIFECYCLE COST ANALYSIS 1.3.3.1 Yes – additional instrumentation, control dampers and commissioning increases capital costs. Precisely varying ventilation to occupant requirements yields operating cost savings and good return on investment. Design engineer must provide analysis of building code required CO_2 monitoring versus degree of monitoring required under this section to understand add cost.
U	1.3.4 CONSTRUCTION QUALITY ASSURANCE 1.3.4.1 Commissioning Agent work closely with controls contractor and mechanical contractor to ensure proper operation. Refer Commissioning and Controls modules for additional requirements.

1.4 Construction indoor air quality (IAQ) management plan	
Reduce indoor air quality (IAQ) problems resulting from construction or renovation and promote the comfort and well-being of construction workers and building occupants	
U	1.4.1 DESIGN 1.4.1.1 Develop and implement an IAQ management plan for the construction and preoccupancy phases of the building 1.4.1.2 During construction meet or exceed recommended control measures of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines For Occupied Buildings Under Construction, 2nd Edition 2007, ANSI/SMACNA 008-2008 (Chapter 3) 1.4.1.3 Protect stored on-site and installed absorptive materials from moisture damage 1.4.1.4 If permanently installed air handlers are used during construction, filtration media must be used at each return air grille that meets one of the following criteria below. Replace all filtration media immediately prior to occupancy: 1.4.1.4.1 Filtration media with a Minimum Efficiency Reporting Value (MERV) of 8 as determined by ASHRAE Standard 52.2-1999 (with errata but without addenda) 1.4.1.4.2 Filtration media is Class F5 or higher, as defined by CEN Standard EN 779-2002, Particulate air filters for general ventilation, Determination of the filtration performance 1.4.1.4.3 Filtration media with a minimum dust spot efficiency of 30% or higher and greater than 90% arrestance on a particle size of 3–10 micron
U	1.4.2 IMPLEMENTATION 1.4.2.1 Draft and adopt IAQ management plan to protect HVAC system during construction, control pollutant sources and interrupt contamination pathways. Sequence the installation of materials to avoid contamination of absorptive materials, such as insulation, carpeting, ceiling tile and gypsum wallboard.

U	1.4.2.2 Sample plan/policy elements: HVAC equipment 1.4.2.2.1 All HVAC equipment must be protected from collecting dust, odors, or other contaminants 1.4.2.2.2 Use of permanent HVAC equipment will be avoided in construction areas during demolition 1.4.2.2.3 If air handlers must be used during construction, filtration media with a Minimum Efficiency Reporting Value (MERV) of 8 must be used at each supply air intake and return air grill, as determined by ASHRAE 52.2-1999 1.4.2.2.4 Filters are to be replaced as they become loaded, prior to building flush out, and prior to occupancy 1.4.2.2.5 Conduct a minimum 2 week building flush out with new filtration media with 100% outside air prior to occupancy of the affected space. After the flush-out, replace the filtration media with new media, except for filters solely processing outside air 1.4.2.2.6 Whenever the HVAC system is not used during construction, seal off the supply diffusers and return air system openings to prevent the accumulation of dust and debris in the duct system 1.4.2.2.7 Provide periodic duct inspections during construction. If the ducts become contaminated due to inadequate protection, clean the ducts professionally in accordance with NADCA (National Air Duct Cleaning Association) standards 1.4.2.2.8 Do not use mechanical rooms or air handling equipment areas to store construction or waste materials once commissioned. Keep rooms and areas clean and neat Contaminant source control 1.4.2.2.9 Use low or no VOC products as required by specifications 1.4.2.2.10 Restrict traffic volume and prohibit idling of motor vehicles where emissions could be drawn into the building 1.4.2.2.11 Exhaust pollution sources to the outside with portable fan systems. Prevent exhaust from recirculation back into building 1.4.2.2.12 Protect stored on-site or installed absorptive building materials from contaminants and moisture Pathway interruption 1.4.2.2.13 Provide dust curtains or temporary enclosures to prevent dust from migrating to other areas when applicable Housekeeping 1.4.2.2.14 Remove accumulations of water inside the building. Protect porous materials such as insulation, drywall, ceiling tile, and carpet from exposure to moisture
U	1.4.3 COST IMPLICATIONS/ LIFECYCLE COST ANALYSIS 1.4.3.1 Increased labor and air filter costs. Cleaner HVAC system will operate more efficiently but actual savings cannot be reliably estimated for lifecycle cost analysis. Reduced dust and VOC exposure to occupants increases well-being
U	1.4.4 CONSTRUCTION QUALITY ASSURANCE 1.4.4.1 Owner's representative to monitor construction activities and enforce GC's construction IAQ management plan.

1.5 Indoor chemical and pollutant source control	
Minimize exposure of building occupants to potentially hazardous particulates and chemical pollutants with entryway systems and designated hazardous chemical areas (high volume copy/print areas, chemical storage and mixing areas, battery banks, etc.)	
U	1.5.1 DESIGN 1.5.1.1 Exhaust spaces where hazardous gases/ chemicals present (garages, housekeeping and laundry areas, copying and printing rooms) to create 5 Pascals (0.02" water gauge) negative pressure relative to clean adjacent areas 1.5.1.2 Each ventilation fan must be equipped with minimum filtration: 1.5.1.2.1 Minimum efficiency reporting value (MERV) of 13 or higher per ASHRAE Standard 52.2

	1.5.1.2.2 Class F7 or higher, as defined by CEN Standard EN 779: 2002, Particulate air filters for general ventilation
U	1.5.2 IMPLEMENTATION 1.5.2.1 Design facility cleaning, maintenance, shop and garage areas with isolated exhaust systems. 1.5.2.2 Design air handling systems for high performance filtration pressure drops, install high performance filtration systems and change media when loaded
U	1.5.3 COST IMPLICATIONS/ LIFECYCLE COST ANALYSIS 1.5.3.1 Dedicated exhaust typically code required and no cost analysis needed. 1.5.3.2 Equipment designed and commissioned for high performance filtration can always utilize lower quality filtration in future but not vice versa so critical to design high performance filtration capability.
U	1.5.4 CONSTRUCTION QUALITY ASSURANCE 1.5.4.1 Commissioning Agent confirm contaminated areas at minimum negative pressure 1.5.4.2 Commissioning Agent confirms high performance filtration installed, utilize particle counter to confirm no bypass flow around filtration and DDC monitoring system calibrated for specific installed filtration and loaded pressure drop condition to reliably alarm Facilities when filtration loaded/ requiring replacement.

1.6 Control of lighting and temperature	
Provide high level of lighting system control and temperature control by individual occupants for comfort and well-being of building occupants	
U	1.6.1 DESIGN 1.6.1.1 Provide individual lighting controls in following areas: Hotel guest rooms (with occupancy sensors unless not feasible), BOH offices with occupancy sensors 1.6.1.2 Open office areas greater than 150 square meters (1,614 square feet) shall have zoned lighting control. Every 150 square meters (maximum) as a general rule shall have individual lighting control. Evaluate add cost of addressable dimming. 1.6.1.3 Stairwells, garages, FOH corridors in MICE areas, and BOH corridors shall have bi-level switched LED fixtures with local occupancy detectors. Mockups necessary to confirm specific fixtures and grid layout adequately detect motion in each proposed location type to confirm safe occupant and vehicle travel. If allowed by code have bi-level switched LED fixtures with local occupancy detectors on egress lighting circuits also. 1.6.1.4 Atria, other areas such as perimeter and rooftop level of aboveground parking garages subject to daylight shall have automatic daylight sensing and dimming capability. 1.6.1.5 Exhibition halls shall have wireless addressable dimming to specific fixtures such as Daintree system. 1.6.1.6 MICE areas shall have local control with occupancy sensors and override capability as well as remote master control based upon scheduled occupancy automatically coordinated with MICE space sales. 1.6.1.7 All exterior lighting shall be networked and automatically controlled to ensure general security and theme lighting does not operate during daylight periods. Photocells are allowed to operate general security lighting in event storm clouds cause dark conditions during daylight periods. Refer Lighting Module for additional requirements. 1.6.1.8 Provide individual temperature controls with occupancy sensors in following areas: Hotel guest rooms, VIP BOH offices, individual MICE rooms. 1.6.1.9 Provide individual temperature control serving multiple (non-VIP) BOH offices consistently with equipment served areas (e.g. one FCU serves three adjacent offices and locate single thermostat in center office). Occupancy sensors can be installed in all served areas to reset thermostat when unoccupied. 1.6.1.10 Open office areas greater than 150 square meters (1,614 square feet) shall have zoned temperature control to extent zoned HVAC reasonable. Consideration must be given to building exposure areas and center ‘core’ areas with zoning considerations.
U	1.6.2 IMPLEMENTATION 1.6.2.1 Design and mock up test all areas with lighting controls based upon occupancy sensing, bi-level switching, daylight dimming, MICE local control with automatic remote scheduling, and wireless addressable dimming.

U	1.6.3	COST IMPLICATIONS/ LIFECYCLE COST ANALYSIS 1.6.3.1 If local building code does not require sophisticated lighting controls bid the lighting controls as an Add Alternate to understand the incremental cost and estimate incremental cost savings of each upgrade to determine if upgrade satisfies acceptable ROI criteria.
U	1.6.4	CONSTRUCTION QUALITY ASSURANCE 1.6.4.1 Commissioning Agent confirms all lighting controls work properly to yield estimated energy savings.

1.7 Thermal comfort		
Provide comfortable thermal environment for comfort and well-being of building occupants		
U	1.7.1	DESIGN 1.7.1.1 Design heating, ventilating and air conditioning (HVAC) systems and the building envelope to meet the requirements of: OPTION 1. ASHRAE Standard 55-2004 or Non-U.S. Equivalent Meet requirements of ASHRAE Standard 55-2004, Thermal Environmental Conditions for Human Occupancy (with errata but without addenda 37). Demonstrate design compliance in accordance with Section 6.1.1 documentation. Projects outside U.S. may use local equivalent to ASHRAE Standard 55-2004 Thermal Comfort Conditions for Human Occupancy Section 6.1.1. OR OPTION 2. ISO 7730: 2005 & CEN Standard EN 15251: 2007 Projects outside U.S. may design heating, ventilating and air conditioning (HVAC) systems and building envelope to meet requirements of International Organization for Standardization (ISO) 7730: 2005 Ergonomics of the thermal environment, Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria; and CEN Standard EN 15251: 2007, Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.
U	1.7.2	IMPLEMENTATION 1.7.2.1 Design HVAC and building envelope to comply with requirements confirmed by building simulation consultant. If compliance deemed difficult or expensive versus default building code compliant construction identify specific issues and review with Owner.
U	1.7.3	COST IMPLICATIONS/ LIFECYCLE COST ANALYSIS 1.7.3.1 Compliance does not usually involve appreciable design or construction cost. If particular project would incur difficulty or significant cost increase to comply a meeting with Owner shall occur to determine whether compliance justified
U	1.7.4	CONSTRUCTION QUALITY ASSURANCE 1.7.4.1 Commissioning Agent confirms HVAC system and controls work properly to yield compliant indoor thermal conditions.

1.8 Casino air quality		
Provide reasonable air quality in casinos where smoking is permitted and balance air quality with energy consumption		
U	1.8.1	DESIGN 1.8.1.1 Design airflow patterns and supply air filtration to comply with specific performance testing requirements such as PM2.5, VOCs, etc. 1.8.1.2 Smoking areas must be maintained at negative pressure relative to adjacent non-smoking areas with significant operational flexibility. Capability for outside air flow rates, return air flow rates and exhaust air flow rates to independently vary from 0% to 100% with variable speed drives on all fan motors and full air flow monitoring at each PAU, AHU and exhaust fan. 1.8.1.3 PAUs if final supply, and AHUs must be configured to utilize H13 HEPA grade final air filtration, with F9 pre-filters or similar. Filter racks must be of heavy duty construction designed for high performance filtration 1.8.1.4 Raised access floors with a height of 450mm above structural slab expected. Power and data distribution is routed through underfloor and at intersections could require up to

U		200mm of available space. Engineer must endeavor to utilize grid distribution and low profile fitments to maximize underfloor space for limited supply air capability 1.8.1.5 To provide improved air quality directly to dealer and pit areas in smoking areas, 30% of H13 filtered primary ventilation air as constant volume conditioned and distributed into floor plenum to supply pit areas with displacement style low velocity diffusers; and to provide air directly into custom gaming tables and furniture. Furniture to be provided with integral fan and diffusers, or low profile Titus booster fan to be deployed into raised floor under gaming furniture. In situ concrete slab formed with concrete knock out panels, to be dimensioned and spaced by engineer and coordinated with structural engineer, to provide underfloor supply air via duct from under slab in ceiling area below floor. If floor is designated fire separation zone, necessary to utilize motorized fire smoke damper at floor penetration. 1.8.1.6 Remaining 70% maximum ventilation outdoor air and general HVAC supply air to be provided through ceiling at regularly spaced intervals. Special diffusers required, configured to horizontally displace air across ceiling surface are required on an expected 6m to 8m spacing to dedicated opposing return air inlet openings just below ceiling that are fully ducted above the ceiling. Objective of horizontal under ceiling air movement pattern is to entrain and remove ambient tobacco smoke. Ideal configuration of ceiling supply air is for movement from center of expected pit area towards guest circulation areas – causing supply air movement from behind dealers toward guest areas. Diffusers must be carefully developed to maintain NC-30 or less ambient noise and maintain uniform velocity from supply outlet to return receiver. 1.8.1.7 Fire smoke extract fans configured with variable frequency drives and able to provide general exhaust and also fire smoke extract service.
U	1.8.2	IMPLEMENTATION 1.8.2.1 Engineer to design systems compliant with these requirements. CFD modeling may be utilized to confirm design to yield desired protective airflows.
U	1.8.3	COST IMPLICATIONS/ LIFECYCLE COST ANALYSIS 1.8.3.1 Compliance involves additional design and construction cost. Lifecycle cost analysis not necessary.
U	1.8.4	CONSTRUCTION QUALITY ASSURANCE 1.8.4.1 Commissioning Agent confirms HVAC system and controls work properly to yield desired airflow patterns and improved air quality at edges of smoking areas and within dealer/pit areas.

2.0 Submittals

2.1 Minimum indoor air quality		
U	2.1.1 2.1.2	Design Development 2.1.1.1 Mechanical Engineer Responsibility: Provide spreadsheet documenting use of the ASHRAE Ventilation Rate Procedure and the calculated ventilation rates. Construction Documents (100%) 2.1.2.1 Mechanical Engineer Responsibility: Provide updated spreadsheet documenting use of the ASHRAE Ventilation Rate Procedure and the calculated ventilation rates and final space occupancy values. Equipment schedules shall be updated as necessary.

2.2 Environmental tobacco smoke control		
U	2.2.1 2.2.2	Design Development 2.2.1.1 Architect Responsibility: Floorplan drawings highlighting any interior areas where smoking is allowed (smoking floors) with clear boundaries and any exterior areas with evidence of 25 foot separation from building openings. Construction Documents (100%)

		2.2.2.1 Architect Responsibility: Floorplan drawings highlighting any interior areas where smoking is allowed (smoking floors) with clear boundaries and any exterior areas with evidence of 25 foot separation from building openings

2.3 Outdoor air delivery monitoring		
U	2.3.1	Design Development
		2.3.1.1 Mechanical Engineer Responsibility: Provide documentation of areas proposed to be equipped with monitoring and/or CO2 controlled ventilation
	2.3.2	Construction Documents (100%)
		2.3.2.1 Commissioning Agent Responsibility: Provide documentation confirming the requisite instrumentation and control components as well as detailed sequences of operation will be installed to precisely monitor and efficiently vary CO2 levels in served spaces

2.4 Construction indoor air quality (IAQ) management plan		
U	2.4.1	Construction Documents (100%)
		2.4.1.1 General Contractor Responsibility: Develop and adopt Construction IAQ management plan
		2.4.1.2 General Contractor Responsibility: Provide cut sheets of conforming filtration

2.5 Indoor chemical and pollutant source control		
U	2.5.1	Design Development
		2.5.1.1 Architect Responsibility: Floorplan drawings highlighting contaminated areas and required doors/isolation to achieve negative pressure with exhaust
		2.5.1.2 Mechanical Engineer Responsibility: Design dedicated exhaust systems
	2.5.2	Construction Documents (100%)
		2.5.2.1 Commissioning Agent: Review of proposed design of containment areas and certification systems should comply with target negative pressurization.

2.6 Control of lighting and temperature		
U	2.6.1	Design Development
		2.6.1.1 Electrical Engineer and/or Lighting Designer Responsibility: Provide spreadsheet tabulation of specific areas, proposed lighting controls and basis of design equipment
		2.6.1.2 Mechanical Engineer Responsibility: Provide spreadsheet tabulation of specific areas, proposed temperature controls and basis of design equipment
	2.6.2	Construction Documents (100%)
		2.6.2.1 Electrical Engineer and/or Lighting Designer Responsibility: Review all fixture and control submittals and substitutions to assure quality of design intent is maintained
		2.6.2.2 Mechanical Engineer Responsibility and/or Commissioning Agent Responsibility: Review all equipment and control submittals and substitutions to assure quality of design intent is maintained

2.7 Thermal comfort		
U	2.7.1	Design Development
		2.7.1.1 Mechanical Engineer, Building Simulation Consultant and Curtain Wall Designer Responsibility: Confirm specific project HVAC system, climate and expected curtain wall performance expected to comply
	2.7.2	Construction Documents (100%)

	2.7.2.1 Mechanical Engineer, Building Simulation Consultant and Curtain Wall Designer Responsibility: Provide updated documentation actual HVAC system design, climate and curtain wall performance per shop drawing submittals comply

2.8 Casino air quality	
U	2.8.1 Design Development 2.8.1.1 Mechanical Engineer Responsibility: Confirm specific project HVAC system performance expected to comply. Mockups and/or CFD simulation may be necessary. 2.8.2 Construction Documents (100%) 2.8.2.1 Mechanical Engineer and Commissioning Agent Responsibility: Provide updated documentation of actual HVAC system design and shop drawing submittals comply with performance requirements.